SEL-351P-3
Recloser Control

Instruction Manual

IMPORTANT: Use this manual in conjunction with the *SEL-351P-3 Quick-Start Installation and User's Guide.*

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SEL SCHWEITZER ENGINEERING LABORATORIES, INC.

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

ATTENTION: Le relais contient des pièces sensibles aux décharges électrostatiques (DES). Quand on travaille sur le relais avec le panneau avant ou du dessus enlevé, les surfaces de travail et le personnel doivent être mis à la terre convenablement pour éviter les dommages à l'équipement.

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.

ATTENTION: Il y a un danger d'explosion si la pile électrique n'est pas correctement remplacée. Utiliser exclusivement Ray-O-Vac® No. BR2335 ou un équivalent recommandé par le fabricant. Se débarrasser des piles usagées suivant les instructions du fabricant.

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 équipement 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 accès non-autorisé à l'équipement pourrait être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.

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SECTION 1: FACTORY-SET LOGIC

INTRODUCTION

This section describes the factory-set logic (SELOGIC® control equations, set with the **SET L *n*** command) that makes the SEL-351P-3 Recloser Control operate as a recloser control. ***Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements*** through ***Section 9: Setting the SEL-351P-3 Recloser Control*** provide more settings information and settings variation details. Important: Use this manual in conjunction with the ***SEL-351P-3 Quick-Start Installation and User's Guide***.

Factory Default Settings

Factory default settings are listed under subsection ***SHO Command (Show/View Settings)*** in ***Section 10: Serial Port Communications and Commands***.

Installation Variations and Logic Changes

For traditional recloser control installations (see Figure 2.1 in ***Section 2: Additional Installation Details***), none of the factory-set logic has to be changed. If the SEL-351P-3 is 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-351P-3 Recloser Control*** provides details on making settings changes.

EZ Settings vs. "Regular" Settings

The ***Settings*** section in the ***SEL-351P-3 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-351P-3 Recloser Control describes:

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

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. The EZ global settings override certain "regular" global settings if EZ recloser control settings are enabled for at least settings group 1. Global setting EZGRPS determines if EZ recloser control settings are enabled for a particular setting group.

The correlation between EZ recloser control settings and "regular" settings is given in Table 1.1. The correlation between EZ global settings and "regular" global settings is also given at the end of Table 1.1.

Table 1.1: Correspondence Between EZ Settings and "Regular" Settings

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) Circuit Identifier (30 characters)	RID TID
CT Ratio PT Ratio	CTR, CTRN PTR, PTRS
Min. trip—phase Min. trip—ground Min. trip—SEF	51P1P, 51P2P, 50P4P, 50P6P 51G1P, 51G2P, 50G6P, 51N1P, 51N2P, 50N6P 50N3P, 50N4P
Fast curve – phase Time dial—phase fast curve EM reset—phase fast curve	51P1C 51P1TD 51P1RS
Fast curve—ground Time dial—ground fast curve EM reset—ground fast curve	51G1C 51N1C 51G1TD 51N1TD 51G1RS 51N1RS
Delay curve – phase Time dial—phase delay curve EM reset—phase delay curve	51P2C 51P2TD 51P2RS
Delay curve – ground Time dial—ground delay curve EM reset—ground delay curve	51G2C 51N2C 51G2TD 51N2TD 51G2RS 51N2RS
Time delay—SEF	67N3D
Operations—phase fast curve Operations—ground fast curve Operations to lockout—phase Operations to lockout—ground Operations to lockout—SEF	OPPH OPGR OPLKPH OPLKGR OPLKSF
Reclose interval 1 Reclose interval 2 Reclose interval 3 Reclose interval 4	790I1 790I2 790I3 790I4
Reset time for auto reclose Reset time from lockout Close power wait time	79RSD 79RSLD 79CLSD

EZ Recloser Control Settings (SHO EZ *n* command; SET EZ *n* command)	**Corresponding "Regular" Settings (SHO *n* command; SET *n* command)**
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
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

EZ Recloser Control Settings (SHO EZ *n* command; SET EZ *n* command)	Corresponding "Regular" Settings (SHO *n* command; SET *n* command)
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 Restore min. trip—ground Restore min. trip—SEF	RPPH RPGR RPSEF
Sequence coordination (Y/N) Ground trip precedence (Y/N)	ESEQ PRECED
Underfrequency loadshedding (Y/N)	
Underfrequency pickup Underfrequency time delay	81D1P 81D1D
Demand meter time constant	DMTC

EZ Global Settings (SHO FZ command; SET FZ command	Corresponding "Regular" Global Settings (SHO G command; SET G command)
System Frequency Phase Rotation	NFREQ PHROT
Recloser Wear Monitor (AUTO, Y, N)	EBMON
Interrupt rating	COS1, COS2, COS3 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 (POC, NEG)	CTPOL

EZ Global Settings (SHO FZ command; SET FZ command	Corresponding “Regular” Global 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
SF6 low pressure warning threshold	SF6PRS

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 1.2.

Table 1.2: 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

Overcurrent Element	Function with EZ Settings Operative	Associated Settings
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 Tables 9.3 and 9.4). The associated overcurrent element settings listed in Table 1.2 and SELOGIC control equations settings are found in the settings sheets at the end of ***Section 9: Setting the SEL-351P-3 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. If current channel IN is wired residually with phase current input channels I1, I2, and I3, the residual ground and neutral ground overcurrent elements see the same magnitude zero-sequence current.

Phase current input channels I1, I2, and I3 are rated 1A 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 complimentary 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)

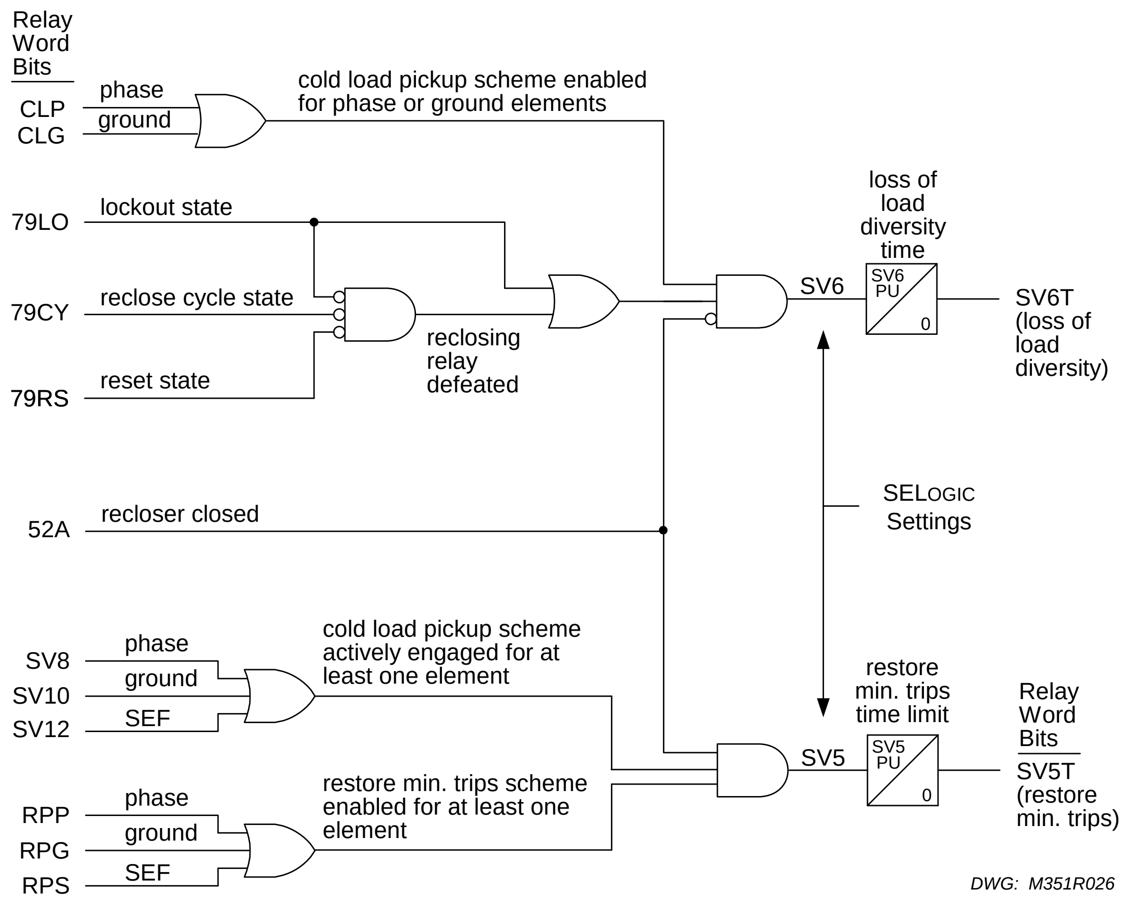


Figure 1.1 Loss of Load Diversity (top) and Restore Min. Trips (bottom) Logic for Cold Load Pickup Scheme

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-351P-3 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 through Figure 1.4 for phase, ground, and SEF overcurrent elements, respectively. The logic in these three figures operates similarly—let's 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).

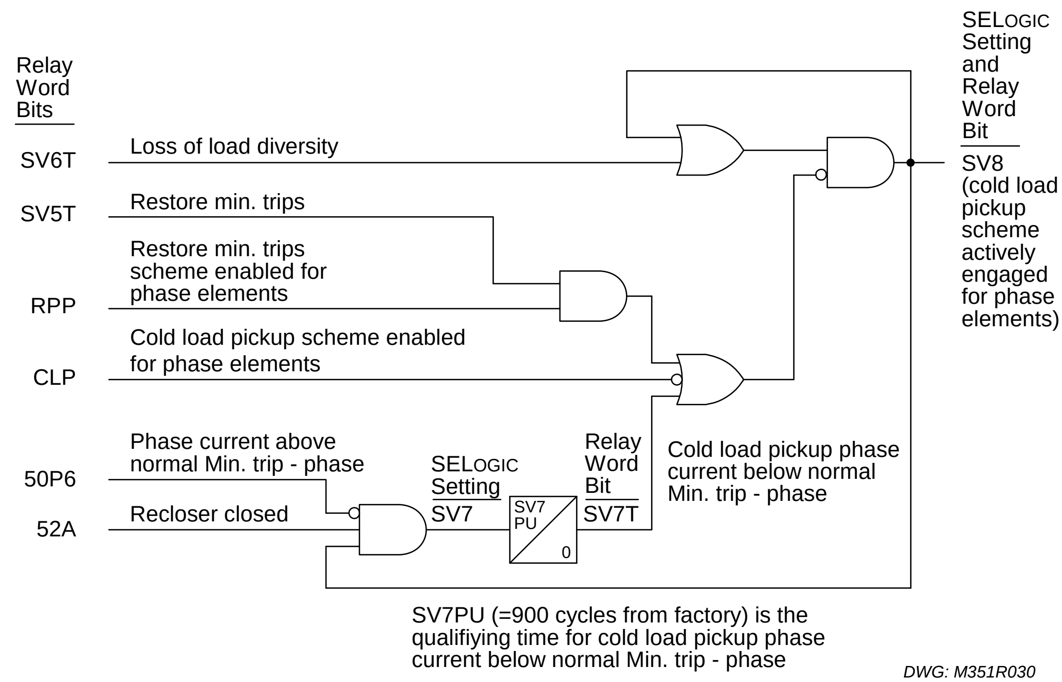


Figure 1.2: Cold Load Pickup Scheme Seal-In Logic for Phase Overcurrent Elements

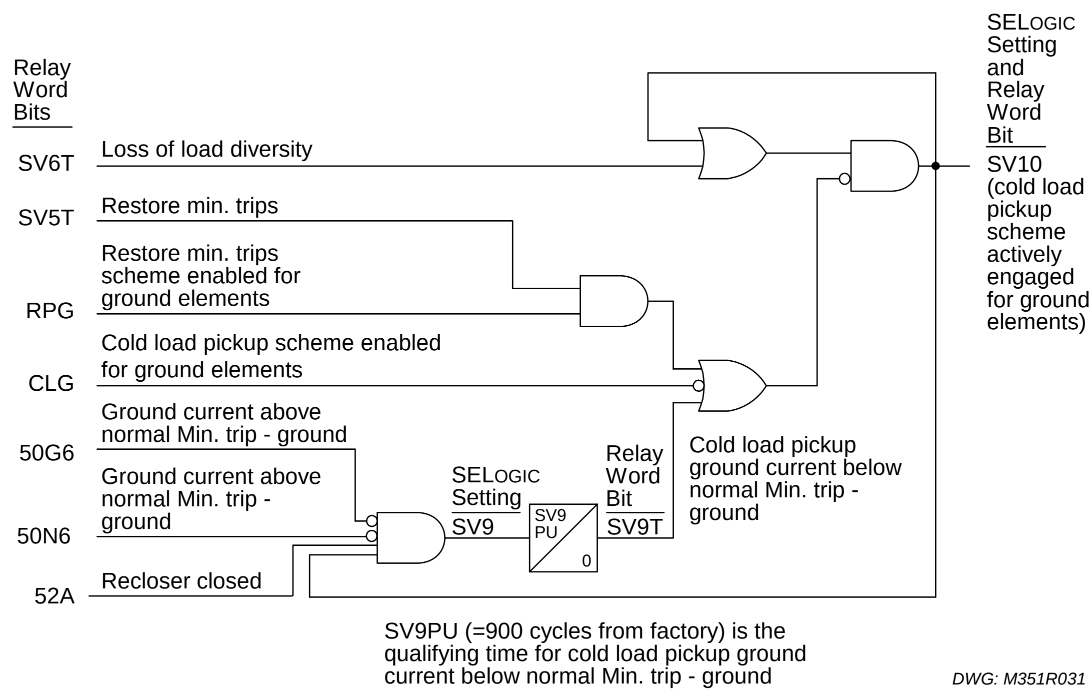


Figure 1.3: Cold Load Pickup Scheme Seal-In Logic for Ground Overcurrent Elements

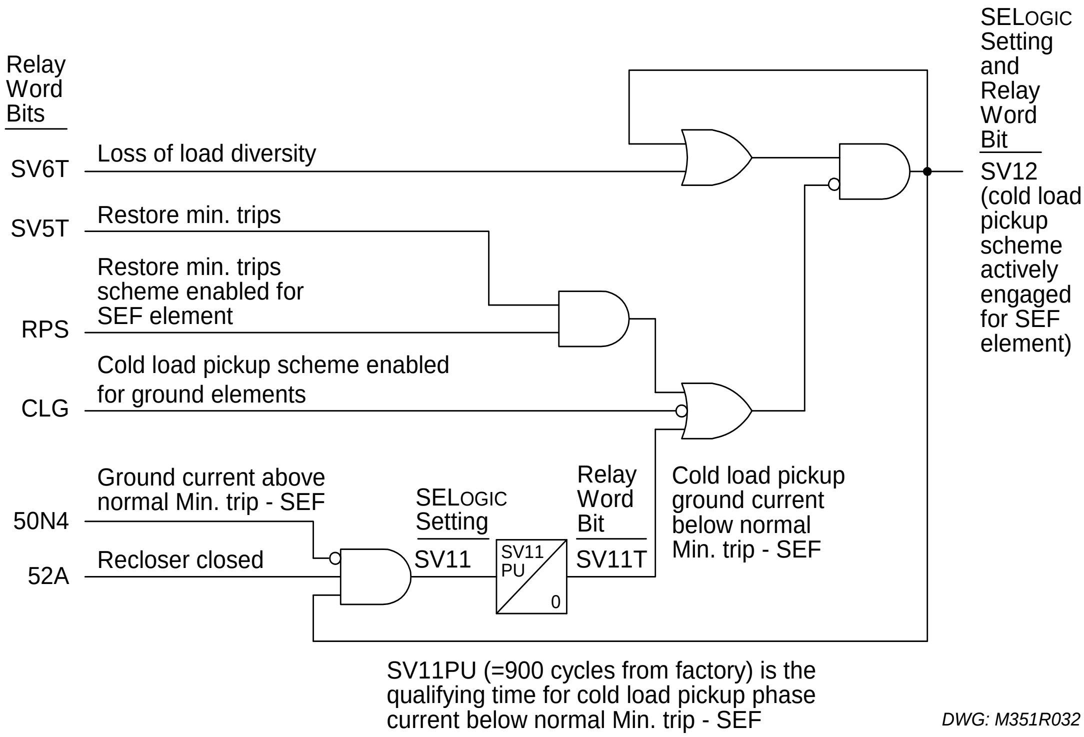


Figure 1.4: Cold Load Pickup Scheme Seal-In Logic for SEF Overcurrent Elements

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.

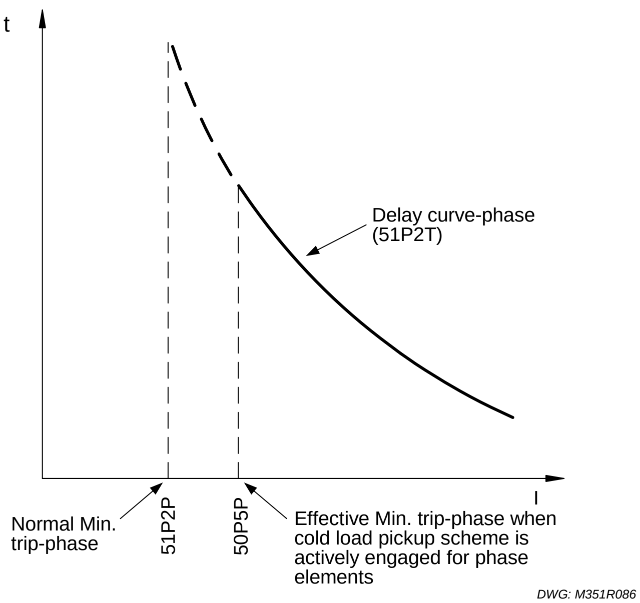


Figure 1.5: Disable Lower Portion of Delay Curve-Phase for Cold Load Pickup

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 through SH4 assert during different periods of a reclose cycle as the shot (reclose) counter increments. The shot counter increments just before each reclose. See also Figure 6.6 and Table 6.3.

Table 1.3: Conditions for Assertion of Relay Word Bits SH0 Through 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)

Note: The above table presumes that five trip operations are set (four reclosures in between them). If the SEL-351P-3 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.

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 1.3, SH0 = logical 1 during the first trip, SH1 = logical 1 during the second trip, and so forth.

Refer to Figure 1.6. For example, to enable Fast curve-phase for the first and second trip operations, make EZ setting Operations-phase fast curve = 2 (OPGR = 2). 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 trips 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.

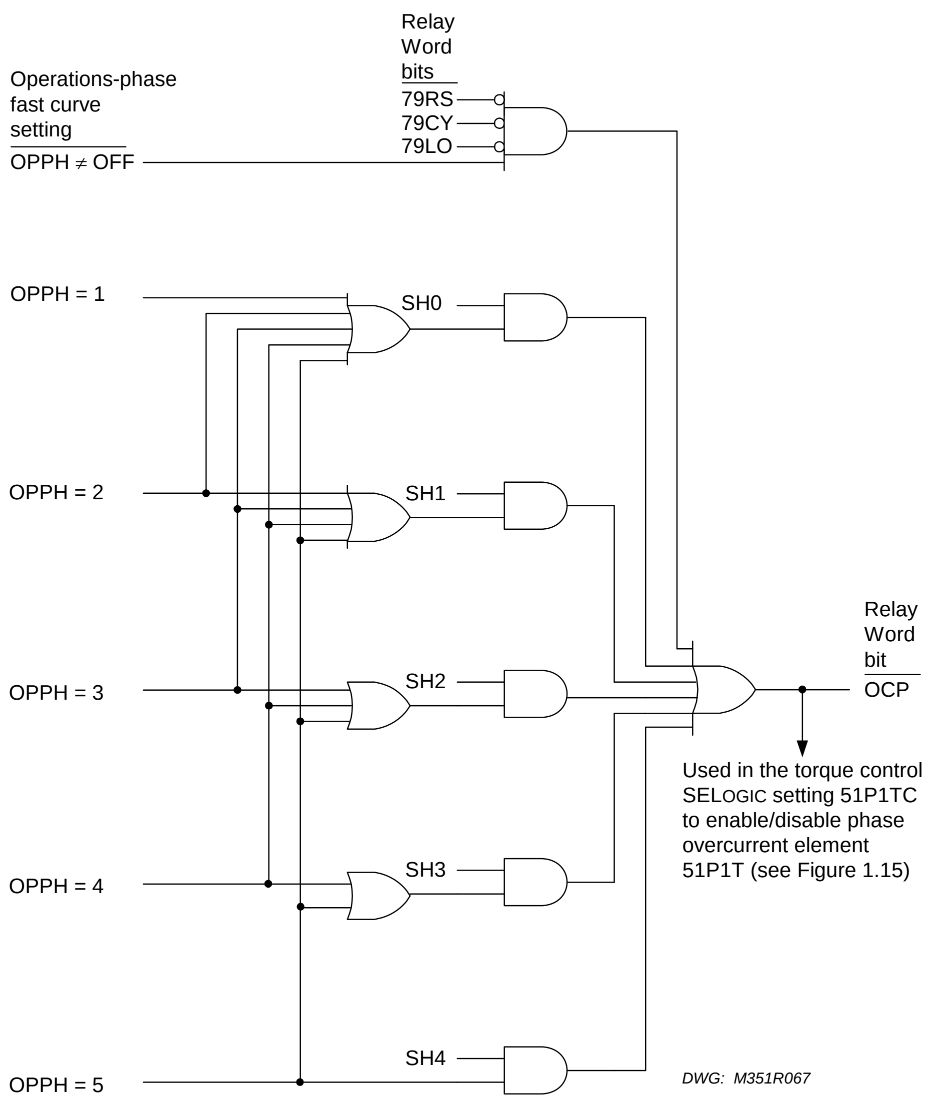


Figure 1.6: Operations-Phase Fast Curve Logic

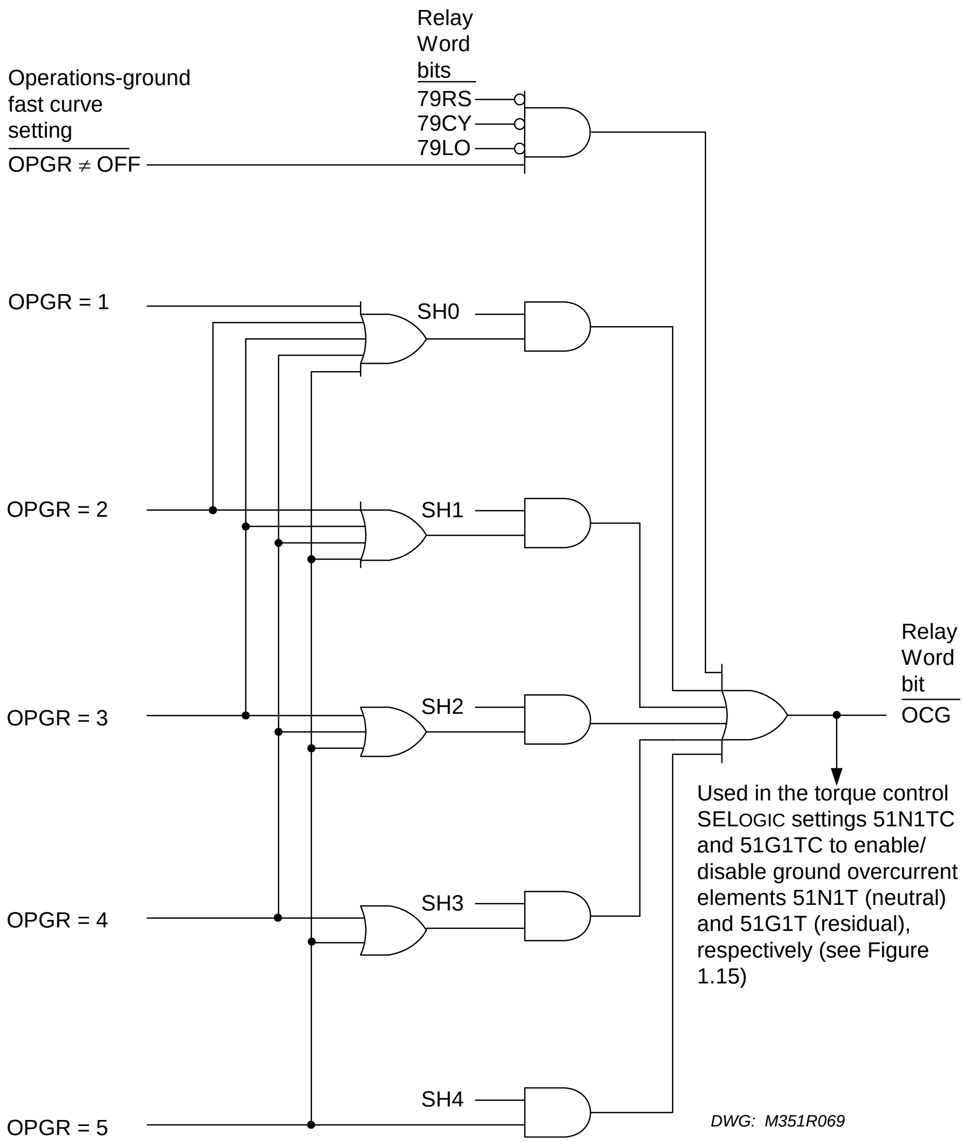


Figure 1.7: Operations-Ground Fast Curve Logic

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

Note the symmetry amongst Figure 1.8 through Figure 1.14. Relay Word bits SH0 through 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 1.3 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 1.3, SH0 = logical 1 during the first trip, SH1 = logical 1 during the second trip and so forth.

Refer to Figure 1.11. For example, to enable the High current trip—phase for the third and fourth trip operations, make setting Activate high current trip—phase = 3 (HITRPH = 3). 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 1.9, Figure 1.10, Figure 1.12, Figure 1.13, and 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.

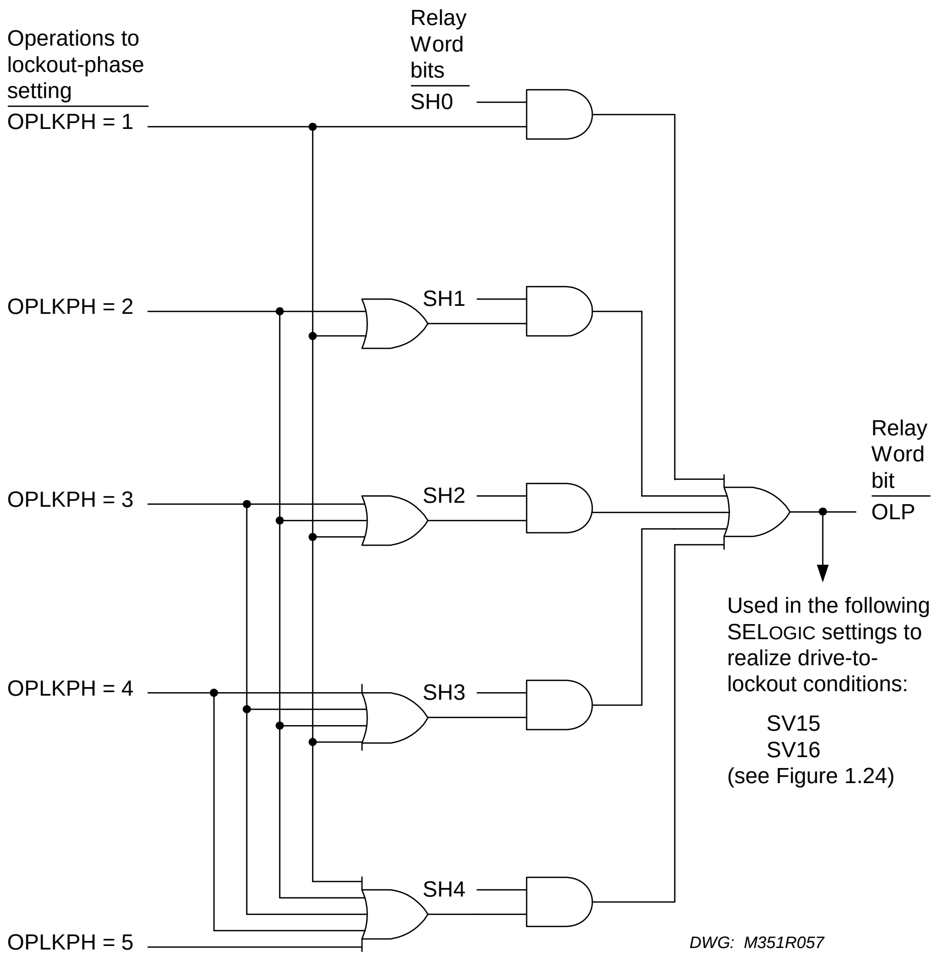


Figure 1.8: Operations to Lockout—Phase Logic

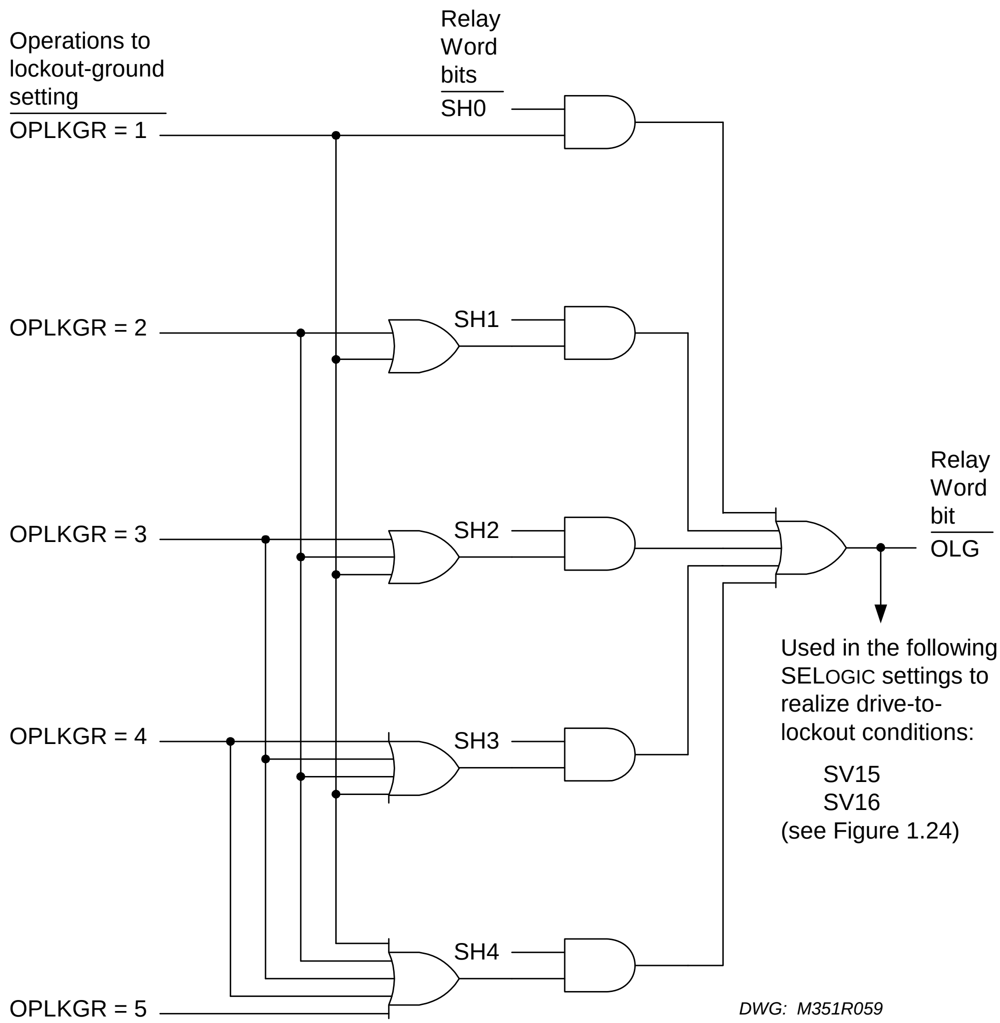


Figure 1.9: Operations to Lockout—Ground Logic

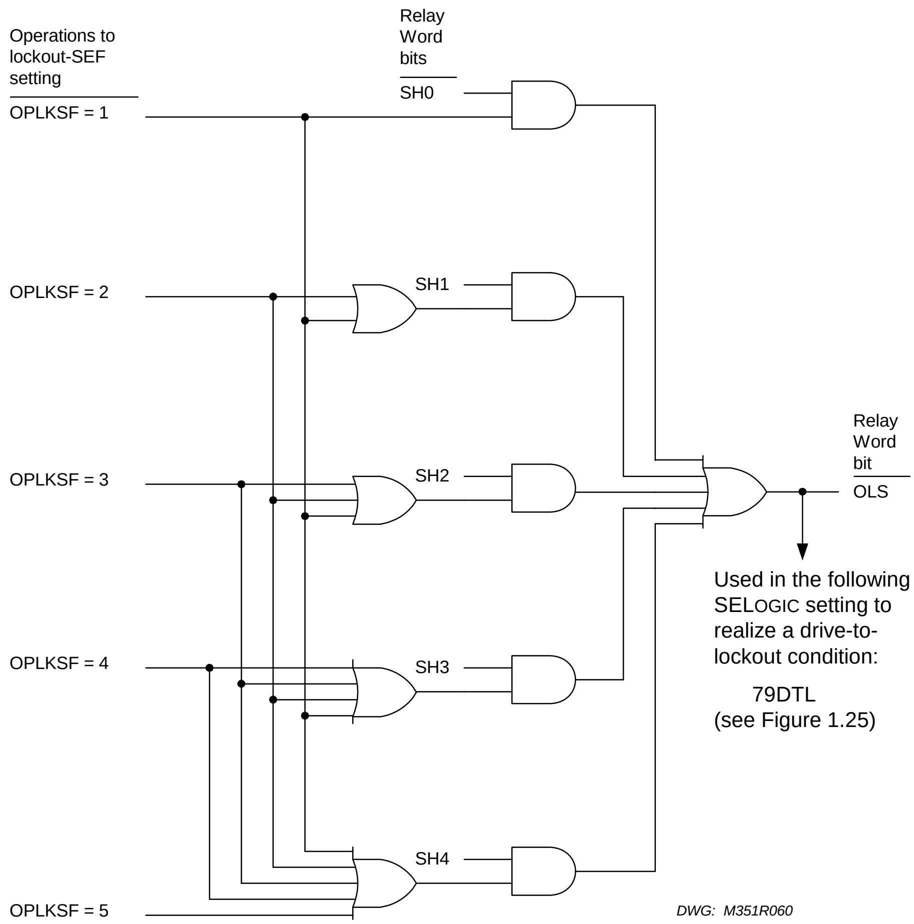


Figure 1.10: Operations to Lockout—SEF Logic

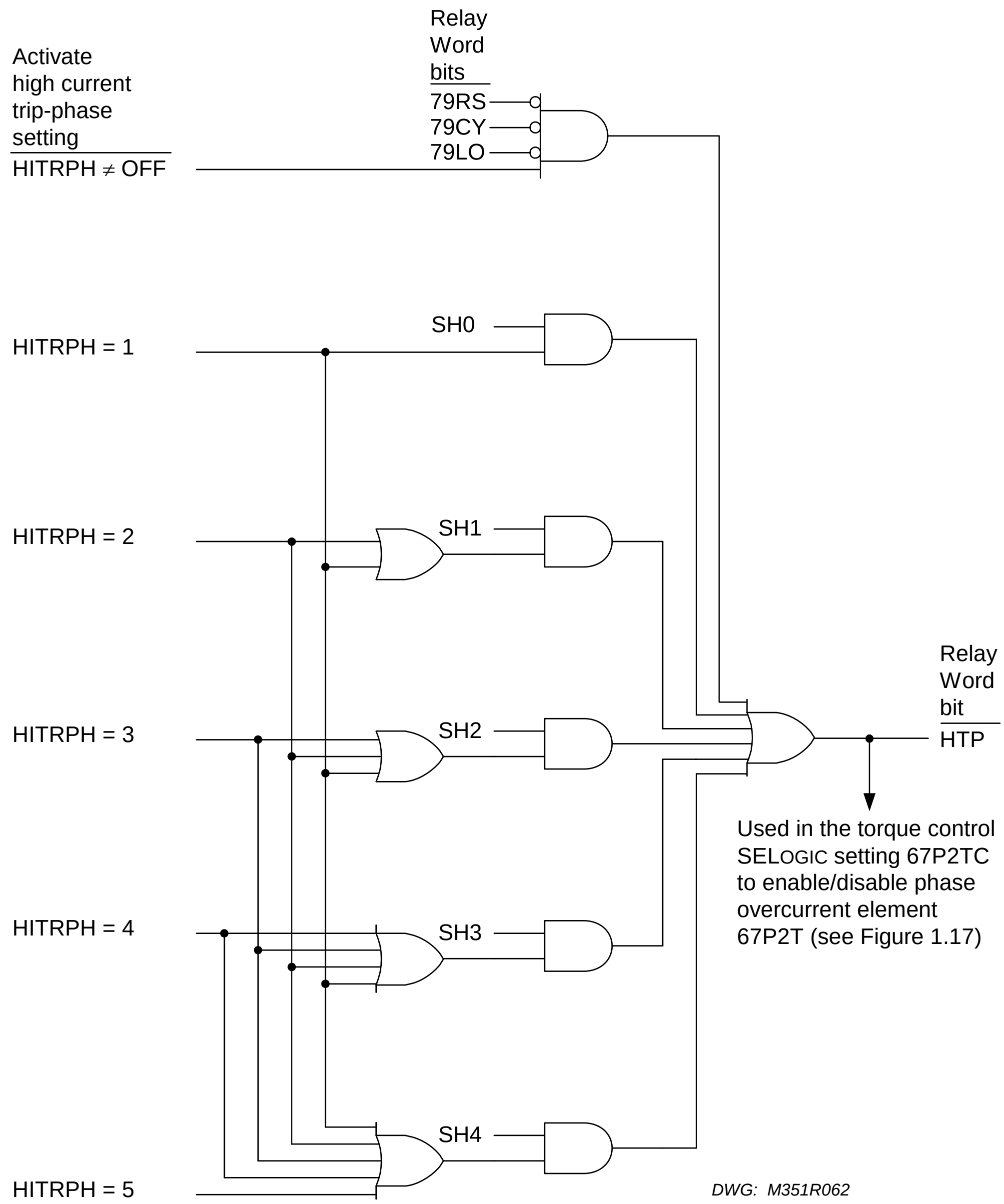


Figure 1.11: Activate High Current Trip—Phase Logic

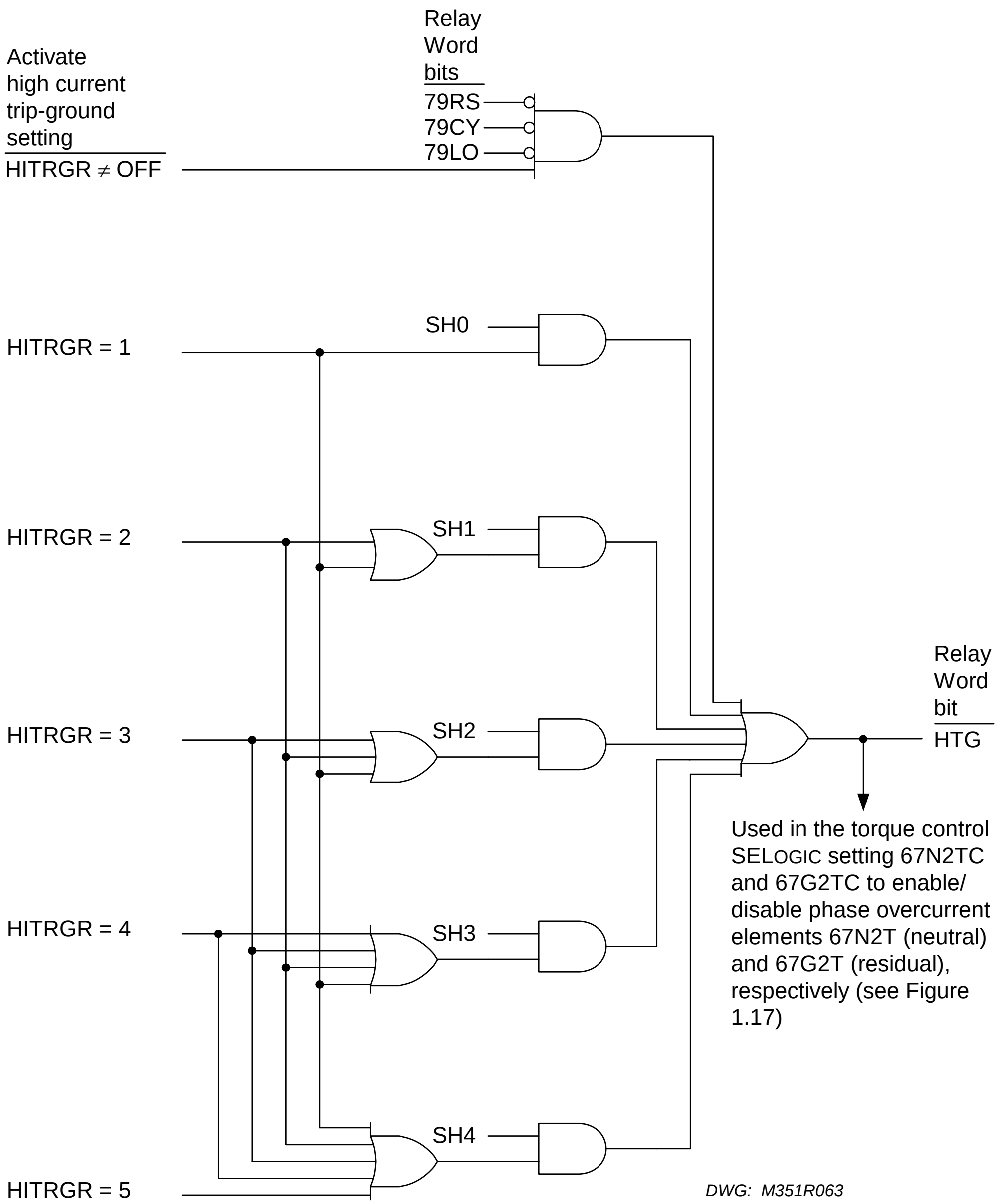


Figure 1.12: Activate High Current Trip—Ground Logic

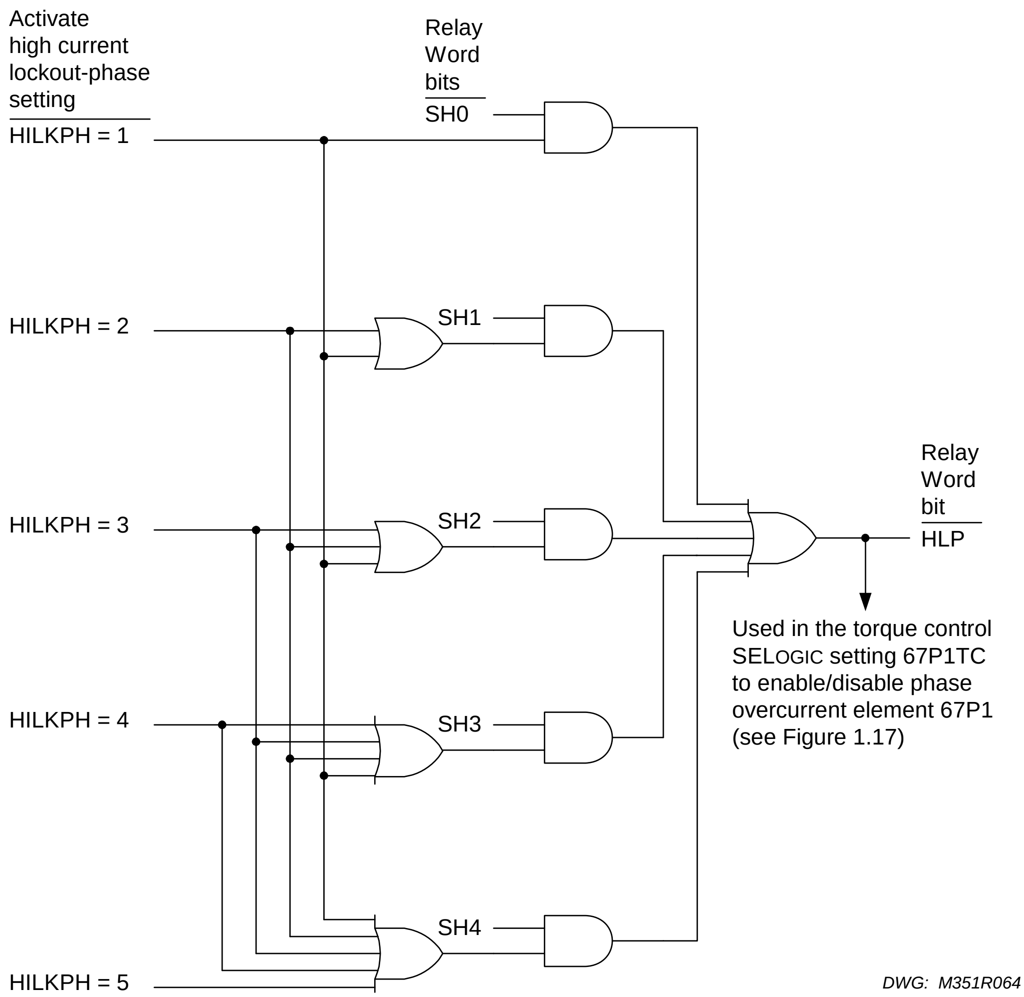


Figure 1.13: Activate High Current Lockout—Phase Logic

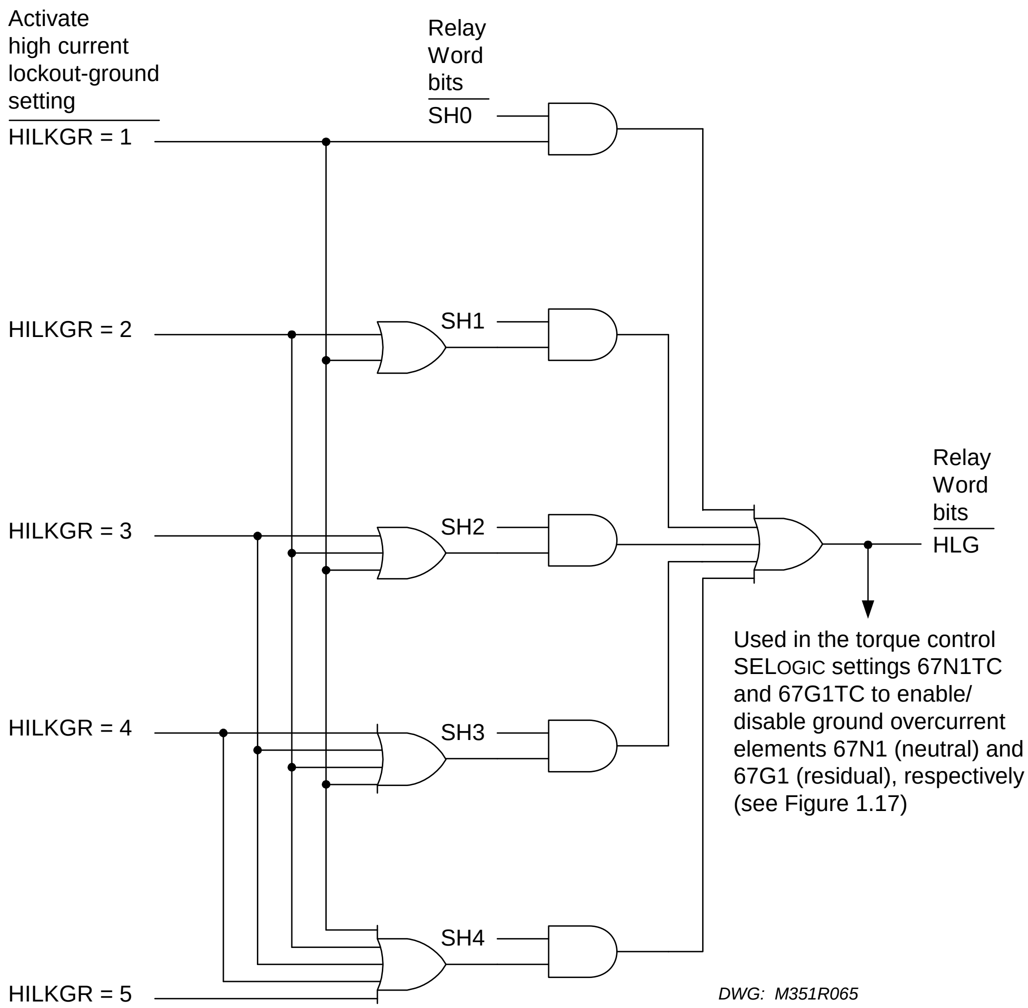


Figure 1.14: Activate High Current Lockout—Ground Logic

Overcurrent Element Enable/Disable Logic

The logic in Figure 1.15 through 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 overcurrent elements are controlled by the EARTH FAULT ENABLED/ FALLA A TIERRA HABILITADA operator control (via Relay Word bit LT1) and the SEF overcurrent elements are controlled by the SEF ENABLED/SEF HABILITADO operator control (via Relay Word bit LT5).

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.

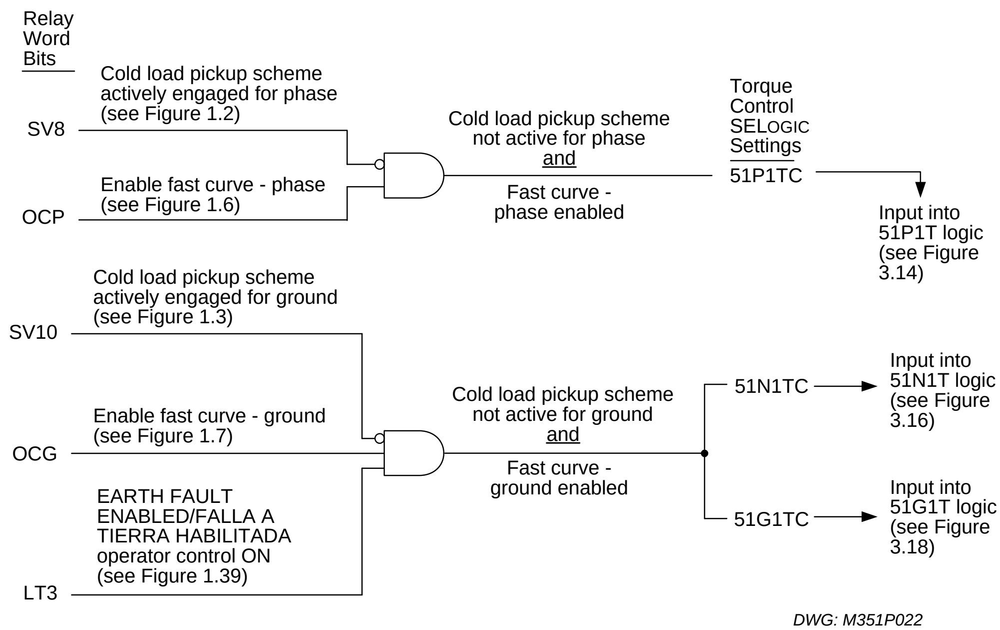


Figure 1.15: Fast Curve—Phase (top) and Fast Curve—Ground (bottom) Enable/Disable Logic

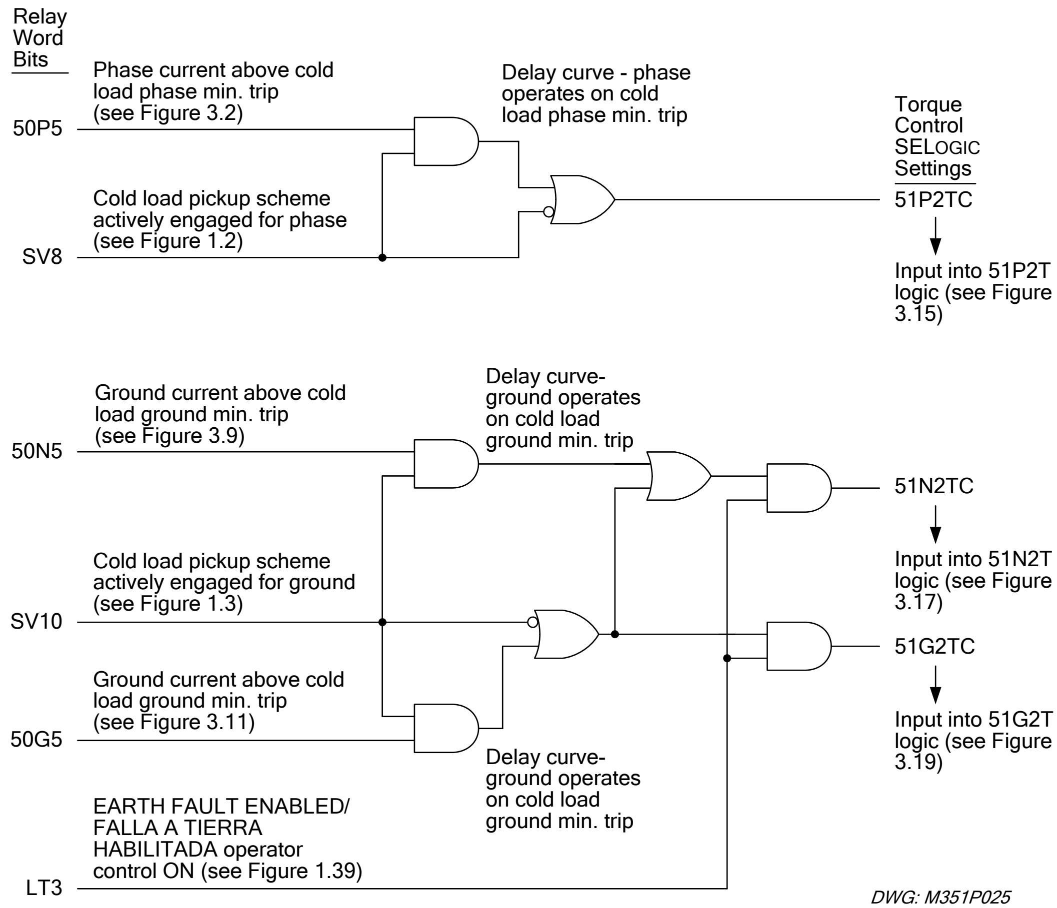


Figure 1.16: Delay Curve—Phase (top) and Delay Curve—Ground (bottom) Enable/Disable Logic

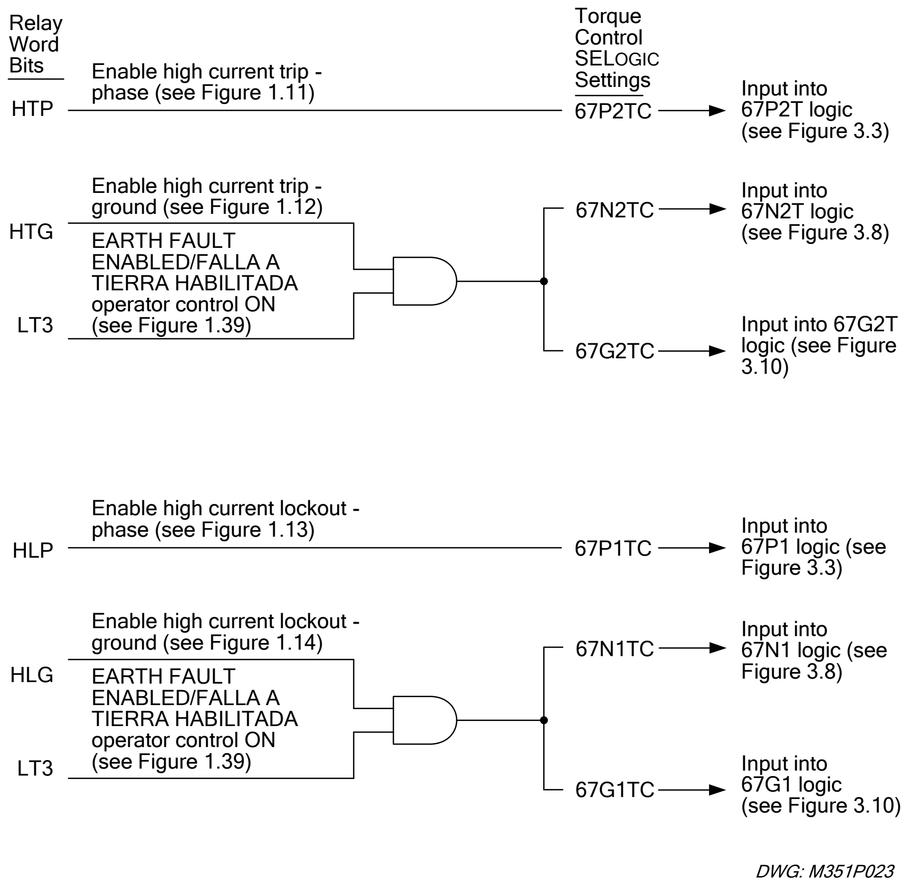


Figure 1.17: High Current Trip (top) and High Current Lockout (bottom) Enable/Disable Logic

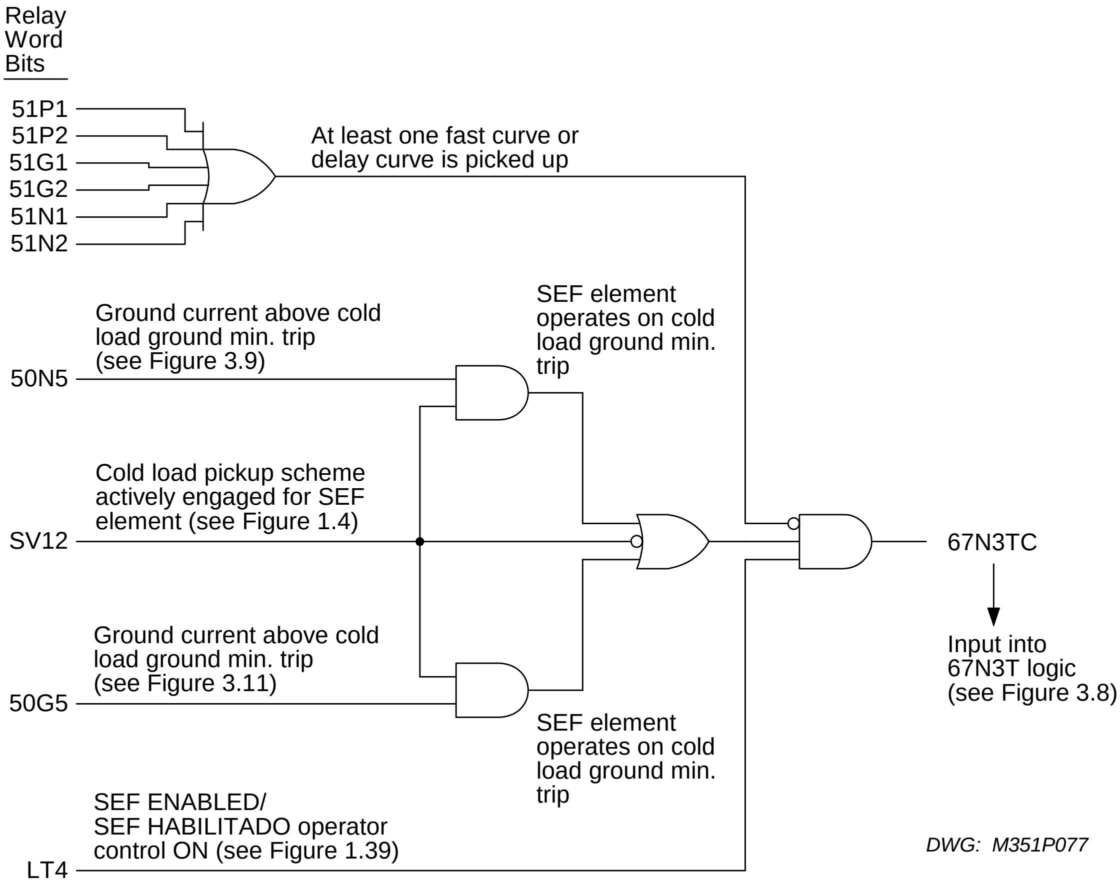


Figure 1.18: SEF Element Enable/Disable Logic

Trip Logic

See Figure 1.19. The overcurrent elements in Figure 1.19 are controlled by the logic in Figure 1.15 through 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 routed to the final trip/close logic and subsequent output contacts (see Figure 7.29).

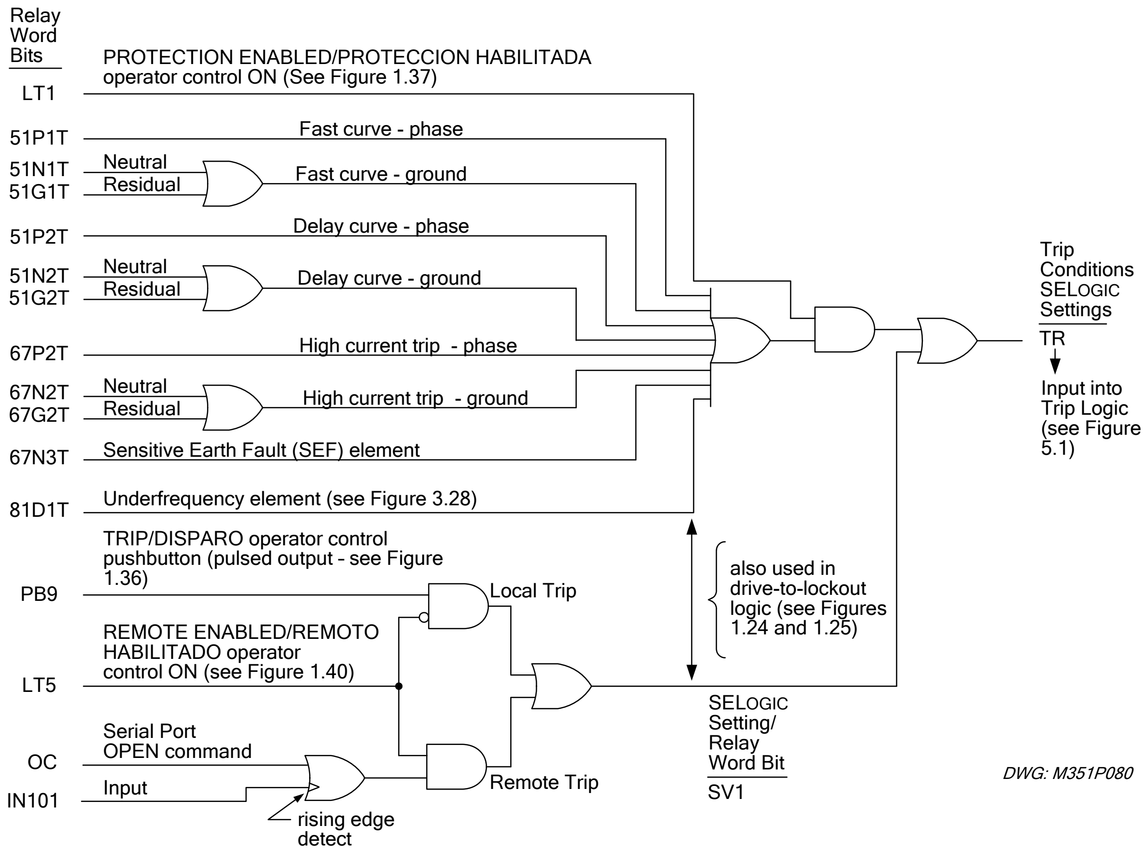


Figure 1.19: Trip Conditions

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/CIERRE operator control (local)
- Input IN102 or serial port **CLOSE** command (remote)

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

- REMOTE ENABLED/REMOTO HABILITADO operator control—switches between the CLOSE/CIERRE operator control (local) and Input IN102 or the serial port **CLOSE** command (remote)
- LIVE LINE ENABLED/LINEA VIVA HABILITADA operator control—supervises CLOSE/CIERRE operator control, serial port **CLOSE** command, and input IN102

- Trip capacitor charged—supervises CLOSE/CIERRE operator control, serial port **CLOSE** command, and input IN102 (the recloser might need to trip right after it is closed)
- Close capacitor charged—supervises CLOSE/CIERRE operator control, serial port **CLOSE** command, and input IN102

Other close logic details in Figure 1.20:

- REMOTE ENABLED/REMOTO HABILITADO supervises the other operator controls, too (see Figure 1.40)
- LIVE LINE ENABLED/LINEA VIVA HABILITADA operator control also supervises auto-reclosing (see Figure 1.25)
- The trip and close capacitor charged conditions also supervises auto-reclosing (see Figure 1.30)
- No standing close is possible with this logic. The CLOSE/CIERRE 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 LIVE LINE ENABLED/LINEA VIVA HABILITADA operator control (Relay Word bit LT6) is turned ON or OFF, no surprise close takes place—there is no standing close condition waiting to get through.

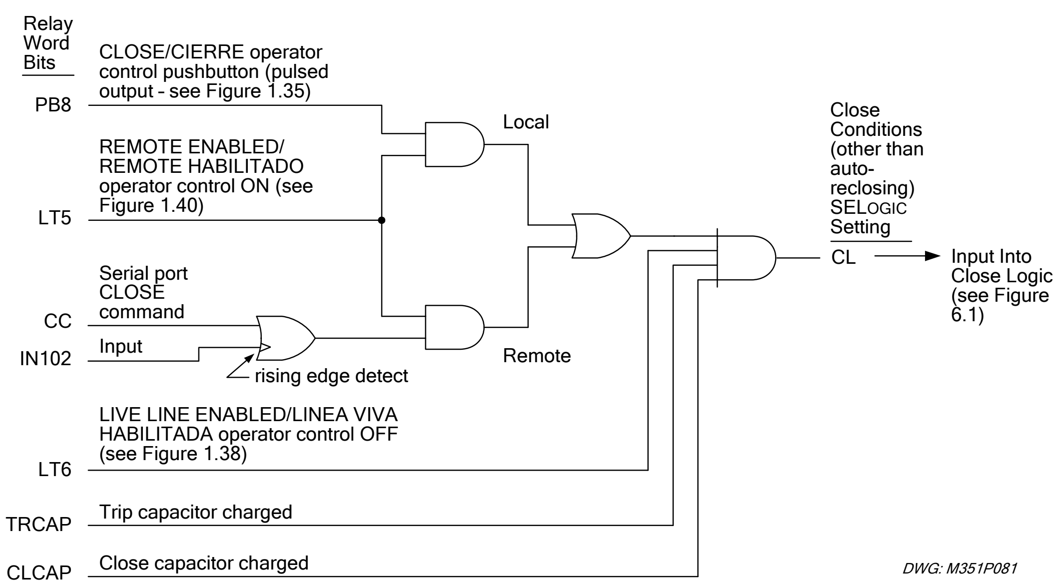


Figure 1.20: Close Conditions – Other Than Auto-Reclosing

Unlatch Close Conditions

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

- When the CLOSE/CIERRE operator control is set with a time delay (PB8D > 0; see Figure 1.35) and is timing to a pending close, the corresponding LED flashes as a timing indication. Besides unlatching the close signal output, the unlatch close SELOGIC setting (ULCL) also prevents the CLOSE/CIERRE 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 LED from flashing, by preventing the CLOSE/CIERRE operator control from starting to time when the LIVE LINE ENABLED/LINEA VIVA HABILITADA operator control is ON.

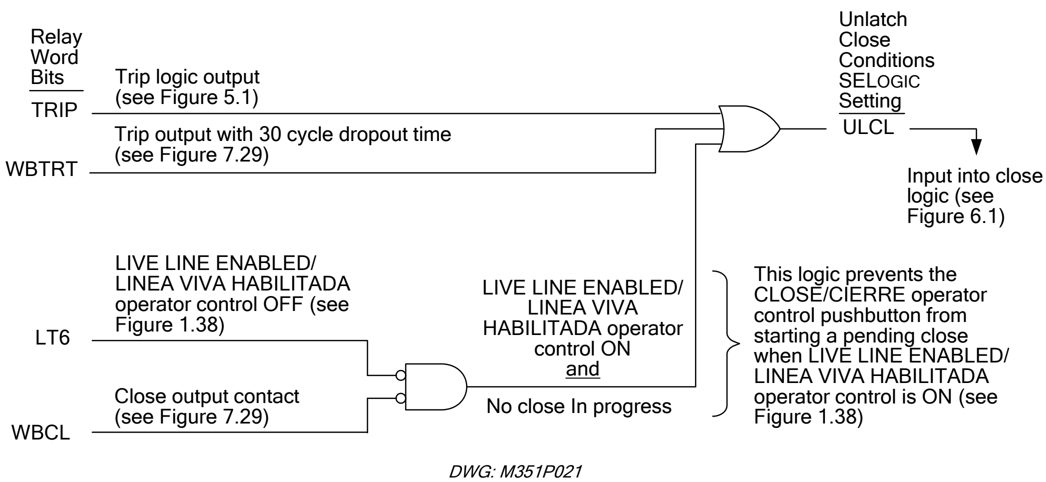


Figure 1.21: Unlatch Close Conditions

Recloser Status

Recloser status is determined from a recloser 52a auxiliary contact, run through a qualifying timer, as shown in Figure 1.22 (see also Figure 7.29). The greater pickup delay (1 cycle) compensates for the recloser auxiliary contacts operating faster than the circuit breaker main contacts for close operations and provides more time qualification for contact bounce.

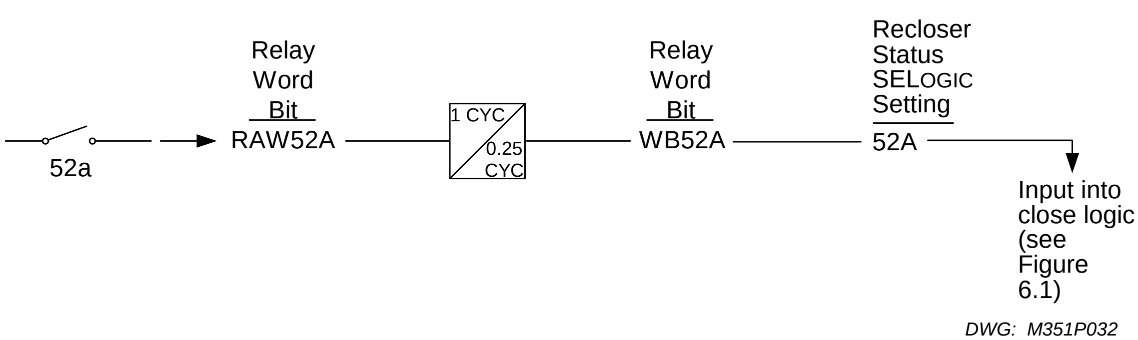


Figure 1.22: Recloser Status Determination

Figure 1.20 through Figure 1.22 all propagate into the close logic (see Figure 6.1). The close signal output (Relay Word bit CLOSE) is then routed to the final trip/close logic and subsequent output contacts (see Figure 7.29).

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 through 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 through 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-351P-3 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-351P-3 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-351P-3 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-351P-3 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 are 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-351P-3 trips, the SEL-351P-3 is driven to lockout.

- If setting High current lockout—ground is set effectively below 0.1 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-351P-3 is driven to lockout if a trip operation occurs or the recloser opens while either of the following is true:

- RECLOSE ENABLED/RECIERRE HABILITADO operator control OFF
- LIVE LINE ENABLED/LINEA VIVA HABILITADA operator control ON

The SEL-351P-3 is driven to lockout if any of the following occur:

- Underfrequency element operates
- TRIP/DISPARO operator control pressed (and REMOTE ENABLED/REMOTO HABILITADO is “off”)
- Serial port **OPEN** command executed (and REMOTE ENABLED/REMOTO HABILITADO is “on”)

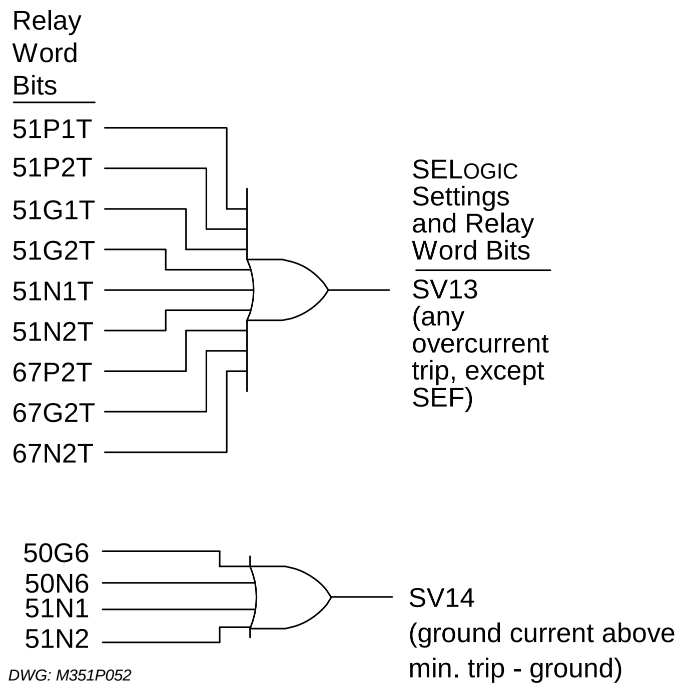


Figure 1.23: Drive-to-Lockout Logic – Part 1 of 3

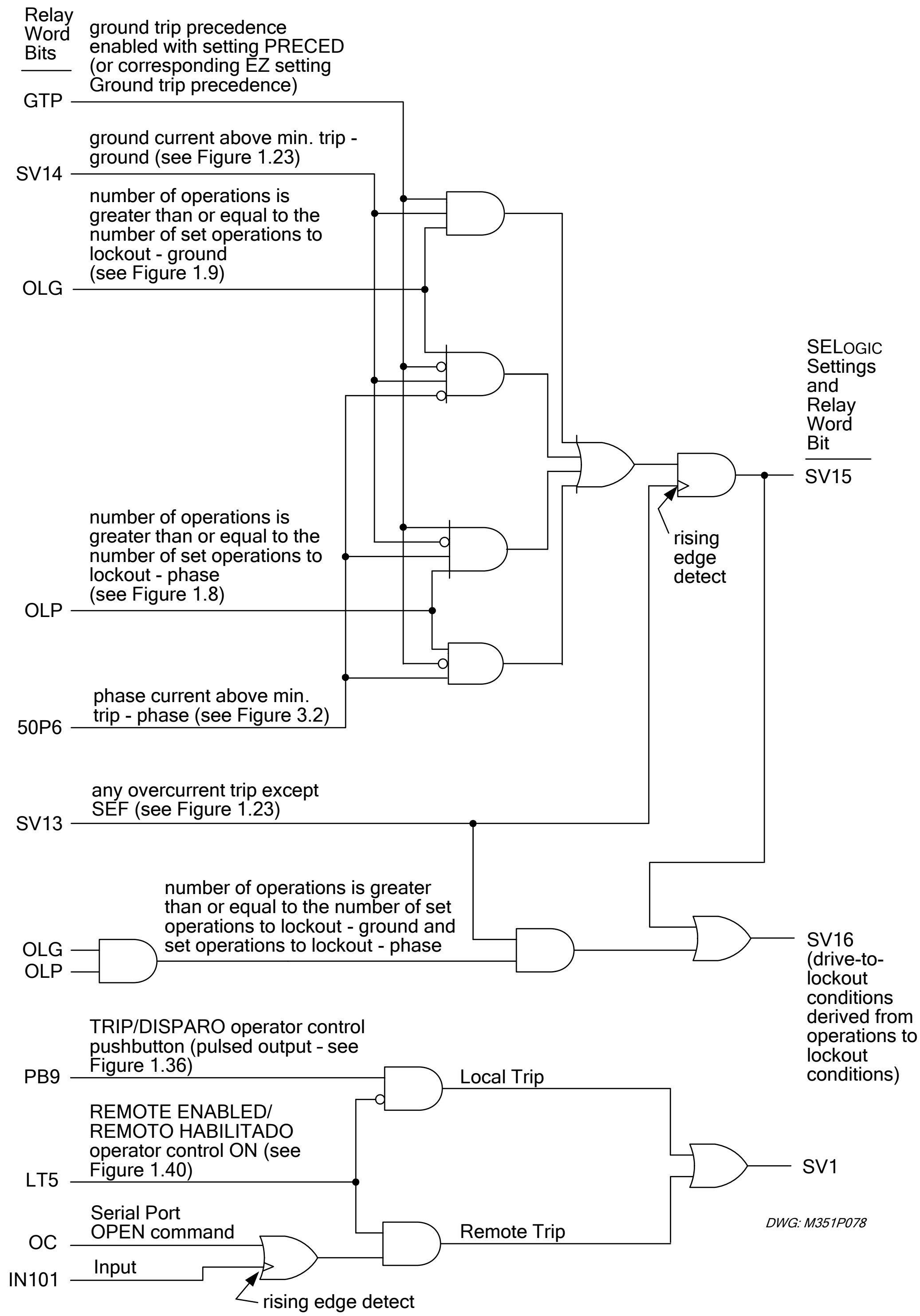


Figure 1.24: Drive-to-Lockout Logic – Part 2 of 3

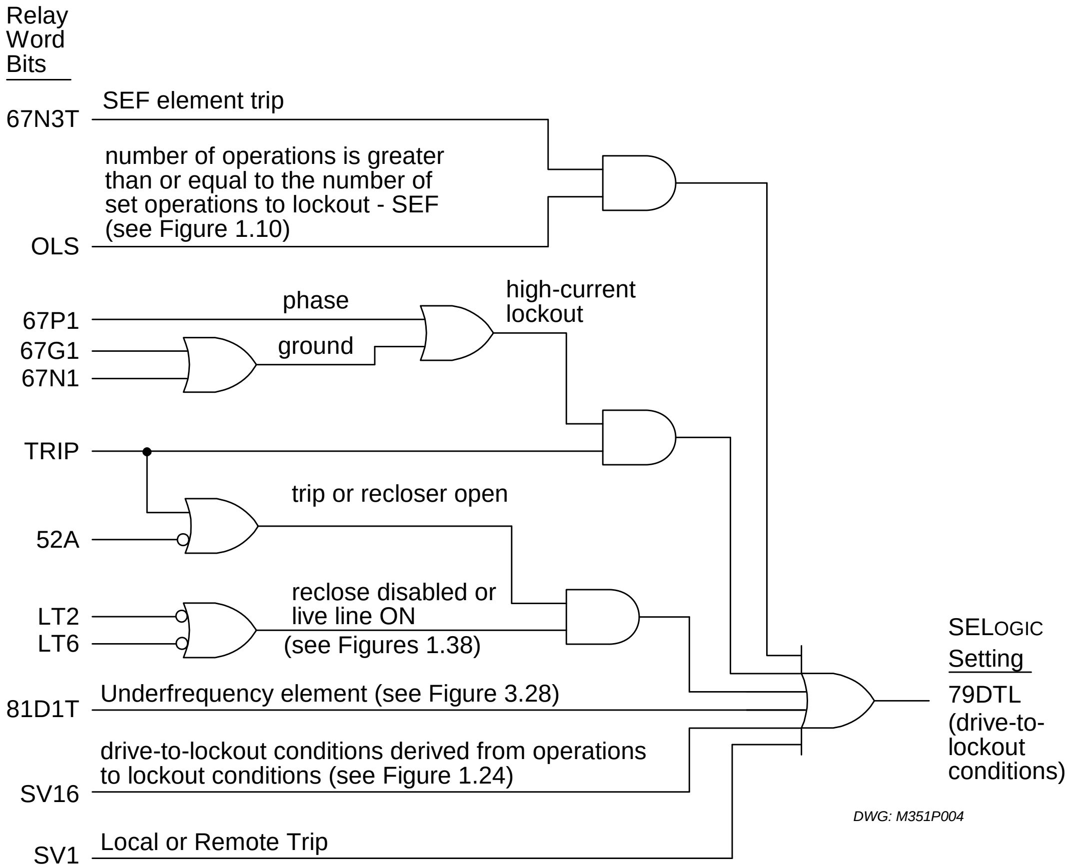


Figure 1.25: Drive-to-Lockout Logic – Part 3 of 3

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.

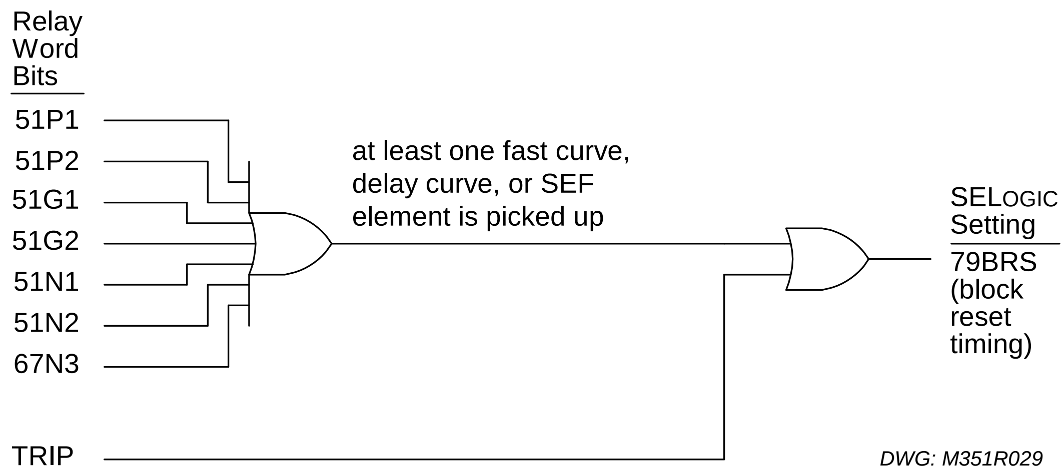


Figure 1.26: Block Reset Timing Logic

Sequence Coordination

Refer to subsection ***Sequence Coordination Setting (79SEQ)*** in ***Section 6: Close and Reclose Logic*** 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-351P-3 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.

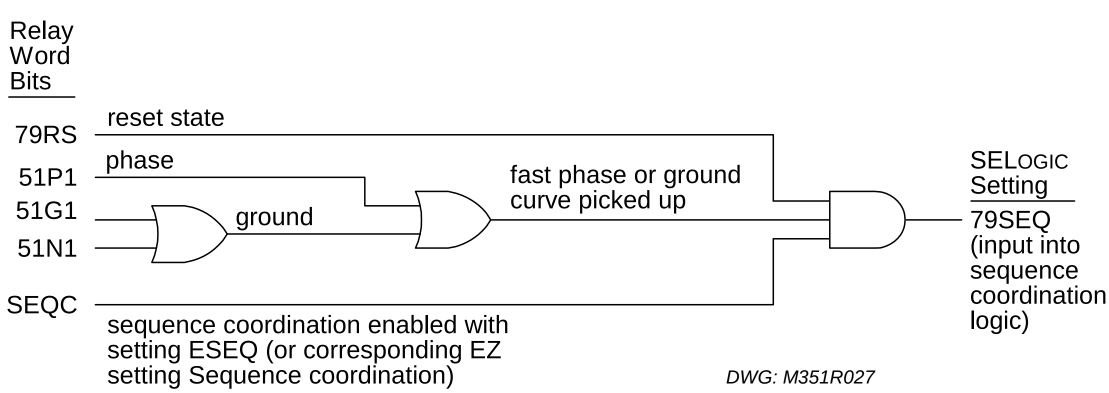


Figure 1.27: Sequence Coordination Logic

Refer to the example in Figure 1.28. The sequence coordination logic in Figure 1.27 keeps SEL-351P-3(1) from overtripping for a fault beyond SEL-351P-3(2).

Refer to Figure 1.29. The following are factory settings for SEL-351P-3(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-351P-3(1) sequence coordination logic for a fault beyond downstream SEL-351P-3(2). Each time SEL-351P-3(2) interrupts the phase fault, the SEL-351P-3(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-351P-3(2) is operating on Delay curve—phase, the SEL-351P-3(1) Fast curves are out of the way—the SEL-351P-3(1) does not overtrip for a fault beyond SEL-351P-3(2).

As stated in subsection ***Sequence Coordination Setting (79SEQ)*** in ***Section 6: Close and Reclose Logic***, 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).

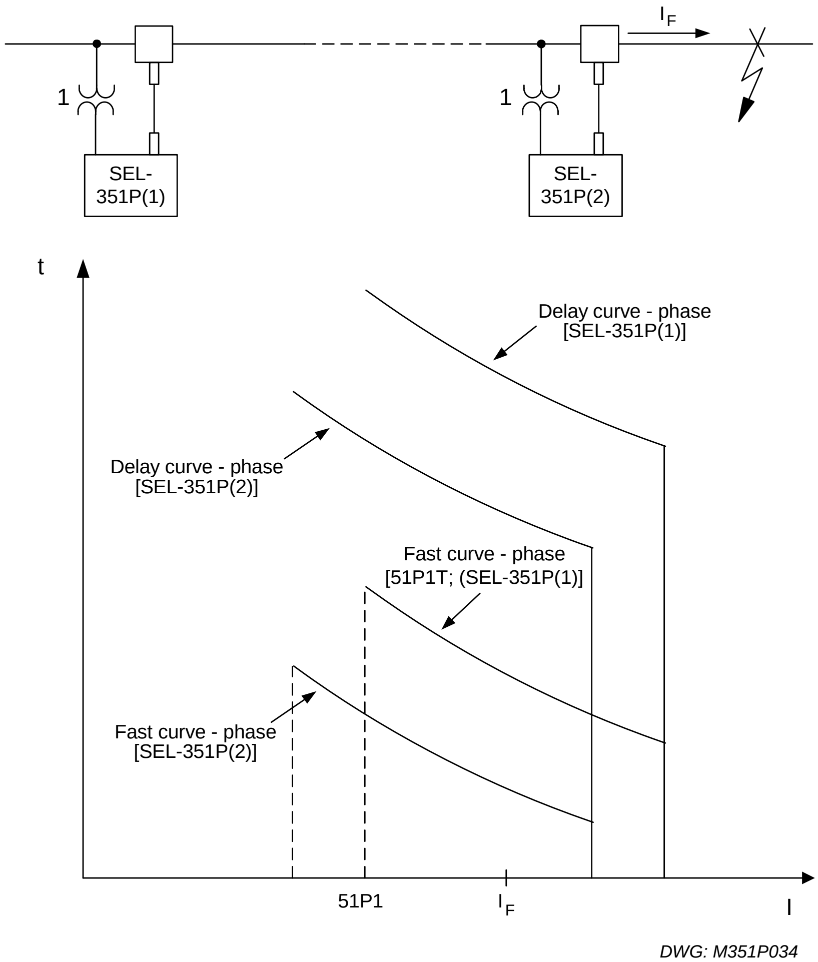


Figure 1.28: Phase Coordination of SEL-351P-3s in Series

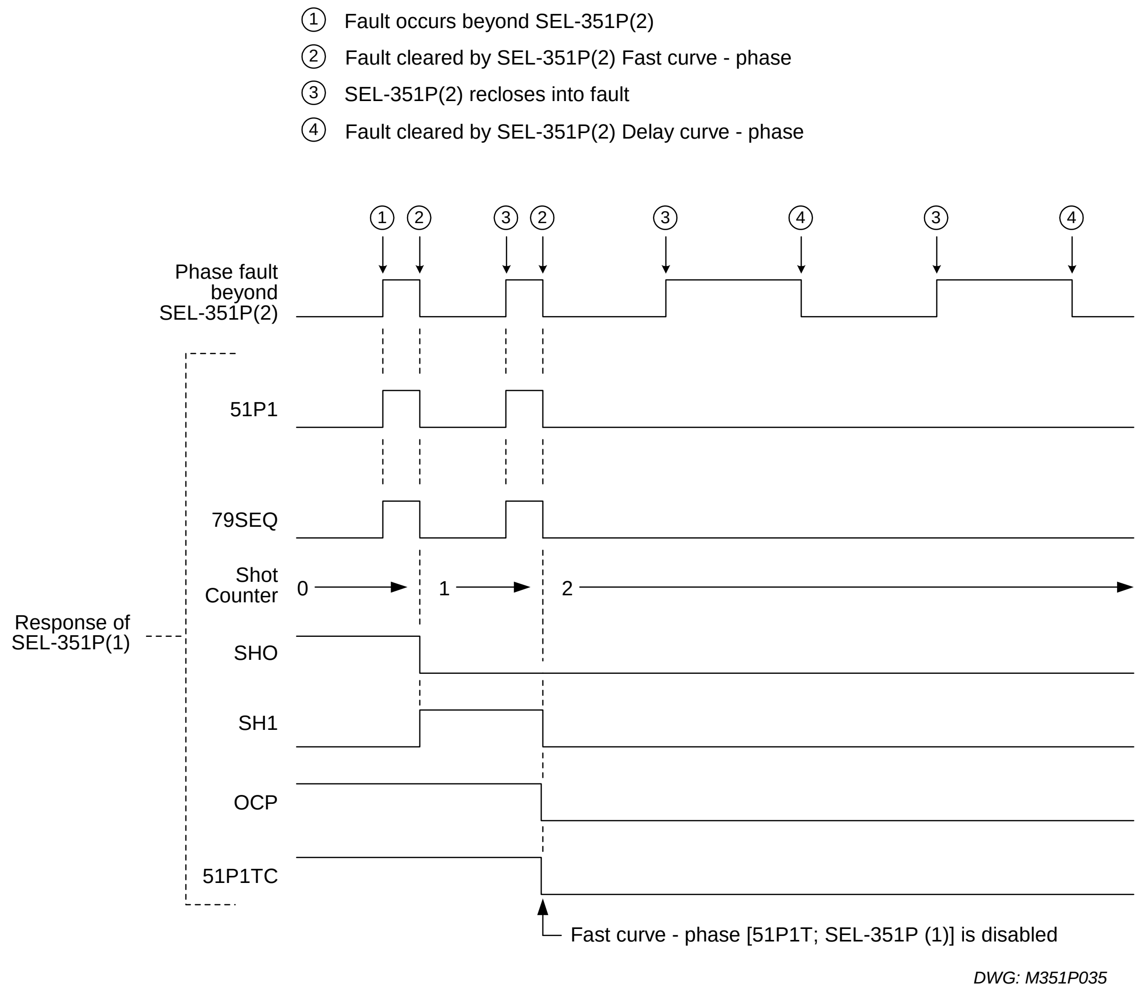


Figure 1.29: Operation of SEL-351P-3(1) Sequence Coordination Logic for Phase Fault Beyond Downstream SEL-351P-3(2)

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-351P-3 auto-recloses the recloser. For auto-reclosing to proceed, all the following conditions must be met:

- Trip and reclose capacitors charged
- Healthy battery

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.

Note that the reclose supervision logic in Figure 1.30 uses some of the same logic that drives the BATTERY PROBLEM/ PROBLEMA BATERIA LED (see Figure 1.42).

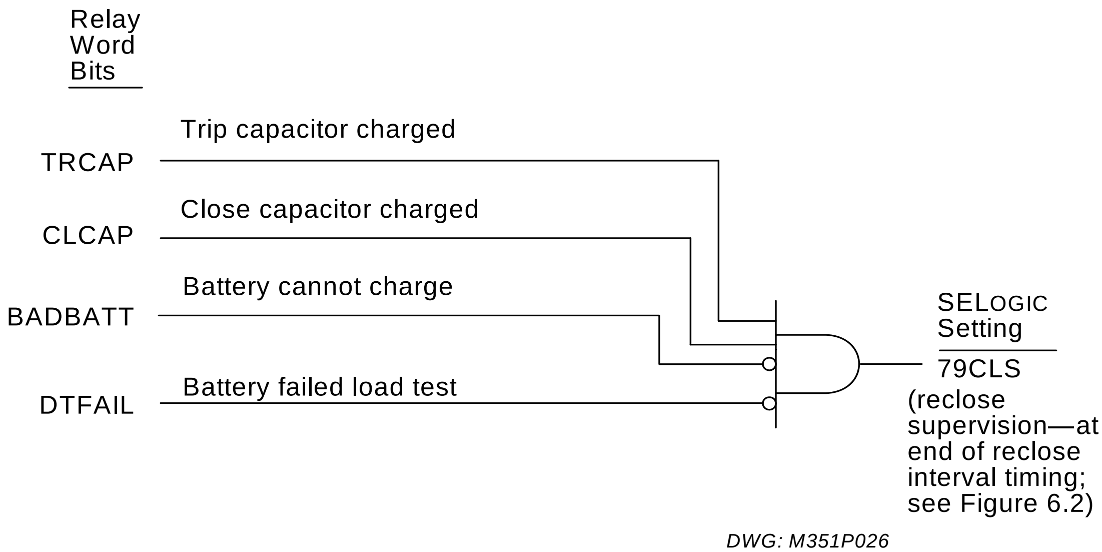


Figure 1.30: Reclose Supervision Logic

Trip and Close Capacitors Charged

Relay Word bits TRCAP and CLCAP (in Figure 1.30 logic) indicate that sufficient trip and close energy is stored in the trip and close capacitors, respectively, for a reclose operation. It is important that the trip capacitor be fully charged because the recloser might need to be tripped right after it is reclosed. See subsection ***Trip and Close Circuits, Breaker Status, and SF6 Gas Pressure*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** for more information on trip and close capacitors.

Healthy Battery

Relay Word bits BADBATT and DTFAIL (as used in Figure 1.30 logic) indicate that the battery is healthy. 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 the ***Battery*** section in the ***SEL-351P-3 Quick-Start Installation and User's Guide*** and subsection ***Battery System Monitor*** in ***Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions*** for more information.

Operator Control Logic

See ***Operator Controls*** subsection in the ***Front-Panel Interface*** section in the ***SEL-351P-3 Quick-Start Installation and User's Guide*** for an explanation of the factory-set operation for the operator controls.

See Figure 1.31 and Figure 1.32. The operator controls (except WAKE UP/DESPERTAR) are programmable. Relay Word bits PB1 through PB9 are the outputs of operator control pushbuttons PROTECTION ENABLED/PROTECCION HABILITADA through TRIP/DISPARO, respectively.

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

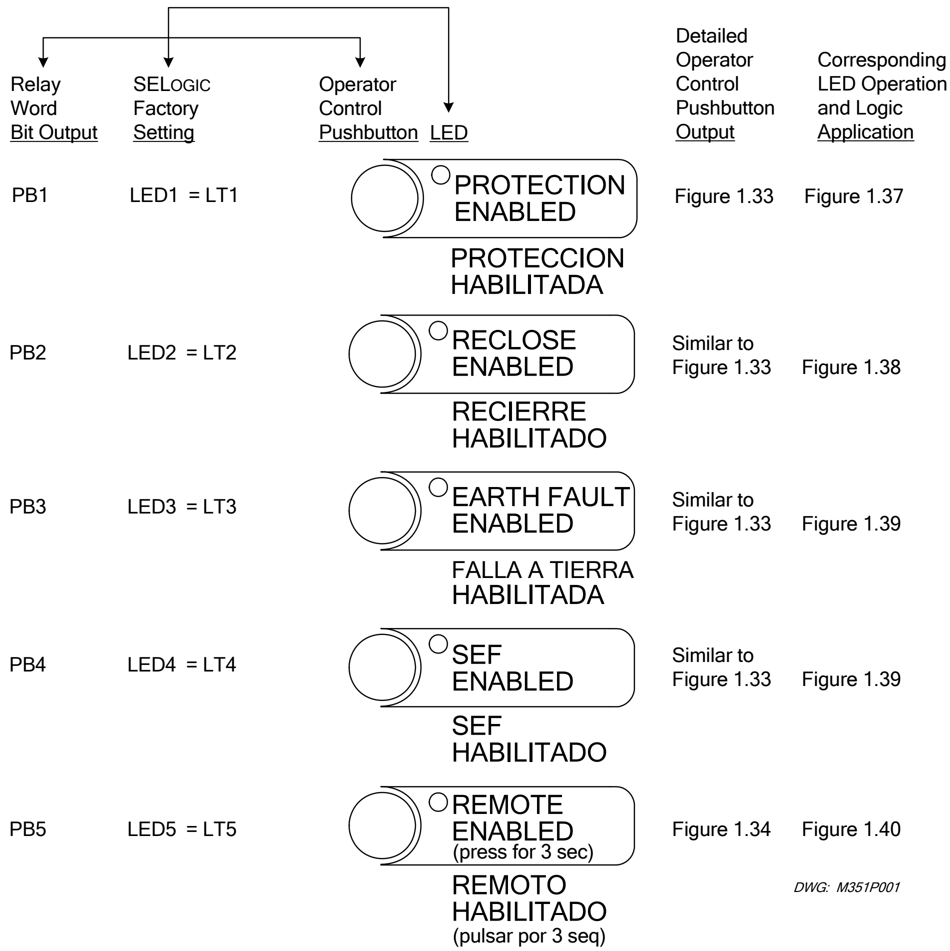


Figure 1.31: Operator Controls – PROTECTION ENABLED/PROTECCION HABILITADA Through REMOTE ENABLED/REMOTO HABILITADO

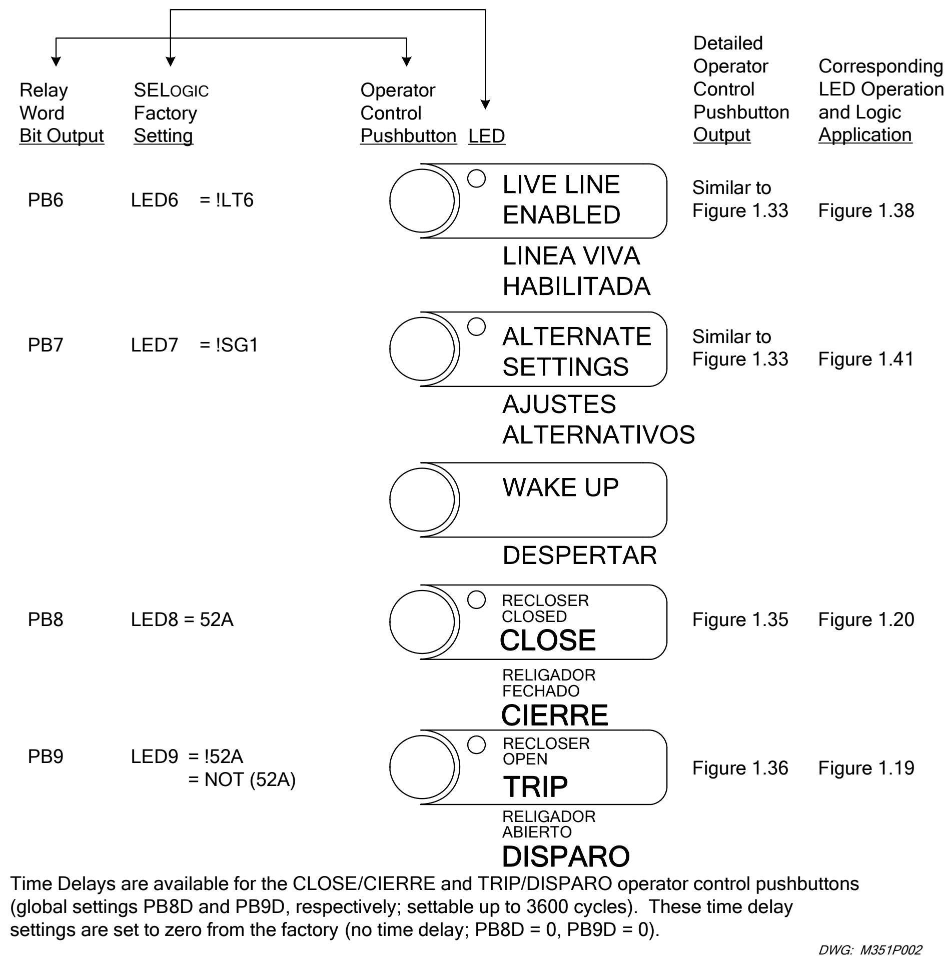


Figure 1.32: Operator Controls—LIVE LINE ENABLED/LINEA VIVA HABILITADA Through TRIP/DISPARO

Detailed Operator Control Pushbutton Output

Figure 1.31 and Figure 1.32 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 PROTECTION ENABLED/PROTECCION HABILITADA operator control pushbutton) corresponds number-wise to the LED setting (e.g., SELOGIC setting LED1 for the PROTECTION ENABLED/ PROTECCION HABILITADA LED). See also Table 1.4.

PROTECTION ENABLED/PROTECCION HABILITADA Operator Control Pushbutton Output

Figure 1.33 describes the PROTECTION ENABLED/ PROTECCION HABILITADA operator control pushbutton output. Every time the PROTECTION ENABLED/ PROTECCION HABILITADA operator control pushbutton is pressed momentarily, Relay Word bit PB1 asserts to logical 1 immediately for one processing interval.

The corresponding PROTECTION ENABLED/ PROTECCION HABILITADA LED (controlled by SELOGIC setting LED1) is independent of the PROTECTION ENABLED/ PROTECCION HABILITADA operator control pushbutton.

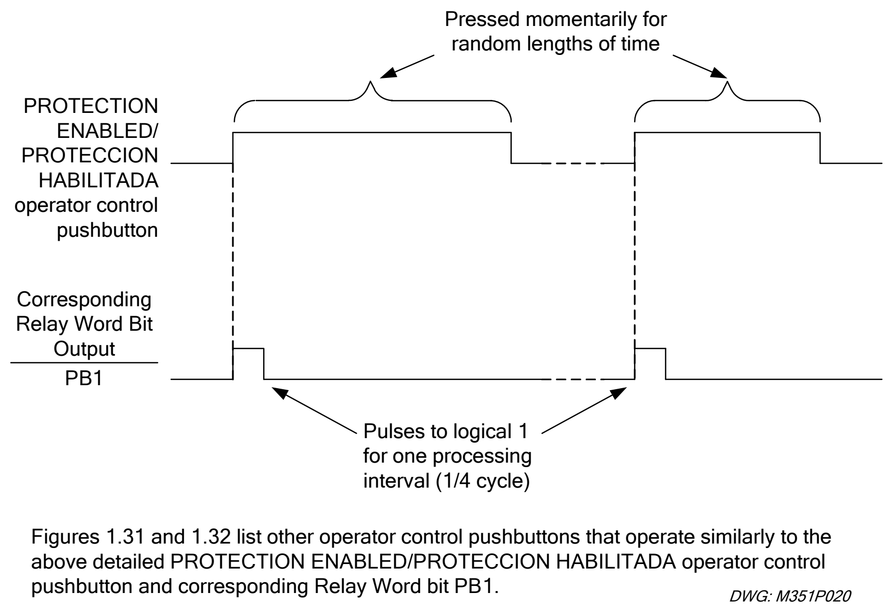


Figure 1.33: PROTECTION ENABLED/ PROTECCION HABILITADA Operator Control Pushbutton Output

Other Operator Control Pushbutton Outputs Operate Similarly to PROTECTION ENABLED/ PROTECCION HABILITADA

The following operator control pushbutton outputs operate similarly to the PROTECTION ENABLED/ PROTECCION HABILITADA operator control pushbutton output described in Figure 1.33 (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/
RECIERRE HABILITADO (PB2)

EARTH FAULT ENABLED/
FALLA A TIERRA HABILITADO (PB3)

SEF ENABLED/
SEF HABILITADO (PB4)

LIVE LINE ENABLED/
LINEA VIVA HABILITADA (PB6)

ALTERNATE SETTINGS/
AJUSTES ALTERNATIVOS (PB7)

REMOTE ENABLED/REMOTO HABILITADO Operator Control Pushbutton Output

Figure 1.34 describes the output of the unique REMOTE ENABLED/REMOTO HABILITADO operator control pushbutton. Note the need to press the REMOTE ENABLED/REMOTO HABILITADO operator control pushbutton continually for three seconds until Relay Word bit PB5 asserts to logical 1 for one processing interval.

The corresponding REMOTE ENABLED/REMOTO HABILITADO LED (controlled by SELOGIC setting LED5) is independent of the REMOTE ENABLED/REMOTO HABILITADO operator control pushbutton, unless the REMOTE ENABLED/REMOTO HABILITADO operator control pushbutton is pressed for the three seconds (and the LED flashes), as described in Figure 1.34.

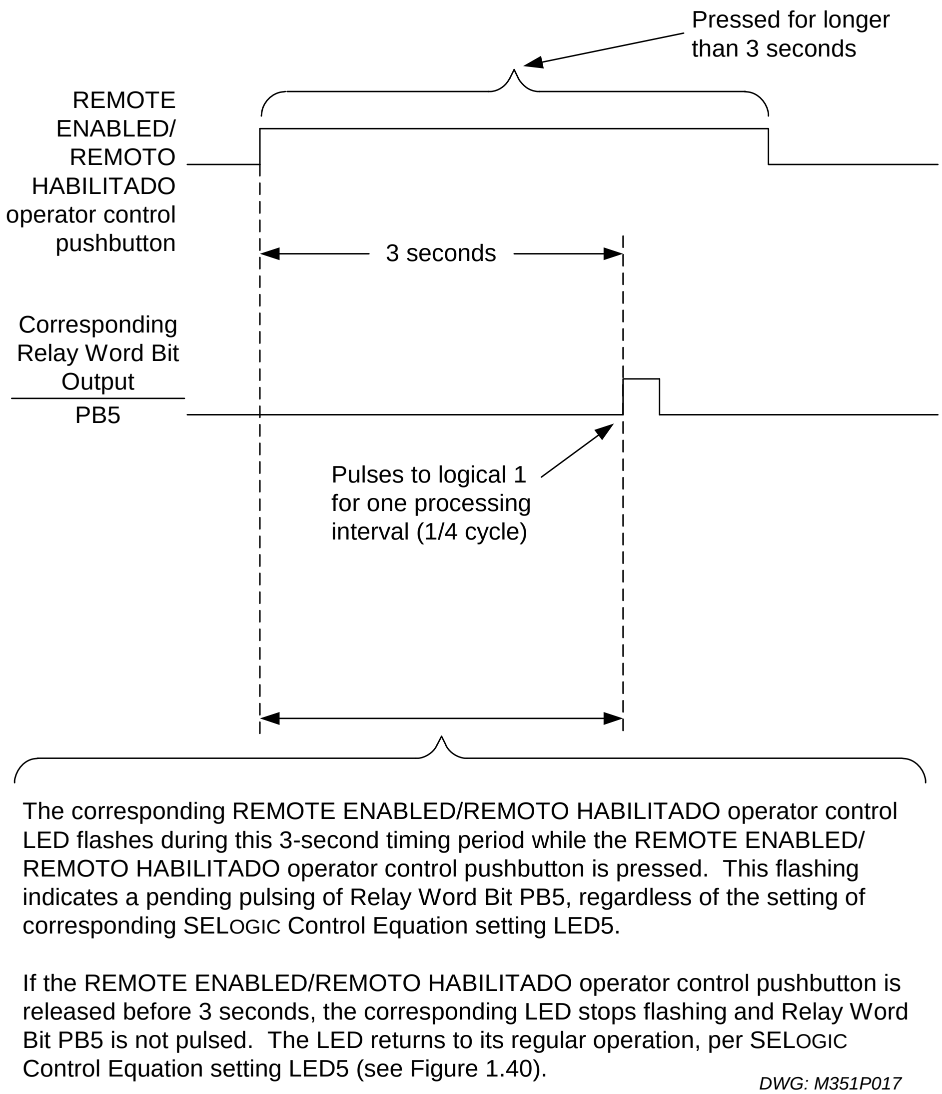


Figure 1.34: REMOTE ENABLED/REMOTO HABILITADO Operator Control Pushbutton Output

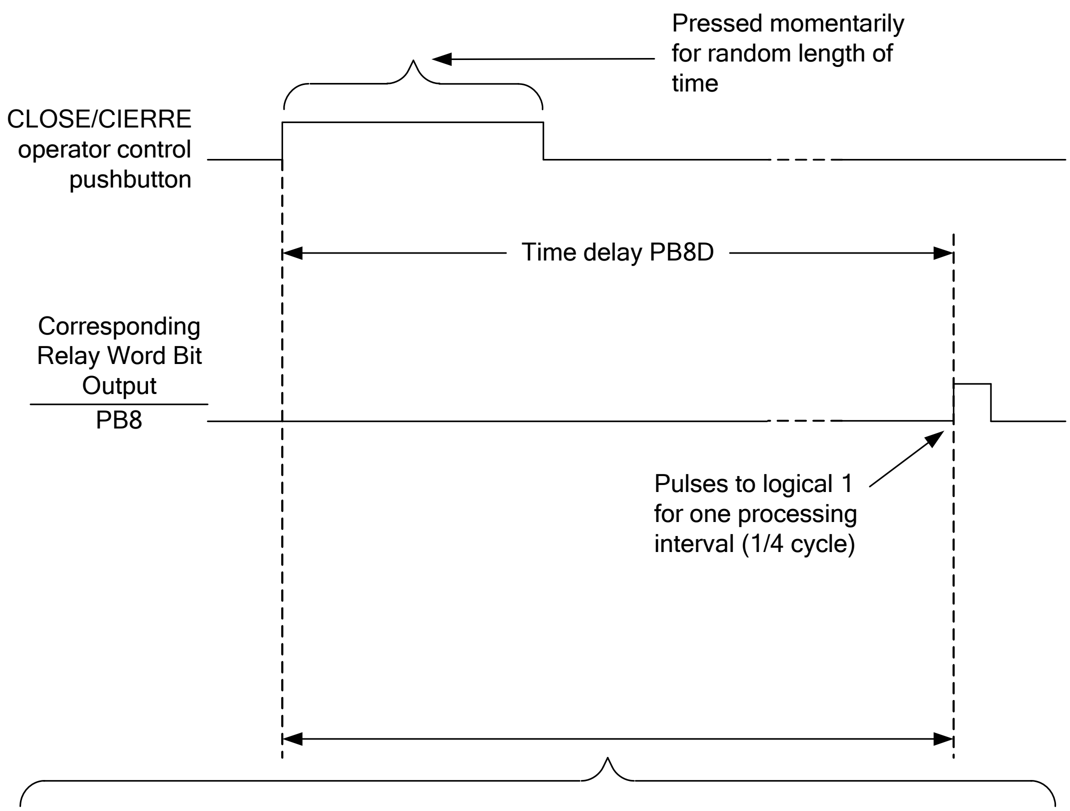
CLOSE/CIERRE and TRIP/DISPARO Operator Control Pushbutton Outputs

Figure 1.35 and Figure 1.36 describe the operation of the CLOSE/CIERRE and TRIP/DISPARO operator control pushbutton outputs, respectively.

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/CIERRE and TRIP/DISPARO pushbuttons as described in Figure 1.35 and Figure 1.36, whereby a pending close can be turned off by pressing the TRIP/DISPARO pushbutton and a pending trip can be turned off by pressing the CLOSE/CIERRE pushbutton.

The corresponding RECLOSER CLOSED/RESTAURADOR CERRADO and RECLOSER OPEN/RESTAURADOR ABIERTO LEDs (controlled by SELOGIC settings LED8 and LED9, respectively) are independent of the CLOSE/CIERRE and TRIP/DISPARO operator control pushbuttons, unless the CLOSE/CIERRE or TRIP/DISPARO operator control pushbutton is pressed and a pending close or trip results (and LED flashes), as described in Figure 1.35 and Figure 1.36.

CLOSE/CIERRE and TRIP/DISPARO operator control outputs (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/RESTAURADOR CERRADO 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/CIERRE operator control pushbutton is pressed again (or the TRIP/DISPARO operator control pushbutton is pressed) while PB8D is timing, the RECLOSER CLOSED/ RESTAURADOR CERRADO LED stops flashing, PB8D stops timing, and Relay Word Bit PB8 is not pulsed. The pending close operation is aborted. The RECLOSER CLOSED/ RESTAURADOR CERRADO LED returns to its regular operation, per SELOGIC Control Equation setting LED8 (see Figure 1.32).

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/CIERRE 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), then Relay Word bit PB8 functions in a manner similar to Figure 1.33.

DWG: M351P018

Figure 1.35: CLOSE/CIERRE Operator Control Pushbutton Output

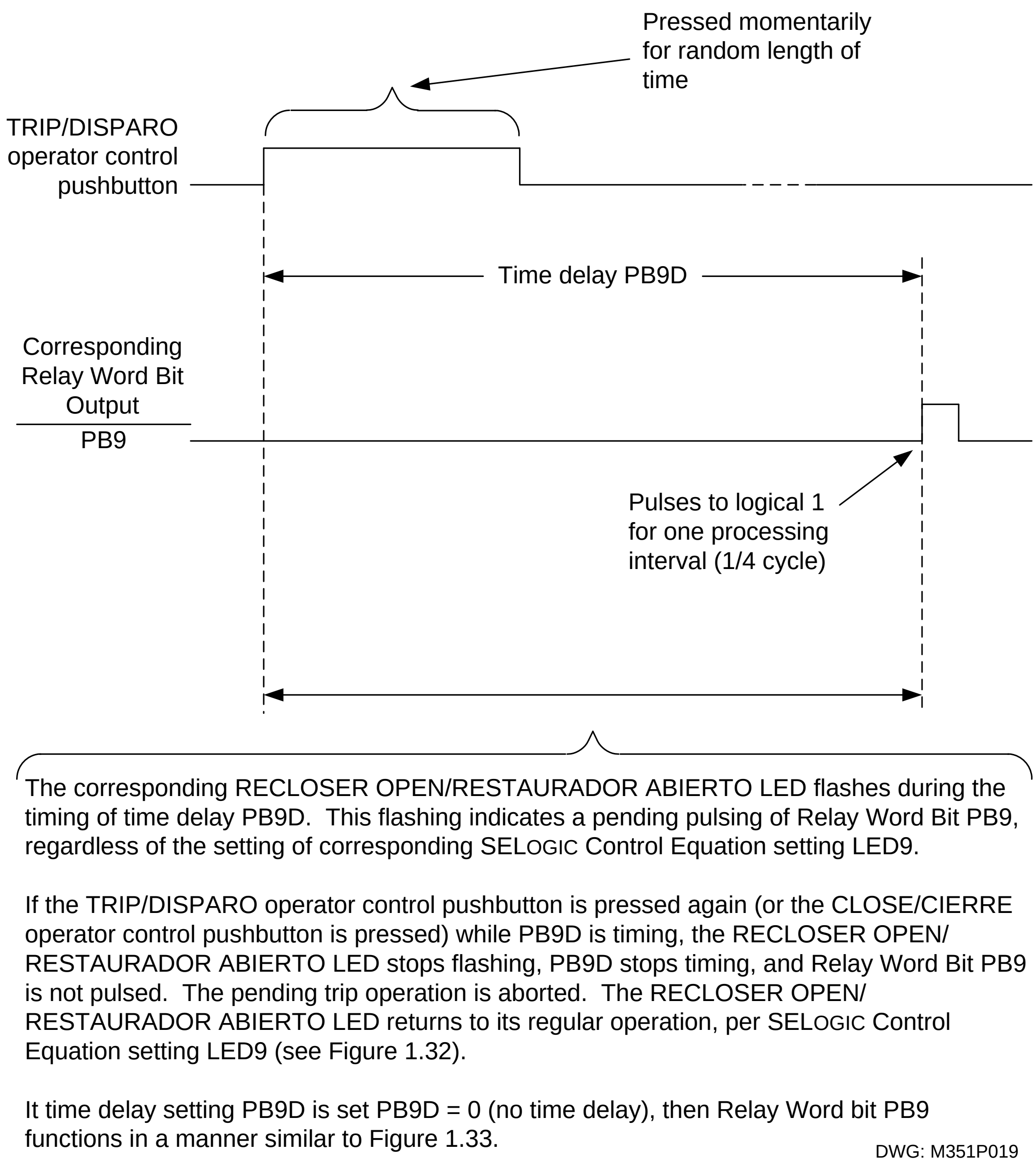


Figure 1.36: **TRIP/DISPARO Operator Control Pushbutton Output**

Operator Control Logic

Figure 1.31, Figure 1.32, and the following Table 1.4, summarize the local/remote inputs and the logic outputs for each of the operator controls. Note the numerical correspondence within the logic for most of the operator controls—for example:

PROTECTION ENABLED/PROTECCION HABILITADA input: PB1, RB1

PROTECTION ENABLED/PROTECCION HABILITADA output: LT1, LED1

Table 1.4: Operator Control Input/Output

Operator Control Function	Figure	Local Control	Remote Control	Latch Setting	Latch Output	LED Setting
PROTECTION ENABLED/ PROTECCION HABILITADA	1.37	PB1	RB1	SET1 RST1	LT1	LED1
RECLOSE ENABLED/ RECIERRE HABILITADO	1.38	PB2	RB2	SET2 RST2	LT2	LED2
EARTH FAULT ENBABLED/ FALLA A TIERRA HABILITADA	1.39	PB3	RB3	SET3 RST3	LT3	LED3
SEF ENABLED/ SEF HABILITADO	1.39	PB4	RB4	SET4 RST4	LT4	LED4
REMOTE ENABLED/ REMOTO HABILITADO	1.40	PB5	N/A	SET5 RST5	LT5	LED5
LIVE LINE ENABLED/ LINEA VIVA HABILITADA	1.38	PB6	RB6	SET6 RST6	LT6	LED6
ALTERNATE SETTINGS/ AJUSTES ALTERNATIVOS	1.41	PB7	RB7	SET7 RST7	LT7	LED7
CLOSE/CIERRE	1.20	PB8	CC (**OPEN** Command)	N/A	N/A	LED8
TRIP/DISPARO	1.19	PB9	OC (**CLOSE** Command)	N/A	N/A	LED9

Table 1.5: SELOGIC Control Equations for Operator Controls

Operator Control Function	SELOGIC Control Equations
PROTECTION ENABLED /PROTECCION HABILITADA	SET1 = (PB1 + PB8)*!LT5*!LT1 + (/RB1 + CC + /IN102)*LT5*!LT1 RST1 = (PB1*!LT5 + /RB1*LT5)*LT1 LED1 = LT1
RECLOSE ENABLED /RECIERRE HABILITADO	SET2 = (PB2*!LT5 + /RB2*LT5 + /IN06*LT5)*!LT2*LT6 RST2 = (PB2*!LT5 + /RB2*LT5 + /IN106*LT5)*LT2 + !LT6 + !(79RS + 79CY + 79LO) LED2 = LT2
EARTH FAULT ENABLED /FALLA A TIERRA HABILITADA	SET3 = (PB3*!LT5 + /RB3*LT5 + /IN05*LT5 + LT4)*!LT3 RST3 = (PB3*!LT5 + /RB3*LT5 + /IN105*LT5)*LT3 LED3 = LT3
SEF ENABLED /SEF HABILITADO	SET4 = (PB4*!LT5 + /RB4*LT5 + /IN04*LT5)*!LT4 RST4 = (PB4 + PB3)*!LT5*LT4 + (/RB4 + /RB3 + /IN104 + /IN105)*LT5*LT4 LED4 = LT4

Operator Control Function	SELOGIC Control Equations
REMOTE ENABLED /REMOTO HABILITADO	SET5 = PB5*!LT5 RST5 = PB5*LT5 LED5 = LT5
LIVE LINE ENABLED /LINEA VIVA HABILITADA	SET6 = (PB6*!LT5 + /RB6*LT5)*!LT6 RST6 = (PB6*!LT5 + /RB6*LT5)*LT6 LED6 = !LT6
ALTERNATE SETTINGS /AJUSTES ALTERNATIVOS	SET7 = (PB7*!LT5 + /RB7*LT5 + /IN03*LT5)*!LT7*LT6 RST7 = (PB7*!LT5 + /RB7*LT5 + /IN03*LT5)*LT7*LT6 LED7 = LT7*LT6
CLOSE/CIERRE	52A = WB52A CL = (PB8*!LT5 + CC*LT5 + /IN102*LT5)*LT6*TRCAP*CLCAP ULCL = TRIP + WBTRT + !(LT6 + WBCL) LED8 = 52A
TRIP/DISPARO	SV1 = (PB9*!LT5) + (OC + /IN101)*LT5 TR = SV1 + LT1*(51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T + 67G2T + 67N2T + 67N3T + 81D1T) LED9 = RAW52B

Notes:

1. The logic output (LT5) of the REMOTE ENABLED/REMOTO HABILITADO operator control (Figure 1.40) influences the logic of every other function summarized in Table 1.4. The REMOTE ENABLED/REMOTO HABILITADO operator control switches local/remote control back and forth.
2. RECLOSE ENABLED/RECIERRE HABILITADO and LIVE LINE ENABLED/LINEA VIVA HABILITADA operator controls have interlocking logic (see Figure 1.38). EARTH FAULT ENABLED/FALLA A TIERRA HABILITADA and SEF ENABLED/SEF HABILITADO operator controls also have interlocking logic (see Figure 1.39). See the ***Front-Panel Interface*** section of the ***SEL-351P-3 Recloser Control Quick-Start Installation and User's Guide*** for an explanation of how these and all front panel operator controls function.
3. Remote bits RB1 through RB4, RB6, and RB7 provide remote control capability for many of the operator controls. Control the remote bits with the **CON** serial port command. The CC and OC Relay Word bits provide similar remote control for the close and trip functions, respectively, with the **CLO** and **OPE** serial port commands (see ***Section 10: Serial Port Communications and Commands***).
4. Latch outputs LT1 through LT7 are discussed in detail in the ***Latch Control Switches*** subsection of ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***. The multiple settings group capability behind the ALTERNATE SETTINGS/AJUSTES ALTERNATIVOS operator control is discussed in detail in the ***Multiple Settings Groups*** subsection in the same section.

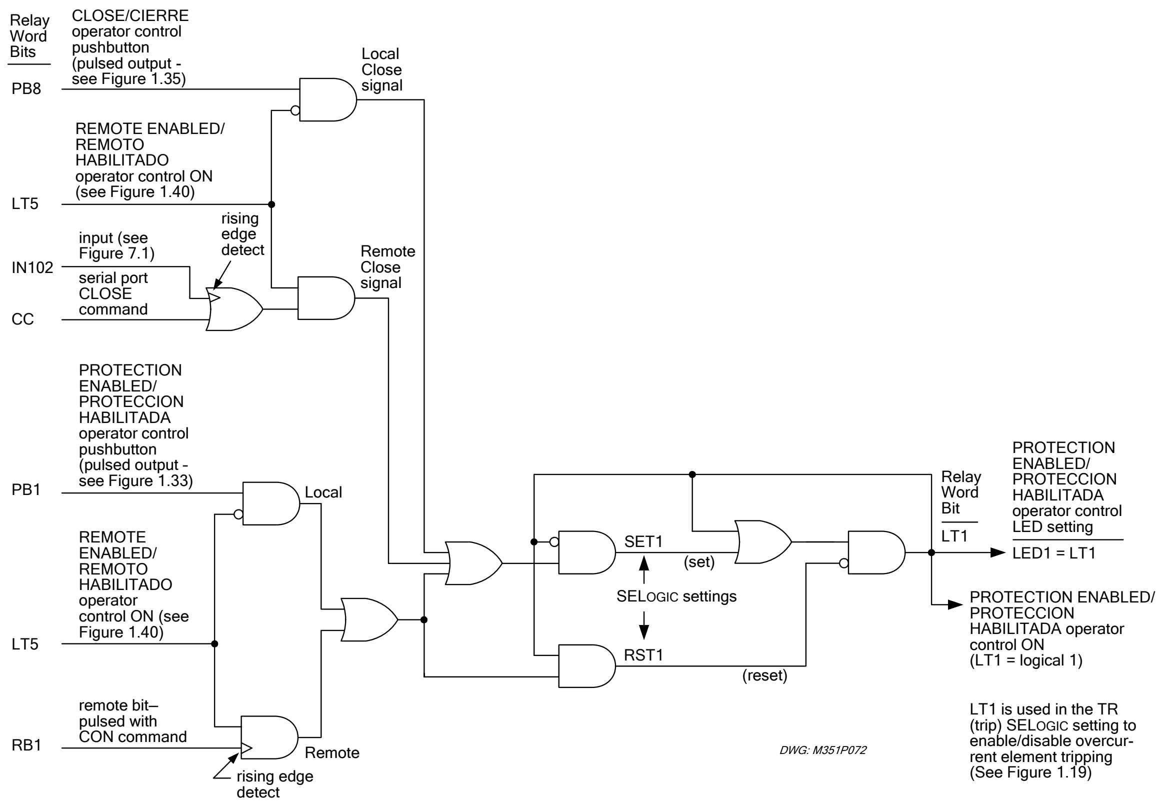


Figure 1.37: PROTECTION ENABLED/PROTECCION HABILITADA Operator Control Logic

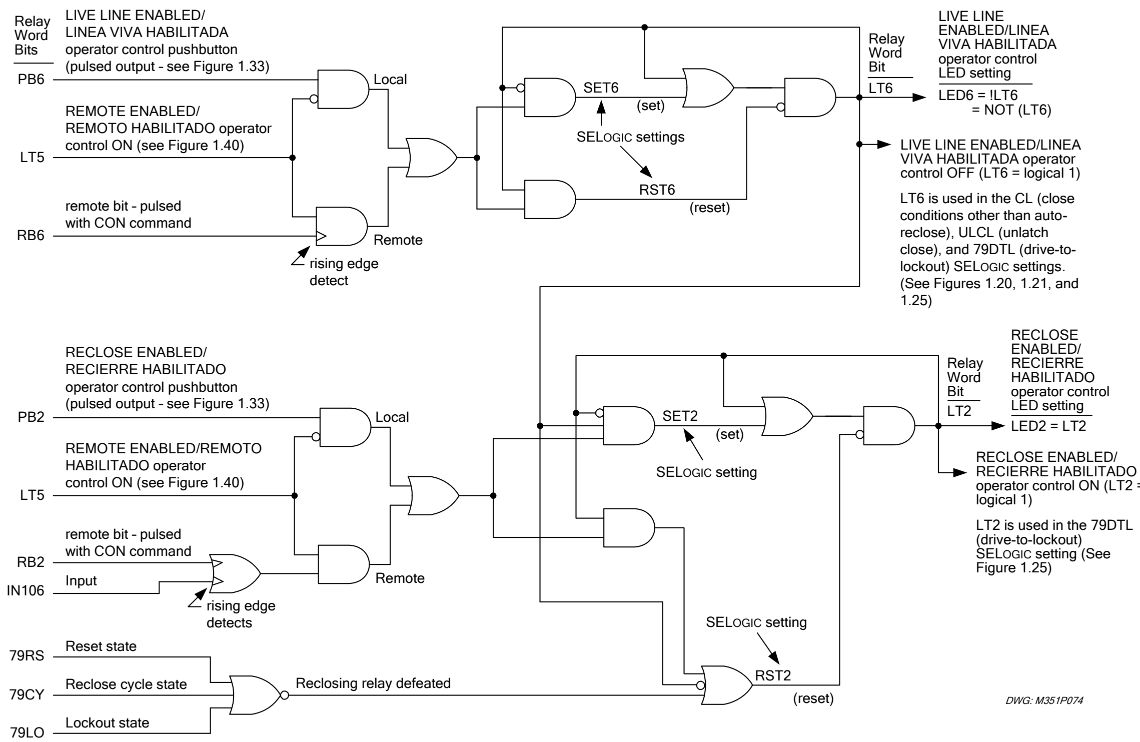


Figure 1.38: RECLOSE ENABLED/RECIERRE HABILITADO and LIVE LINE ENABLED/LINEA VIVA HABILITADA Operator Control Logic

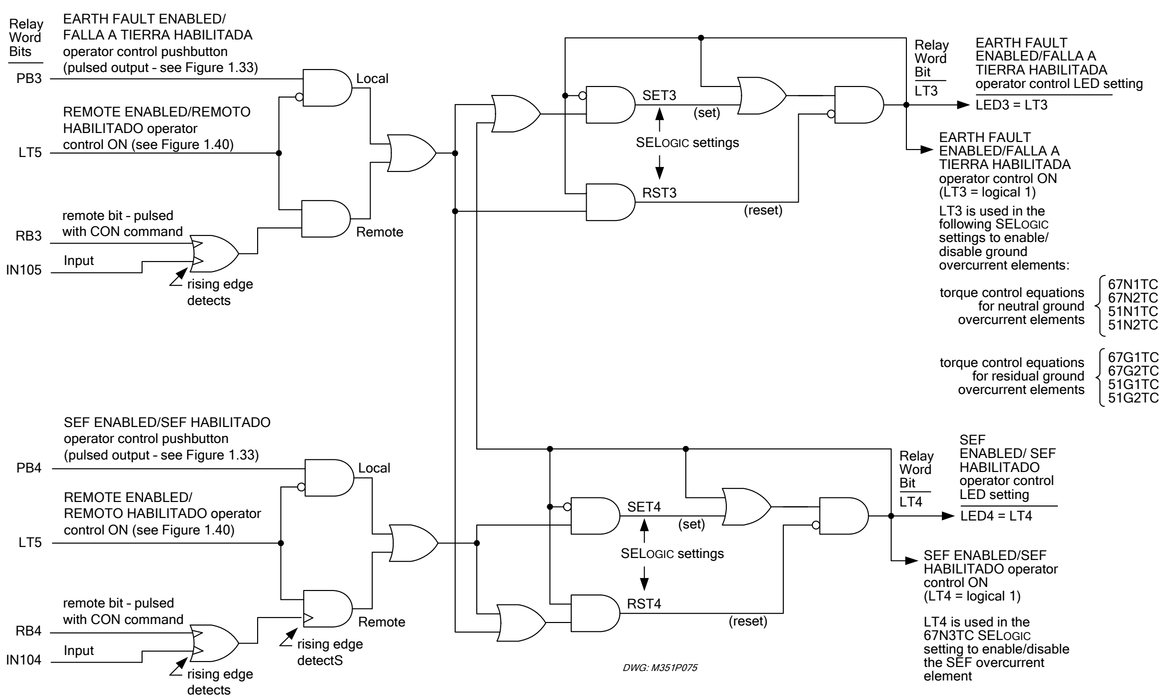
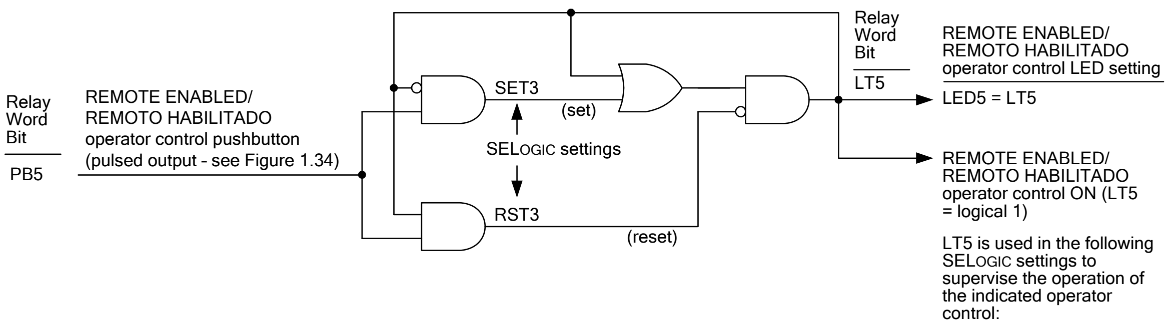


Figure 1.39: EARTH FAULT ENABLED/FALLA A TIERRA HABILITADA and SEF ENABLED/SEF HABILITADO Operator Control Logic



Operator Control	SELOGIC Settings	Logic Application
PROTECTION ENABLED/ PROTECCION HABILITADA	SET1 , RST1	Figure 1.37
RECLOSE ENABLED/ RESTAURADOR HABILITADO	SET2 , RST2	Figure 1.38
EARTH FAULT ENABLED/ FALLA A TIERRA HABILITADA	SET3 , RST3	Figure 1.39
SEF ENABLED/ SEF HABILITADO	SET4 , RST4	Figure 1.39
LIVE LINE ENABLED/ LINEA VIVA HABILITADA	SET6 , RST6	Figure 1.38
ALTERNATE SETTINGS/ AJUSTES ALTERNATIVOS	SET7, RST7	Figure 1.41
CLOSE/CIERRE	CL	Figure 1.20
TRIP/DISPARO	SV1	Figure 1.19

Figure 1.40: REMOTE ENABLED/REMOTO HABILITADO Operator Control Logic

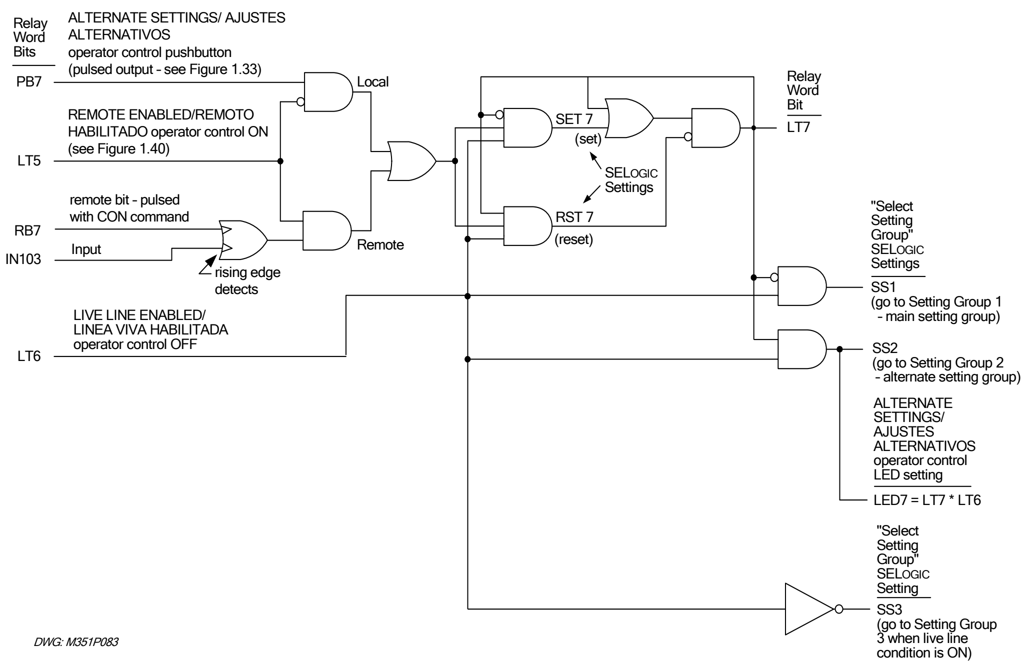


Figure 1.41: ALTERNATE SETTINGS/AJUSTES ALTERNATIVOS Operator Control Logic

FRONT-PANEL STATUS AND TRIP TARGET LEDS

See Figure 8 in the ***Front-Panel Interface*** section in the ***SEL-351P-3 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 1.42 through Figure 1.48. The front-panel status and trip target LEDs (except the CONTROL ENABLED/CONTROL HABILITADO 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 = ACPWR; the AC SUPPLY/ALIM CA LED illuminates when Relay Word bit ACPWR asserts to logical 1; ACPWR asserts to logical 1 when nominal Vac power is applied.

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

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

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

  The AC SUPPLY/ALIM CA LED illuminates when Relay Word bit ACPWR asserts to logical 1, 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 UNDER FREQ./BAJA FREC. (underfrequency trip) LED illuminates when Relay Word bit 81D1T is asserted to logical 1 and a rising-edge of TRIP occurs.

Trip-target LEDs [e.g., the UNDER FREQ./ BAJA FREC. (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]

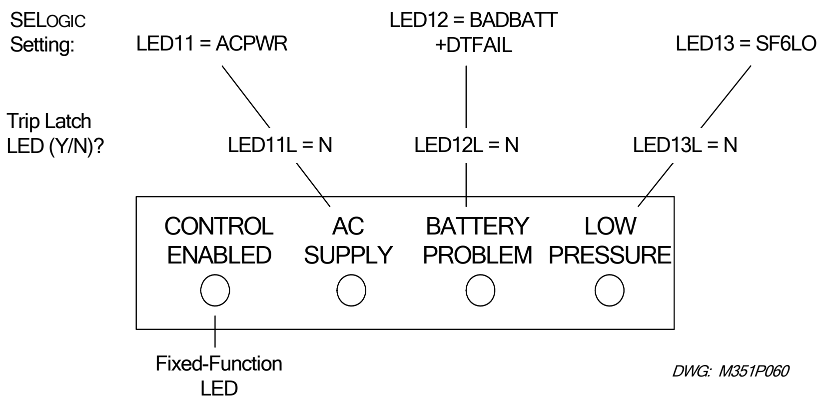


Figure 1.42: Front-Panel Status LEDs (English)

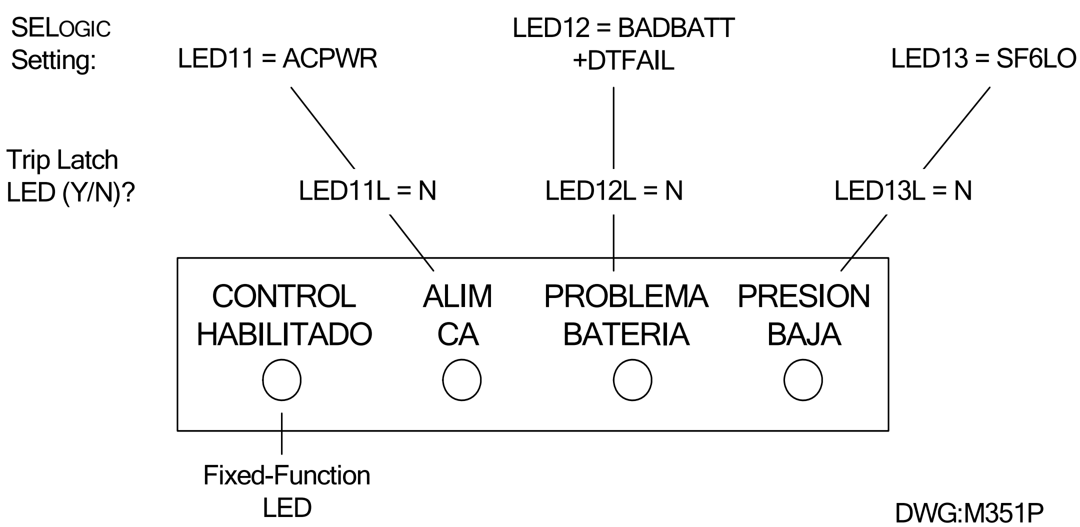


Figure 1.43: Front-Panel Status LEDs (Spanish)

Figure 2.1 through Figure 2.4 and associated text in subsection ***Voltage Connections*** in ***Section 2: Additional Installation Details*** discuss possible changes necessary to the factory default AC SUPPLY/FONTE CA LED SELOGIC control equations setting LED11, for various voltage connections.

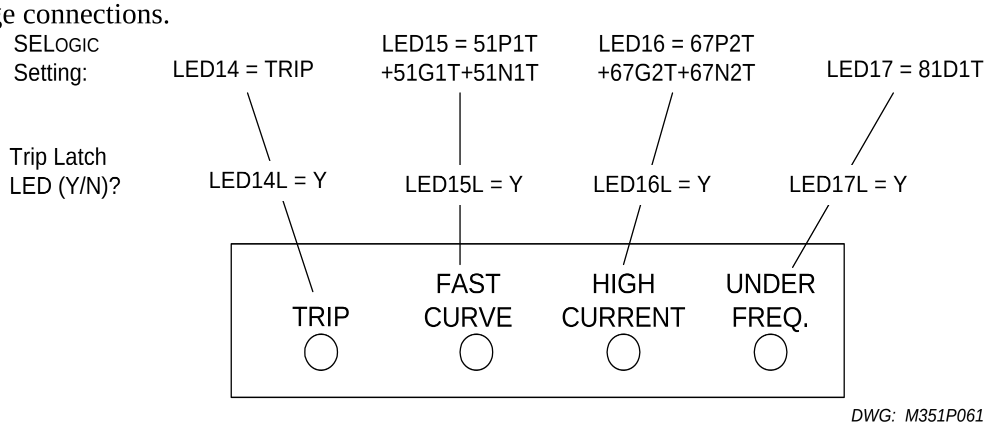


Figure 1.44: Front-Panel Trip Target LEDs (English)

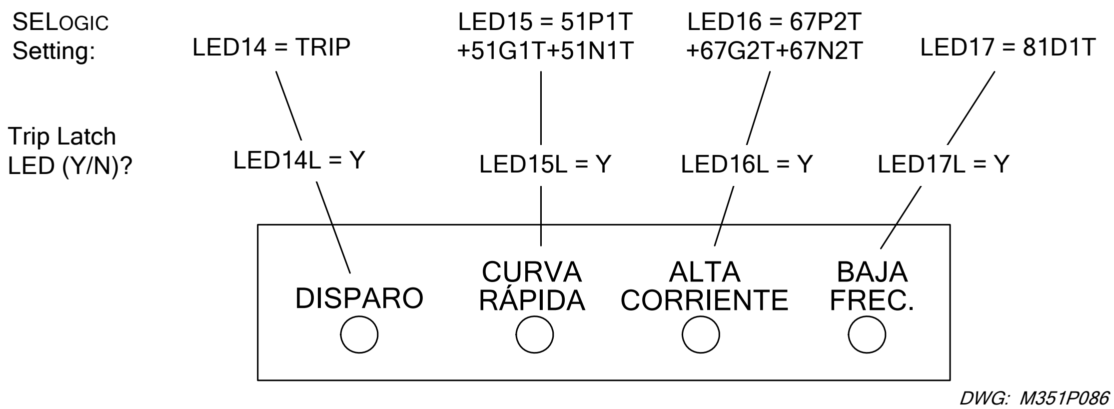


Figure 1.45: Front-Panel Trip Target LEDs (Spanish)

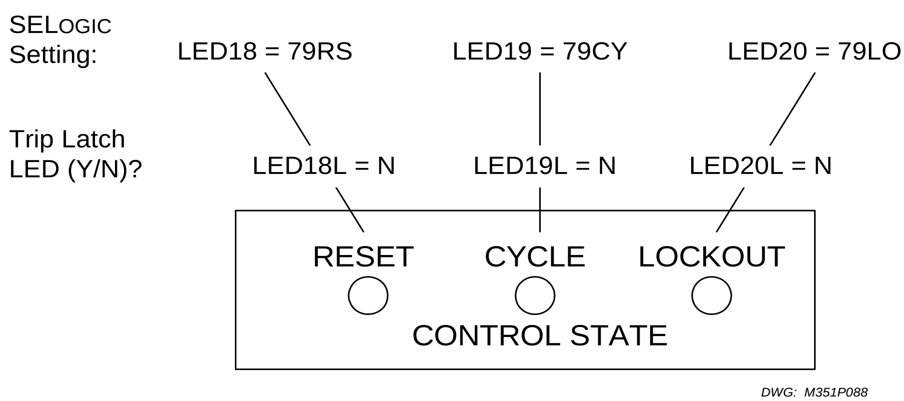


Figure 1.46: Front-Panel Reclosing Relay Status LEDs (English)

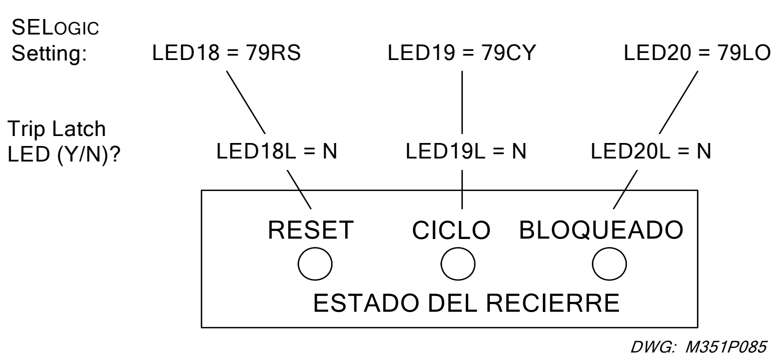


Figure 1.47: Front-Panel Reclosing Relay Status LEDs (Spanish)

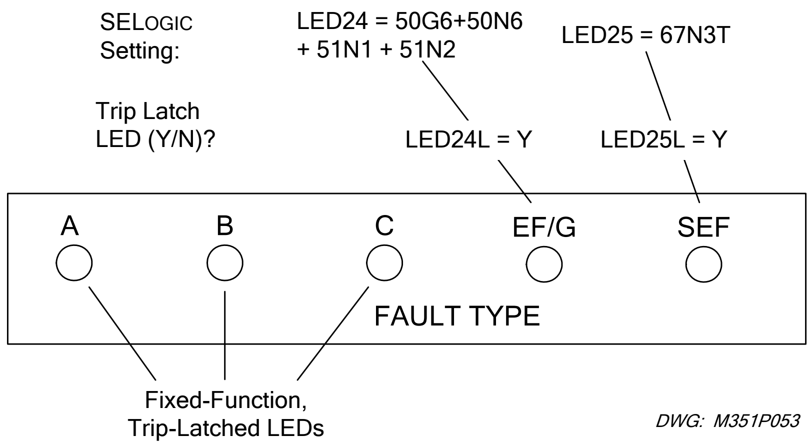


Figure 1.48: Front-Panel Fault-Type Trip Target LEDs (English)

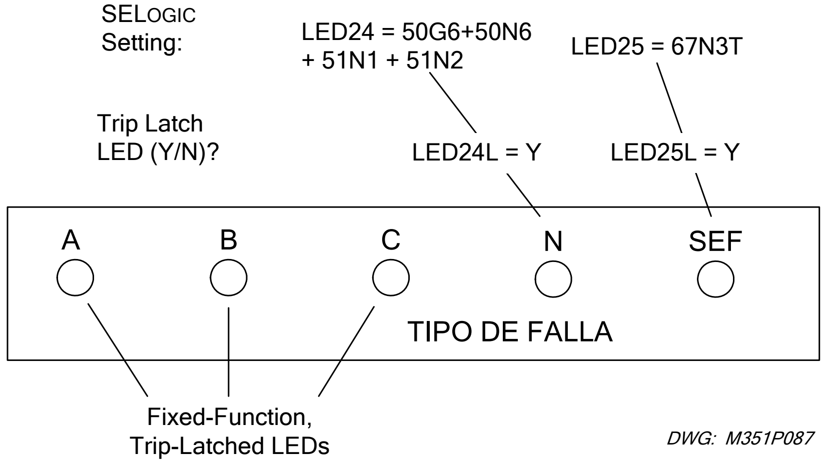


Figure 1.49: Front-Panel Fault-Type Trip Target LEDs (Spanish)

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TABLES

SECTION 2: ADDITIONAL INSTALLATION DETAILS

Introduction

This section describes additional SEL-351P-3 Recloser Control installation details not covered in the ***Installation*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide***. Refer also to Figure 6 in the guide.

Output Contact Jumpers

Table 2.1 shows the correspondence between output contact jumpers and the output contacts they control. Figure 6 in the ***Communications*** section of the ***SEL-351P-3 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 deenergized 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 deenergized and open when the output contact coil is energized. These jumpers are soldered in place.

In Figure 3 in the ***Installation*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide***, note that the ALARM output contact is a "b" type output contacts and the other output contacts are all "a" type output contacts. This is how these jumpers are configured in a standard SEL-351P-3 Recloser Control shipment. Refer to corresponding Figure 7.27 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-351P-3 has a dedicated alarm output contact (labeled ALARM—see Figure 3 in the ***Installation*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide***). 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.

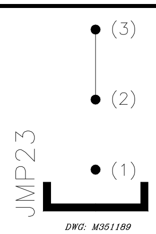
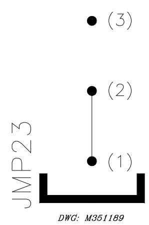
The output contact next to the dedicated ALARM output contact can be converted to operate as an "extra alarm" output contact by moving a jumper on the main board (see Table 2.2).

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-351P-3 shipment (see Figure 7.27)
	“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 7.27)

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 relay shipment. In a standard SEL-351P-3 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 preceding subsection ***Output Contact Jumpers***). 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 Relay Shipments

Password Jumper/Position (for standard relay shipments)	Breaker Jumper/Position (for standard relay 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[1] for serial ports and front panel
	OFF (removed/not in place)	enable password protection[1] for serial ports and front panel
Breaker	ON (in place)	enable serial port commands **OPEN**[2], **CLOSE**[2], and **PULSE**[2]
	OFF (removed/not in place)	disable serial port commands **OPEN**[2], **CLOSE**[2], and **PULSE**[2]

[1] View or set the passwords with the **PASSWORD** command (see ***Section 10: Serial Port Communications and Commands***).

[2] 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 6 in the ***Communications*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide*** has multiple jumpers A through 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. See Table 10.1 in ***Section 10: Serial Port Communications and Commands*** for EIA-232 serial port pin functions.

In a standard SEL-351P-3 shipment, the jumpers are "OFF" (removed/not in place) so that the +5 Vdc is not connected to Pin 1 on the corresponding EIA-232 serial ports. Put the jumpers "ON" (in place) so that the +5 Vdc is connected to Pin 1 on the corresponding EIA-232 serial ports.

Table 2.6: EIA-232 Serial Port Voltage Jumper Positions for Standard Relay Shipments

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

Clock Battery

Refer to Figure 6 in the ***Communications*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide*** for clock battery location (front of main board). A lithium battery powers the relay 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-351P-3 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 relay is installed. The battery cannot be recharged.

If the relay does not maintain the date and time after power loss, replace the battery. Follow the instructions in the ***Password Jumper*** subsection in the ***Communications*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide*** to remove the relay main board.

⚠ 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.

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

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SECTION 3: OVERCURRENT, VOLTAGE, SYNCHRONISM CHECK, AND FREQUENCY ELEMENTS 3-1

TABLES

FIGURES

SECTION 3: OVERCURRENT, VOLTAGE, SYNCHRONISM CHECK, AND FREQUENCY ELEMENTS

Many of the elements described in this section are used in the factory-set logic for the SEL-351P-3 Recloser Control. Refer to Table 1.1 in ***Section 1: Factory-Set Logic*** 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 1.2 in ***Section 1: Factory-Set Logic*** 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 3.2, and Figure 3.3.

Level 2 element 67P2S in Figure 3.3 is used in directional comparison blocking schemes (see ***Directional Comparison Blocking (DCB) Logic*** in ***Section 5: Trip and Target Logic***). 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 through 50P6P:

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

Setting range for definite-time settings 67P1D through 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

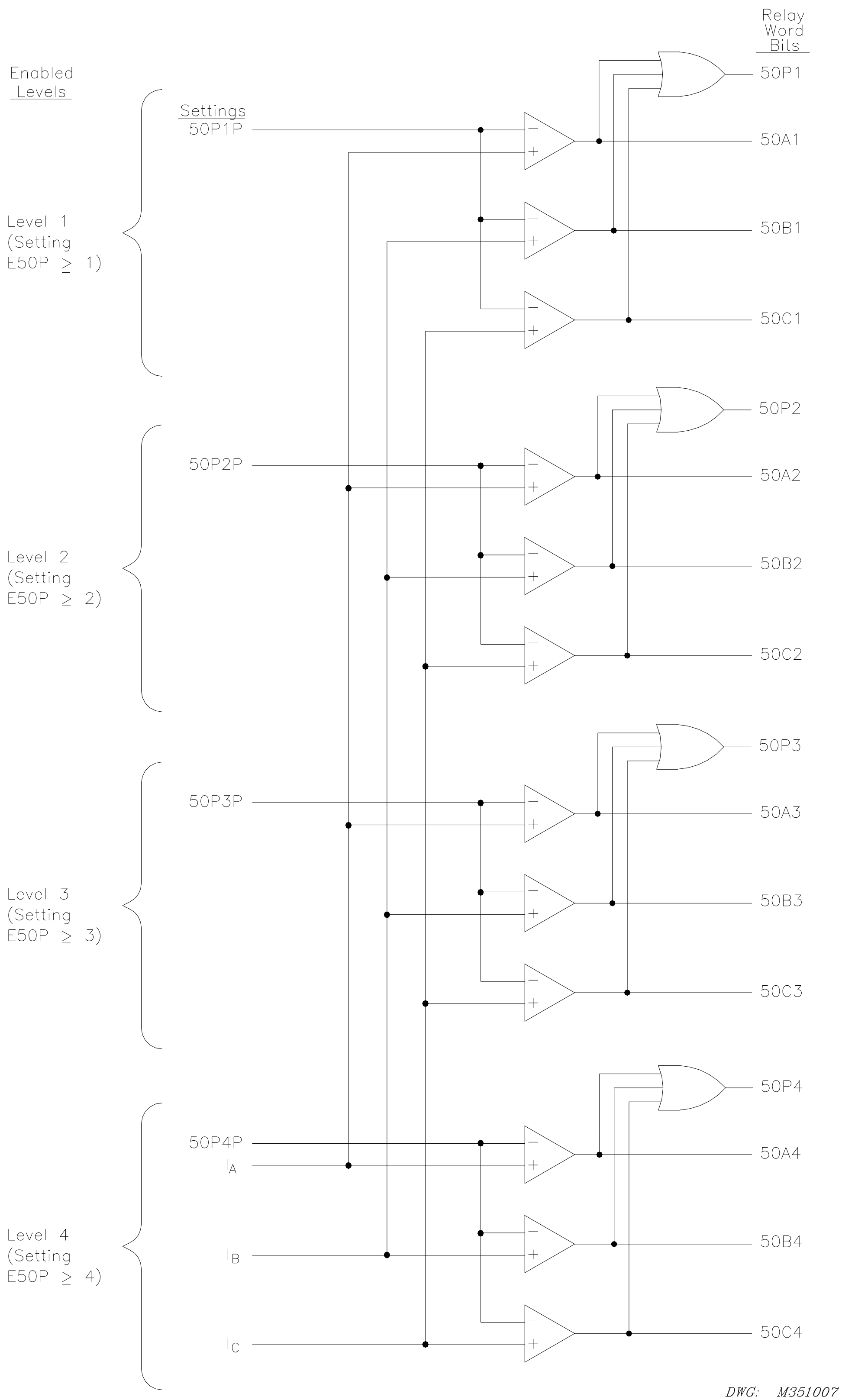


Figure 3.1: Levels 1 Through 4 Phase Instantaneous Overcurrent Elements

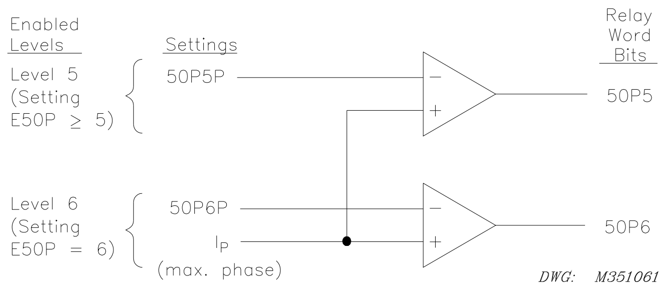


Figure 3.2: Levels 5 Through 6 Phase Instantaneous Overcurrent Elements

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 through 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):

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

50B1 = 1 (logical 1), if I_B > pickup setting 50P1P
= 0 (logical 0), if $I_B \leq$ 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 through 67P4 will display in an organized fashion in event reports (see Figure 3.3 and Table 12.3).

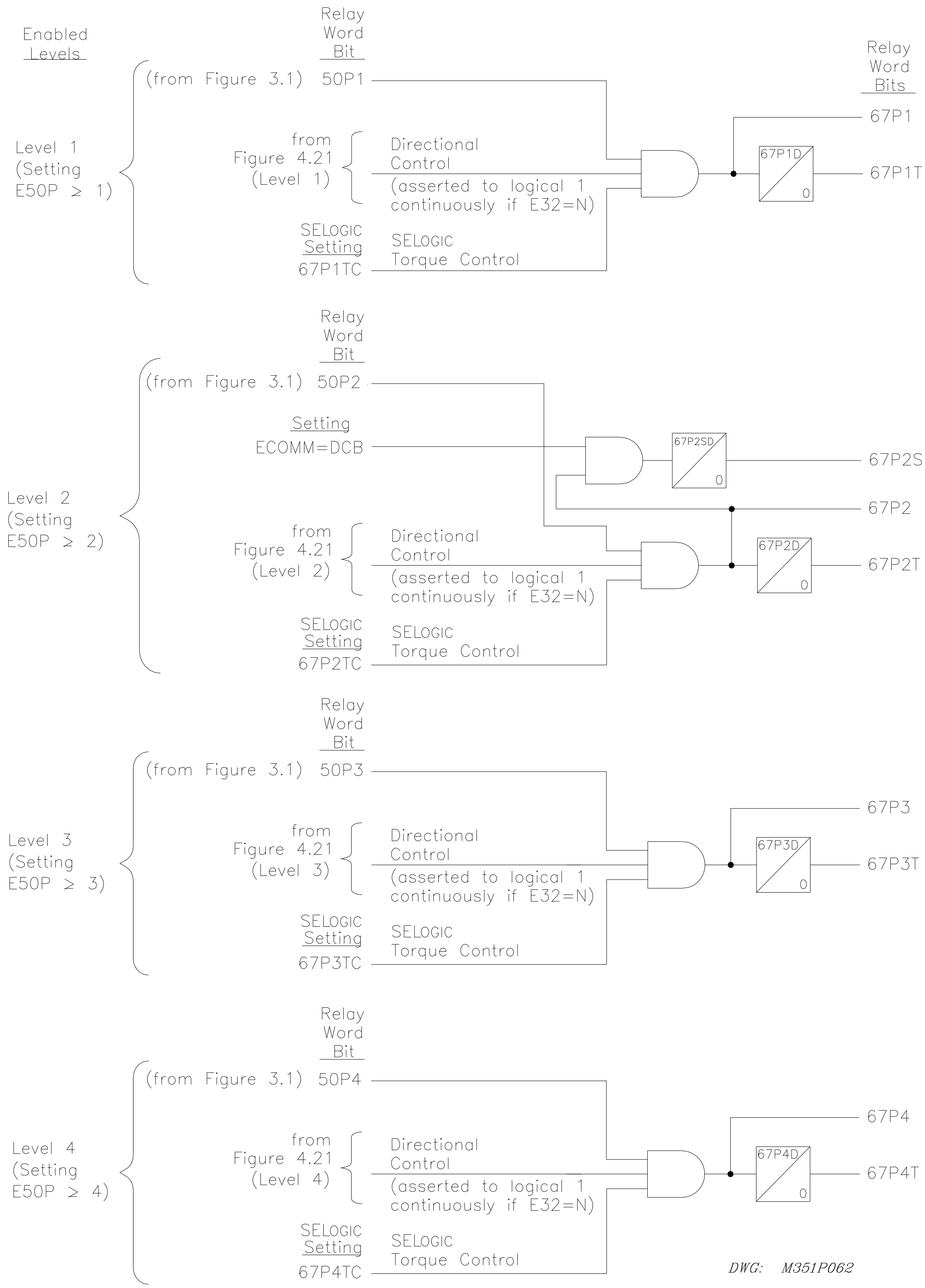


Figure 3.3: Levels 1 Through 4 Phase Instantaneous/Definite-Time Overcurrent Elements (with Directional Control Option)

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 through 4 in Figure 3.3 have corresponding directional control options. See Figure 4.21 in ***Section 4: Loss-of-Potential, Load Encroachment, and Directional Element Logic*** 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

Levels 1 through 4 in Figure 3.3 have corresponding SELOGIC control equation torque control settings 67P1TC through 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.

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)*** in ***Section 10: Serial Port Communications and Commands*** for a list of the factory default settings.

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 4.18 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.

Sometimes SELOGIC control equation torque control settings are set to provide directional control. See ***Directional Control Provided by Torque Control Settings*** at the end of ***Section 4: Loss-of-Potential, Load Encroachment, and Directional Element Logic***.

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.

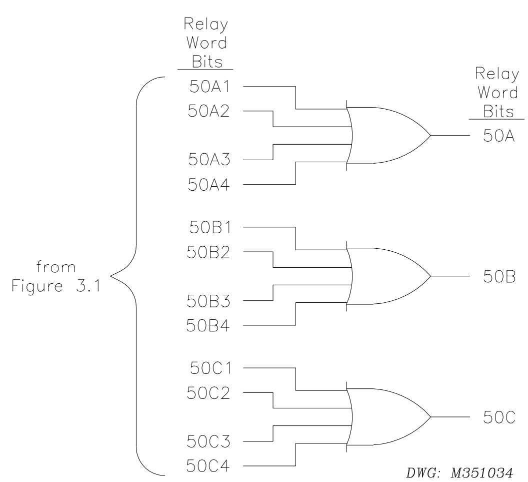


Figure 3.4: Combined Single-Phase Instantaneous Overcurrent Elements

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-351P-3 (60 Hz or 50 Hz relays). These times do <u>not</u> 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 cycles for a 60 Hz relay; 0.20 cycles for a 50 Hz relay).

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

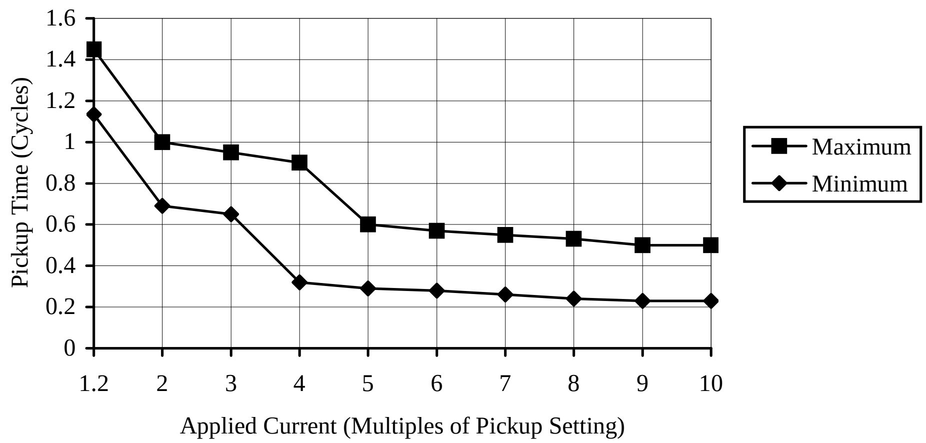


Figure 3.5: SEL-351P-3 Recloser Control Nondirectional Instantaneous Overcurrent Element Pickup Time Curve

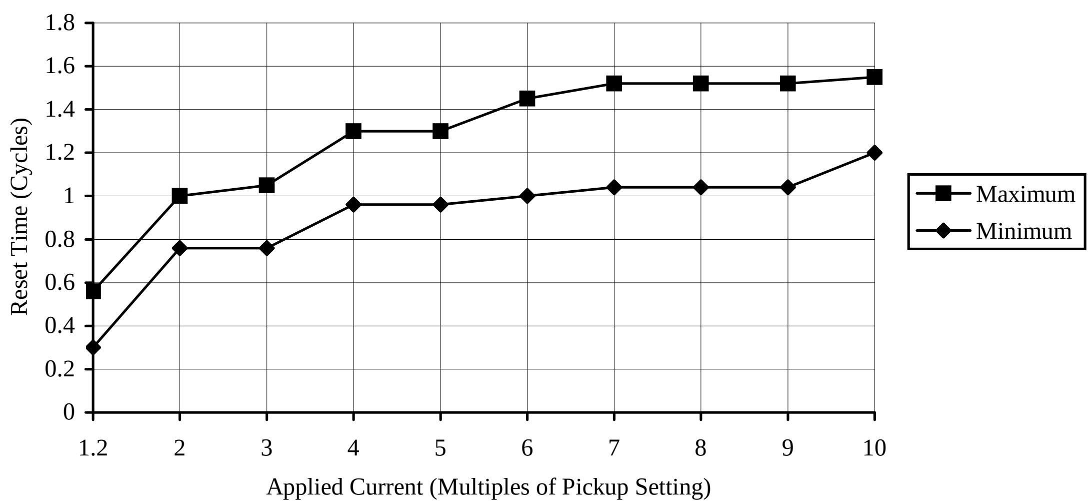


Figure 3.6: SEL-351P-3 Recloser Control Nondirectional Instantaneous Overcurrent Element Reset Time Curve

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 through 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 through 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*** in ***Section 5: Trip and Target Logic***). 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 3.2, and Figure 3.3 in the preceding ***Phase Instantaneous/Definite-Time Overcurrent Elements*** subsection, substituting current I_N (channel IN current) for phase currents and substituting like settings and Relay Word bits.

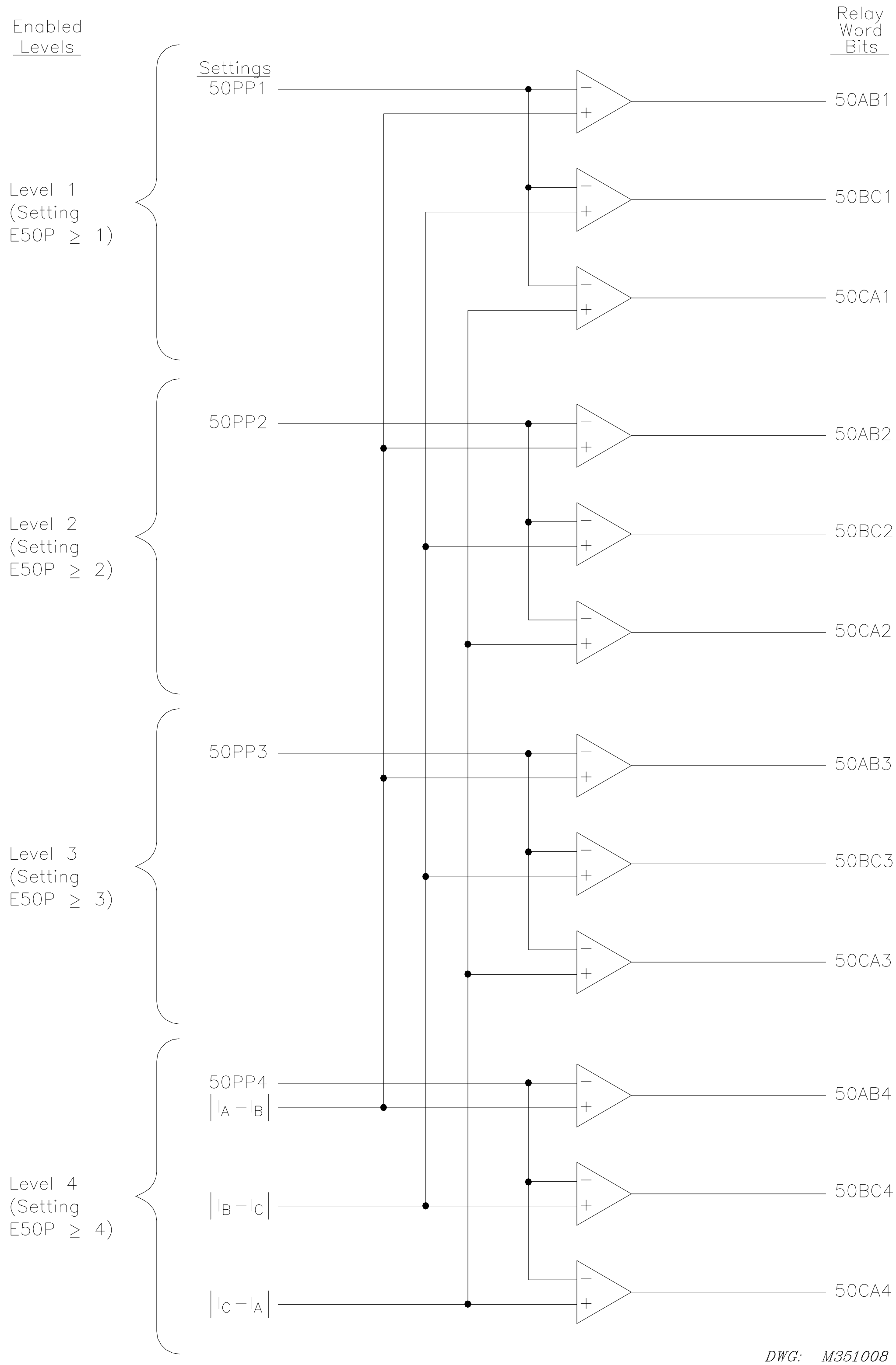


Figure 3.7: Levels 1 Through 4 Phase-to-Phase Instantaneous Overcurrent Elements

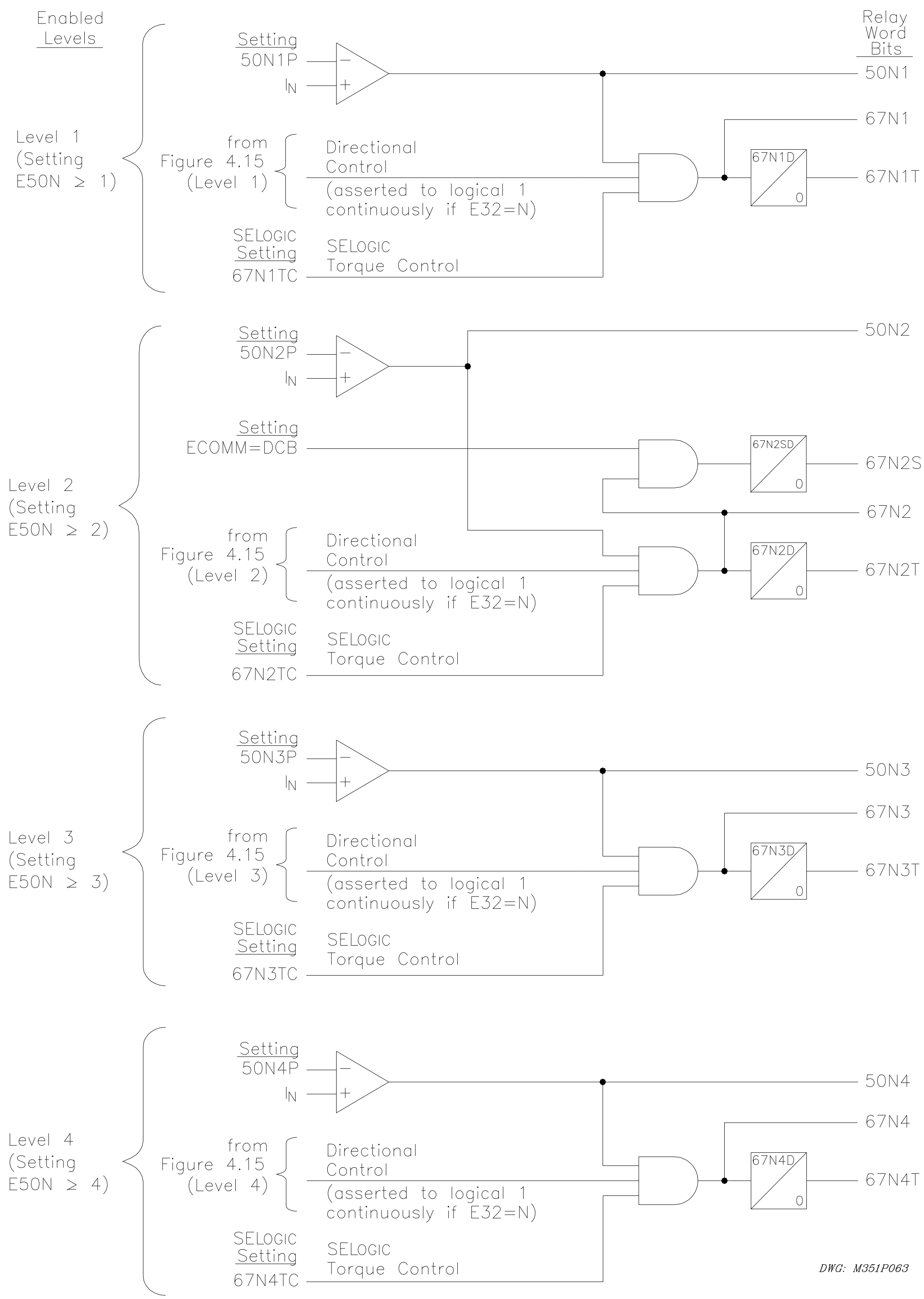


Figure 3.8: Levels 1 Through 4 Neutral Ground Instantaneous/Definite-Time Overcurrent Elements (with Directional Control Option)

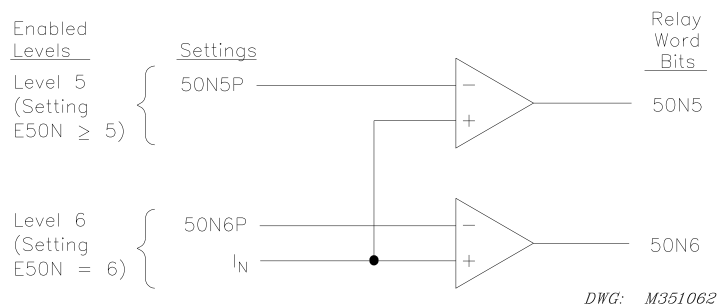


Figure 3.9: Levels 5 Through 6 Neutral Ground Instantaneous Overcurrent Elements

Settings Ranges

Setting range for pickup settings 50N1P through 50N6P:

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

Setting range for definite-time settings 67N1D through 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

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.

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.

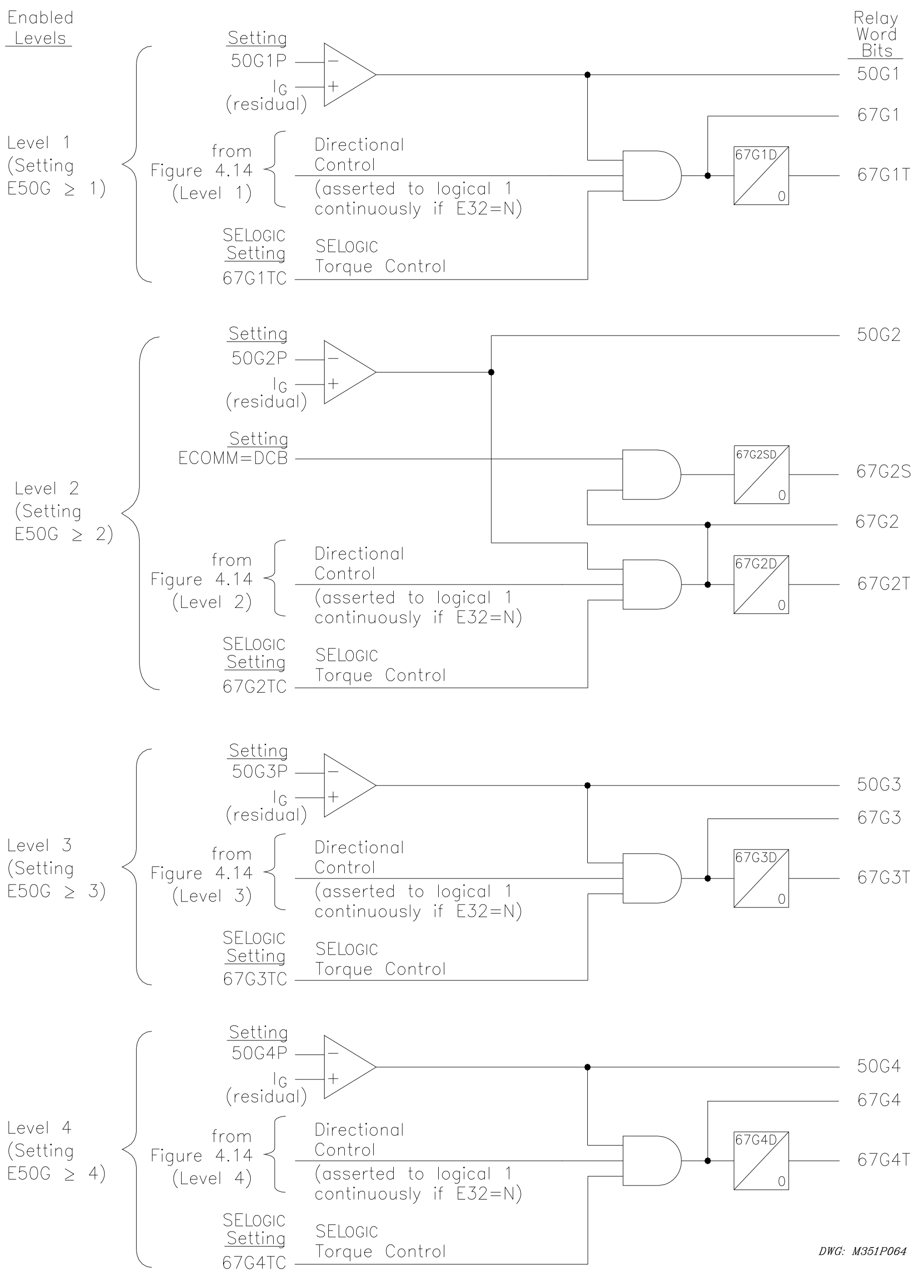


Figure 3.10: Levels 1 Through 4 Residual Ground Instantaneous/Definite-Time Overcurrent Elements (with Directional Control Option)

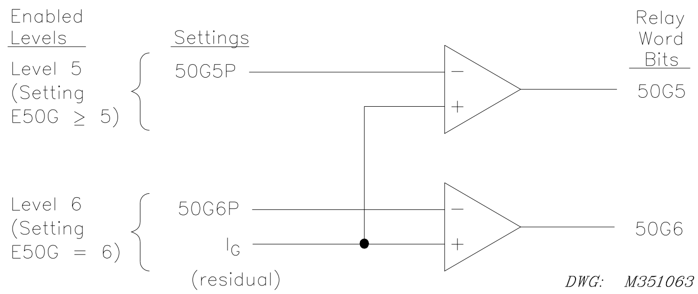


Figure 3.11: Levels 5 Through 6 Residual Ground Instantaneous Overcurrent Elements

Level 2 element 67G2S in Figure 3.10 is used in directional comparison blocking schemes (see ***Directional Comparison Blocking (DCB) Logic*** in ***Section 5: Trip and Target Logic***). 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 3.2, and Figure 3.3 in the preceding ***Phase Instantaneous/Definite-Time Overcurrent Elements*** subsection, 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 through 50G6P:

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

Setting range for definite-time settings 67G1D through 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*** in ***Section 5: Trip and Target Logic***). 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 3.2, and Figure 3.3 in the preceding ***Phase Instantaneous/Definite-Time Overcurrent Elements*** subsection, 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 phase currents and substituting like settings and Relay Word bits.

Settings Ranges

Setting range for pickup settings 50Q1P through 50Q6P:

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

Setting range for definite-time settings 67Q1D through 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.

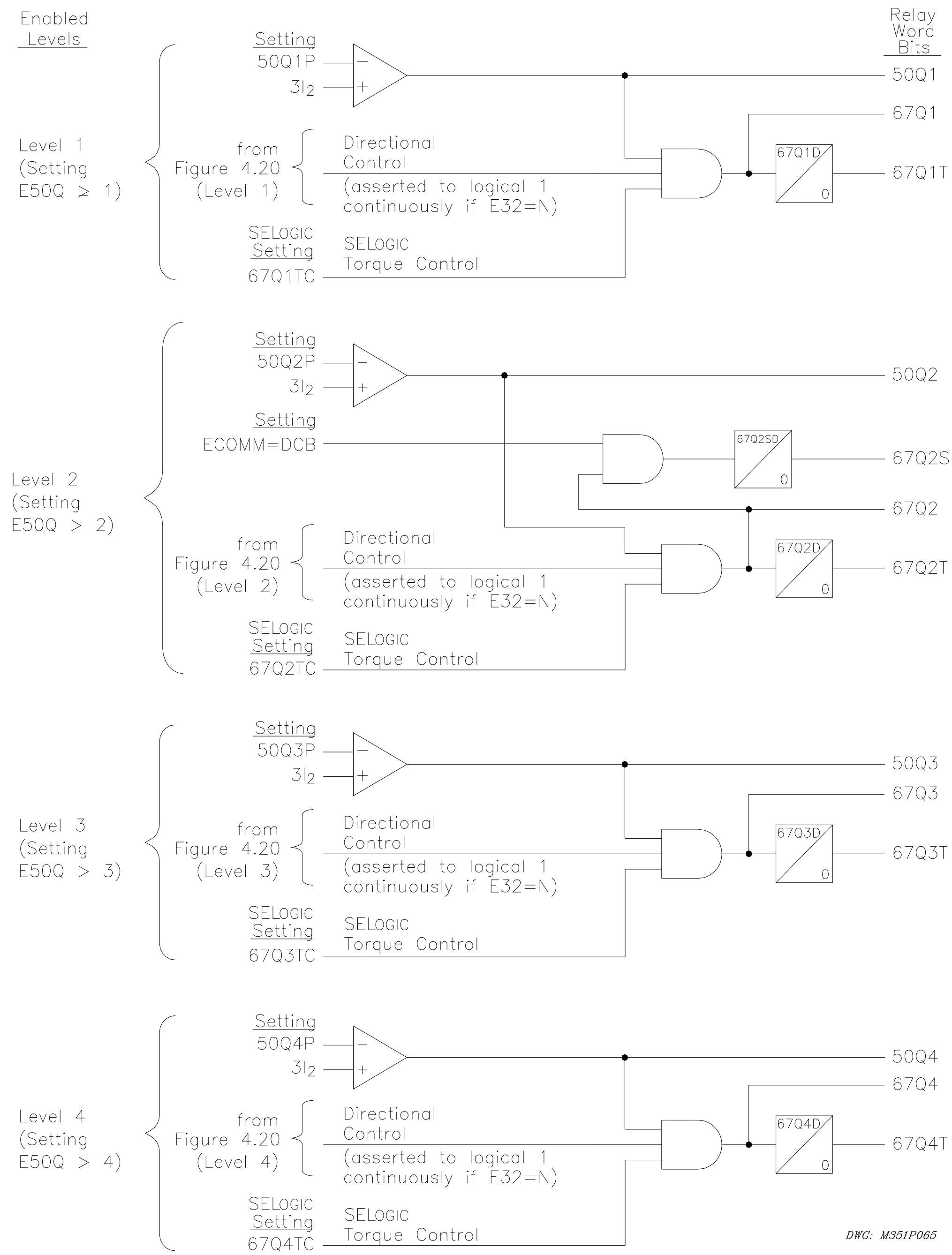


Figure 3.12: Levels 1 Through 4 Negative-Sequence Instantaneous/Definite-Time Overcurrent Elements (with Directional Control Option)

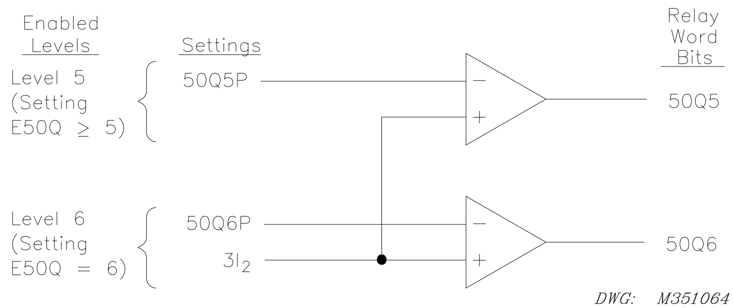


Figure 3.13: Levels 5 Through 6 Negative-Sequence Instantaneous Overcurrent Elements

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 follows:

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 following settings:

Table 3.2: Phase Time-Overcurrent Elements Settings

Setting	Definition	Range
51P1P 51P2P	pickup	0.10 - 3.20 A secondary (1 A nominal phase currents, IA, IB, IC)
51P1C 51P2C	curve type	U1–U5 (US 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 (US 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 (see Note 1)
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)—see Note 2

Note 1: The electromechanical reset setting (51P1RS) is not available when the curve selection setting (51P1C) is set to a recloser curve. In this situation, 51P1RS is effectively set to "N" internally. Similarly, setting 51P2RS is not available when setting 51P2C is set to a recloser curve.

Note 2: SELOGIC control equation torque control settings (e.g., 51P1TC) cannot be set directly to logical 0.

See ***Section 9: Setting the SEL-351P-3 Recloser Control*** for additional time-overcurrent element setting information.

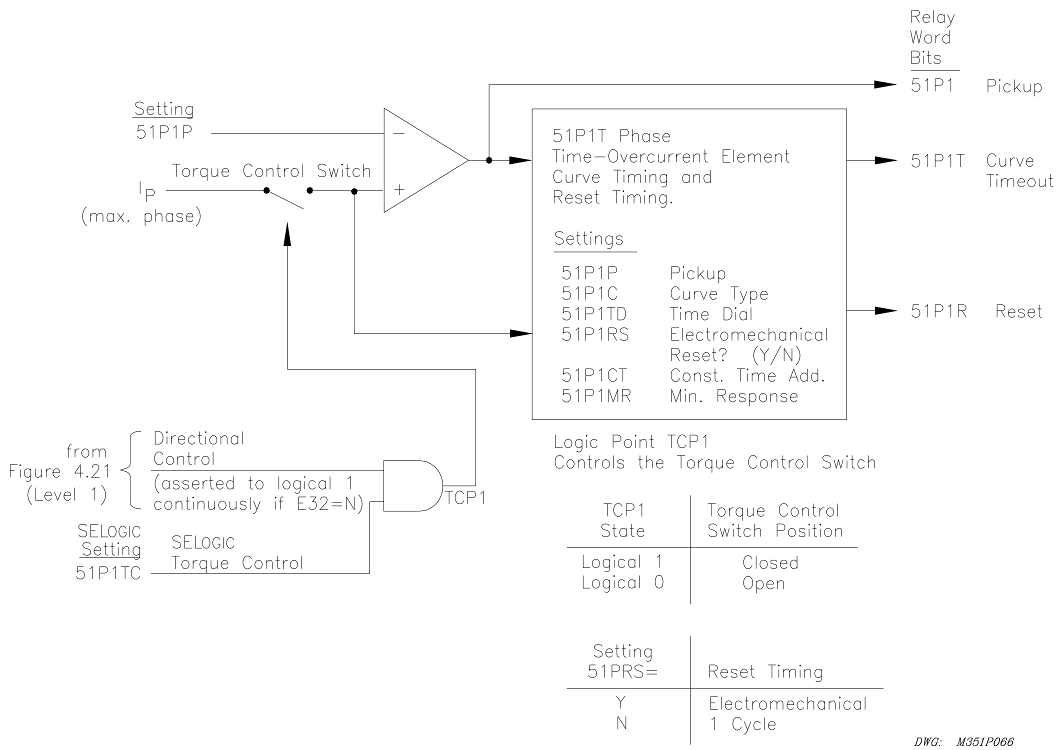


Figure 3.14: Phase Time-Overcurrent Element 51P1T (with Directional Control Option)

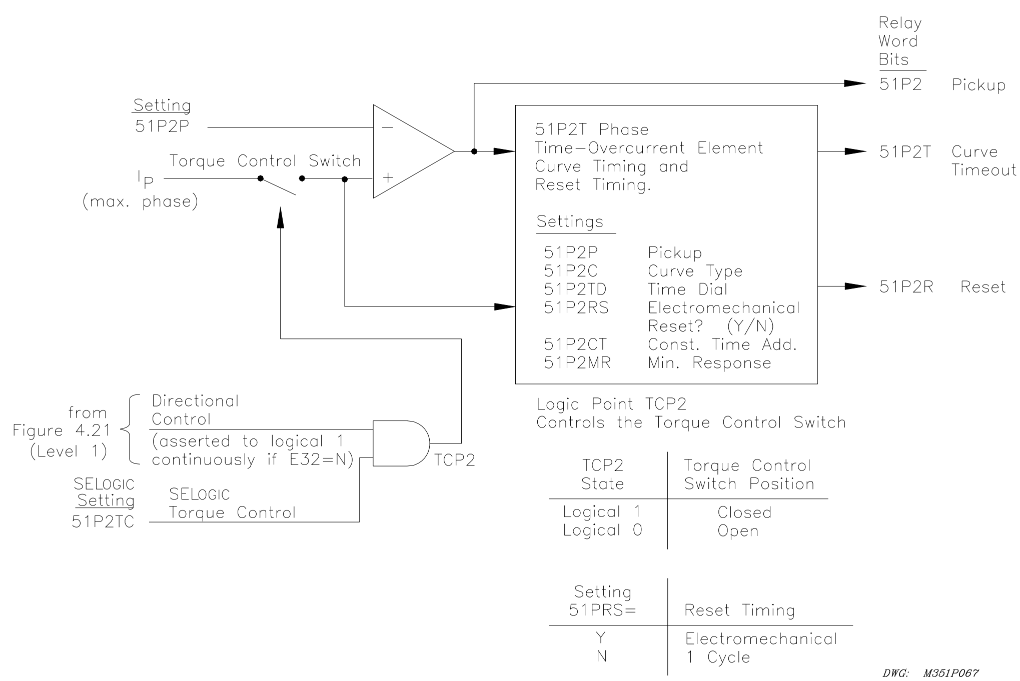


Figure 3.15: Phase Time-Overcurrent Element 51P2T (with Directional Control Option)

Accuracy

Pickup: ±0.01 A secondary and ±3% of setting (1 A nominal phase current inputs, 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 following Relay Word bits:

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*** in ***Section 5: Trip and Target Logic***.
51P1T	Phase time-overcurrent element is timed out on its curve.	Tripping and other control applications. See ***Trip Logic*** in ***Section 5: Trip and Target Logic***.
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 $I_P \leq$ 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 $I_P \leq$ pickup setting 51P1P

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

= 0 (logical 0), if $I_P \leq$ 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 in ***Section 4: Loss-of-Potential, Load Encroachment, and Directional Element Logic*** 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.

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.

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)*** in ***Section 10: Serial Port Communications and Commands*** for a list of the factory default settings.

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*** at the end of ***Section 4: Loss-of-Potential, Load Encroachment, and Directional Element Logic***.

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 1-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 1-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

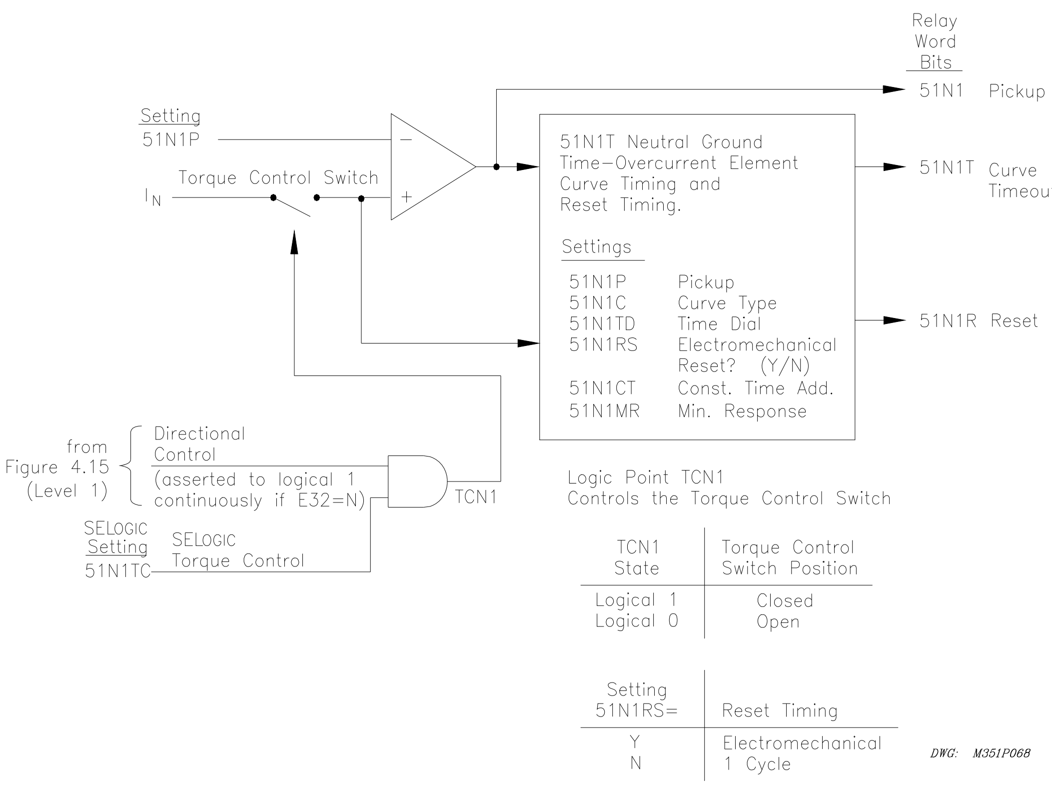


Figure 3.16: Neutral Ground Time-Overcurrent Element 51N1T (with Directional Control Option)

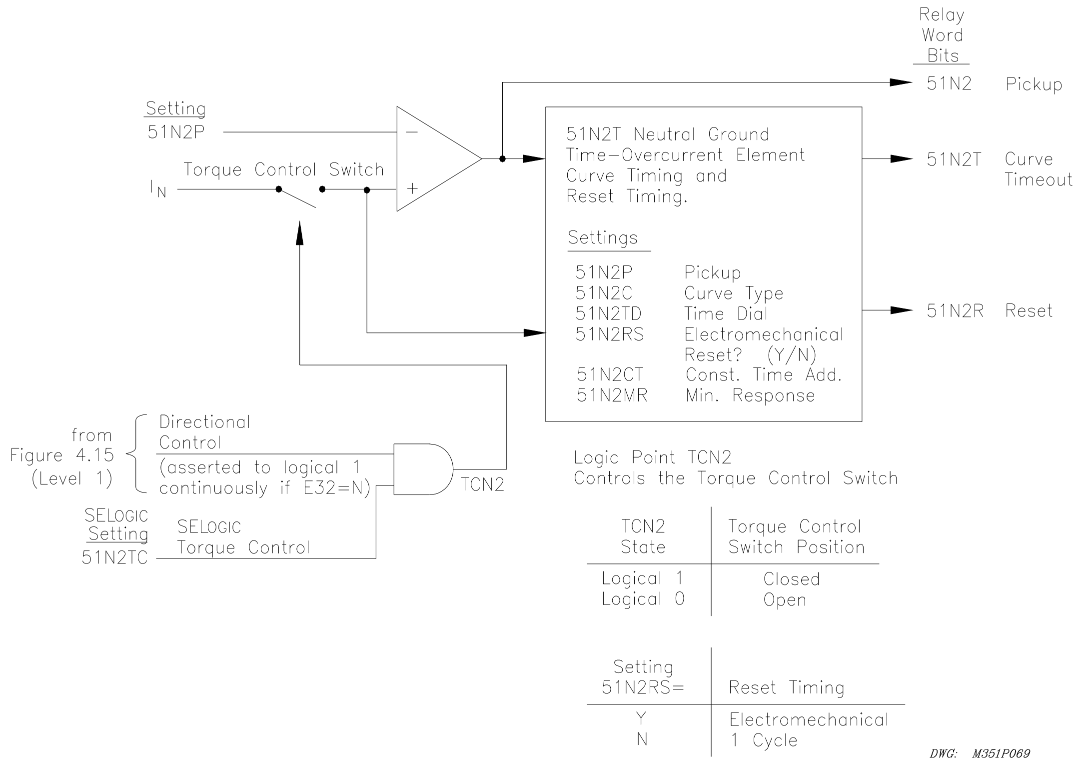


Figure 3.17: Neutral Ground Time-Overcurrent Element 51N2T (with Directional Control Option)

To understand the operation of Figure 3.16 and Figure 3.17, follow the explanation given for Figure 3.14 in the preceding ***Phase Time-Overcurrent Elements*** subsection, 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 (US 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 (US 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 (see Note 1)
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 9.3 or set directly to logical 1 (= 1) or logical 0 (= 0) —see Note 2

Note 1: The electromechanical reset setting (51N1RS) is not available when the curve selection setting (51N1C) is set to a recloser curve. In this situation, 51N1RS is effectively set to "N" internally. Similarly, setting 51N2RS is not available when setting 51N2C is set to a recloser curve.

Note 2: 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. 51N2T is similar.

See ***Section 9: Setting the SEL-351P-3 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 the preceding ***Phase Time-Overcurrent Elements*** subsection, 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.

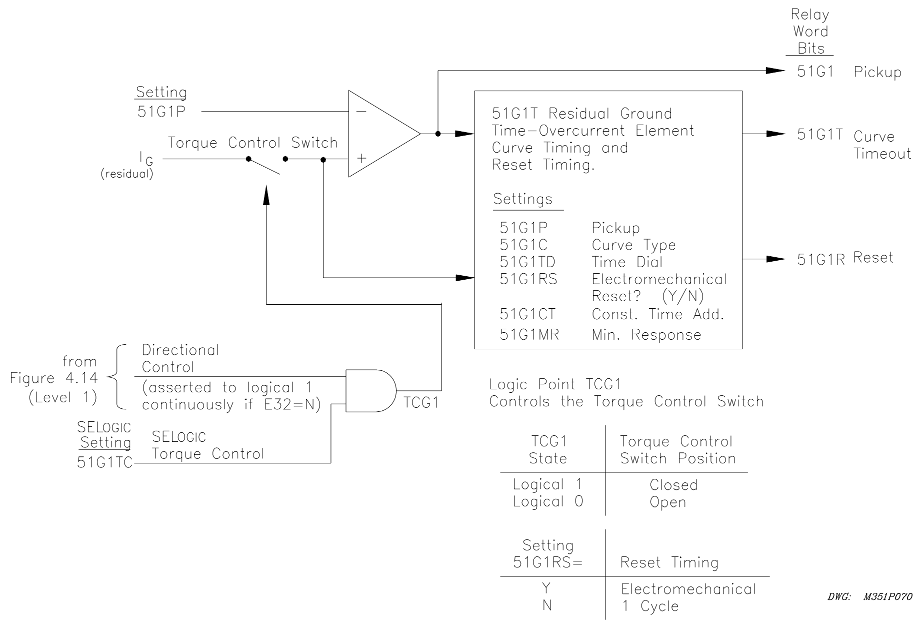


Figure 3.18: Residual Ground Time-Overcurrent Element 51G1T (with Directional Control Option)

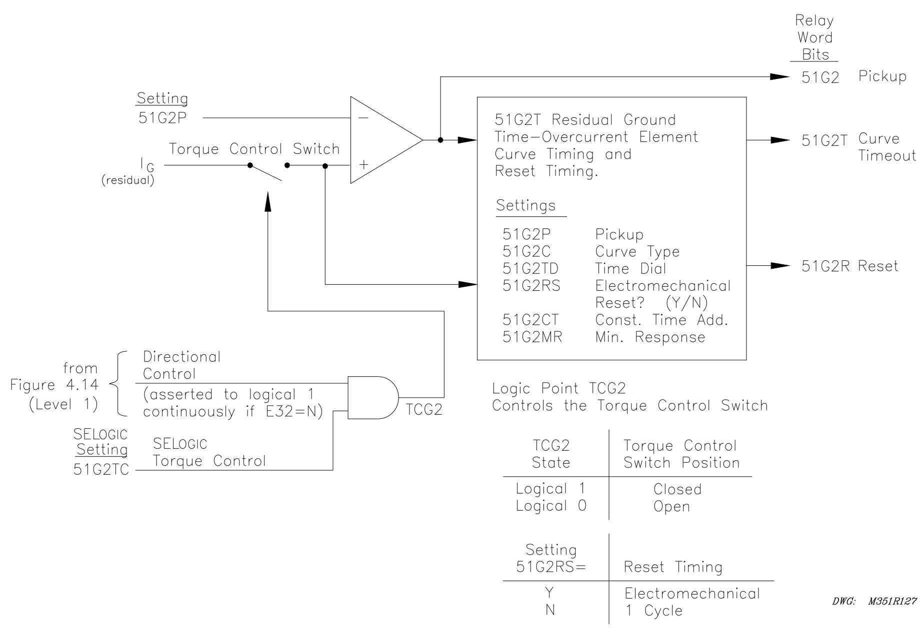


Figure 3.19: Residual Ground Time-Overcurrent Element 51G2T (with Directional Control Option)

Settings Ranges

Table 3.5: Residual Ground Time-Overcurrent Elements Settings

Setting	Definition	Range
51G1P 51G2P	pickup	0.10–3.20 A secondary (1 A nominal phase currents, IA, IB, IC)
51G1C 51G2C	curve type	U1–U5 (US curves), C1–C5 (IEC curves), recloser or user curves see Figure 9.1–Figure 9.20
51G1RS 51G2RS	electromechanical reset timing	Y, N (See Note 1)
51G1TD 51G2TD	time dial (has no multiplying effect on constant time adder or minimum response time)	0.50–15.00 (US 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 9.3 or set directly to logical 1 (= 1) or logical 0 (= 0) —see Note 2

Note 1: The electromechanical reset setting (51G1RS) is not available when the curve selection setting (51G1C) is set to a recloser curve. In this situation, 51G1RS is effectively set to "N" internally. Similarly, setting 51G2RS is not available when setting 51G2C is set to a recloser curve.

Note 2: 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. 51G2T is similar.

See ***Section 9: Setting the SEL-351P-3 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

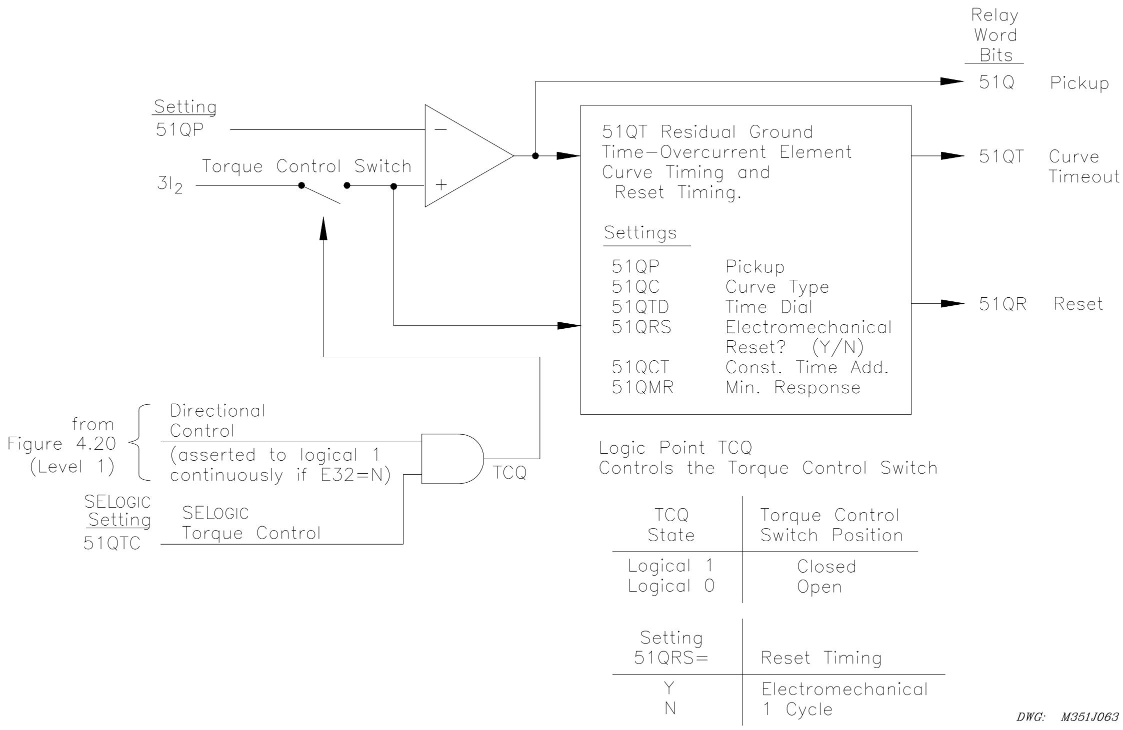


Figure 3.20: Negative-Sequence Time-Overcurrent Element 51QT (with Directional Control Option)

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

To understand the operation of Figure 3.20, follow the explanation given for Figure 3.14 in the preceding ***Phase Time-Overcurrent Elements*** subsection, 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	0.10–3.20 A secondary (1 A nominal phase currents, IA, IB, IC)
51QC	curve type	U1–U5 (US 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 (US 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 (See Note 1)
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 9.3 or set directly to logical 1 (= 1) or logical 0 (= 0) —see Note 2

Note 1: The electromechanical reset setting (51QRS) is not available when the curve selection setting (51QC) is set to a recloser curve. In this situation, 51QRS is effectively set to "N" internally.

Note 2: 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-351P-3 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.

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-351P-3 rear-panel voltage input VS*

*****Voltage V_S is used in the synchronism check elements described in the following subsection ***Synchronism Check Elements***. 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

Voltage Element (Relay Word bits)	Operating Voltage	Pickup Setting/Range	See Figure
27A1	V_A	27P1P 0.0–300.0 V secondary	Figure 3.21
27B1	V_B		
27C1	V_C		
3P27 = 27A1 * 27B1 * 27C1			
27A2	V_A	27P2P 0.0–300.0 V secondary	
27B2	V_B		
27C2	V_C		
59A1	V_A	59P1P 0.0–300.0 V secondary	
59B1	V_B		
59C1	V_C		
3P59 = 59A1 * 59B1 * 59C1			
59A2	V_A	59P2P 0.0–300.0 V secondary	
59B2	V_B		
59C2	V_C		
27AB	V_{AB}	27PP 0.0–520.0 V secondary	Figure 3.22
27BC	V_{BC}		
27CA	V_{CA}		
59AB	V_{AB}	59PP 0.0–520.0 V secondary	
59BC	V_{BC}		
59CA	V_{CA}		
59N1	$3V_0$	59N1P 0.0–300.0 V secondary	
59N2	$3V_0$	59N2P 0.0–300.0 V secondary	
59Q	V_2	59QP 0.0–100.0 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	

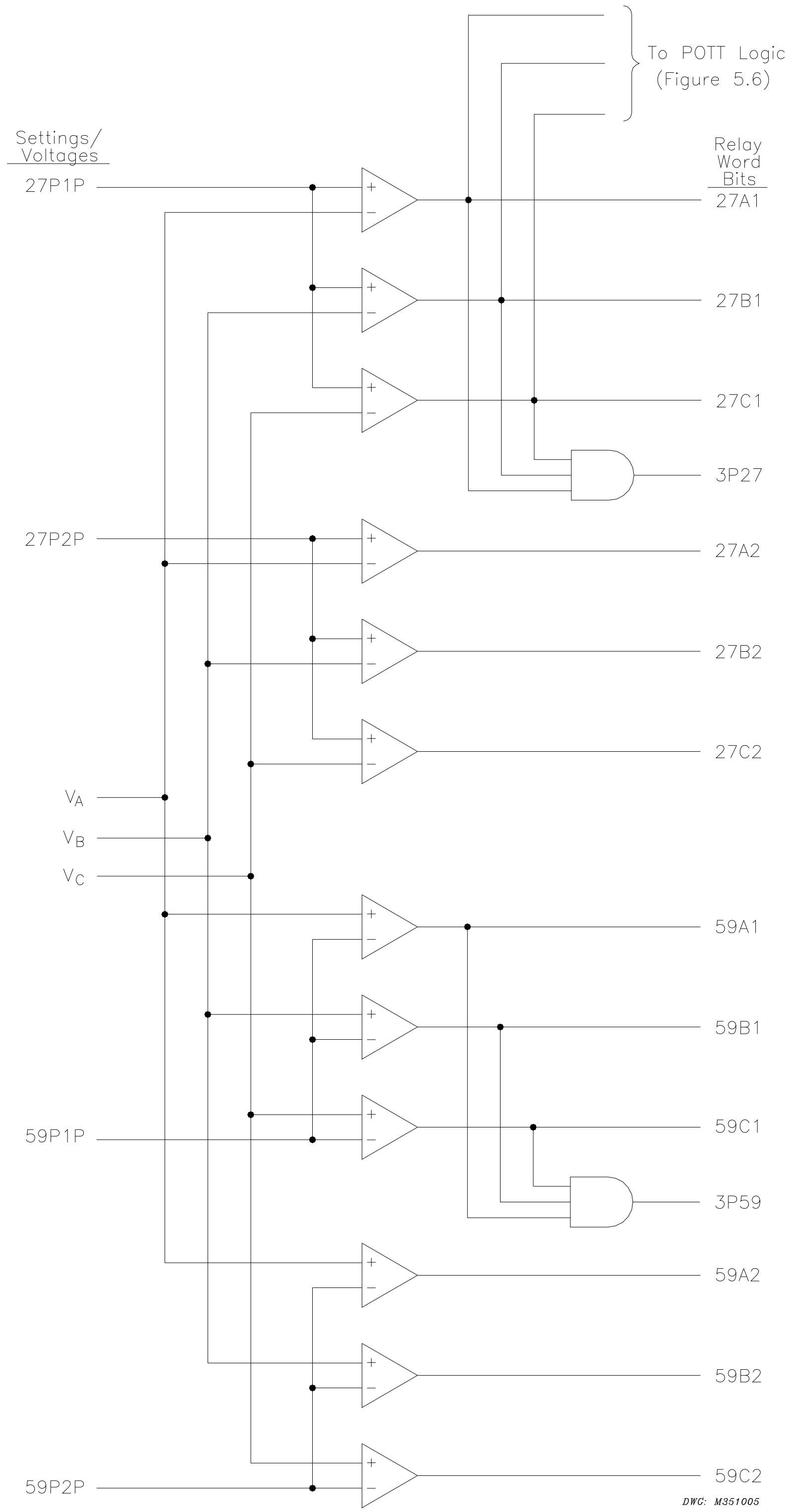


Figure 3.21: Single-Phase and Three-Phase Voltage Elements

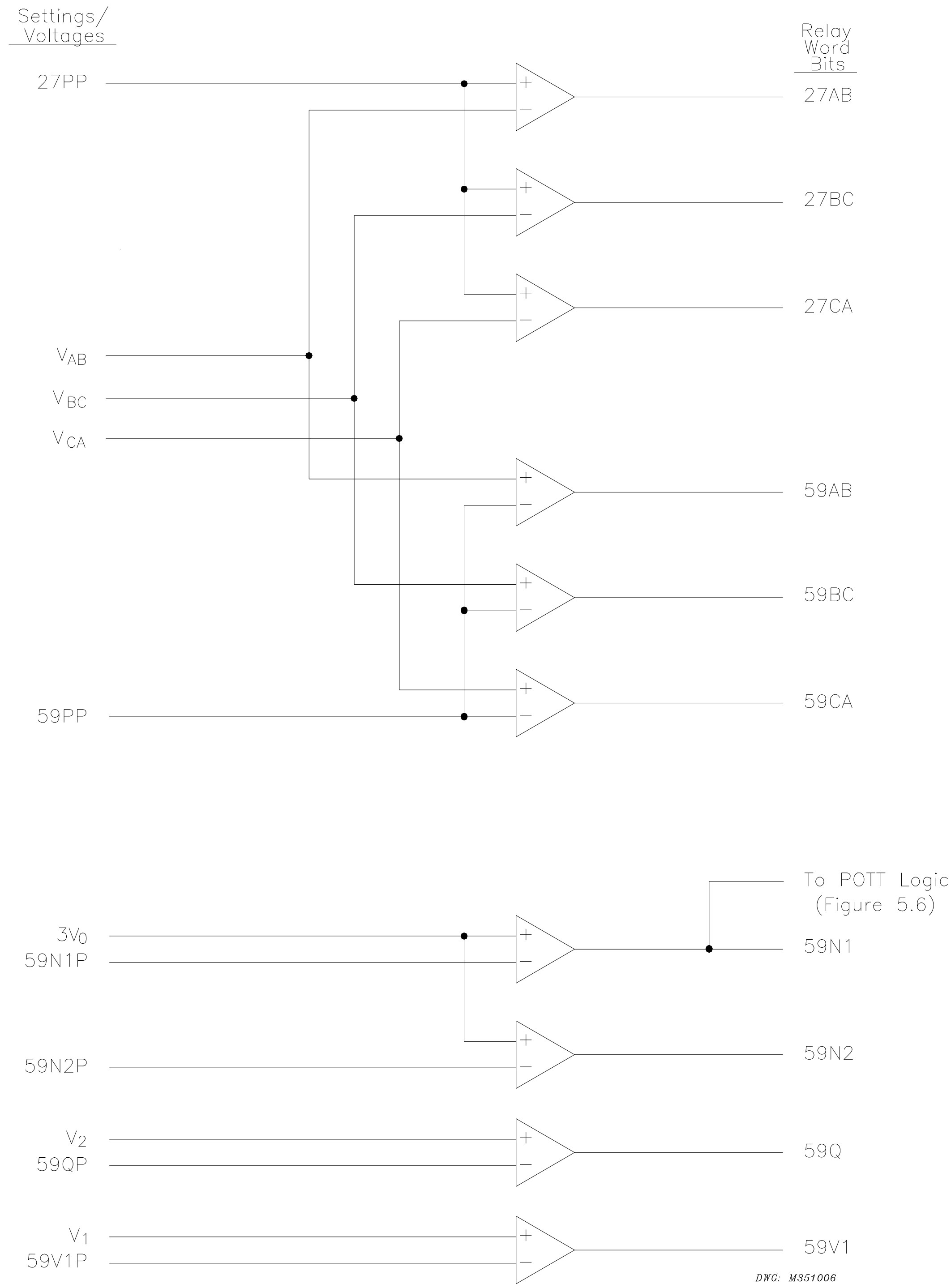


Figure 3.22: Phase-to-Phase and Sequence Voltage Elements

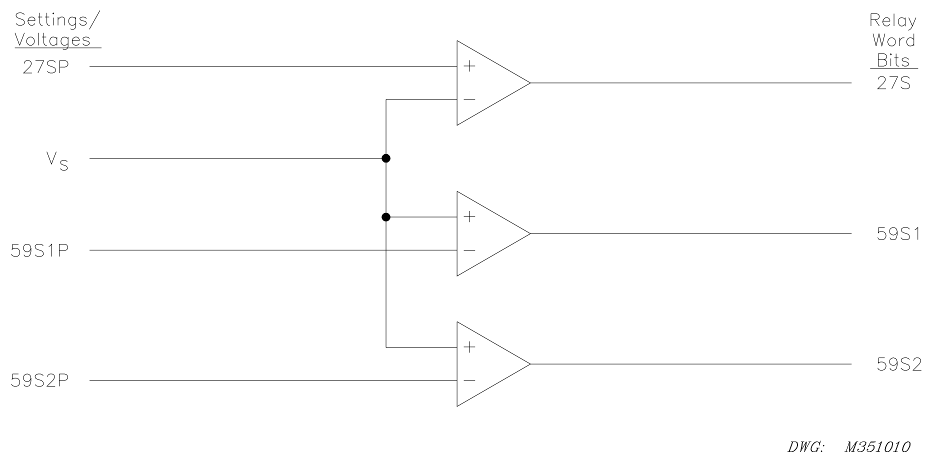


Figure 3.23: Channel VS Voltage Elements

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 VB < pickup setting 27P1P
= 0 (logical 0), if VB ≥ pickup setting 27P1P

27C1 = 1 (logical 1), if VC < pickup setting 27P1P
= 0 (logical 0), if VC ≥ 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 (VA, VB, VC) 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 3.23).

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 3.23. 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 3.23. 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-NS 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° to 80°
25ANG2	synchronism check element 25A2 maximum angle	0° to 80°
SYNCP	synchronizing phase or the number of degrees that synchronism check voltage V_S constantly lags voltage V_A	VA, VB, or VC 0° to 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 9.3

Setting SYNCP

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCP are referenced to V_A. They indicate how many degrees V_S constantly lags V_A. In any synchronism check application, voltage input VA-N always has to be connected to determine system frequency on one side of the circuit breaker (to determine the slip between V_S and V_A). V_A always has to meet the "healthy voltage" criteria (settings 25VHI and 25VLO—see Figure 3.24). Thus, for situations where V_S cannot be in phase with V_A, V_B, or V_C, it is most straightforward to have the angle setting choices (0, 30, …, 300, or 330 degrees) referenced to V_A. See the Application Guide 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.

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 relay will display the setting entered (SYNCP = VA or SYNCP = 0).

Accuracy

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

Voltage Transient Overreach: ±5% of setting

Slip Pickup: 0.003 Hz

Angle Pickup: ±4°

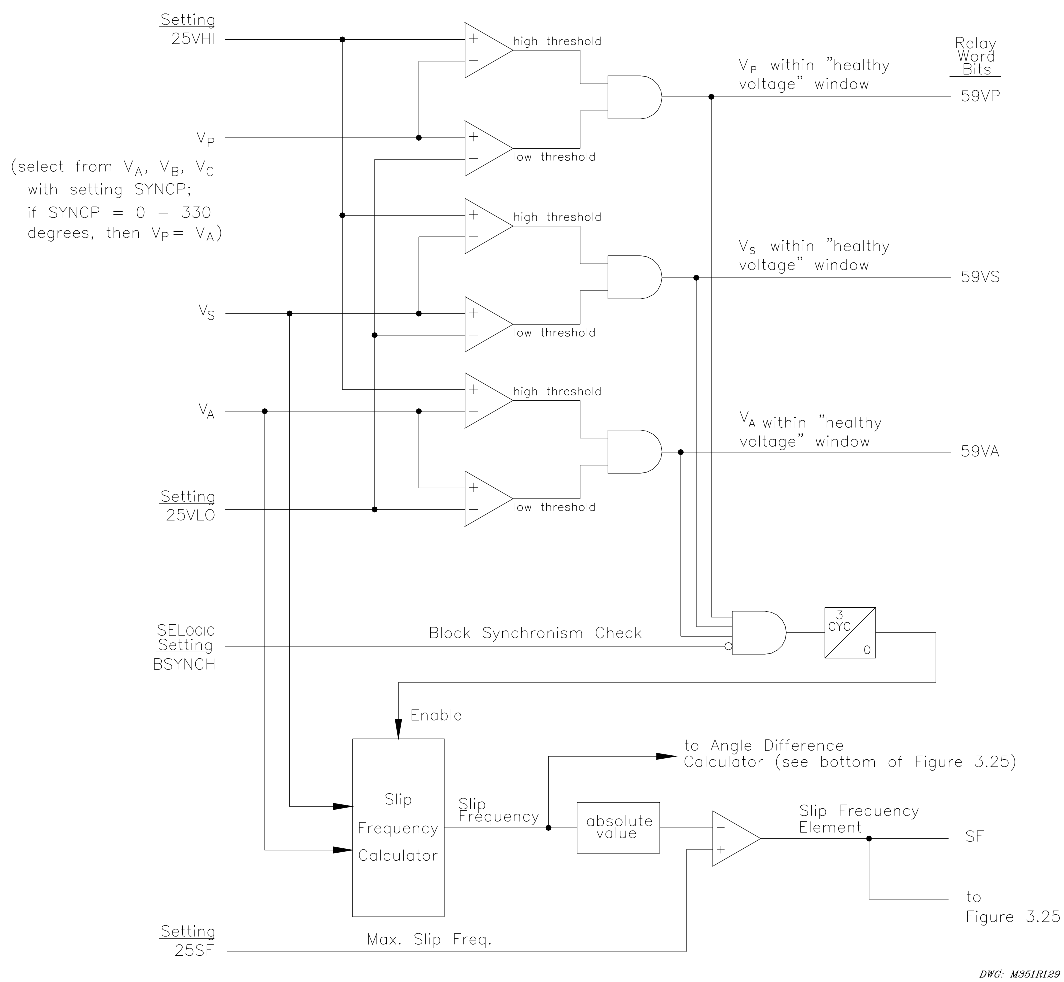


Figure 3.24: Synchronism Check Voltage Window and Slip Frequency Elements

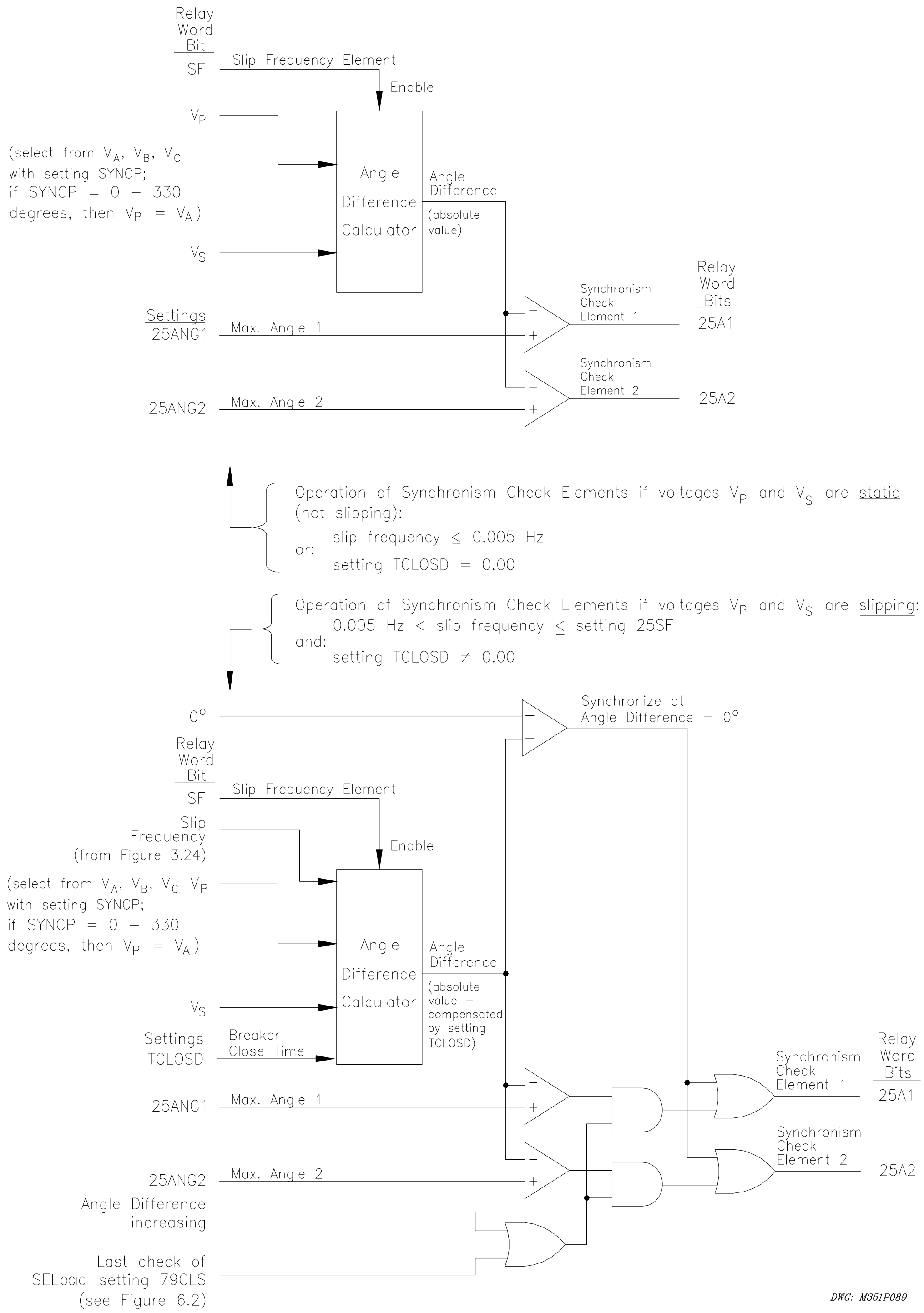


Figure 3.25: Synchronism Check Elements

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-351P-3 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.

System Frequencies Determined from Voltages V1 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, even if another voltage (e.g., voltage V_B) is to be synchronized with voltage V_S.

In most applications, all three system voltages VA, VB, and VC are connected to the three-phase power system and no additional connection concerns are needed for voltage connection V1-N. The presumption is that the frequency determined for the phase connected to V1 is also valid for B- and C-phase 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°)

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°). See the SEL Application Guide 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:

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 V1 are healthy (59VP, 59VS, and 59VA asserted to logical 1) <u>and</u> 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 relay 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 V_A are healthy (59VP, 59VS, and 59VA asserted to logical 1) <u>and</u> 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 (in units of Hz = cycles/second)
(determined from input V1)

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

A complete slip cycle is one single 360° 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°.

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).

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:

$$\text{Angle Difference} = \left|(\angle V_P - \angle V_S)\right|$$

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:

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

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.

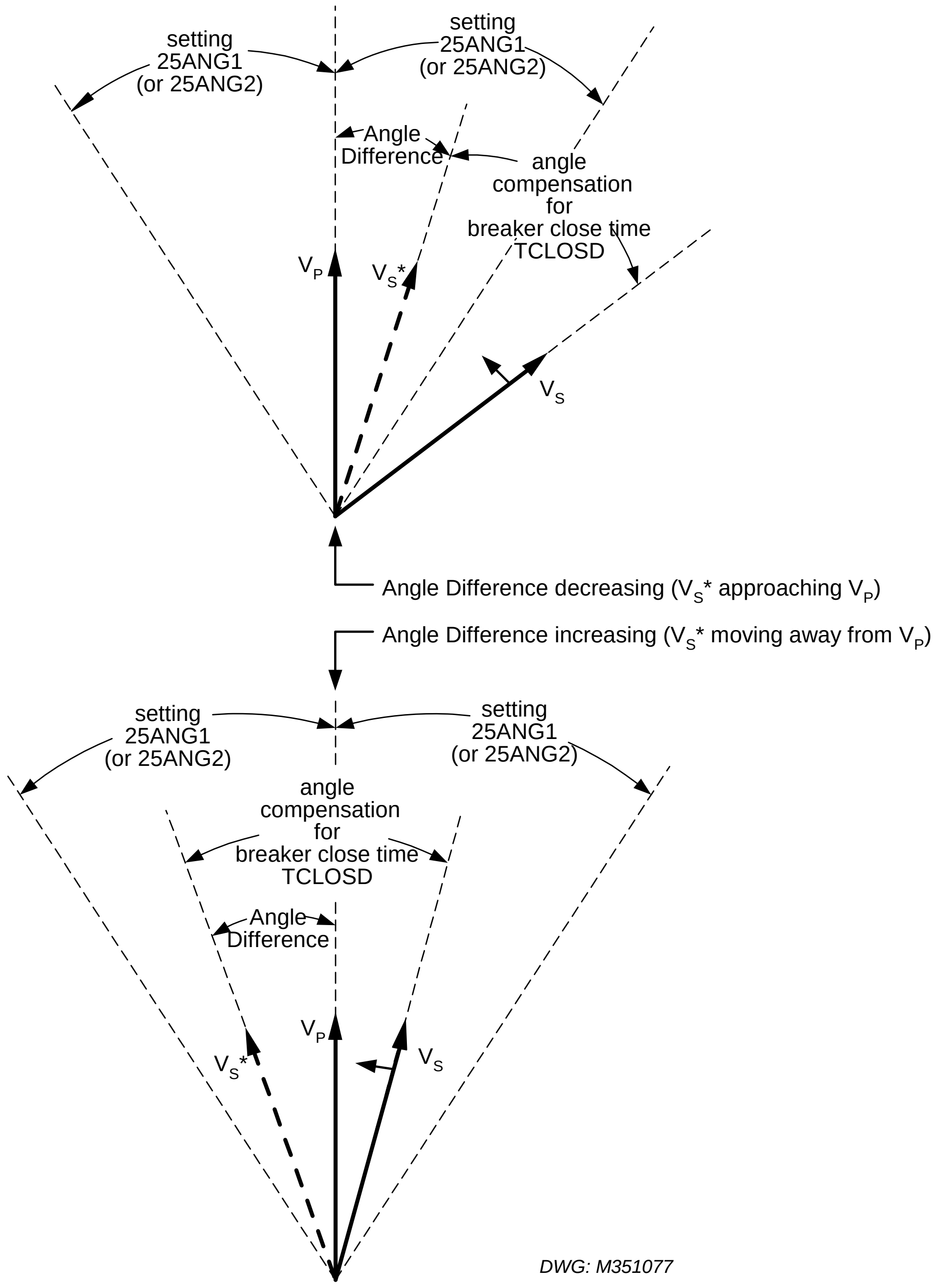


Figure 3.26: Angle Difference Between V_P and V_S Compensated by Breaker Close Time ($f_P < f_S$; V_P shown as reference in this example)

If the slip frequency is greater than 0.005 Hz and breaker close time setting TCLOSD ≠ 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:

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

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:

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

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:

$$\begin{aligned}\text{Angle Difference} &= \left|(\angle V_P - \angle V_S) + [(f_P - f_S) \cdot \text{TCLOSD} \cdot (1\ \text{second}/60\ \text{cycles}) \cdot (360°/\text{slip cycle})]\right| \\ &= \left|(\angle V_P - \angle V_S) + [-0.10 \cdot 0.167 \cdot 360°]\right| \\ &= \left|(\angle V_P - \angle V_S) - 6°\right|\end{aligned}$$

During the breaker close time (TCLOSD), the voltage angle difference between voltages V_P and V_S changes by 6°. This 6° angle compensation is applied to voltage V_S, resulting in derived voltage V_S^*, as shown in Figure 3.26 (**Note**: The angle compensation in Figure 3.26 appears much greater than 6°. Figure 3.26 is for general illustrative purposes only).

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" <u>and</u> Setting TCLOSD ≠ 0

Refer to bottom of Figure 3.25. If V_P and V_S are "slipping" with respect to one another <u>and</u> breaker close time setting TCLOSD ≠ 0, 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 <u>decreasing</u>—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 <u>increasing</u>—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 <u>increasing</u>, 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 <u>less restrictive</u>. 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*** in ***Section 6: Close and Reclose Logic***.

   Refer to the bottom of Figure 6.2 in ***Section 6: Close and Reclose Logic***. 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 in ***Section 6: Close and Reclose Logic***. 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 in ***Section 6: Close and Reclose Logic***. Element 25A2 operates similarly.

Synchronism Check Applications for Automatic Reclosing and Manual Closing

Refer to ***Close Logic*** and ***Reclose Supervision Logic*** in ***Section 6: Close and Reclose Logic***.

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°) than for an automatic reclose (15°).

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 through 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 in ***Section 1: Factory-Set Logic*** in this manual and the Underfrequency loadshedding setting in Table 8 and subsection ***Settings Descriptions*** in the ***Settings*** section in the ***SEL-351P-3 Quick-Start Installation and User's Guide***).

For various connections, Figure 1.31 through Figure 1.34 and associated text in subsection ***Reclose Supervision Logic*** in ***Section 1: Factory-Set Logic*** discuss possible changes necessary to the factory default undervoltage block setting 27B81P (see Figure 3.27 and Table 3.10).

Frequency Element Settings

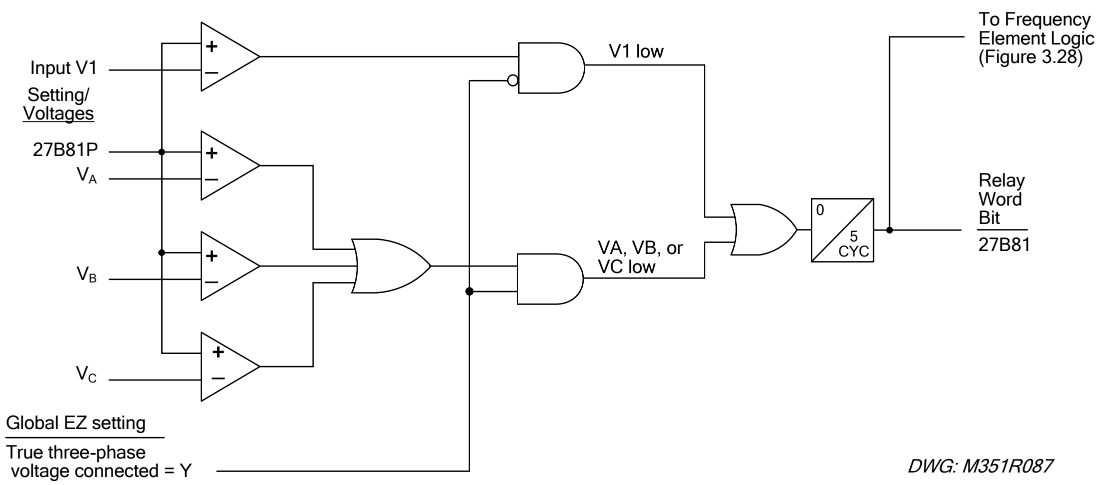


Figure 3.27: Undervoltage Block for Frequency Elements

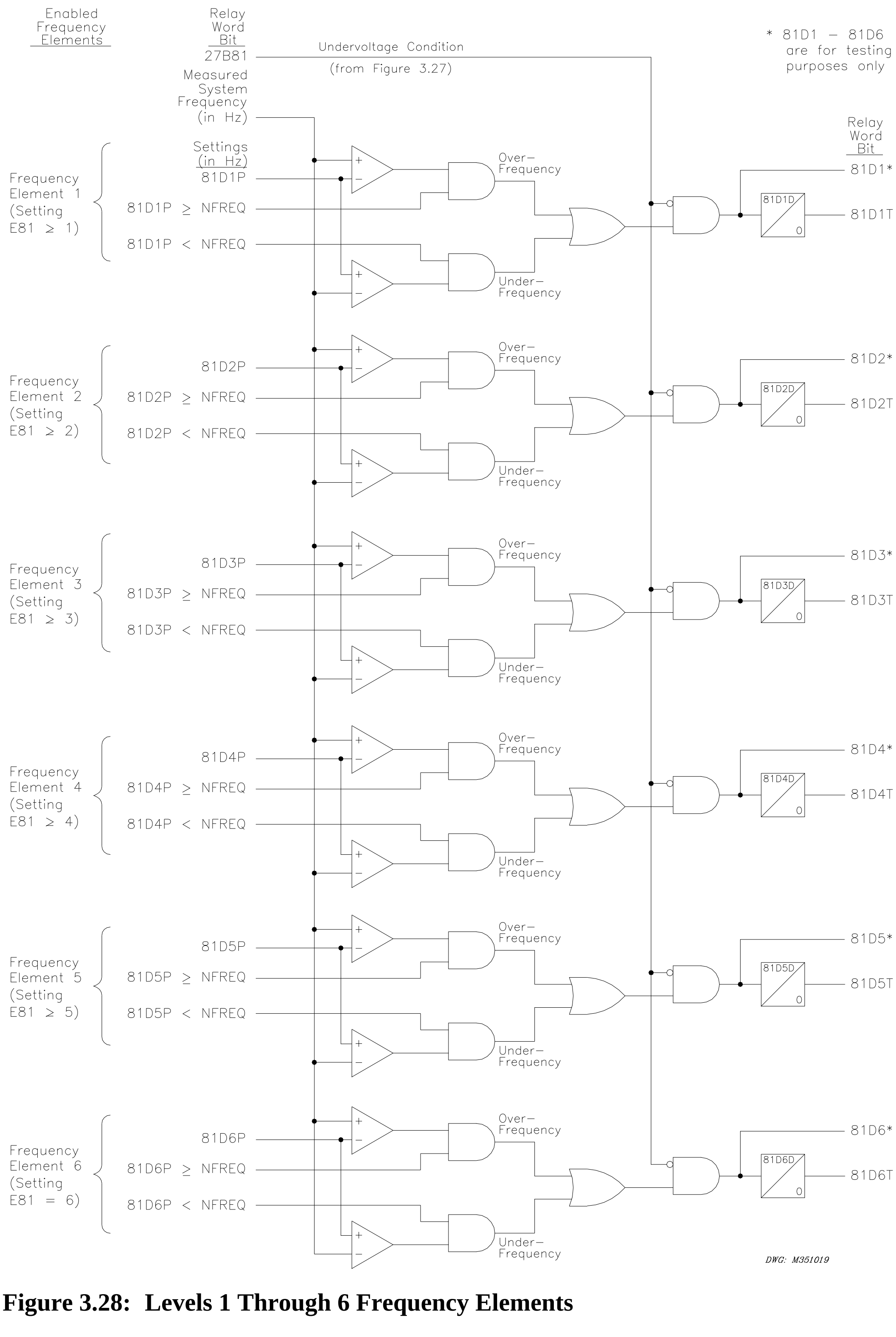


Figure 3.28: Levels 1 Through 6 Frequency Elements

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 through 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 V_A 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 through 81D6T) do not have to be used.

Frequency Element Uses

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

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

TABLE OF CONTENTS

SECTION 4: LOSS-OF-POTENTIAL, LOAD ENCROACHMENT, AND DIRECTIONAL ELEMENT LOGIC 4-1

TABLES

FIGURES

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.

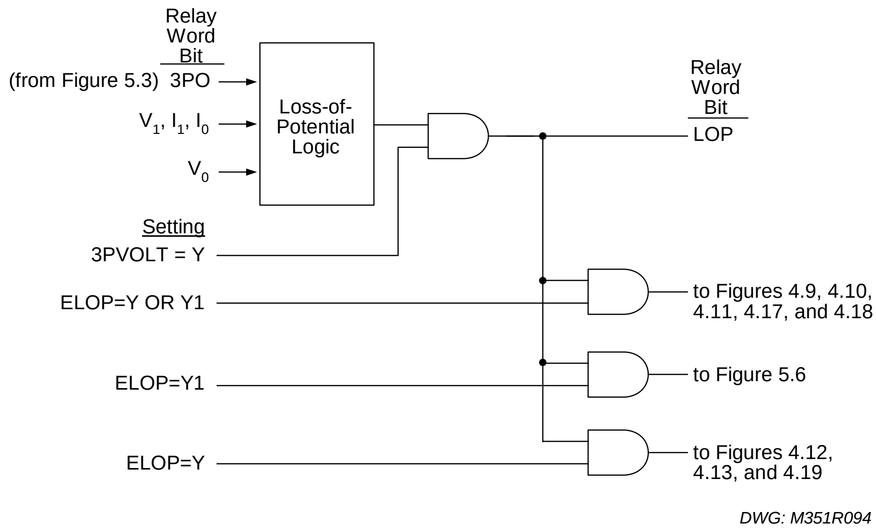


Figure 4.1: Loss-of-Potential Logic

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-351P-3.

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 the following Setting ELOP = Y discussion).

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.

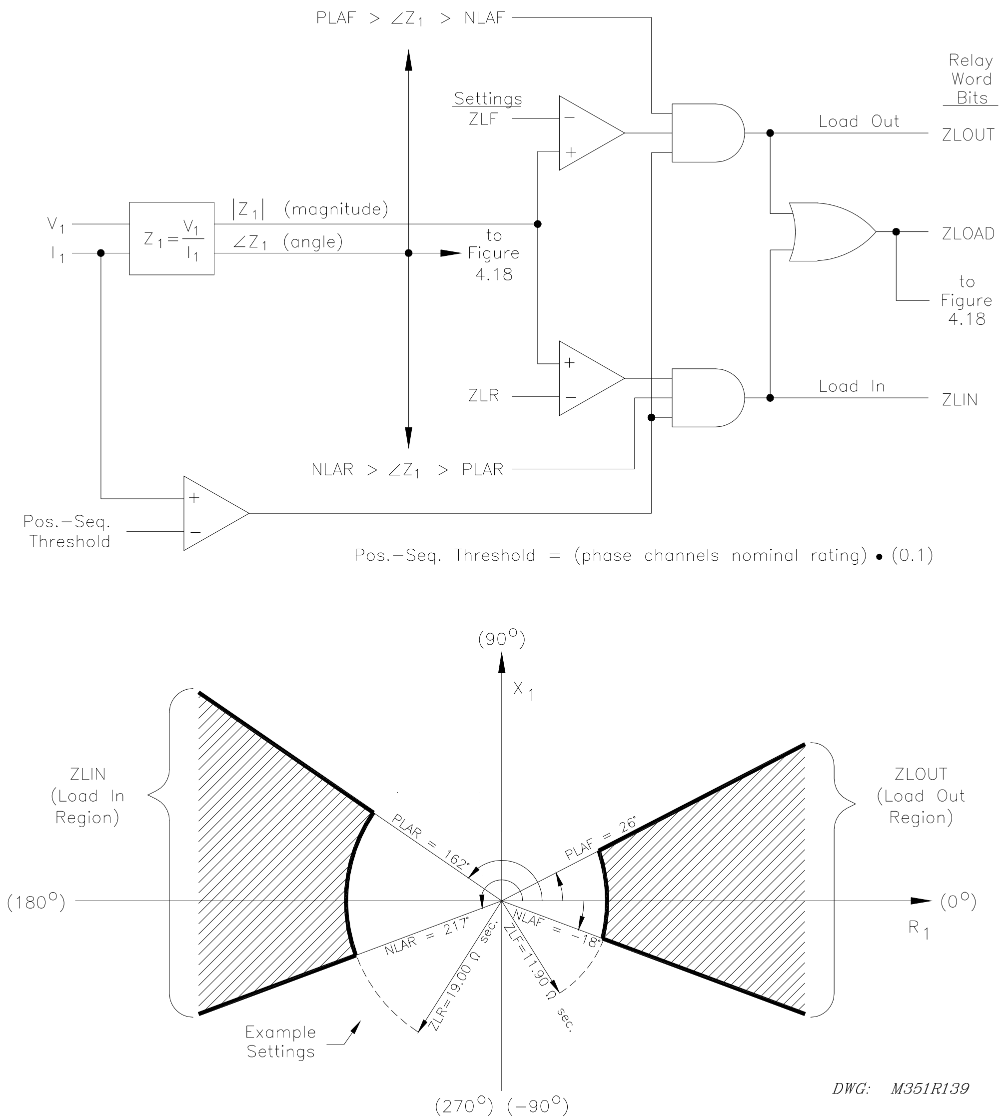


Figure 4.2: Load-Encroachment Logic

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 current inputs, 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:

Nominal Line-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 MVA • (1/3) = 267 MVA per phase
230 kV • (1/√3) = 132.8 kV line-to-neutral

267 MVA • (1/132.8 kV) • (1000 kV/MV) = 2010 A primary
2010 A primary • (1/CT ratio) = 2010 A primary • (1 A seconday/400 A primary)
= 5.03 A secondary

132.8 kV • (1000 V/kV) = 132800 V primary
132800 V primary • (1/PT ratio) = 132800 V primary • (1 V secondary/2000 V primary)
= 66.4 V secondary

Now, calculate the equivalent secondary impedance:

66.4 V secondary/5.03 A secondary = 13.2 Ω secondary

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

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

Again, for the maximum forward load:

$[(230)^2 \bullet (400)]/[(800) \bullet (2000)] = 13.2\ \Omega$ secondary

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

ZLF = 13.2 Ω secondary • 0.9 = 11.90 Ω secondary

For the maximum reverse load:

$[(230)^2 \bullet (400)]/[(500) \bullet (2000)] = 21.1\ \Omega$ secondary

Again, to provide a margin for setting ZLR:

ZLR = 21.1 Ω secondary • 0.9 = 19.00 Ω 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 = $180° – \cos^{-1}(0.80) = 180° – 18° = 162°$
Setting NLAR = $180° + \cos^{-1}(0.95) = 180° + 37° = 217°$

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 <u>within</u> the ZLOUT area, resulting in:

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

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

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

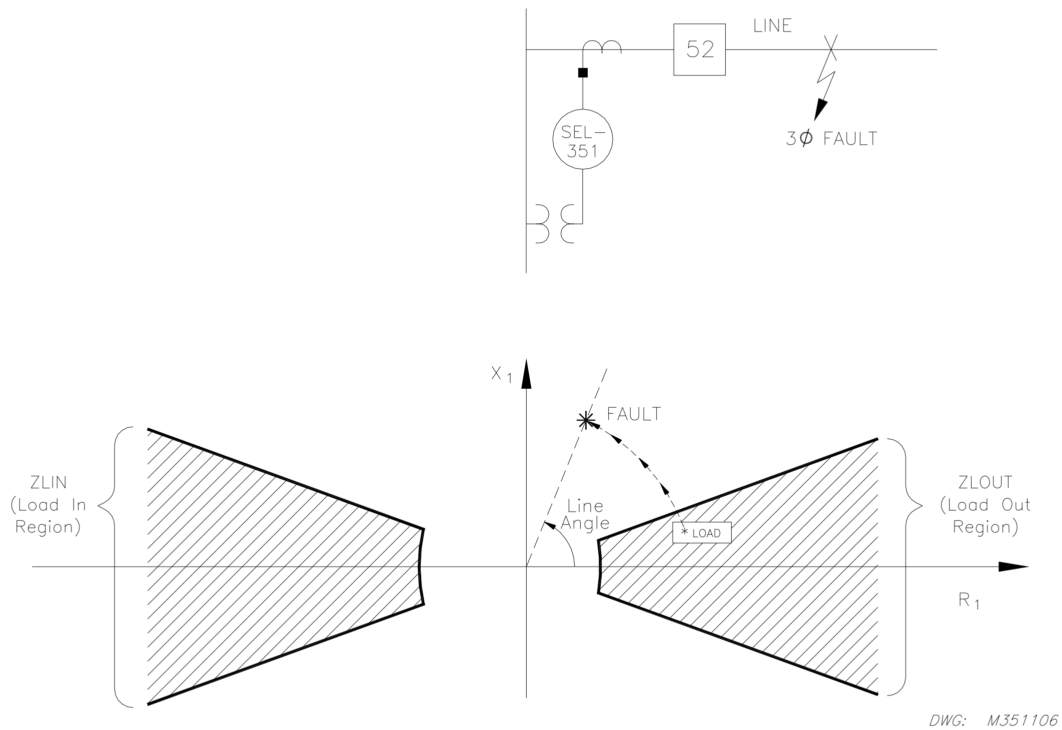


Figure 4.3: Migration of Apparent Positive-Sequence Impedance for a Fault Condition

Refer to Figure 3.14 in ***Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements***. 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-351P-3 Recloser Control

The load-encroachment logic and settings in the SEL-351P-3 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-351P-3. Note that ***Application Guide AG93-10*** discusses applying the load-encroachment feature to phase distance elements in the SEL-321 Relay. Although the SEL-351P-3 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 the following subsection ***Directional Control Settings***.

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)

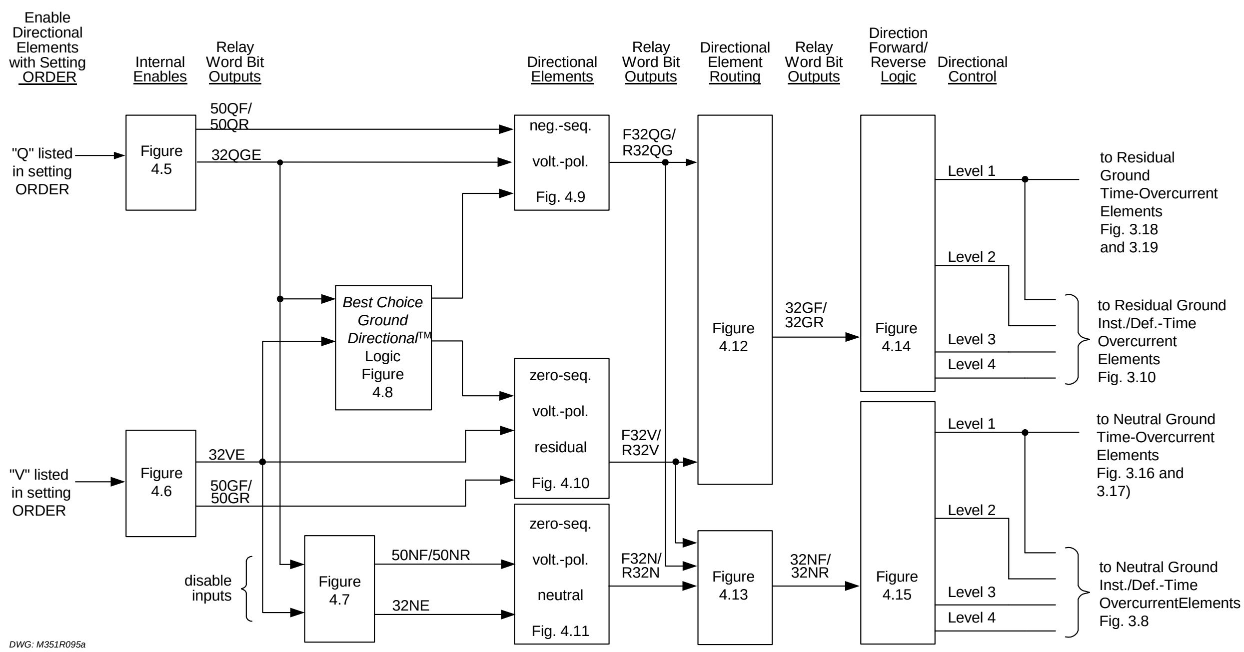


Figure 4.4: General Logic Flow of Directional Control for Neutral Ground and Residual Ground Overcurrent Elements

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*™ logic control. See discussion on setting ORDER in the following subsection ***Directional Control Settings***.

Internal Enables

Refer to Figure 4.4, Figure 4.5, Figure 4.6, and 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 the following subsection ***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™ 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* 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, Figure 4.9, Figure 4.10, and Figure 4.11.

The enable output of *Best Choice Ground Directional* logic in Figure 4.8, and the internal enables in Figure 4.5, Figure 4.6, and 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 4.10, and 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 4.10, and 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 through DIR4.

Table 4.1 shows the overcurrent elements that are controlled by each level direction setting. Note in Table 4.1 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 following subsection ***Directional Control Settings*** for discussion of the operation of level direction settings DIR1 through DIR4 when the directional control enable setting E32 is set to E32 = N.

In some applications, level direction settings DIR1 through DIR4 are not flexible enough in assigning the desired direction for certain overcurrent elements. Subsection ***Directional Control Provided by Torque Control Settings*** at the end of this section describes how to avoid this limitation for special cases.

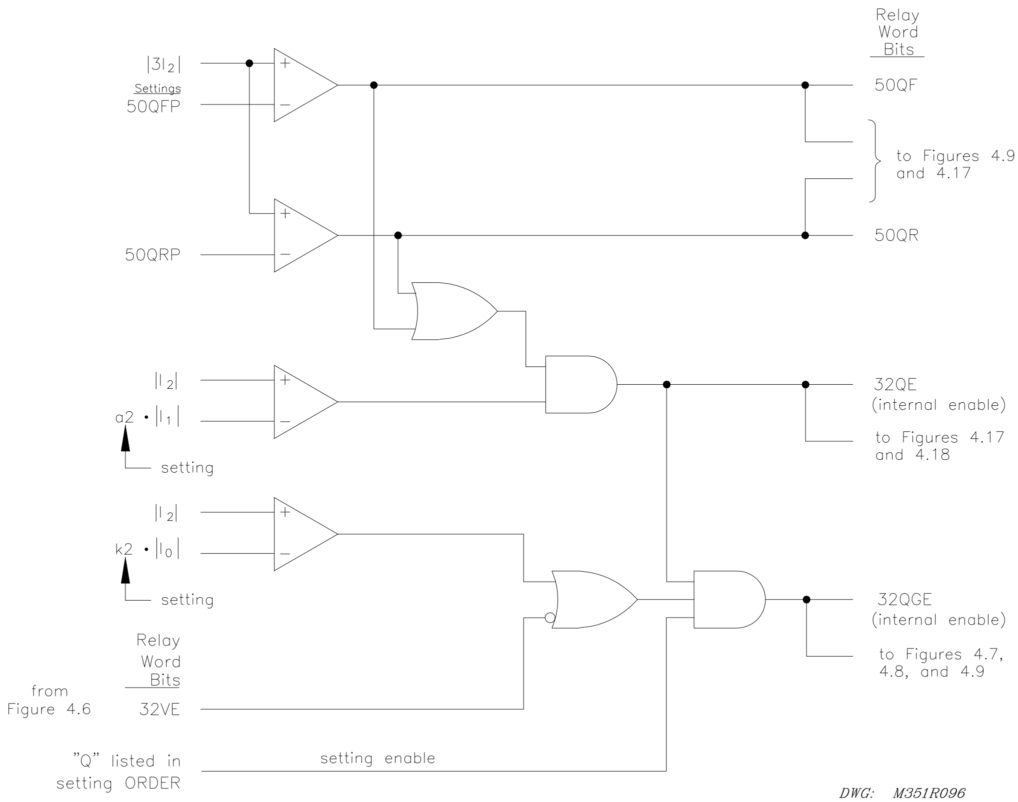


Figure 4.5: Internal Enables (32QE and 32QGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements

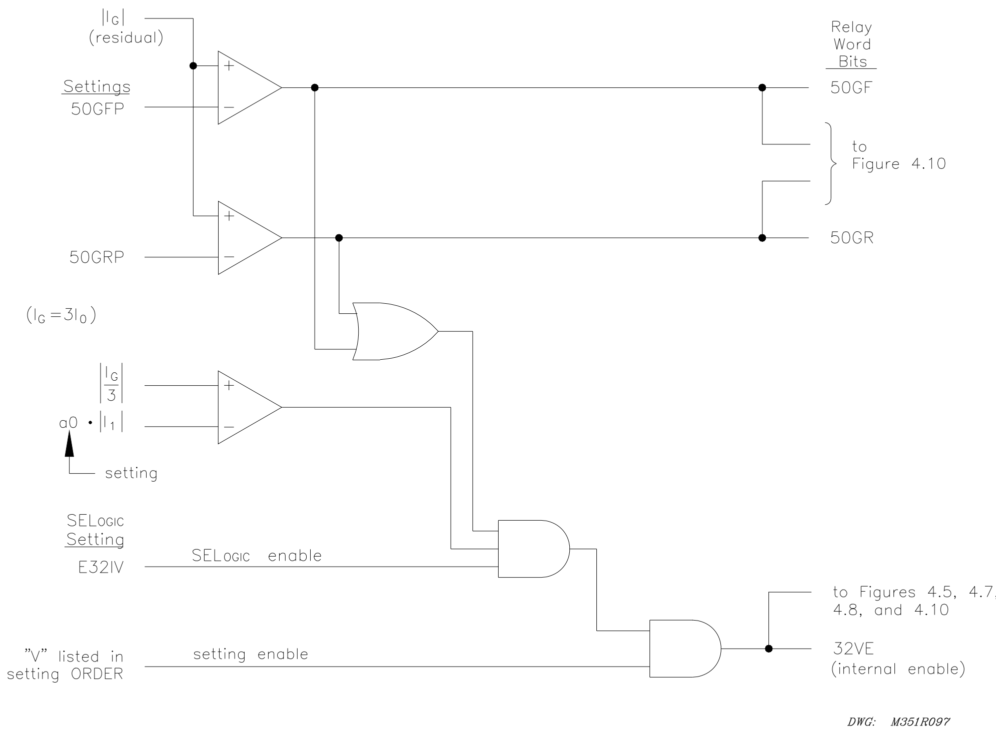


Figure 4.6: Internal Enable (32VE) Logic for Zero-Sequence Voltage-Polarized, Residual-Current Directional Element

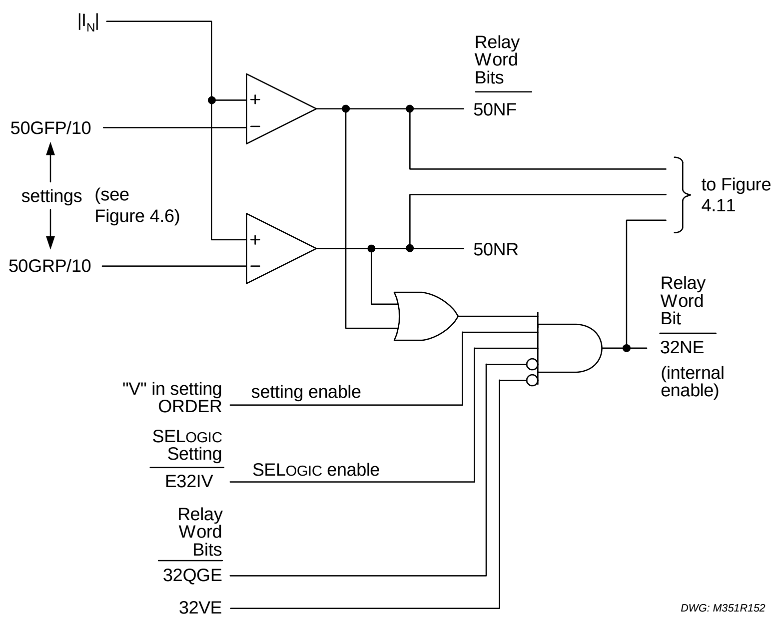


Figure 4.7: Internal Enable (32NE) for Zero-Sequence Voltage-Polarized, Neutral-Current Directional Element

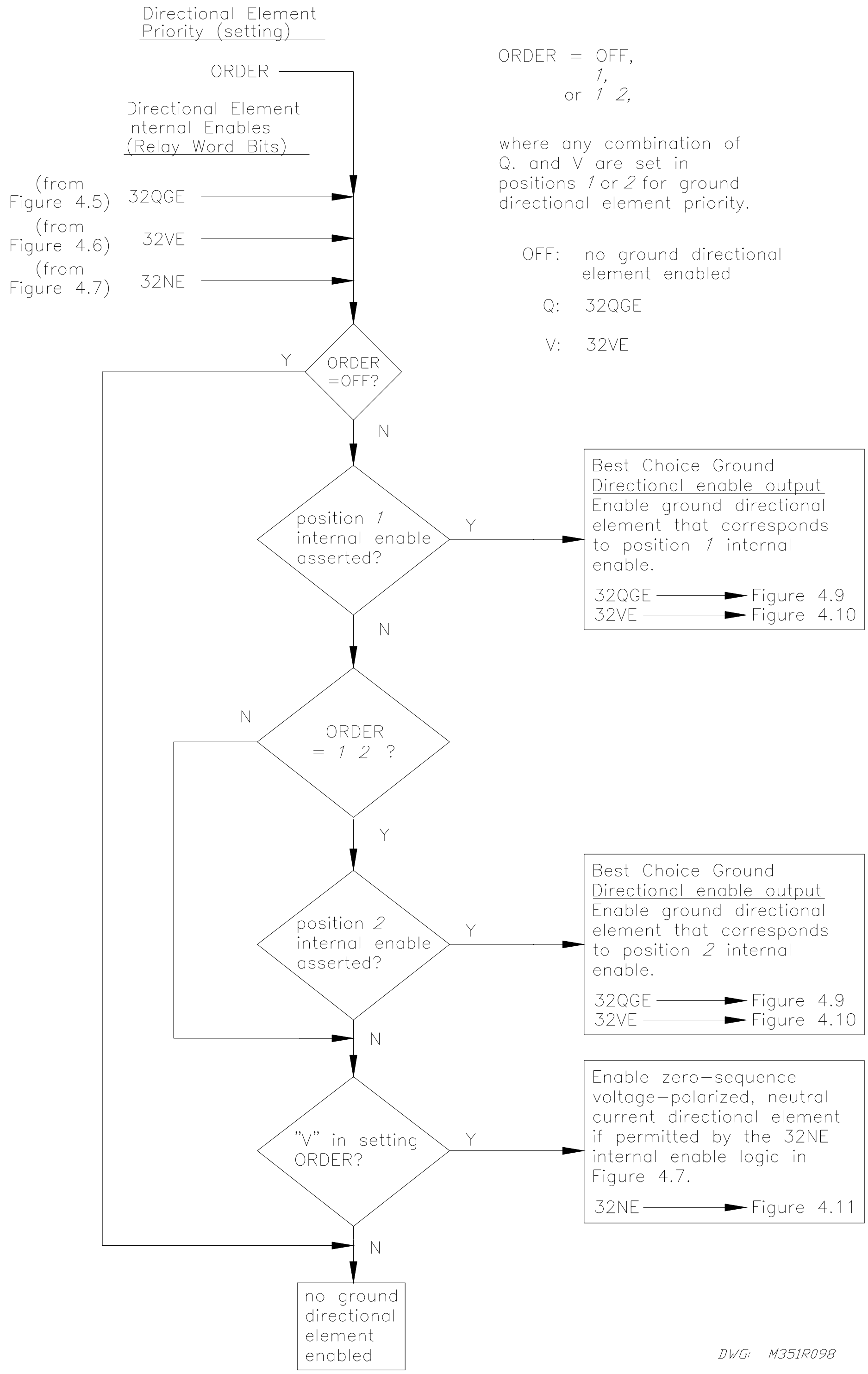
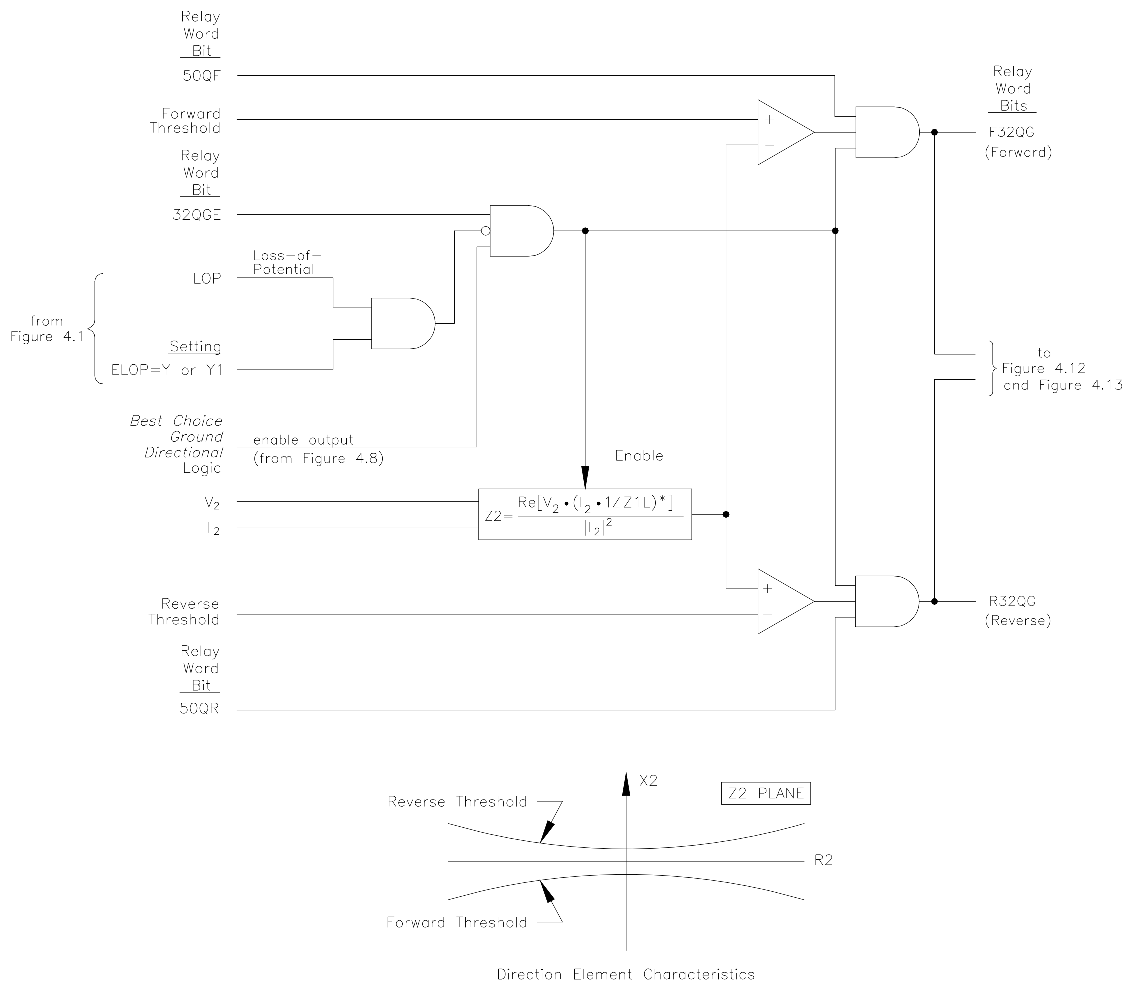


Figure 4.8: ***Best Choice Ground Directional*** **Logic**



Forward Threshold:

If Z2F Setting $\leq$ 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:

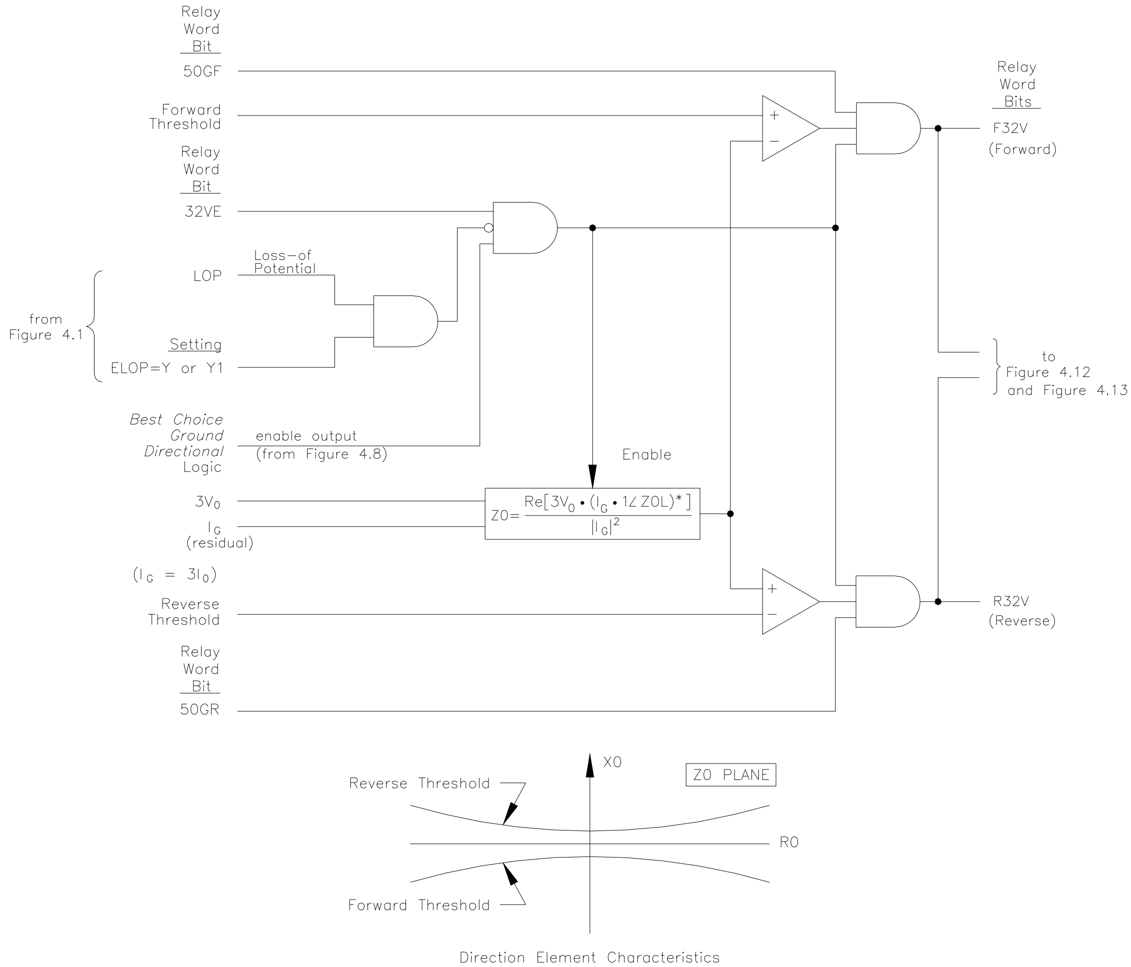
If Z2R Setting $\geq$ 0, Reverse Threshold $= 0.75 \cdot Z2R + 0.25 \cdot \left| \frac{V_2}{I_2} \right|$

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

Note: $1\angle Z1L$ = One OHM At The Positive-Sequence Line Angle

DWG: M351R153

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



Forward Threshold:

If Z0F Setting $\leq$ 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:

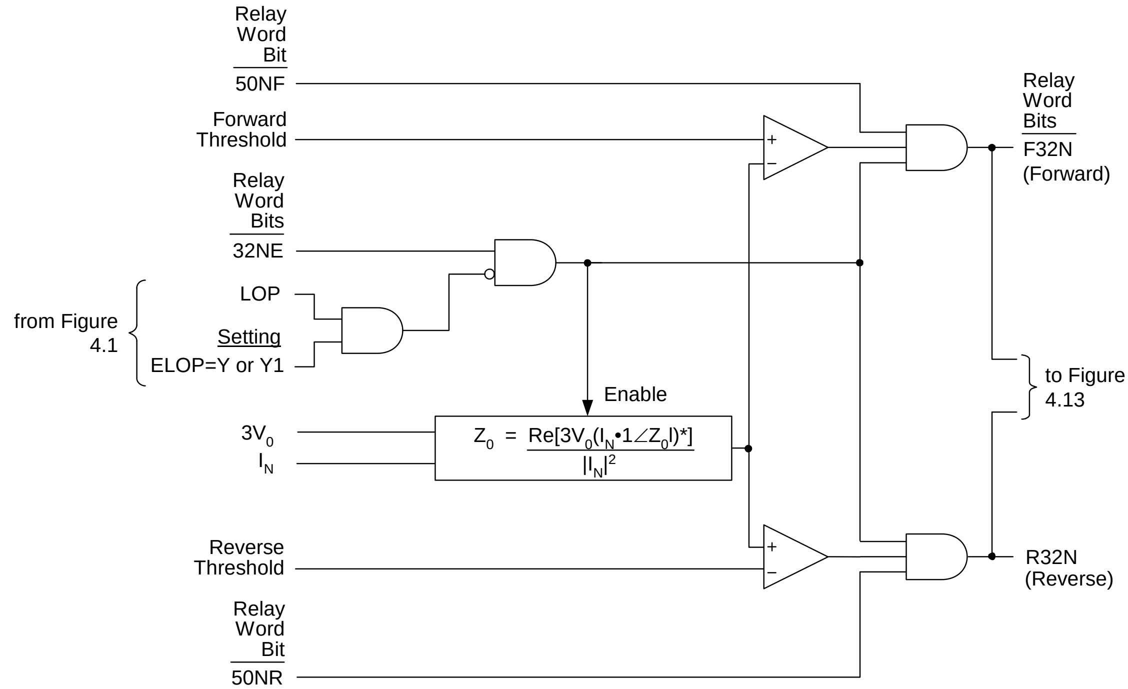
If Z0R Setting $\geq$ 0, Reverse Threshold = $0.75 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

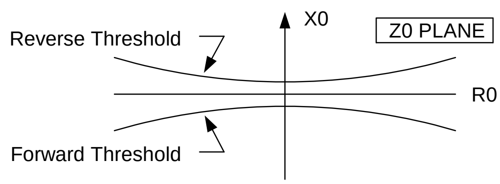
If Z0R Setting < 0, Reverse Threshold = $1.25 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

Note: $1\angle Z0L$ = One OHM At The Zero-Sequence Line Angle

DWG: M351R154

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





Direction Element Characteristics

<u>Forward Threshold:</u>

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

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

<u>Reverse Threshold:</u>

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

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

DWG: M351R155

Note: 1 ∠Z0L = One OHM At The Zero-Sequence Line Angle

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

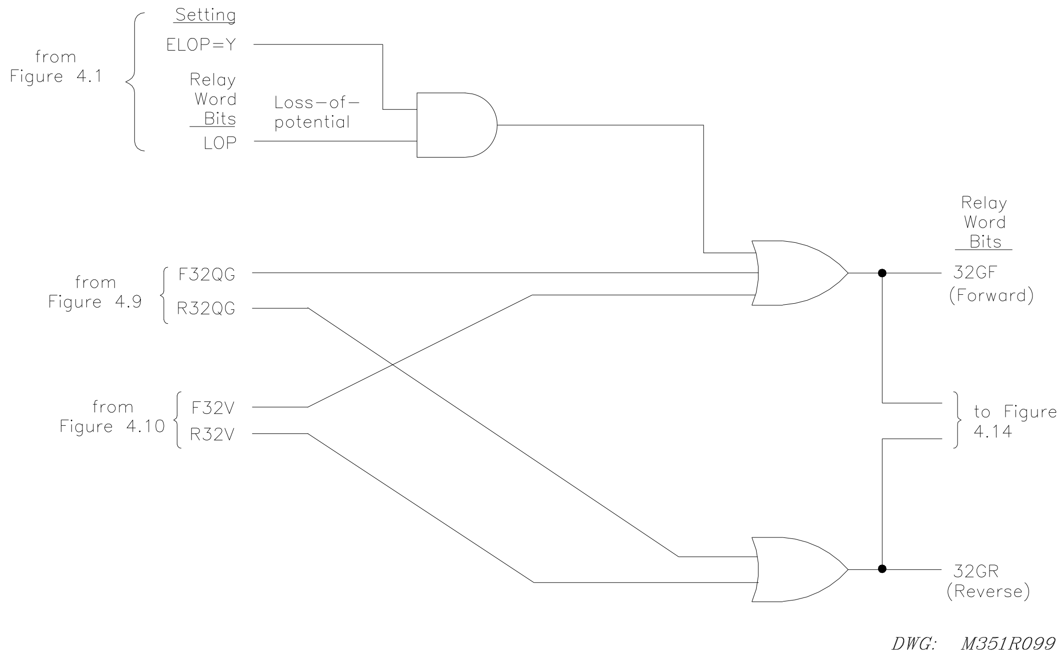


Figure 4.12: Routing of Directional Elements to Residual Overcurrent Elements

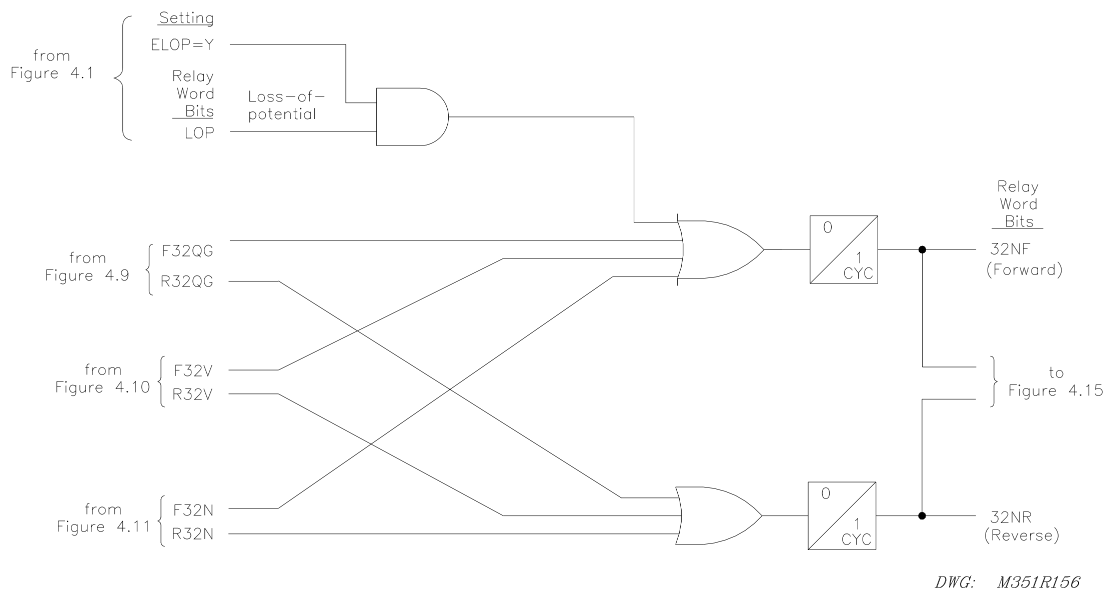


Figure 4.13: Routing of Directional Elements to Neutral Ground Overcurrent Elements

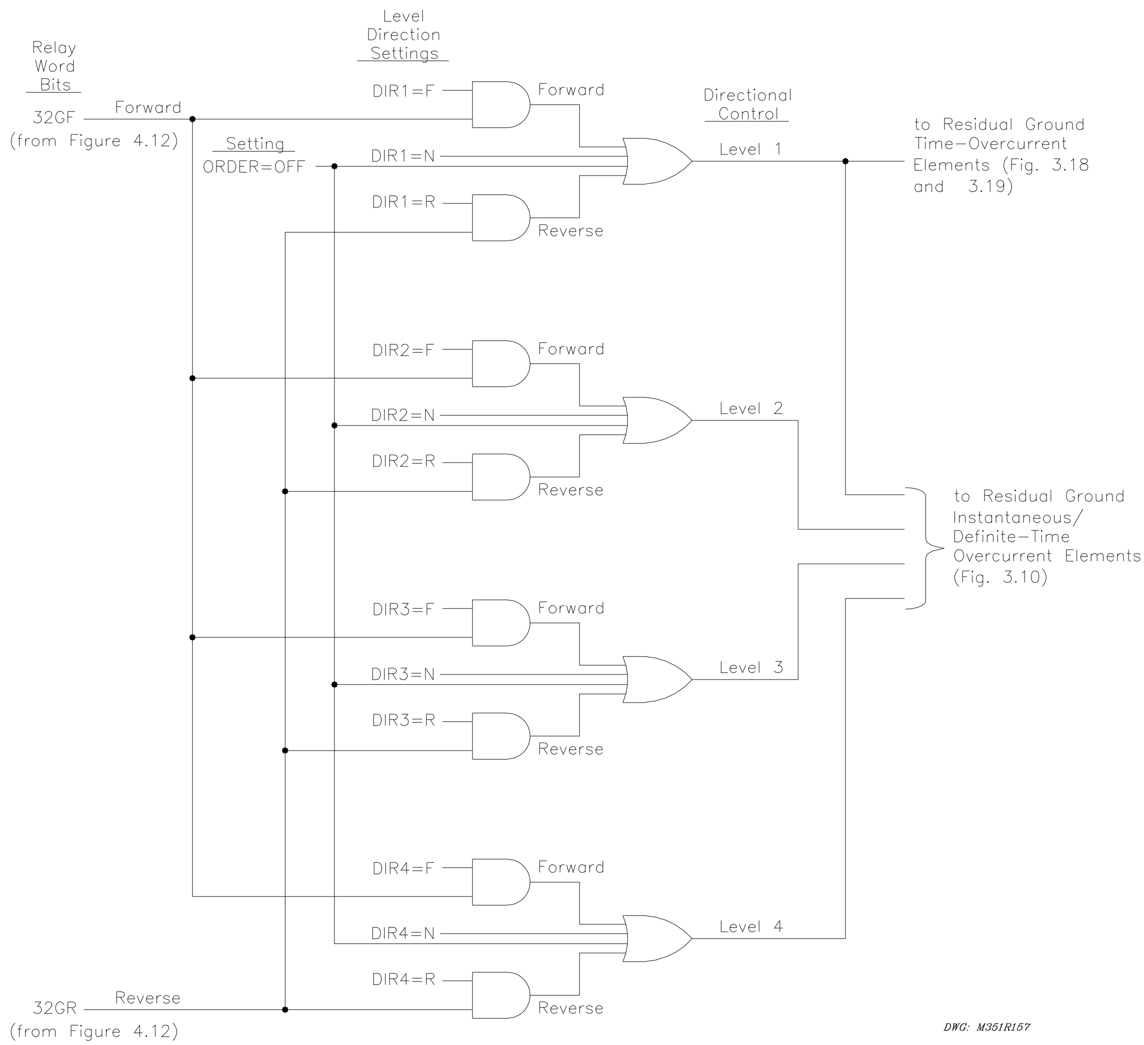


Figure 4.14: Direction Forward/Reverse Logic for Residual Ground Overcurrent Elements

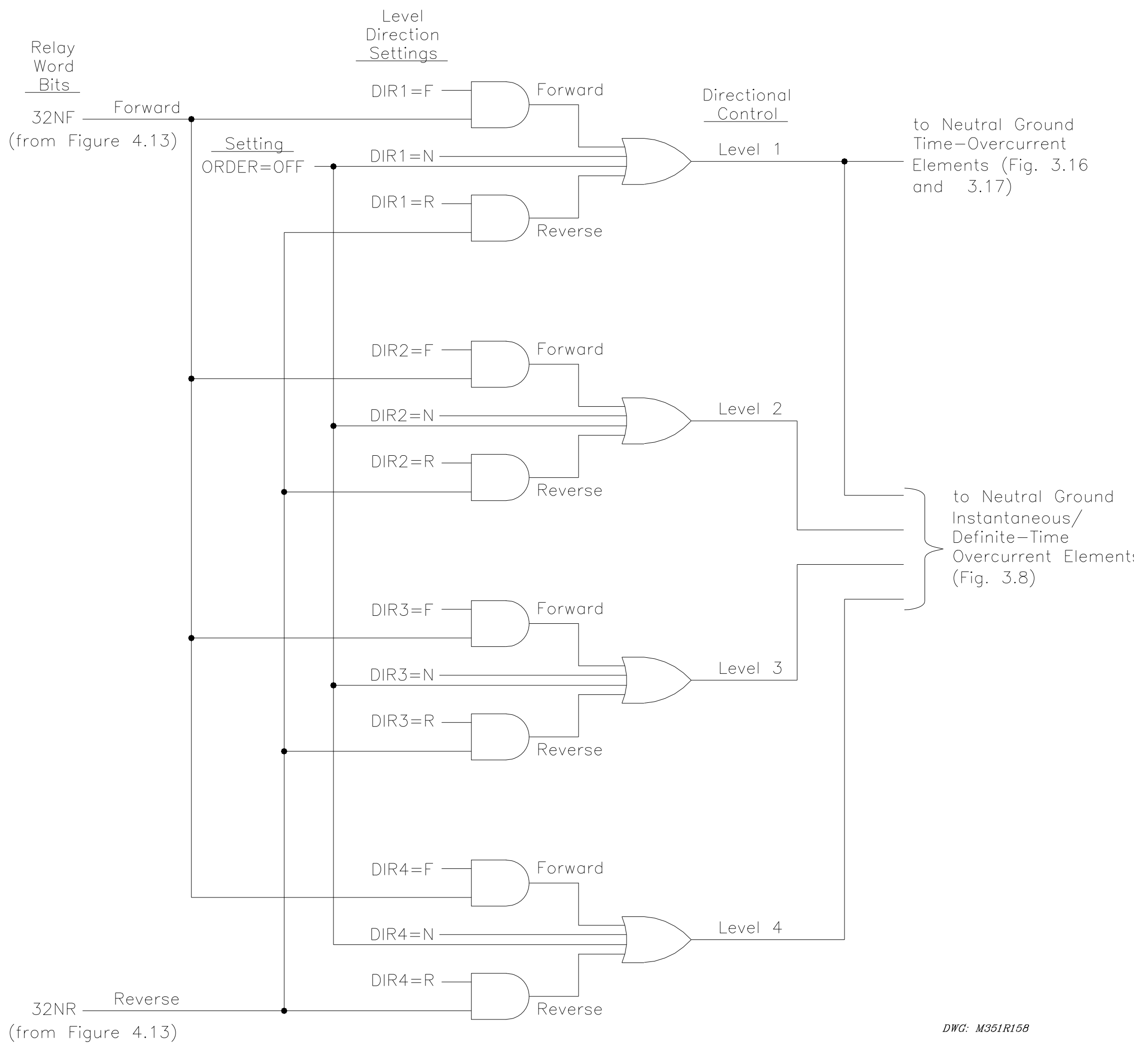


Figure 4.15: Direction Forward/Reverse Logic for Neutral Ground Overcurrent Elements

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 the following subsection ***Directional Control Settings***.

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.

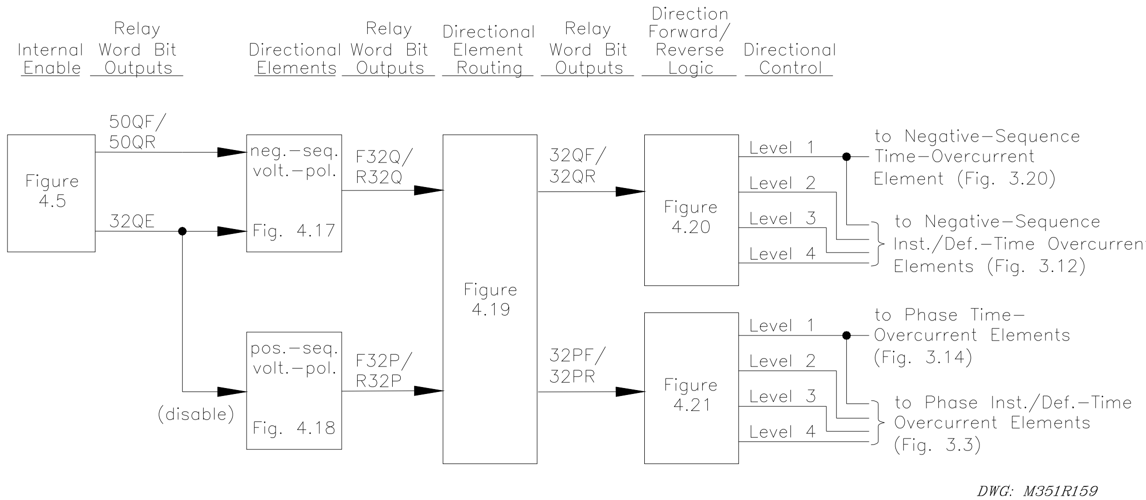


Figure 4.16: General Logic Flow of Directional Control for Negative-Sequence and Phase Overcurrent Elements

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 a following subsection ***Directional Control Settings***.

Directional Elements

Refer to Figure 4.16, Figure 4.17, and 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 through DIR4.

Table 4.1 shows the overcurrent elements that are controlled by each level direction setting. Note in Table 4.1 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)

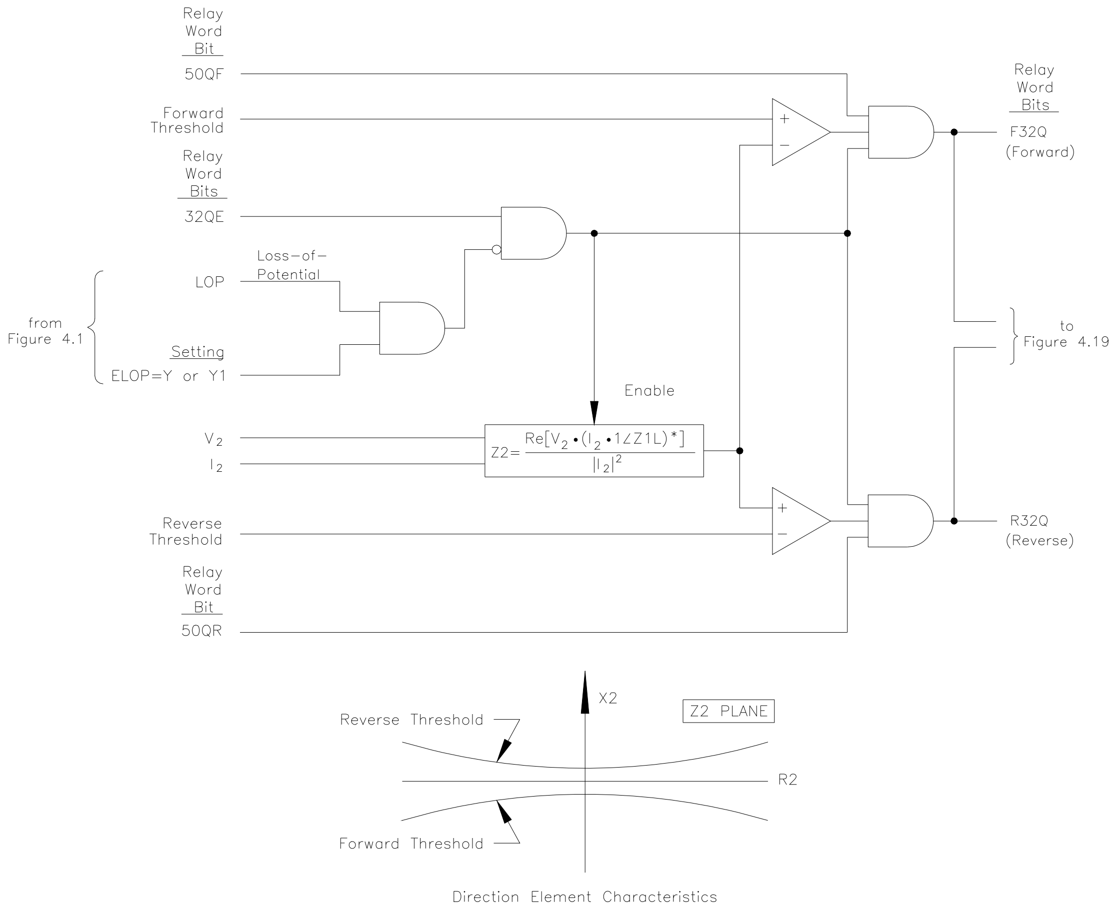
If a level direction setting (e.g., DIR1) is set:

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 following subsection ***Directional Control Settings*** for discussion of the operation of level direction settings DIR1 through DIR4 when the directional control enable setting E32 is set to E32 = N.

In some applications, level direction settings DIR1 through DIR4 are not flexible enough in assigning the desired direction for certain overcurrent elements. Subsection ***Directional Control Provided by Torque Control Settings*** at the end of this section describes how to avoid this limitation for special cases.



Forward Threshold:

If Z2F Setting $\leq$ 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 $\geq$ 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: $1\angle Z1L$ = One OHM At The Positive-Sequence Line Angle

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

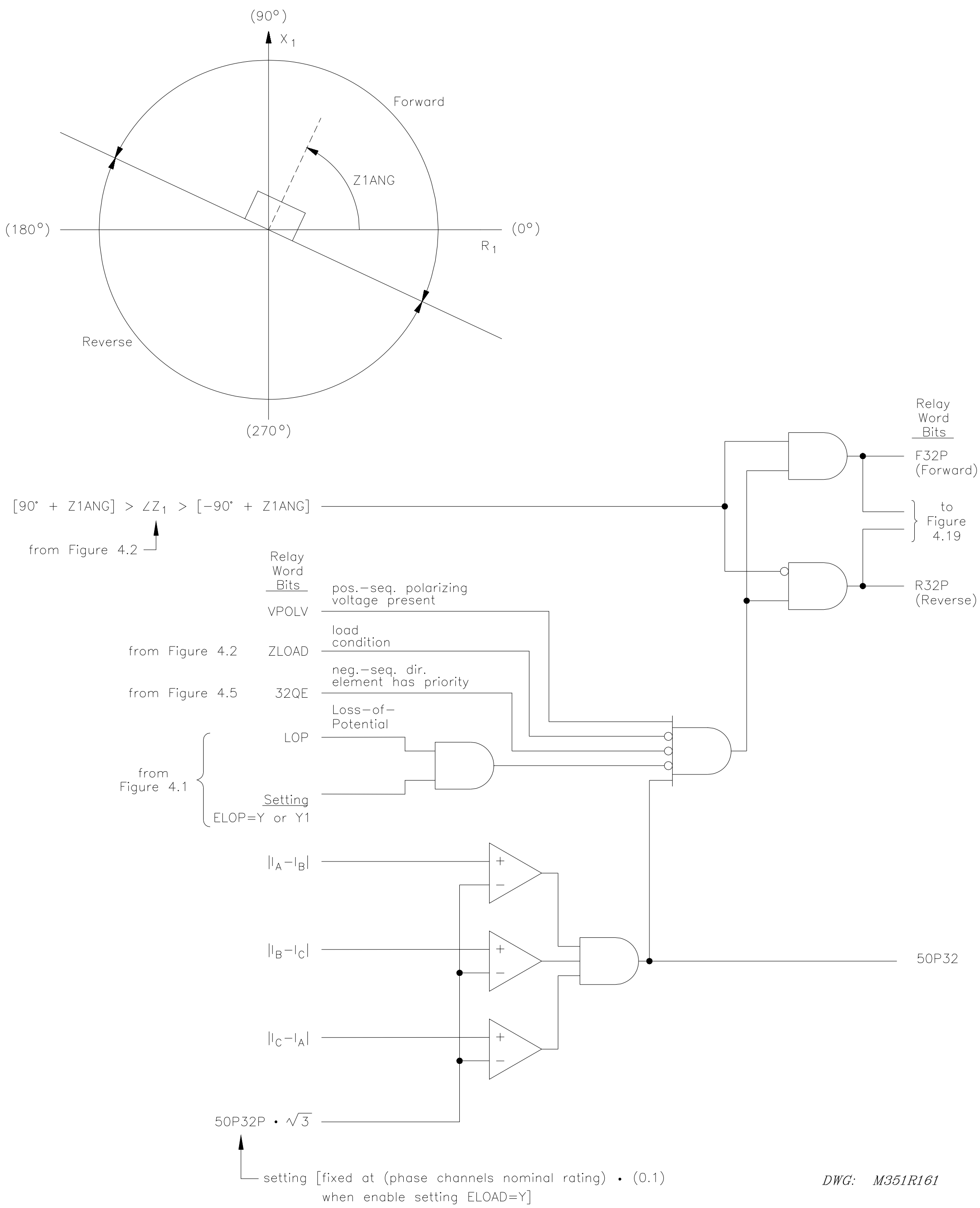

Figure 4.18: Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements

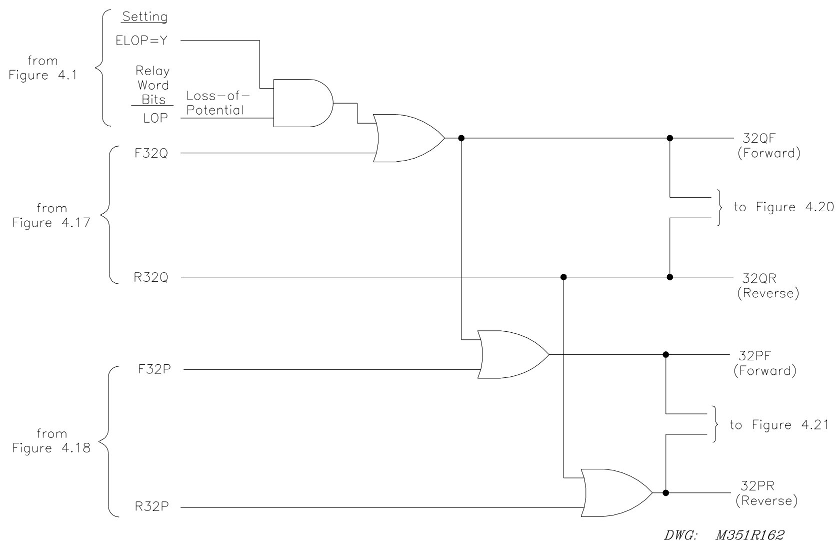

Figure 4.19: Routing of Directional Elements to Negative-Sequence and Phase Overcurrent Elements

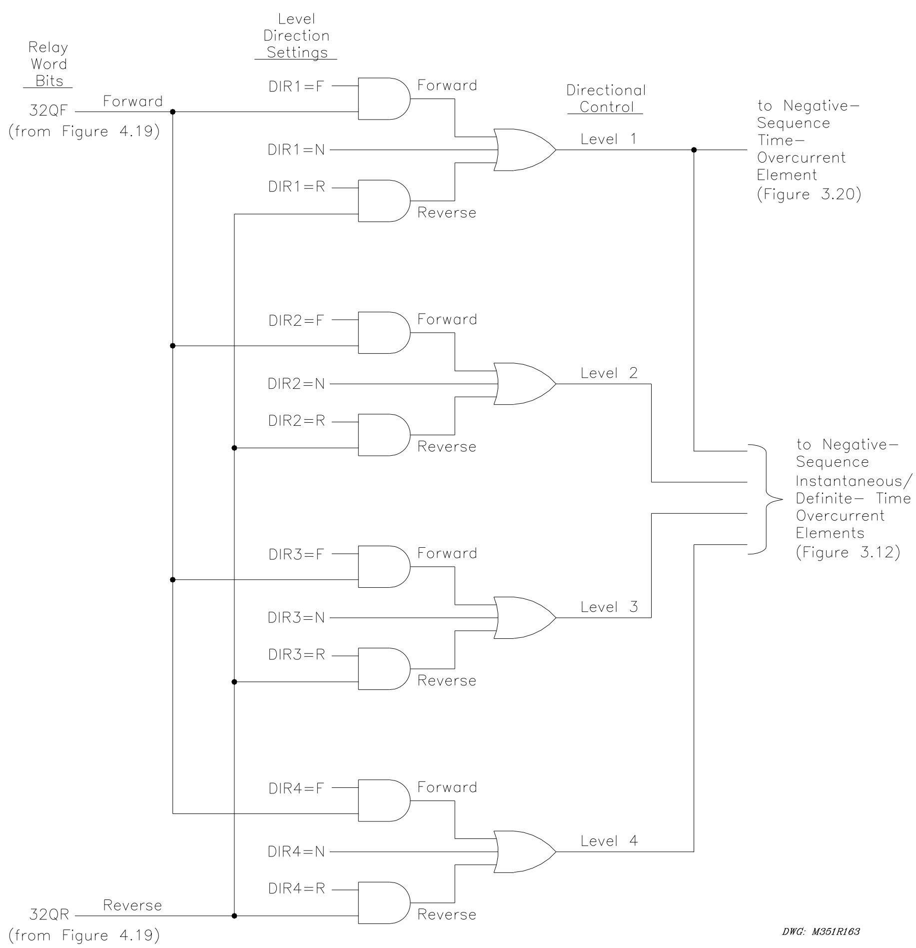

Figure 4.20: Direction Forward/Reverse Logic for Negative-Sequence Overcurrent Elements

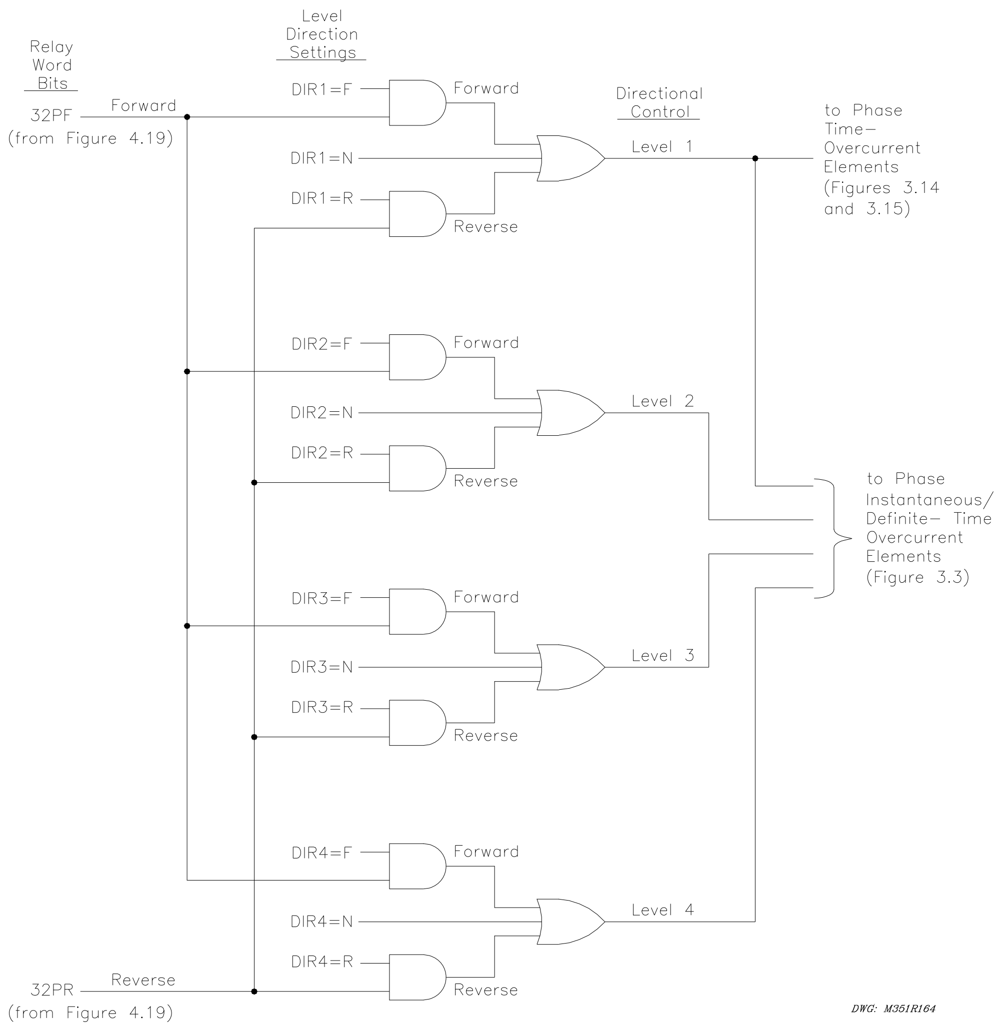

Figure 4.21: Direction Forward/Reverse Logic for Phase Overcurrent Elements

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

Note: 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 4.15, Figure 4.20 and Figure 4.21 assert to logical 1. The referenced overcurrent elements in Figure 4.14, Figure 4.15, 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.

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 4.1 shows the overcurrent elements that are controlled by each level direction setting. Note in Table 4.1 that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. Figure 4.14, Figure 4.15, Figure 4.20, and Figure 4.21 show the logic implementation of the control listed in Table 4.1.

Table 4.1: Overcurrent Elements Controlled by Level Direction Settings DIR1 Through DIR4 (corresponding overcurrent element figure numbers in parentheses)

Level Direction Settings	Phase	Neutral Ground	Residual Ground	Negative-Sequence
DIR1	67P1 (3.3) 67P1T (3.3) 51P1T (3.14) 51P2T (3.15)	67N1 (3.8) 67N1T (3.8) 51N1T (3.16) 51N2T (3.17)	67G1 (3.10) 67G1T (3.10) 51G1T (3.18) 51G2T (3.19)	67Q1 (3.12) 67Q1T (3.12) 51QT (3.20)
DIR2	67P2 (3.3) 67P2T (3.3) 67P2S (3.3)	67N2 (3.8) 67N2T (3.8) 67N2S (3.8)	67G2 (3.10) 67G2T (3.10) 67G2S (3.10)	67Q2 (3.12) 67Q2T (3.12) 67Q2S (3.12)
DIR3	67P3 (3.3) 67P3T (3.3)	67N3 (3.8) 67N3T (3.8)	67G3 (3.10) 67G3T (3.10)	67Q3 (3.12) 67Q3T (3.12)
DIR4	67P4 (3.3) 67P4T (3.3)	67N4 (3.8) 67N4T (3.8)	67G4 (3.10) 67G4T (3.10)	67Q4 (3.12) 67Q4T (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 through DIR4 are not flexible enough in assigning the desired direction for certain overcurrent elements. Subsection ***Directional Control Provided by Torque Control Settings*** at the end of this section 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* 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 due to 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 $\left(|I_2| > 0.1 \bullet |I_1|\right)$.

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 relay 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 $\left(|I_2| > 0.2 \bullet |I_0|\right)$. Again, this presumes at least one of the internal enables 32VE or 32IE 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 due to 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 $\left(|I_0| > 0.1 \bullet |I_1|\right)$.

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-351P-3:

E32IV = IN106 (52a connected to optoisolated input IN106)

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 through DIR4 are used to set overcurrent elements direction forward, reverse, or nondirectional. Table 4.1 shows the overcurrent elements that are controlled by each level direction setting. Note in Table 4.1 that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. See Figure 4.14, Figure 4.15, 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 4.15, 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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FIGURES

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*** later in this section 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*** subsection in ***Section 1: Factory-Set Logic***).

TRSOTF Switch-Onto-Fault Trip Conditions.

Setting TRSOTF is supervised by the switch-onto-fault condition SOTFE. See ***Switch-Onto-Fault (SOTF) Trip Logic*** later in this section 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 under-reaching 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.

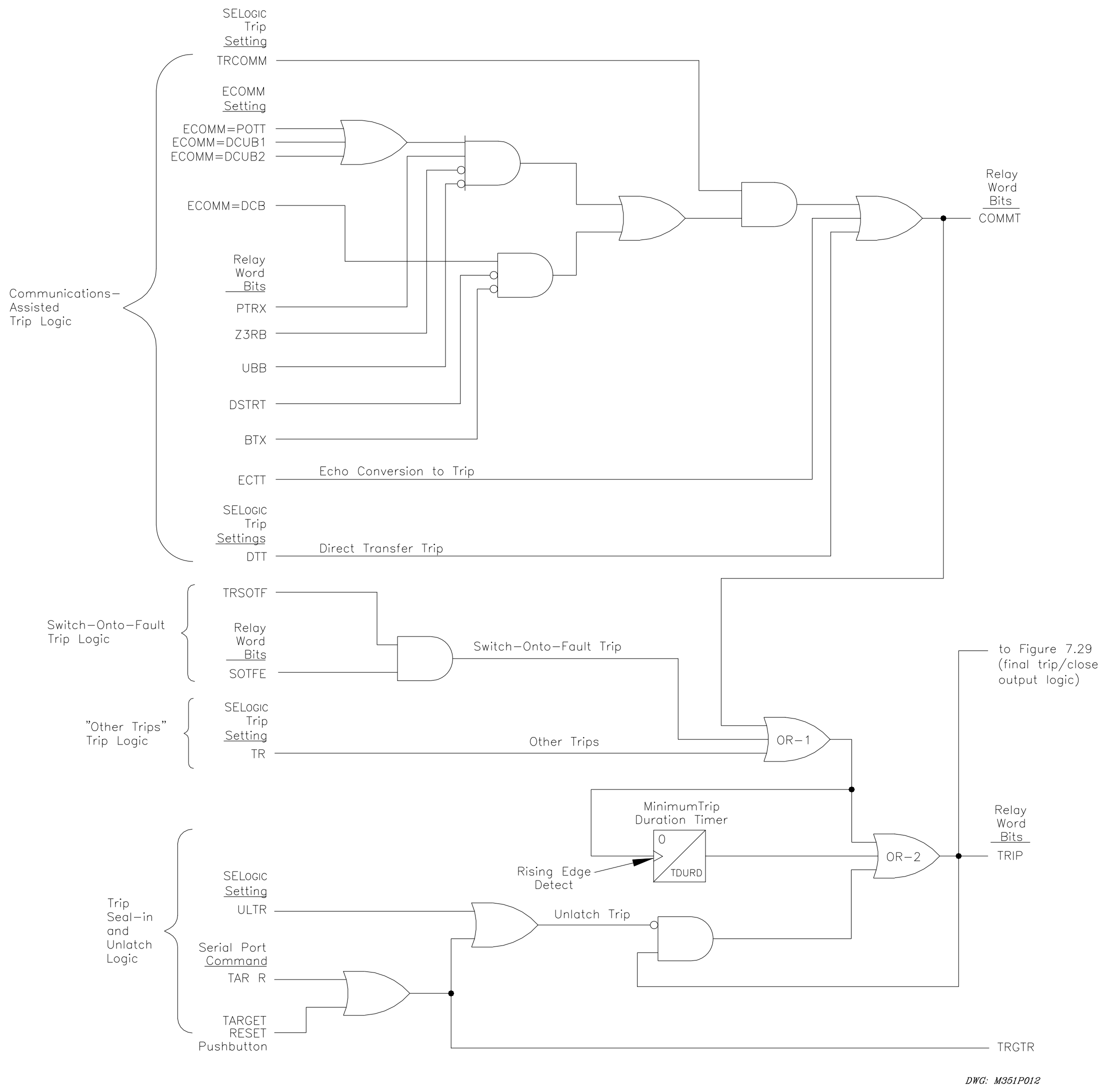

Figure 5.1: Trip Logic

The TRIP Relay Word bit output of the trip logic in Figure 5.1 propagates to the trip/close logic in Figure 13 in the *SEL-351P-3 Quick-Start Installation and User's Guide*. This logic controls dedicated trip and close FET outputs and prevents the trip and close FET outputs from being asserted at the same time.

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 4 cycles.

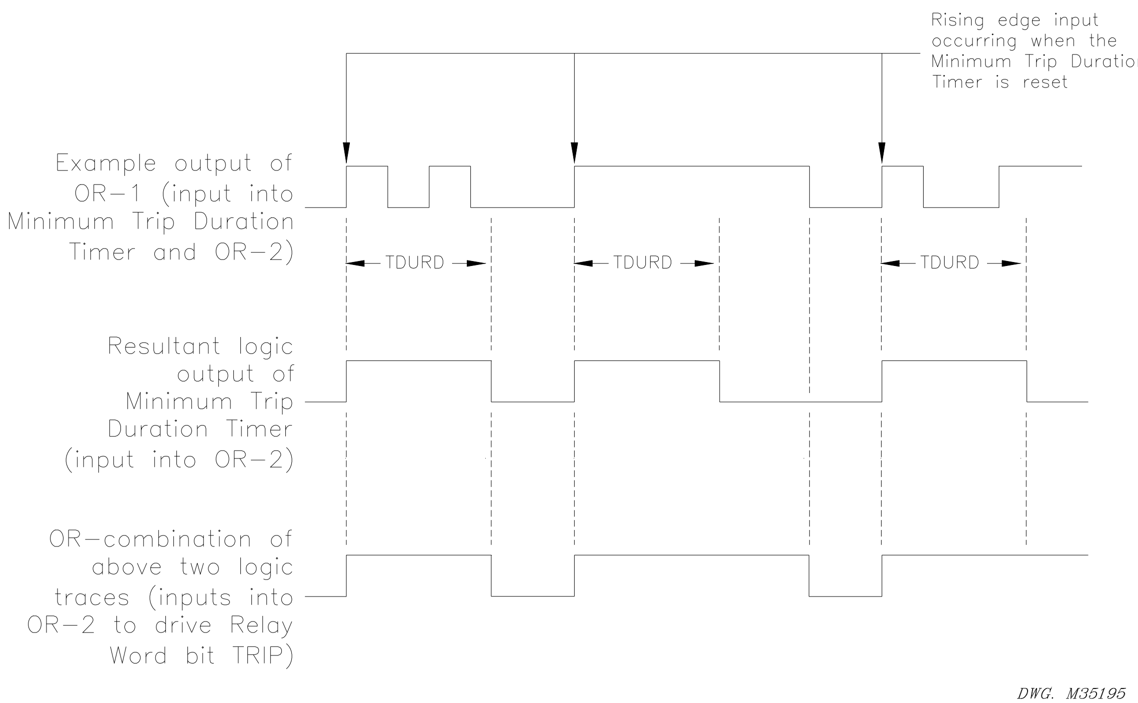

Figure 5.2: Minimum Trip Duration Timer Operation (see bottom of Figure 5.1)

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 button is pressed,
  - Or the **TAR R** (Target Reset) command is executed via the serial port.

The front-panel TARGET RESET button 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 much 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 = SV1 + LT1 * (51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T
+ 67P2T + 67G2T + 67N2T + 67N3T + 81D1T) (trip conditions)

ULTR = 1 (always equal to logical 1) (unlatch trip conditions)

The factory setting for the Minimum Trip Duration Timer setting is:

TDURD = 4.00 cycles

With setting TDURD = 4.00 cycles, once the TRIP Relay Word bit asserts via SELOGIC control equation setting TR, it remains asserted at logical 1 for a minimum of 4 cycles.

Note: There is no need to set TDURD greater than 4 cycles. The final trip/close logic in Figure 7.29 takes care of all timing issues concerning the dedicated trip output contact. The TRIP Relay Word bit output of the trip logic in Figure 5.1 (that follows the TDURD timer) propagates to the final trip/close logic in Figure 7.29.

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

The final trip/close logic in Figure 7.29 (that has input from Figure 5.1) controls dedicated trip and close output contacts.

If additional TRIP output contacts are needed, program the extra output contacts with the TRIP (Figure 5.1) or WBTR (Figure 7.29) Relay Word bits, depending on the application (e.g., OUT101 = TRIP; OUT102 = WBTR). 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 output 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.

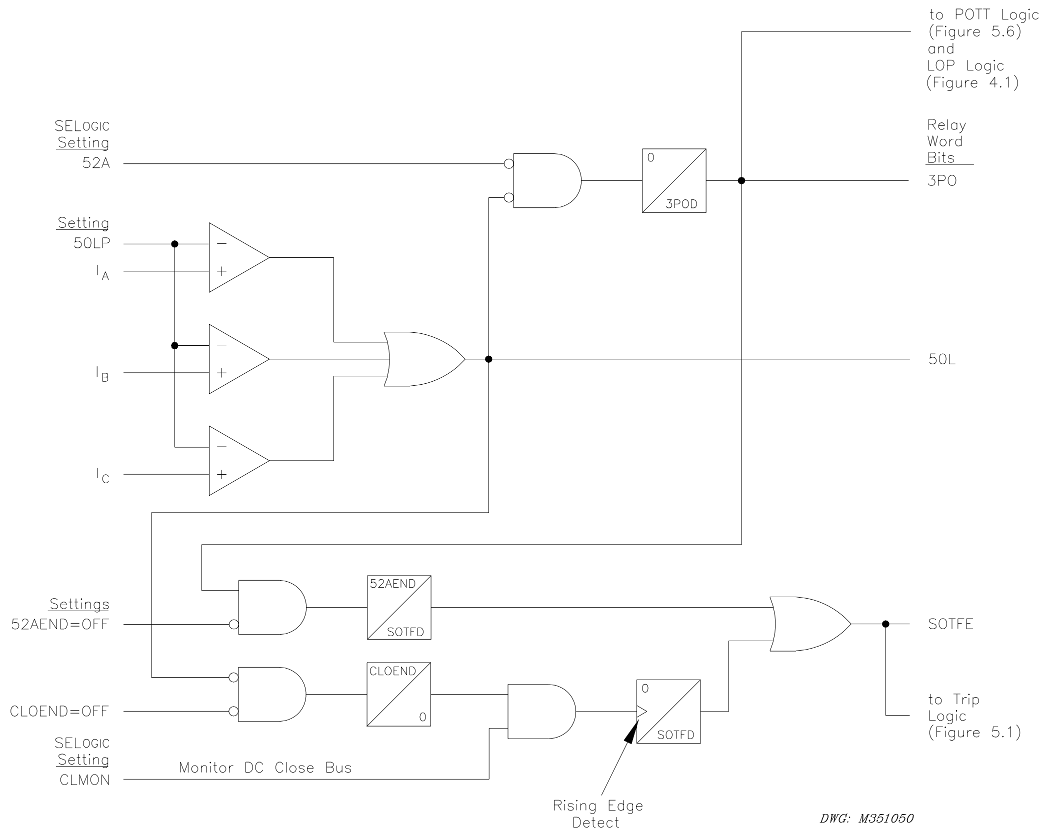

Figure 5.3: Three-Pole Open Logic (top) and Switch-Onto-Fault Logic (bottom)

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 Settings Sheet 1 of 28 in ***Section 9: Setting the SEL-351P-3 Recloser Control***).

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-351P-3 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-351P-3 (see Figure 7.25 example in ***Output Contacts*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***) 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 output, 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-351P-3 (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 output, SOTFE, asserts to logical 1 for SOTFD time.

Switch-Onto-Fault Logic Output (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 relay 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 deenergized, the relay 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 relay 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-351P-3 includes communications-assisted tripping schemes that provide unit-protection for transmission lines with the help of communications. No external coordination devices are required.

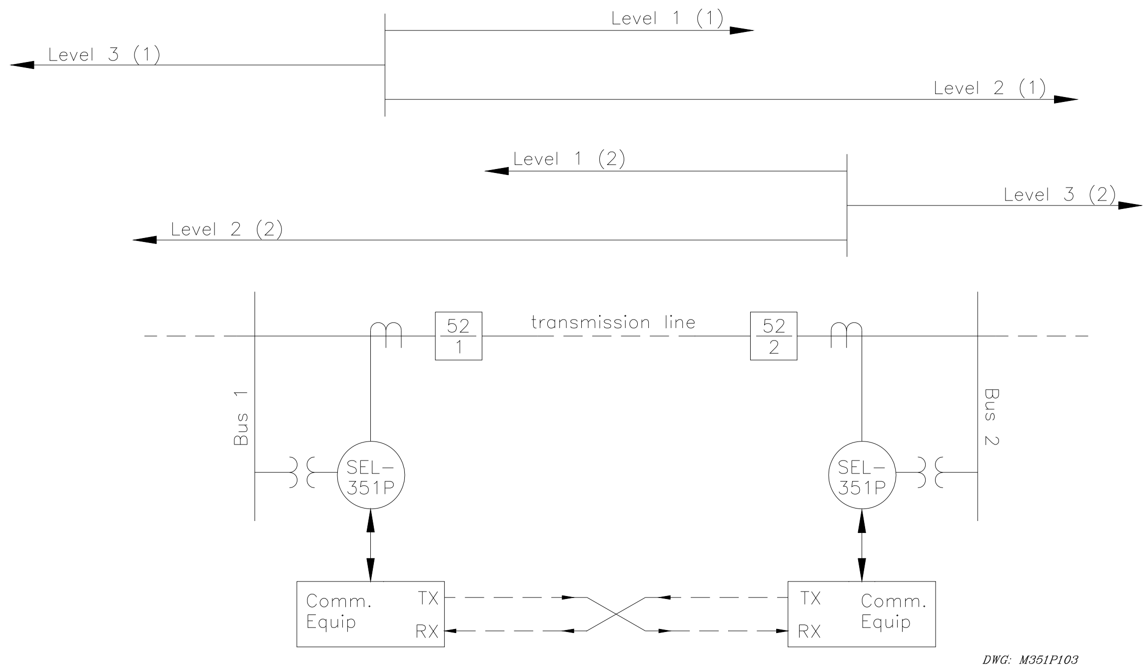

Figure 5.4: Communications-Assisted Tripping Scheme

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.

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*** subsection in ***Section 4: Loss-of-Potential, Load Encroachment, and Directional Element Logic*** for more information on level direction settings DIR1 through DIR4.

POTT, PUTT, DCUB, and DCB communications-assisted tripping schemes are explained in subsections that follow.

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 1.2 and the EZ settings explanation preceding Table 1.1 in ***Section 1: Factory-Set Logic*** for more information on EZ settings and overcurrent element applications for traditional recloser control schemes.

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 preceding subsection ***Switch-Onto-Fault (SOTF) Trip Logic***.

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*** subsection in ***Section 1: Factory-Set Logic***).

Use Existing SEL-321 Relay Application Guides for the SEL-351P-3 Recloser Control

The communications-assisted tripping schemes settings in the SEL-351P-3 are very similar to those in the SEL-321 Relay. Existing SEL-321 Relay application guides can also be used in setting up these schemes in the SEL-351P-3. The following application guides are available from SEL:

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-351s and SEL-351Rs 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-351P-3 Recloser Control

The SEL-351P-3 does not have optoisolated input settings like the SEL-321 Relay. Rather, the optoisolated inputs of the SEL-351P-3 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-351P-3	
IN2 = PT	PT1 = IN102	(received permissive trip)

In the above SEL-351P-3 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-351P-3. See ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** for more information on optoisolated inputs.

Trip Settings Differences Between the SEL-321 and SEL-351P-3 Recloser Control

Some of the SELOGIC control equation trip settings of the SEL-321 and SEL-351P-3 have different labels, yet are operationally the same. The correspondence is:

SEL-321 Relay	SEL-351P-3	
MTCS	TRCOMM	(Communications-Assisted Trip Conditions)
MTO	TRSOTF	(Switch-Onto-Fault Trip Conditions)
MTU	TR	(Unconditional or Other Trip Conditions)

The SEL-321 Relay handles trip unlatching with setting TULO. The SEL-351P-3 handles trip unlatching with SELOGIC control equation setting ULTR.

The SEL-321 Relay has single-pole trip logic. The SEL-351P-3 does not have single-pole trip logic.

Using MIRRORED BITS® to Implement Communications-Assisted Tripping Schemes

The MIRRORED BITS® relay-to-relay communications protocol is available in the SEL-351P-3, in addition to several other SEL products. MIRRORED BITS implementations have these advantages over traditional communications equipment:

- Less equipment (increases reliability)
- Increased speed (no contact closure delay)
- Better security (through built-in channel monitoring)
- Reduced wiring complexity

The subsections that follow use traditional communications equipment in the examples. If using MIRRORED BITS communications, change some of the SELOGIC control equations to use Transmit MIRRORED BITS instead of output contacts, and Receive MIRRORED BITS instead of optoisolated inputs. Also, MIRRORED BITS communications do not require dc wiring between the relay and communications equipment.

See ***Appendix I*** for details on configuring a relay port to communicate using MIRRORED BITS.

Several Application Guides available on the SEL website (www.selinc.com) give application examples of MIRRORED BITS in Communications-Assisted Tripping Schemes. Although some of the guides were written for the SEL-321-1 and SEL-311C Distance Relays, these relays are similar to the SEL-351P-3, so the guides will still be helpful in designing SEL-351P-3 applications.

PERMISSIVE OVERREACHING TRANSFER TRIP (POTT) LOGIC

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-351P-3 Recloser Control

Use the existing SEL-321 Relay POTT application guide (AG95-29) to help set up the SEL-351P-3 in a POTT scheme (see preceding subsection ***Communications-Assisted Trip Logic—General Overview*** for more setting comparison information on the SEL-321/SEL-351P-3).

External Inputs

See ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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-351P-3 (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-351P-3 (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).

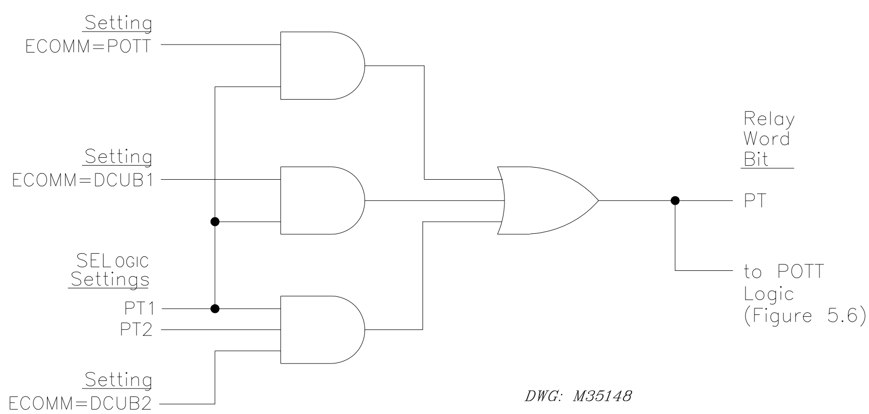

Figure 5.5: Permissive Input Logic Routing to POTT Logic

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-351P-3 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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).

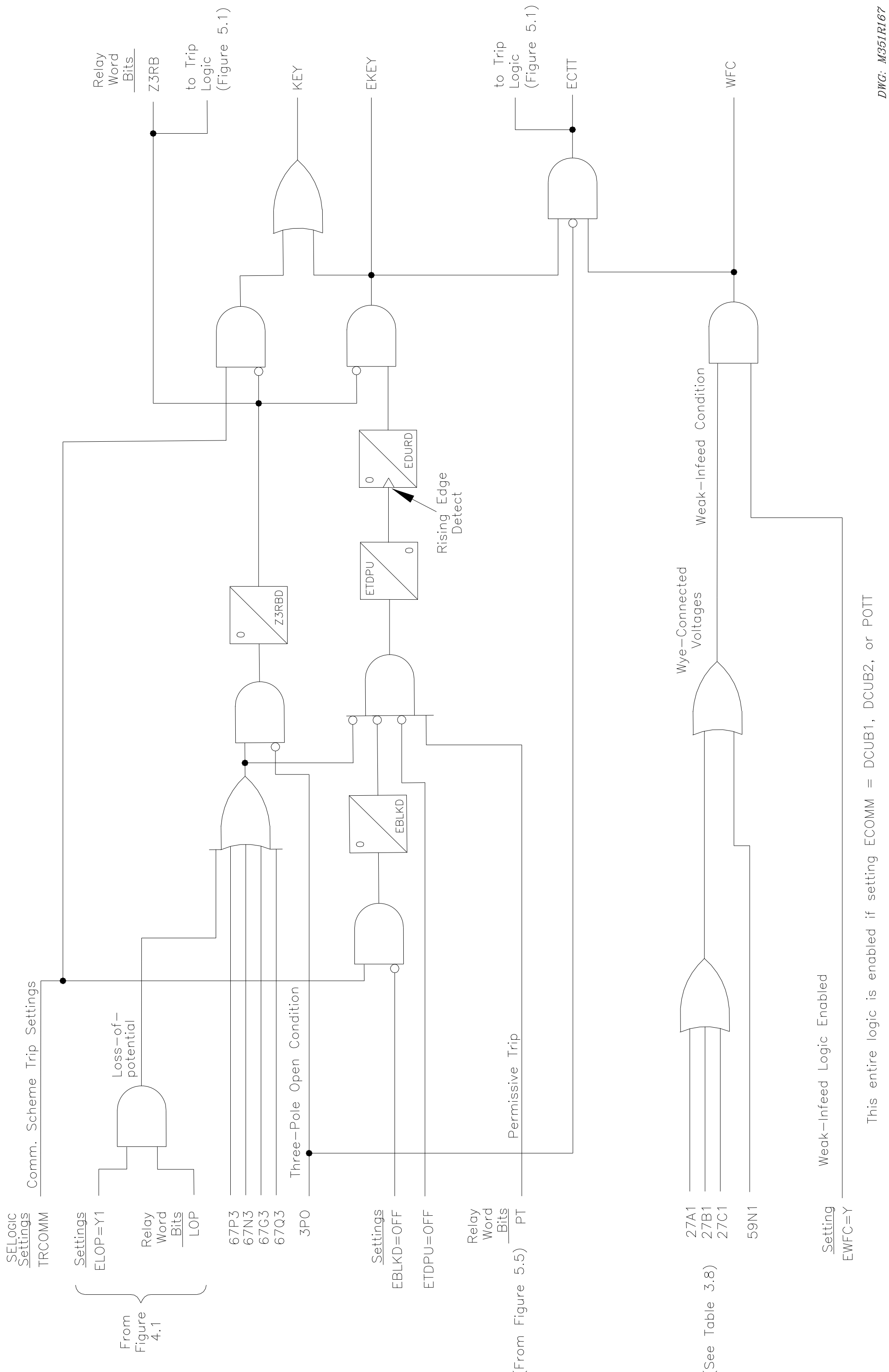

Figure 5.6: POTT Logic

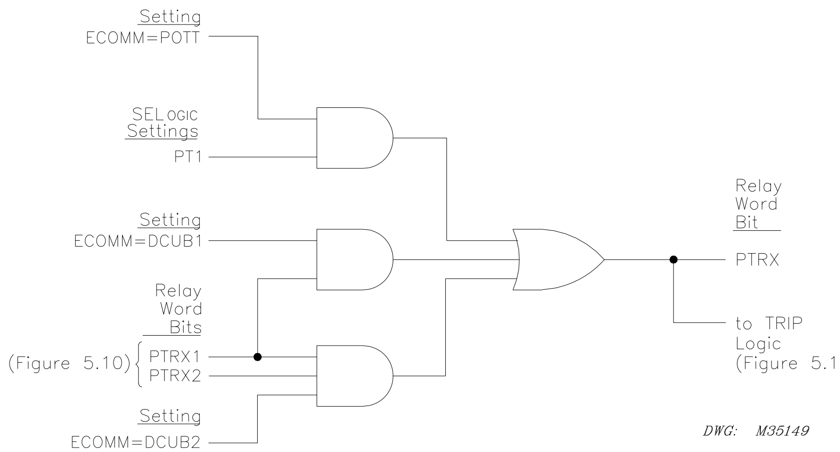

Figure 5.7: Permissive Input Logic Routing to Trip Logic

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):

OUT105 = 67P1 + 67N1 + 67G1 + 67Q1 (**Note**: only use enabled elements)

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 communication equipment in Figure 5.9. Then output contact OUT107 can be used for another function.

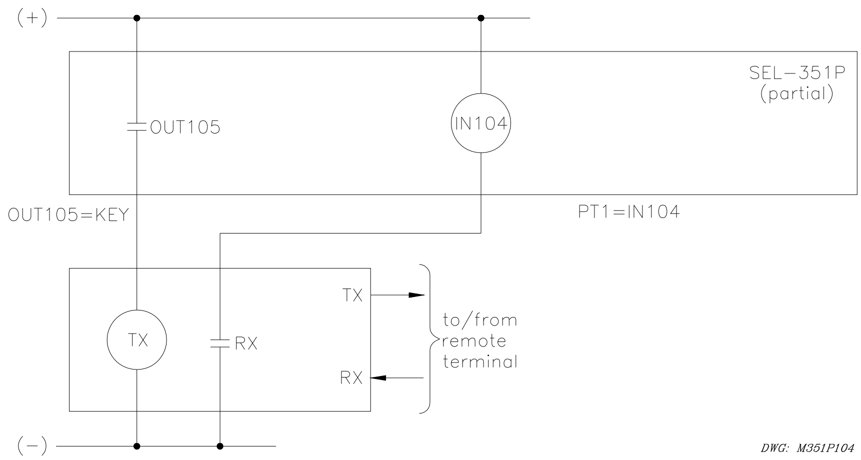

Figure 5.8 SEL-351P-3 Recloser Control Connections to Communications Equipment for a Two-Terminal Line POTT Scheme

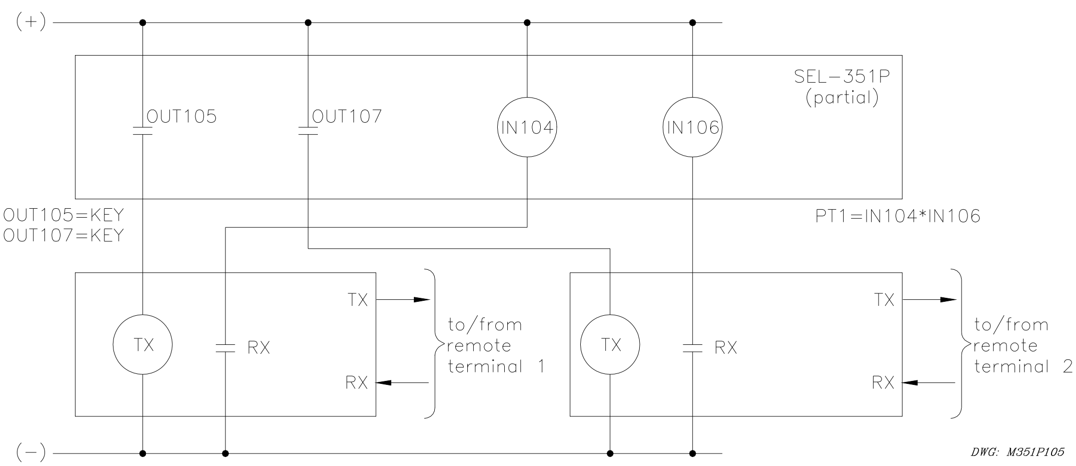

Figure 5.9 SEL-351P-3 Recloser Control Connections to Communications Equipment for a Three-Terminal Line POTT Scheme

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 relay 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-351P-3 Recloser Control

Use the existing SEL-321 Relay DCUB application guide (AG96-19) to help set up the SEL-351P-3 in a DCUB scheme (see preceding subsection ***Communications-Assisted Trip Logic—General Overview*** for more setting comparison information on the SEL-321/SEL-351P-3s).

External Inputs

See ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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-351P-3 (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-351P-3 (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 the preceding POTT subsection, 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-351P-3 (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-351P-3 (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-351P-3 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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.

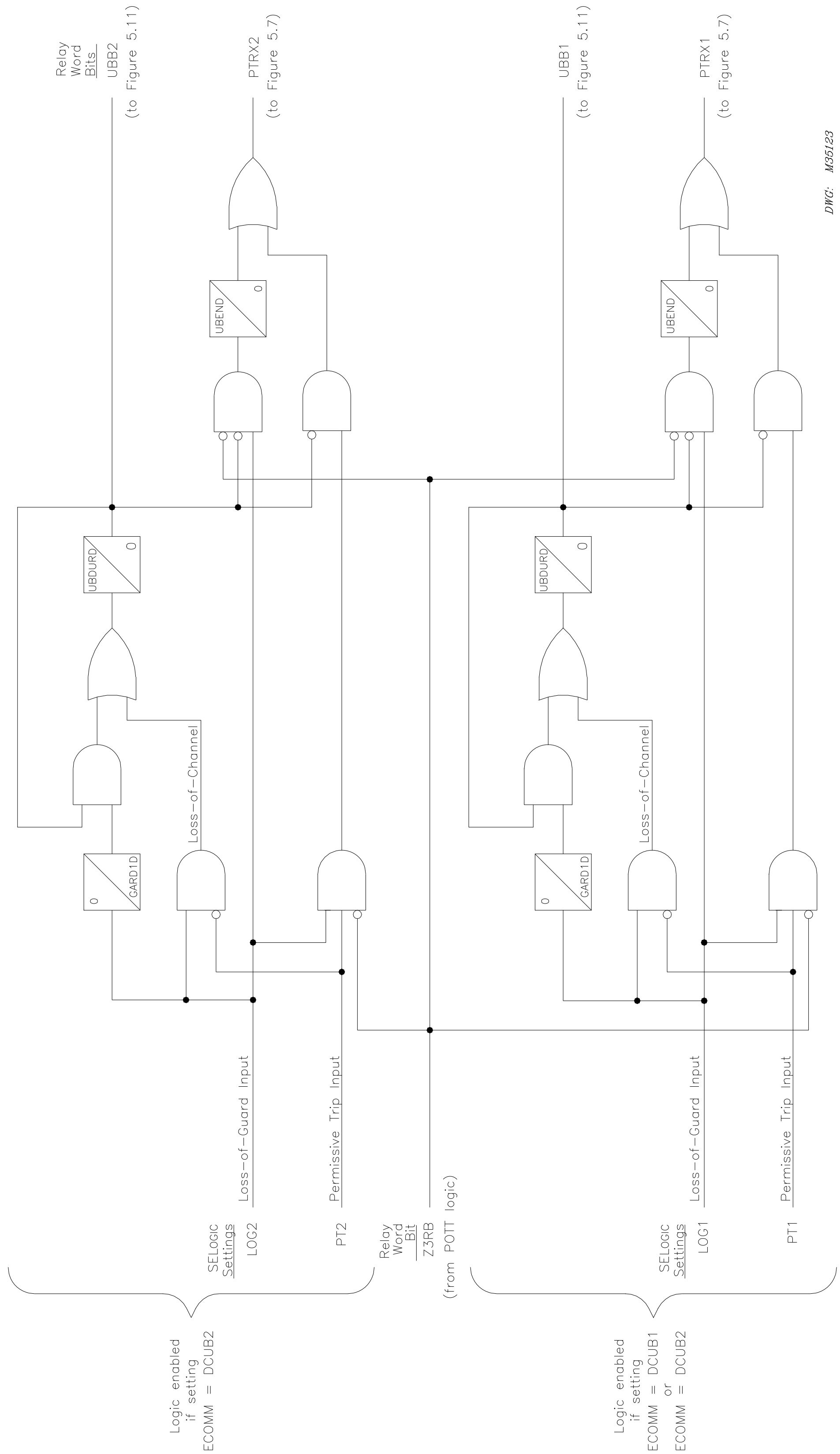

Figure 5.10: DCUB Logic

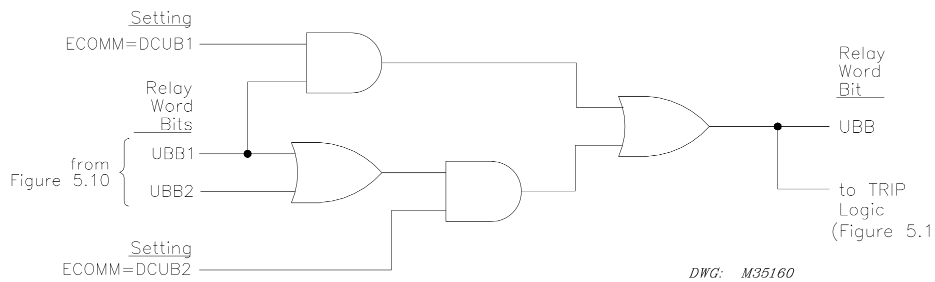

Figure 5.11: Unblocking Block Logic Routing to Trip Logic

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.

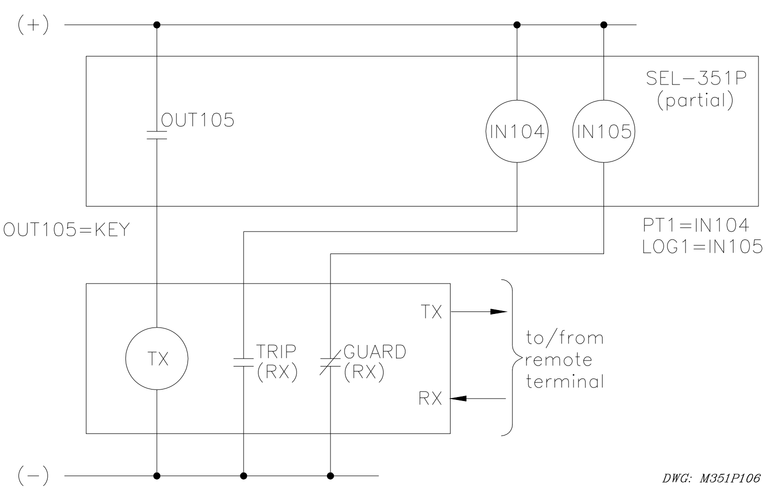

Figure 5.12: SEL-351P-3 Recloser Control Connections to Communications Equipment for a Two-Terminal Line DCUB Scheme (setting ECOMM = DCUB1)

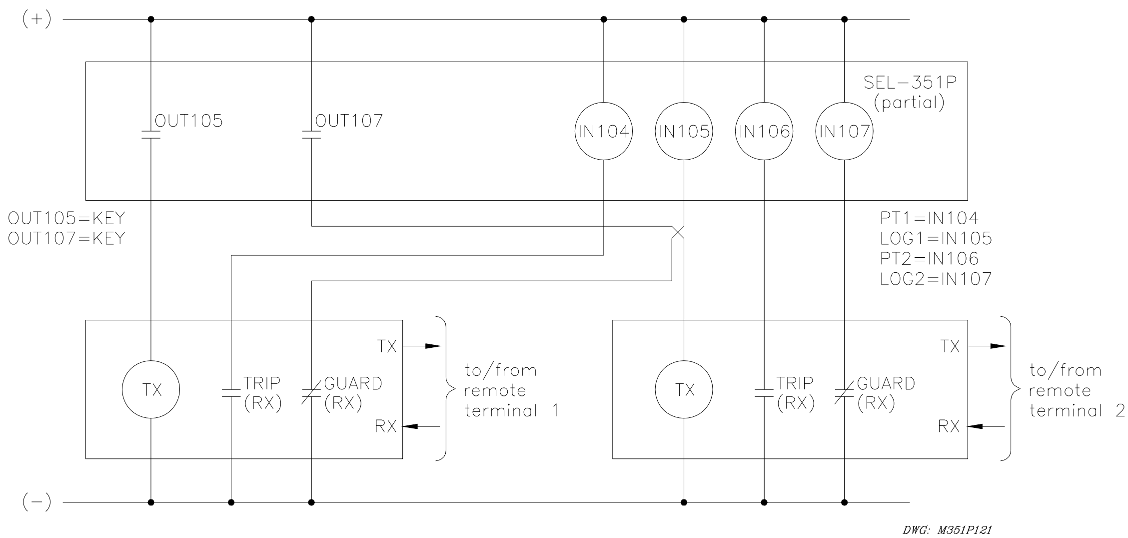

Figure 5.13: SEL-351P-3 Recloser Control Connections to Communications Equipment for a Three-Terminal Line DCUB Scheme (setting ECOMM = DCUB2)

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-351P-3 Recloser Control

Use the existing SEL-321 Relay DCB application guide (AG93-06) to help set up the SEL-351P-3 in a DCB scheme (see preceding subsection ***Communications-Assisted Trip Logic—General Overview*** for more setting comparison information on the SEL-321/SEL-351P-3).

External Inputs

See ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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-351P-3 (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-351P-3 (e.g., input 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-351P-3 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 1 cycle.

Logic Outputs

The following logic outputs can be tested by assigning them to output contacts. See ***Output Contacts*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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.

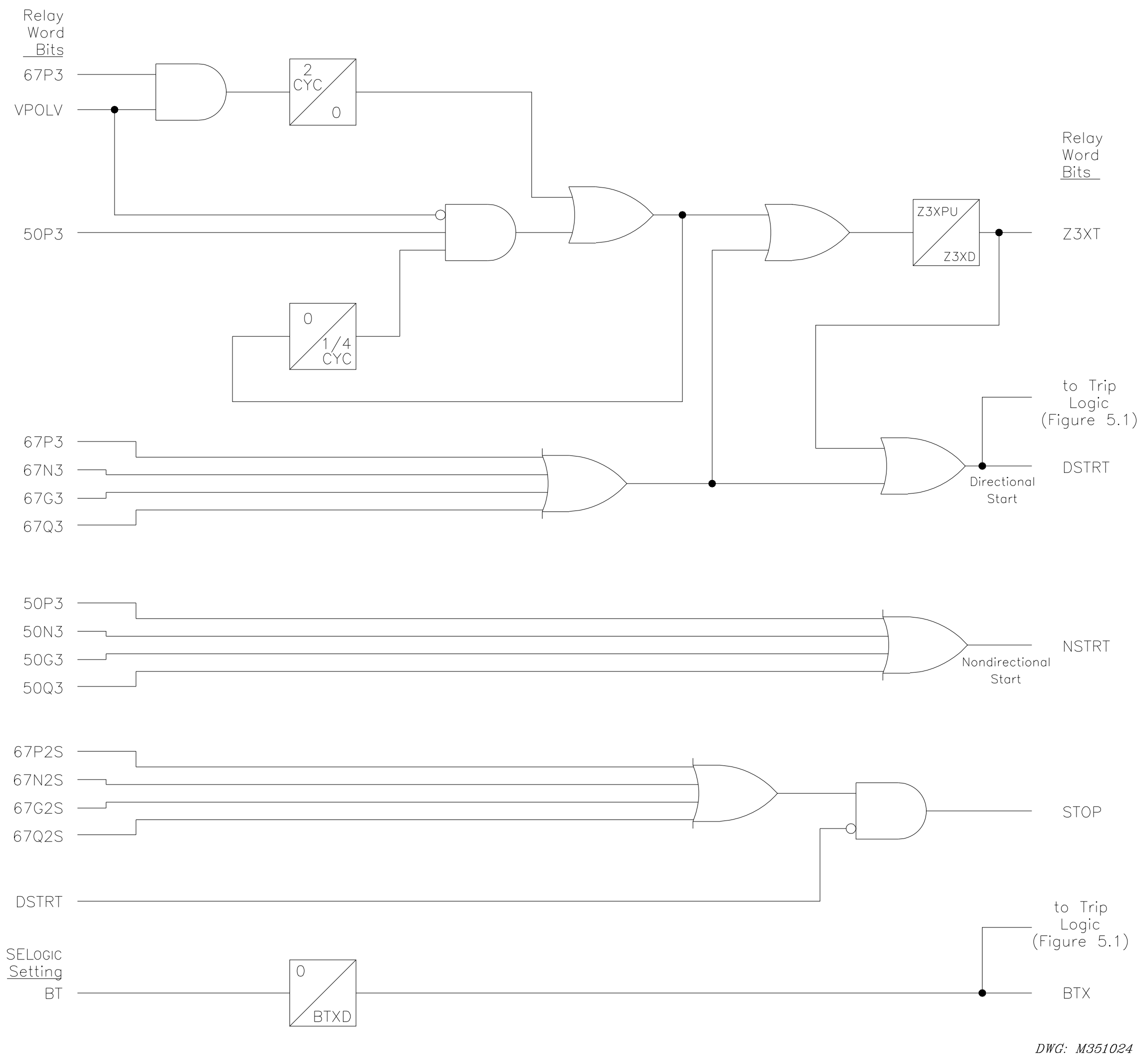

Figure 5.14: DCB Logic

Installation Variations

Figure 5.16 shows output contacts OUT104, OUT105, OUT106, and 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-351P-3. 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:

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.

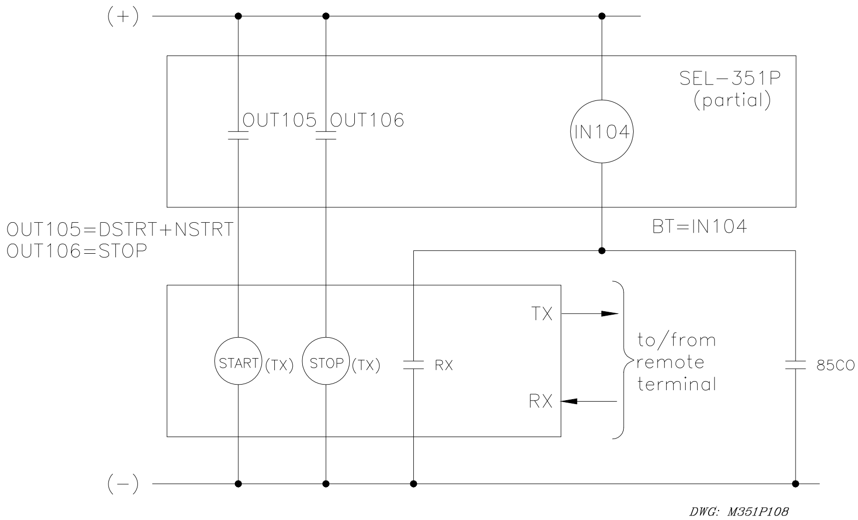

Figure 5.15: SEL-351P-3 Recloser Control Connections to Communications Equipment for a Two-Terminal Line DCB Scheme

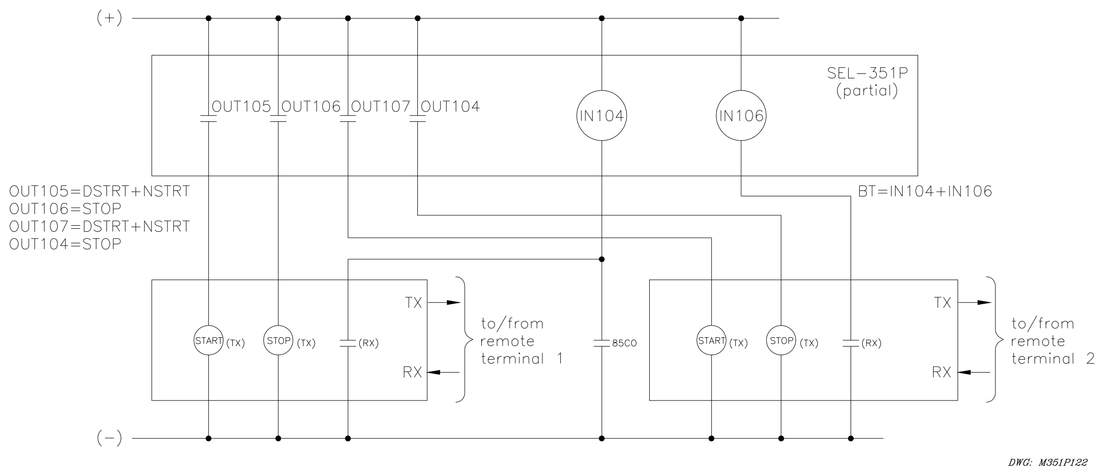

Figure 5.16: SEL-351P-3 Recloser Control Connections to Communications Equipment for a Three-Terminal Line DCB Scheme

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-351P-3
- 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 one (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 7.25 in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***. 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*** in ***Sections 7: Inputs, Outputs, Timers, and Other Control Logic*** and ***Section 11: Standard Event Reports and SER***. See Figure 5.17).

SV8 = (SV8 + SV7T) * !TRGTR

DP3 = SV8

DP3_1 = BREAKER FAILURE

DP3_0 = (blank)

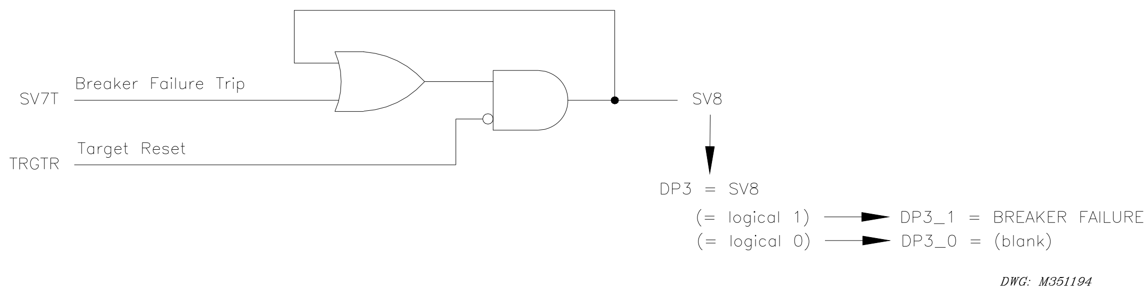

Figure 5.17: Seal-In of Breaker Failure Occurrence for Message Display

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 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 preceding ***A, B, and C Target LEDs*** subsection.
- Demand Meter—FAULT is used to suspend demand metering peak recording. See subsection ***Demand Metering*** in ***Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions***.
- Maximum/Minimum Metering—FAULT is used to block Maximum/Minimum metering updating. See subsection ***Maximum/Minimum Metering*** in ***Section 8: Breaker/ Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions***.

TABLE OF CONTENTS

TABLES

FIGURES

SECTION 6: CLOSE AND RECLOSE LOGIC

This section is made up of three subsections:

Close Logic

This subsection describes the final logic that controls the close output. 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-351P-3 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

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.

Reclose Logic

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 through 4 are the number of desired automatic reclosures.

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).

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-351P Recloser Control*** for setting ranges.

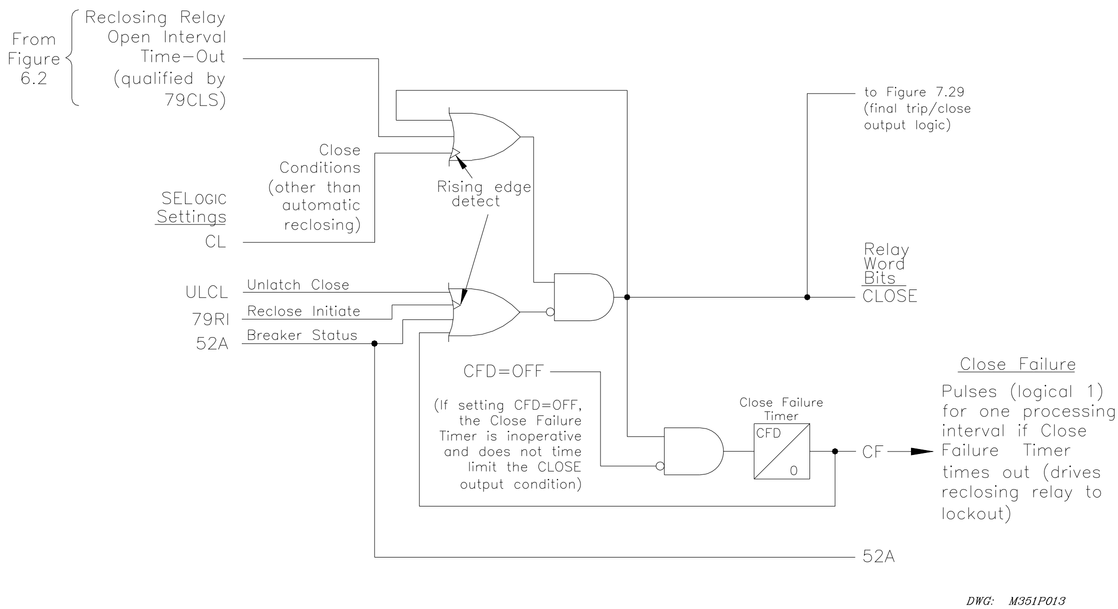

Figure 6.1: Close Logic

Set Close

If <u>all</u> 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).

The CLOSE Relay Word bit output of the close logic in Figure 6.1 propagates to the final trip/close logic in Figure 7.30. The logic in Figure 7.30 controls dedicated trip and close output contacts and prevents the trip and close output contacts from being asserted at the same time.

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	=	WB52A
CL	=	(PB8 * !LT5 + CC * LT5 + /IN102 * LT5) * LT6 * TRCAP * CLCAP
ULCL	=	TRIP + WBTR + ! (LT6 + WBCL)

The factory setting for the Close Failure Timer setting is:

CFD	=	15.00 cycles

With setting CFD = 15.00 cycles, once the CLOSE Relay Word bit asserts, it remains asserted at logical 1 no longer than a maximum of 15 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 (and the reclosing relay to lockout if it was an auto-reclosure).

Note: There is no need to set CFD to other than 15 cycles. The final trip/close logic in Figure 7.30 takes care of all timing issues concerning the dedicated close output contact. The CLOSE Relay Word bit output of the close logic in Figure 6.1 (that precedes the CFD timer) propagates to the final trip/close logic in Figure 7.30.

See Figure 1.20, Figure 1.21, and Figure 1.22 in ***Section 1: Factory-Set Logic*** for more information on factory-set SELOGIC control equation settings CL, ULCL, and 52A.

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*** later in this section).

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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***. 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

The final trip/close logic in Figure 7.30 (that has input from Figure 6.1) controls dedicated trip and close output contacts.

See ***Output Contacts*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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.

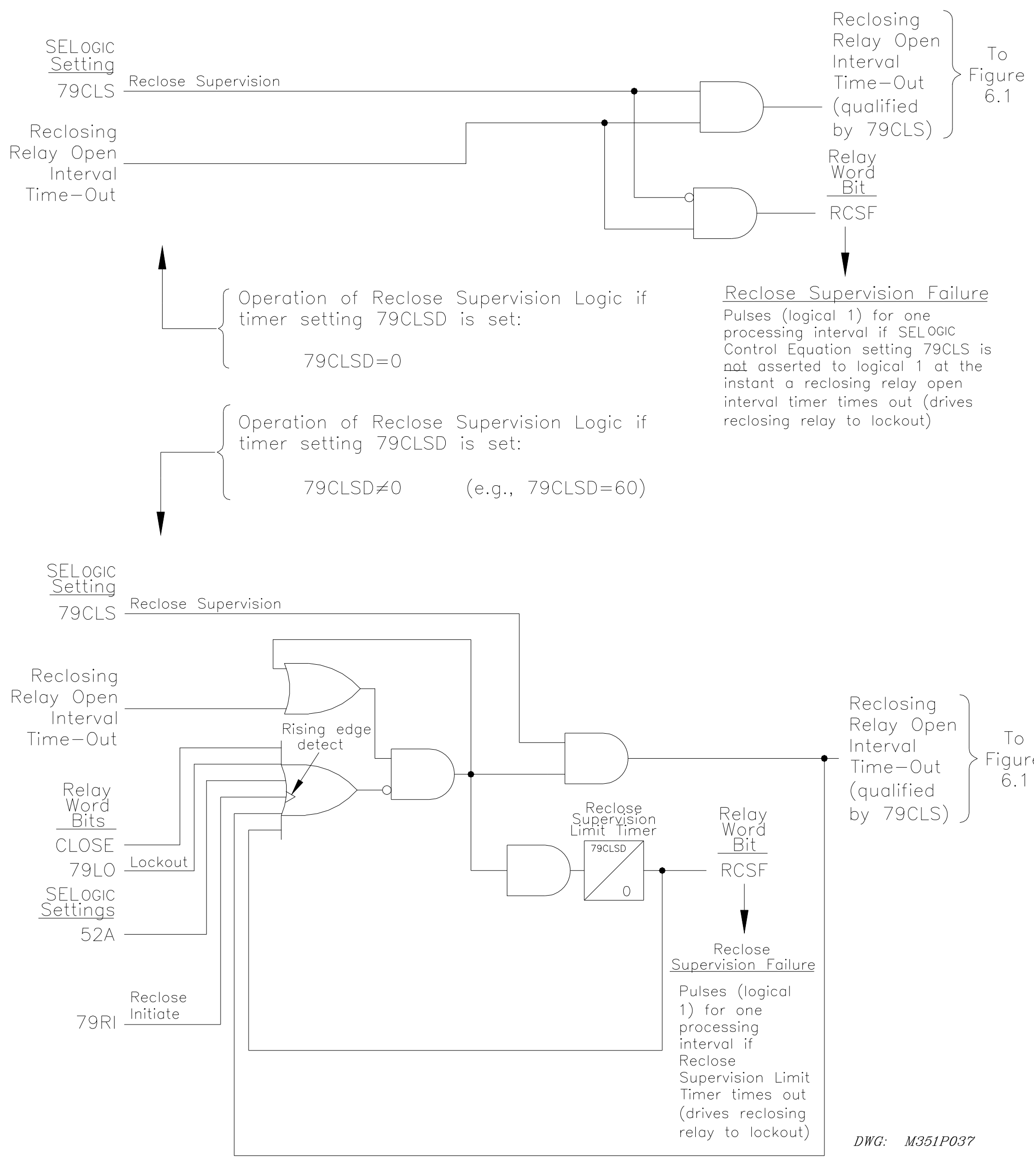

Figure 6.2: Reclose Supervision Logic (following open interval time-out)

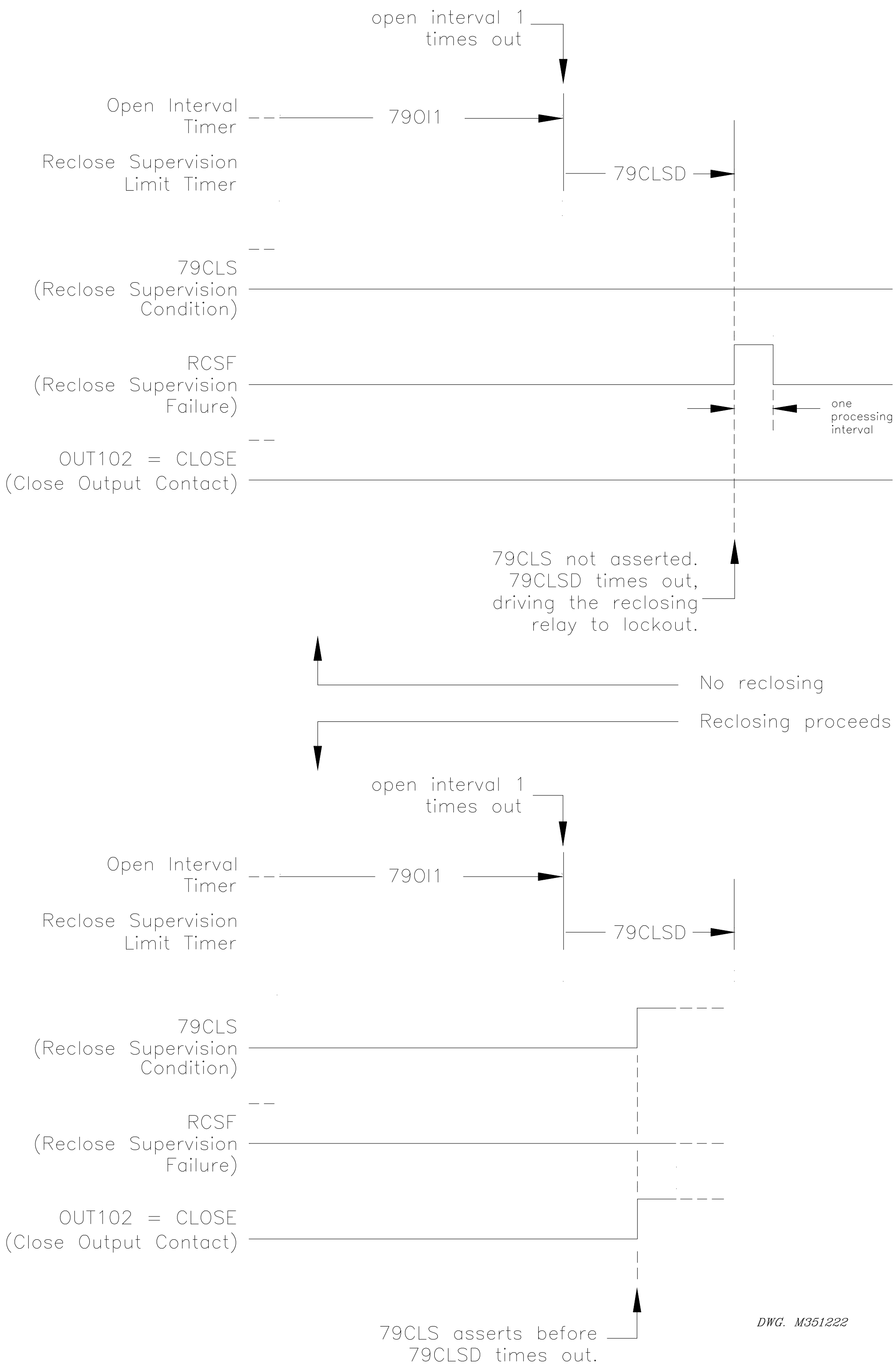

Figure 6.3: Reclose Supervision Limit Timer Operation (refer to bottom of Figure 6.2)

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 settings sheets at the end of ***Section 9: Setting the SEL-351P Recloser Control*** 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 ***Settings Example 1*** that follows in this subsection.

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 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*** that follows in this subsection.

Settings Example 1

Refer to the top of Figure 6.2 and Figure 6.4.

SEL-351P-3s 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-351P-3(1) recloses circuit breaker 52/1 first, followed by the SEL-351P-3(2) reclosing circuit breaker 52/2, after a synchronism check across circuit breaker 52/2.

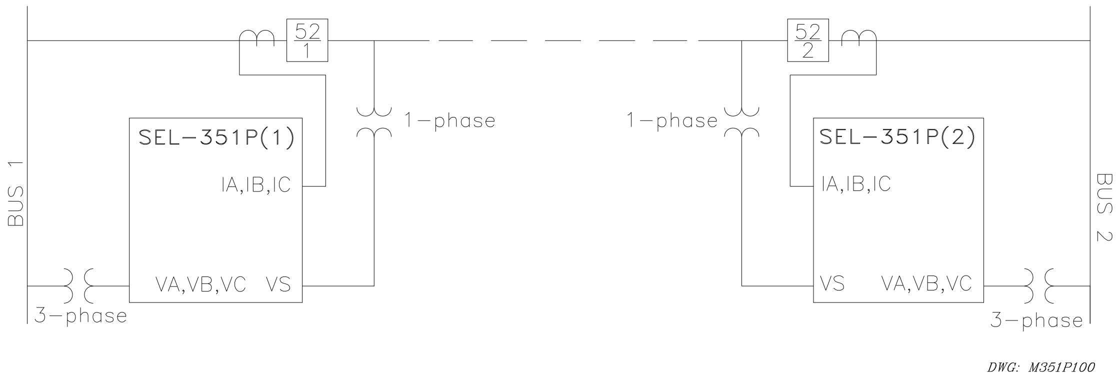

Figure 6.4: SEL-351P-3 Recloser Controls Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme

SEL-351P-3(1) Recloser Control

Before allowing circuit breaker 52/1 to be reclosed after an open interval time-out, the SEL-351P-3(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-351P-3(2) Recloser Control

The SEL-351P-3(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-351P-3(1) and SEL-351P-3(2) Recloser Controls

Refer to ***Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, respectively)*** in the following ***Reclosing Relay*** subsection.

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-351P-3(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-351P-3(2) starts open interval timing after circuit breaker 52/1 at the remote end has reenergized the line. The SEL-351P-3(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-351P-3(2) open interval timing is stalled when the transmission line voltage and Bus 2 voltage are <u>not</u> in synchronism across open circuit breaker 52/2:

79STL = !25A1 [=NOT(25A1)]

Note: 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-351P-3(2) Relay 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-351P-3(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-351P-3(2) (see Figure 7.23 and Figure 7.24). Note the built-in 3-cycle qualification of the synchronism check voltages shown in Figure 3.24.

<u>Settings Example 2</u>

Refer to subsection ***Synchronism Check Elements*** in ***Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements***. 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 subsection ***Synchronism Check Elements***, note item 3 under ***Synchronism Check Element Outputs, Voltages V_P and V_S are "Slipping."*** 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 (4) 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 through 4 are the number of desired automatic reclosures (see ***Open Interval Timers*** that follows in this subsection).

Reclosing Relay States and General Operation

Figure 6.5 explains in general the different states of the reclosing relay and its operation.

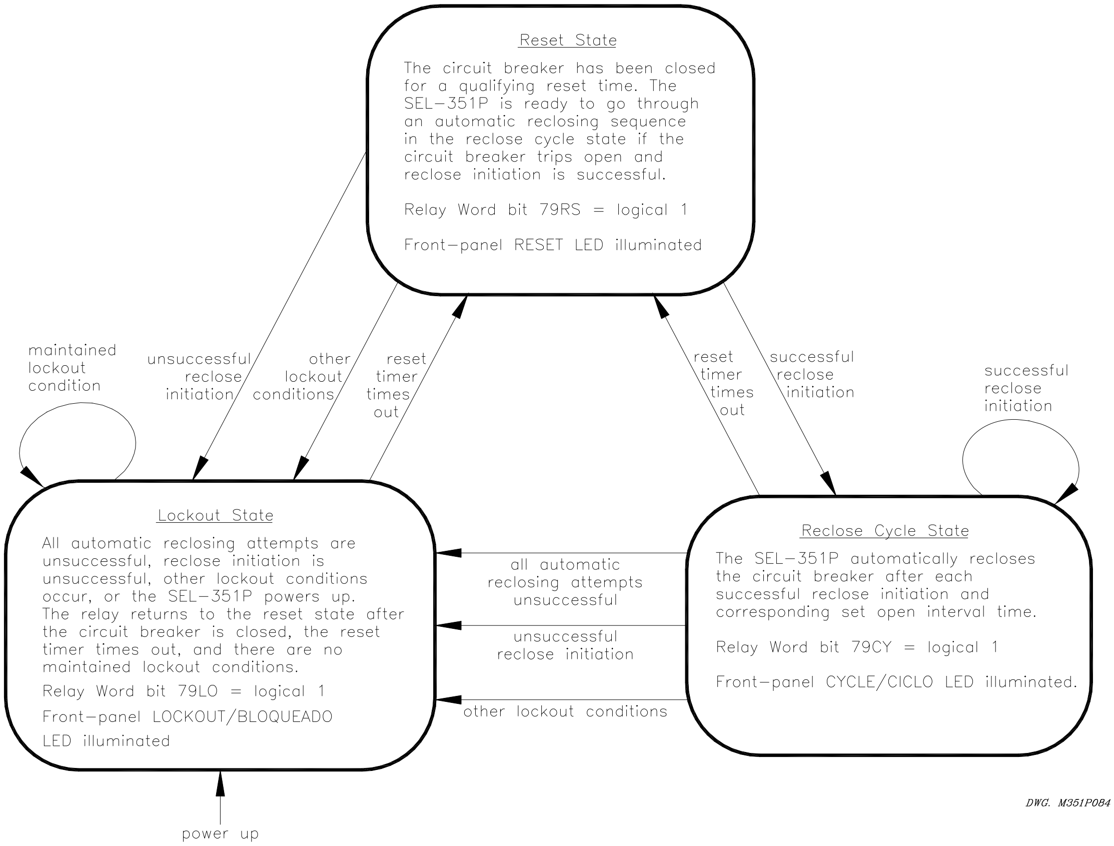

Figure 6.5: Reclosing Relay States and General Operation

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	RESET
Reclose Cycle	79CY	CYCLE/CICLO
Lockout	79LO	LOCKOUT/BLOQUEADO

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)*** later in this subsection].
- 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)*** later in this subsection.
- 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)*** later in this subsection].
- The Reclose Supervision Limit Timer (setting 79CLSD) times out (see Figure 6.2 and top of Figure 6.3).
- A new reclose initiation occurs while the reclosing relay is timing on an open interval (e.g., flashover in the tank while breaker is open).

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-351P-3 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 settings sheets at the end of ***Section 9: Setting the SEL-351P-3 Recloser Control***.

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 RESET, CYCLE/CICLO, and LOCKOUT/BLOQUEADO 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*** earlier in this section for more discussion on SELOGIC control equation settings 52A and CL. Also see ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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)	32.50	open interval 1 time
79OI2 (0.00–999999 cyc)	45.00	open interval 2 time
79OI3 (0.00–999999 cyc)	245.00	open interval 3 time
79OI4 (0.00–999999 cyc)	0.00	open interval 4 time
79RSD (0.00–999999 cyc)	50.00	reset time from reclose cycle state
79RSLD (0.00–999999 cyc)	50.00	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 settings sheets at the end of ***Section 9: Setting the SEL-351P-3 Recloser Control***.

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 790I3 and 79OI4 would both 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.

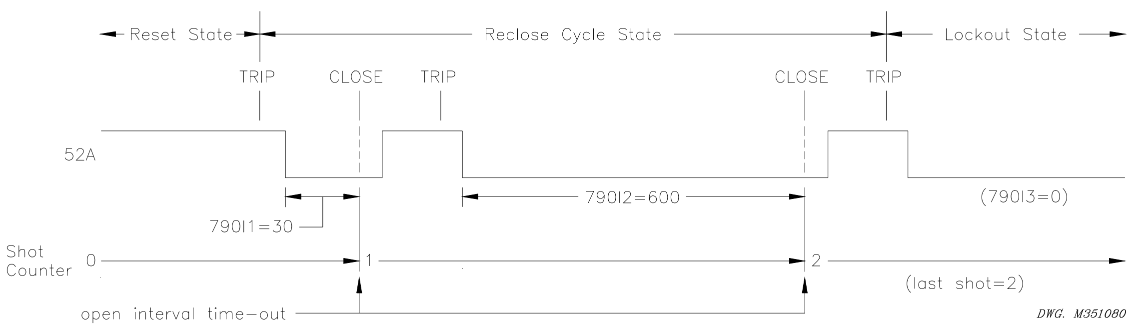

Figure 6.6: Reclosing Sequence from Reset to Lockout With Example Settings

Note: Open intervals should not be set less than 30 cycles, otherwise the control will go to lockout prematurely.

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)*** later in this subsection].

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	=	32.50
79OI2	=	45.00
79OI3	=	245.00
790I4	=	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/VARIOS pushbutton). See ***Functions Unique to the Front-Panel Interface*** in ***Section 11: Additional Front-Panel Interface Details***.

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*** earlier in this section for more discussion on SELOGIC control equation setting 52A. Also see ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** for more discussion on SELOGIC control equation setting 52A.)

Setting 79RSD:

Qualifies closures when the SEL-351P-3 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)*** discussed later in this subsection].

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-351P-3, 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-351P-3 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*** earlier in this subsection).

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)*** later in this subsection].

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-351P-3 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-351P-3 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-351P-3 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)*** later in this subsection].

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)*** later in this subsection.

Reclosing Relay Shot Counter

Refer to Figure 6.6.

The shot counter increments for each reclose operation. For example, when the SEL-351P-3 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)*** earlier in this subsection]. 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)*** later in this subsection].

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 + !LT6) * (TRIP + !52A) + 81D1T + SV16 + SV1	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	TRCAP * CLCAP * !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-351P-3 to successfully initiate reclosing and start timing on the first open interval. The SEL-351P-3 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-351P-3 is in the reclose cycle state (79CY = logical 1) and the SEL-351P-3 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-351P-3 sees the recloser close.

If a flashover occurs in a recloser tank during an open interval (recloser open and the SEL-351P-3 calls for a trip), the SEL-351P-3 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 in ***Section 5: Trip and Target Logic***).

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 Figures 1.21 and 6.1 and accompanying explanation) when 79RI = !52A. Making this change to the ULCL setting keeps the SEL-351P-3 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/BLOQUEADO 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 ¼ cycle—see Figure 1.25)

- reclose initiation is by the breaker contact opening (e.g., 79RI = !52A—see ***Additional Settings Example*** in the preceding setting 79RI [reclose initiation] discussion.

Then the drive-to-lockout condition overlaps reclose initiation and the SEL-351P-3 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*** earlier in this subsection).

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-351P-3 is in the lockout state (Relay Word bit 79LO = logical 1), the SEL-351P-3 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*** earlier in this subsection).

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*** earlier in this subsection).

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*** earlier in this subsection).

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-351P-3 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-351P-3 as shown in Figure 6.7.

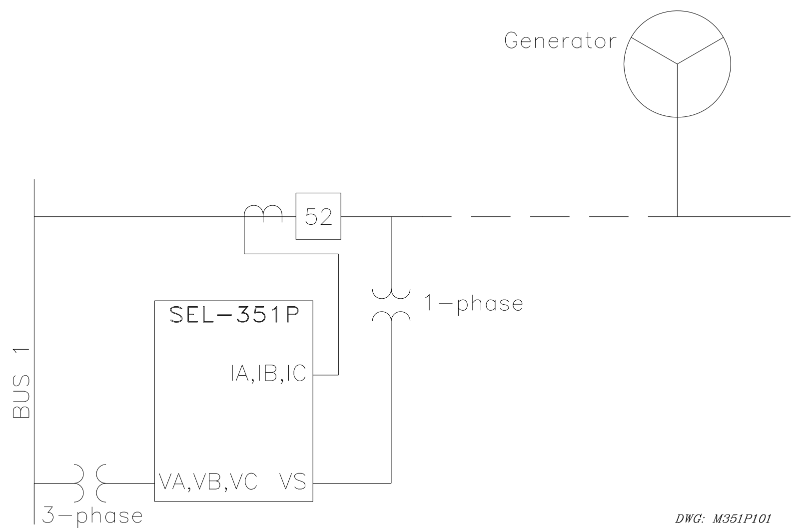

Figure 6.7: Reclose Blocking for Islanded Generator

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*** earlier in this subsection).

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-351P-3 in step with a downstream recloser control (another SEL-351P-3 or otherwise; see Figure 6.8). Sequence coordination prevents overreaching SEL-351P-3 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-351P-3 (1) to increment the shot counter by one count to keep in step with the operation of downstream SEL-351P-3 (2), all the following have to occur in SEL-351P-3 (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)*** earlier in this subsection].

See Figure 1.27 in ***Section 1: Factory-Set Logic*** for the 79SEQ factory settings and accompanying example.

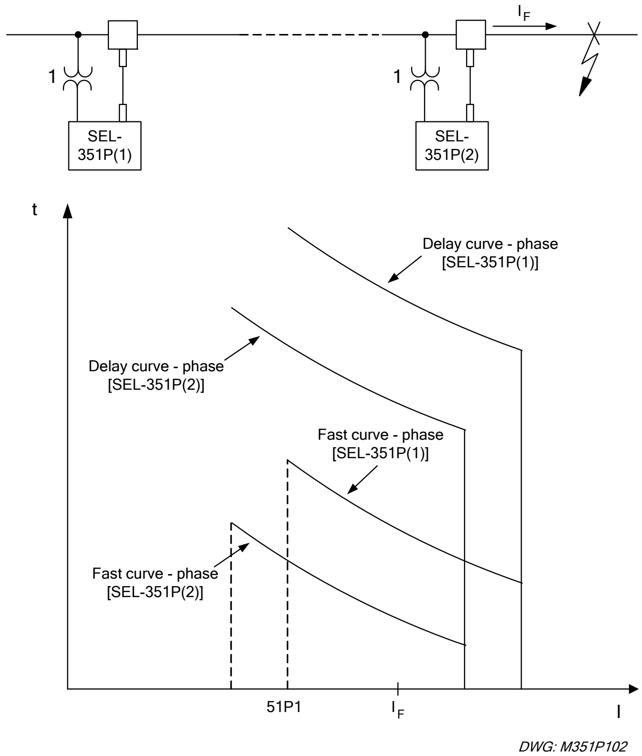

Figure 6.8: SEL-351P-3 Recloser Controls in Series, Requiring Sequence Coordination

Reclose Supervision Setting (79CLS)

See Reclose Supervision Logic earlier in this section.

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SECTION 7: INPUTS, OUTPUTS, TIMERS, AND OTHER CONTROL LOGIC 7-1

TABLES

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SECTION 7: INPUTS, OUTPUTS, TIMERS, AND OTHER CONTROL LOGIC

This section explains the settings and operation of:

• Optoisolated inputs	IN101–IN106
• Extra local control switches	local bits LB1–LB16
• Remote control switches	remote bits RB1–RB16
• Latch control switches	latch bits LT1–LT16
• SELOGIC® counters	counters SC1–SC8
• Multiple setting groups	group switching settings SS1–SS6
• SELOGIC control equations variables/timers	SV1/SV1T–SV16/SV16T
• Output contacts	OUT101–OUT107 and ALARM
• Rotating default displays	display points DP1–DP16

The above items are all the logic input/output of the relay. 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-351P-3 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 through IN106 in Figure 7.1) that follow corresponding optoisolated inputs (e.g., optoisolated inputs IN101 through IN106 in Figure 7.1) for the different SEL-351P-3 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 and Figure 3 in the ***Installation*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide***).

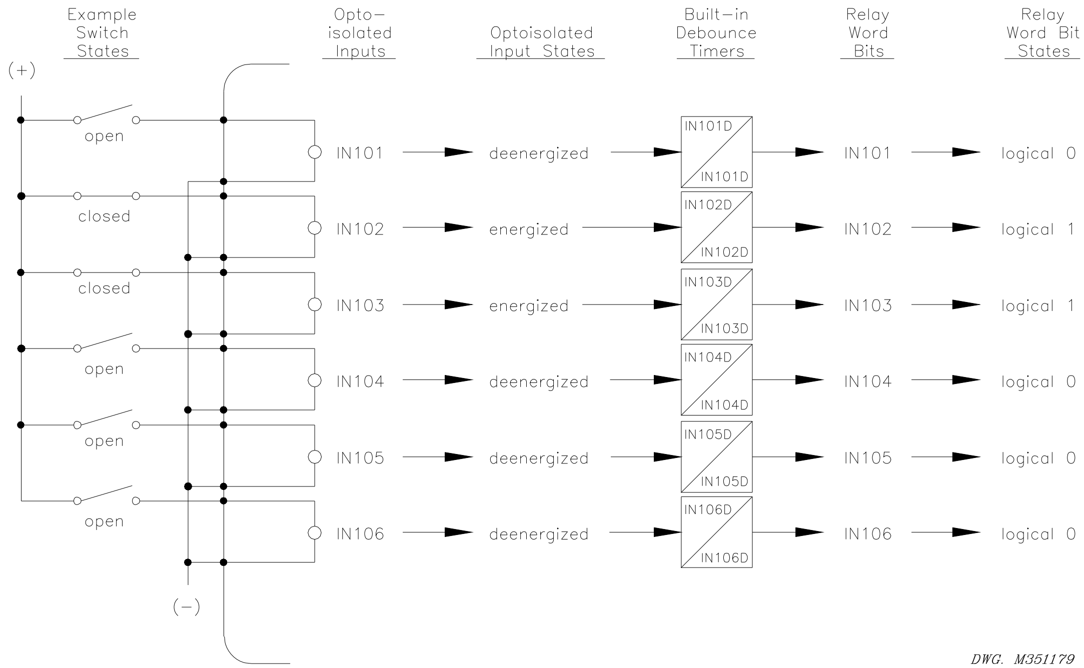

Figure 7.1: Example Operation of Optoisolated Inputs IN101 Through IN106

Input Debounce Timers

See Figure 7.1.

Each input has settable pickup/dropout timers (IN101D through IN106D) for input energization/deenergization 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 through IN106D are settable from 0.00 to 1.00 cycles (or to "AC"—discussed below). The SEL-351P-3 takes the entered time setting and internally runs the timer at the nearest 1/16-cycle. For example, if setting IN105D = 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)*** in ***Section 10: Serial Port Communications and Commands*** 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 relay processing interval is 1/4-cycle, so Relay Word bits IN101 through 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 through IN106 are updated every 1/4-cycle.

If more than 1 cycle of debounce is needed, run Relay Word bit IN*n* (*n* = 101 through 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 through IN106 receive their function by the way their corresponding Relay Word bits IN101 through IN106 are used in SELOGIC control equations.

Settings Examples

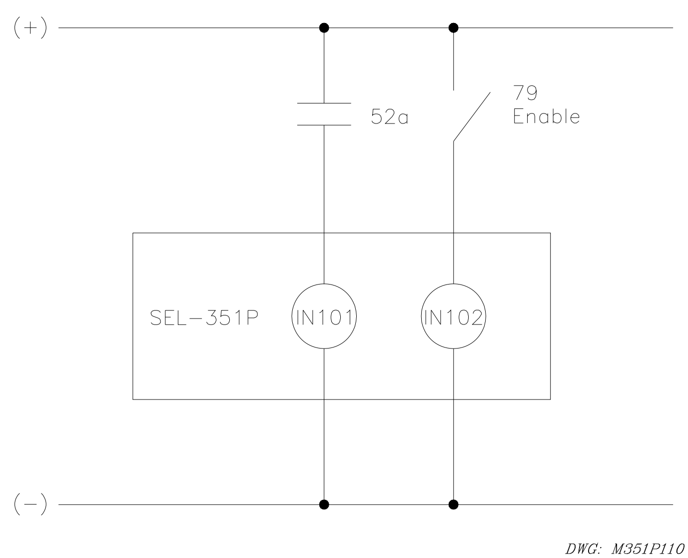

Figure 7.2: Circuit Breaker Auxiliary Contact and Reclose Enable Switch Connected to Optoisolated Inputs IN101 and IN102

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*** in ***Section 6: Close and Reclose Logic*** 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*** at the end of this section)]. 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-351P-3 contains sixteen (16) local control switches. Control of these local switches is through the front-panel keyboard/display (see ***Section 11: Additional Front-Panel Interface Details***).

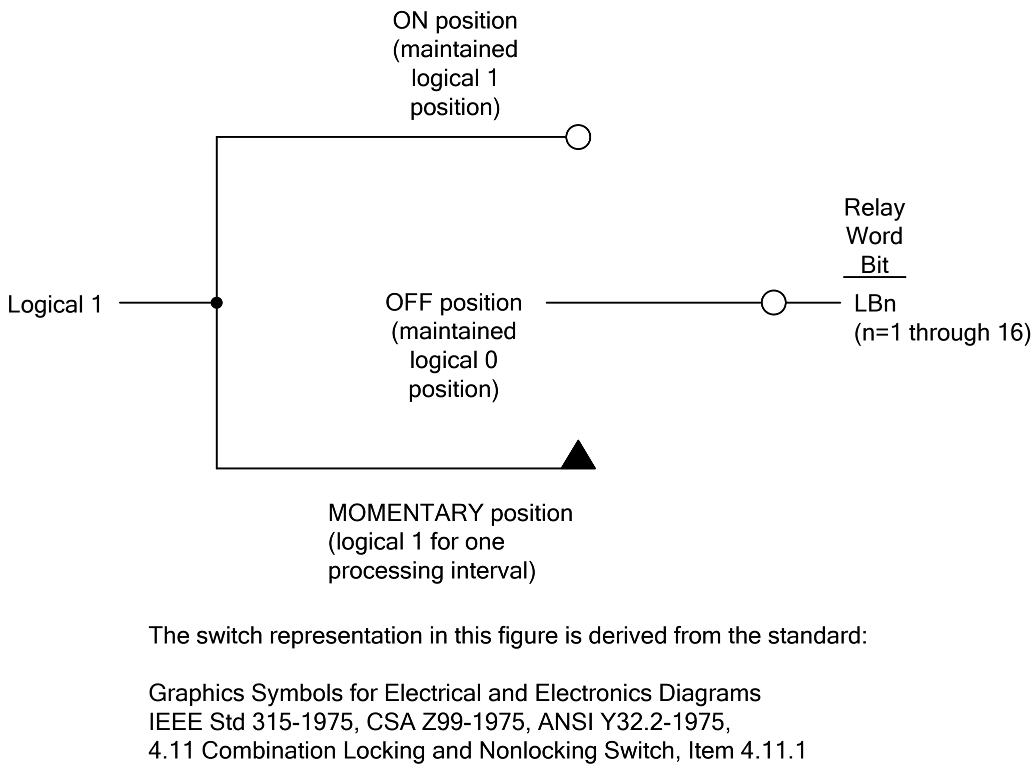

Figure 7.3: Local Control Switches Drive Local Bits LB1 Through LB16

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 through 16. The local control switch logic in Figure 7.3 repeats for each local bit LB1 through 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

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
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-351P-3 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.

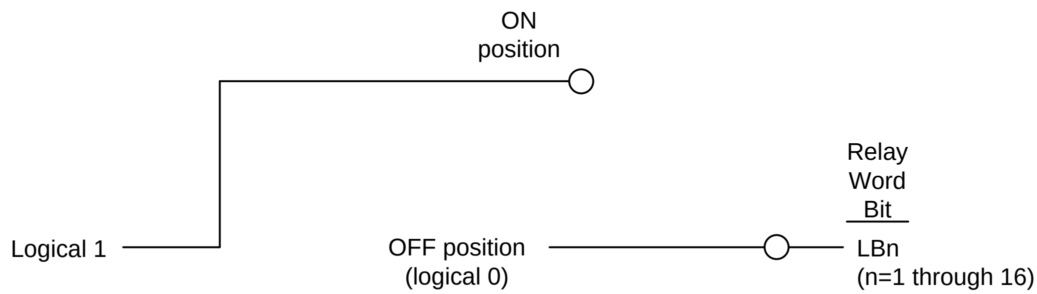

Figure 7.4: Local Control Switch Configured as an ON/OFF Switch

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).

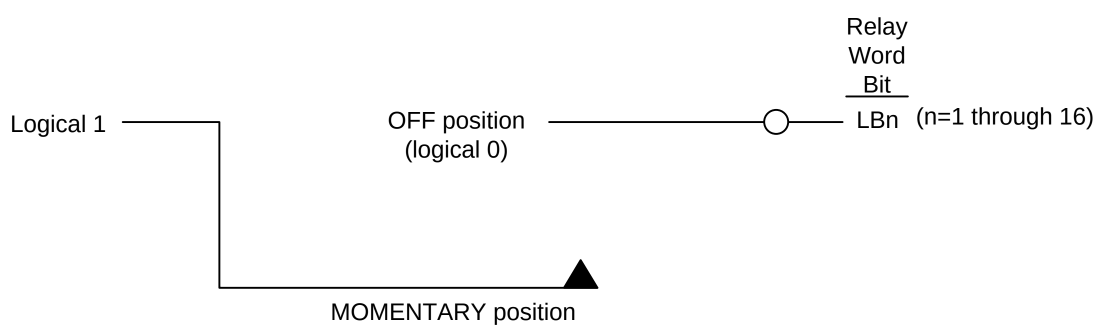

Figure 7.5: Local Control Switch Configured as an OFF/MOMENTARY Switch

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).

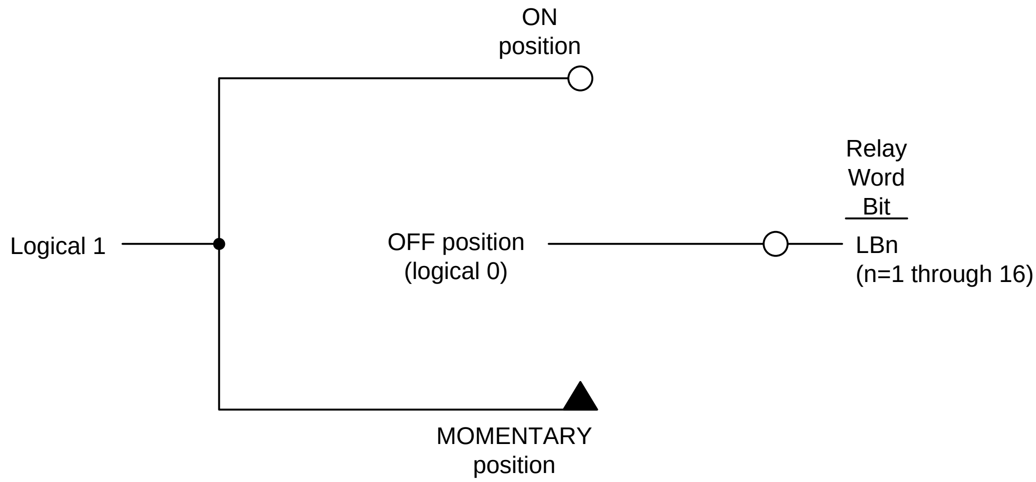

Figure 7.6: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

Table 7.2: Correspondence Between Local Control Switch Types and Required Label Settings

Local Switch Type	**Label NLB*n***	**Label CLB*n***	**Label SLB*n***	**Label PLB*n***
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-351P-3 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

Local Bit	Label Settings	Function
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.

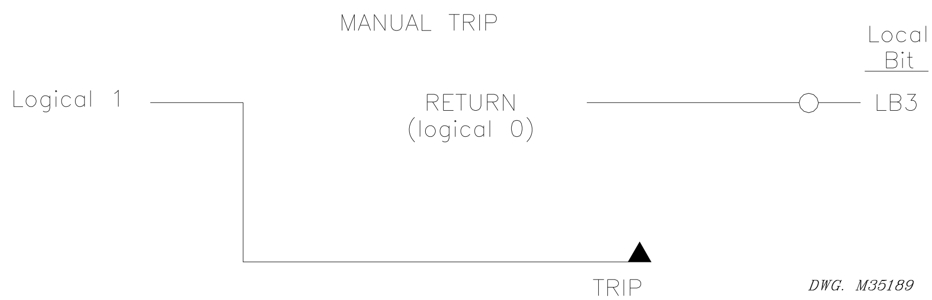

Figure 7.7: Configured Manual Trip Switch Drives Local Bit LB3

Local bit LB3 is set to trip in the following SELOGIC control equation trip setting example (see Figure 5.1 in ***Section 5: Trip and Target Logic***):

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

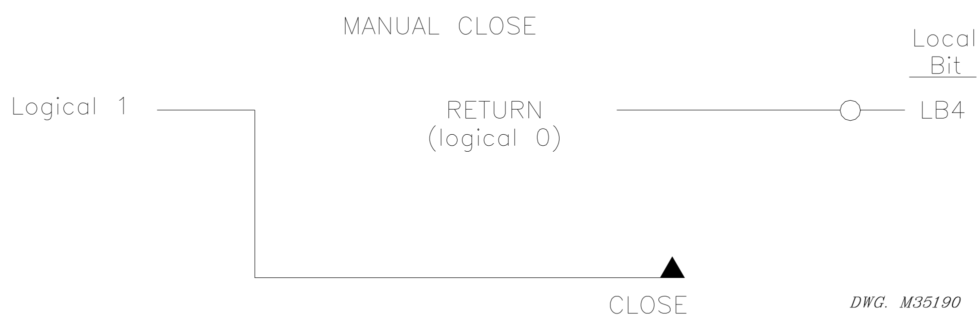

Figure 7.8: Configured Manual Close Switch Drives Local Bit LB4

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 in ***Section 6: Close and Reclose Logic***).

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 through LB16 is retained if power to the relay 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 through 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 relay 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)*** in ***Section 10: Serial Port Communications and Commands***).

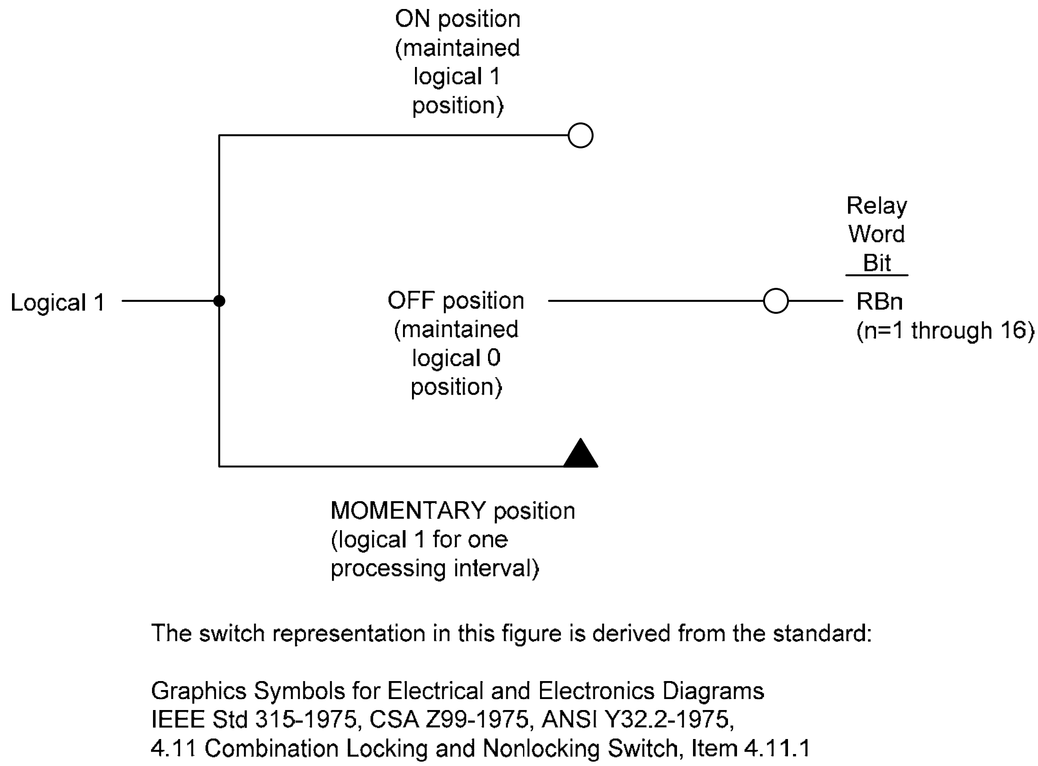

Figure 7.9: Remote Control Switches Drive Remote Bits RB1 Through RB16

The outputs of the remote control switches in Figure 7.9 are Relay Word bits RB*n* called remote bits, where *n* = 1 through 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 the preceding section on ***Local Control Switches***).

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 through RB8 (RB1 through RB16 for the SEL-351P-2) are not retained if power to the relay 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 relay.

Remote Bit States Retained When Settings Changed or Active Setting Group Changed

The state of each remote bit RB1 through RB16 is retained if a relay setting within any group, or the active setting 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 relay is not momentarily disabled.

Latch Control Switches

The latch control switch feature of this relay replaces latching relays. Traditional latching relays maintain their output contact state when set. The SEL-351P-3 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 relay, 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).

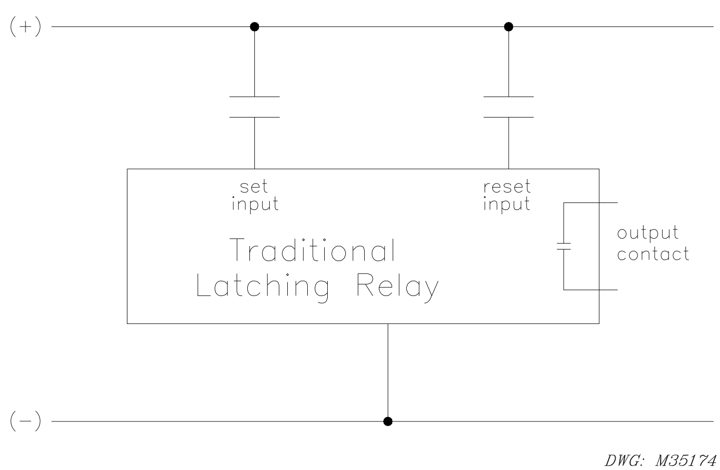

Figure 7.10: Traditional Latching Relay

The sixteen (16) latch control switches in the SEL-351P-3 provide latching relay type functions.

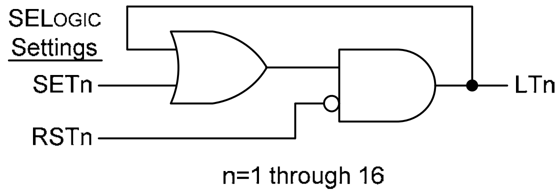

Figure 7.11: Latch Control Switches Drive Latch Bits LT1 Through LT16

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 through 16. The latch control switch logic in Figure 7.11 repeats for each latch bit LT1 through 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-351P-3.

Reclosing Relay Enable/Disable Setting Example

Use a latch control switch to enable/disable the reclosing relay in the SEL-351P-3. 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.

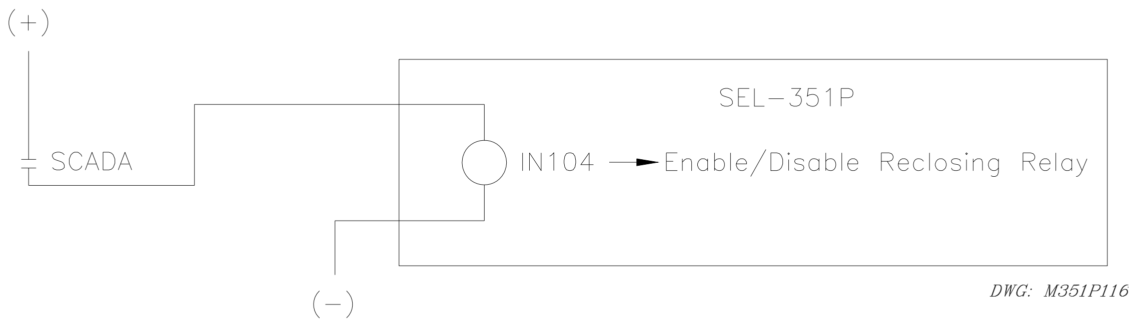

Figure 7.12: SCADA Contact Pulses Input IN4 to Enable/Disable Reclosing Relay

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]

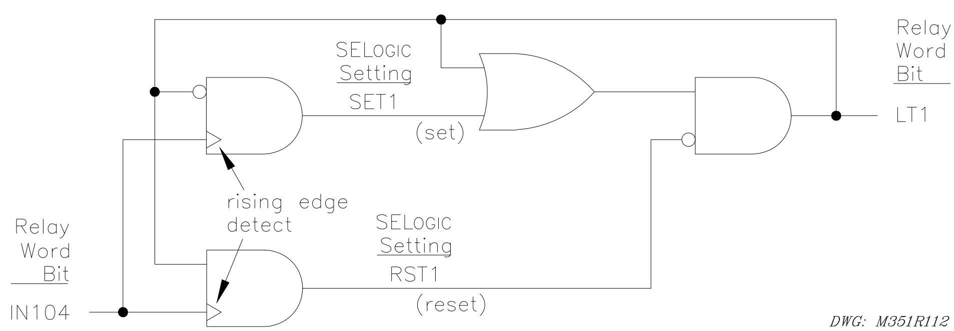

Figure 7.13: Latch Control Switch Controlled by a Single Input to Enable/Disable Reclosing

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

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

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.

Note: Refer to preceding subsection ***Optoisolated Inputs*** 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.

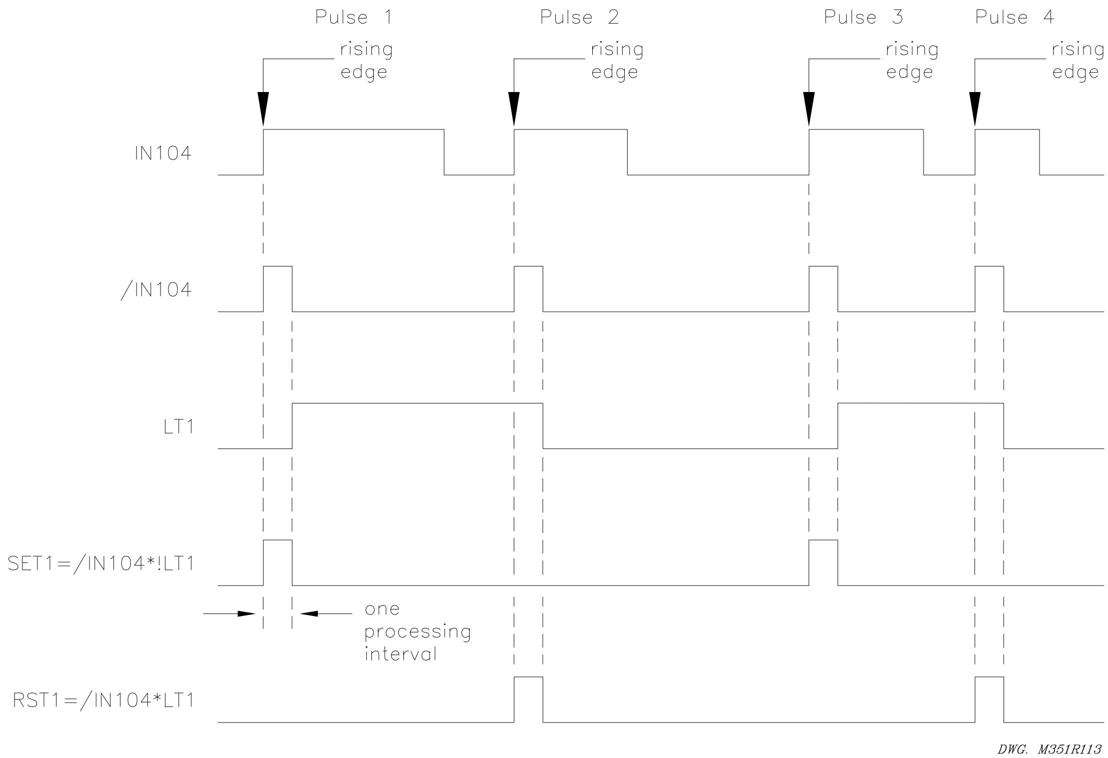

Figure 7.14: Latch Control Switch Operation Time Line

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 through 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

The states of the latch bits LT1 through LT16 are retained if power to the relay 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 when power is lost, it comes back deasserted (LT3 = logical 0) 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.

Note: Although the relay retains the state of a latched bit when power is cycled, the relay cannot hold contact closure when power is removed from the relay.

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 through 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 relay 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 through 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 through 16. Relay Word bits SG1 through SG6 indicate the active setting Group 1 through 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) + ...]

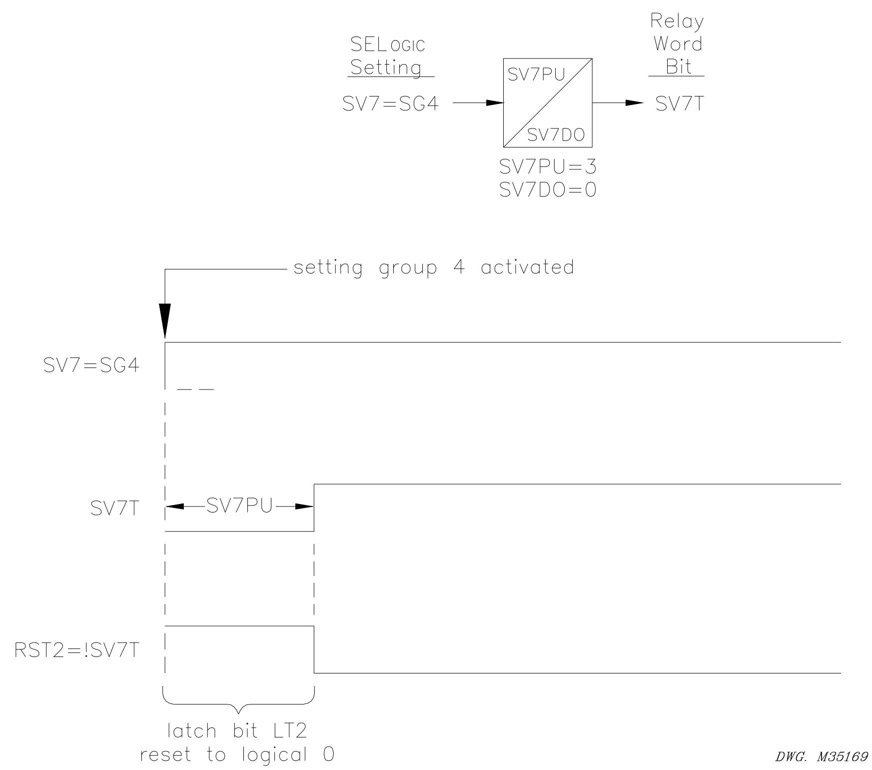

Figure 7.15: Time Line for Reset of Latch Bit LT2 After Active Setting Group Change

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.

Note: 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. <u>This limit translates to an average of 70 cumulative latch bit state changes per day for a 25-year relay service life</u>. 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 through 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).

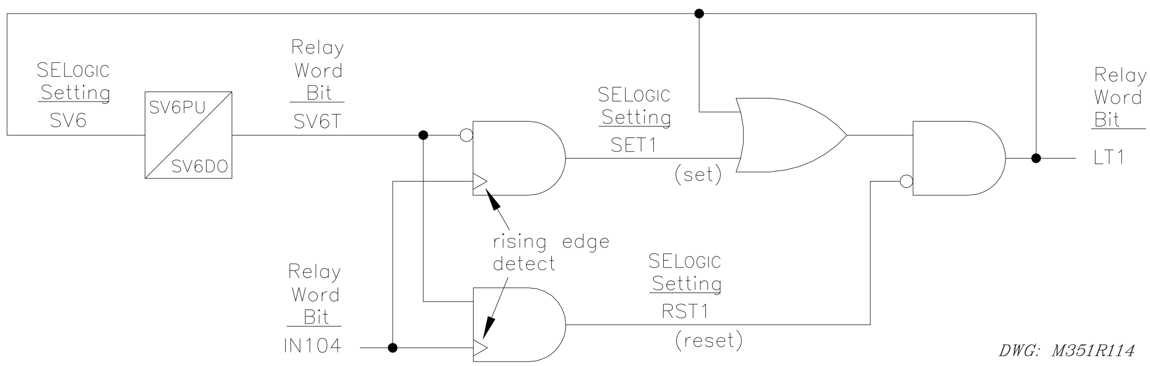

Figure 7.16: Latch Control Switch (with Time Delay Feedback) Controlled by a Single Input to Enable/Disable Reclosing

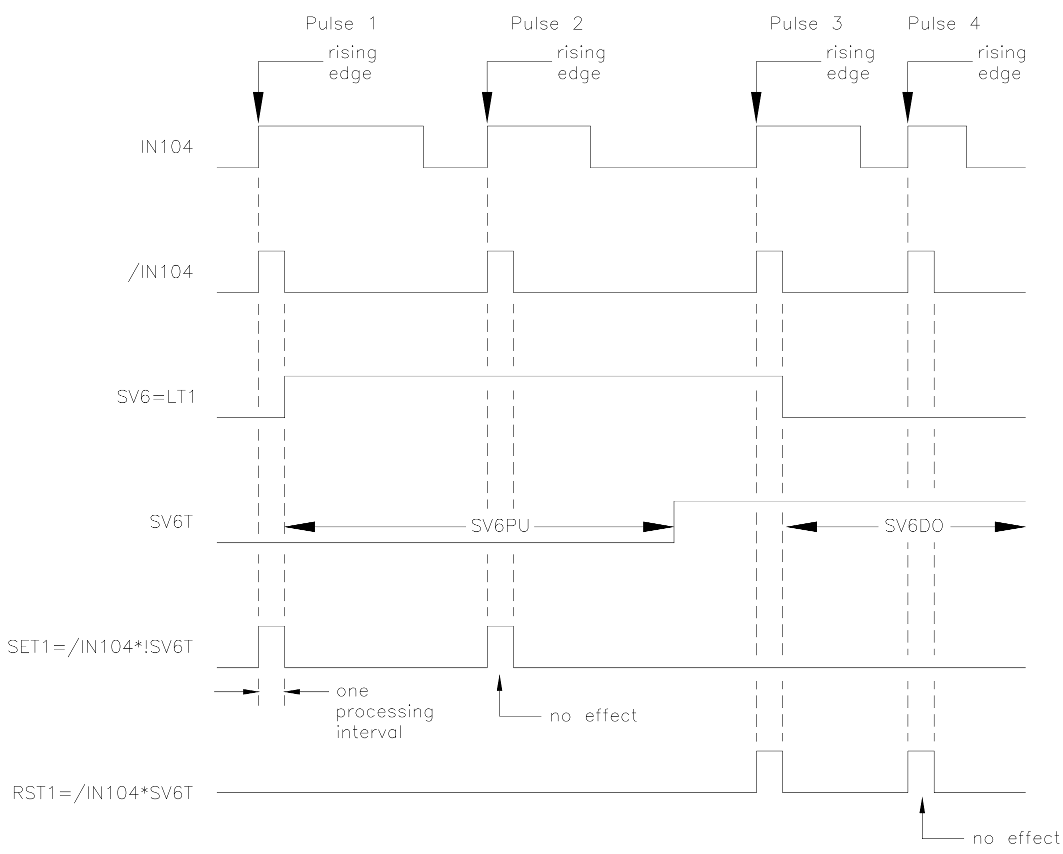

Figure 7.17: Latch Control Switch (with Time Delay Feedback) Operation Time Line

MULTIPLE SETTING GROUPS

The relay has six (6) independent setting groups. Each setting group has complete relay (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 through SG6 indicate the active setting group:

Table 7.3: Definitions for Active Setting Group Indication Relay Word Bits SG1 Through SG6

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
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 through 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 through 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 Through SS6

Each setting group has its own set of SELOGIC control equation settings SS1 through 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 through 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 relay 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 through SS6 have priority over the serial port **GROUP** command and the front-panel GROUP pushbutton in selecting the active setting group. If any <u>one</u> of SS1 through 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 through SS6 <u>all</u> 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-351P-3 Disabled Momentarily During Active Setting Group Change

The SEL-351P-3 is disabled for a **few seconds** while in the process of changing active setting groups. SEL-351P-3 elements, timers, and logic are reset, unless indicated otherwise in the specific logic description. For example, during an active setting group change, the SEL-351P-3 retains states for local bits LB1 through LB16 and latch bits LT1 through LT16. The output contacts go to their de-energized state during an active setting group change, regardless of their corresponding SELOGIC control equation settings. See Figure 7.27 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-351P-3. In this example, optoisolated input IN105 on the relay 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.

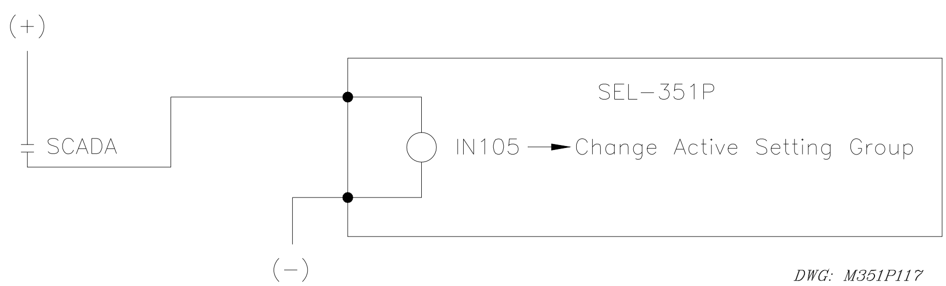

Figure 7.18: SCADA Contact Pulses Input IN105 to Switch Active Setting Group Between Setting Groups 1 and 4

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.

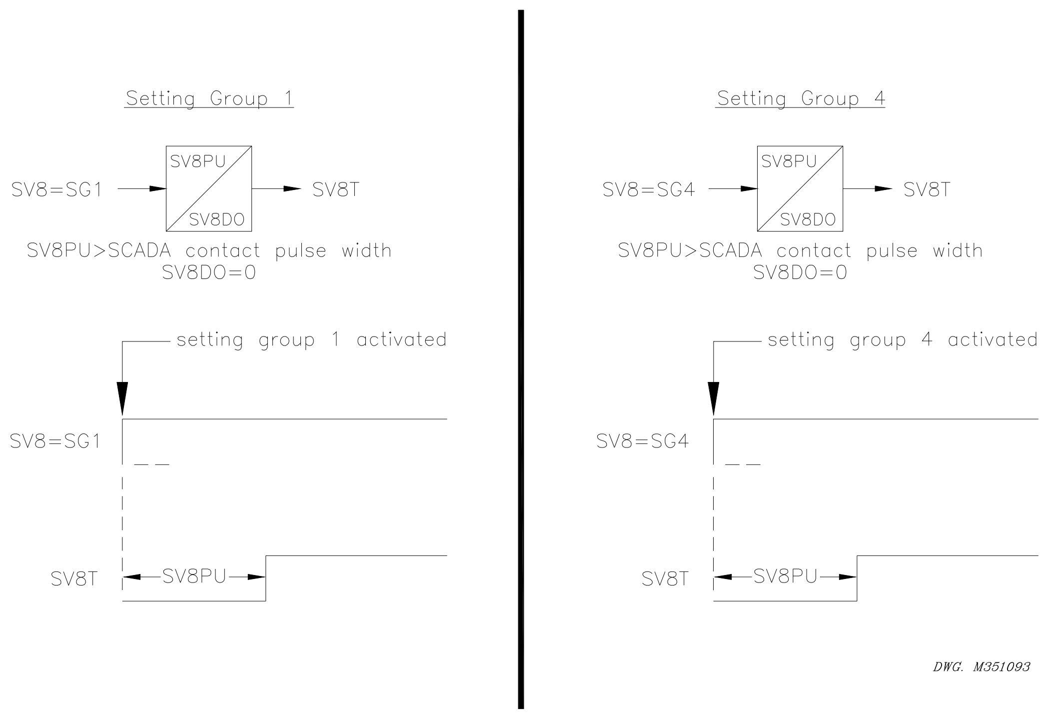

Figure 7.19: SELOGIC Control Equation Variable Timer SV8T Used in Setting Group Switching

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 relay 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 relay 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).

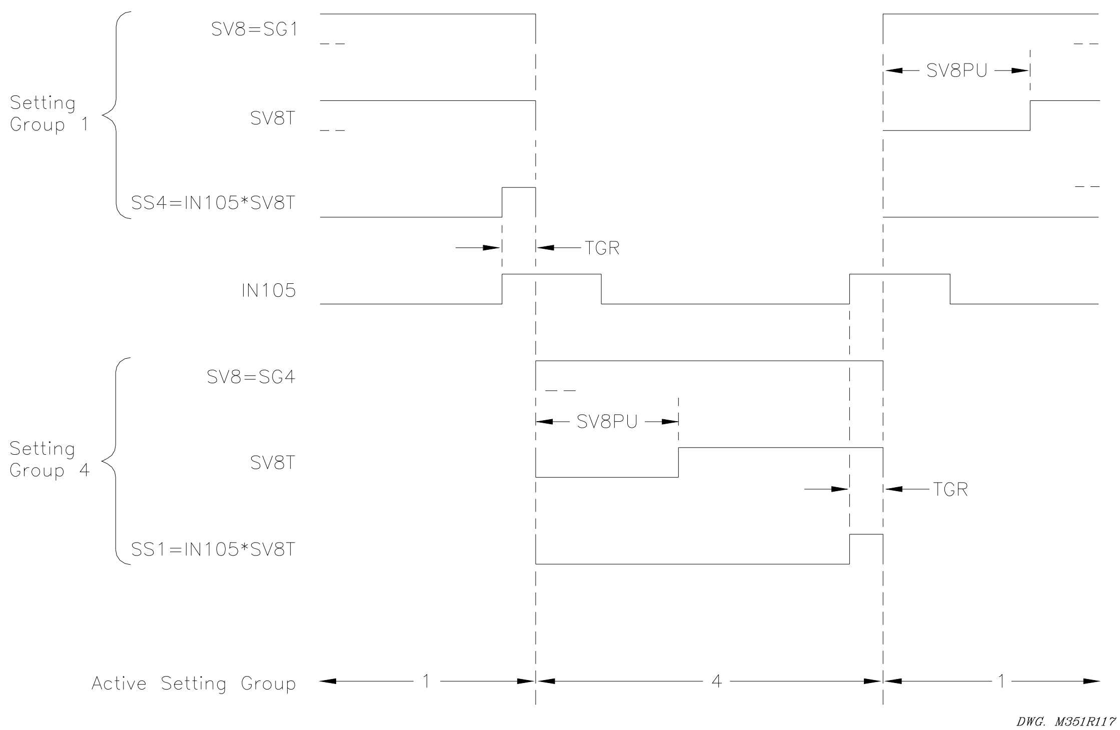

Figure 7.20: Active Setting Group Switching (with Single Input) Time Line

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
IN103	**IN102**	**IN101**	**Setting Group**
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-351P-3 can be programmed to operate similarly. Use three optoisolated inputs to switch between the six setting groups in the SEL-351P-3. In this example, optoisolated inputs IN101, IN102, and IN103 on the relay are connected to a rotating selector switch in Figure 7.21.

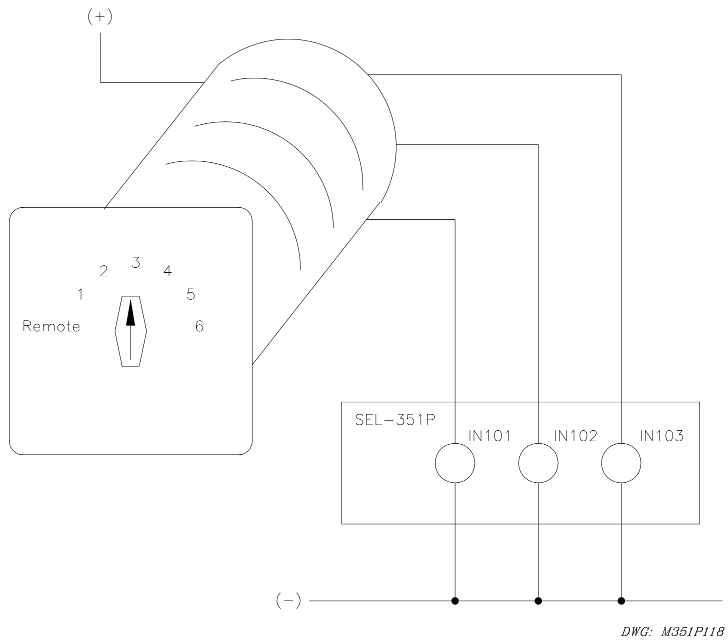

Figure 7.21: Rotating Selector Switch Connected to Inputs IN101, IN102, and IN103 for Active Setting Group Switching

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

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 through 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 the position 3 to position 5 on the selector switch, the switch passes through the 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 the 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 7.19, all inputs IN101, IN102, and IN103 are de-energized and all settings SS1 through 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 through 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.

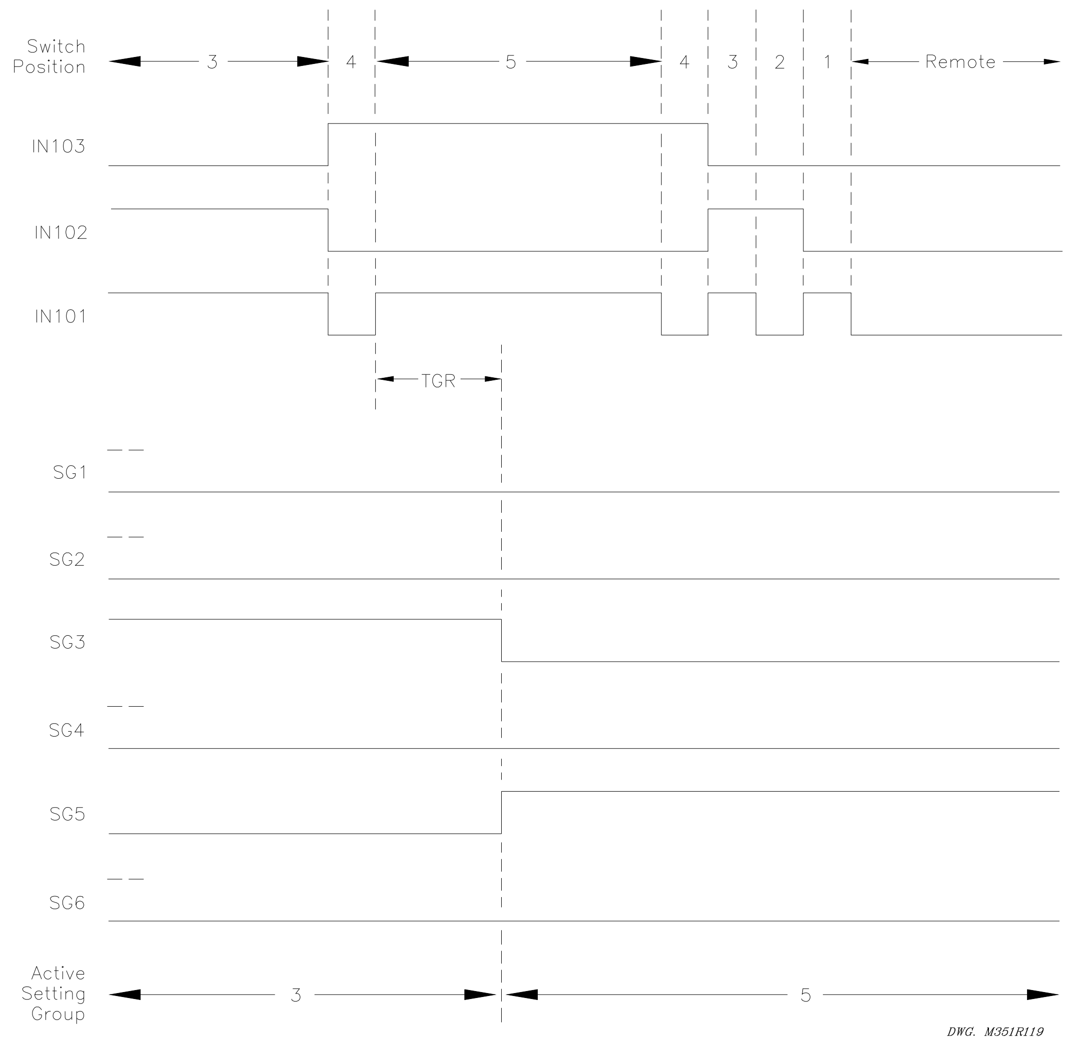

Figure 7.22: Active Setting Group Switching (with Rotating Selector Switch) Time Line

Active Setting Group Retained

Power Loss

The active setting group is retained if power to the relay 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 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 active setting group (the relay is not momentarily disabled).

If the individual settings change causes a change in one or more SELOGIC control equation settings SS1 through SS6, the active setting group can be changed, subject to the newly enabled SS1 through SS6 settings.

Note: 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 relay service life. Therefore, set equations SS1 through SS6 with care so continuous cyclical changing of the active setting group does not occur. Time setting TGR qualifies settings SS1 through SS6 before changing the active setting group. If optoisolated inputs IN101 through IN106 are used in settings SS1 through 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 through SV6T 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

Timers SV7T through SV16T in Figure 7.24 have a setting range of almost 4.5 minutes:

0.00–16000.00 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 through 16).

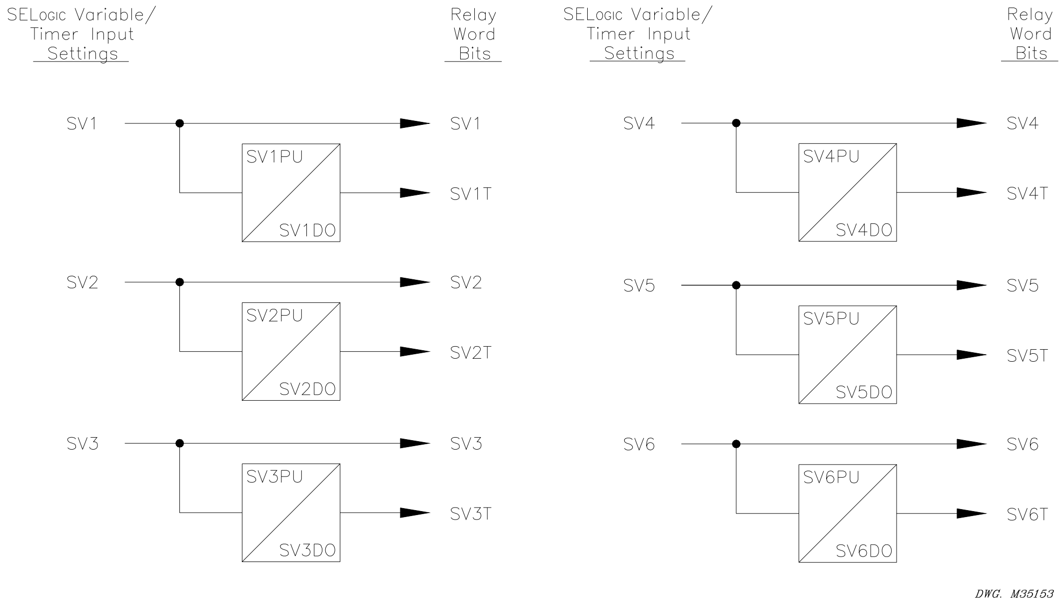

Figure 7.23: SELOGIC Control Equation Variables/Timers SV1/SV1T Through SV6/SV6T

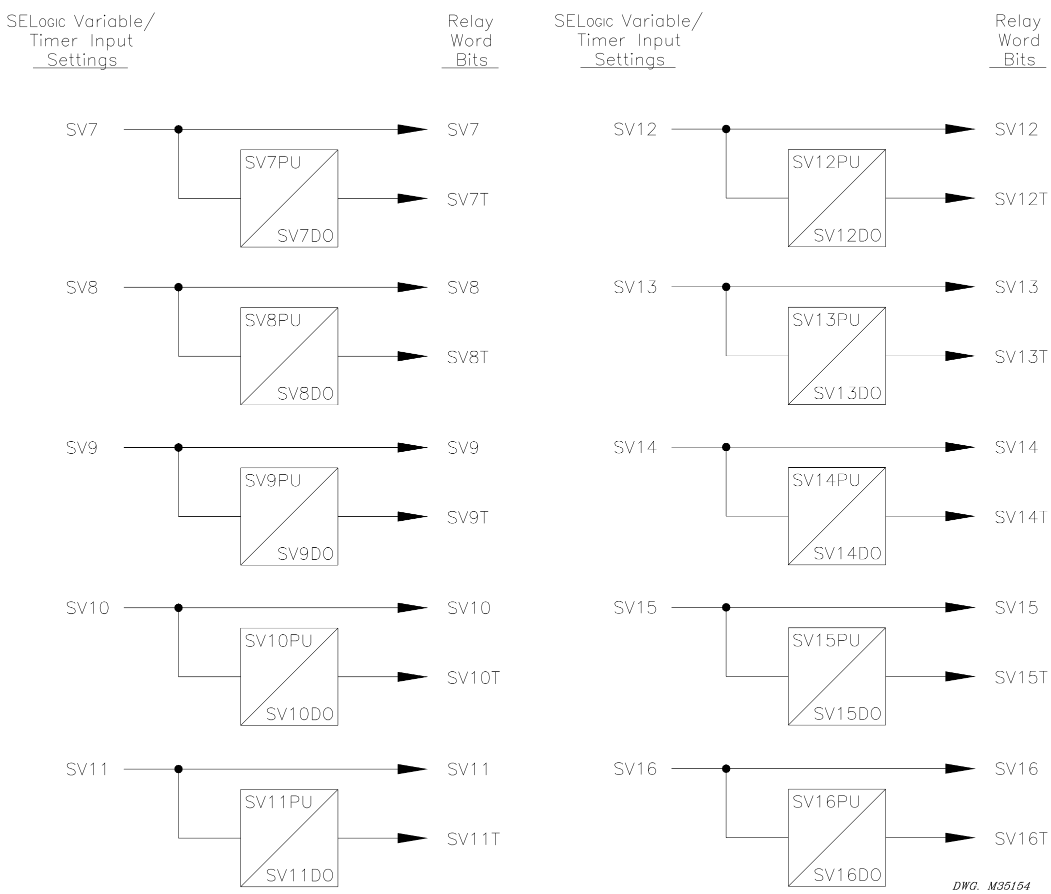

Figure 7.24: SELOGIC Control Equation Variables/Timers SV7/SV7T Through SV16/SV16T

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 2-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 7.25):

SV6 = IN101	(breaker failure initiate)
SV7 = (SV7 + IN101) * (50P1 + 50N1)	
OUT101 = SV6T	(retrip)
OUT102 = SV7T	(breaker failure trip)

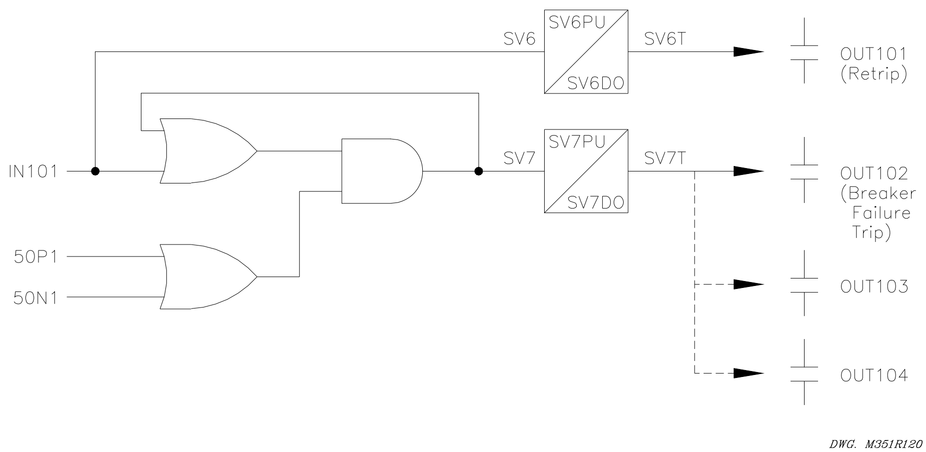

Figure 7.25: Dedicated Breaker Failure Scheme Created With SELOGIC Control Equation Variables/Timers

Note that the above SELOGIC control equation setting SV7 creates a seal-in logic circuit (as shown in Figure 7.25) 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 dropout).

Note that Figure 7.25 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 7.25 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 relay, 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 through 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 7.25 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 relay, 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

Eight (8) SELOGIC counters are available in the SEL-351P-3. Three SELOGIC control equations per counter define when the counter increments, decrements, or resets to zero, see Figure 7.26. 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.

Note: The SELOGIC counters also reset to zero if power is lost to the relay. 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.

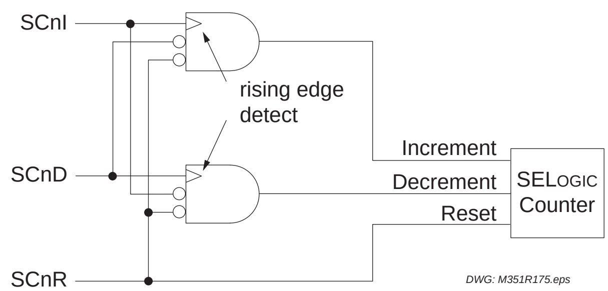

Figure 7.26: SELOGIC Counter

The value of each SELOGIC counter is accessible through a comparison statement within a SELOGIC control equation; see ***SELOGIC Control Equation Analog Compares*** in ***Appendix G: Setting SELOGIC® Control Equations***.

OUTPUT CONTACTS

Figure 7.27 shows an example operation of output contact Relay Word bits (e.g., Relay Word bits OUT101 through OUT107 in Figure 7.27) due to:

SELOGIC control equation operation (e.g., SELOGIC control equation settings OUT101 through OUT107 in Figure 7.27)

or

PULSE command execution

The output contact Relay Word bits in turn control the output contacts (e.g., output contacts OUT101 through OUT107 in Figure 7.27).

Alarm logic/circuitry controls the ALARM output contact (see Figure 7.27)

Figure 7.27 is used for 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*** earlier in this section)
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 Through OUT107

Refer to Figure 7.27.

The execution of the serial port command **PULSE *n*** (*n* = OUT101 through OUT107) asserts the corresponding Relay Word bit (OUT101 through OUT107) to logical 1. The assertion of SELOGIC control equation setting OUT*m* (*m* = 101 through 107) to logical 1 also asserts the corresponding Relay Word bit OUT*m* (*m* = 101 through 107) to logical 1.

The assertion of Relay Word bit OUT*m* (*m* = 101 through 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 7.27. 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 7.27 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*** in ***Section 2: Additional Installation Details*** for output contact type options.

Output contact pickup/dropout time is 4 ms.

ALARM Output Contact

Refer to Figure 7.27 and ***Relay Self-Tests*** in ***Section 13: Testing and Troubleshooting***.

When the relay 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 7.27. 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 relay is operational. When the serial port command **PULSE ALARM** is executed, the ALARM Relay Word bit momentarily asserts to logical 1. Also, when the relay 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 7.27 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*** in ***Section 2: Additional Installation Details*** for output contact type options.

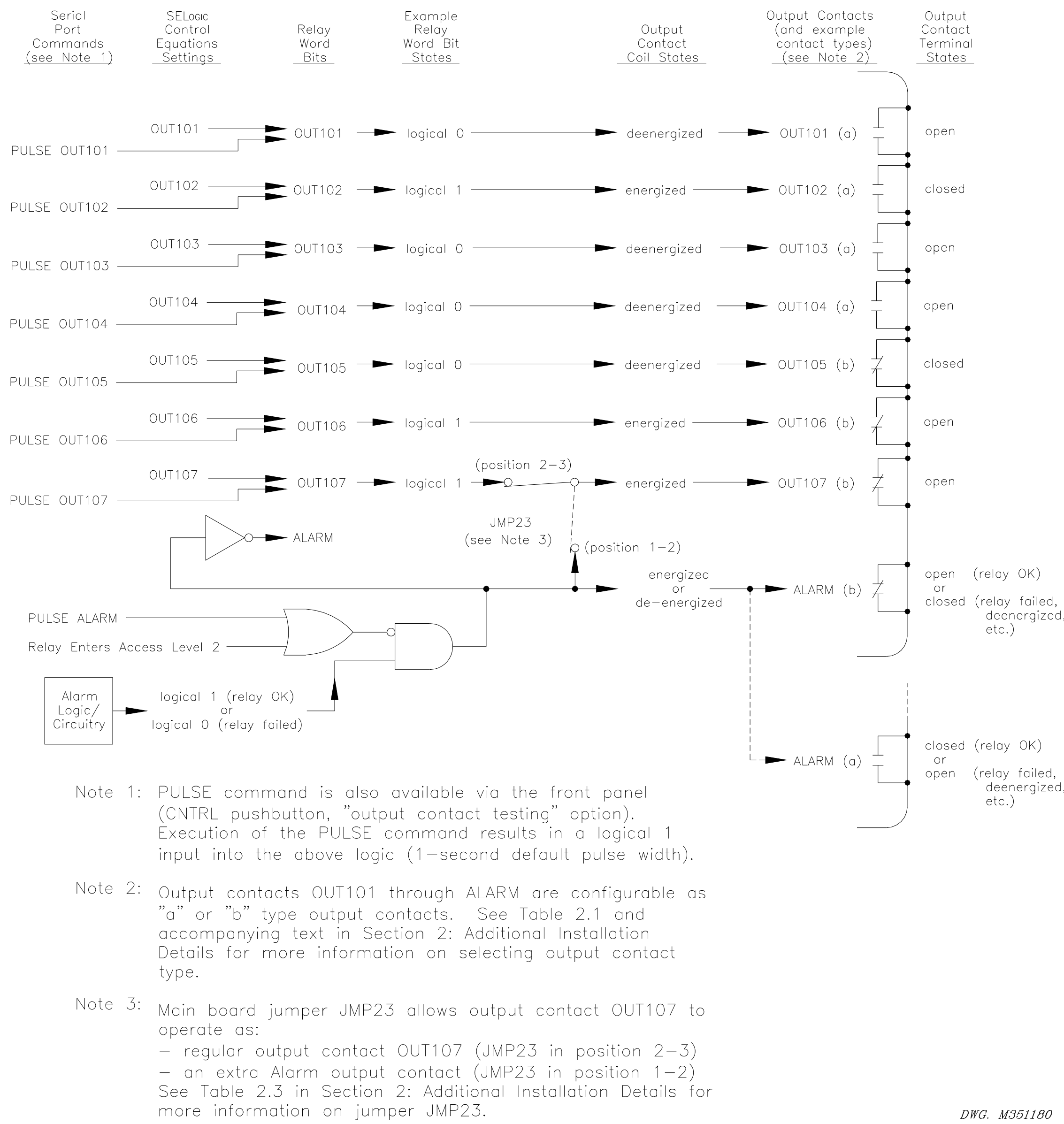

Figure 7.27: Logic Flow for Example Output Contact Operation

ROTATING DEFAULT DISPLAY

The rotating default display on the relay 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 7.28 shows traditional indicating panel lights wired in parallel with SEL-351P-3 optoisolated inputs. Input IN101 provides circuit breaker status to the relay, and input IN102 enables/disables reclosing in the relay via the following SELOGIC control equation settings:

52A = IN101

79DTL = !IN102 [= NOT(IN102); drive-to-lockout setting]

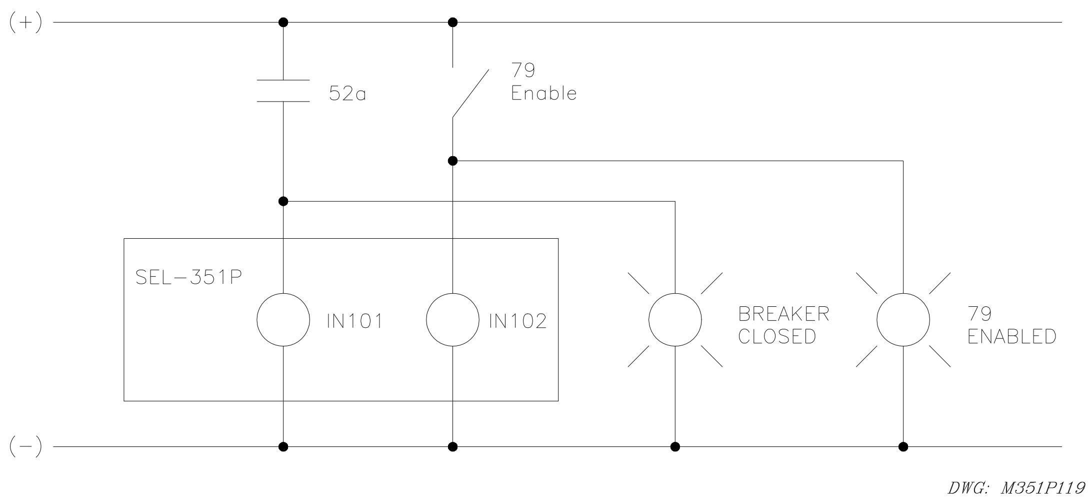

Figure 7.28: Traditional Panel Light Installations

Note that Figure 7.28 corresponds to Figure 7.2 (settings example).

Reclosing Relay Status Indication

In Figure 7.28, 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 7.28, 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-351P-3 is used. Figure 7.29 shows the elimination of the indicating panel lights by using the rotating default display.

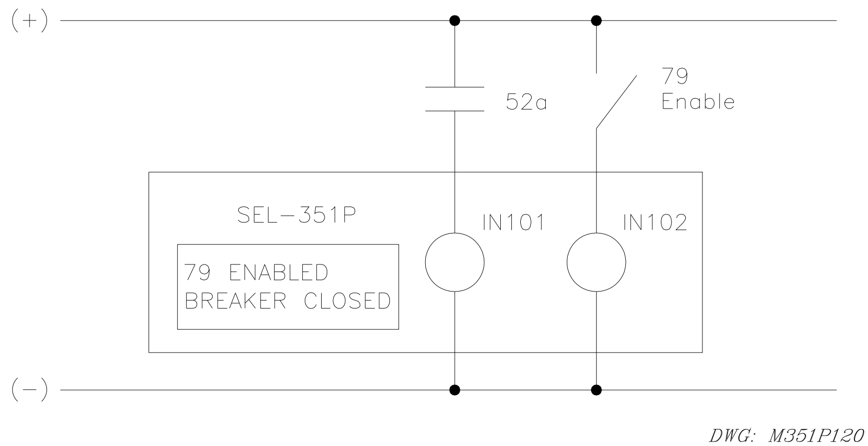

Figure 7.29: Rotating Default Display Replaces Traditional Panel Light Installations

There are sixteen (16) default displays available in the SEL-351P-3. 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 through 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-351P-3 Recloser Control*** and ***Section 10: Serial Port Communications and Commands***). These text settings are displayed on the SEL-351P-3 front-panel display on a 2-second rotation (see ***Rotating Default Display*** in ***Section 11: Additional Front-Panel Interface Details*** for more specific operation information).

The following factory settings examples use optoisolated inputs IN101 and IN102 in the display points settings. Local bits LB1 through LB4, latch bits LT1 through LT4, remote bits RB1 through RB16, setting group indicators SG1 through 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 7.29 for the traditional indicating panel lights in Figure 7.28.

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 7.29, 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 7.29, 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 7.29, 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 7.29, 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 7.29)
DP2_1 = BREAKER CLOSED	(displays when DP2 = logical 1)
DP2_0 =	(blank)

Circuit Breaker Closed

In Figure 7.29, 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 7.29, 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-351P-3 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 through 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 7.29 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 7.29, 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 7.29, 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 through 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 through DP4 above are permanently set to logical 0 in this example. This causes the corresponding DPn_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*** subsection in ***Section 11: Additional Front-Panel Interface Details*** 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 relay 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 relay 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= 8.32A     0°
```

(three digits behind the decimal point)

If the magnitude is greater than or equal to 10, it displays with two or less 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 above IA, IB, IC example is perhaps absurd in magnitude difference, but 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 choices (shown with example values):

CTRL TRIPS= 1043	(corresponding mnemonic CTRLTR)
OPS CNTR= 1043	(corresponding mnemonic OPSCNTR)

display the same value—the number of trips issued by the SEL-351P-3 Recloser Control. The display "OPS CNTR" is more akin to the displays used in traditional recloser controls.

Also, the following display pair (shown with example values):

EF/G TRIPS= 845	(corresponding mnemonic EFGTR)
GND CNTR= 845	(corresponding mnemonic GNDCNTR)

display the same value—the number of trips, involving ground, issued by the SEL-351P-3 Recloser Control.

Combined Display Values

Note that the following display choices from Table 7.10 (shown with example values):

A-OPS= 752 72%	(corresponding mnemonic ATRWR)
B-OPS= 829 78%	(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-351P-3 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 (neutral current transformer ratio setting CTRN for the neutral-ground time-overcurrent element pickups 51N1P and 51N2P, operating off of the IN channel; all the other time-overcurrent element pickups use the phase current transformer ratio setting CTR). 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 x setting 51P1P = 1000 x 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 CTRN Multiplier

Again, neutral current transformer ratio setting CTRN is the multiplier (instead of setting CTR) 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
CTRN = 100	DP3_0 = NEUTRAL TRIPS AT	DP3 = 0
51N1P = 0.5	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 CTRN • setting 51N1P = 100 • 0.50 = 50.00

Note: Typically, the CTR and CTRN settings would have the same value (e.g., CTR = 1000 and CTRN = 1000) in a recloser application (channel IN wired residually with the phase current inputs—factory standard for the SEL-351P-3). The above examples (where CTR = 1000 and CTRN = 100) are for demonstration purposes only.

Table 7.8: Mnemonic Settings for Metering on the Rotating Default Display

Mnemonic	Display	Description
IA	IA= x.xxxA yyy°	IA input current
IB	IB= x.xxxA yyy°	IB input current
IC	IC= x.xxxA yyy°	IC input current
IN	IN= x.xxxA yyy°	IN input current
VA	VA=x.xxxKV yyy°	VA input voltage
VB	VB=x.xxxKV yyy°	VB input voltage
VC	VC=x.xxxKV yyy°	VC input voltage
VS	VS=x.xxxKV yyy°	VS input voltage
IG	IG= x.xxxA yyy°	IG=IA+IB+IC (residual)
3I0	3I0= x.xxxA yyy°	3I0=IG (zero-sequence)
I1	I1= x.xxxA yyy°	positive-sequence current
3I2	3I2= x.xxxA yyy°	negative-sequence current
3V0	3V0=x.xxxKV yyy°	zero-sequence voltage
V1	V1=x.xxxKV yyy°	positive-sequence voltage
V2	V2=x.xxxKV yyy°	negative-sequence voltage
MWA	MW A= xx.xxx	A megawatts
MWB	MW B= xx.xxx	B megawatts
MWC	MW C= xx.xxx	C megawatts
MW3	MW 3P= xx.xxx	three-phase megawatts
MVARA	MVAR A= xx.xxx	A megavars
MVARB	MVAR B= xx.xxx	B megavars
MVARC	MVAR C= xx.xxx	C megavars
MVAR3	MVAR 3P= xx.xxx	three-phase megavars
PFA	PF A= x.xx LEAD	A power factor
PFB	PF B= x.xx LAG	B power factor
PFC	PF C= x.xx LAG	C power factor
PF3	PF 3P= x.xx LEAD	three-phase power factor
FREQ	FRQ=xx.x	system frequency from VA
VAB	VAB=x.xxxKV yyy°	AB voltage
VBC	VBC=x.xxxKV yyy°	BC voltage
VCA	VCA=x.xxxKV yyy°	CA voltage
IADEM	IA DEM = x.xxx	IA demand current
IAPK	IA PEAK = x.xxx	IA peak current
IBDEM	IB DEM = x.xxx	IB demand current
IBPK	IB PEAK = x.xxx	IB peak current
ICDEM	IC DEM = x.xxx	IC demand current
ICPK	IC PEAK = x.xxx	IC peak current
INDEM	IN DEM = x.xxx	IN demand current
INPK	IN PEAK = x.xxx	IN peak current
IGDEM	IG DEM = x.xxx	IG demand current

Mnemonic	Display	Description
IGPK	IG PEAK = x.xxx	IG peak current
3I2DEM	3I2 DEM = x.xxx	3I2 demand current
3I2PK	3I2 PEAK = x.xxx	3I2 peak current
MWADI	MWA IN DEM=x.xxx	A demand megawatts in
MWAPI	MWA IN PK =x.xxx	A peak megawatts in
MWBDI	MWB IN DEM=x.xxx	B demand megawatts in
MWBPI	MWB IN PK =x.xxx	B peak megawatts in
MWCDI	MWC IN DEM=x.xxx	C demand megawatts in
MWCPI	MWC IN PK =x.xxx	C peak megawatts in
MW3DI	MW3 IN DEM=x.xxx	three-phase demand megawatts in
MW3PI	MW3 IN PK =x.xxx	three-phase peak megawatts in
MVRADI	MVRA I DEM=x.xxx	A demand megavars in
MVRAPI	MVRA I PK =x.xxx	A peak megavars in
MVRBDI	MVRB I DEM=x.xxx	B demand megavars in
MVRBPI	MVRB I PK =x.xxx	B peak megavars in
MVRCDI	MVRC I DEM=x.xxx	C demand megavars in
MVRCPI	MVRC I PK =x.xxx	C peak megavars in
MVR3DI	MVR3 I DEM=x.xxx	three-phase demand megavars in
MVR3PI	MVR3 I PK =x.xxx	three-phase peak megavars in
MWADO	MWA O DEM=x.xxx	A demand megawatts out
MWAPO	MWA O PK =x.xxx	A peak megawatts out
MWBDO	MWB O DEM=x.xxx	B demand megawatts out
MWBPO	MWB O PK =x.xxx	B peak megawatts out
MWCDO	MWC O DEM=x.xxx	C demand megawatts out
MWCPO	MWC O PK =x.xxx	C peak megawatts out
MW3DO	MW3 O DEM=x.xxx	three-phase demand megawatts out
MW3PO	Mw3 O PK =x.xxx	three-phase peak megawatts out
MVRADO	MVRA O DEM=x.xxx	A demand megavars out
MVRAPO	MVRA O PK =x.xxx	A peak megavars out
MVRBDO	MVRB O DEM=x.xxx	B demand megavars out
MVRBPO	MVRB O PK =x.xxx	B peak megavars out
MVRCDO	MVRC O DEM=x.xxx	C demand megavars out
MVRCPO	MVRC O PK =x.xxx	C peak megavars out
MVR3DO	MVR3 O DEM=x.xxx	three-phase demand megavars out
MVR3PO	MVR3 O PK =x.xxx	three-phase peak megavars out
MWHAI	MWh A IN= xx.xxx	A megawatt-hours in
MWHAO	MWh A OUT=xx.xxx	A megawatt-hours out
MWHBI	MWh B IN= xx.xxx	B megawatt-hours in
MWHBO	MWh B OUT=xx.xxx	B megawatt-hours out
MWHCI	MWh C IN= xx.xxx	C megawatt-hours in
MWHCO	MWh C OUT=xx.xxx	C megawatt-hours out
MWH3I	MWh 3 IN= xx.xxx	three-phase megawatt-hours in
MWH3O	MWh 3 OUT=xx.xxx	three-phase megawatt-hours out
MVRHAI	MVARh A I=xx.xxx	A megavar-hours in

Mnemonic	Display	Description
MVRHAO	MVARh A O=xx.xxx	A megavar-hours out
MVRHBI	MVARh B I=xx.xxx	B megavar-hours in
MVRHBO	MVARh B O=xx.xxx	B megavar-hours out
MVRHCI	MVARh C I=xx.xxx	C megavar-hours in
MVRHCO	MVARh C O=xx.xxx	C megavar-hours out
MVRH3I	MVARh 3 I=xx.xxx	three-phase megavar-hours in
MVRH3O	MVARh 3 O=xx.xxx	three-phase megavar-hours out

Table 7.9: Mnemonic Settings for Self-Check Status on the Rotating Default Display

Mnemonic	Display	Description
5VPS	+5V_PS= x.xx	5 V supply
5VREG	+5V_REG= x.xx	A/D 5 V supply
-5VREG	-5V_REG= -x.xx	A/D -5 V supply
12VPS	+12V_PS= xx.xx	12 V supply
-12VPS	-12V_PS=-xx.xx	-12 V supply
15VPS	+15V_PS= xx.xx	15 V supply
-15VPS	-15V_PS=-xx.xx	-15 V supply
TEMP	TEMP= xx.x	mainboard temperature
MODE	MODE= NOBATT	battery charger mode
BATCAP	%CAP	percent battery capacity
HOURS	HRS_LFT= hh:ss	battery hours left
HC5VPS	5V_PSBC= x.xx	battery charger 5 V supply
12VAUX	12_AUX= xx.xx	battery charger 12 V aux. supply
BATTV	VBATT= xx.xx	battery voltage
CHARGE	IBAT= -xxxx	(dis)charge current

Table 7.10: Mnemonic Settings for Breaker Wear/Counters on the Rotating Default Display

Mnemonic	Display	Description
BRKDATE	RST DAT:mm/dd/yy	last reset date
BRKTIME	RST TIM:hh:mm:ss	last reset time
CTRLTR	CTRL TRIPS=xxxxx	internal trip count
OPSCNTR	OPS CNTR= xxxxx	internal plus external trip count
CTRLIA	CTRL IA=xxxxx kA	internal trip Σ IA
CTRLIB	CTRL IB=xxxxx kA	internal trip Σ IB
CTRLIC	CTRL IC=xxxxx kA	internal trip Σ IC
EXTTR	EXT TRIPS= xxxxx	external trip count
EXTIA	EXT IA= xxxxx kA	external trip Σ IA
EXTIB	EXT IB= xxxxx kA	external trip Σ IB
EXTIC	EXT IC= xxxxx kA	external trip Σ IC
APHTR	A-PH TRIPS=xxxxx	A phase trip count
BPHTR	B-PH TRIPS=xxxxx	B phase trip count
CPHTR	C-PH TRIPS=xxxxx	C phase trip count
EFGTR	EF/G TRIPS=xxxxx	Ground trip count
GNDCNTR	GND CNTR= xxxxx	Ground trip count
SEFTR	SEF TRIPS= xxxxx	SEF trip count
WEARA	WEAR A= yyy%	A phase wear monitor
WEARB	WEAR B= yyy%	B phase wear monitor
WEARC	WEAR C= yyy%	C phase wear monitor
ATRWR	A-OPS=xxxxx yyy%	A phase trip & wear
BTRWR	B-OPS=xxxxx yyy%	B phase trip & wear
CTRWR	C-OPS=xxxxx yyy%	C phase trip & wear

Table 7.11: Mnemonic Settings for Time-Overcurrent (TOC) Element Pickups on the Rotating Default Display

Mnemonic	Display	Description
51P1P	xxx.xx A pri	pickup for phase TOC element 51P1T
51P2P	xxx.xx A pri	pickup for phase TOC element 51P2T
51N1P	xxx.xx A pri	pickup for neutral ground TOC element 51N1T
51N2P	xxx.xx A pr	pickup for neutral ground TOC element 51N2T
51G1P	xxx.xx A pri	pickup for residual ground TOC element 51G1T
51G2P	xxx.xx A pri	pickup for residual ground TOC element 51G2T
51QP	xxx.xx A prI	pickup for negative-sequence TOC element 51QT

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SECTION 8: BREAKER/RECLOSER MONITOR, BATTERY SYSTEM MONITOR, METERING, AND LOAD PROFILE FUNCTIONS

INTRODUCTION

The SEL-351P-3 Recloser Control monitoring functions include:

- Breaker/Recloser Contact Wear Monitor
- Battery System Monitor

In addition to instantaneous metering, the SEL-351P-3 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-351P-3 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-351P-3 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-351P-3 updates and stores the contact wear information, and the number of trip operations, in non-volatile memory. You can view this information through the front-panel display and by communicating with the SEL-351P-3 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%. 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:

- *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 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 that define the maintenance curve (see Figure 8.2).

- *Recloser Wear Monitor (AUTO, Y, N)* = **AUTO** presents you with subsequent global EZ setting:

  Interrupt rating (6000, 8000, 10000, 12500, 16000 A pri.)

  Use Table 8.2 to make this setting. The settings in Table 8.1 are then made automatically, in accordance with the parameters in Table 8.3.

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".

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*	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*	kA Interrupted set point 3—maximum	0.10–999.00 kA in 0.01 kA steps

*The ratio of settings KASP3/KASP1 must be: $5 \leq \text{KASP3/KASP1} \leq 100$

Table 8.2: Access Level E (EZ) Global Settings for Contact Wear Monitor

Recloser Model	Setting: Interrupt Rating (Amps primary)
GVR (15.5 kV, 6 kA)	6000
GVR (38 kV, 8 kA)	8000
GVR (38 kV, 10 kA)	10000
GVR (15.5 kV, 12.5 kA)	12500
GVR (27 kV, 12.5 kA)	12500
GVR (15.5 kV, 16 kA)	16000

Table 8.3: Parameters Used to Automatically Set Contact Wear Monitor

Table 8.1 Settings	Interrupt Rating = 6000	Interrupt Rating = 8000 or 10000	Interrupt Rating = 12500 or 16000
EBMON =	Y	Y	Y
COSP1 =	30000	30000	30000
COSP2 =	2070	2100	1000
COSP3 =	230	144	39
KASP1 =	0.63	0.63	0.63
KASP2 =	2.00	4.00	5.00
KASP3 =	6.00	10.00	16.00

The parameters in Table 8.3 are derived by Whipp & Bourne Switchgear for their GVR Auto-Recloser. 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-351P-3 is connected to a GVR (27 kV, 12.5 kA) 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
- Interrupt Rating (6000, 8000, 10000, 12500, 16000 A pri.) = 12500

When you enter and save the above global EZ settings, the SEL-351P-3 automatically sets the following set points in the Access Level 2 global settings:

- EBMON = Y
- COSP1 = 30000
- COSP2 = 1000
- COSP3 = 39
- KASP1 = 0.63
- KASP2 = 5.00
- KASP3 = 16.00

The SEL-351P-3 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 = WBTR + WBTRT + \52A, which causes the contact wear monitor to integrate and increment each time the SEL-351P-3 trip output asserts or the recloser is opened externally.

For more information on the **SET G** and **SET L** commands, see Table 9.1 in ***Section 9: Setting the SEL-351P-3 Recloser***. Also, refer to ***BRE Command (Breaker Monitor Data)*** and ***BRE n***

Command (Preload/Reset Breaker Wear) in ***Section 10: Serial Port Communications and Commands***.

Breaker Monitor Setting Example

If your recloser is not included in Table 8.2, or you adapt the SEL-351P-3 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 8.4: Breaker Maintenance Information for a 25 kV Circuit Breaker

Current Interruption Level (kA)	Permissible Number of Close/Open Operations*
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

* The action of a circuit breaker closing and then later opening is counted as one close/open operation.

The breaker maintenance information in Table 8.4 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-351P-3 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.

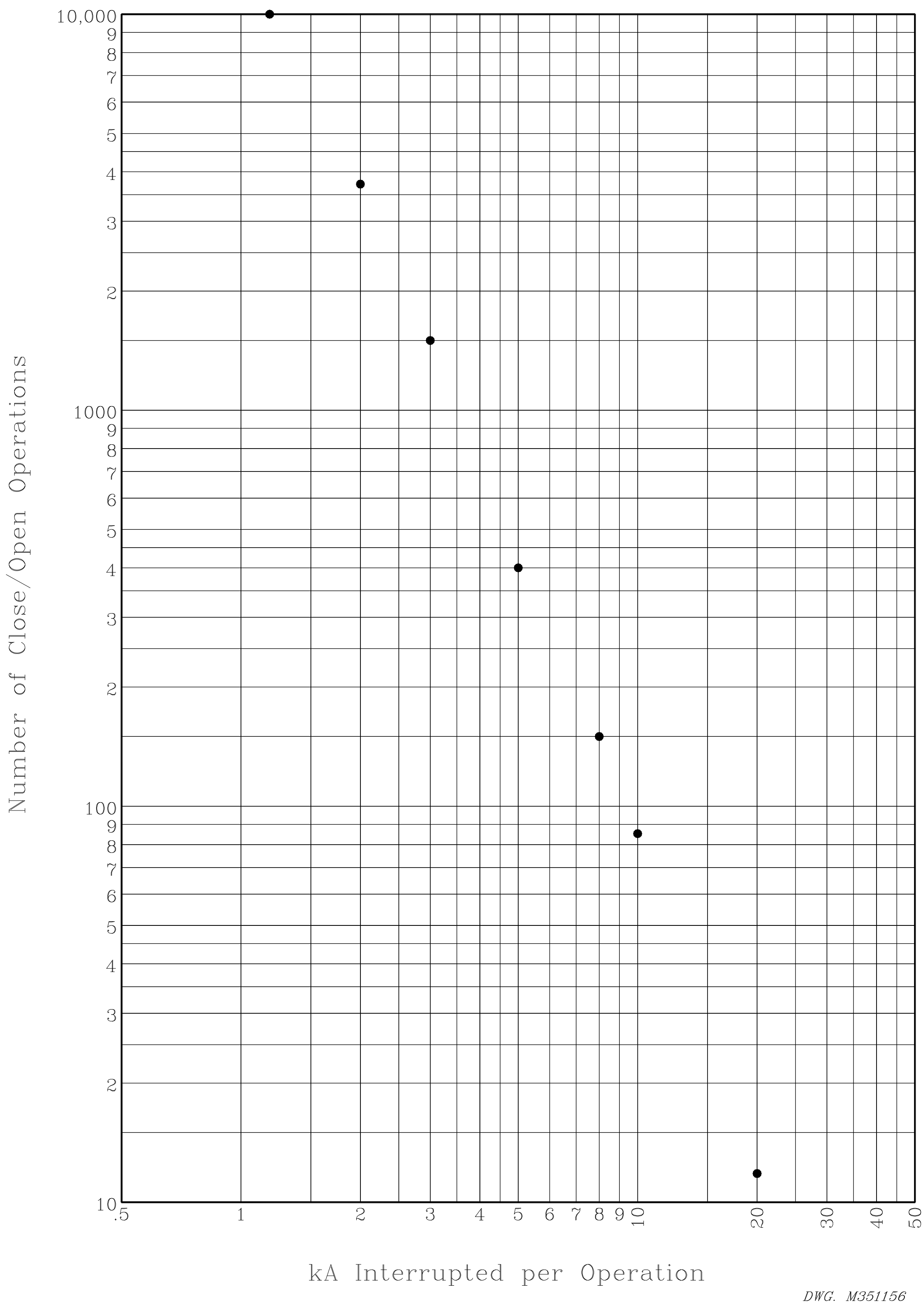

Figure 8.1: Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

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-351P-3 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 8.4 and Figure 8.1.

In this example, set point KASP2, COSP2 provides an intermediate breaker maintenance point in the breaker maintenance information in Table 8.4 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).

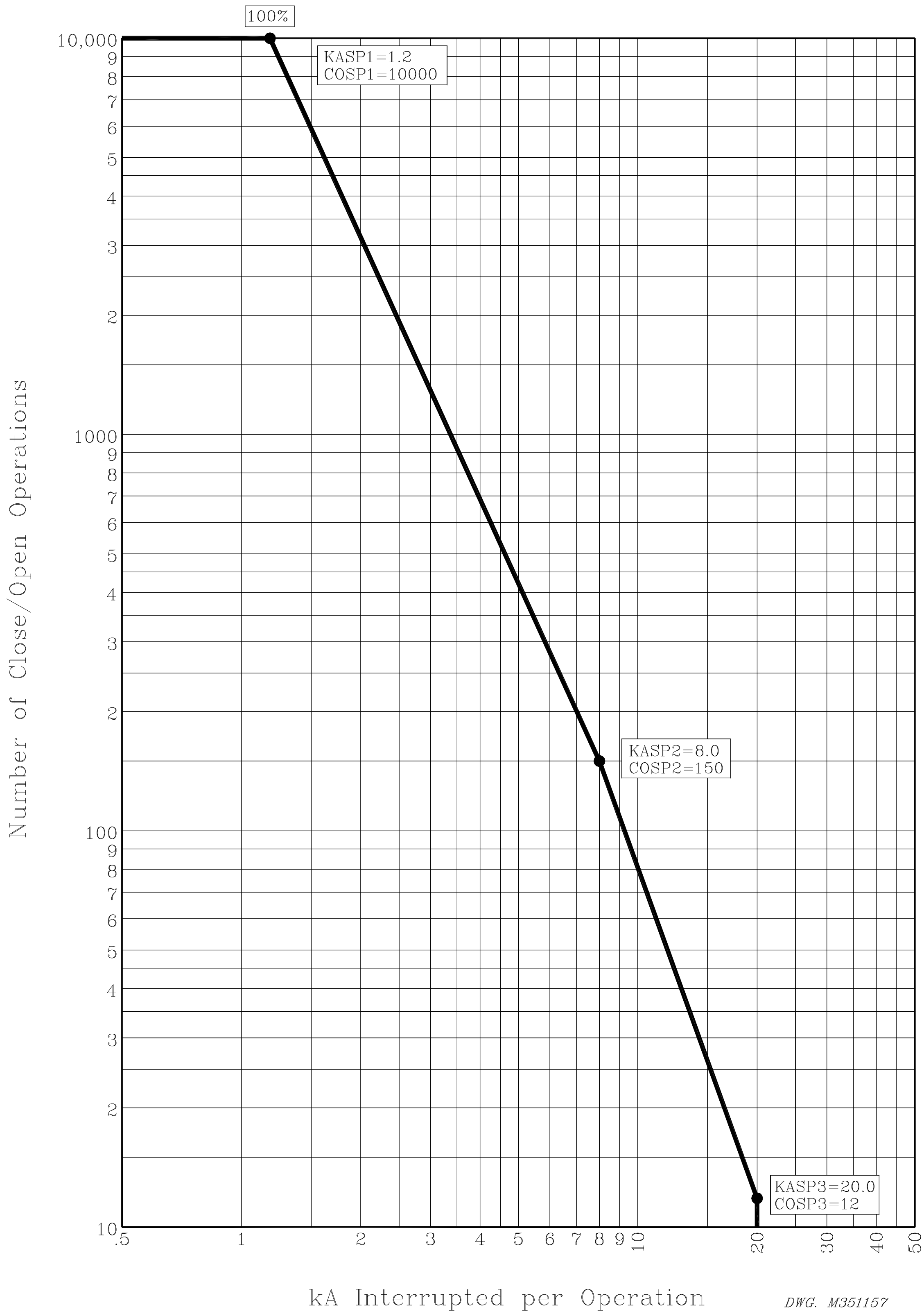

Figure 8.2: Recloser Control Breaker Maintenance Curve for a 25 kV Circuit Breaker

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 Command (Breaker Monitor Data)*** in ***Section 10: Serial Port Communications and Commands***].

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 = WBTR + WBTRT + \52A   (WBTR and WBTRT are the trip logic outputs of Figure 7.30)

Refer to Figure 8.3. When BKMON asserts (e.g., Relay Word bit WBTR 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.

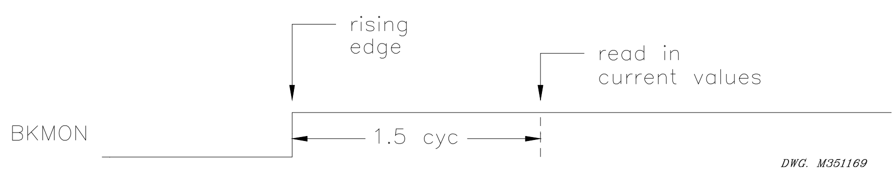

Figure 8.3:   Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

See the following subsection ***Determination of Relay Initiated Trips and Externally Initiated Trips***, for more information on the other part of the factory setting (. . . + WBTRT + \52A).

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 through 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 through 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% to 10% 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% to the 10% wear level.

Compare the 100% and 10% curves and note that for a given current value, the 10% curve has only 1/10 of the close/open operations of the 100% curve.

10% to 25% 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% wear level to the 25% wear level.

Compare the 100% and 25% curves and note that for a given current value, the 25% curve has only 1/4 of the close/open operations of the 100% curve.

25% to 50% 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% wear level to the 50% wear level.

Compare the 100% and 50% curves and note that for a given current value, the 50% curve has only 1/2 of the close/open operations of the 100% curve.

50% to 100% 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% wear level to the 100% wear level.

When the breaker maintenance curve reaches 100% for a particular phase, the percentage wear remains at 100% (even if additional current is interrupted) until reset by the **BRE R** command (see ***View or Reset Breaker Monitor Information*** that follows later). 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.

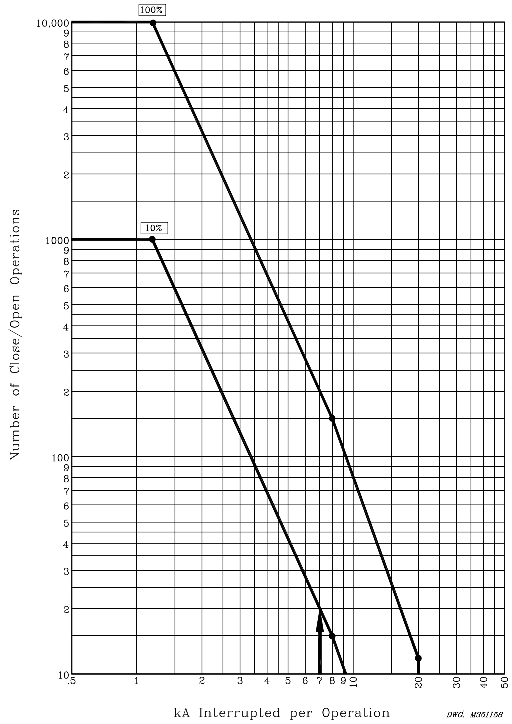

Figure 8.4: Breaker Monitor Accumulates 10% Wear

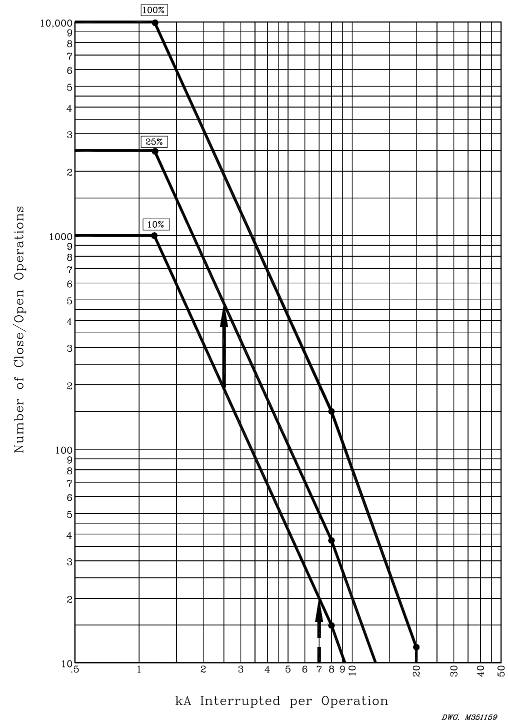

Figure 8.5: Breaker Monitor Accumulates 25% Wear

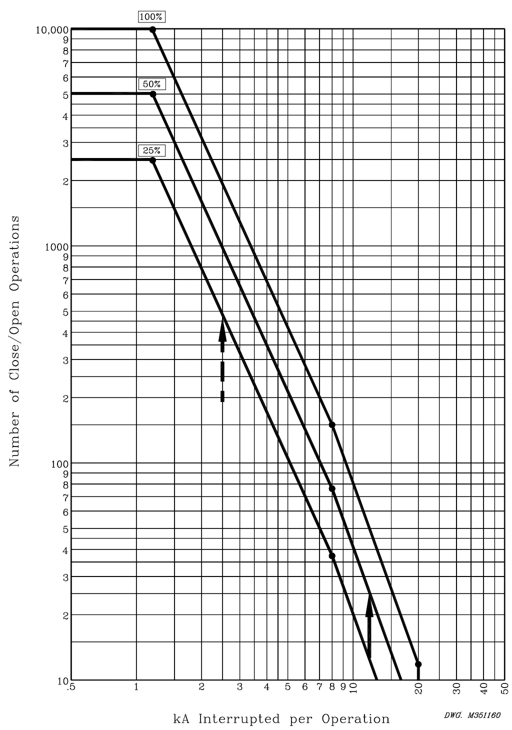

Figure 8.6: Breaker Monitor Accumulates 50% Wear

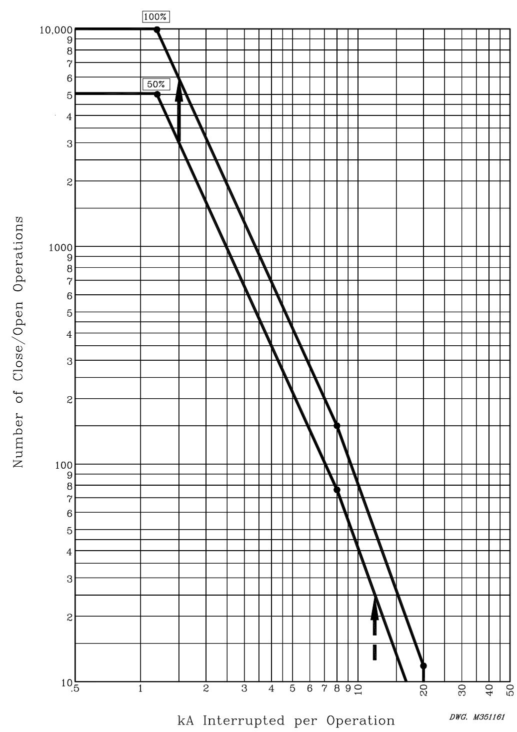

Figure 8.7: Breaker Monitor Accumulates 100% Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100% 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 relay to lockout the next time the relay trips:

79DTL = … + TRIP * BCW

View or Reset Breaker Monitor Information

Accumulated breaker wear/operations data are retained if the relay 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 Command (Breaker Monitor Data)*** in ***Section 10: Serial Port Communications and Commands***. The **BRE** command displays the following information:

- Accumulated number of relay initiated trips
- Accumulated interrupted current from relay 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 (EF/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 (see correspondence to EF/G LED in Figure 1.50).

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 n Command (Preload/Reset Breaker Wear)*** in ***Section 10: Serial Port Communications and Commands***. 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% 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% 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 the ***Pushbutton Primary Functions*** subsection in the ***Front-Panel Interface*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide***.

Determination of Relay Initiated Trips and Externally Initiated Trips

See ***BRE Command (Breaker Monitor Data)*** in ***Section 10: Serial Port Communications and Commands***. 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 this 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 relay 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 relay 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 relay 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 through Figure 8.7).

Factory Default Setting Example

Previously as discussed, the SELOGIC control equation breaker monitor initiation factory default setting is:

BKMON = WBTR + WBTRT + \52A

Thus, any new assertion of WBTR is classified as a recloser control trip (TRIP is asserted at the same time), and the current and trip count information is accumulated under recloser control initiated trips (Cntrl Trip).

Refer to Figure 7.30. Relay Word bit WBTRT asserts ¼ cycle after WBTR (trip output) asserts. WBTRT remains asserted for an additional 30 cycles after WBTR (trip output) deasserts. This 30-cycle dropout time overlaps any operation of the 52a auxiliary contact (52A = WB52A). The momentary assertion of \52A (falling-edge detection of 52A) is not noticed by the BKMON setting when the control issues a trip—it is already asserted to logical 1 by WBTRT.

Any momentary assertion of \52A (falling edge of 52A), without the overlap of WBTRT, is indicative of the recloser being opened manually (i.e., opened via the external manual trip/lockout lever) and is classified as an external trip and the trip count information is accumulated under externally initiated trips (Ext Trips). 52A status lags the main contacts by over a cycle, so it is doubtful that any current information will be accumulated for a manual trip (would be load current anyway).

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.

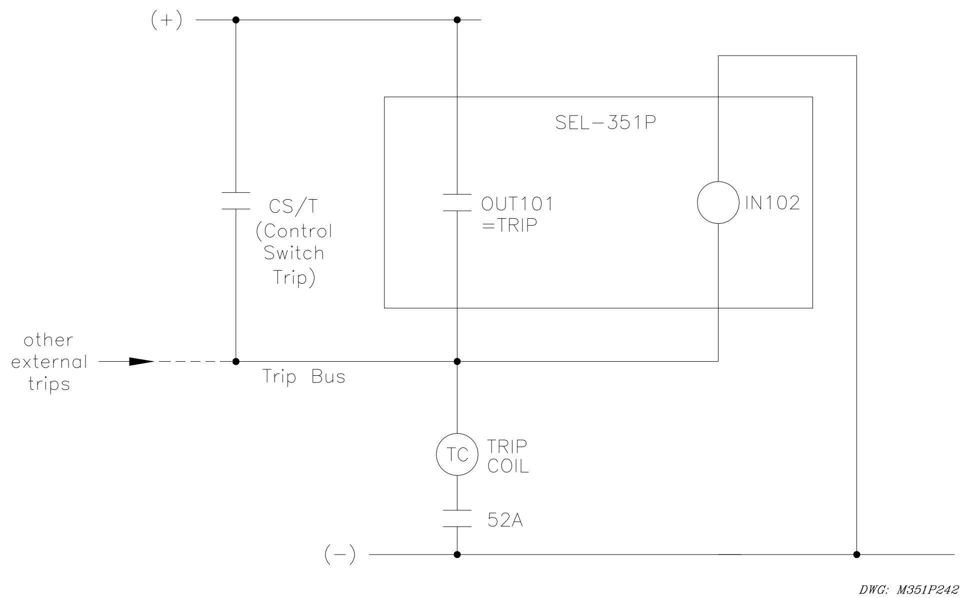

Figure 8.8: Input IN102 Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set:

BKMON = IN102

then the SEL-351P-3 monitor sees all trips.

If output contact OUT101 asserts, energizing the trip bus, the contact wear monitor classifies it as a <u>recloser control initiated trip</u>. 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 <u>recloser control initiated trip</u> (Cntrl Trips).

If the control switch trip (or some other external trip) asserts, energizing the trip bus, the breaker monitor classifies it as an <u>externally initiated trip</u> 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 <u>externally initiated trips</u> (Ext Trips).

Battery System Monitor

First, see the ***Installation*** and ***Battery*** sections of the ***SEL- 351P-3 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 Quick-Start Installation and User's Guide***.

Table 8.5: 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_UP
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 1.1* and the ***Settings*** section of the *SEL- 351R Quick-Start Installation and User's Guide* for more information on Global EZ settings.

Battery Charging

If 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 batter 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- 351P-3 recloser control load
  (Relay Word bit DISCHG asserts)

Limits on Battery Discharging

Time Limits

If 120 Vac power is lost, the SEL- 351P-3 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 120 Vac power 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- 351P-3 was asleep (120 Vac power is lost and the unit is not operating on battery power), then the {**WAKE UP/DESPERTAR**} 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- 351P-3 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- 351P-3 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; factory default V_LOW1 = 20.5 V)
- 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- 351P-3 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 the ***Battery*** section of the *SEL- 351R 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 120 Vac power is present, and resume charging
- Discharge state (Relay Word bit DISCHRG asserts), if 120 Vac power is lost, and continue discharging

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

BATTERY PROBLEM/PROBLEMA BATERIA LED

Figure 1.42 and Figure 1.43 show the factory-default programming for the BATTERY PROBLEM/PROBLEMA BATERIA LED.

Reclose Supervision Logic

Figure 1.30 shows the factory-default programming for the reclose supervision logic setting 79CLS.

Metering

The SEL-351P-3 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 to power the SEL-351P-3, 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 and may not even be connected to primary Phase A. Therefore, with only single-phase voltage connected to the SEL-351P-3, the voltage and power metering values reported by the SEL-351P-3 will not represent accurately primary voltage and power flow. See ***Phantom Voltages*** below.

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-351P-3 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-351P-3 IPCONN and CTPOL settings to obtain the proper phase and phase polarity.

In addition to instantaneous metering, the SEL-351P-3 metering functions include Demand Metering, Energy Metering, and Maximum/Minimum Metering.

Phantom Voltages

The SEL-351P-3-3 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 the ***Settings*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide*** or ***Other Global Settings*** in the ***Settings Sheet*** section of ***Section 9: Setting the SEL-351P-3 Recloser Control***.

Global setting PHANTV is set as shown in Table 8.6, 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.

Table 8.6: 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∠ 0°	1 ∠ 0°
V_B	B	1 ∠ 120°	1 ∠ (–120)°
V_C	C	1 ∠ (–120)°	1 ∠ 120°
V_{AB}	AB	1/•3 ∠ –30°	1/•3 ∠ 30°
V_{BC}	BC	1/•3 ∠ 90°	1/•3 ∠ –90°
V_{CA}	CA	1/•3 ∠ –150°	1/•3 ∠ 150°

When the phantom voltage V_{phnt} signal created through use of Table 8.6 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.

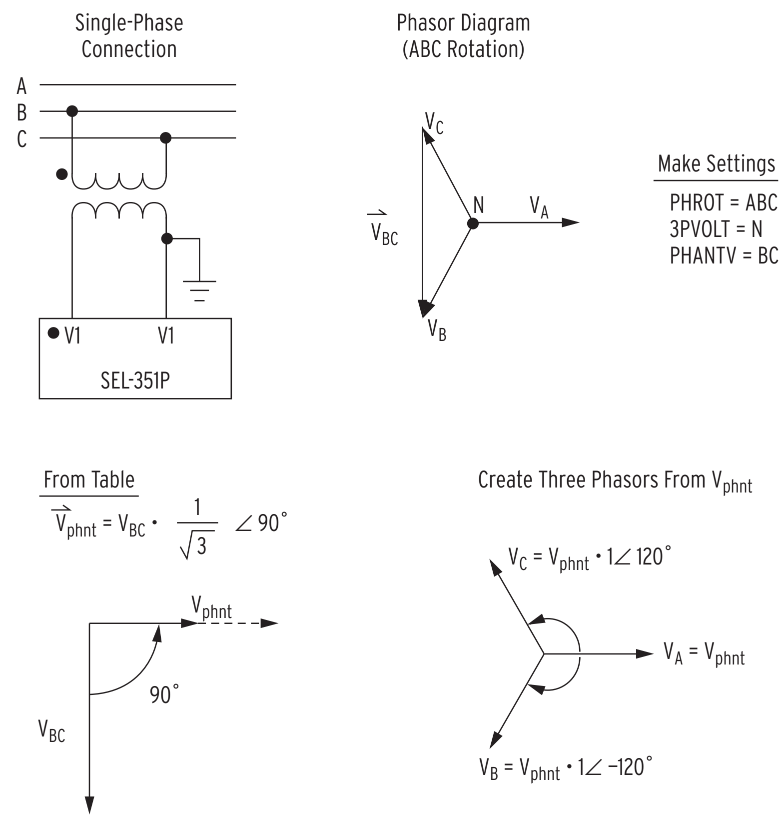

Figure 8.9: Example Phasor Diagram of Phantom Voltage Adjustment

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.

Note: The phantom voltage settings have no effect on the protection elements in the SEL-351P-3. See ***Voltage Elements*** in ***Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements***.

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-351P-3 factory default settings enable the control to provide Thermal Demand Metering. The SEL-351P-3 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 8.7 are available via the Access Level 2 **SET** command (see Table 9.1 in ***Section 9: Setting the SEL-351P-3 Recloser Control*** and also Settings Sheet 10 of 28 at the end of ***Section 9***. Also, refer to ***MET D—Demand Metering*** in ***MET Command (Metering Data)***, in ***Section 10: Serial Port Communications and Commands***).

With either Thermal Demand, or Rolling Average Demand enabled, the SEL-351P-3 provides demand and peak demand metering for the following values:

Currents	$I_{A,B,C,N}$	Input currents (A primary)
	I_G	Residual ground current (A primary; IG = 3I0 = IA + IB + IC)
	$3I_2$	Negative-sequence current (A primary)
Power	$MW_{A,B,C,3P}$	Single- and three-phase megawatts
	$MVAR_{A,B,C,3P}$	Single- and three-phase megavars

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”).

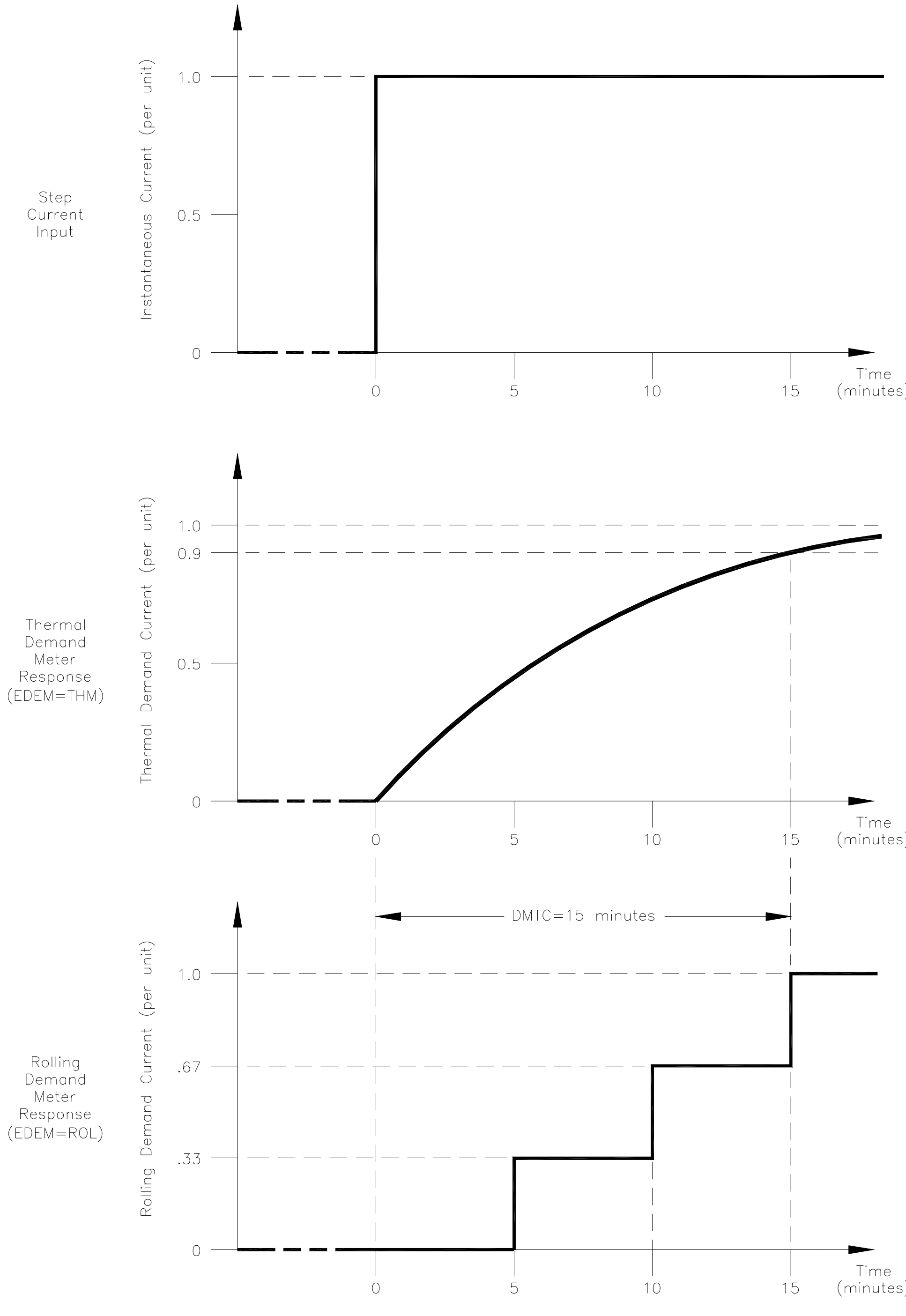

Figure 8.10: Response of Thermal and Rolling Demand Meters to a Step Input (setting DMTC = 15 minutes)

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.

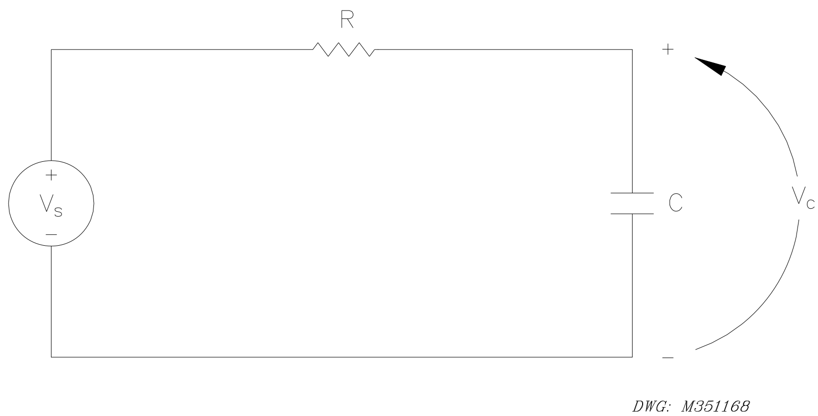

Figure 8.11: Voltage V_s Applied to Series RC Circuit

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 8.7). Note in Figure 8.10, the thermal demand meter response (middle) is at 90% (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-351P-3 updates thermal demand values approximately every 2 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 8.7). Note in Figure 8.10, the rolling demand meter response (bottom) is at 100% (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 5-minute intervals. The integration is performed approximately every 2 seconds. The average value for an integrated 5-minute interval is derived and stored as a 5-minute total. The rolling demand meter then averages a number of the 5-minute totals to produce the rolling demand meter response. In the Figure 8.10 example, the rolling demand meter averages the three latest 5-minute totals because setting DMTC = 15 (15/5 = 3). The rolling demand meter response is updated every 5 minutes, after a new 5-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 5-minute intervals in the sliding time-window at "Time = 0 minutes" each integrate into the following 5-minute totals:

5-Minute Totals	Corresponding 5-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 5-minute intervals in the sliding time-window at "Time = 5 minutes" each integrate into the following 5-minute totals:

5-Minute Totals	Corresponding 5-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 5-minute intervals in the sliding time-window at “Time = 10 minutes” each integrate into the following 5-minute totals:

5-Minute Totals	Corresponding 5-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 5-minute intervals in the sliding time-window at “Time = 15 minutes” each integrate into the following 5-minute totals:

5-Minute Totals	Corresponding 5-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

Table 8.7: 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*	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	

*0.005–0.160A (0.05 A nominal channel IN current input)

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.

The demand current pickup settings in Table 8.7 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.

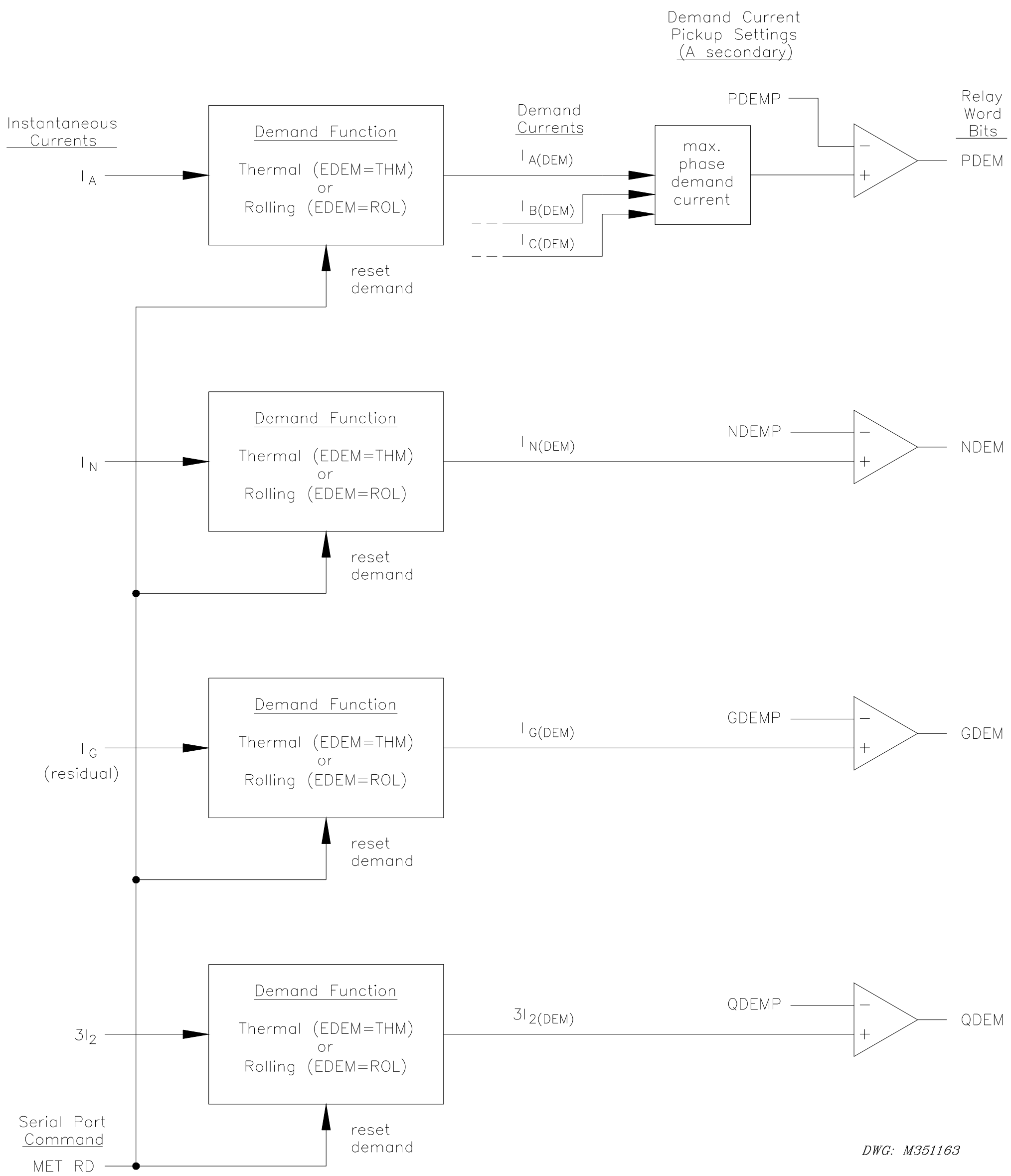

Figure 8.12: Demand Current Logic Outputs

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 8.7, 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.

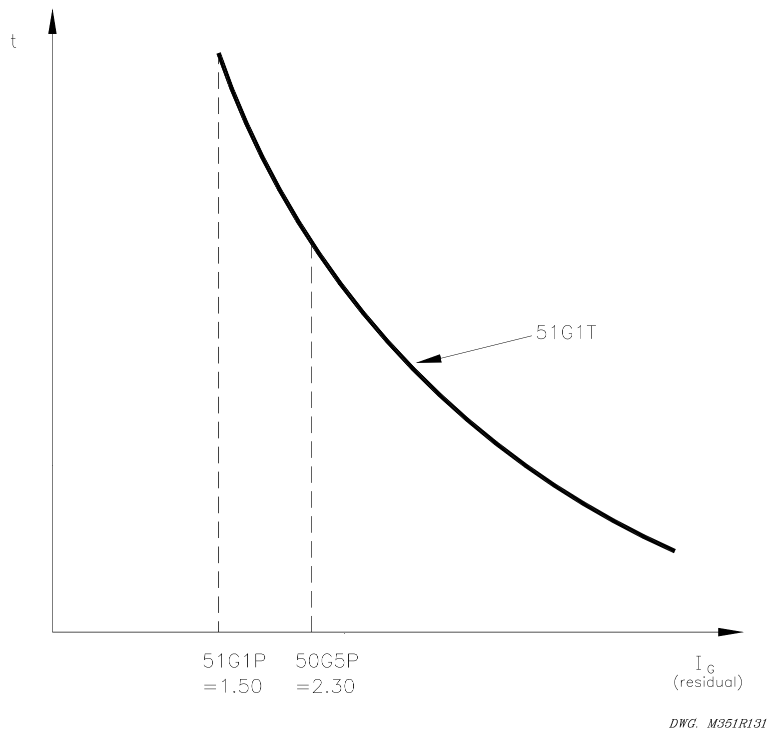

Figure 8.13: Raise Pickup of Residual Ground Time-Overcurrent Element for Unbalance Current

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*** in subsection ***MET Command (Metering Data)***, in ***Section 10: Serial Port Communications and Commands***. The **MET D** command displays demand and peak demand metering for the following values:

Currents	$I_{A,B,C,N}$	Input currents (A primary)
	I_G	Residual ground current (A primary; IG =3I0 = IA + IB + IC)
	$3I_2$	Negative-sequence current (A primary)
Power	$MW_{A,B,C}$	Single-phase megawatts (wye-connected voltages only)
	$MVAR_{A,B,C}$	Single-phase megavars (wye-connected voltages only)
	MW_{3P}	Three-phase megawatts
	$MVAR_{3P}$	Three-phase megavars

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/MEDICIÓN pushbutton. See the METER/MEDICIÓN pushbutton in the ***Pushbutton Primary Functions*** subsection in the ***Front-Panel Interface*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide***.

Demand Metering Updating and Storage

The SEL-351P-3 updates demand values approximately every 2 seconds.

The relay 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 the following ***Maximum/Minimum Metering*** subsection.

Energy Metering

View or Reset Energy Metering Information

Via Serial Port

See ***MET E—Energy Metering*** in subsection ***MET Command (Metering Data)*** in ***Section 10: Serial Port Communications and Commands***. 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/ MEDIÇIÓN pushbutton. See the METER/ MEDIÇIÓN pushbutton in the ***Pushbutton Primary Functions*** subsection in the ***Front-Panel Interface*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide***.

Energy Metering Updating and Storage

The SEL-351P-3 updates energy values approximately every 2 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.

Maximum/Minimum Metering

View or Reset Maximum/Minimum Metering Information

Via Serial Port

See ***MET M—Maximum/Minimum Metering*** in subsection ***MET Command (Metering Data)*** in ***Section 10: Serial Port Communications and Commands***. The **MET M** command displays maximum/minimum metering for the following values:

Currents	$I_{A,B,C,N}$	Input currents (A primary)
	I_G	Residual ground current (A primary; IG = 3I0 = IA + IB + IC)
Voltages	$V_{A,B,C}$	Input voltages (kV primary)
	V_S	Input voltage (kV primary)
Power	MW_{3P}	Three-phase megawatts
	$MVAR_{3P}$	Three-phase megavars

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/ MEDIÇIÓN pushbutton. See the METER/ MEDIÇIÓN pushbutton in the ***Pushbutton Primary Functions*** subsection in the ***Front-Panel Interface*** section of the ***SEL-351P-3 Quick- Start Installation and User's Guide***.

Maximum/Minimum Metering Updating and Storage

The SEL-351P-3 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 ***Front-Panel Target LEDs*** in ***Section 5: Trip and Target Logic***).]
- The metering value is above the previous maximum or below the previous minimum for 2 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-351P-3 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 (Only Available in Firmware Versions 1 and Greater)

At the interval given by load profile acquisition rate setting LDAR, the SEL-351P-3 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 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)
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

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 non-volatile 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-351P-3 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-351P-3 displays all records in the load buffer. If the command is entered with a single numeric parameter [a] (i.e., **LDP 10**), the SEL-351P-3 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-351P-3 displays load buffer records

[a] through [b]. If the command is entered with a single data parameter [a] (i.e., **LDP 7/7/96**), the SEL-351P-3 displays all load buffer records for the specified date. If the command is entered with two date parameters [a] [b] (i.e., **LDP 7/7/96 8/8/96**), the SEL-351P-3 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 3/30/10	If **LDP** is entered with one date following it (date 3/30/10 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 2/17/10 3/23/10	If **LDP** is entered with two dates following it (date 2/17/10 chronologically precedes date 3/23/10 in this example), all the rows between (and including) dates 2/17/10 and 3/23/10 are displayed, if they exist. They display with the oldest row (date 2/17/10) at the beginning (top) of the report and the latest row (date 3/23/10) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.

LDP 3/16/10 1/5/10 If **LDP** is entered with two dates following it (date 3/16/10 chronologically follows date 1/5/10 in this example), all the rows between (and including) dates 1/5/10 and 3/16/10 are displayed, if they exist. They display with the latest row (date 3/16/10) at the beginning (top) of the report and the oldest row (date 1/5/10) 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 7/23/10<Enter>
<STX>
SEL-351P-3 RECLOSER CONTROL                    Date: 07/25/10    Time: 10:18:25.105
FEEDER

FID=SEL-351P-3-R400-V100100-D20100211       CID=6AFA

#     DATE     TIME     label1    label2    label3    label4    label5    ... labeln
512   07/23/10 07:00:35 xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx ... xxxxx.xxx
511   07/23/10 08:00:15 xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx xxxxx.xxx ... xxxxx.xxx
510   07/23/10 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 relay 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-351P-3 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.

TABLE OF CONTENTS

SECTION 9: SETTING THE SEL-351P-3 RECLOSER CONTROL 9-1

TABLES

FIGURES

SECTION 9: SETTING THE SEL-351P-3 RECLOSER CONTROL

INTRODUCTION

Change or view settings with the **SET** and **SHOWSET** serial port commands and the front-panel SET/CONFIG 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 settings group *n* (*n* = 1, 2, 3, 4, 5, 6).	1–12*
SET L *n*	Logic	SELOGIC® control equations for settings group *n* (*n* = 1, 2, 3, 4, 5, 6).	13–19*
SET G	Global	Breaker monitor, battery monitor, optoisolated input debounce timers, etc.	20–22*
SET R	SER	Sequential Events Recorder trigger conditions and Load Profile settings.	23*
SET T	Text	Front-panel default display and local control text.	24–27*
SET P *n*	Port	Serial port settings for serial port *n* (*n* = 1, 2, 3, or F).	28*
SET EZ *n*	EZ Recloser Control	Traditional recloser control settings (e.g., minimum trips, fast/delay curves, reclose intervals) for settings group *n* (*n* = 1, 2, 3, 4, 5, 6)	1–3**
SET FZ	EZ Global	Automatic recloser monitor, battery monitor, etc.	3**

* located at the end of this section
** located at the end of the ***Settings*** section in the ***SEL-351P-3 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 (Showset)*** in ***Section 10: Serial Port Communications and Commands***.

Refer to the ***Settings*** section in the ***SEL-351P-3 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 the ***Access Level E (EZ) Commands*** subsection of ***Section 10: Serial Port Communications and Commands*** 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).

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-351P-3 front-panel SET/ CONFIG pushbutton. The exceptions are settings corresponding to the **SET L *n***, **SET R**, and **SET T** commands. See the SET/ CONFIG pushbutton in the ***Pushbutton Primary Functions*** subsection in the ***Front-Panel Interface*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide*** for more information on making settings via the front-panel interface.

SETTINGS CHANGES VIA THE SERIAL PORT

Note: In this manual, commands you type appear in bold/uppercase: **OTTER**. Computer keys you press appear in bold/ brackets: **<Enter>**.

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-351P-3 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-351P-3 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 setting.
> <Enter>	Moves to next setting.
END<Enter>	Exits editing session, then prompts you to save the settings.
<Ctrl> X	Aborts editing session without saving changes.

The SEL-351P-3 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.

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-351P-3 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-351P-3 is disabled while it saves the new settings. The ALARM contact closes momentarily for “b” contact (opens for an “a”; see Figure 7.27), and the CONTROL ENABLED/CONTROL HABILITADO LED extinguishes while the control is disabled. The SEL-351P-3 is disabled for about 1 second. If Logic settings are changed for the active group, the SEL-351P-3 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-351P-3 is not disabled while it saves the new settings. The ALARM contact closes momentarily for “b” contact (opens for an “a”; see Figure 7.27), but the CONTROL ENABLED/CONTROL HABILITADO LED remains on while the new settings are saved.

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 through Figure 3.20). The time-overcurrent relay curves in Figure 9.1 through Figure 9.10 conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

tp = operating time in seconds
tr = electromechanical induction-disk emulation reset time in seconds (if electromechanical reset setting is made)
TD = time dial setting
M = applied multiples of pickup current [for operating time (tp), $M>1$; for reset time (tr), $M\leq1$].

U.S. Moderately Inverse Curve: U1

$tp = TD*(0.0226 + 0.0104/(M^{0.02} – 1))$
$tr = TD*(1.08/(1 – M^2))$

U.S. Inverse Curve: U2

$tp = TD*(0.180 + 5.95/(M^2 – 1))$
$tr = TD*(5.95/(1 – M^2))$

U.S. Very Inverse Curve: U3

$tp = TD*(0.0963 + 3.88/(M^2 – 1))$
$tr = TD*(3.88/(1 – M^2))$

U.S. Extremely Inverse Curve: U4

$tp = TD*(0.0352 + 5.67/(M^2 – 1))$
$tr = TD*(5.67/(1 – M^2))$

U.S. Short-Time Inverse Curve: U5

$tp = TD*(0.00262 + 0.00342/(M^{0.02} – 1))$
$tr = TD*(0.323/(1 – M^2))$

I.E.C. Class A Curve (Standard Inverse): C1

$tp = TD*(0.14/(M^{0.02} – 1))$
$tr = TD*(13.5/(1 – M^2))$

I.E.C. Class B Curve (Very Inverse): C2)

$tp = TD*(13.5/(M – 1))$
$tr = TD*(47.3/(1 – M^2))$

I.E.C. Class C Curve (Extremely Inverse): C3

$tp = TD*(80.0/(M^2 – 1))$
$tr = TD*(80.0/(1 – M^2))$

I.E.C. Long-Time Inverse Curve: C4

$tp = TD*(120.0/(M – 1))$
$tr = TD*(120.0/(1 – M))$

I.E.C. Short-Time Inverse Curve: C5

$tp = TD*(0.05/(M^{0.04} – 1))$
$tr = TD*(4.85/(1 – M^2))$

All 38 traditional recloser control response curves are available and shown in Figure 9.11 through 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 designation101

Use either designation in making curve settings in the SEL-351P-3.

See Table 8 and Table 9 and following text in the ***Settings*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide*** for more information on available time-overcurrent curves, including user-programmable curves.

Note: The electromechanical reset setting is not available with recloser curves. It is only available with traditional electromechanical time-overcurrent relay curves (U1–U5 and C1–C5). See Table 3.2, and Table 3.4 through Table 3.6 in ***Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements*** for further information.

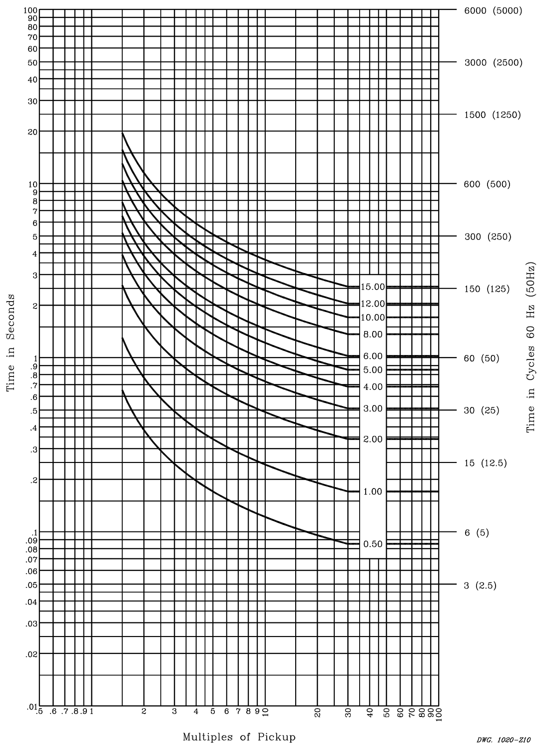

Figure 9.1: U.S. Moderately Inverse Curve: U1

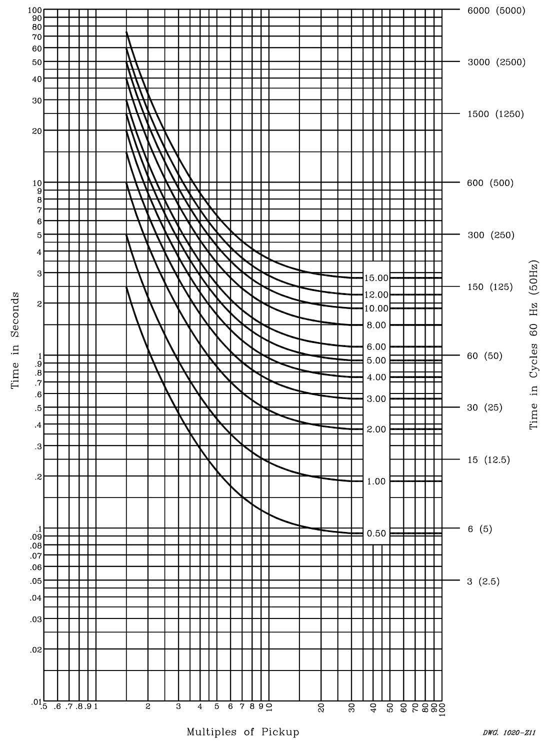

Figure 9.2: U.S. Inverse Curve: U2

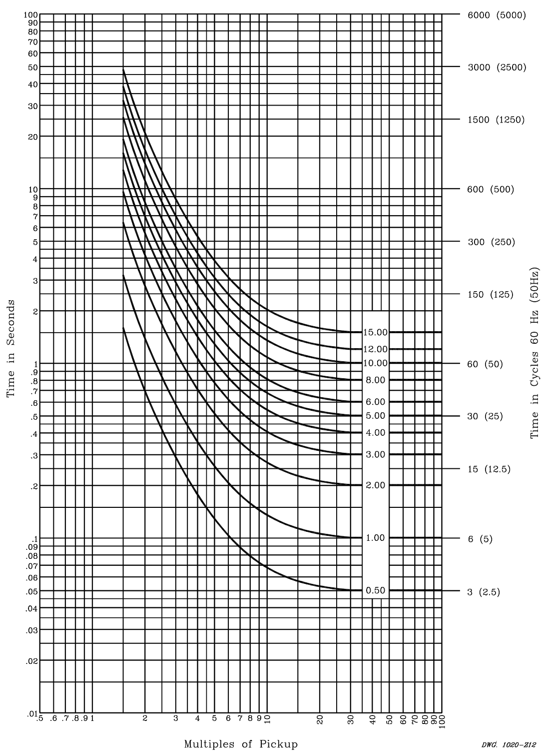

Figure 9.3: U.S. Very Inverse Curve: U3

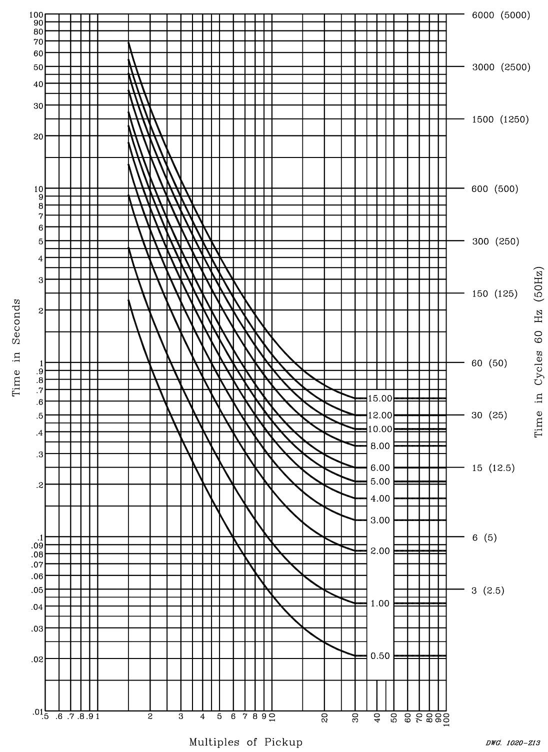

Figure 9.4: U.S. Extremely Inverse Curve: U4

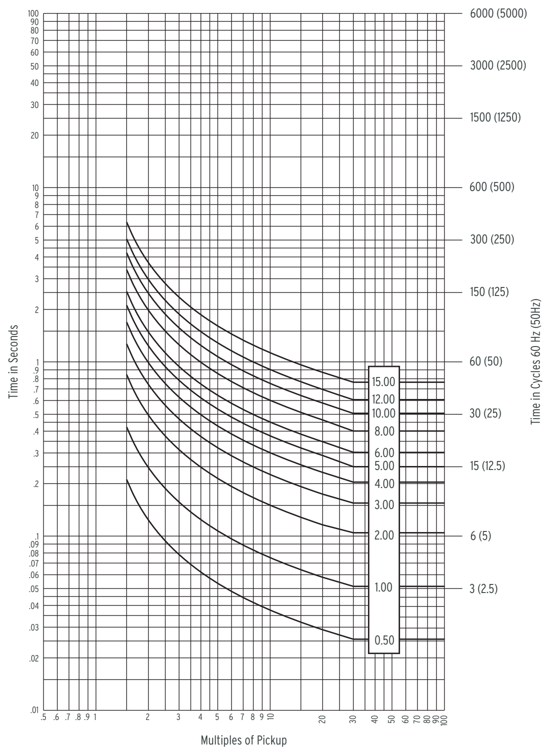

Figure 9.5: U.S. Short-Time Inverse Curve: U5

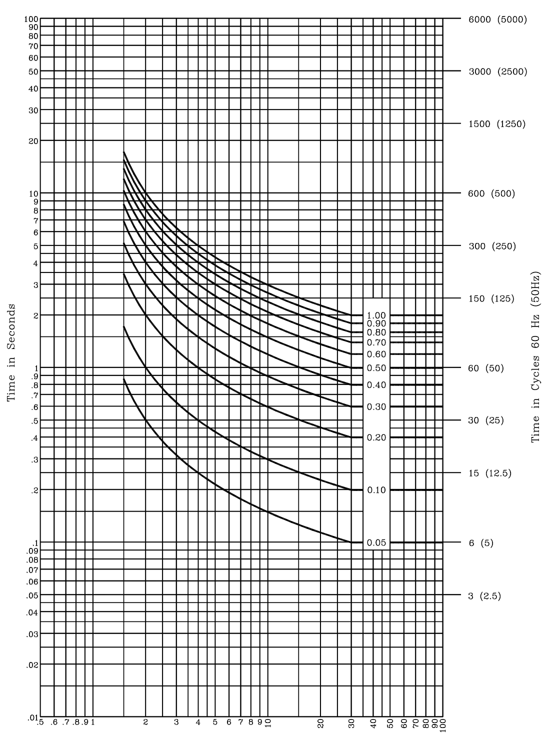

Figure 9.6: I.E.C. Class A Curve (Standard Inverse): C1

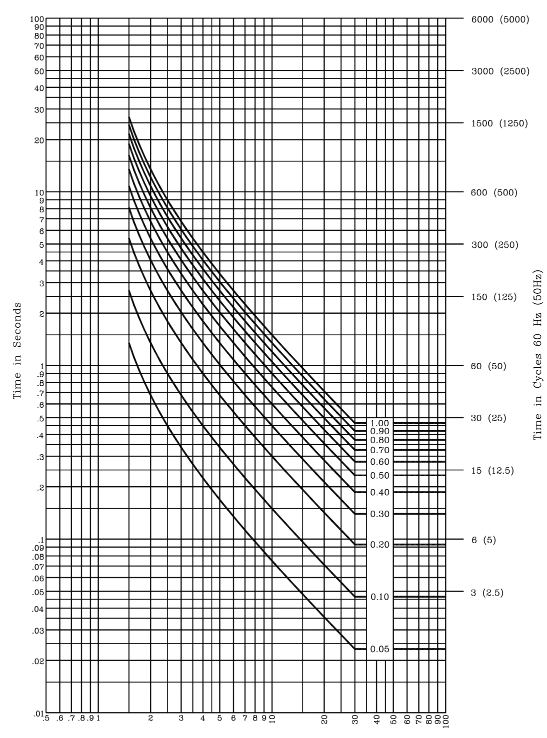

Figure 9.7: I.E.C. Class B Curve (Very Inverse): C2

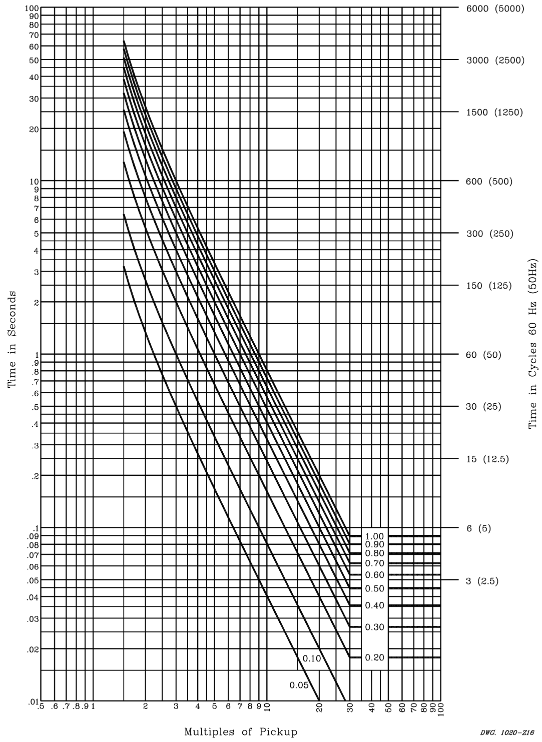

Figure 9.8: I.E.C. Class C Curve (Extremely Inverse): C3

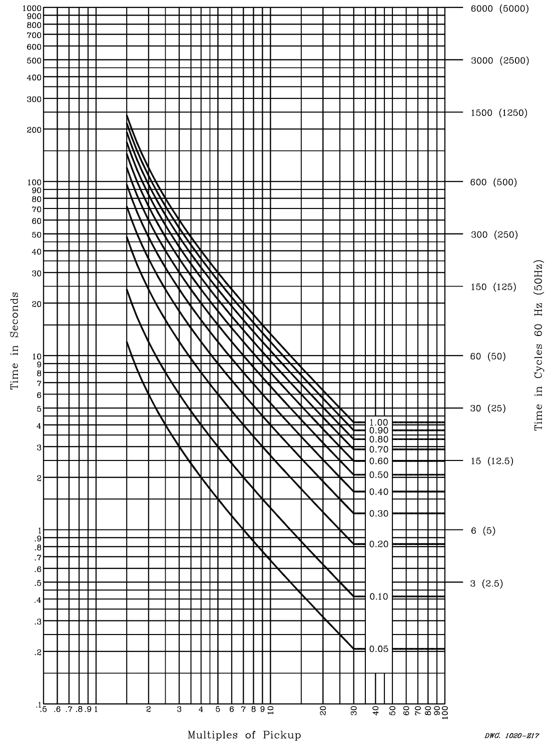

Figure 9.9: I.E.C. Long-Time Inverse Curve: C4

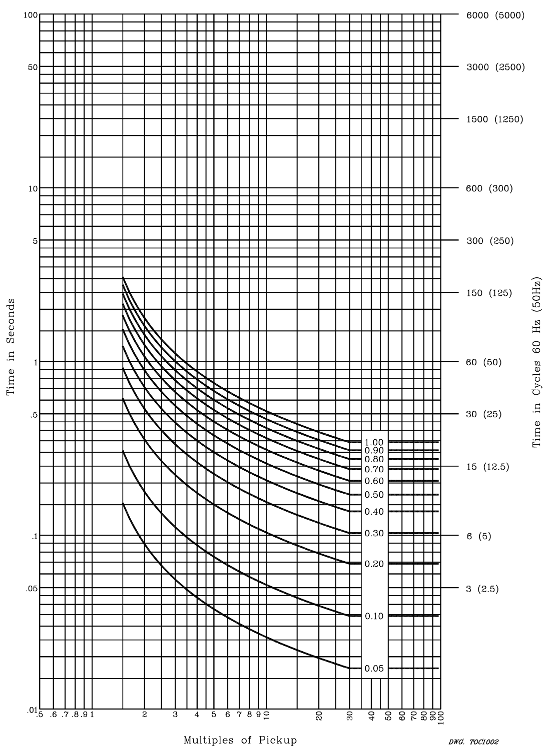

Figure 9.10: I.E.C. Short-Time Inverse Curve: C5

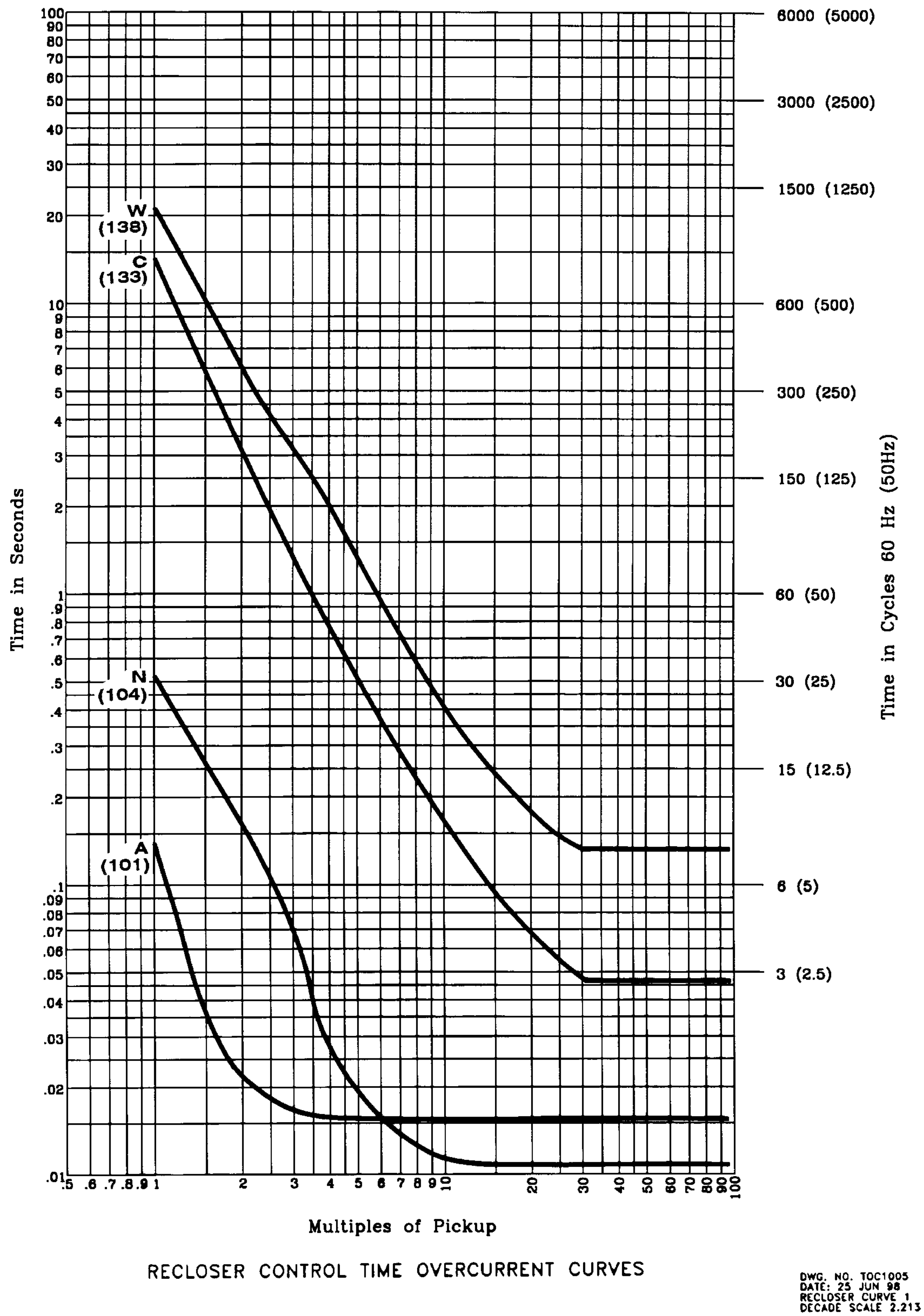

Figure 9.11: Recloser Control Response Curves A, C, N, and W

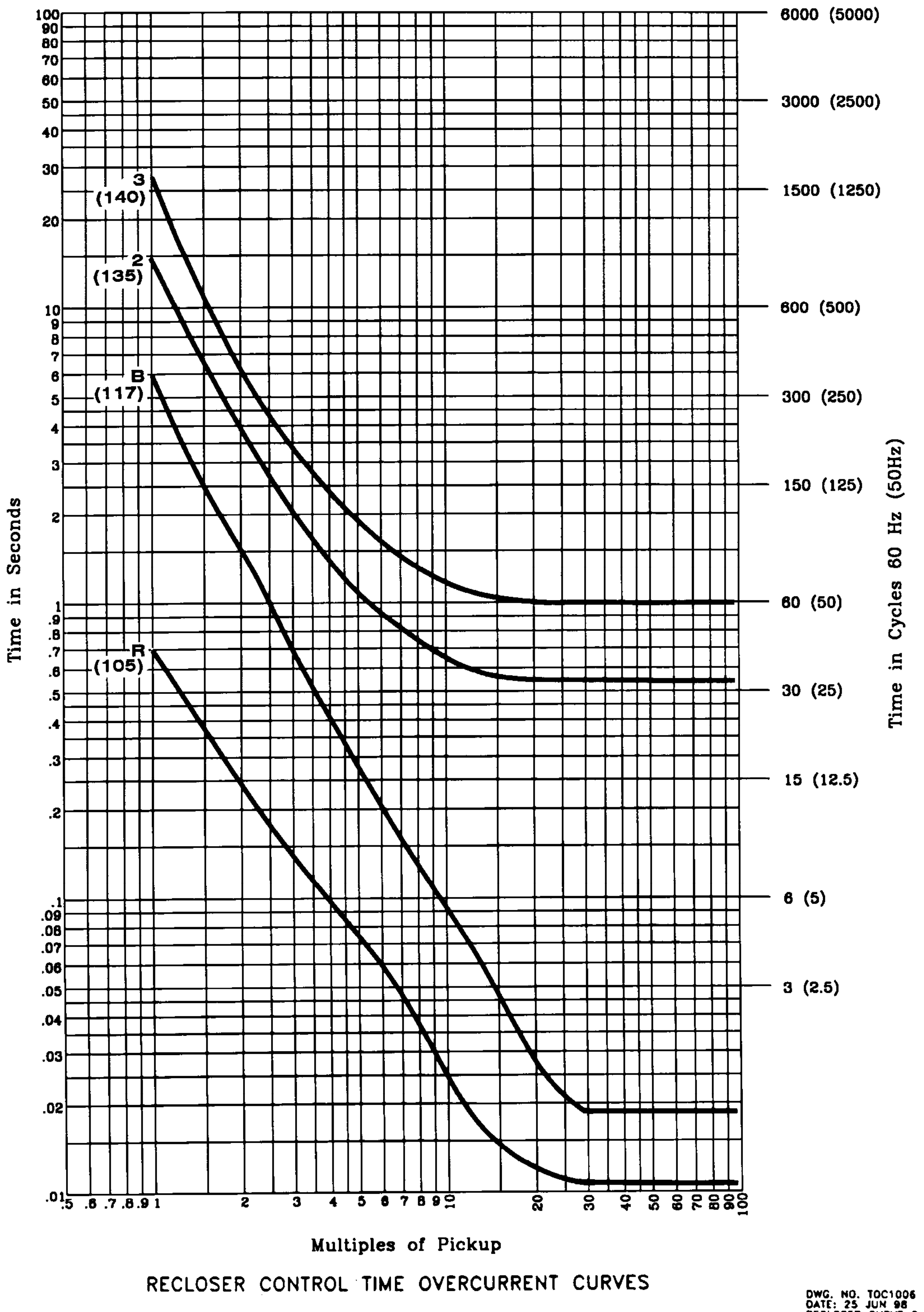

Figure 9.12: Recloser Control Response Curves B, R, 2, and 3

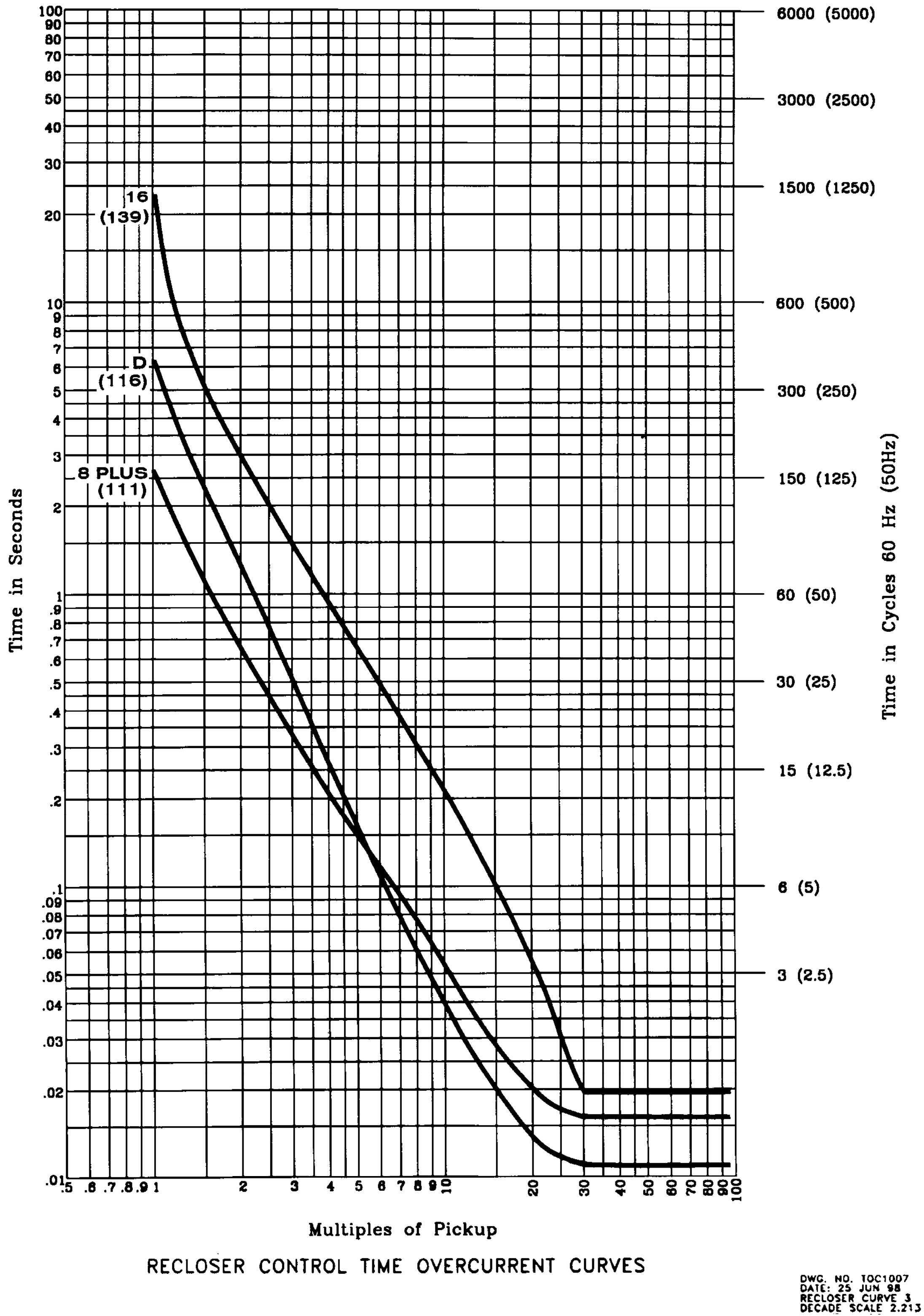

Figure 9.13: Recloser Control Response Curves D, 8PLUS, and 16

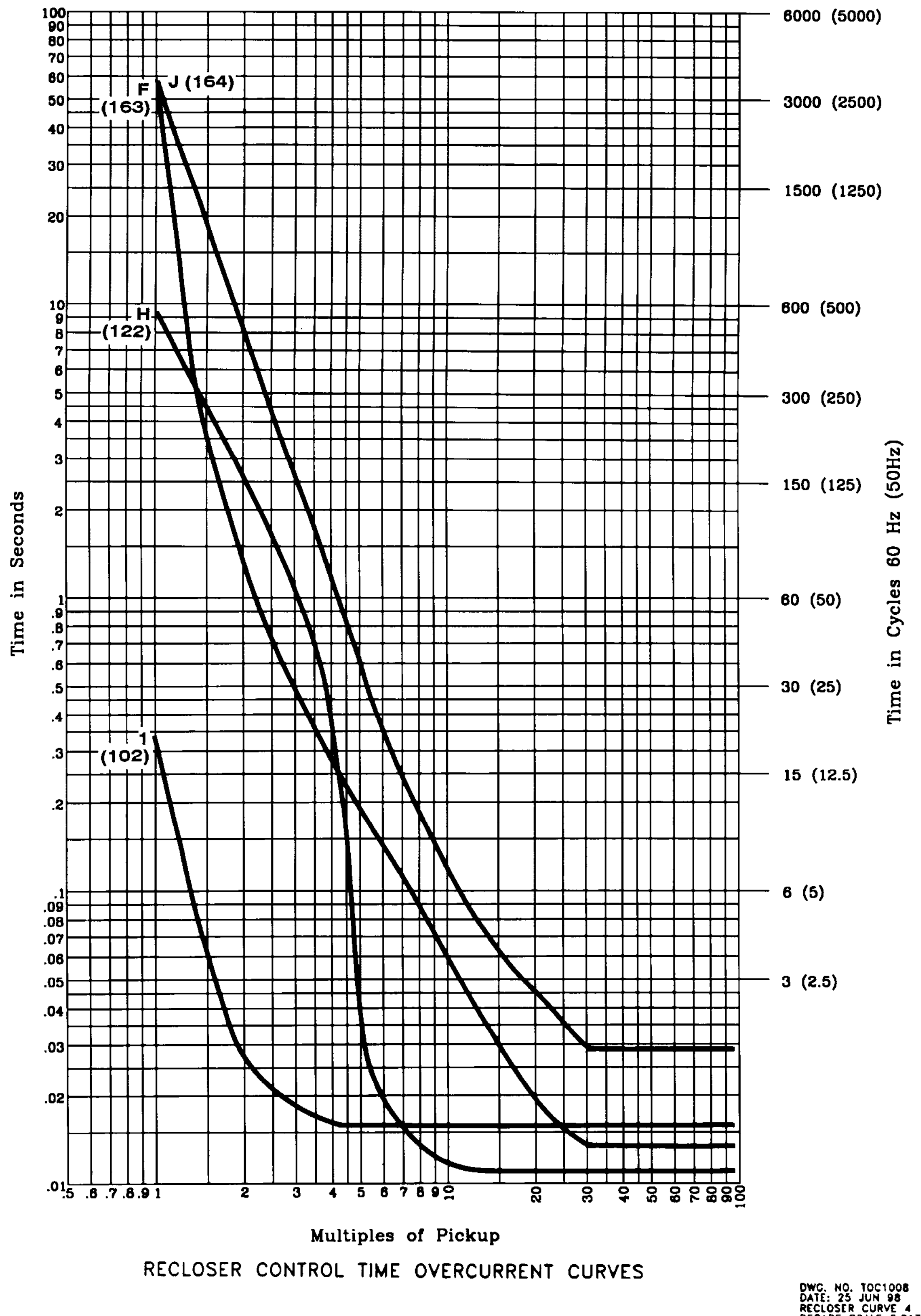

Figure 9.14: Recloser Control Response Curves F, H, J, and 1

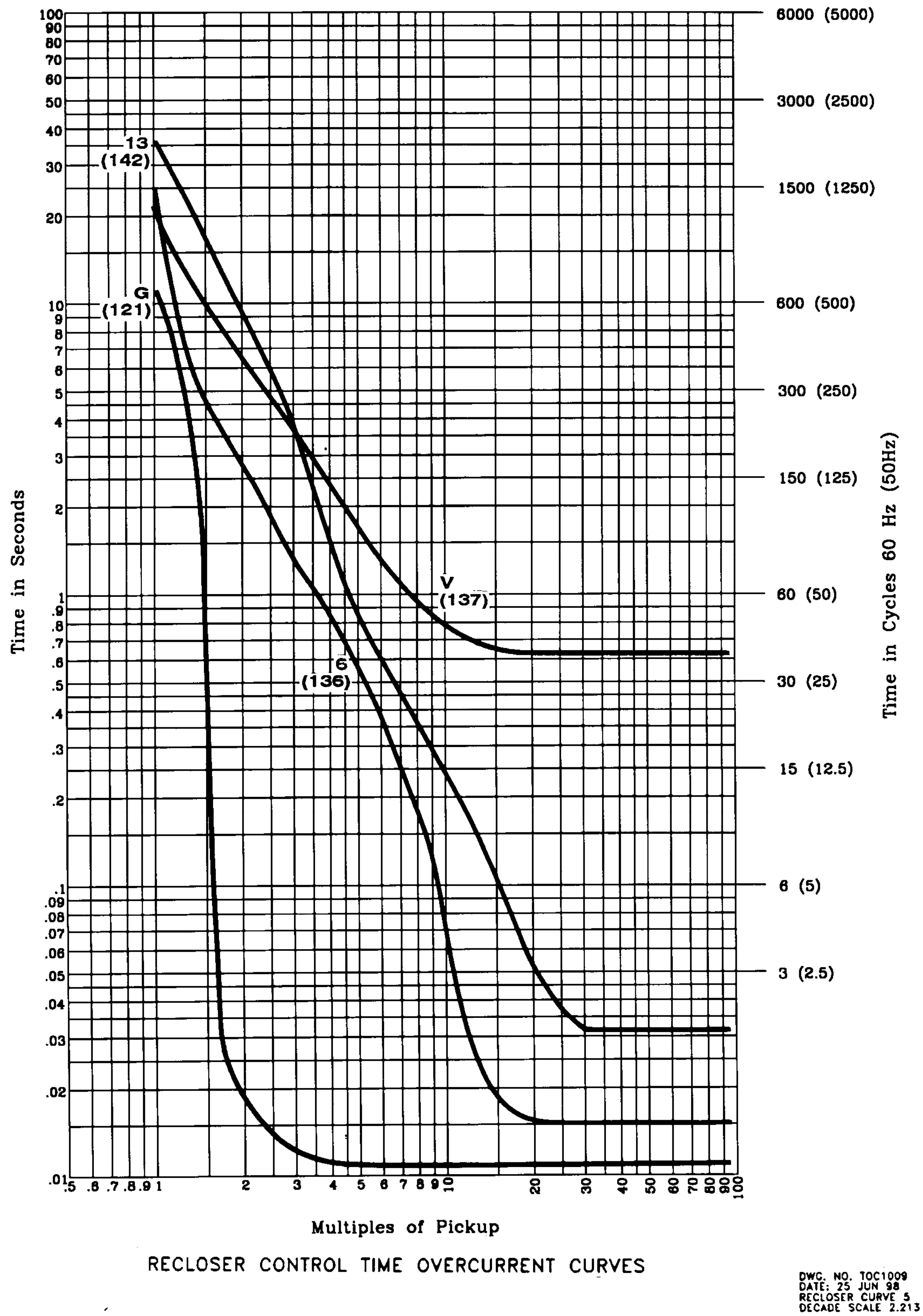

Figure 9.15: Recloser Control Response Curves G, V, 6, and 13

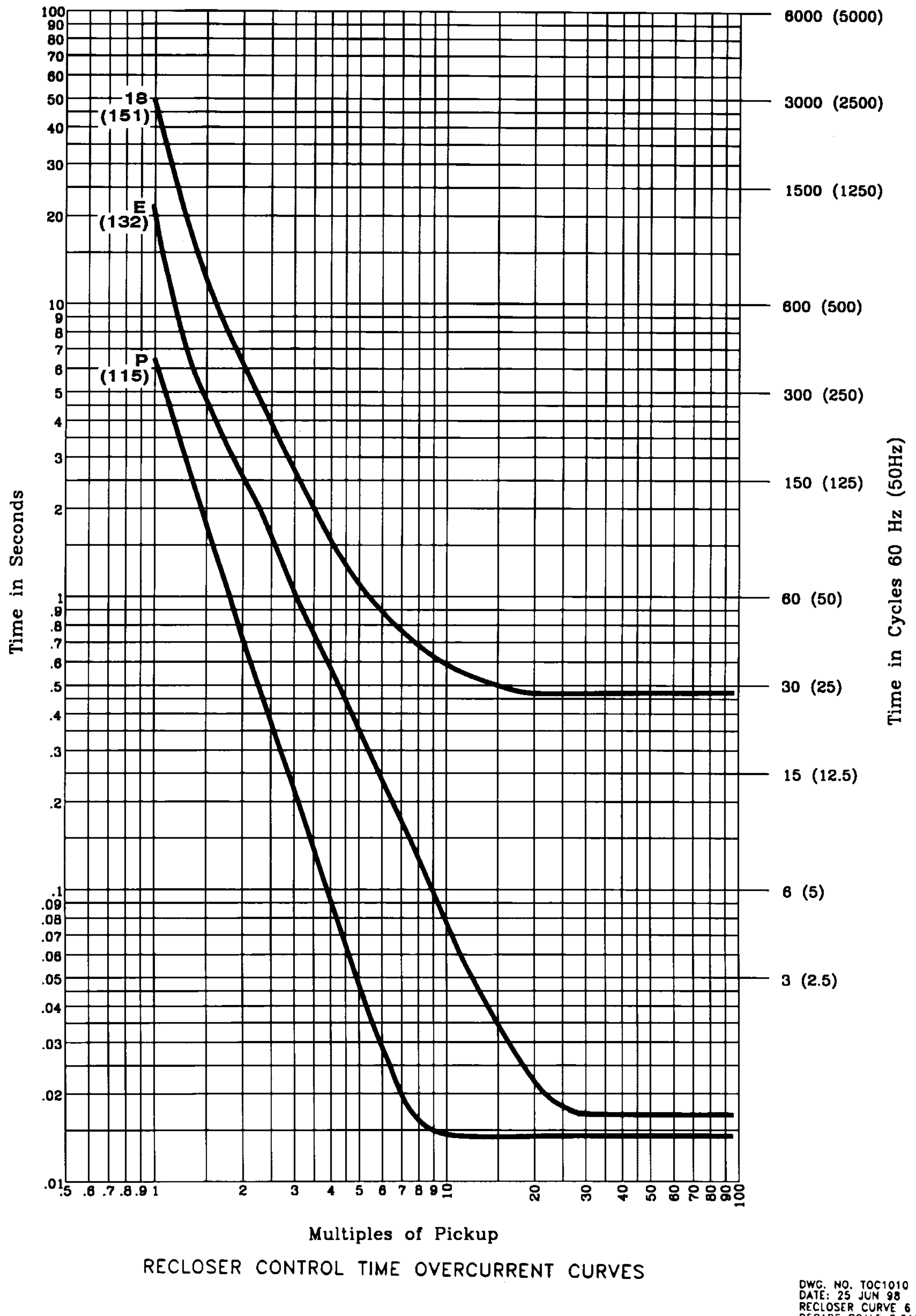

Figure 9.16: Recloser Control Response Curves E, P, and 18

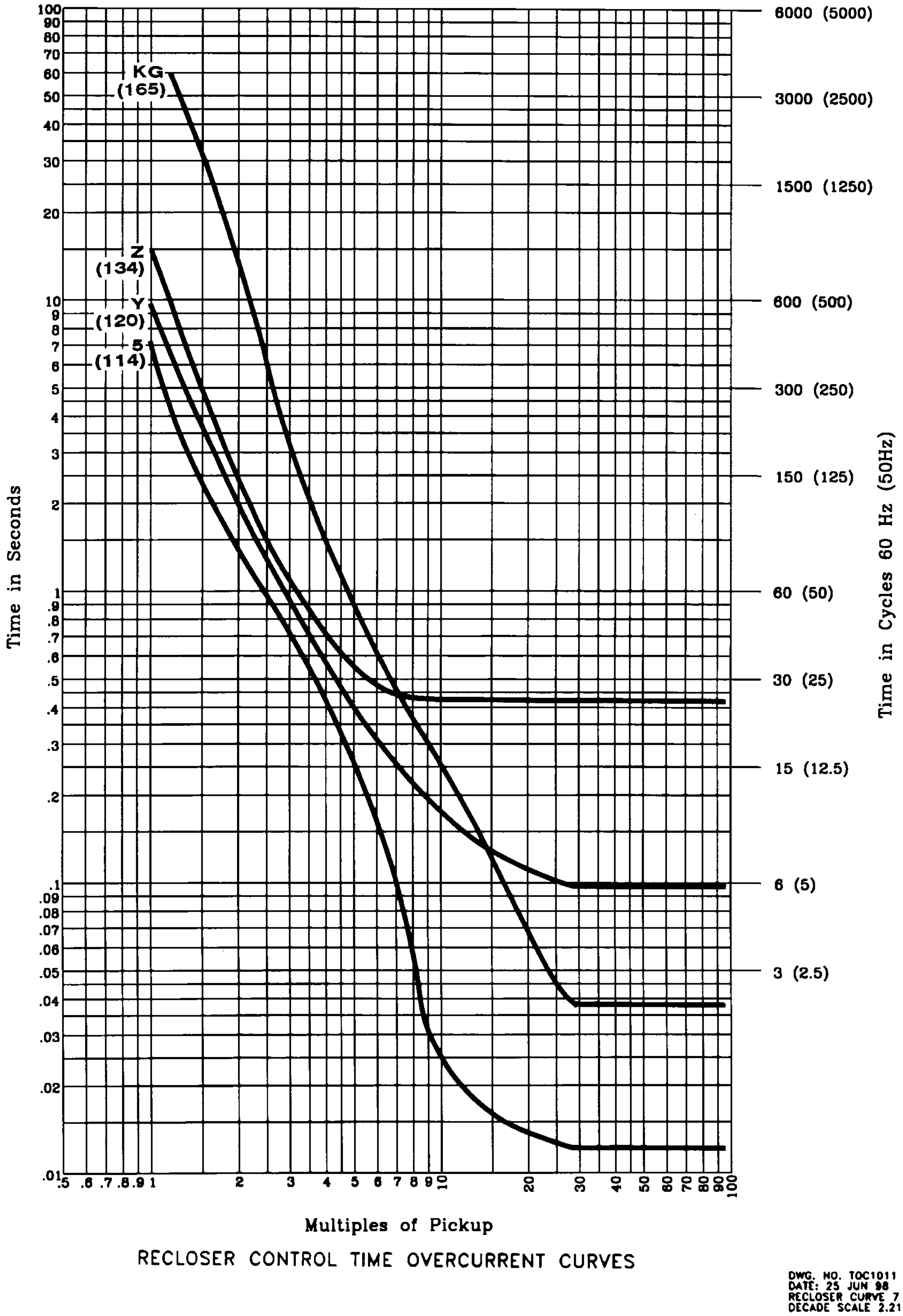

Figure 9.17: Recloser Control Response Curves KG, Y, Z, and 5

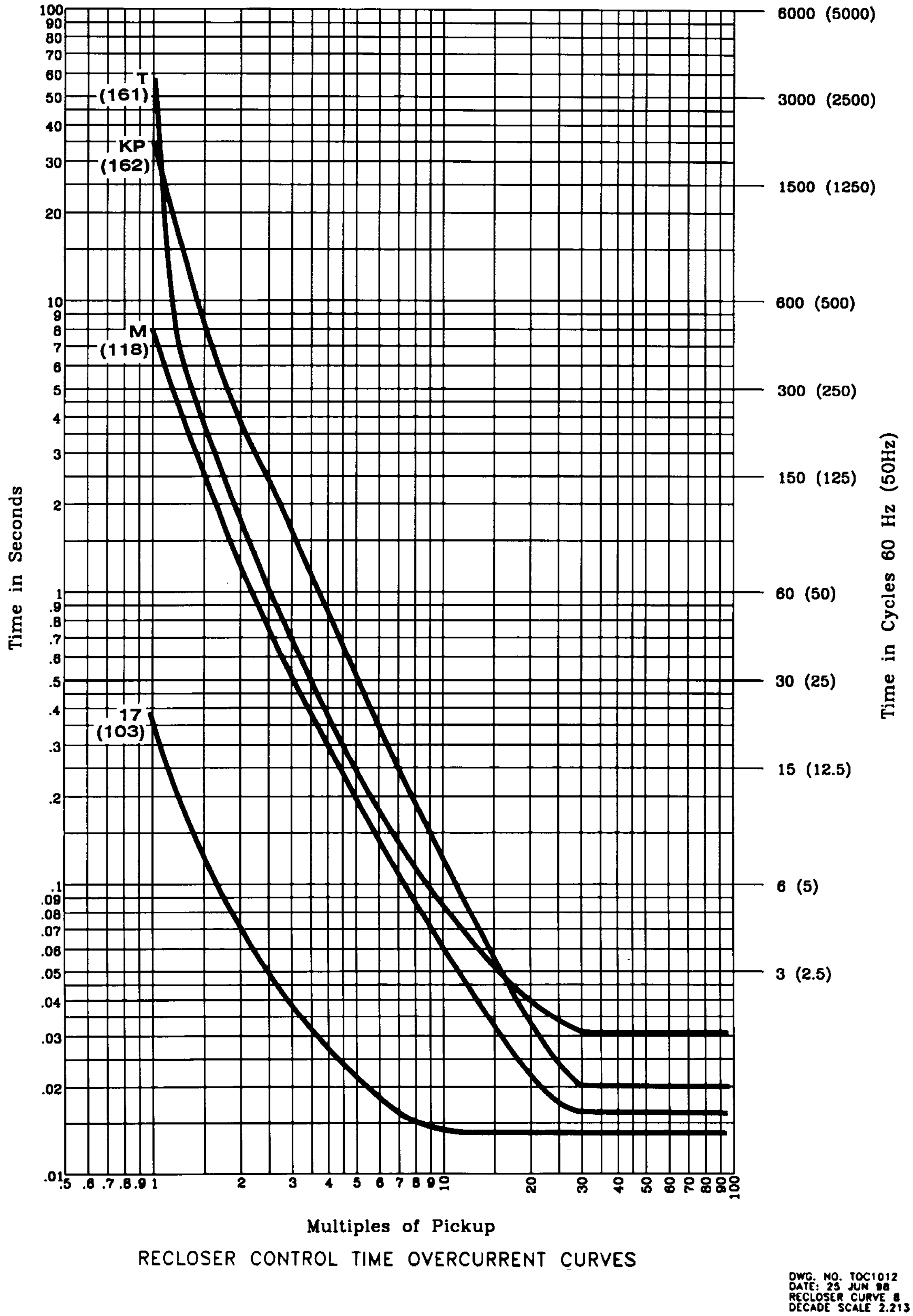

Figure 9.18: Recloser Control Response Curves KP, M, T, and 17

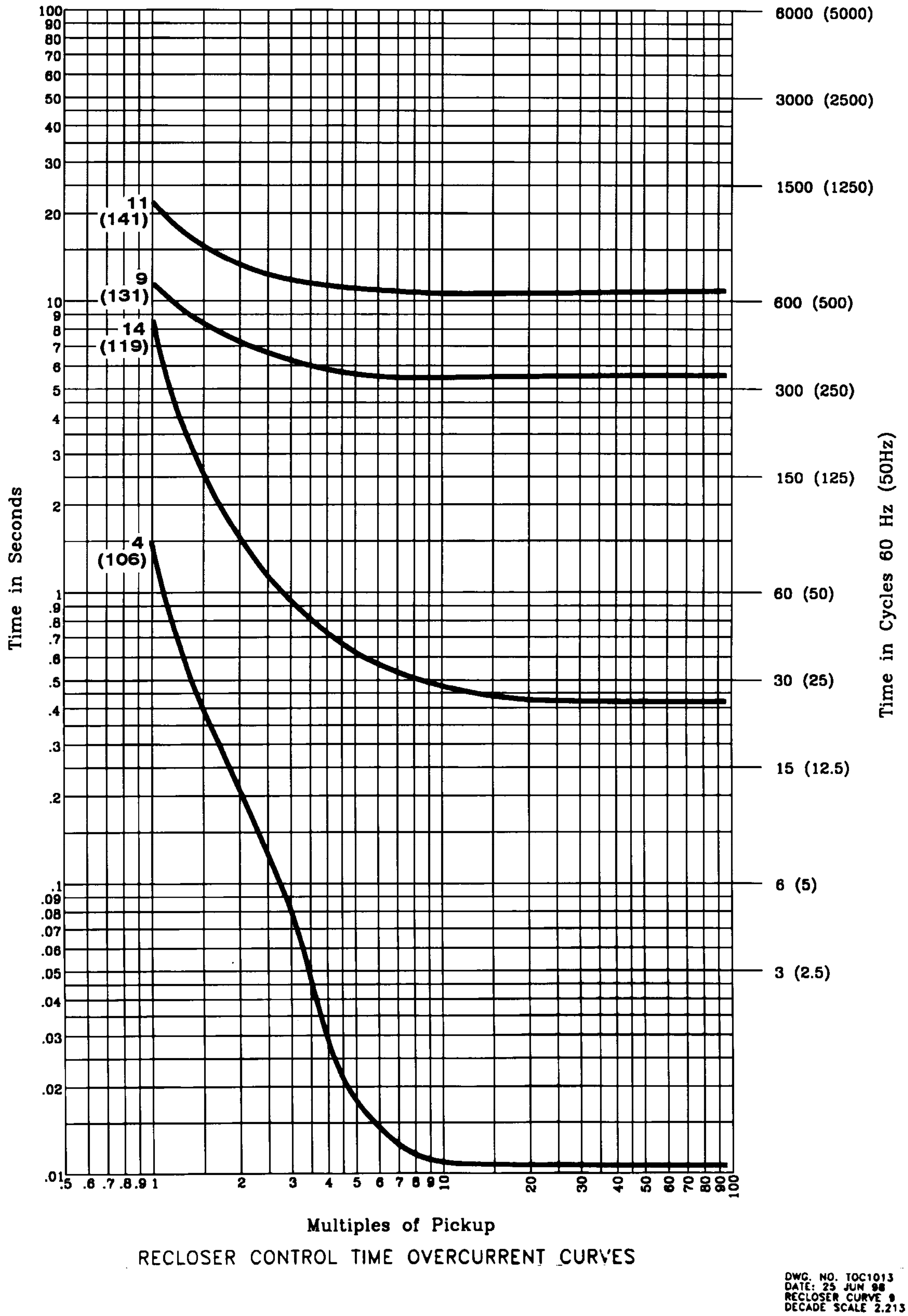

Figure 9.19: Recloser Control Response Curves 4, 9, 11, and 14

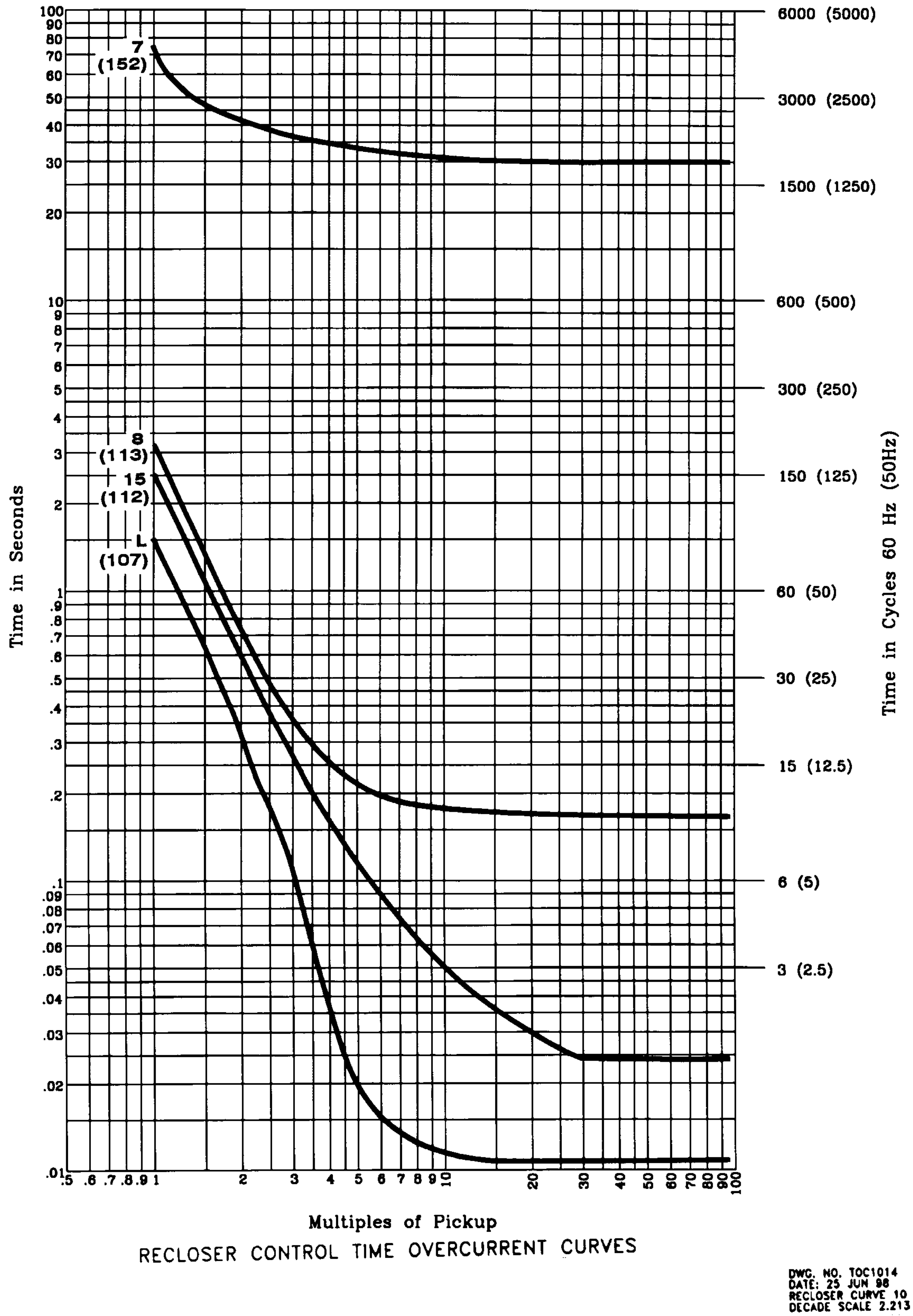

Figure 9.20: Recloser Control Response Curves L, 7, 8, and 15

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 (Target)*** in ***Section 10: Serial Port Communications and Commands***]. Rows 0 and 1 are reserved for the display of the two front-panel target LED rows.

Table 9.3: SEL-351P-3 Recloser Control Relay Word Bits

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	50NF	50NR	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
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

Row	Relay Word Bits							
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	HICHRG
41	67P2S	67N2S	67G2S	67Q2S	PDEM	NDEM	GDEM	QDEM
42	PB1	PB2	PB3	PB4	PB5	PB6	PB7	PB8
43	PB9	32NF	32NR	*	WBTRT	SF6LO	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	*	*	*	*	*	*	*	*
53	*	*	*	*	*	*	*	*
54	*	*	*	*	*	*	*	*
55	*	*	*	*	*	*	*	*
56	RAW52B	RAW52A	WB52A	WBBRK	WBCL	WBTR	CLCAP	TRCAP
57	BATVL1	BATVL2	IDSCHG	ACPWR	CLSBPS	*	DCONN	DDATA
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

Table 9.4: Relay Word Bit Definitions for SEL-351P-3 Recloser Control

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)	

Row	Bit	Definition	Primary Application
	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)	

Row	Bit	Definition	Primary Application
	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)	
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

Row	Bit	Definition	Primary Application
	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**	Negative-sequence current above pickup setting 51QP for negative-sequence time-overcurrent element 51QT (see Figure 3.20)	Testing, Control
	51QT**	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

Row	Bit	Definition	Primary Application
	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)	
	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)	

Row	Bit	Definition	Primary Application
	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**	Level 1 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q1P; see Figure 3.12)	Testing, Control
	50Q2**	Level 2 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q2P; see Figure 3.12)	
	50Q3**	Level 3 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q3P; see Figure 3.12)	
	50Q4**	Level 4 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q4P; see Figure 3.12)	

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**	Level 1 negative-sequence instantaneous overcurrent element (derived from 50Q1; see Figure 3.12)	Testing, Control
	67Q2**	Level 2 negative-sequence instantaneous overcurrent element (derived from 50Q2; see Figure 3.12)	
	67Q3**	Level 3 negative-sequence instantaneous overcurrent element (derived from 50Q3; see Figure 3.12)	
	67Q4**	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**	Level 1 negative-sequence definite-time overcurrent element 67Q1T timed out (derived from 67Q1; see Figure 3.12)	
	67Q2T**	Level 2 negative-sequence definite-time overcurrent element 67Q2T timed out (derived from 67Q2; see Figure 3.12)	
	67Q3T**	Level 3 negative-sequence definite-time overcurrent element 67Q3T timed out (derived from 67Q3; see Figure 3.12)	

Row	Bit	Definition	Primary Application
	67Q4T**	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**	Level 5 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q5P; see Figure 3.13)	Control
	50Q6**	Level 6 negative-sequence instantaneous overcurrent element (negative-sequence current above pickup setting 50Q6P; see Figure 3.13)	
15	50QF	Forward direction negative-sequence overcurrent threshold exceeded (see Figures 4.4, 4.5, 4.9, 4.16, and 4.17)	Testing
	50QR	Reverse direction negative-sequence overcurrent threshold exceeded (see Figures 4.4, 4.5, 4.9, 4.16, and 4.17)	
	50GF	Forward direction residual ground overcurrent threshold exceeded (see Figures 4.4, 4.6, and 4.10)	
	50GR	Reverse direction residual ground overcurrent threshold exceeded (see Figures 4.4, 4.6, and 4.10)	
	32VE	Internal enable for zero-sequence voltage-polarized, residual-current directional element (see Figures 4.4, 4.6, 4.8, and 4.10)	

Row	Bit	Definition	Primary Application
	32QGE	Internal enable for negative-sequence voltage-polarized directional element (for ground; see Figures 4.4, 4.5 and 4.8)	
	32NE	Internal enable for zero-sequence voltage-polarized, neutral-current directional element (see Figures 4.4, 4.7, and 4.11)	
	32QE	Internal enable for negative-sequence voltage-polarized neutral-current directional element (see Figures 4.4, 4.5, 4.16, and 4.17)	
16	F32P	Forward positive-sequence voltage-polarized directional element (see Figures 4.16, 4.18 and 4.19)	Testing, Special directional control schemes
	R32P	Reverse positive-sequence voltage-polarized directional element (see Figures 4.16, 4.18 and 4.19)	
	F32Q	Forward negative-sequence voltage-polarized directional element (see Figures 4.16, 4.17 and 4.19)	
	R32Q	Reverse negative-sequence voltage-polarized directional element (see Figures 4.16, 4.17 and 4.19)	
	F32QG	Forward negative-sequence voltage-polarized directional element (for ground; see Figures 4.4, 4.9, 4.12, and 4.13)	
	R32QG	Reverse negative-sequence voltage-polarized directional element (for ground; see Figures 4.4, 4.9, 4.12, and 4.13)	
	F32V	Forward zero-sequence voltage-polarized residual-current directional element (see Figures 4.4, 4.10, 4.12, and 4.13)	
	R32V	Reverse zero-sequence voltage-polarized residual-current directional element (see Figures 4.4, 4.10, 4.12, and 4.13)	
17	F32N	Forward zero-sequence, voltage-polarized, neutral current directional element (see Figures 4.4, 4.11, and 4.13)	
	R32N	Reverse zero-sequence, voltage-polarized, neutral current directional element (see Figures 4.4, 4.11, and 4.13)	
	32PF	Forward directional control routed to phase overcurrent elements (see Figures 4.19 and 4.21)	
	32PR	Reverse directional control routed to phase overcurrent elements (see Figures 4.19 and 4.21)	

Row	Bit	Definition	Primary Application
	32QF	Forward directional control routed to negative-sequence overcurrent elements (see Figures 4.19 and 4.20)	
	32QR	Reverse directional control routed to negative-sequence overcurrent elements (see Figures 4.19 and 4.20)	
	32GF	Forward directional control routed to residual ground overcurrent elements (see Figures 4.4, 4.12, and 4.14)	
	32GR	Reverse directional control routed to residual ground overcurrent elements (see Figures 4.4, 4.12, and 4.14)	
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)	

Row	Bit	Definition	Primary Application
	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)	
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

Row	Bit	Definition	Primary Application
	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)	

Row	Bit	Definition	Primary Application
	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
24	50NF	Forward direction neutral ground overcurrent threshold exceeded (see Figures 4.4, 4.7, and 4.11)	Testing
	50NR	Reverse direction neutral ground overcurrent threshold exceeded (see Figures 4.4, 4.7, and 4.11)	
	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)	

Row	Bit	Definition	Primary Application
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 7.25)
	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)	

Row	Bit	Definition	Primary Application
29	SV5 SV6 SV7 SV8	SELOGIC control equation variable timer input SV5 asserted (see Figure 7.23) SELOGIC control equation variable timer input SV6 asserted (see Figure 7.23) SELOGIC control equation variable timer input SV7 asserted (see Figure 7.24) SELOGIC control equation variable timer input SV8 asserted (see Figure 7.24)	Testing, Seal-in functions, etc. (see Figure 7.25)
	SV5T SV6T SV7T SV8T	SELOGIC control equation variable timer output SV5T asserted (see Figure 7.23) SELOGIC control equation variable timer output SV6T asserted (see Figure 7.23) SELOGIC control equation variable timer output SV7T asserted (see Figure 7.24) SELOGIC control equation variable timer output SV8T asserted (see Figure 7.24)	Control
30	SV9 SV10 SV11 SV12	SELOGIC control equation variable timer input SV9 asserted (see Figure 7.24) SELOGIC control equation variable timer input SV10 asserted (see Figure 7.24) SELOGIC control equation variable timer input SV11 asserted (see Figure 7.24) SELOGIC control equation variable timer input SV12 asserted (see Figure 7.24)	Testing, Seal-in functions, etc. (see Figure 7.25)
	SV9T SV10T SV11T SV12T	SELOGIC control equation variable timer output SV9T asserted (see Figure 7.24) SELOGIC control equation variable timer output SV10T asserted (see Figure 7.24) SELOGIC control equation variable timer output SV11T asserted (see Figure 7.24) SELOGIC control equation variable timer output SV12T asserted (see Figure 7.24)	Control
31	SV13 SV14 SV15 SV16	SELOGIC control equation variable timer input SV13 asserted (see Figure 7.24) SELOGIC control equation variable timer input SV14 asserted (see Figure 7.24) SELOGIC control equation variable timer input SV15 asserted (see Figure 7.24) SELOGIC control equation variable timer input SV16 asserted (see Figure 7.24)	Testing, Seal-in functions, etc. (see Figure 7.25)

Row	Bit	Definition	Primary Application
	SV13T	SELOGIC control equation variable timer output SV13T asserted (see Figure 7.24)	Control
	SV14T	SELOGIC control equation variable timer output SV14T asserted (see Figure 7.24)	
	SV15T	SELOGIC control equation variable timer output SV15T asserted (see Figure 7.24)	
	SV16T	SELOGIC control equation variable timer output SV16T asserted (see Figure 7.24)	
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*** in ***Section 6: Close and Reclose Logic***)	Testing
	RSTMN	Reset timer is timing (see ***Reclosing Relay*** in ***Section 6: Close and Reclose Logic***)	
	FSA	A-phase fault identification logic output used in A-phase targeting (see Table 5.1)	Control
	FSB	B-phase fault identification logic output used in B-phase targeting (see Table 5.1)	
	FSC	C-phase fault identification logic output used in C-phase targeting (see Table 5.1)	

Row	Bit	Definition	Primary Application
34	BCW	BCWA + BCWB + BCWC	Indication
	50P32	Three-phase overcurrent threshold exceeded (see Figure 4.18)	Testing
	BADBAT 59VA	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*** in ***Section 8*****)** Channel VA voltage window element (channel VA voltage between threshold settings 25VLO and 25VHI; see Figure 3.24)	Indication
	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 Figures 5.1 and 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*** in ***Section 8***)	Indication
35	SG1 SG2 SG3 SG4 SG5 SG6	Setting group 1 active (see Table 7.3) Setting group 2 active (see Table 7.3) Setting group 3 active (see Table 7.3) Setting group 4 active (see Table 7.3) Setting group 5 active (see Table 7.3) Setting group 6 active (see Table 7.3)	Indication
	ZLOUT ZLIN	Load encroachment "load out" element (see Figure 4.2) Load encroachment "load in" element (see Figure 4.2)	Special phase overcurrent element control
36	ZLOAD	ZLOUT + ZLIN (see Figure 4.2)	
	BCWA BCWB	A-phase breaker contact wear has reached 100% wear level (see ***Breaker/Recloser Contact Wear Monitor*** in ***Section 8***) B-phase breaker contact wear has reached 100% wear level (see ***Breaker/Recloser Contact Wear Monitor*** in ***Section 8***)	Indication

Row	Bit	Definition	Primary Application
	BCWC	C-phase breaker contact wear has reached 100% wear level (see ***Breaker/Recloser Contact Wear Monitor*** in ***Section 8***)	
	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*** in ***Section 8***)	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*** in ***Section 8***)	
	DISTST	Battery discharge test in progress (see ***Battery System Monitor*** in ***Section 8***)	Indication
	DTFAIL	Battery discharge test has failed (see ***Battery System Monitor*** in ***Section 8***)	Alarm, indication
37	ALARM	Output contact ALARM asserted (see Figure 7.27)	
	OUT107	Output contact OUT107 asserted (see Figure 7.27)	
	OUT106	Output contact OUT106 asserted (see Figure 7.27)	
	OUT105	Output contact OUT105 asserted (see Figure 7.27)	
	OUT104	Output contact OUT104 asserted (see Figure 7.27)	
	OUT103	Output contact OUT103 asserted (see Figure 7.27)	
	OUT102	Output contact OUT102 asserted (see Figure 7.27)	
	OUT101	Output contact OUT101 asserted (see Figure 7.27)	
38	3PO	Three pole open condition (see Figure 5.3)	Testing
	SOTFE	Switch-onto-fault condition (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)	

Row	Bit	Definition	Primary Application
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**	Asserts 1/4 cycle for **OPEN** command execution (see Figure 1.19)	Tripping, Control
	CC**	Asserts 1/4 cycle for **CLOSE** command execution (see Figure 1.20)	
	CLG	Ground cold load pickup scheme enabled (see Figures 1.3 and 1.4)	Control
	HICHRG	Charging current above 100 mA (with 5% hysteresis; see ***Battery System Monitor*** in ***Section 8*****)**	Indication
41	67P2S	Level 2 directional phase definite-time (short delay) overcurrent element 67P2S timed out (derived from 67P2; see Figures 3.3 and 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 Figures 3.8 and 5.14)	
	67G2S	Level 2 directional residual ground definite-time (short delay) overcurrent element 67G2S timed out (derived from 67G2; see Figures 3.10 and 5.14)	

Row	Bit	Definition	Primary Application
	67Q2S	Level 2 directional negative-sequence definite-time (short delay) overcurrent element 67Q2S timed out (derived from 67Q2; see Figures 3.12 and 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)	
42	PB1	PROTECTION ENABLED/PROTECCION HABILITADA pushbutton output (see Figure 1.31)	Control
	PB2	RECLOSE ENABLED/RECIERRE HABILITADO pushbutton output (see Figure 1.31)	
	PB3	EARTH FAULT ENABLED/FALLA A TIERRA HABILITADA pushbutton output (see Figure 1.31)	
	PB4	SEF ENABLED/SEF HABILITADO pushbutton output (see Figure 1.31)	
	PB5	REMOTE ENABLED/REMOTO HABILITADO pushbutton output (see Figure 1.31)	
	PB6	LIVE LINE ENABLED/LINEA VIVA HABILITADA pushbutton output (see Figure 1.32)	
	PB7	ALTERNATE SETTINGS/AJUSTES ALTERNATIVOS pushbutton output (see Figure 1.32)	
	PB8	CLOSE/CIERRE pushbutton output (see Figure 1.32)	
43	PB9	TRIP/DISPARO pushbutton output (see Figure 1.32)	
	32NF	Forward directional control routed to neutral ground overcurrent elements (see Figures 4.4, 4.13, and 4.15)	Testing, Special directional control schemes
	32NR	Reverse directional control routed to neutral ground overcurrent elements (see Figures 4.4, 4.13, and 4.15)	
	WBTRT	Trip output of final trip/close logic, with 30 cycle dropout time added (see Figure 7.30).	Indication
	SF6LO	SF6 gas pressure below SF6PRS setting	
	DISCHG	Battery is discharging (see ***Battery System Monitor*** in ***Section 8***)	

Row	Bit	Definition	Primary Application
	LED9	RECLOSER OPEN/RESTAURADOR ABIERTO LED (see Figure 1.32)	
44	LED1	PROTECTION ENABLED/ PROTECCION HABILITADA LED (see Figure 1.31)	
	LED2	RECLOSE ENABLED/RECIERRE HABILITADO LED (see Figure 1.31)	
	LED3	EARTH FAULT ENABLED/FALLA A TIERRA HABILITADO LED (see Figure 1.31)	
	LED4	SEF ENABLED/SEF HABILITADO LED (see Figure 1.31)	
	LED5	REMOTE ENABLED/REMOTO HABILITADO LED (see Figure 1.31)	
	LED6	LIVE LINE ENABLED/LINEA VIVA HABILITADA LED (see Figure 1.32)	
	LED7	ALTERNATE SETTINGS/AJUSTES ALTERNATIVOS LED (see Figure 1.32)	
	LED8	RECLOSER CLOSED/RESTAURADOR CERRADO LED (see Figure 1.32)	
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 Figures 1.1 and 1.2)	
	RPG	Restore pickup—ground (see Figures 1.1 and 1.3)	
	RPS	Restore pickup—Sensitive earth fault (see Figure 1.1 and Figure 1.4)	
	SEQC	Sequence coordination enabled (see Figure 1.27)	

Row	Bit	Definition	Primary Application
	3PHV	Three phase voltage hooked up to control (see Figure 4.1)	
	GTP	Ground trip precedence enabled (see Figure 1.24)	
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
	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	

Row	Bit	Definition	Primary Application
	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	
52	*	Reserved for future use.	
53	*	Reserved for future use.	
54	*	Reserved for future use.	
55	*	Reserved for future use.	
56	RAW52B	52b breaker auxiliary status—not time-qualified (see Figure 13 and corresponding *CONTROL Connector J5 Details* discussion in the *Installation* section of the *SEL-351P-3 Quick-Start Installation and User's Guide*)	Testing
	RAW52A	52a breaker auxiliary status—not time-qualified (see Figure 13 and corresponding *CONTROL Connector J5 Details* discussion in the *Installation* section of the *SEL-351P-3 Quick-Start Installation and User's Guide*)	
	WB52A	Time-qualified (1-cycle pickup and 0.25 cycles dropout) 52a breaker auxiliary status	Breaker status
	WBBRK	Holdover Relay Word bit from previous SEL-351P-3 models—it is not used in the SEL-351P-3	Testing
	WBCL	Close FET outputs asserted (see Figure 13 and corresponding *CONTROL Connector J5 Details* discussion in the *Installation* section of the *SEL-351P-3 Quick-Start Installation and User's Guide*)	

Row	Bit	Definition	Primary Application
	WBTR	Trip FET outputs asserted (see Figure 13 and corresponding *CONTROL Connector J5 Details* discussion in the *Installation* section of the *SEL-351P-3 Quick-Start Installation and User's Guide*)	
	CLCAP	Close capacitor charged higher than 20 Vdc (see Figure 13 and corresponding *CONTROL Connector J5 Details* discussion in the *Installation* section of the *SEL-351P-3 Quick-Start Installation and User's Guide*)	Closing, Control
	TRCAP	Trip capacitor fully charged, higher than 80 Vdc (see Figure 13 and corresponding *CONTROL Connector J5 Details* discussion in the *Installation* section of the *SEL-351P-3 Quick-Start Installation and User's Guide*)	Tripping, Closing, Control
57	BATVL1	Battery voltage below global setting V_LOW1 level (factory default is V_LOW1 = 20.5 V; see *Battery System Monitor* in Section 8)	Indication
	BATVL2	Battery voltage below 19.2 V level	
	IDSCHG	Indication that battery discharge current is greater than 50 mA	
	ACPWR	Indication that the external 120/240 Vac power source is present (usually connected to terminals 1 and 2 of POWER IN connector J7 – see Figure 12 in the *SEL-351P-3 Quick-Start Installation and User's Guide*; also see LED11 setting in Figure 1.42 and Figure 1.43)	
	CLSBPS	Boost Power Switch is closed (see Figure 13 and corresponding *CONTROL Connector J5 Details* discussion in the *Installation* section of the *SEL-351P-3 Quick-Start Installation and User's Guide*)	
	DCONN DDATA	DNP port is connected DNP has unsolicited data ready to send	Automatic Dial-Out
58	LB9 LB10 LB11 LB12 LB13 LB14 LB15 LB16	Local Bit 9 asserted (see Figure 7.3) Local Bit 10 asserted (see Figure 7.3) Local Bit 11 asserted (see Figure 7.3) Local Bit 12 asserted (see Figure 7.3) Local Bit 13 asserted (see Figure 7.3) Local Bit 14 asserted (see Figure 7.3) Local Bit 15 asserted (see Figure 7.3) Local Bit 16 asserted (see Figure 7.3)	Control via front panel—replacing traditional panel-mounted control switches

Row	Bit	Definition	Primary Application
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)	
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)	

** **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 Settings Sheet 1 of 28.

The SEL-351P-3 has two identifier labels: the Relay Identifier (RID) and the Terminal Identifier (TID). The Relay 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-351P-3 tags each report (event report, meter report, etc.) with the Relay 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 and Potential Transformer Ratios

Refer to Settings Sheet 1 of 28.

Phase and neutral current transformer ratios are set independently. The IN channel is wired up as a sensitive residual current channel in the SEL-351P-3. The neutral current transformer ratio will be set equal to the phase current transformer ratio. The neutral current channel is scaled to measure sensitive residual currents (less than 1.5 A secondary). The internally derived residual elements (G elements) are scaled the same as the phase channels and measure larger currents (up to 150 A secondary).

The ***Installation*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide*** discusses in detail the making of current and potential transformer ratio settings for low-level current and voltage inputs.

Line Settings

Refer to Settings Sheet 1 of 28.

Line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are used in the fault locator (see ***Fault Location*** in ***Section 12: Standard Event Reports and SER***) and in automatically making directional element settings Z2F, Z2R, Z0F, and Z0R (see ***Settings Made Automatically*** in ***Section 4: Loss-of-Potential, Load Encroachment, and Directional Element Logic***). 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:

$$\Omega \text{ primary} \bullet (CTR/PTR) = \Omega \text{ secondary}$$

where:

CTR = phase (IA, IB, IC) current transformer ratio
PTR = phase (VA, VB, VC) potential transformer ratio

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 Settings Sheets 1, 2, and 20 of 28.

The enable settings on Settings Sheets 1 and 2 (E50P through EDEM) control the settings that follow, through Sheet 11. Enable setting EBMON on Settings Sheet 20 controls the settings that immediately follow it. This helps limit the number of settings that need to be made.

Each setting subgroup on Settings Sheets 2 through 12 has a reference back to the controlling enable setting. For example, the neutral ground time-overcurrent elements settings on Sheet 5 (settings 51N1P through 51N1RS and 51N2P through 51N2RS) are controlled by enable setting E51N.

Other System Parameters

Refer to Settings Sheet 20 of 28.

The global settings NFREQ and PHROT allow you to configure the SEL-351P-3 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.

Set DATE_F to format the date displayed in relay 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.

Current and Voltage Connection Settings

See ***Global Settings: Current and Voltage Connection Settings*** in the ***Setting Sheets***.

The SEL-351P-3 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-351P-3 recloser control algorithm. Using the following settings designates the power system A-B-C wiring to the relay terminal V1-V2-V3 connections for the relay algorithms.

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.

The SEL-351P-3 side panel terminals are shown in Figure 3 through Figure 11 in the ***SEL-351P-3 Quick-Start User and Installation 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-351P-3 current and voltage input terminals is used:

- For currents: I1, I2, I3, IN
- For voltages: V1, V2, V3

This simplified list does not include the polarity marks on the current or voltage inputs. For example, the current channel I1 is comprised of the physical terminals numbered 1 (I1 polarity, indicated with a dot above the terminal) and 2 (I1 non-polarity), but will be referred to as only the I1 channel.

Phantom Voltage Setting (PHANTV)

The SEL-351P-3 can be configured to create phantom three-phase voltage signals from an applied single-phase voltage. Table 9.5 shows the setting choices for PHANTV setting to be made. See ***Phantom Voltages*** in ***Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions***.

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-351P-3 has three analog voltage inputs called V1, V2, and V3. This section deals with the settings that determine how the SEL-351P-3 processes the signals measured on these terminals.

The SEL-351P-3 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-351P-3. 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-351P-3.

Voltage Terminal Designations (simplified):

- Voltage terminals: V1, V2, V3

Unlike the CT connections shown in Table 9.6, it is possible to operate the recloser control with less than three voltages on the set of terminals. Table 9.5 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.

Note: In Table 9.5, the phase-to-phase connections shown (AB, BC, CA) are single-phase measurements.

Table 9.5: 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 9.5 lists single-phase and phase-phase connection options for voltage input V1. These voltage input V1 connections are between terminals •V1–V1 (see Figure 3 through Figure 11 in the ***SEL-351P-3 Quick-Start Installation and User's Guide***).

Figure 9.11 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 9.11 are used in the voltage elements (see ***Voltage Elements***, Figure 3.28, Figure 3.21, and Figure 3.22 in ***Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements***) and in the event report columns (see Figure 12.27 in ***Section 12: Standard Event Reports and SER***). Even though single-phase and phase-to-phase connections to V1 are shown in Figure 9.11 (and “no connections” are shown at the bottom of Figure 9.11), all the voltage terminals and subsequent internal voltages are active for the aforementioned voltage elements and event report columns.

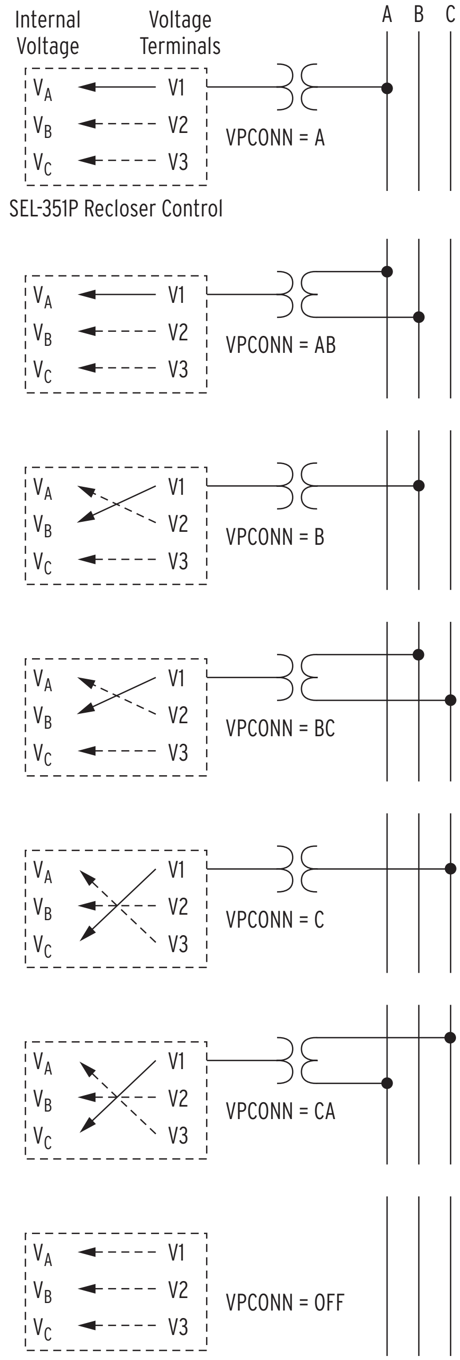

Figure 9.11: Terminal Assignments for Single-Phase and Phase-to-Phase Voltage Connections

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-351P-3 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-351P-3 is interpreting signals. ***Section 10: Communications*** contains a sample **MET** command capture. ***Metering Check*** in the ***Installation*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide*** gives a quick troubleshooting routine.

Note: Metering values may take several seconds to update after IPCONN, VTCONN, or CTPOL settings changes.

Event reports are also powerful diagnostic tools (see ***Section 12: Standard Event Reports and SER***). SEL-5601 Analytic Assistant software allows graphical representation of compressed event report data, including oscillography and phasor display.

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-351P-3 cabinet via a prewired control cable. The factory connection includes a residual connection to the channel IN terminals, and the I1, I2, and I3 phase current terminals.

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 9.6 shows the required setting for IPCONN for the various CT signal connections.

Table 9.6: 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-351P-3 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.

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 SEL-5601 Analytic Assistant software, extract the same phase information that the SEL-351P-3 is using.

Transition Between Power System A-B-C and Terminals 1-2-3

In Figure 9.12, the SEL-351P-3 “1-2-3” connections provide a transition between the:

“A-B-C” power system outside

and the

“A-B-C” algorithm inside the SEL-351P-3.

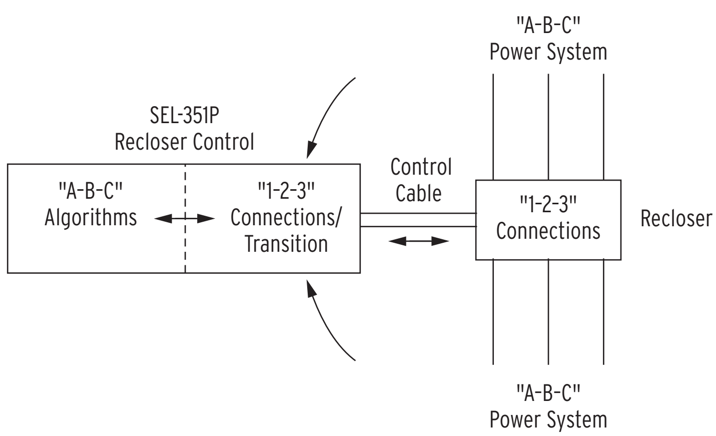

Figure 9.12: Overview of Transition Between A-B-C Inside and Outside the SEL-351P-3

Wiring 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-351P-3 algorithms. Preceding Table 9.5, Table 9.6, and Figure 9.11 list the settings and all possible settings combinations that realize the correct “A-B-C” designations within the SEL-351P-3 for the numerous possible power system connections.

Figure 9.13 and Figure 9.14 are a more in-depth look at the transition idea given in Figure 9.12. The underlying assumption in Figure 9.13 and Figure 9.14 is that the wiring from the control cable is factory-standard in the way it connects to both the SEL-351P-3 and the recloser (i.e., there is no rearrangement of the factory-standard cable wiring).

Straight-Through Phase Connections

From inspection of the SEL-351P-3 settings and connections in Figure 9.13, one can see that the correspondence between the power system and the SEL-351P-3 connections is as follows:

A ←→ 1

B ←→ 2

C ←→ 3

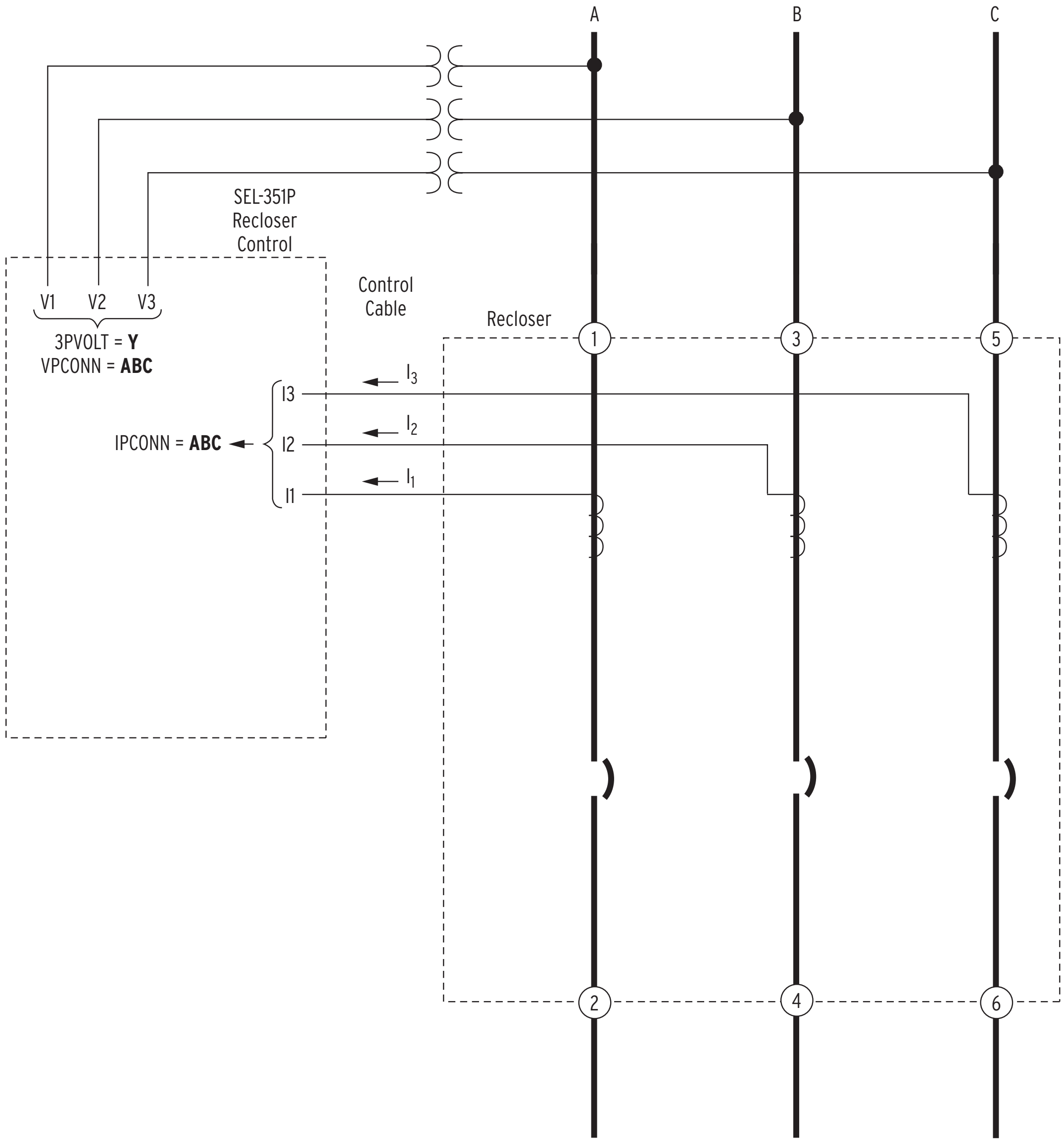

Figure 9.13: Recloser With Straight-Through Connections

Complex Phase Connections

Figure 9.14 is similar to Figure 9.13, but it has the added complication of primary phase swapping. The correspondence between the power system and the SEL-351P-3 connections is first, at the top of Figure 9.14:

A ←→ 1

B ←→ 2

C ←→ 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-351P-3 connections is as follows:

C ←→ 1

A ←→ 2

B ←→ 3

With IPCONN = CAB

(current terminals: I1 • C-phase, I2 • A-phase, I3 • B-phase)

and:

Coil 1 ←→ C-phase

Coil 2 ←→ A-phase

Coil 3 ←→ B-phase

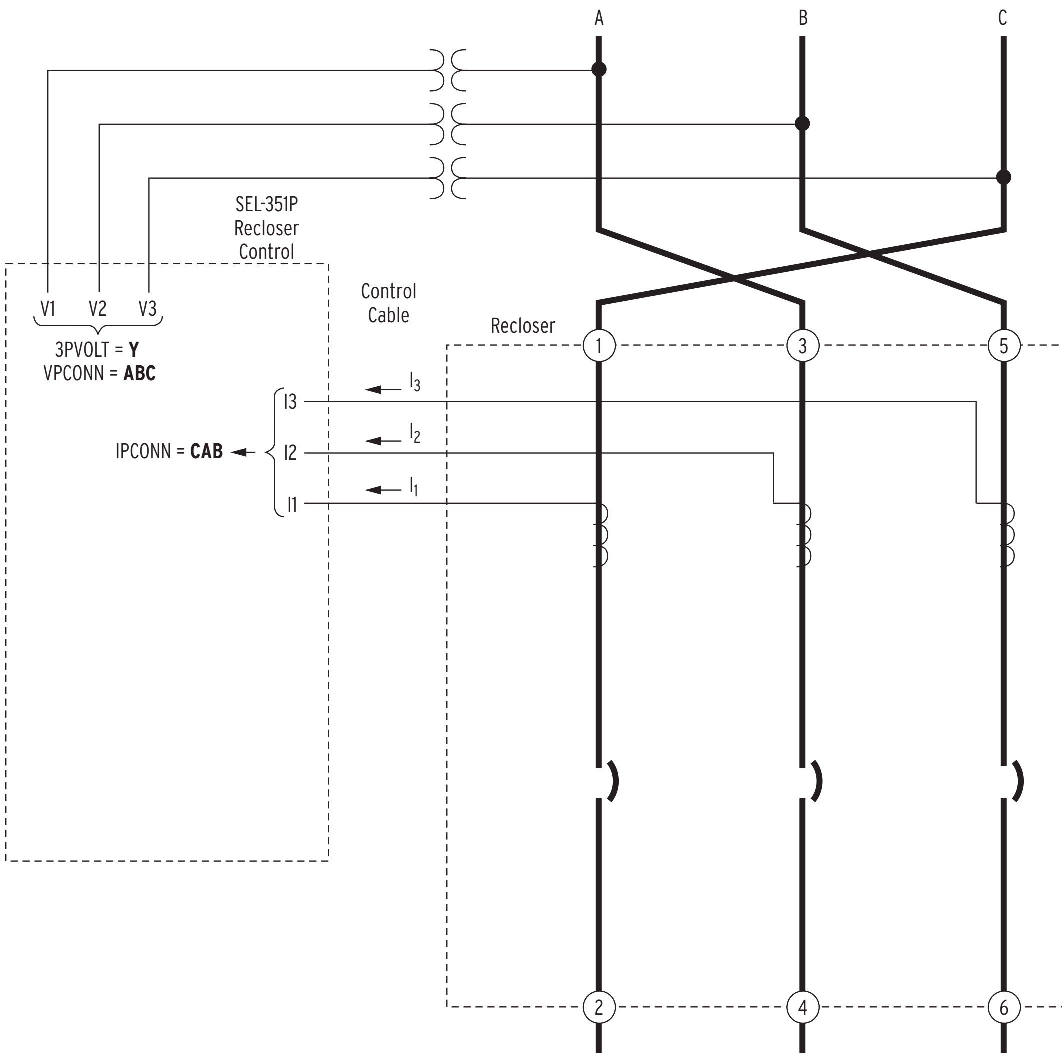

Figure 9.14: Recloser With complex Connections

Settings Sheets

The settings sheets that follow include the definition and input range for most of the settings in the SEL-351P-3. The settings sheets for the EZ settings are located at the end of the ***Settings*** section in the ***SEL-351P-3 Quick-Start Installation and User's Guide***. See Table 9.1 for settings sheets references.

SETTINGS SHEET
FOR THE SEL-351P-3 RECLOSER CONTROL
GROUP SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Identifier Labels (see *Settings Explanations* in Section 9)

Relay Identifier (30 characters)	RID =	________
Terminal Identifier (30 characters)	TID =	________

Current and Potential Transformer Ratios (see *Settings Explanations* in Section 9)

Phase (IA, IB, IC) Current Transformer Ratio (1.0–6000.0)	CTR =	________
Neutral (IN) Current Transformer Ratio (1.0–10000.0)	CTRN =	________
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 *Settings Explanations* in Section 9)

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 Figures 3.1, 3.2, 3.3, and 3.7)	E50P =	________
Neutral ground element levels—channel IN (N, 1–6) (see Figures 3.8 and 3.9)	E50N =	________
Residual ground element levels (N, 1–6) (see Figures 3.10 and 3.11)	E50G =	________
Negative-sequence element levels (N, 1–6) (see Figures 3.12 and 3.13)	E50Q =	________

Time-Overcurrent Enable Settings

Phase elements (N, 1, 2) (see Table 3.1, Figures 3.14 and 3.15)	E51P =	________
Neutral ground elements—channel IN (N, 1, 2) (see Figures 3.16 and 3.17)	E51N =	________
Residual ground elements (N, 1, 2) (see Figures 3.18 and 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*** in Section 4)	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 Figures 3.21, 3.22, and 3.23)	EVOLT =	________

Synchronism check (Y, N) (see Figures 3.24 and 3.25)	E25 =	________
Fault location (Y, N) (see Table 12.1 and ***Fault Location*** in Section 12)	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*** in Section 5)	ECOMM =	________
Frequency elements (N, 1–6) (see Figure 3.28)	E81 =	________
Reclosures (N, 1–4) (see ***Reclosing Relay*** in Section 6)	E79 =	________
SELOGIC® Control Equation Variable Timers (N, 1–16) (see Figures 7.23 and 7.24)	ESV =	________
Demand Metering (THM = Thermal, ROL = Rolling) (see Figure 8.9)	EDEM =	________

Phase Inst./Def.-Time Overcurrent Elements (see Figures 3.1, 3.2, and 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 Figures 3.8 and 3.9)

(Number of neutral ground element pickup settings dependent on preceding enable setting E50N = 1–6)

Pickup (OFF, 0.005–1.500A)	50N1P =	________
Pickup (OFF, 0.005–1.500A)	50N2P =	________
Pickup (OFF, 0.005–1.500A)	50N3P =	________
Pickup (OFF, 0.005–1.500A)	50N4P =	________
Pickup (OFF, 0.005–1.500A)	50N5P =	________
Pickup (OFF, 0.005–1.500A)	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 Figures 3.10 and 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 Figures 3.12 and 3.13)*

(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)*

(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 =	________

* **IMPORTANT**: See ***Appendix F*** for information on setting negative-sequence overcurrent elements.

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, 0.10–3.20 A)	51P1P =	________
Curve (U1–U5, C1–C5, recloser or user curve; see Figures 9.1 through 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 Figures 9.1 through 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 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 Figures 9.1 through 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 Figures 9.1 through 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, 0.10–3.20 A)	51G1P =	________
Curve (U1–U5, C1–C5, recloser or user curve; see Figures 9.1 through 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 Figures 9.1 through 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)*

(Make the following settings if preceding enable setting E51Q = Y)

Pickup (OFF, 0.10–3.20 A)	51QP =	____________
Curve (U1–U5, C1–C5, recloser or user curve; see Figures 9.1 through 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=	____________

* **IMPORTANT**: See ***Appendix F*** for information on setting negative-sequence overcurrent elements.

Load-Encroachment Elements (see Figure 4.2)

(Make the following settings if preceding enable setting ELOAD = Y)

Forward load impedance (0.50–640.00 Ω secondary)	ZLF =	____________
Reverse load impedance (0.50–640.00 Ω secondary)	ZLR =	____________
Positive forward load angle (–90° to +90°)	PLAF =	____________
Negative forward load angle (–90° to +90°)	NLAF =	____________
Positive reverse load angle (+90° to +270°)	PLAR =	____________
Negative reverse load angle (+90° to +270°)	NLAR =	____________

Directional Elements (see *Directional Control Settings* in Section 4)

(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 Q, V, or OFF	ORDER =	________

(Make setting 50P32P if preceding enable settings 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)	50QFP =	________
Reverse directional negative-sequence current pickup (0.05–1.00 A)	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)	50GFP =	________
Reverse directional residual ground pickup (0.05–1.00 A)	50GRP =	________
Positive-sequence current restraint factor, I0/I1 (0.02–0.50, unitless)	a0 =	________
Forward directional Z0 threshold (–640.00 to +640.00Ω secondary)	Z0F =	________
Reverse directional Z0 threshold (–640.00 to +640.00 Ω secondary)	Z0R =	________

Voltage Elements (see Figures 3.21, 3.22, and 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 Figures 3.24 and 3.25)

(Make the following settings if preceding enable setting E25 = Y)

Voltage window—low threshold (0.0–300.0 V secondary)	25VLO =	________
Voltage window—high threshold (0.0–300.0 V secondary)	25VHI =	________
Maximum slip frequency (0.005–0.500 Hz)	25SF =	________
Maximum angle 1 (0°–80° in 1-degree steps)	25ANG1 =	________
Maximum angle 2 (0°–80° in 1-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 Element (see Figures 3.27 and 3.28)

(Make the following settings if preceding enable setting E81 = Y)

Phase undervoltage block (20.0–300.0 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)	81D5D =	________
Level 6 pickup (OFF, 40.10–65.00 Hz)	81D6P =	________
Level 6 time delay (2.00–16000.00 cycles in 0.25-cycle steps)	81D6D =	________

Reclosing Relay (see Tables 6.2 and 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 =	________
52 A 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 Figures 8.9 and 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: (OFF, 0.10–3.20 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 Figures 7.23 and 7.24)

(Number of timer pickup/dropout settings dependent on preceding enable setting ESV = 1–16)

SV1 Pickup Time (0–999999.00 cycles in 0.25-cycle steps)	SV1PU =	________
SV1 Dropout Time (0–999999.00 cycles in 0.25-cycle steps)	SV1DO =	________
SV2 Pickup Time (0–999999.00 cycles in 0.25-cycle steps)	SV2PU =	________
SV2 Dropout Time (0–999999.00 cycles in 0.25-cycle steps)	SV2DO =	________
SV3 Pickup Time (0–999999.00 cycles in 0.25-cycle steps)	SV3PU =	________
SV3 Dropout Time (0–999999.00 cycles in 0.25-cycle steps)	SV3DO =	________
SV4 Pickup Time (0–999999.00 cycles in 0.25-cycle steps)	SV4PU =	________
SV4 Dropout Time (0–999999.00 cycles in 0.25-cycle steps)	SV4DO =	________
SV5 Pickup Time (0–999999.00 cycles in 0.25-cycle steps)	SV5PU =	________
SV5 Dropout Time (0–999999.00 cycles in 0.25-cycle steps)	SV5DO =	________
SV6 Pickup Time (0–999999.00 cycles in 0.25-cycle steps)	SV6PU =	________
SV6 Dropout Time (0–999999.00 cycles in 0.25-cycle steps)	SV6DO =	________
SV7 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV7PU =	________
SV7 Dropout Time (0–16000.00 cycles in 0.25-cycle steps)	SV7DO =	________
SV8 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV8PU =	________
SV8 Dropout Time (0–16000.00 cycles in 0.25-cycle steps)	SV8DO =	________
SV9 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV9PU =	________
SV9 Dropout Time (0–16000.00 cycles in 0.25-cycle steps)	SV9DO =	________
SV10 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV10PU =	________
SV10 Dropout Time (0–16000.00 cycles in 0.25-cycle steps)	SV10DO =	________
SV11 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV11PU =	________
SV11 Dropout Time (0–16000.00 cycles in 0.25-cycle steps)	SV11DO =	________
SV12 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV12PU =	________
SV12 Dropout Time (0–16000.00 cycles in 0.25-cycle steps)	SV12DO =	________
SV13 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV13PU =	________
SV13 Dropout Time (0–16000.00 cycles in 0.25-cycle steps)	SV13DO =	________
SV14 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV14PU =	________
SV14 Dropout Time (0–16000.00 cycles in 0.25-cycle steps)	SV14DO =	________
SV15 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV15PU =	________
SV15 Dropout Time (0–16000.00 cycles in 0.25-cycle steps)	SV15DO =	________
SV16 Pickup Time (0–16000.00 cycles in 0.25-cycle steps)	SV16PU =	________
SV16 Dropout Time (0–16000.00 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 =	________

SETTINGS SHEET
FOR THE SEL-351P-3 RECLOSER CONTROL
SELOGIC CONTROL EQUATION SETTINGS (SERIAL PORT COMMAND SET L)

SELOGIC control equation settings consist of Relay Word bits (see Table 9.3) 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 3 through 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 Figures 5.5, 5.7, and 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 Figures 5.5 and 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* in Section 6)

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 (see Figure 3.20)	51QTC =	____________

SELOGIC Control Equation Variable Timer Input Equations (see Figures 7.23 and 7.24)

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 Output Equations (see Figure 7.30)

Recloser Trip via control cable	RCTR=	________
Recloser Close via control cable	RCCL=	________

Output Contact Equations (see Figure 7.27)

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 Figures 1.35, 1.36, and 1.51 through 1.54)

LED1 (PROTECTION ENABLED/PROTEÇÃO HABILITADA)	LED1 =	________
LED2 (RECLOSE ENABLED/RELIGAMENTO HABILITADO)	LED2 =	________
LED3 (EARTH FAULT ENABLED/TERRA HABILITADO)	LED3 =	________
LED4 (SEF ENABLED/SEF HABILITADO)	LED4 =	________
LED5 (REMOTE ENABLED/REMOTO HABILITADO)	LED5 =	________
LED6 (LIVE LINE ENABLED/LINHA VIVA HABILITADA)	LED6 =	________
LED7 (ALTERNATE SETTINGS/AJUSTES ALTERNATIVOS)	LED7 =	________
LED8 (RECLOSER CLOSED/RELIGADOR FECHADO)	LED8 =	________
LED9 (RECLOSER OPEN/RELIGADOR ABERTO)	LED9 =	________
LED11 (AC SUPPLY/FONTE CA)	LED11 =	________
LED12 (BATTERY PROBLEM/BATERIA PROBLEMA)	LED12 =	________
LED13 (LOW PRESSURE/PRESSÃO BAIXA)	LED13 =	________
LED14 (TRIP)	LED14 =	________
LED15 (FAST CURVE/CURVA RÁPIDA)	LED15 =	________
LED16 (HIGH CURRENT/ALTA CORRENTE)	LED16 =	________
LED17 (UNDER FREQ./RELE FREQ.)	LED17 =	________
LED18 (RESET)	LED18 =	________
LED19 (CYCLE/CICLO)	LED19 =	________
LED20 (LOCKOUT/BLOQUEADO)	LED20 =	________
LED24 (G/N)	LED24 =	________
LED25 (SEF)	LED25 =	________

Display Point Equations (see *Rotating Default Display* in Sections 7 and 11)

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*** and ***Maximum/Minimum Metering*** in Section 8])	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 element (see Figure 4.6)	E32IV =	________

MIRRORED BITS® Transmit Equations

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 =	____________

SETTINGS SHEET
FOR THE SEL-351P-3 RECLOSER CONTROL
GLOBAL SETTINGS (SERIAL PORT COMMAND SET G AND FRONT PANEL)

Settings Group Change Delay (see *Multiple Setting Groups* in Section 7)

Group change delay (0.00–16000.00 cycles in 0.25-cycle steps)	TGR =	________

Power System Configuration and Date Format (see *Settings Explanations* in Section 9)

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)

Front-panel display time-out (0–30 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)

Length of event report (15, 30 cycles)	LER =	________
Length of prefault 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* in Section 8)

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. (0.10–999.00 kA primary in 0.01 kA steps)	KASP1 =	________
kA Interrupted set point 2—mid. (0.10–999.00 kA primary in 0.01 kA steps)	KASP2 =	________
kA Interrupted set point 3—max. (0.10–999.00 kA primary in 0.01 kA steps)	KASP3 =	________

Trip Latch LEDs Settings (see Figures 1.51 through 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/FECHAR operator control time delay (0–3600 cyc) (see Figure 1.39)	PB8D =	________
TRIP/ABRIR operator control time delay (0–3600 cyc) (see Figure 1.40)	PB9D =	________

Current and Voltage Connection Settings

____

See ***Current and Voltage Connection Settings*** in ***Section 9: Setting the SEL-351P-3 Recloser Control***

True three-phase voltage connected (Y,N) (see Figure 4.1 in Section 4 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)*** in Section 10]	EZGRPS = ______

Battery, 12 V Power, and Wake-Up Port Settings (see *Battery System Monitor* in Section 8)

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 = ______
SF6 low pressure warning threshold (0.9-2.0 atmospheres)	SF6PRS = ______

See ***Sequential Events Recorder (SER) Report*** in ***Section 12: Standard Event Reports and SER***.

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 =	________

See ***Load Profile*** in Section 8.

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):

ELEMENT	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 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)
IADEM, IBDEM, ICDEM, INDEM, IGDEM, 3I2DEM	Demand ammeter quantities
MWADI, MWBDI, MWCDI, MW3DI	Phase and 3 phase demand megaWATTs in
MWDADO, 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

SETTINGS SHEET
FOR THE SEL-351P-3 RECLOSER CONTROL
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 Tables 7.1 and 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* in Sections 7 and 11)

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* in Section 11)

Reclosing Relay Last Shot Label (14 char.) 79LL = ________________
Reclosing Relay Shot Counter Label (14 char.) 79SL = ________________

Protocol Settings

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 (0, 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, DTA) 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-351P-3 Relay Fast Operate commands.

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SECTION 10: SERIAL PORT COMMUNICATIONS AND COMMANDS

INTRODUCTION

The SEL-351P-3 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-351P-3 serial ports to a computer serial port for local communication or to a modem for remote communication. Other devices useful for communications include SEL Communications Processors. You can use a variety of terminal emulation programs on your personal computer to communicate with the SEL-351P-3. Examples of PC-based terminal emulation programs include: ProComm® Plus, Relay Gold®, Microsoft® Windows® Terminal, SmartCOM®, and CROSSTALK®. Typically, VT-100 terminal emulation provides the best display.

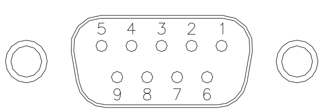
Serial Port Default Settings (for all ports)

Baud Rate	=	2400 (ports 1 and 2); 38400 (port F)
Data Bits	=	8
Parity	=	N
Stop Bits	=	1
RTS/CTS	=	N

Note: Serial Port 3 is factory-set as a DNP port with a baud rate of 19200. See ***Appendix H: Distributed Network Protocol (DNP3)*** for more information.

To change the port settings, use the Access Level 2 **SET P** command (see ***Section 9: Setting the SEL-351P-3 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-351P-3 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-351P-3 to an SEL

Communications Processor with Cable C273A (see cable diagrams that follow in this section). The communications processor distributes demodulated IRIG-B time code through all of its 16 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[1]	N/C or +5 Vdc[1]	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

[1] See Table 2.6 in ***Section 2: Additional Installation Details*** and the ***Communications*** section in the ***SEL-351P-3 Quick-Start Installation and User's Guide***.

Table 10.2: Terminal Functions for EIA-485 Serial Port 1 (Optional)

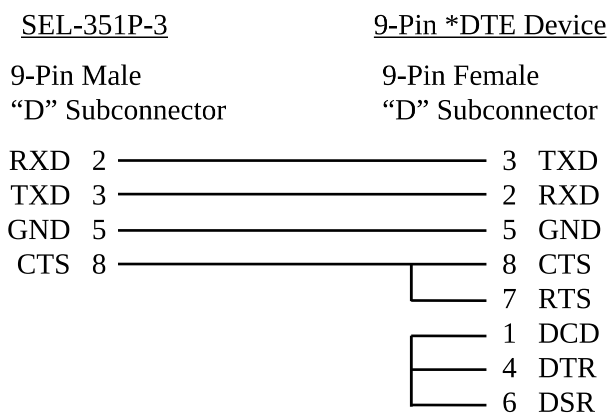
Terminal	Function
1	+TX
2	-TX
3	+RX
4	-RX
5	SHIELD
6	N/C
7	+IRIG-B
8	-IRIG-B

The following cable diagrams show several types of EIA-232 serial communications cables that you can use to connect the SEL-351P-3 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. These cables do not apply to the wake-up port.

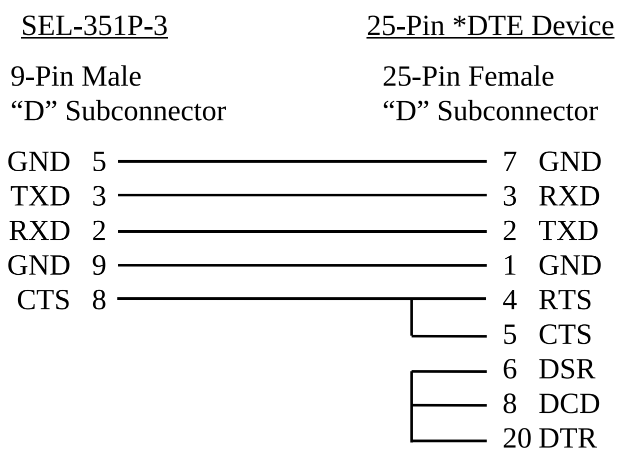
Permanently connected metallic communication cables should be restricted to use inside a substation control house to reduce the hazards of ground potential rise. SEL recommends that the metallic cable length be limited to 100 feet or less. If your devices require more than 100 feet of cable, you should 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-351P-3 Recloser Control to Computer

Cable C234A



Cable C227A



SEL-351P-3 Recloser Control to Modem

Cable C222 (externally powered modem)

SEL-351P-3 9-Pin Male "D" Subconnector			**DCE Device 25-Pin Male "D" Subconnector
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

Cable C220 (modem powered from Pin 1 [5 vdc][1])

SEL-351P-3 9-Pin Male "D" Subconnector			**DCE Device 25-Pin Male "D" Subconnector
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	PWR (IN)
GND	9	1	GND

[1] See Table 2.6 in ***Section 2: Additional Installation Details*** for jumper information.

SEL-351P-3 Recloser Control to SEL-PRTU

Cable C231

SEL-PRTU 9-Pin Male Round Conxall			SEL-351P-3 9-Pin Male “D” Subconnector
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-351P-3 Recloser Control to SEL Communications Processor

Cable C273A

SEL Communications Processor 9-Pin Male “D” Subconnector			SEL-351P-3 9-Pin Male “D” Subconnector
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-351P-3 Recloser Control to SEL-DTA2

Cable C272A

SEL-DTA2 9-Pin Male “D” Subconnector			SEL-351P-3 9-Pin Male “D” Subconnector
RXD	2	3	TXD
TXD	3	2	RXD
GND	5	5	GND
RTS	7	7	RTS
CTS	8	8	CTS

* DTE = Data Terminal Equipment (Computer, Terminal, Printer, etc.)
** DCE = Data Communications Equipment (Modem, etc.)

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-351P-3 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-351P-3 permanently asserts the RTS line.

If RTSCTS = Y, the SEL-351P-3 deasserts RTS when it is unable to receive characters.

If RTSCTS = Y, the SEL-351P-3 does not send characters until the CTS input is asserted.

Software Protocols

The SEL-351P-3 provides standard SEL protocols: SEL ASCII, SEL Distributed Port Switch Protocol (LMD), SEL Fast Meter, SEL Compressed ASCII, and Distributed Network Protocol (DNP3). The SEL-351P-3 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.

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 lower case characters may be used without distinction, except in passwords.

   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.

2. The SEL-351P-3 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-351P-3 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-351P-3 port that is set for SEL or LMD 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-351P-3 port that is set for SEL or LMD protocol.

Distributed Network Protocol (DNP3)

The control provides Distributed Network Protocol (DNP3), Level 2 slave support. DNP is an optional protocol and is described in ***Appendix H: Distributed Network Protocol (DNP3)***.

MIRRORED BITS Communications

The SEL-351P-3 Relay supports MIRRORED BITS® relay-to-relay communications on two ports simultaneously (see ***Appendix I***).

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-351P-3 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)*** in this section.
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)*** in this section.

Serial Port Access Levels

You can issue commands to the SEL-351P-3 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)

Note: In this manual, commands you type appear in bold/uppercase: **SHO G**. Computer keys you press appear in bold//brackets: **<Enter>**.

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 the 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-351P-3 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** through **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) in the ***Command Explanations*** subsection 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) in the ***Command Explanations*** subsection 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) in the ***Command Explanations*** subsection 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-351P-3 is in Access Level E, the control sends the prompt:

```
=+>
```

Commands **BTT** through **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** through **TRI** in Table 10.5).

Access Level B

When the SEL-351P-3 is in Access Level B, the control sends the prompt:

```
==>
```

Commands **BRE** ***n*** through **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** through **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** through **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** through **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) in the ***Command Explanations*** subsection 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.

Again, a higher access level can access the serial port commands in a lower access level. The commands are shown in upper-case letters, but you can also enter them with lower-case letters.

Table 10.5: Serial Port Command Summary

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

Access Level	Prompt	Serial Port Command	Command Description	Corresponding Front-Panel Pushbutton
1	=>	**COM**	MIRRORED BITS communications statistics	
1	=>	**COU**	Display SELOGIC® counter values	
1	=>	**DAT**	View/change date	OTHER
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
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	=>>	**LOO**	MIRRORED BITS loopback	
2	=>>	**PAS**	View/change passwords	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	

Access Level	Prompt	Serial Port Command	Command Description	Corresponding Front-Panel Pushbutton
2	=>>	**STA C**	Clear Status Report	
2	=>>	**VER**	Show version information	

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-351P-3 command set shown in Table 10.5, the control responds:

```
Invalid Command
```

Many of the command responses display the following header at the beginning:

```
SEL-351P-3 RECLOSER CONTROL           Date: 03/05/10    Time: 17:03:26.484
FEEDER
```

The definitions are:

SEL-351P-3 RECLOSER CONTROL:	This is the Recloser ID, RID, setting (the control is shipped with the default setting RID = SEL-351P-3 RECLOSER CONTROL; see ***Identifier Labels*** in ***Section 9: Setting the SEL-351P-3 Recloser Control***).
FEEDER:	This is the Terminal ID, TID, setting (the control is shipped with the default setting TID = FEEDER; see ***Identifier Labels*** in ***Section 9: Setting the SEL-351P-3 Recloser Control***).
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*** subsection 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 explanation later in this section 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 later in this section. At the above prompt enter the default password and press the **<Enter>** key.

The control responds:

```
SEL-351P-3 RECLOSER CONTROL          Date: 03/05/10    Time: 08:31:10.361
FEEDER


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-351P-3 responds:

```
SEL-351P-3 RECLOSER CONTROL           Date: 03/05/10    Time: 08:31:10.361
FEEDER


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>

SEL-351P-3 RECLOSER CONTROL           Date: 02/02/10    Time: 08:40:14.802
FEEDER

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 12/27/09 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>

SEL-351P-3 RECLOSER CONTROL           Date: 02/02/10    Time: 08:40:28.529
FEEDER

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 12/27/09 15:32:59
=>
```

See ***BRE n Command (Preload/Reset Breaker Wear)*** in ***Access Level B Commands*** that follows in this section and ***Breaker/Recloser Contact Wear Monitor*** in ***Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions*** 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>

SEL-351P-3 RECLOSER CONTROL           Date: 04/20/10    Time: 18:36:11.748
FEEDER

FID=SEL-351P-3-R100-V0-Z100100-D20100211       CID=6AFA
Summary for Mirrored Bits channel A

For 04/20/10 18:36:09.279 to 04/20/10 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>

SEL-351P-3 RECLOSER CONTROL           Date: 02/20/10    Time: 18:37:36.125
FEEDER

FID=SEL-351P-3-R400-V0-Z100100-D20100211       CID=6AFA
Summary for Mirrored Bits channel A

For 02/05/10 17:18:12.993 to 02/20/10 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   02/20/10 18:36:09.279  02/20/10 18:37:36.114     2.835  Relay Disabled
2   02/14/10 13:18:09.236  02/14/10 13:18:09.736     0.499  Parity error
3   02/08/10 11:43:35.547  02/08/10 11:43:35.637     0.089  Underrun
4   02/05/10 17:18:12.993  02/05/10 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 through 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 2/8/10 L <Enter>**. To display all the COMM records that started between a range of dates, supply both dates as parameters, i.e., **COMM 2/21/10 2/7/10 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>

SEL-351P-3 RECLOSER CONTROL            Date: 02/15/10    Time: 12:21:48.226
FEEDER

      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, 2010, enter:

```
=>DATE 6/1/10 <Enter>
6/1/10
=>
```

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)*** in ***Access Level B Commands*** that follows in this section and ***Multiple Setting Groups*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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>
SEL-351P-3 RECLOSER CONTROL           Date: 02/01/10    Time: 08:40:16.740
FEEDER

#     DATE      TIME     EVENT   LOCAT  CURR  FREQ GRP SHOT TARGETS

1  02/01/10 08:33:00.365 TRIG  $$$$$$$     1 60.00  3    2  11000000 10000000
2  01/31/10 20:32:58.361 ER    $$$$$$$   231 60.00  2    2  11000000 10000000
3  01/29/10 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:

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:

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 are shown first and the bottom row of LEDs are 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):

1 → Control Enabled LED illuminated

1 → AC Supply LED illuminated

0 → Battery Problem LED not illuminated

etc...

For more information on front-panel target LEDs, see ***Front-Panel Status and Trip Target LEDs*** in ***Section 1: Factory-Set Logic***. 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-351P-3 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-351P-3 successfully synchronizes to IRIG, it sends the following header and access level prompt:

```
SEL-351P-3 RECLOSER CONTROL            Date: 03/05/10    Time: 10:15:09.609
FEEDER

=>
```

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-351P-3 synchronizes its internal clock with IRIG-B. It is not necessary to issue the IRI command to synchronize the SEL-351P-3 internal clock with IRIG-B. You can use the IRI command to determine if the SEL-351P-3 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	$I_{A,B,C,N}$	Input 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 inputs (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 VA)

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 relay measures only one voltage. In this case the relay 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 relay 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-351P-3 with three-phase wye-connected voltage inputs is shown:

```
=>MET <Enter>

SEL-351P-3 RECLOSER CONTROL            Date: 02/01/10    Time: 15:00:52.615
FEEDER
                 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      0.973
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	$I_{A,B,C,N}$	Input 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 inputs (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 VA)

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-351P-3 is shown:

```
=>MET X <Enter>

SEL-351P-3 RECLOSER CONTROL           Date: 12/12/10    Time: 11:31:22.626
FEEDER
                 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	$I_{A,B,C,N}$	Input currents (A primary)
	I_G	Residual ground current (A primary; IG =3I0 = IA + IB + IC)
	$3I_2$	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-351P-3 with three-phase wye-connected voltage inputs is shown:

```
=>MET D <Enter>

SEL-351P-3 RECLOSER CONTROL          Date: 02/01/10    Time: 15:08:05.615
FEEDER
            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 01/27/10 15:31:51.238   LAST PEAK RESET 01/27/10 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*** in ***Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions***.

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 megavar hours (in and out; wye-connected voltage inputs only)
	$MVARh_{3P}$	Three-phase megavar 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-351P-3 with three-phase wye-connected voltage inputs is shown:

```
=>MET E <Enter>

SEL-351P-3 RECLOSER CONTROL          Date: 02/01/10    Time: 15:11:24.056
FEEDER
        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 01/31/10 23:31:28.864

=>
```

Reset the energy values using the **MET RE** command. For more information on energy metering, see ***Energy Metering*** in ***Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions***.

MET M—Maximum/Minimum Metering

The **MET M** command displays the maximum and minimum values of the following quantities:

Currents	$I_{A,B,C,N}$	Input currents (A primary)
	I_G	Residual ground current (A primary; IG =3I0 = IA + IB + IC)
Voltages	$V_{A,B,C,S}$	Wye-connected voltage inputs (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-351P-3 with three-phase wye-connected voltage inputs is shown:

```
=>MET M <Enter>

SEL-351P-3 RECLOSER CONTROL           Date: 02/01/10    Time: 15:16:00.239
FEEDER
           Max    Date      Time              Min    Date      Time
IA(A)      196.8  02/01/10  15:00:42.574      30.0  02/01/10  14:51:02.391
IB(A)      195.0  02/01/10  15:05:19.558      31.8  02/01/10  14:50:55.536
IC(A)      200.4  02/01/10  15:00:42.578      52.2  02/01/10  14:51:02.332
IN(A)       42.6  02/01/10  14:51:02.328      42.6  02/01/10  14:51:02.328
IG(A)       42.0  02/01/10  14:50:55.294      42.0  02/01/10  14:50:55.294
VA(kV)      11.7  02/01/10  15:01:01.576       3.4  02/01/10  15:00:42.545
VB(kV)      11.7  02/01/10  15:00:42.937       2.4  02/01/10  15:00:42.541
VC(kV)      11.7  02/01/10  15:00:42.578       3.1  02/01/10  15:00:42.545
VS(kV)      11.7  02/01/10  15:01:01.576       3.4  02/01/10  15:00:42.545
MW3P         6.9  02/01/10  15:00:44.095       0.4  02/01/10  15:00:42.545
MVAR3P       1.0  02/01/10  15:00:42.578       0.1  02/01/10  15:00:42.545
LAST RESET 01/27/10 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*** in ***Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions***.

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-351P-3 sets the port access level to 0 and responds:

```
SEL-351P-3 RECLOSER CONTROL          Date: 03/05/10    Time: 08:55:33.986
FEEDER

=
```

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.

SHO *n*	Show "regular" settings for settings group *n*. ***n*** specifies the settings group (1, 2, 3, 4, 5, or 6); ***n*** defaults to the active settings group if not listed.
SHO EZ *n*	Show EZ recloser control settings for settings group ***n***. ***n*** specifies the settings group (1, 2, 3, 4, 5, or 6); *n* defaults to the active settings group if not listed.
SHO FZ	Show EZ global settings.
SHO G	Show global settings.
SHO L *n*	Show SELOGIC control equation settings for settings group ***n***. ***n*** specifies the settings 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 in ***Section 9: Setting the SEL-351P-3 Recloser Control*** 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-351P-3 showing all the **factory default settings**. Settings groups 1 through 6 have the same settings for **SHO *n***, **SHO EZ *n***, and **SHO L *n***.

```
=>SHO <Enter>
Group 1
Group Settings:

RID   =SEL-351P-3 RECLOSER CONTROL       TID   =FEEDER
CTR   = 400.0    CTRN  = 400.0    PTR   = 100.0    PTRS  = 100.0
Z1MAG = 12.80    Z1ANG = 68.86
Z0MAG = 38.30    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 = 0.50
50P5P = OFF      50P6P = 0.50
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 = 0.025    50N4P = 0.025
50N5P = OFF      50N6P = 0.050
67N1D = 0.00     67N2D = 0.00     67N3D = 50.00    67N4D = 0.00
50G1P = OFF      50G2P = OFF      50G3P = OFF      50G4P = OFF

Press RETURN to continue
50G5P = OFF      50G6P = OFF
67G1D = 0.00     67G2D = 0.00     67G3D = 0.00     67G4D = 0.00
51P1P = 0.50     51P1C = C5       51P1TD= 0.05     51P1RS= N
51P1CT= 0.00     51P1MR= 0.00
51P2P = 0.50     51P2C = C1       51P2TD= 0.10     51P2RS= N
51P2CT= 0.00     51P2MR= 0.00
51N1P = 0.050    51N1C = C5       51N1TD= 0.05     51N1RS= N
51N1CT= 0.00     51N1MR= 0.00
51N2P = 0.050    51N2C = C1       51N2TD= 0.10     51N2RS= N
51N2CT= 0.00     51N2MR= 0.00
51G1P = OFF      51G1C = C5       51G1TD= 0.05     51G1RS= N
51G1CT= 0.00     51G1MR= 0.00
51G2P = OFF      51G2C = C1       51G2TD= 0.10     51G2RS= N
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
27B81P= 80.0     81D1P = OFF      81D1D = 6.00
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 = 32.50    79OI2 = 45.00    79OI3 = 245.00   79OI4 = 0.00
79RSD = 50.00    79RSLD= 50.00    79CLSD= 0.00
DMTC  = 5
PDEMP = OFF      NDEMP = OFF      GDEMP = OFF      QDEMP = OFF
TDURD = 4.00     CFD   = 15.00    3POD  = 1.50     50LP  = 0.05
SV1PU = 0.00     SV1DO = 0.00     SV2PU = 250.00   SV2DO = 0.00
SV3PU = 0.00     SV3DO = 0.00     SV4PU = 300.00   SV4DO = 120.00
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  = 3        OPGR  = 3        OPLKPH= 4        OPLKGR= 4
OPLKSF= 4        HITRPH= OFF      HITRGR= OFF      HILKPH= OFF
```

Continued on Next Page

```
                         Continued from Previous Page

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)                     =SEL-351P-3 RECLOSER CONTROL
Circuit Identifier (30 chars)                     =FEEDER
CT Ratio (1.0-6000)                               = 400.0
PT Ratio (1.0-10000)                              = 100.0
Min. trip - phase (OFF,40.00-1279.99 A pri.)      = 200.00
Min. trip - ground (OFF,2.00-1279.99 A pri.)      = 20.00
Min. trip - SEF (OFF,2.00-599.99 A pri.)          = 10.00
Fast curve - phase
(OFF,U1-U5,C1-C5,recloser or user curve)          = C5
Time-dial - phase fast curve (0.05-1.00)          = 0.05
EM reset - phase fast curve (Y/N)                 = N
Fast curve - ground
(OFF,U1-U5,C1-C5,recloser or user curve)          = C5
Time-dial - ground fast curve (0.05-1.00)         = 0.05
EM reset - ground fast curve (Y/N)                = N
Delay curve - phase
(OFF,U1-U5,C1-C5,recloser or user curve)          = C1
Time-dial - phase delay curve (0.05-1.00)         = 0.10
EM reset - phase delay curve (Y/N)                = N
Delay curve - ground
(OFF,U1-U5,C1-C5,recloser or user curve)          = C1
Time-dial - ground delay curve (0.05-1.00)        = 0.10

Press RETURN to continue
EM reset - ground delay curve (Y/N)               = N
Time delay - SEF (0.00-16000cyc)                  = 50.00
Operations - phase fast curve (OFF,1-5)           = 3
Operations - ground fast curve (OFF,1-5)          = 3
Operations to lockout - phase (3-5)               = 4
Operations to lockout - ground (3-5)              = 4
Operations to lockout - SEF (OFF,1-5)             = 4
Reclose interval 1 (0.00-999999cyc)               = 32.50
Reclose interval 2 (0.00-999999cyc)               = 45.00
Reclose interval 3 (0.00-999999cyc)               = 245.00
Reset time for auto-reclose (0.00-999999cyc)      = 50.00
Reset time from lockout (0.00-999999cyc)          = 50.00
Close power wait time (0.00-16000cyc)             = 0.00
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

Press RETURN to continue
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)                          = 50
Phase Rotation (ABC,ACB)                             = ABC
Recloser Wear Monitor (AUTO,Y,N)                     = AUTO
Interrupt rating (6000,8000,12000 A pri.)            = 12500
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)                           = 8.0
Power-off Delay After AC Loss (OFF, 1-1440 min)     = 180
Power-off Delay After Wake Up (OFF, 1-1440 min)     = 20
Power-off Voltage Level 1 (19.2-24 Vdc)             = 20.5
SF6 low pressure warning threshold in atm.(0.9-2)    = 1.1

=>
```

```
=>SHO G <Enter>

Global Settings:
TGR   = 1.00     NFREQ = 50       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 = 30000    COSP2 = 1000     COSP3 = 39
KASP1 = 0.63     KASP2 = 5.00     KASP3 = 16.00
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= 6        AMPHR = 8.0
PWR_AC= 180      PWR_WU = 20      V_LOW1= 20.5
SF6PRS= 1.1
=>
```

```
=>SHO L <Enter>
SELogic group 1

SELogic Control Equations:
TR    =SV1 + LT1 * (51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T
        + 67G2T + 67N2T + 67N3T + 81D1T)
TRCOMM=0
TRSOTF=0
DTT   =0
ULTR  =1
PT1   =0
LOG1  =0
PT2   =0
LOG2  =0
BT    =0
52A   =WB52A
CL    =(PB8 * !LT5 + CC * LT5 + /IN102 * LT5) * LT6 * TRCAP * CLCAP
ULCL  =TRIP + WBTRT + !(LT6 + WBCL)
79RI  =TRIP
79RIS =52A + 79CY
79DTL =67N3T * OLS + (67P1 + 67G1 + 67N1) * TRIP + (!LT2 + !LT6) * (TRIP
        + !52A) + 81D1T + SV16 + SV1

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 =TRCAP * CLCAP * !BADBAT * !DTFAIL
SET1  =(PB1 + PB8) * !LT5 * !LT1 + (/RB1 + CC + /IN102) * LT5 * !LT1
RST1  =(PB1 * !LT5 + /RB1 * LT5) * LT1
SET2  =(PB2 * !LT5 + /RB2 * LT5 + /IN106 * LT5) * !LT2 * LT6
RST2  =(PB2 * !LT5 + /RB2 * LT5 + /IN106 * LT5) * LT2 + !LT6 + !(79RS
        + 79CY + 79LO)
SET3  =(PB3 * !LT5 + /RB3 * LT5 + /IN105 * LT5 + LT4) * !LT3
RST3  =(PB3 * !LT5 + /RB3 * LT5 + /IN105 * LT5) * LT3
SET4  =(PB4 * !LT5 + /RB4 * LT5 + /IN104 * LT5) * !LT4
RST4  =(PB4 + PB3) * !LT5 * LT4 + (/RB4 + /RB3 + /IN104 + /IN105) * LT5
        * LT4
SET5  =PB5 * !LT5
RST5  =PB5 * LT5
SET6  =(PB6 * !LT5 + /RB6 * LT5) * !LT6
RST6  =(PB6 * !LT5 + /RB6 * LT5) * LT6

Press RETURN to continue
SET7  =(PB7 * !LT5 + /RB7 * LT5 + /IN103 * LT5) * !LT7 * LT6
RST7  =(PB7 * !LT5 + /RB7 * LT5 + /IN103 * LT5) * LT7 * LT6
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
```

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```
Press RETURN to continue
67P1TC=HLP
67P2TC=HTP
67P3TC=1
67P4TC=1
67N1TC=HLG * LT3
67N2TC=HTG * LT3
67N3TC=LT4 * !(51P1 + 51P2 + 51G1 + 51G2 + 51N1 + 51N2) * (!SV12 + SV12
        * 50G5 + SV12 * 50N5)
67N4TC=1
67G1TC=HLG * LT3
67G2TC=HTG * LT3
67G3TC=1
67G4TC=1
67Q1TC=1
67Q2TC=1
67Q3TC=1
67Q4TC=1
51P1TC=!SV8 * OCP
51N1TC=!SV10 * OCG * LT3
51G1TC=!SV10 * OCG * LT3

Press RETURN to continue
51P2TC=!SV8 + SV8 * 50P5
51N2TC=(!SV10 + SV10 * 50G5 + SV10 * 50N5) * LT3
51G2TC=(!SV10 + SV10 * 50G5) * LT3
51QTC =1
SV1   =(PB9 * !LT5) + (OC + /IN101) * LT5
SV2   =0
SV3   =0
SV4   =!TRCAP + !CLCAP
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)

Press RETURN to continue
SV16  =SV15 + SV13 * OLP * OLG
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
```

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```
SC6I  =0
SC6D  =0
SC7R  =1

Press RETURN to continue
SC7I  =0
SC7D  =0
SC8R  =1
SC8I  =0
SC8D  =0
OUT101=LT1
OUT102=LT2
OUT103=LT3
OUT104=LT4
OUT105=!LT6
OUT106=LT7 * LT6
OUT107=TRIP
LED1  =LT1
LED2  =LT2
LED3  =LT3
LED4  =LT4
LED5  =LT5
LED6  =!LT6
LED7  =LT7 * LT6
LED8  =52A

Press RETURN to continue
LED9  =RAW52B
LED11 =ACPWR
LED12 =BADBAT + DTFAIL
LED13 =SF6LO
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
DP1   =0
DP2   =0
DP3   =0
DP4   =0
DP5   =SV4T
DP6   =SV4T
DP7   =0

Press RETURN to continue
DP8   =0
DP9   =0
DP10  =0
DP11  =0
DP12  =0
DP13  =0
DP14  =0
DP15  =0
DP16  =0
SS1   =!LT7 * LT6
SS2   =LT7 * LT6
SS3   =!LT6
SS4   =0
SS5   =0
SS6   =0
```

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```
ER    =/51P1 + /51P2 + /51G1 + /51G2 + /51N1 + /51N2 + /67N3
FAULT =51P1 + 51P2 + 51G1 + 51G2 + 51N1 + 51N2 + 67N3
BSYNCH=52A
CLMON =0
BKMON =WBTR + WBTRT + \52A

Press RETURN to continue
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 <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 = DNP
SPEED = 19200    DNPADR= 5        ECLASS= 2        TIMERQ= 0
DECPLA= 1        DECPLV= 1        DECPLM= 1
STIMEO= 1.0      DRETRY= 3        DTIMEO= 1
MINDLY= 0.05     MAXDLY= 0.10     PREDLY= OFF      PSTDLY= 0.00
ANADB = 100      UNSOL = N        PUNSOL= N        REPADR= 3
NUMEVE= 10       AGEEVE= 2.0      UTIMEO= 2

=> SHO P f <ENTER>
Port F

PROTO = SEL
SPEED = 38400    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 =
NLB12 =               CLB12 =        SLB12 =        PLB12 =
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 = LOW TRIP/CLOSE   DP5_0 =
DP6_1 = CAPACITOR VOLTAG 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-351P-3 status report output appears as shown below:

```
=>STA <Enter>
SEL-351P-3 RECLOSER CONTROL            Date: 09/02/10    Time: 10:34:06.996
FEEDER

FID=SEL-351P-3-R400-V0-Z100100-D20100211       CID=6AFA


SELF TESTS

W=Warn    F=Fail

       I1      I2      I3      IN      V1      V2      V3      VS      MOF
OS      4       3       1       2       2       4       9       2       0

       +5V_PS  +5V_REG -5V_REG +12V_PS -12V_PS +15V_PS -15V_PS
PS      5.08    5.00   -4.96    11.98  -12.15   15.12  -15.18

       TEMP    RAM     ROM     A/D     CR_RAM  EEPROM  SF6
        34.0   OK      OK      OK      OK      OK      1.16

       MODE    HRS_LFT 12V_AUX VBAT    IBAT
BATT   CHARGE  XX:XX   12.29   26.27   0

Relay Enabled
Battery Discharge Test OK
=>
```

STA Command Row and Column Definitions

FID — FID is the firmware identifier string. It identifies the firmware revision.

CID — CID is the recloser control firmware checksum identifier.

W (Warning) or F (Failure) 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.

If a warning indication (W) is appended to a dc offset value for a channel in the OS row, the dc offset value and “W” are latched in and any subsequent measured dc offset values for the latched-in channel are ignored until the relay is rebooted (e.g., STA C command executed).

There is no failure mode (F) for analog channels I1 through VS.

If a failure indication (F) is appended to the dc offset value for the MOF channel in the OS row, the dc offset value and “F” are latched in and any subsequent measured dc offset values for the latched-in MOF channel are ignored until the relay is rebooted (e.g., STA C command executed).

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.

SF6 — Displays SF6 gas pressure in atmospheres.

BATT — Displays status and mode of the battery charger:

MODE — Mode that battery charger is in:

- CHARGE Battery is charging (CHRGG Relay Word bit asserted).
- DISCHG Battery is discharging (DISCHG Relay Word bit asserted).
- DISTST Battery discharge test at 1 Amp for up to 5 seconds duration (DISTST Relay Word bit asserted).
- BADBAT Battery had been charging at a high current level for too long—battery can't take a charge (charger now off; BADBAT Relay Word bit asserted).

HRS_LFT — The HRS_LFT column shows the amount of discharge time left (in hours and minutes) until the control puts itself to sleep. If the control is charging, this column reads "XX:XX".

12V_AUX — Voltage level in Vdc of the 12-volt auxiliary port supply.

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.

Battery Discharge Test status is **OK** if the battery discharge test passed (DTFAIL Relay Word bit deasserted). Battery Discharge Test status is **Failure** if the battery discharge test failed (DTFAIL Relay Word bit asserted).

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 10.6. (note the correspondence with Table 9.3).

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-351P-3 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 the ***Pushbutton Primary Functions*** subsection in the ***Front-Panel Interface*** section of the ***SEL-351P-3 Quick-Start Installation and User's Guide***).

The **TAR** command options are:

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 10.6. ***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. **Note:** The **TAR R** command cannot reset the latched target LEDs if a TRIP condition is present.

Table 10.6: SEL-351P-3 Recloser Control Relay Word and Its Correspondence to TAR Command

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
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	50NF	50NR	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	HICHRG
TAR 41	67P2S	67N2S	67G2S	67Q2S	PDEM	NDEM	GDEM	QDEM
TAR 42	PB1	PB2	PB3	PB4	PB5	PB6	PB7	PB8
TAR 43	PB9	32NF	32NR	*	WBTRT	SF6LO	DISCHG	LED9
TAR 44	LED1	LED2	LED3	LED4	LED5	LED6	LED7	LED8
TAR 45	OCP	OCG	OLP	OLG	OLS	HTP	HTG	HLP
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	*	*	*	*	*	*	*	*
TAR 53	*	*	*	*	*	*	*	*
TAR 54	*	*	*	*	*	*	*	*
TAR 55	*	*	*	*	*	*	*	*
TAR 56	RAW52B	RAW52A	WB52A	WBBRK	WBCL	WBTR	CLCAP	TRCAP
TAR 57	BATVL1	BATVL2	IDSCHG	ACPWR	CLSBPS	*	DCONN	DDATA
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

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:

```
SEL-351P-3 RECLOSER CONTROL           Date: 02/02/10    Time: 12:57:01.737
FEEDER

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 no other parameters are entered with the **BTT** command, the control checks the status of the battery charger board by looking at the BCBOK Relay Word element. If this element is not asserted, the battery charger board has failed and the control responds:

```
=+>BTT <Enter>
Battery Charger Board FAILED
=+>
```

If there is no battery present, the control responds:

```
=+>BTT <Enter>
Battery not present or failed
=+>
```

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 is: OK
Time until next battery test:  XX hours
```

If the battery failed the previous load test, the DTFAIL Relay Word element is asserted and the response is:

```
=+>BTT <Enter>
Battery test is: FAILED
Time until next battery test:  XX hours
```

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 5 seconds
.
.
.
.
.
Battery test state is: OK
=+>
```

Each period is displayed at about one second intervals as the control times through the rest.

See the ***Battery System Monitor*** subsection in ***Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions***.

SET EZ and SET FZ Commands (Change EZ Settings)

The **SET EZ *n*** command allows you to change the EZ recloser control settings for settings group *n* (*n* specifies the settings 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 settings 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 settings groups 1 and 2 also override a number of the “regular” settings in the respective setting group. If EZGRPS = 2, the EZ settings for settings groups 3 through 6 cannot be made, nor are the EZ settings for settings groups 3 through 6 active (none of the “regular” settings in settings groups 3 through 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 n Command (Preload/Reset Breaker Wear)

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>

SEL-351P-3 RECLOSER CONTROL          Date: 02/02/10    Time: 08:44:33.920
FEEDER

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 01/27/09 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 command below.

```
==>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>

SEL-351P-3 RECLOSER CONTROL          Date: 02/02/10    Time: 08:44:33.920
FEEDER

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
```

Continued on Next Page

```
                              Continued from Previous Page

A-phase Trips=   14
B-phase Trips=    9
C-phase Trips=   10
EF/G Trips=      12
SEF Trips=        0

LAST RESET 12/27/09 15:32:59

==>
```

Use the **BRE R** command to reset the breaker/recloser contact wear monitor and trip operation counters:

```
==>BRE R <Enter>

SEL-351P-3 RECLOSER CONTROL            Date: 02/03/10    Time: 08:44:20.802
FEEDER

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 12/27/09 15:32:59

Reset Trip Counters and Accumulated Currents/Wear
Are you sure (Y/N) ? Y <Enter>

SEL-351P-3 RECLOSER CONTROL            Date: 02/03/10    Time: 08:44:33.920
FEEDER

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 02/03/10 08:44:28
```

See ***Breaker/Recloser Contact Wear Monitor*** in ***Section 8: Breaker/Recloser Monitor, Battery System Monitor, Metering, and Load Profile Functions*** for further details on the breaker monitor.

CLO Command (Close Breaker)

The **CLO** (**CLOSE**) command asserts Relay Word bit CC for ¼ 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 output contact WBCL to close the recloser (see Figure 7.30).

See the ***Close Logic*** subsection in ***Section 6: Close and Reclose Logic*** 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 settings Group 2, enter the following:

```
==>GRO 2 <Enter>
Change to Group 2
Are you sure (Y/N) ? Y <Enter>
Active Group = 2
==>
```

The SEL-351P-3 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:

```
==>
SEL-351P-3 RECLOSER CONTROL          Date: 02/02/10    Time: 09:40:34.611
FEEDER

Active Group = 2
==>
```

The SELOGIC control equations Group Selector Switch elements, SS1 through SS6, have priority over the **GRO** command in active setting group control. If any of the Group Selector Switch elements, SS1 through SS6, are asserted (logical 1), the Group *n* Command has no affect 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 = IN1 and optoisolated input IN1 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***.

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 output WBTR to trip the recloser, see Figure 7.30.

See the ***Trip Logic*** subsection in ***Section 5: Trip and Target Logic*** 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-351P-3 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 7.27).
y is the pulse duration (1–30) in seconds. If ***y*** is not specified, the pulse duration defaults to 1 second.

To pulse OUT101 for 5 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 through 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 through RB16. See Row 26 and Row 59 in Table 9.4. 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-351P-3 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 is received.

PAS Command (View/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 inspect or change existing passwords. The factory default passwords for Access Levels 1, E, B, 2, and C are:

Access Level	Factory Default Password
1	OTTER
E	DAKOTA
B	EDITH
2	TAIL
C	CLARKE

To inspect passwords, type:

```
=>>PAS <Enter>
1:OTTER
E:DAKOTA
B:EDITH
2:TAIL
=>>
```

To change the password for Access Level 1 to Ot3579, enter the following:

```
=>>PAS 1 Ot3579 <Enter>
Set
=>>
```

Similarly, **PAS E**, **PAS B**, and **PAS 2** can be used to change the Level E, Level B, and Level 2 passwords, respectively.

Passwords may include up to six characters. Valid characters consist of: 'A–Z', 'a–z', '0–9', '-', and '.'. Upper- and lower-case letters are treated as different characters. Strong passwords consist of six characters, with at least one special character or digit and mixed case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks. Examples of valid, distinct passwords include:

Ot3579 A24.68 Ih2dcs 4u-Iwg .351P.

After entering new passwords, type **PAS <Enter>** to inspect them. Make sure they are what you intended, and record the new passwords.

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. For example, **PAS 1 DISABLE** disables password protection for Level 1.

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 *n*	Change "regular" settings for settings group *n*. *n* specifies the settings 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 settings group *n*. *n* specifies the settings group (1, 2, 3, 4, 5, or 6); *n* defaults to the active settings group if not listed. See additional information in subsection ***Access Level E (EZ) Commands***.
SET FZ	Change EZ global settings. See additional information in subsection ***Access Level E (EZ) Commands***.
SET G	Change global settings.
SET L *n*	Change SELOGIC control equation settings for settings group *n*. *n* specifies the settings 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 subsection ***Settings Changes via the Serial Port*** in ***Section 9: Setting the SEL-351P-3 Recloser Control*** for more setting command information.

STA C Command (Status Clear Command)

The recloser control latches all mainboard 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 in ***Section 13: Testing and Troubleshooting*** for self-test thresholds and corrective actions.

VER Command (Show Version Information)

The Version command, **VER**, allows you to view information about the SEL-351P-3.

The response to the **VER** command has the following format:

```
=>>VER <Enter>
Partnumber: 0351P312X1X13XXXX

Mainboard: 0311
Data FLASH Size:  1024 KBytes
Analog Input Voltage (PT): 300 Vac Phase, 300 Vac Synch
Analog Input Current (CT): 1 Amp Phase, 0.05 Amp Neutral
Extended Relay Features:
  DNP
  Mirrored Bits
  Load Profile

FID=SEL-351P-3-R400-V0-Z100100-D20100211

SELboot checksum 6AFA OK
No SELboot FID

If above information is unexpected. . .
contact SEL for assistance
=>>
```

The FID (firmware identification) line displays the firmware version (Rxxx) and datecode (Dxxxxxxxx).

The following change in the **VER** command output, depending on the "Secondary Input Voltages;Currents" ordered for the SEL-351P-3 model:

```
Analog Input Voltage (PT):
Analog Input Current (CT):
```

These "Analog Input" strings change according to the portion of the Part Number for the "Secondary Input Voltage; Current" as shown in the following table:

Portion of Part Number for "Secondary Input Voltage; Current"	Corresponding strings in the VER command output for voltage/current
2X	Analog Input Voltage (PT): 300 Vac Phase, 300 Vac Synch Analog Input Current (CT): 1 Amp Phase, 0.05 Amp Neutral
AX	Analog Input Voltage (PT): 3 Vac Phase, 300 Vac Synch Analog Input Current (CT): 1 Amp Phase, 0.05 Amp Neutral
BX	Analog Input Voltage (PT): 300 Vac Phase, 300 Vac Synch Analog Input Current (CT): 0.01 Amp Phase, 0.005 Amp Neutral
CX	Analog Input Voltage (PT): 3 Vac Phase, 300 Vac Synch Analog Input Current (CT): 0.01 Amp Phase, 0.005 Amp Neutral
DX	Analog Input Voltage (PT): 3 Vac Phase, 3 Vac Synch Analog Input Current (CT): 1 Amp Phase, 0.05 Amp Neutral
EX	Analog Input Voltage (PT): 3 Vac Phase, 3 Vac Synch Analog Input Current (CT): 0.01 Amp Phase, 0.005 Amp Neutral

SEL-351P-3 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* L	Show a long format communications summary report for all events on MIRRORED BITS® channel *p* (where *p* = A or B).
COM *p n*	Show a communications summary for latest *n* event on MIRRORED BITS channel *p*.
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS channel *p*.
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)
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.
EVE *n*	Show event report number *n* with 1/4-cycle resolution.
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 C *n*	Show compressed event report number *n* for use with SEL-5601 Analytic Assistant.
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 *n*	Show the latest *n* rows in the Load Profile report.
LDP *m n*	Show rows *m* through *n* in the Load Profile report.
LDP d1	Show rows in the Load Profile report from date d1.
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).
MET *k*	Display instantaneous metering data. Enter *k* for repeat count.
MET X *k*	Display same as **MET** command with phase-to-phase voltages. 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.
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
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).
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 R	Reset the front-panel tripping targets.
TAR *n k*	Display Relay Word row. If *n* = 0 through 59, display row *n*. If *n* is an element name (e.g., 50A1) display the row containing element *n*. Enter *k* for repeat count.
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.

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 W	Preload breaker/recloser contact wear.
BRE W A	Preload breaker/recloser contact wear and trip operation counters.
BRE R	Reset 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 password jumper is not in place, the control prompts you for 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 RB*n*. 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*.
LOO	Set MIRRORED BITS port to loopback.
PAS	Show existing Access Level 1, E (EZ), B, 2, and C passwords.
PAS 1 xxxxxx	Change Access Level 1 password to xxxxxx.
PAS E xxxxxx	Change Access Level E (EZ) password to xxxxxx.
PAS B xxxxxx	Change Access Level B password to xxxxxx.
PAS 2 xxxxxx	Change Access Level 2 password to xxxxxx.
PAS C xxxxxx	Change Access Level C password to xxxxxx.

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.

Key Stroke Commands

<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

<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.

TABLE OF CONTENTS

FIGURES

SECTION 11: ADDITIONAL FRONT-PANEL INTERFACE DETAILS

INTRODUCTION

This section describes additional SEL-351P-3 Recloser Control front-panel interface details not covered in the ***Front-Panel Interface*** section of the ***SEL-351P-3 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/VARIOS pushbutton)
- Extra local control (accessed via the CNTRL/CONTROL AUX. pushbutton; this is not the control available via the operator control pushbuttons on the bottom half of the SEL-351P-3 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/VARIOS 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
```

(or = 3)

If the reclosing function does not exist (see ***Reclosing Relay*** in ***Section 6: Close and Reclose Logic***), 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-351P-3 Recloser Control*** and ***SHO Command (Show/View Settings)*** in ***Section 10: Serial Port Communications and Commands***].

The top numeral in the above example screen (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 screen [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/BLOQUEADO LED on front panel is illuminated), RECLOSE COUNT = 3.

SEL-351P-3 Recloser Control Shot Counter Screen Operation (with factory settings)

With the recloser closed and the SEL-351P-3 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-351P-3 trips the recloser open and goes to the reclose cycle state (front-panel CYCLE/CICLO 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-351P-3 recloses the recloser. The shot counter screen shows the incremented shot counter:

```
SET RECLOSURES=3
RECLOSE COUNT =1
```

The SEL-351P-3 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-351P-3 recloses the recloser. The shot counter screen shows the incremented shot counter:

```
SET RECLOSURES=3
RECLOSE COUNT =2
```

If the SEL-351P-3 trips, recloses, then trips again, the SEL-351P-3 goes to the lockout state (front-panel LOCKOUT/BLOQUEADO 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-351P-3 goes to the reset state (front-panel LOCKOUT/ BLOQUEADO 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 through LB16. These local bits are available as Relay Word bits and are used in SELOGIC® control equations (see Rows 25 and 58 in Table 9.4).

Local control can emulate the following switch types in Figure 11.1 through Figure 11.3.

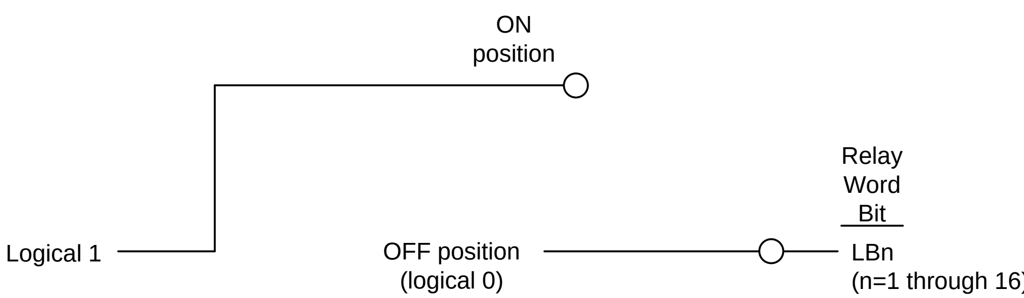


Figure 11.1: Local Control Switch Configured as an ON/OFF Switch

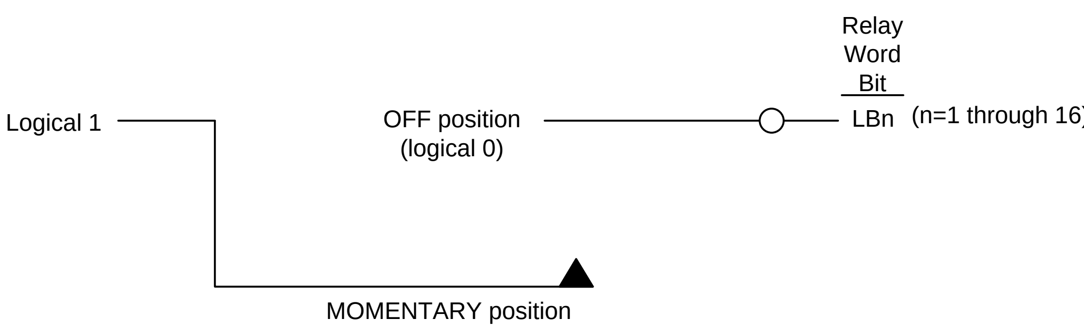


Figure 11.2: Local Control Switch Configured as an OFF/MOMENTARY Switch

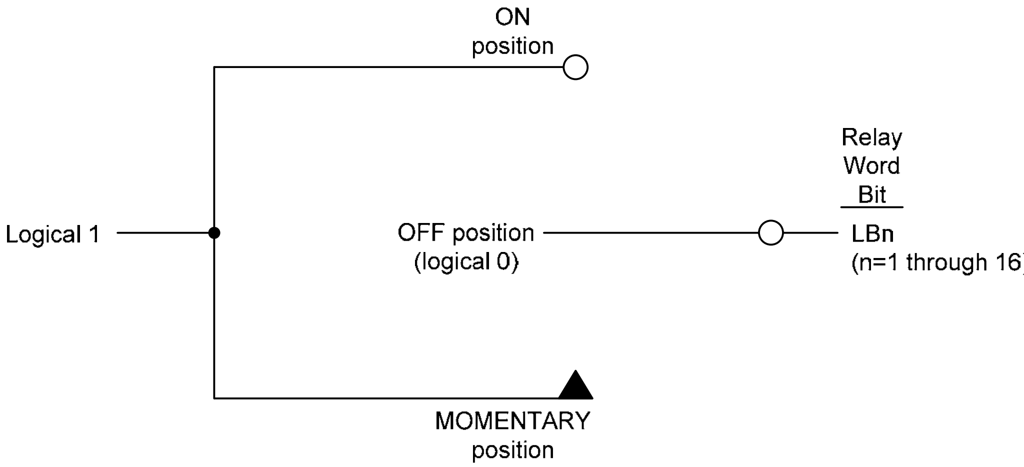


Figure 11.3: Local Control Switch Configured as an ON/OFF/MOMENTARY Switch

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-351P-3 Recloser Control*** and ***SHO Command (Show/View Settings)*** in ***Section 10: Serial Port Communications and Commands***]. See ***Local Control Switches*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** for more information on local control.

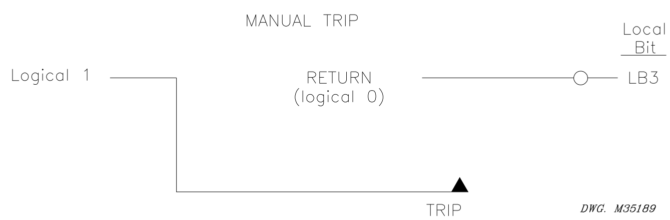
View Extra Local Control (example settings)

Access extra local control via the CNTRL/CONTROL AUX. 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
```

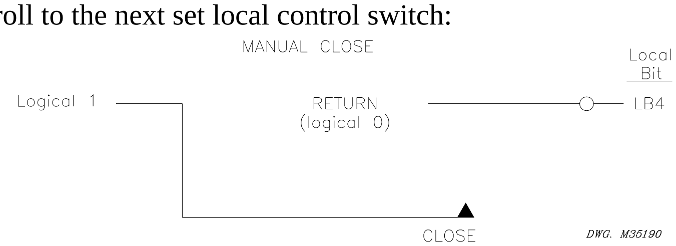
Press the CNTRL pushbutton, and the first set local control switch displays (shown here with example settings):

```
MANUAL TRIP  ←→
Position: RETURN
```



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:

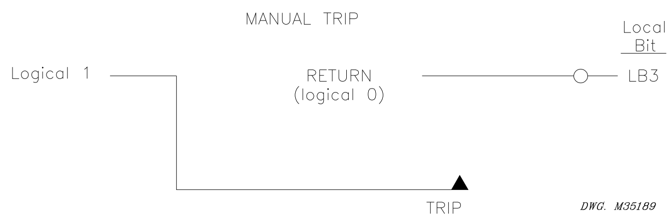
```
Output Contact←→
Testing
```

This front-panel function provides the same function as the serial port **PUL** command.

Operate Extra Local Control (example settings)

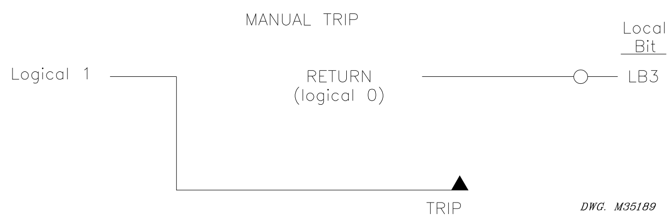
Press the right arrow pushbutton, and scroll back to the first set local control switch in the example settings:

```
MANUAL TRIP  ←→
Position: RETURN
```



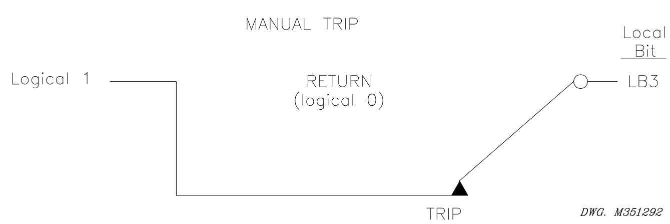
Press the SELECT pushbutton, and the operate option for the displayed local control switch displays:

```
MANUAL TRIP
TRIP ? Yes No←→
```



Scroll left with the left arrow button and then select “Yes”. The display then shows the new local control switch position:

```
MANUAL TRIP
Position:  TRIP
```



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:

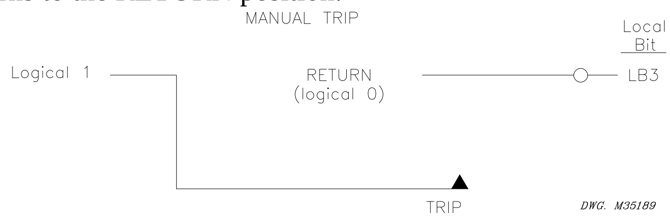
> TRIP position for one processing interval (1/4 cycle; long enough to assert the corresponding local bit LB3 to logical 1).

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 2 seconds (long enough to be seen), and then it returns to the RETURN position:

```
MANUAL TRIP  ←→
Position: RETURN
```



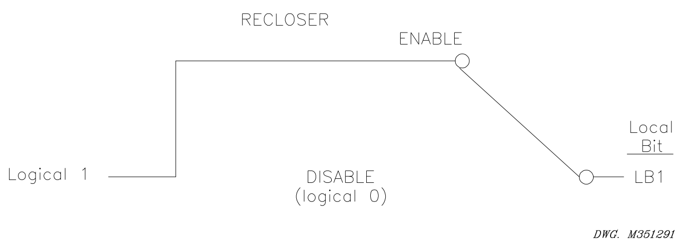
The MANUAL CLOSE switch is an OFF/MOMENTARY type switch, like the MANUAL TRIP switch, and operates similarly.

See ***Local Control Switches*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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 Relay Deenergized

Local bit states are stored in nonvolatile memory, so when power to the relay 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:

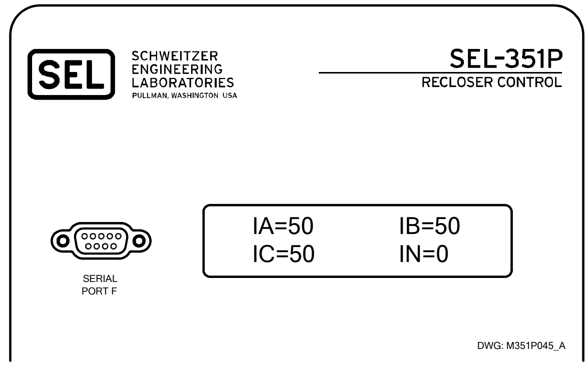


If power to the relay is turned off and then turned on again, local bit LB1 remains at logical 1, and reclosing is still enabled. This is akin to a traditional panel, where enabling/disabling of reclosing and other functions is accomplished by panel-mounted switches. If dc control voltage to the panel 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.

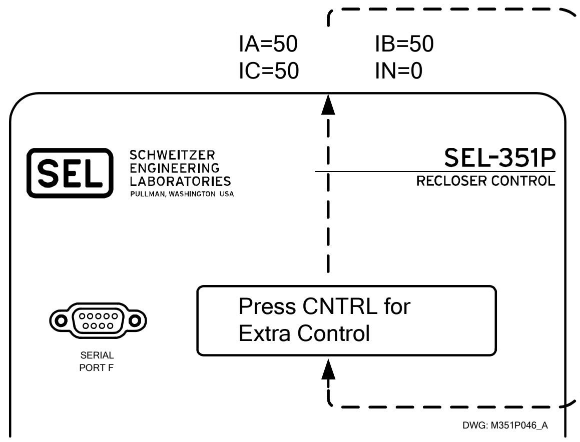
See ***Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, respectively)*** in ***Section 6: Close and Reclose Logic*** for more information on setting 79DTL.

Rotating Default Display

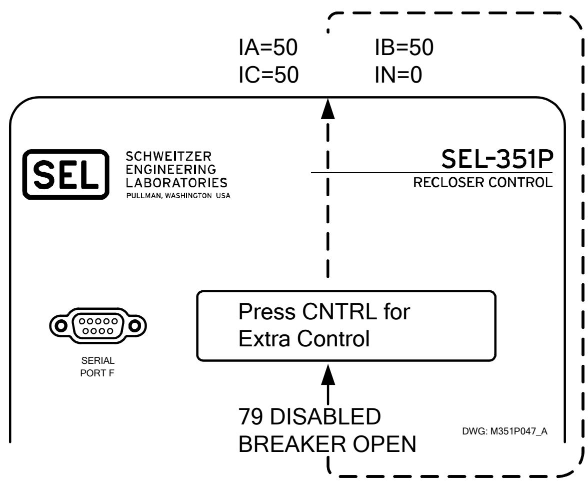
The channel IA, IB, IC, and IN current values (in A primary) display continually if no local control is operational (i.e., no corresponding switch position label settings were made) and no display point labels are enabled for display.



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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** 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.

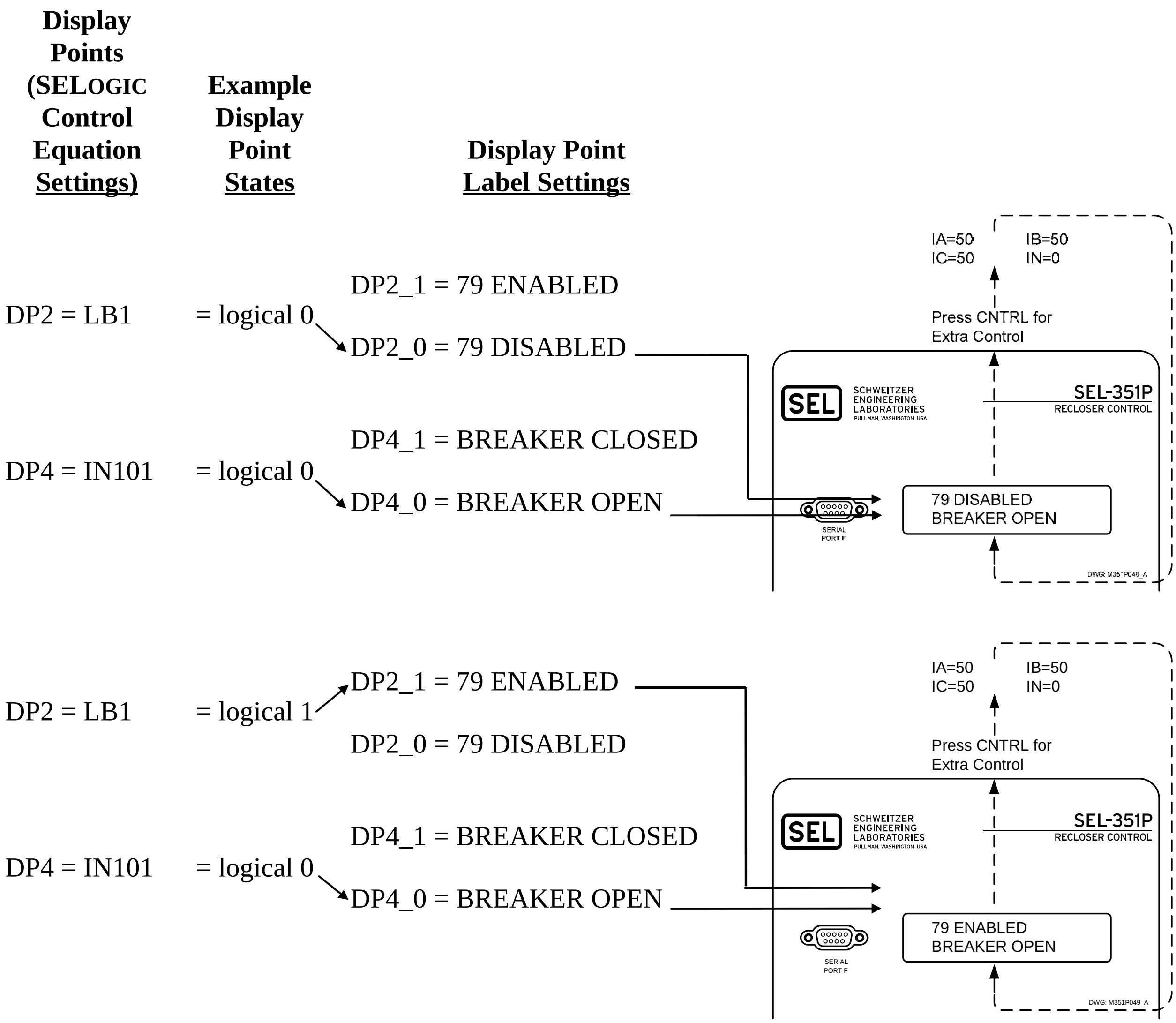


The following table and figures demonstrate the correspondence between changing display point states (e.g., DP2 and DP4) and enabled display point labels (DP2_1/DP2_0 and DP4_1/DP4_0, respectively). The display is on a 2-second rotation for each screen.

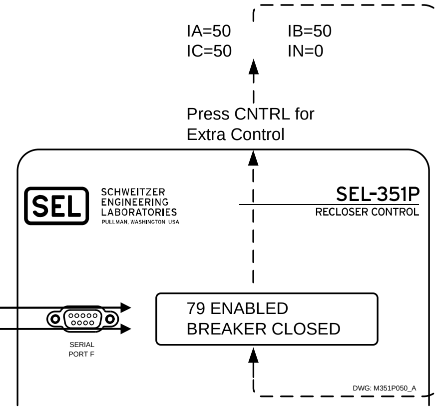
The display point example settings are:

DP2 = LB1 (local bit LB1)
DP4 = IN101 (optoisolated input IN101)

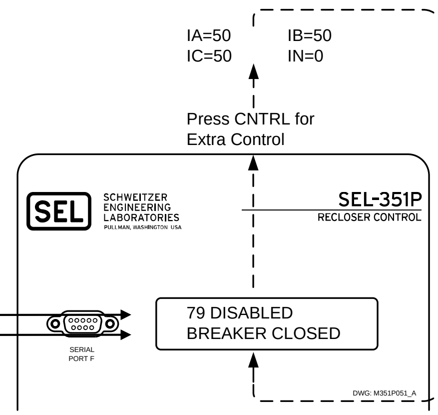
Local bit LB1 is used as a recloser enable/disable in this example. Optoisolated input IN101 is used as a circuit breaker status input in this example (a 52a circuit breaker auxiliary contact is connected to input IN101; see ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers and Other Control Logic***).



Display Points (SELOGIC Control Equation Settings)	Example Display Point States	Display Point Label Settings
DP2 = LB1	= logical 1	DP2_1 = 79 ENABLED DP2_0 = 79 DISABLED
DP4 = IN101	= logical 1	DP4_1 = BREAKER CLOSED DP4_0 = BREAKER OPEN



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 1	DP4_1 = BREAKER CLOSED DP4_0 = BREAKER OPEN



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-351P-3 Recloser Control*** and ***SHO Command (Show/View Settings)*** in ***Section 10: Serial Port Communications and Commands***].

For more detailed information on the logic behind the rotating default display, see ***Rotating Default Display*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***.

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

INTRODUCTION

The SEL-351P-3 Recloser Control offers two styles of event reports:

- Standard 15/30-cycle event reports
- Sequential Events Recorder (SER) Report

Resolution: 1 ms

Accuracy: +1/4 cycle

These event reports contain date, time, current, voltage, frequency, relay element, optoisolated input, output contact, and fault location information.

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. Up to 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

See Figure 12.2 for an example event report (**Note**: Figure 12.2 is on multiple pages).

Event Report Length (Settings LER and PRE)

The SEL-351P-3 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 Settings Sheet 20 of 28 in ***Section 9: Setting the SEL-351P-3 Recloser Control*** 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 through 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 trip settings TR and DTT control equations are unsupervised. Any trip condition that asserts in setting TR or DTT causes the TRIP Relay Word bit to assert immediately. The factory default trip settings are:

TR = SV1 + LT1 * (51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T + 67G2T + 67N2T + 67N3T + 81D1T)

DTT = 0

If any of the individual conditions assert, Relay Word bit TRIP asserts, and an event report is generated automatically. All of the 51xxT and 67xxT Relay Word bits represent time-delayed overcurrent tripping functions. SV1 is a combination of remote and local tripping functions (see Figure 1.24). 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.

The TRIP Relay Word bit output of the trip logic in Figure 5.1 propagates to the final trip/close logic in Figure 7.30. The logic in Figure 7.30 controls dedicated trip and close output contacts and prevents the trip and close output contacts from being asserted at the same time.

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-351P-3 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-351P-3 triggers an event on the pickup (rising edge) of any of the time-overcurrent elements, 51xx, 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 in ***Appendix G: Setting SELOGIC® Control Equations*** 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 through 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 relay front-panel CNTRL/CONTROL AUX. pushbutton.

See ***Section 10: Serial Port Communications and Commands*** and the ***Pushbutton Primary Functions*** subsection (CNTRL/CONTROL AUX. pushbutton) in the ***Front-Panel Interface*** section of the ***SEL-351P-3 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:

- Relay 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.

The example event summary in Figure 12.1 corresponds to the full-length standard 15-cycle event report in Figure 12.2 (**Note**: Figure 12.2 is on multiple pages):

```
SEL-351P-3 RECLOSER CONTROL            Date:  06/01/10    Time:  12:23:52.527
FEEDER

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 the table below. Note the correspondence to the preceding event report triggering conditions (see ***Standard Event Report Triggering*** in this section).

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 (fault locator could not operate successfully to determine the phase involvement, 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 through CAG in Table 12.1 only are entered in the "Event:" field if the fault locator operates successfully. If the fault locator does not operate successfully, just TRIP or ER is displayed.

Fault Location

The relay 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-351P-3 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 Settings Sheet 1 of 28 in ***Section 9: Setting the SEL-351P-3 Recloser Control*** 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*** in ***Section 1: Factory-Set Logic***.

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* S*x* 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 SEL-5601 Analytic Assistant.

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-351P-3 provides compressed ASCII event reports to facilitate event report storage and display. The SEL-2032, SEL-2030, SEL-2020 Communications Processor and the SEL-5601 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-351P-3 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 through IN106

The filters for ac current and voltage are fixed. You can adjust the optoisolated input debounce via debounce settings (see Figure 7.1 in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***).

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

Refer to the example event report in Figure 12.2 to view event report columns (**Note**: Figure 12.2 is on multiple pages). 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 channel VS (primary kV)
Freq	Frequency of voltage channel VA (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 Tables 9.3 and 9.4 in ***Section 9: Setting the SEL-351P-3 Recloser Control*** for more information on Relay Word bits shown in Table 12.3.

Table 12.3: Output, Input, Protection, and Control Element Event Report Columns

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	OUT101, OUT102	1 2 b	Output contact OUT101 asserted. Output contact OUT102 asserted. Both OUT101 and OUT102 asserted.
Out 34	OUT103, OUT104	3 4 b	Output contact OUT103 asserted. Output contact OUT104 asserted. Both OUT103 and OUT104 asserted.
Out 56	OUT105, OUT106	5 6 b	Output contact OUT105 asserted. Output contact OUT106 asserted. Both OUT105 and OUT106 asserted.
Out 7A	OUT107, ALARM	7 A b	Output contact OUT107 asserted. Output contact ALARM asserted. Both OUT107 and ALARM asserted.
Out TC	WBTR, WBCL	T C b	Trip FET output (WBTR) asserted. Close FET output (WBCL) asserted. Both WBTR and WBCL asserted.
Out Br	WBBRK	*	This element is a holdover from previous SEL-351P-3 models and is not used in the SEL-351P-3.

In 12	IN101, IN102	1 2 b	Optoisolated input IN101 asserted. Optoisolated input IN102 asserted. Both IN101 and IN102 asserted.
In 34	IN103, IN104	3 4 b	Optoisolated input IN103 asserted. Optoisolated input IN104 asserted. Both IN103 and IN104 asserted.
In 56	IN105, IN106	5 6 b	Optoisolated input IN105 asserted. Optoisolated input IN106 asserted. Both IN105 and IN106 asserted.
52A	RAW52A	*	Breaker auxiliary contact 52a asserted—breaker closed (RAW52A).
52B	RAW52B	*	Breaker auxiliary contact 52b asserted—breaker open (RAW52B).
Chg	TRCAP, CLCAP	T C b	Trip capacitor charged higher than 80 Vdc (TRCAP). Close capacitor charged higher than 20 Vdc (CLCAP). Both TRCAP and CLCAP asserted.
SF6	SF6LO	L	SF6 gas pressure below SF6PRS setting.
Digital Protection and Control Section of Event Report			
51P1 51P2 51N1 51N2 51G1 51G2 51Q	51P1, 51P1T, 51P1R 51P2, 51P2T, 51P2R 51N1, 51N1T, 51N1R 51N2, 51N2T, 51N2R 51G1, 51G1T, 51G1R 51G2, 51G2T, 51G2R 51Q, 51QT, 51QR	. p T r 1	Time-overcurrent element reset (51_R). Time-overcurrent element picked up and timing (51_). Time-overcurrent element timed out (51_T). Time-overcurrent element timing to reset. 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 B C a b c 3	Single-phase instantaneous overcurrent element 50A picked up. Single-phase instantaneous overcurrent element 50B picked up. Single-phase instantaneous overcurrent element 50C picked up. Both 50A and 50B picked up. Both 50B and 50C picked up. Both 50C and 50A picked up. 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 element F32V picked up.
	R32V	v	Reverse zero-sequence voltage-polarized R32V picked up.
	F32N	N	Forward channel IN current-polarized directional element F32I picked up.
	R32N	n	Reverse channel IN current-polarized directional element R32I picked up.
67 P 67 N 67 G 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.

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 B C a b c 3	A-phase instantaneous overvoltage element 59A1 or 59A2 picked up. B-phase instantaneous overvoltage element 59B1 or 59B2 picked up. C-phase instantaneous overvoltage element 59C1 or 59C2 picked up. 59A_ and 59B_ elements picked up. 59B_ and 59C_ elements picked up. 59C_ and 59A_ elements picked up. 59A_, 59B_, and 59C_ elements picked up.
59 PP	59AB, 59BC, 59CA	A B C a b c 3	AB phase-to-phase instantaneous overvoltage element 59AB picked up. BC phase-to-phase instantaneous overvoltage element 59BC picked up. CA phase-to-phase instantaneous overvoltage element 59CA picked up. 59AB and 59CA elements picked up. 59AB and 59BC elements picked up. 59BC and 59CA elements picked up. 59AB, 59BC, and 59CA elements picked up.
59 V1Q	59V1, 59Q	1 Q b	Positive-sequence instantaneous overvoltage element 59V1 picked up. Negative-sequence instantaneous overvoltage element 59Q picked up. Both 59V1 and 59Q picked up.
59 N	59N1, 59N2	1 2 b	First ground instantaneous overvoltage element 59N1 picked up. Second ground instantaneous overvoltage element 59N2 picked up. Both 59N1 and 59N2 picked up.
59 S	59S1, 59S2	1 2 b	First channel VS instantaneous overvoltage element 59S1 picked up. Second channel VS instantaneous overvoltage element 59S2 picked up. Both 59S1 and 59S2 picked up.

59 V	59VP, 59VS	P S b	Phase voltage window element 59VP picked up (used in synchronism check). Channel VS voltage window element 59VS picked up (used in synchronism check). Both 59VP and 59VS picked up.
25 SF	SF	*	Slip frequency element SF picked up (used in synchronism check).
25 A	25A1, 25A2	1 2 b	First synchronism check element 25A1 element picked up. Second synchronism check element 25A2 element picked up. Both 25A1 and 25A2 picked up.
81 27B	27B81	*	Frequency logic instantaneous undervoltage element 27B81 picked up.
81 12	81D1, 81D2	1 2 b	Frequency element 81D1 picked up. Frequency element 81D2 picked up. Both 81D1 and 81D2 picked up.
81 34	81D3, 81D4	3 4 b	Frequency element 81D3 picked up. Frequency element 81D4 picked up. Both 81D3 and 81D4 picked up.
81 56	81D5, 81D6	5 6 b	Frequency element 81D5 picked up. Frequency element 81D6 picked up. Both 81D5 and 81D6 picked up.
79	RCSF, CF, 79RS, 79CY, 79LO	. S F R C L	Reclosing function disabled. Reclose supervision failure condition (RCSF asserts for only 1/4 cycle). Close failure condition (CF asserts for only 1/4 cycle). Reclosing relay in Reset State (79RS). Reclosing relay in Reclose Cycle State (79CY). Reclosing relay in Lockout State (79LO).
Time	OPTMN, RSTMN	o r	Recloser open interval timer is timing. Recloser reset interval timer is timing.

Shot	SH0, SH1, SH2 SH3, SH4	. 0 1 2 3 4	Reclosing function disabled. shot = 0 (SH0). shot = 1 (SH1). shot = 2 (SH2). shot = 3 (SH3). shot = 4 (SH4).
Zld	ZLIN, ZLOUT	i o	Load encroachment “load in” element ZLIN picked up. Load encroachment “load out” element ZLOUT picked up.
LOP	LOP	*	Loss-of-potential element LOP picked up.
Lcl 12	LB1, LB2	1 2 b	Local bit LB1 asserted. Local bit LB2 asserted. Both LB1 and LB2 asserted.
Lcl 34	LB3, LB4	3 4 b	Local bit LB3 asserted. Local bit LB4 asserted. Both LB3 and LB4 asserted.
Lcl 56	LB5, LB6	5 6 b	Local bit LB5 asserted. Local bit LB6 asserted. Both LB5 and LB6 asserted.
Lcl 78	LB7, LB8	7 8 b	Local bit LB7 asserted. Local bit LB8 asserted. Both LB7 and LB8 asserted.
Rem 12	RB1, RB2	1 2 b	Remote bit RB1 asserted. Remote bit RB2 asserted. Both RB1 and RB2 asserted.
Rem 34	RB3, RB4	3 4 b	Remote bit RB3 asserted. Remote bit RB4 asserted. Both RB3 and RB4 asserted.
Rem 56	RB5, RB6	5 6 b	Remote bit RB5 asserted. Remote bit RB6 asserted. Both RB5 and RB6 asserted.
Rem 78	RB7, RB8	7 8 b	Remote bit RB7 asserted. Remote bit RB8 asserted. Both RB7 and RB8 asserted.
Rem OC	OC, CC	o c	**OPE** (Open) command executed. **CLO** (Close) command executed.
Ltch 12	LT1, LT2	1 2 b	Latch bit LT1 asserted. Latch bit LT2 asserted. Both LT1 and LT2 asserted.

Ltch 34	LT3, LT4	3 4 b	Latch bit LT3 asserted. Latch bit LT4 asserted. Both LT3 and LT4 asserted.
Ltch 56	LT5, LT6	5 6 b	Latch bit LT5 asserted. Latch bit LT6 asserted. Both LT5 and LT6 asserted.
Ltch 78	LT7, LT8	7 8 b	Latch bit LT7 asserted. Latch bit LT8 asserted. 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 T d	SELOGIC control equation variable timer input SV_ asserted; timer timing on pickup time; timer output SV_T not asserted. SELOGIC control equation variable timer input SV_ asserted; timer timed out on pickup time; timer output SV_T asserted. 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 SOTF enable asserted.
PT	PT	*	Permissive Trip received (POTT logic).
PTRX	PTRX1, PBTX2	1 2 b	Permissive Trip Received input 1 asserted and Permissive Trip Received input 2 deasserted (DCUB logic). Permissive Trip Received input 1 deasserted and Permissive Trip Received input 2 asserted (DCUB logic). Permissive Trip Received input 1 asserted and Permissive Trip Received input 2 asserted (DCUB logic).
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 2 b	UnBlocking Block element 1 asserted and UnBlocking Block element 2 deasserted. UnBlocking Block element 1 deasserted and UnBlocking Block element 2 asserted. 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 2 b	Transmit MIRRORED BIT 1 channel A asserted and Transmit MIRRORED BIT 2 channel A deasserted. Transmit MIRRORED BIT 1 channel A deasserted and Transmit MIRRORED BIT 2 channel A asserted. Transmit MIRRORED BIT 1 channel A asserted and Transmit MIRRORED BIT 2 channel A asserted.
TMB A 34	TMB3A, TMB4A	3 4 b	Transmit MIRRORED BIT 3 channel A asserted and Transmit MIRRORED BIT 4 channel A deasserted. Transmit MIRRORED BIT 3 channel A deasserted and Transmit MIRRORED BIT 4 channel A asserted. Transmit MIRRORED BIT 3 channel A asserted and Transmit MIRRORED BIT 4 channel A asserted.

TMB A 56	TMB5A, TMB6A	5 6 b	Transmit MIRRORED BIT 5 channel A asserted and Transmit MIRRORED BIT 6 channel A deasserted. Transmit MIRRORED BIT 5 channel A deasserted and Transmit MIRRORED BIT 6 channel A asserted. Transmit MIRRORED BIT 5 channel A asserted and Transmit MIRRORED BIT 6 channel A asserted.
TMB A 78	TMB7A, TMB8A	7 8 b	Transmit MIRRORED BIT 7 channel A asserted and Transmit MIRRORED BIT 8 channel A deasserted. Transmit MIRRORED BIT 7 channel A deasserted and Transmit MIRRORED BIT 8 channel A asserted. Transmit MIRRORED BIT 7 channel A asserted and Transmit MIRRORED BIT 8 channel A asserted.
RMB A 12	RMB1A, RMB2A	1 2 b	Receive MIRRORED BIT 1 channel A asserted and Receive MIRRORED BIT 2 channel A deasserted. Receive MIRRORED BIT 1 channel A deasserted and Receive MIRRORED BIT 2 channel A asserted. Receive MIRRORED BIT 1 channel A asserted and Receive MIRRORED BIT 2 channel A asserted.
RMB A 34	RMB3A, RMB4A	3 4 b	Receive MIRRORED BIT 3 channel A asserted and Receive MIRRORED BIT 4 channel A deasserted. Receive MIRRORED BIT 3 channel A deasserted and Receive MIRRORED BIT 4 channel A asserted. Receive MIRRORED BIT 3 channel A asserted and Receive MIRRORED BIT 4 channel A asserted.
RMB A 56	RMB5A, RMB6A	5 6 b	Receive MIRRORED BIT 5 channel A asserted and Receive MIRRORED BIT 6 channel A deasserted. Receive MIRRORED BIT 5 channel A deasserted and Receive MIRRORED BIT 6 channel A asserted. Receive MIRRORED BIT 5 channel A asserted and Receive MIRRORED BIT 6 channel A asserted.

RMB A 78	RMB7A, RMB8A	7 8 b	Receive MIRRORED BIT 7 channel A asserted and Receive MIRRORED BIT 8 channel A deasserted. Receive MIRRORED BIT 7 channel A deasserted and Receive MIRRORED BIT 8 channel A asserted. Receive MIRRORED BIT 7 channel A asserted and Receive MIRRORED BIT 8 channel A asserted.
ROK	ROKA, ROKB	A B b	Receive channel A OK element asserted and Receive channel B OK element deasserted. Receive channel A OK element deasserted and Receive channel B OK element asserted. Receive channel A OK element asserted and Receive channel B OK element asserted.
RBAD	RBADA, RBADB	A B b	Receive channel A BAD for certain time element asserted and Receive channel B BAD for certain time element deasserted. Receive channel A BAD for certain time element deasserted and Receive channel B BAD for certain time element asserted. Receive channel A BAD for certain time element asserted and Receive channel B BAD for certain time element asserted.
CBAD	CBADA, CBADB	A B b	Channel A communications availability BAD element asserted and Channel B communications availability BAD element deasserted. Channel A communications availability BAD element deasserted and Channel B communications availability BAD element asserted. Channel A communications availability BAD element asserted and Channel B communications availability BAD element asserted.
PB1	PB1 (see Figure 1.31)	*	PROTECTION ENABLED/ PROTECCION HABILITADA pushbutton output
PB2	PB2	*	RECLOSE ENABLED/ RECIERRE HABILITADO pushbutton output

PB3	PB3	*	EARTH FAULT ENABLED/ FALLA A TIERRA HABILITADO pushbutton output
PB4	PB4	*	SEF ENABLED/SEF HABILITADO pushbutton output
PB5	PB5	*	REMOTE ENABLED/REMOTO HABILITADO output
PB6	PB6 (see Figure 1.32)	*	LIVE LINE ENABLED/LINEA VIVA HABILITADA pushbutton output
PB7	PB7	*	ALTERNATE SETTINGS/ AJUSTES ALTERNATIVOS pushbutton output
PB8	PB8	*	CLOSE/CIERRE output
PB9	PB9	*	TRIP/DISPARO pushbutton output

**Output contacts can be A or B type contacts (see Table 2.1 and Figure 7.27).

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 9.3. 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 relay 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), reclose operations, and manual close from front-panel pushbutton (PB8)
- When control is powered down due to low battery (TOSLPV) or discharge time limit (TOSLPT)
- 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 prevents these oscillating items from being recorded in the SER. 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:

- Set Report setting ESERDL (Enable SER Delete) to Y to enable this function.
- 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 start 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 9.3 for references to valid recloser control element (Relay Word bit) names. See the **SET R** command in Table 9.1 and corresponding Settings Sheet 23 of 28 at the end of ***Section 9: Setting the SEL-351P-3 Recloser Control***. 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 relay 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).

Make SER Settings With Care

The relay triggers a row in the SER 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 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 (1) state change every three minutes can be made for a 25-year relay service life.

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 number 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 3/30/10	If you enter the **SER** command followed by a date (date 3/30/10 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 2/17/10 3/23/10	If you enter the **SER** command followed by two dates (date 2/17/10 chronologically precedes date 3/23/10 in this example), all the rows between and including dates 2/17/10 and 3/23/10 are displayed, if they exist. They display with the oldest row (date 2/17/10) at the beginning (top) of the report and the newest row (date 3/23/10) at the end (bottom) of the report. Chronological progression through the report is down the page and in descending row number.
SER 3/16/10 1/5/10	If you enter the **SER** commands followed by two dates (date 3/16/10 chronologically follows date 1/5/10 in this example), all the rows between and including dates 1/5/10 and 3/16/10 are displayed, if they exist. They display with the latest row (date 3/16/10) at the beginning (top) of the report and the oldest row (date 1/5/10) 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 **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 above 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 relay removes from the SER records and the present auto-removal settings. If automatic removal is not enabled (ESERDL = N), the relay 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.

This asterisk (*) indication of maximum phase current is only applicable to a standard (filtered) event report. This asterisk (*) indication is also found in the same location in the corresponding raw (unfiltered) event report for the same event. But, in the raw (unfiltered) event report, this asterisk (*) location is not necessarily a point of maximum current for the entire raw (unfiltered) event report. The raw (unfiltered) event report currents can contain dc offset current and/or harmonic current and, thus, the location of maximum current may very well be a different location within the raw (unfiltered) event report.

```
=+>EVE <Enter>                                                       see Figure 12.1

SEL-351P-3 RECLOSER CONTROL        Date:  06/01/10    Time:  12:23:52.527
FEEDER                                                               firmware identifier

FID=SEL-351P-3-R400-V0-Z100100-D20100211     CID=6AFA                firmware checksum
                                                                     identifier

                                                        Out   In  55CS
      Currents (Amps Pri)       Voltages (kV Pri)       1357TB 135 22hF
    IA    IB    IC    IG     VA     VB     VC     VS  Freq 246ACr 246 ABg6
[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.   one cycle of data
  -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.
[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.

  -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. ... *.b.
  -826   -56   157  -725   -1.2    1.8    7.5   -0.0 60.01 ....T. ... *.b.
[7]
  -548  -151    28  -671    0.8   -7.8    2.3    0.0 60.07 ....T. ... *.b.
   702    64  -123   643    2.7   -1.2   -6.9    0.0 60.07 ....T. ... *.b.
   299    82   -15   366   -1.9    7.3   -2.8    0.0 60.07 ....T. ... **.b.
  -291   -37    44  -284   -5.1    0.3    6.1    0.0 60.07 ....T* ...  .*b.
[8]
   -27    -8     0   -35    3.2   -6.8    3.3   -0.0 60.07 ....T* ...  .*b.
     0     0     0     0    5.8   -0.0   -5.8    0.0 60.07 ....T* ...  .*b.
     0     0     0     0   -3.3    6.7   -3.4    0.0 60.07 ....T* ...  .*b.
    -1    -1    -1    -3   -5.8    0.0    5.8   -0.0 60.07 ....T* ...  .*b.
[9]
    -1     0     0    -1    3.3   -6.7    3.4    0.0 60.00 ....T* ...  .*b.
     0     0     0     0    5.8   -0.0   -5.8   -0.0 60.00 .....* ...  .*b.
     0    -1     0    -1   -3.3    6.7   -3.4    0.0 60.00 ...... ...  .*b.
     0    -1    -1    -2   -5.8    0.0    5.8    0.0 60.00 ...... ...  .*b.
[10]
    -1     0    -1    -2    3.3   -6.7    3.4   -0.0 60.01 ...... ...  .*b.
    -1     0     0    -1    5.8   -0.0   -5.8   -0.0 60.01 ...... ...  .*b.
     0     0     0     0   -3.4    6.7   -3.4    0.0 60.01 ...... ...  .*b.
     0    -1     0    -1   -5.8    0.0    5.8   -0.0 60.01 ...... ...  .*b.
[11]
    -1    -1    -1    -3    3.4   -6.7    3.4    0.0 60.01 ...... ...  .*b.
     0     0    -1    -1    5.8   -0.0   -5.8   -0.0 60.01 ...... ...  .*b.
     0     0     0     0   -3.4    6.7   -3.4    0.0 60.01 ...... ...  .*b.
    -1    -1     0    -2   -5.8   -0.0    5.8    0.0 60.01 ...... ...  .*b.
[12]
    -1    -1    -1    -3    3.4   -6.7    3.3   -0.0 60.01 ...... ...  .*b.
     0     0     0     0    5.8    0.0   -5.8    0.0 60.01 ...... ...  .*b.
    -1     0    -1    -2   -3.4    6.7   -3.3    0.0 60.01 ...... ...  .*b.
    -1    -1     0    -2   -5.8   -0.0    5.8    0.0 60.01 ...... ...  .*b.
[13]
     0    -1     0    -1    3.4   -6.7    3.3   -0.0 60.01 ...... ...  .*b.
     0     0    -1    -1    5.8    0.0   -5.8   -0.0 60.01 ...... ...  .*b.
     0     0    -1    -1   -3.4    6.7   -3.3    0.0 60.01 ...... ...  .*b.
     0    -1     0    -1   -5.8   -0.0    5.8    0.0 60.01 ...... ...  .*b.
[14]
    -1    -1    -1    -3    3.4   -6.7    3.3   -0.0 60.01 ...... ...  .*b.
     0     0     0     0    5.8    0.0   -5.8    0.0 60.01 ...... ...  .*b.
     0     0     0     0   -3.4    6.7   -3.3    0.0 60.01 ...... ...  .*b.
    -1    -1    -1    -3   -5.8   -0.0    5.8    0.0 60.01 ...... ...  .*b.
[15]
     0    -1    -1    -2    3.4   -6.7    3.3   -0.0 60.01 ...... ...  .*b.
     0     0     0     0    5.8    0.0   -5.8   -0.0 60.01 ...... ...  .*b.
    -1    -1     0    -2   -3.4    6.7   -3.3    0.0 60.01 ...... ...  .*b.
     0    -1    -1    -2   -5.8   -0.0    5.8    0.0 60.01 ...... ...  .*b.

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 10 1357135701357         1111111
```

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see Figure 12.3 and Figure 12.4 for details on this example one cycle of phase A (channel IA) current

```
121212QPP QG PNGQ QG PPSPPQNS VFA B246 9et dP 24682468C2468 1234567890123456
[1]
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
[2]
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
[3]
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
[4]
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
......... .. .... .. ........ ... *... R.0 .. .........b..7 ................
....pp... .. .... .. ........ ... *... R.0 .. .........b..7 ............T..   14  13  12
pp..Tp... .. .... .. ........ ... *... C.0 .. .........b..7 ............TT..>
[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]
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...   8  7
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
30  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]
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
[2]
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
[3]
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
[4]
.. ........ ..... .... .... .... .... ... .........
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[5]
.. ........ ..... .... .... .... .... ... .........
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[6]
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
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.. ........ ..... .... .... .... .... ... .........
[7]
.. ........ ..... .... .... .... .... ... .........
.. ........ ..... .... .... .... .... ... .........
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.. ........ ..... .... .... .... .... ... .........
[8]
.. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
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*. ........ ..... .... .... .... .... ... .........
[9]
*. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
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*. ........ ..... .... .... .... .... ... .........
[10]
*. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
[11]
*. ........ ..... .... .... .... .... ... .........
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*. ........ ..... .... .... .... .... ... .........
[12]
*. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
*. ........ ..... .... .... .... .... ... .........
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*. ........ ..... .... .... .... .... ... .........
[13]
*. ........ ..... .... .... .... .... ... .........
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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.

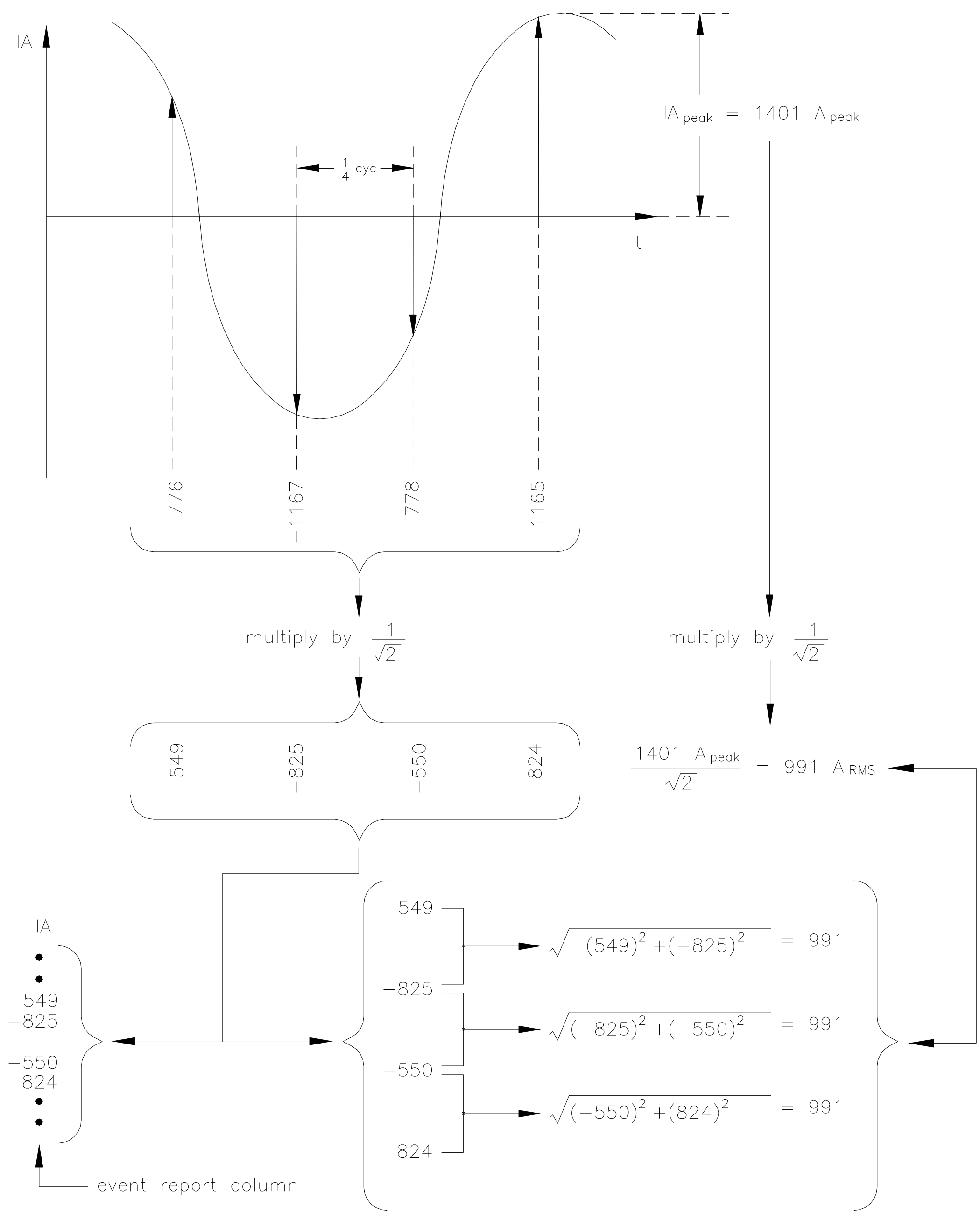

Figure 12.3: Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

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.

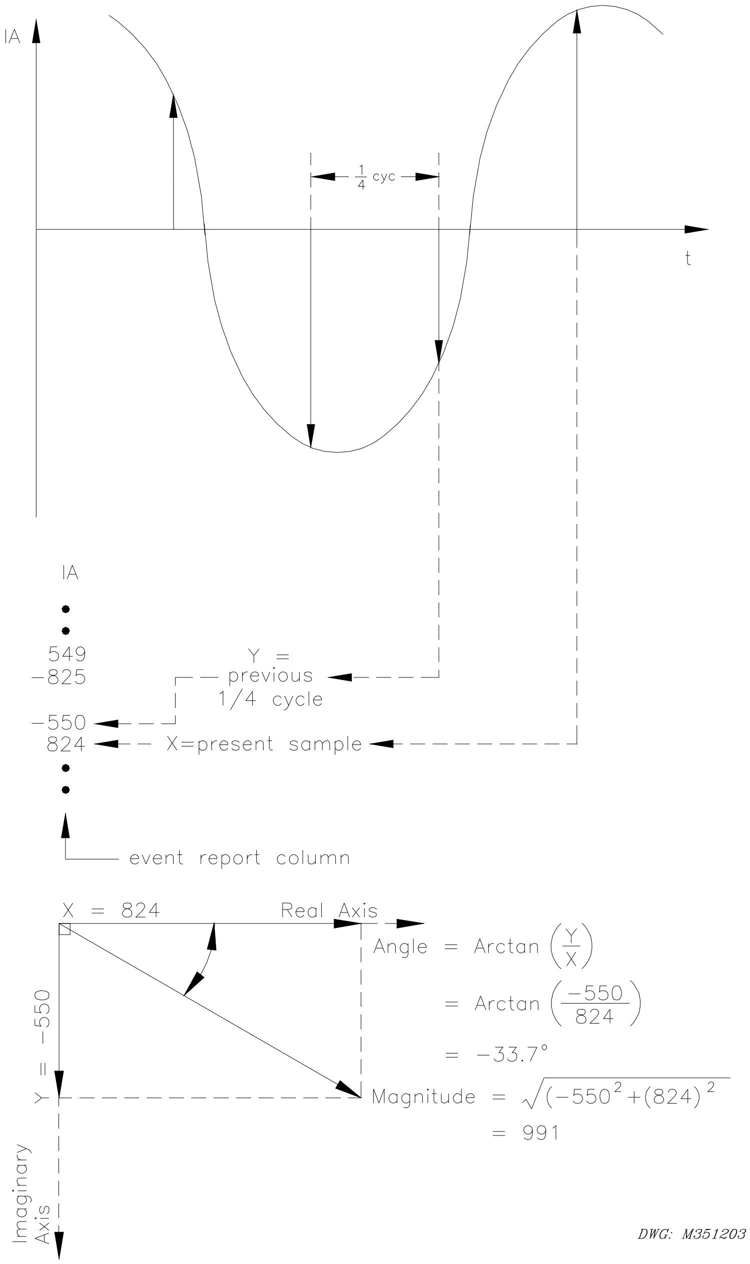

Figure 12.4: Derivation of Phasor RMS Current Values From Event Report Current Values

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 A ∠–33.7°

The present sample (IA = 824 A) is a real RMS current value that relates to the phasor RMS current value:

$$991 \text{ A} * \cos(-33.7°) = 824 \text{ A}$$

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.

```
SEL-351P-3 RECLOSER CONTROL           Date:  06/01/10    Time:  12:24:25.371
FEEDER

FID=SEL-351P-3-R400-V0-Z100100-D20100211       CID=6AFA

#     DATE      TIME           ELEMENT            STATE

24    06/01/10  12:00:00.000   Relay newly powered up or settings changed
23    06/01/10  12:23:26.915   CLOSE              Asserted
22    06/01/10  12:23:26.915   PB8                Asserted
21    06/01/10  12:23:26.920   PB8                Deasserted
20    06/01/10  12:23:26.961   CLOSE              Deasserted
19    06/01/10  12:23:26.965   52A                Asserted
18    06/01/10  12:23:36.971   79LO               Deasserted
17    06/01/10  12:23:36.971   79RS               Asserted
16    06/01/10  12:23:36.975   SH3                Deasserted
15    06/01/10  12:23:36.975   SH0                Asserted
14    06/01/10  12:23:52.527   51G1T              Asserted
13    06/01/10  12:23:52.527   79CY               Asserted
12    06/01/10  12:23:52.527   79RS               Deasserted
11    06/01/10  12:23:52.527   TRIP               Asserted
10    06/01/10  12:23:52.535   51P1T              Asserted
9     06/01/10  12:23:52.581   52A                Deasserted
8     06/01/10  12:23:52.598   51P1T              Deasserted
7     06/01/10  12:23:52.602   51G1T              Deasserted
6     06/01/10  12:23:52.602   TRIP               Deasserted
5     06/01/10  12:23:57.598   CLOSE              Asserted
4     06/01/10  12:23:57.598   SH1                Asserted
3     06/01/10  12:23:57.598   SH0                Deasserted
2     06/01/10  12:23:57.721   CLOSE              Deasserted
1     06/01/10  12:23:57.725   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 = WB52A
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
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 settings: TR = SV1 + LT1 * (51P1T + 51P2T + 51G1T + 51G2T + 51N1T + 51N2T + 67P2T + 67G2T + 67N2T + 67N3T + 81D1T)**
10	Phase time-overcurrent element time-delayed output, 51P1T. Trip is already in progress due to ground time-overcurrent element.
9	Recloser opens.
8, 7	Phase and ground time-overcurrent elements deassert.
6	Trip deasserts. Reclose interval 1 does not start timing until trip deasserts. Related settings: 79STL = TRIP
5	Close asserts for first automatic reclose. Related settings: Reclose interval 1 = 300.00 Time difference: 12:23:57.598 - 12:23:52.602 = 4.996 seconds (= 300 cycles)
4, 3	Reclose control increments reclose shot counter from 0 to 1 (SH1 asserted, SH0 deasserted).
2, 1	Close deasserts as recloser closes.

TABLE OF CONTENTS

TABLES

SECTION 13: TESTING AND TROUBLESHOOTING

Introduction

This section provides guidelines for determining and establishing test routines for the SEL-351P-3 Recloser Control. Included are discussions on testing philosophies, methods, and tools. SEL-351P-3 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-351P-3 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-351P-3.

Acceptance Testing

When: When qualifying a SEL-351P-3 model to be used on the utility system.

Goals:
a) Ensure that the SEL-351P-3 meets published critical performance specifications such as operating speed and element accuracy.
b) Ensure that the SEL-351P-3 meets the requirements of the intended application.
c) Gain familiarity with SEL-351P-3 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 the ***Testing*** section in the ***SEL-351P-3 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:
a) Ensure that all system ac and dc connections are correct.
b) Ensure that the SEL-351P-3 functions as intended using your settings.
c) 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-351P-3 before it is shipped. This helps ensure that you receive a unit that operates correctly and accurately. Commissioning tests should verify that the SEL-351P-3 is properly connected to the power system and all auxiliary equipment. Verify SEL-351P-3 signal inputs and outputs. Check breaker auxiliary inputs, SCADA control inputs, and monitoring outputs. Use an ac connection check to verify that the SEL-351P-3 current and voltage inputs are of the proper magnitude and phase rotation.

Brief fault tests ensure that the SEL-351P-3 settings are correct. It is not necessary to test every element, timer, and function in these tests.

At commissioning time, use the SEL-351P-3 **METER** command to verify the ac current and voltage magnitude and phase rotation. Use the **PULSE** command to verify SEL-351P-3 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-351P-3.

Maintenance Testing

When: At regularly scheduled intervals or when there is an indication of a problem with the SEL-351P-3 or system.

Goals:
a) Ensure that the SEL-351P-3 is measuring ac quantities accurately.
b) Ensure that scheme logic and protection elements are functioning correctly.
c) 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-351P-3 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-351P-3 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-351P-3 element data, you can determine that the SEL-351P-3 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-351P-3 Recloser Controls are microprocessor-based, their operating characteristics do not change over time. Time-overcurrent operating times are affected only by the SEL-351P-3 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-351P-3 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-351P-3

The following features assist you during SEL-351P-3 testing.

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-351P-3 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-351P-3 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-351P-3 elements using one of three methods: target command indication, output contact closure, or 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-351P-3, 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-351P-3 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/VARIOS pushbutton menu. To display the state of the 51PT element on the front-panel display, press the OTHER/VARIOUS pushbutton, cursor to the TAR option, and press SELECT/ACEPTAR. 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-351P-3 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 9.3 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-351P-3 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-351P-3 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 9.3.

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-351P-3 Recloser Control***. Do not forget to reenter the correct SEL-351P-3 settings when you are finished testing and ready to place the SEL-351P-3 in service.

Testing Via Sequential Events Recorder

You can set the SEL-351P-3 to generate an entry in the Sequential Events Recorder (SER) for testing SEL-351P-3 elements. Use the **SET R** command to include the element(s) under test in any of the SER trigger lists (SER1 through 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-351P-3 settings when you are ready to place the SEL-351P-3 in service.

SEL-351P-3 Self-Tests

The SEL-351P-3 runs a variety of self-tests. The SEL-351P-3 takes the following corrective actions for out-of-tolerance conditions (see Table 13.1):

- Protection Disabled: The SEL-351P-3 disables overcurrent elements and trip/close logic. All output contacts and FETs driving the trip and close pins of the control cable are deenergized. The CONTROL ENABLED/CONTROL HABILITADO front-panel LED is extinguished.
- ALARM Output: The ALARM output contact signals an alarm condition by going to its deenergized state. If the ALARM output contact is a B contact (normally closed), it closes for an alarm condition or if the SEL-351P-3 is deenergized. If the ALARM output contact is an A contact (normally open), it opens for an alarm condition or if the SEL-351P-3 is deenergized. Alarm condition signaling can be a single 5-second pulse (Pulsed) or permanent (Latched).
- The SEL-351P-3 generates automatic STATUS reports at the serial port for warnings and failures.
- The SEL-351P-3 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-351P-3 Recloser Control Self-Tests

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
IA, IB, IC, IN, VA, VB, VC, VS Offset	Warning	46 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	
+5 V PS	Warning	+4.80 V +5.20 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.
	Failure	–50°C +100°C	Yes	Latched	
RAM	Failure		Yes	Latched	Performs a read/write test on system RAM every 60 seconds.

Self-Test	Condition	Limits	Protectio n Disabled	ALARM Output	Description
ROM	Failure	checksum	Yes	Latched	Performs a checksum test on the SEL-351P-3 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-351P-3 settings every 10 seconds.
EEPROM	Failure	checksum	Yes	Latched	Performs a checksum test on the nonvolatile copy of the SEL-351P-3 settings every 10 seconds.
The following two self-tests are performed by dedicated circuitry in the microprocessor and the SEL-351P-3 main board. Failures in these tests shut down the microprocessor and are not shown in the STATUS report.					
Micro-processor Crystal	Failure		Yes	Latched	The SEL-351P-3 monitors the microprocessor crystal. If the crystal fails, the relay displays "CLOCK STOPPED" on the LCD display. The test runs continuously.
Micro-processor (main circuit board)	Failure		Yes	Latched	The microprocessor on the main circuit board examines each program instruction, memory access, and interrupt. The SEL-351P-3 displays "VECTOR *nn*" on the LCD upon detection of an invalid instruction, memory access, or spurious interrupt. The test runs continuously.

Self-Test	Condition	Limits	Protection Disabled	ALARM Output	Description
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 (discharge) 180 mA (charge)	No	Pulsed	Measures battery charge/discharge current every 10 seconds.
SF6 Gas Pressure	Warning	Relay Word bit SF6LO asserts	No	Pulsed	Indicates SF6 gas pressure going below setting level SF6PRS.

SEL-351P-3 Troubleshooting

Inspection Procedure

Complete the following procedure before disturbing the SEL-351P-3. After you finish the inspection, proceed to the ***Troubleshooting Procedure***.

1. Measure and record the ac power supply voltage at the power supply input (pins 1, 2 on connector J7)
2. Record battery voltage (pins 6, 2 on connector J6).
3. Measure and record the voltage at all SEL-351P-3 inputs (if used).
4. Measure and record the state of all output contacts (if used).

Troubleshooting Procedure

All Front-Panel LEDs Dark

1. Input ac power not present and battery discharged.
2. Input ac power not present and battery disconnected or otherwise defective.
3. Self-test failure.

Cannot See Characters on LCD Screen

1. SEL-351P-3 is deenergized. Check to see if the ALARM contact is closed.
2. LCD contrast is out of adjustment. Use the steps below to adjust the contrast.
   a. Press and hold down the OTHER/VARIOS front-panel pushbutton.
   b. Use the UP (▲) and DOWN (▼) arrow pushbuttons to adjust the contrast.

SEL-351P-3 Does Not Respond to Commands From Device Connected to Serial Port

1. Communications device not connected to SEL-351P-3.
2. SEL-351P-3 or communications device at incorrect baud rate or other communication parameter incompatibility, including cabling error.
3. SEL-351P-3 serial port has received an XOFF, halting communications. Type **<Ctrl>Q** to send control an XON and restart communications.

SEL-351P-3 Does Not Respond to Faults

1. SEL-351P-3 improperly set.
2. Improper test source settings.
3. CT or PT input wiring error.
4. Analog input cable between transformer secondary and main board loose or defective.
5. Failed SEL-351P-3 self-test.

Calibration

The SEL-351P-3 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 USA 99163-5603
Telephone: (509) 332-1890
Fax: (509) 332-7990
Internet: www.selinc.com

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APPENDIX A: FIRMWARE AND MANUAL VERSIONS

FIRMWARE

Determining the Firmware Version in Your Relay

To find the firmware revision number in your relay, view the status report using the serial port **STATUS** command or the front-panel STATUS pushbutton. For firmware versions prior to August 27, 1999, the status report displays the Firmware Identification (FID) label:

FID=**SEL-351P-x-Rxxx-Vx-Dxxxxxx**

For firmware versions with the date code of August 27, 1999, or later, the FID label will appear as follows with the Part/Revision number in bold:

FID=**SEL-351P-x-Rxxx-Vx-Z001001-Dxxxxxxxx**

Table A.1 lists the 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 Part/Revision No.	Summary of Revisions	Manual Date Code
SEL-351P-3-R400-V0-Z100100-D20100211	– Manual update only. See Table A.2 for a summary of manual updates.	20120127
SEL-351P-3-R400-V0-Z100100-D20100211	– Initial version.	20100211

INSTRUCTION MANUAL

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

Table A.2 lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.2: Instruction Manual Revision History

Revision Date	Summary of Revisions
20120127	**Section 9** – Updated Figure 9.5. **Section 10** – Added Access Level C information to ***Serial Port Access Levels***. – Added CAL Command information to ***Command Summary*** and ***Command Explanations***.
20100211	– Initial version.

APPENDIX B: FIRMWARE UPGRADE INSTRUCTIONS

FIRMWARE (FLASH) UPGRADE OVERVIEW

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
- 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 (.s19 or .exe) 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® SEL-5030 software
- Your relay instruction manual

Note: The newest release of the SEL-5010 Relay Assistant software (V3.0) has a new 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.

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, be certain `Yes` is highlighted and press the **{SELECT}** pushbutton.

Step 11. Connect an SEL-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 personal computer, you must be able to modify the computer serial communications parameters (i.e., data transmission rate, data bits, parity) and set the file transfer protocol to 1K Xmodem or Xmodem protocol.

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-C234A (or equivalent) serial communications cable to the personal computer 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 personal computer running Windows, you would typically click the **Start** button, point to **Programs**, and point to **Accessories**.

Step 4. Enter a name, select any icon, and click **OK** (Figure B.1).

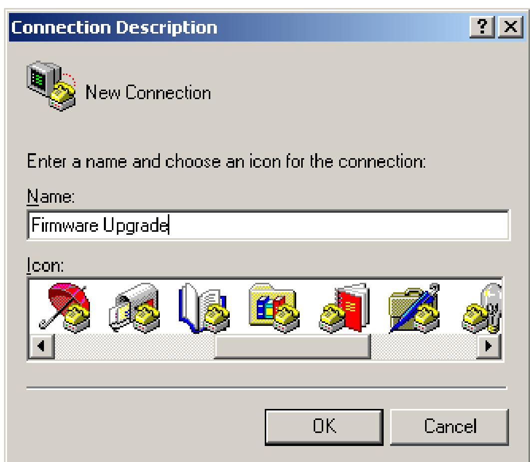

Figure B.1: Establishing a Connection

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.

Figure B.2: Determining the Computer Serial Port

Step 6. Establish serial port communications parameters.

Note: 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**.

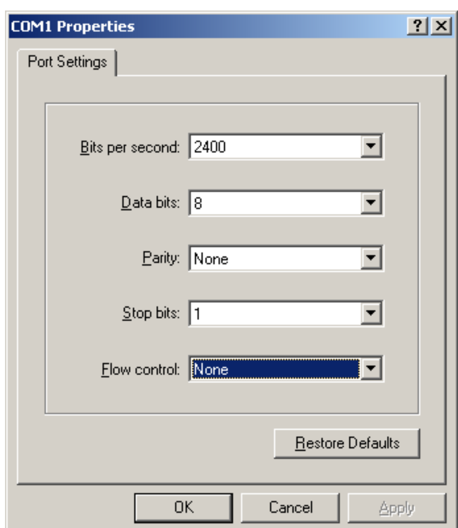

Figure B.3: Determining Communications Parameters for the Computer

Step 7. Set terminal emulation to VT100:

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

b. Select the **Settings** tab in the **Properties** dialog box (Figure B.4).

c. Select **VT100** from the **Emulation:** list box and click **OK**.

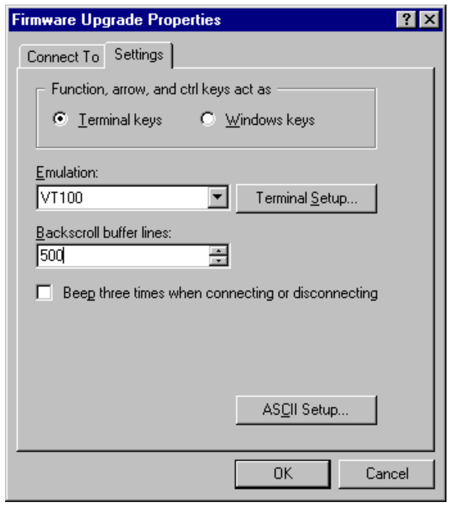

Figure B.4: Setting Terminal Emulation

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. The prompt appears when you press **<Enter>**.

If this is successful, proceed to ***C. Save Settings and Other Data*** on page B-7.

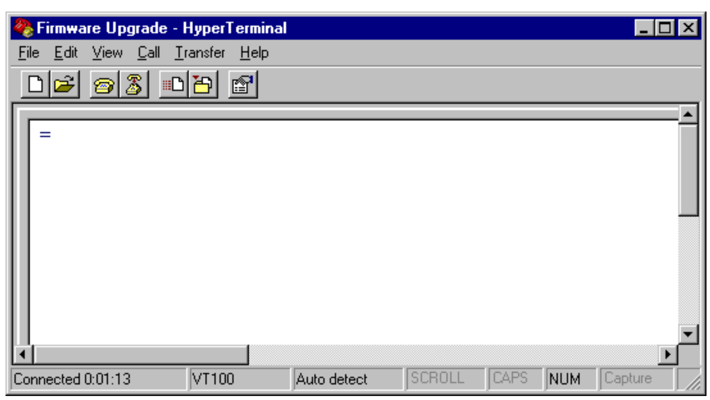

Figure B.5: Terminal Emulation Startup Prompt

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

Step 2. 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 and click **OK**.

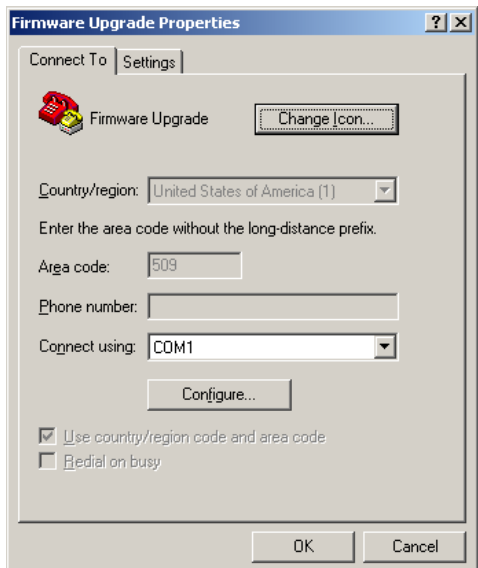

Figure B.6: Correcting Port Setting

Step 3. 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 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.

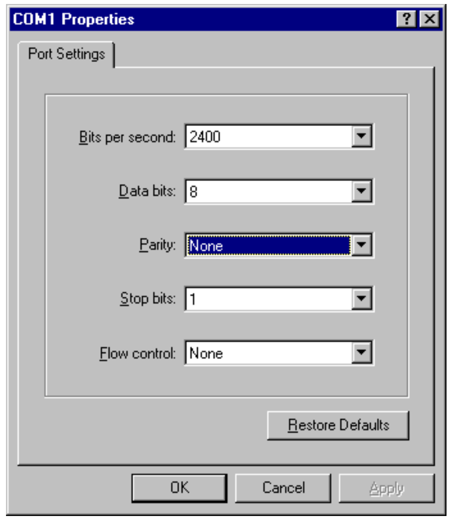

Figure B.7: Correcting the Communications Parameters

Step 4. 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.

Step 3. Type **2AC <Enter>**.

Step 4. Type the Access Level 2 password and press **<Enter>**.

You will see the Access Level 2 =>> 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).

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 ACSELERATOR to record the existing relay settings and proceed to ***D. Start SELBOOT*** on page B-8. 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 Show commands to retrieve your relay settings, which may include the following: **SHO 1–6**; **SHO L 1–6**; **SHO P 1–3**, **F**; **SHO G**; **SHO R**; **SHO T**; **SHO EZ 1–6**; and **SHO FZ**.

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.

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 on page B-5).

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**.

e. Click **OK** twice to go back to the terminal emulation window.

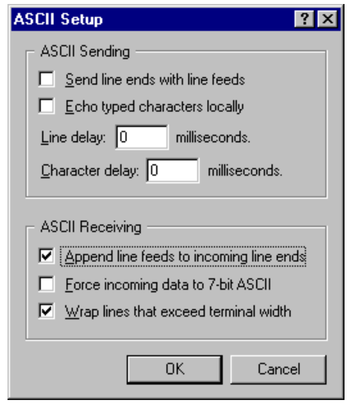

Figure B.8: Preparing HyperTerminal for ID Command Display

f. Type **ID <Enter>** and record the FID number the relay displays.

g. Repeat Step a through 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 Access Level 2, type **L_D <Enter>**.

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

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

The relay responds, `Are you sure (Y/N)?`

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

The relay responds, `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>**:

```
!>HELP <Enter>
SELboot-3xx-R100

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
```

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 your computer communications speed to match the new data transmission rate in the relay (Figure B.9).

d. Click **OK** twice.

e. From the **Call** menu, choose **Connect** to start communication.

Step 8. Press **<Enter>** to check for the SELBOOT `!>` prompt indicating that serial communication is successful.

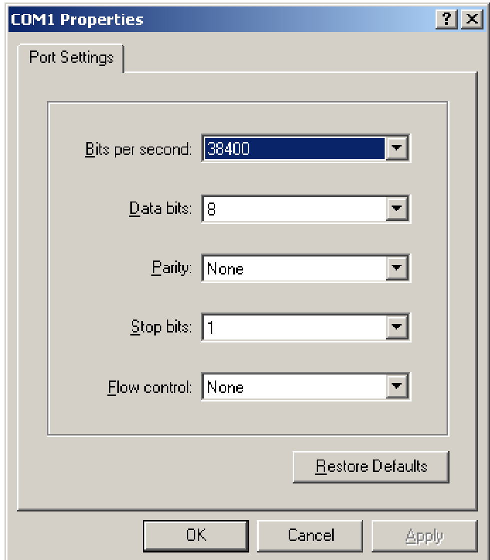

Figure B.9: Matching Computer to Relay Parameters

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, you will need as much as 3 MB of free disk space. This backup procedure takes between 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.10.

Step 3. Enter the pathname 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**.

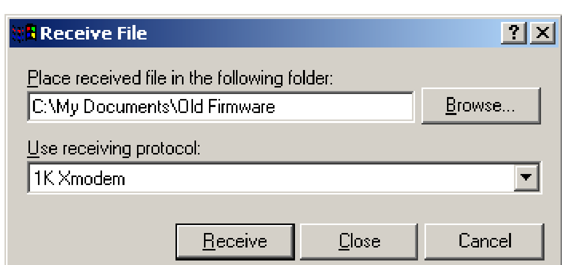

Figure B.10: Example Receive File Dialog box

Step 6. Enter a filename that clearly identifies the existing firmware version (Figure B.11), using the version number from the FID you recorded in Step 1 under ***D. Start SELBOOT*** on page B-8, and click **OK**.

SEL lists the firmware revision number first, then the product number.

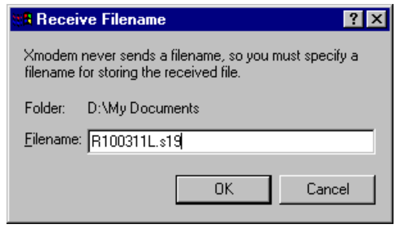

Figure B.11: Example Filename Identifying Old Firmware Version

If Xmodem times out before the download completes, repeat the process from Step 1 on page B-11.

Note: HyperTerminal stored any pathname 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.12. After the transfer, the relay responds, `Download completed successfully!`

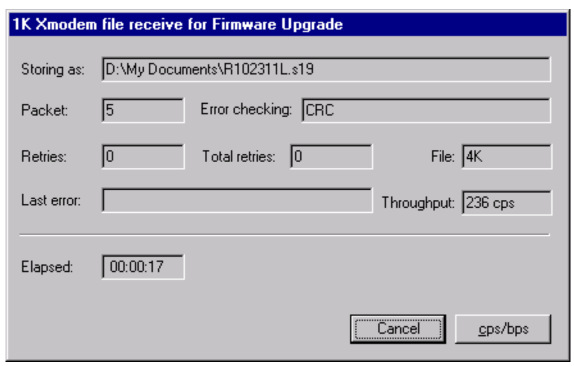

Figure B.12: Downloading Old Firmware

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.

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.

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.

Step 2. Type **REC <Enter>** at the SELBOOT `!>` prompt to command the relay to receive new firmware.

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

Step 3. Type **Y** to erase the existing firmware and load new firmware. (To abort, type **N** or press **<Enter>**).

The relay responds, `Erasing`, and erases the existing firmware.

When finished erasing, the relay responds with the following:

```
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.13).

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.

After the transfer completes, the relay displays `Upload completed successfully. Attempting a restart.`

Note: 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.

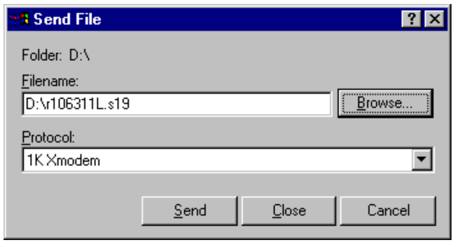

Figure B.13: Selecting the New Firmware to Send to the Relay

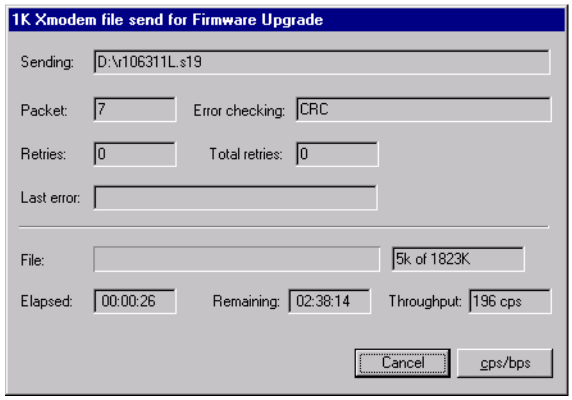

Figure B.14: Transfer of New Firmware to the Relay

Note: Unsuccessful uploads can result from Xmodem time-out, a power failure (see the note after Step 7), 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-12.

If you want to reload the previous firmware, begin at Step 2 on page B-12 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.

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-15.

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 on page B-3 under ***B. Establish a Terminal Connection*** to increase the serial connection data speed. Then resume the firmware upgrade process at ***F. Upload New Firmware***.

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*** on page B-2. (See ***Match Computer Communications Speed to the Relay*** on page B-10): **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*** on page B-2. **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*** on page B-10.
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*** on page B-10). **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-10) 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-18.

IO_BRD Fail Status Message

Note: Perform this procedure if you have only an IO_BRD Fail Status message; for additional fail messages, proceed to ***CR_RAM, EEPROM, IO_BRD Fail Status Messages***.

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***.

a. Type **Y <Enter>** to the question: `Are the new I/O board(s) correct (Y/N)?`

After a brief interval (as long as a minute), the CONTROL ENABLED/CONTROL HABILITADO LED will illuminate.

b. Use the **SHO *n*** command to view relay settings and verify that these match the settings you saved (see ***Backup Relay Settings*** beginning on page B-8).

Note: Depending upon the relay, ***n*** can be 1–6, G, P (1–3, F), L (1–6), T, R, EZ (1–6), or FZ.

Step 2. If the settings do not match, reenter the settings you saved earlier.

a. If you have SEL-5010 Relay Assistant software or ACSELERATOR, restore original settings by following the instructions for the respective software.

b. If you do not have the SEL-5010 Relay Assistant software or ACSELERATOR, restore original settings by issuing the necessary **SET *n*** commands, where ***n*** can be 1–6, G, P (1–3, F), L (1–6), T, R, EZ (1–6), or FZ (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 Calibration, Status, Breaker Wear, and Metering*** on page B-18.

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.

Step 3. Type **Y <Enter>**.

The relay can take as long as two minutes to restore default settings. The relay then reinitializes, and the CONTROL ENABLED/CONTROL HABILITADO LED illuminates.

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 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 corresponding passwords to reenter Access Level 2.

Step 6. Restore the original settings:

a. If you have SEL-5010 Relay Assistant software or ACSELERATOR, 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 ACSELERATOR, restore the original settings by issuing the necessary **SET *n*** commands, where ***n*** can be 1–6, G, P (1–3, F), L (1–6), T, R, EZ (1–6), or FZ (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 the troubleshooting section in the relay instruction manual or contact your customer service representative or the factory for assistance.

H. Verify Settings, Calibration, Status, Breaker Wear, and Metering

Step 1. Use the **AC**C 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-8).

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-17).

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 ***Save Settings and Other Data*** on page B-7, 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 **Properties** dialog box (Figure B.4).

c. Click **ASCII Setup**.

You should see a dialog box similar to Figure B.15.

d. Under **ASCII Receiving**, select the check box to **Append line feeds to incoming line ends**.

e. Click **OK** twice to return to the terminal emulation window.

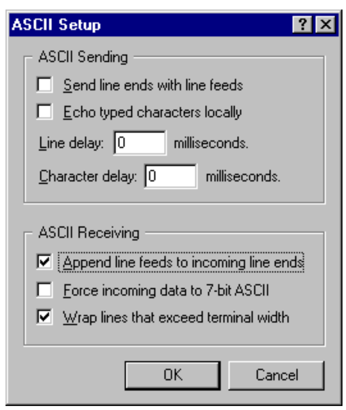

Figure B.15: Preparing HyperTerminal for ID Command Display

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-7.

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** (**TRI**) and **EVENT** (**EVE**) 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 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.

APPENDIX C: SEL DISTRIBUTED PORT SWITCH PROTOCOL

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:

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

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-up 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.

Note: You can use the front-panel SET pushbutton to change the port settings to return to SEL protocol.

APPENDIX D: CONFIGURATION, FAST METER, AND FAST OPERATE COMMANDS

INTRODUCTION

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-351P-3 Recloser Control.

MESSAGE LISTS

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

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-351P-3 sends the following 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
0100	SEL protocol, Fast Operate
0101	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-351P-3 sends the following block:

Data	Description
A5C1	Fast Meter command
84	Length
01	One status flag byte
00	Scale factors in Fast Meter message
00	No scale factors
0A	# of analog input channels
02	# of samples per channel
3D	# of digital banks
01	One calculation block
0004	Analog channel offset
0054	Time stamp offset
005C	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
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
564241540000	Analog channel name (VBAT)
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-351P-3 sends the following block:

Data	Description
A5D1	Command
9C	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 following block:

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
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
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 following block:

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-351P-3 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 following block:

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
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 following message to perform a remote bit operation:

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 contact assertion. You can use any remote bit, RB1–RB16, and any SELOGIC 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 following message to perform a fast breaker open/close:

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-351P-3 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 SEL 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-351P-x-R108-V0-Z001001-D20000602","yyyy"<CR>
"BFID=SELBOOT-351-R101","yyyy"<CR>
"CID=xxxx","yyyy"<CR>
"DEVID=STATION A","yyyy"<CR>
"DEVCODE=30","yyyy"<CR>
"PARTNO=0351P11284X1XXX","yyyy"<CR>
"CONFIG=212322","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 the Relay Word Bits table in ***Section 9: Setting the SEL-351P-3 Recloser Control***. The **DNA** command is available from Access Level 1 and higher.

The DNA message for the SEL-351P-3 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"
"50NF","50NR","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","32NF","32NR","*","WBTRT","SF6LO","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","yyyy"
"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"
"RAW52B","RAW52A","WB52A","WBBRK","WBCL","WBTR","CLCAP","TRCAP","yyyy"
"BATVL1","BATVL2","IDSCHG","ACPWR","CLSBPS","*"," DCONN "," DDATA ","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.

APPENDIX E: COMPRESSED ASCII COMMANDS

INTRODUCTION

The SEL-351P-3 Recloser Control provides compressed ASCII versions of some of the relay's ASCII commands. The compressed ASCII commands allow an external device to obtain data from the relay, in a format which directly imports into spreadsheet or database programs, and which can be validated with a checksum.

The SEL-351P-3 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
mS	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-351P-3

Display the SEL-351P-3 compressed ASCII configuration message by sending:

CAS <CR>

The SEL-351P-3 sends:

<STX>
"**CAS**",5,"YYYY"<CR>
"**CST**",1,"YYYY"<CR>
"1H","FID","YYYY"<CR>
"1D","48S","4S","YYYY"<CR>
"7H","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","YYYY"<CR>
"1D","I","I","I","I","I","I","I","YYYY",<CR>
"16H","IA","IB","IC","IN","VA","VB","VC","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>
"13H","-15V_PS","TEMP","RAM","ROM","A/D","CR_RAM","EEPROM",
"SF6","MODE","HRS_LFT","12V_AUX","VBAT",
"IBAT","YYYY"<CR>
"1D","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S","9S",
"9S","9S","9S","9S","9S","YYYY"<CR>
"**CHI**",1,"YYYY"<CR>

"1H","FID","YYYY"<CR>
"1D","48S","4S","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","4S","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>
"11H","IA","IB","IC","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)",
"FREQ","TRIG","***Names of elements in the relay word rows separated by spaces***","YYYY"<CR>
"60D","I","I","I","I","F","F","F","F","F","2S","116S","YYYY"<CR>
"**CEV C**",1,"YYYY"<CR>
"1H","FID","YYYY"<CR>
"1D","48S","4S","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>
"11H","IA","IB","IC","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)",
"FREQ","TRIG","***Names of elements in the relay word rows separated by spaces***","YYYY"<CR>
"240D","I","I","I","I","F","F","F","F","F","2S","116S","YYYY"<CR>
"**CEV R**",1,"YYYY"<CR>
"1H","FID","YYYY"<CR>
"1D","48S","4S","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>
"11H","IA","IB","IC","IG","VA(kV)","VB(kV)","VC(kV)","VS(kV)",
"FREQ","TRIG","***Names of elements in the relay word rows separated by spaces***","YYYY"<CR>
"256D","I","I","I","I","F","F","F","F","F","2S","116S","YYYY"<CR>
<ETX>

YYYY is the 4-byte hex ASCII representation of the checksum. See the **CEVENT** command for definition of the ***"Names of elements in the relay word rows separated by spaces"*** field.

CSTATUS Command—SEL-351P-3

Display status data in compressed ASCII format by sending:

CST <CR>

The SEL-351P-3 sends:

<STX>"FID","yyyy"<CR>
"***Relay FID string***","yyyy"<CR>
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,yyyy<CR>
"IA","IB","IC","IN","VA","VB","VC","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","SF6",
"MODE","HRS_LFT","12V_AUX","VBAT","IBAT","yyyy"<CR>
"xxxx","xxxx","xxxx","xxxx","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-351P-3

Display history data in compressed ASCII format by sending:

CHI <CR>

The relay sends:

<STX>"FID","yyyy"<CR>
"***Relay FID string***","***Relay Battery Charger Board FID string***","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","yyyy"<CR><ETX>

(the last line is then repeated for each record)

where: xxxx are the data values corresponding to the first line labels and
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-351P-3

Display event report in compressed ASCII format by sending:

CEV [*n* Sx Ly L R C] (parameters in [ ] are optional)

where:
- ***n*** event number (1–30) if LER = 15, (1–15) if LER = 30, defaults to 1
- **Sx** x samples per cycle (4 or 16); defaults to 4
  If Sx parameter is present, it overrides the L parameter
- **Ly** 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 Sx parameter, if present
- **R** specifies raw (unfiltered) data; defaults to 16 samples per cycle unless overridden by the Sx parameter. Defaults to 16 cycles in length unless overridden with the Ly 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>
"***Relay FID string***","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","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,z,"***HEX-ASCII Relay Word***","yyyy"<CR>
"SETTINGS","yyyy"<CR>
"***Relay EZ, group, global, global EZ(FZ), and logic settings as displayed with the showset 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 in section 9 of this manual.

A typical ***HEX-ASCII Relay Word*** is shown below:

"10000004986100000000000000F12028000000000102010000000000000240C008000000000000000000000"

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 through 50Q6 and 67Q1 through 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 through 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 Figures 3.12 and 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 Figures 7.25 and 7.26) and use the outputs of the timers for tripping.

Continue reading in ***Coordinating Negative-Sequence Overcurrent Elements*** in this appendix 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 Figures 9.1 through 9.20 in ***Section 9: Setting the SEL-351P-3 Recloser Control***). 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)

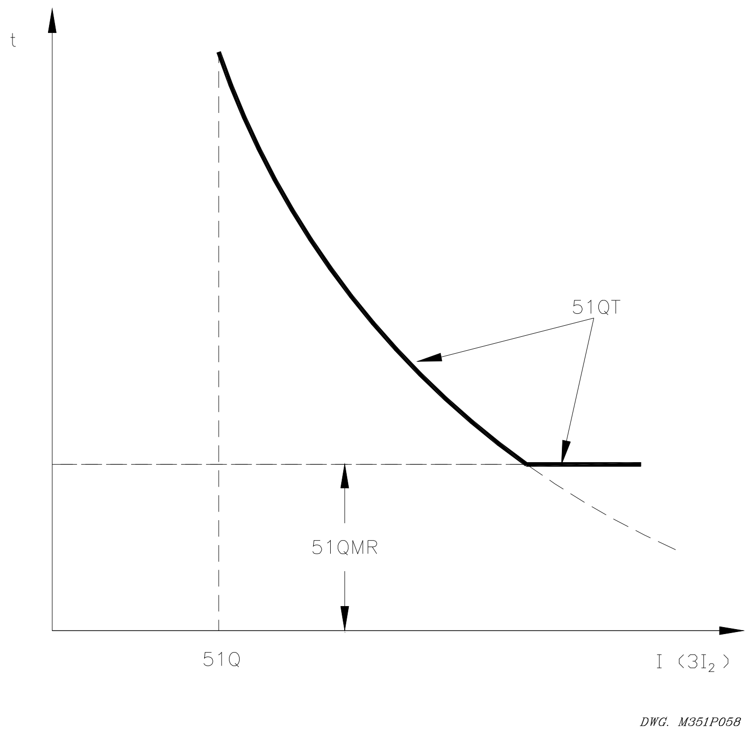

Figure F.1: Minimum Response Time Added to a Negative-Sequence Time-Overcurrent Element 51QT

Continue reading in ***Coordinating Negative-Sequence Overcurrent Elements*** in this appendix 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-351P-3 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-351P-3 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-351P-3 overcurrent elements.

Coordination Guidelines

1. Start with the furthest 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.

$$\left.\begin{array}{c}\text{Negative-sequence}\\ \text{overcurrent}\\ \text{element pickup}\end{array}\right\} = \sqrt{3}\cdot(\text{“equivalent” phase overcurrent element pickup})$$

   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).

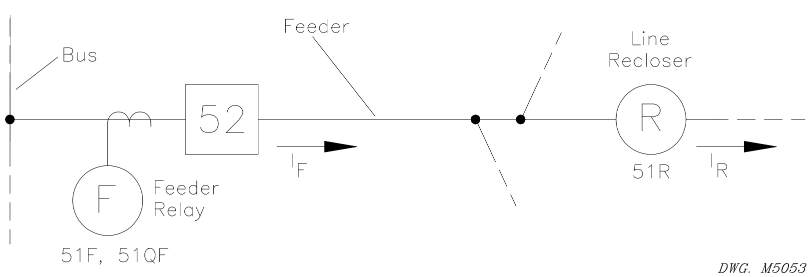

Figure F.2: Distribution Feeder Protective Devices

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

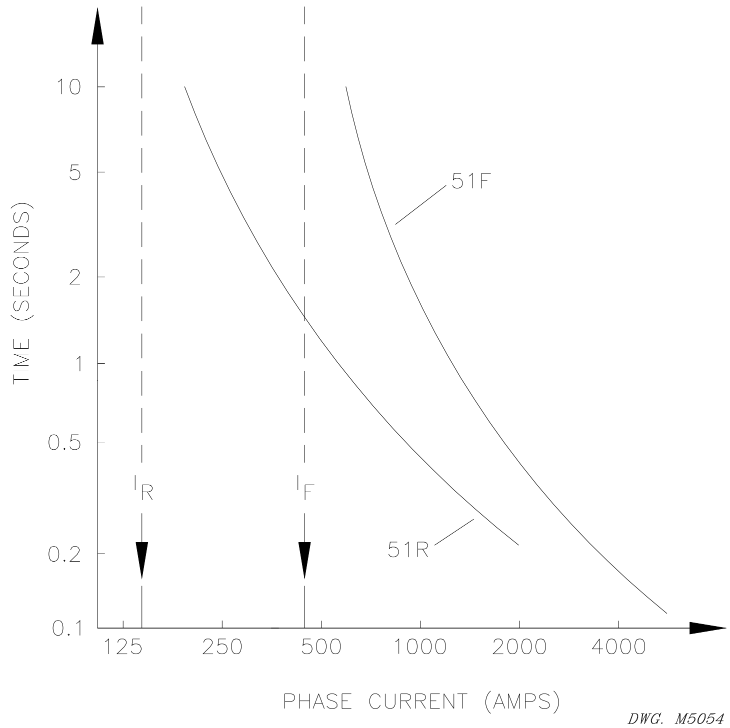

Figure F.3: Traditional Phase Coordination

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.

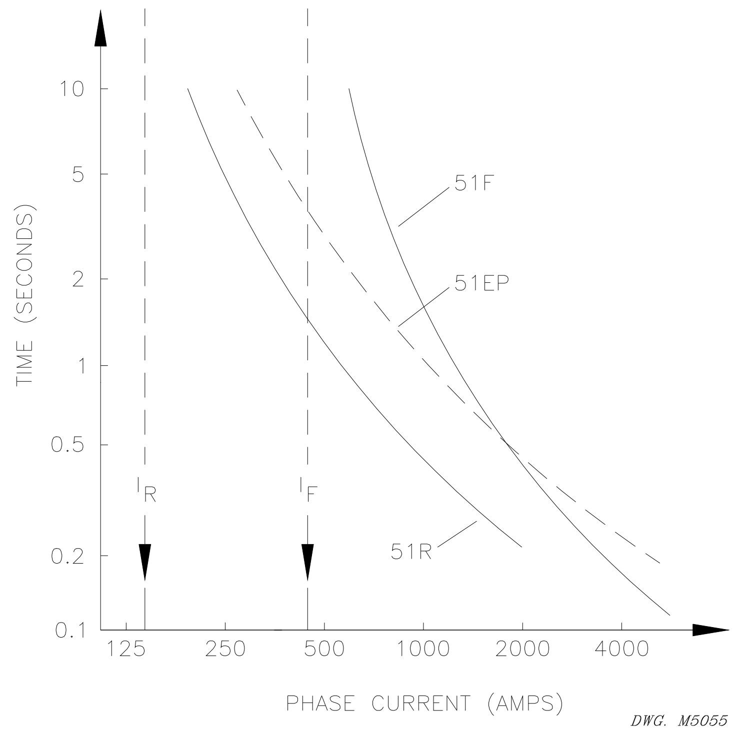

Figure F.4: Phase-to-Phase Fault Coordination

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).

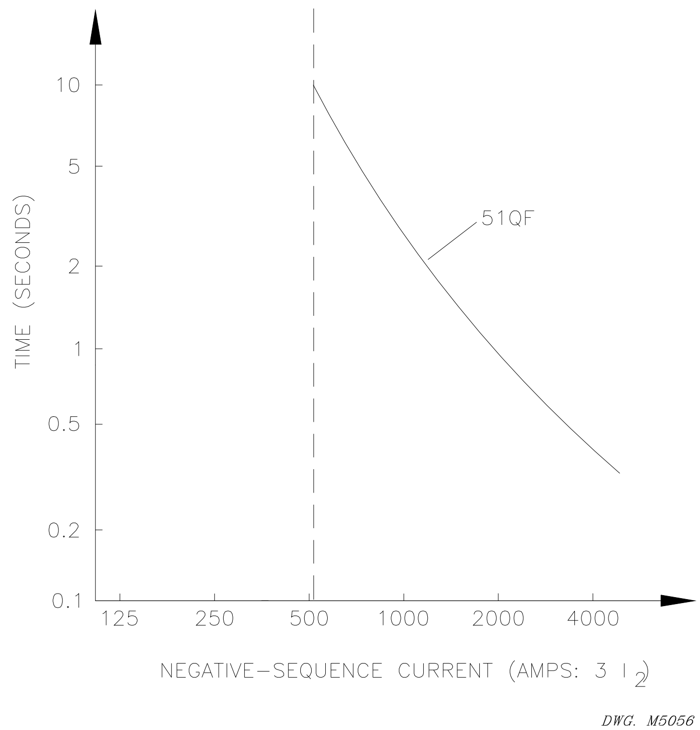

Figure F.5: Negative-Sequence Overcurrent Element Derived From "Equivalent" Phase Overcurrent Element, 51EP

$$51QF:\text{pickup} = \sqrt{3}\cdot(300A) = 520A$$

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.

APPENDIX G: SETTING SELOGIC CONTROL EQUATIONS

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-351P-3 Recloser Control*** (see also Settings Sheets 13 through 17 in the back of ***Section 9***). See the ***SHO command (Show/View Settings)*** in ***Section 10: Serial Port Communications and Commands*** for a list of the factory settings shipped with the SEL-351P-3 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) or 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 9.3 in ***Section 9: Setting the SEL-351P-3 Recloser Control***.

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 in ***Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements***. 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:

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:

51P1	testing (e.g., assign to an output contact for pickup testing) trip unlatch logic (see SELOGIC control equation unlatch trip setting ULTR example later in this section)
51P1T	trip logic (see SELOGIC control equation trip setting TR example later in this section)
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 7.25 in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***. 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-351P-3 operates on 52a circuit breaker auxiliary contact logic. The SELOGIC control equation circuit breaker status setting is labeled 52A. See ***Optoisolated Inputs*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic*** and ***Close Logic*** in ***Section 6: Close and Reclose Logic*** 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 deenergized [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*** in ***Section 5: Trip and Target Logic***.

In this setting example, the unlatch condition comes true only when <u>both</u> 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 <u>both</u> 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:

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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***)

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.

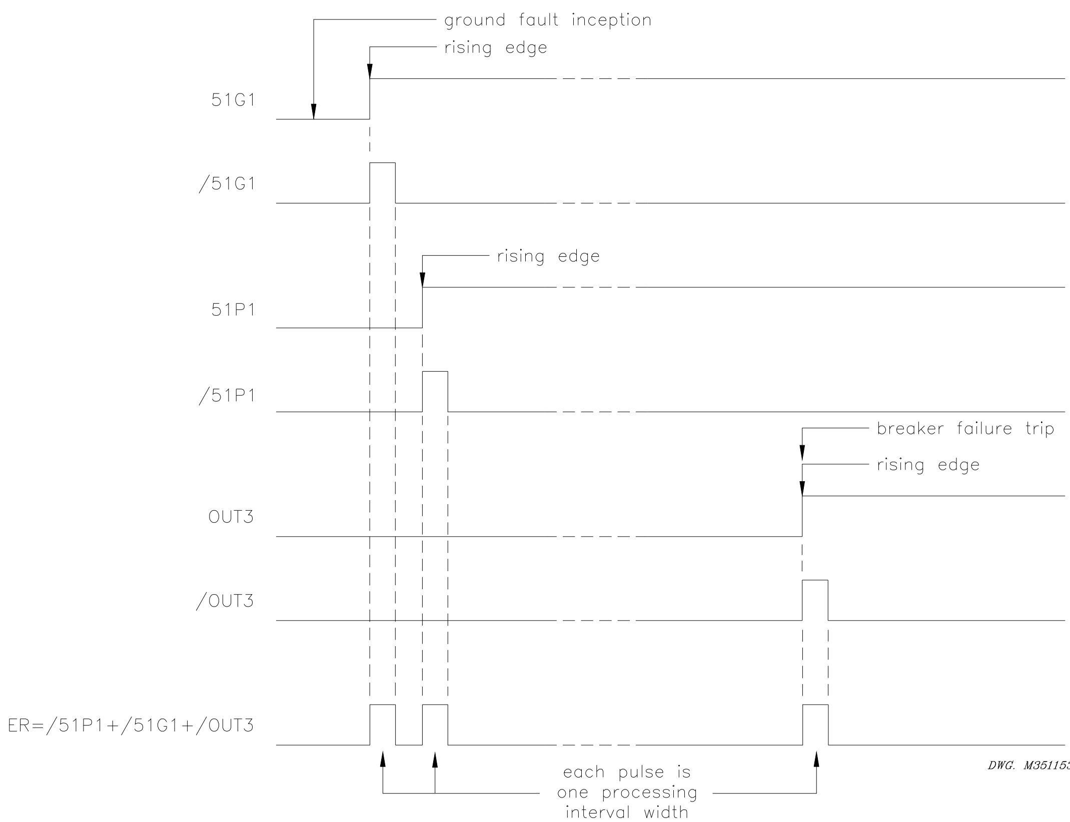

Figure G.1: Result of Rising Edge Operators on Individual Elements in Setting ER

Note in Figure G.1 that setting ER sees three separate rising edges, due to 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 3.30 and Table 3.11 in ***Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements***. Figure G.2 demonstrates the action of the falling edge operator \ on the underfrequency element in setting ER.

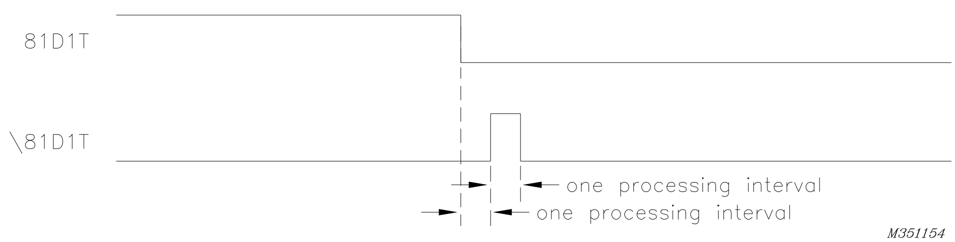

Figure G.2: Result of Falling Edge Operator on a Deasserting Underfrequency Element

SELOGIC Control Equation Analog Compares

The SEL-351P-3 Relay 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 parenthesis 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*** in ***Section 5: Trip and Target Logic***.

Note that Figure 5.1 in ***Section 5: Trip and Target Logic*** 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:

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 <u>above</u> 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 <u>above</u> 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*** in ***Section 7: Inputs, Outputs, Timers, and Other Control Logic***):

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:

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."

Note: SELOGIC control equation torque control settings (e.g., 67P1TC, 51P1TC) cannot be set to logical 0.

Under the ***SHO Command (Show/View Settings)*** in ***Section 10: Serial Port Communications and Commands***, 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 Settings Sheets 13 through 17 at the end of ***Section 9: Setting the Recloser Control***) 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 through 51QTC for the overcurrent elements. The factory settings shipped with the SEL-351P-3 in a standard relay shipment, are all set directly to logical 1. See these factory settings in ***SHO Command (Show/View Settings)*** in ***Section 10: Serial Port Communications and Commands***.

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 in ***Section 3: Overcurrent, Voltage, Synchronism Check, and Frequency Elements*** 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 through 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 through SV16) are processed after the trip equation (SELOGIC control equation trip setting TR). Thus, any tripping via Relay Word bits SV1 through SV16 can be delayed as much as 1/4 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-351P-3 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 (1/4-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 1/4-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)

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, 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
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

Relay Elements and Logic (Corresponding SELOGIC Control Equations Listed in Parentheses)	Resultant Relay Word Bits	Reference Instruction Manual Section
Directional Elements (E32IV)	32QE, 32QGE, 32VE, 32IE, F32P, R32P, F32Q, R32Q, F32QG, R32QG, F32V, R32V, F32I, R32I, 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
(OUT101–OUT107) Recloser Control Trip (WBTR) and Close (WBCL)	OUT101–OUT107 WBTR, WBCL	Section 7

Relay Elements and Logic (Corresponding SELOGIC Control Equations Listed in Parentheses)	Resultant Relay Word Bits	Reference Instruction Manual Section
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	RAW52B, RAW52A, WB52A	Section 7

APPENDIX H: DISTRIBUTED NETWORK PROTOCOL (DNP3)

Overview

The SEL-351P-3 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-351P-3 supports DNP point re-mapping. Two modes of operation are available: Standard, for backwards and cross-platform compatibility, and Extended, with additional features that are both 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

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
ECLASS	Class for event data (0–3)	2
TIMERQ	Time-set request interval (0–32767 min.)	0
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)	3
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.)	0.10
PREDLY	Settle time from RTS on to Tx (OFF,0–30 sec.)	0
PSTDLY	Settle time after Tx to RTS off (0–30 sec.)	0
ANADB	Analog reporting dead band (0–32767 counts)	100
UNSOL	Enable Unsolicited reporting (Y,N,DIAL)	N
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	Age of oldest event to transmit on (0–60 sec.)	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

Extended Mode DNP Operation

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
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)	3
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.)	0.10
PREDLY	Settle time from RTS on to Tx (OFF,0–30 sec.)	0
PSTDLY	Settle time after Tx to RTS off (0–30 sec.)	0
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
REPADR	DNP Address to report to (0–65534)	0
NUMEVE	Number of events to transmit on (1–200)	10
AGEEVE	Age of oldest event to transmit on (0–60 sec.)	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

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-351P-3 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-351P-3 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-351P-3 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-351P-3 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 is available, DNP asserts the DDATA Relay Word bit. If setting UNSOL = Y or DIAL and a connection has been made, the SEL-351P-3 begins transmitting the unsolicited event data and asserts Relay word bit DCONN. If setting UNSOL = DIAL, the SEL-351P-3 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-351P-3 decides to transmit on the DNP link, it has to wait if the physical connection is in use. The SEL-351P-3 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-351P-3 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: Data Access Methods

Data Retrieval Method	Description	Relevant SEL-351S DNP (Standard) Settings	Relevant SEL-351S 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 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 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 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 UNSOL = Y, Set NUMEVE and AGEEVE according to how often messages are desired to be sent.

Device Profile

The following is the device profile as specified in the ***DNP3 Subset Definitions*** document:

DNP3
DEVICE PROFILE DOCUMENT
This document must be accompanied by a table having the following headings:

Object Group	Request Function Codes	Response Function Codes
Object Variation	Request Qualifiers	Response Qualifiers
Object Name (optional)		

Vendor Name: **Schweitzer Engineering Laboratories, Inc.**

Device Name: **SEL-351P-3**

Highest DNP Level Supported: For Requests **Level 2** For Responses **Level 2**	Device Function: ☐ Master ☑ Slave

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

Supports enabling and disabling of unsolicited reports on a class basis.

Maximum Data Link Frame Size (octets): Transmitted 292 Received (must be 292)	Maximum Application Fragment Size (octets): Transmitted 2048 (if >2048, must be configurable) Received 2048 (must be >249)
Maximum Data Link Re-tries: ☐ None ☐ Fixed at ______ ☑ Configurable, range 0 to 15	Maximum Application Layer Re-tries: ☑ None ☐ Configurable, range _____ to _____ (Fixed is not permitted)

Requires Data Link Layer Confirmation:

☐ Never
☐ Always
☐ Sometimes If 'Sometimes', when? ____________
☑ Configurable If 'Configurable', how? by settings.

Requires Application Layer Confirmation:

☐ Never
☐ Always (not recommended)
☑ When reporting Event Data (Slave devices only)
☐ When sending multi-fragment responses (Slave devices only)
☐ Sometimes If 'Sometimes', when? ______________________
☐ Configurable If 'Configurable', how? ______________________

Timeouts while waiting for:

Data Link Confirm	☐ None	☐ Fixed at ______	☐ Variable	☑ Configurable
Complete Appl. Fragment	☑ None	☐ Fixed at ______	☐ Variable	☐ Configurable
Application Confirm	☐ None	☐ Fixed at ______	☐ Variable	☑ Configurable
Complete Appl. Response	☑ None	☐ Fixed at ______	☐ Variable	☐ Configurable

Others ____

Attach explanation if 'Variable' or 'Configurable' was checked for any timeout.

Sends/Executes Control Operations:

WRITE Binary Outputs	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE—NO ACK	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Count > 1	☑ Never	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Pulse Off	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Latch Off	☐ Never	☑ Always	☐ Sometimes	☐ Configurable
Queue	☑ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☑ Never	☐ Always	☐ Sometimes	☐ Configurable

Attach explanation if 'Sometimes' or 'Configurable' was checked for any operation.

FILL OUT THE FOLLOWING ITEM FOR MASTER DEVICES ONLY:

Expects Binary Input Change Events:

☐ Either time-tagged or non-time-tagged for a single event
☐ Both time-tagged and non-time-tagged for a single event
☐ Configurable (attach explanation)

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY

Reports Binary Input Change Events when no specific variation requested:

☐ Never
☑ Only time-tagged
☐ Only non-time-tagged
☐ Configurable to send both, one or the other (attach explanation)

Reports time-tagged Binary Input Change Events when no specific variation requested:

☐ Never
☑ Binary Input Change With Time
☐ Binary Input Change With Relative Time
☐ Configurable (attach explanation)

Sends Unsolicited Responses:	Sends Static Data in Unsolicited Responses:
☐ Never ☑ Configurable (attach explanation) ☐ Only certain objects ☐ Sometimes (attach explanation) ☑ ENABLE/DISABLE UNSOLICITED Function codes supported	☑ Never ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ☐ No Counters Reported ☐ Configurable (attach explanation) ☑ Default object 20 ☐ Default variation 6 ☐ Point-by-point list attached	**Counters Roll Over at:** ☐ No Counters Reported ☐ Configurable (attach explanation) ☑ 16 Bits ☐ 32 Bits ☐ Other Value ______________ ☐ Point-by-point list attached
Sends Multi-Fragment Responses: ☐ Yes ☑ No	

In all cases within the device profile that an item is configurable, it is controlled by SEL-351P-3 settings.

OBJECT TABLE

The supported object, function and qualifier code combinations are given by the following object table.

Table H.2: SEL-351P-3 DNP Object Table

Object			Request (supported)		Response (may generate)	
Obj	Var (*default)	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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*	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
2	2*	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*	Binary Output Status	1	0,1,6,7,8	129	0,1

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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*	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*	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				
22	8	16-Bit Delta Counter Change Event with Time				

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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*	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*	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*	16-Bit Analog Output Status	1	0,1,6,7,8	129	0,1,7,8

Object			Request (supported)		Response (may generate)	
Obj	*default Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)
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				
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			

DATA MAP

The following is the default object map supported by the SEL-351P-3 (FID = SEL-351P-3-Rxxx-V0-Zxxxxxx-Dxxxxxxxx).

Table H.3: SEL-351P-3 DNP Data Map

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 UNDERFREQ.
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[1]	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.

DNP Object Type	Index	Description
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.
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.

DNP Object Type	Index	Description
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[2]	105	Fault type (see table for definition).
30,32[2]	106	Fault location.
30,32[2]	107	Fault current.
30,32[2]	108	Fault frequency.
30,32[2]	109	Fault settings group.
30,32[2]	110	Fault recloser shot counter.
30,32[2]	111–113	Fault time in DNP format (high, middle, and low 16 bits).
30,32[1]	114	Relay internal temperature
30,32[1]	115	Number of unread faults
30,32[1]	116	51P1P setting in primary units
30,32[1]	117	51P2P setting in primary units
30,32[1]	118	51G1P setting in primary units
30,32[1]	119	51G2P setting in primary units
30,32[1]	120	51QP setting in primary units
30,32[1]	121	51N1P setting in primary units
30,32[1]	122	51N2P setting in primary units
40,41	00	Active settings group.

[1] Extended mode (DNPE) only
[2] 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 per second 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 element's point index, consult the Relay Word Bits table in ***Section 9: Setting the SEL-351P-3 Recloser Control.*** Locate the element in question in the table and note the Relay Word row number. From that row number, subtract the row number of the first Relay Word row (usually 2) and multiply that result by 8. This is the index of the right-most element of the Relay Word row of the element in question. Count over to the original element and add that to get the point index. 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.

Analog Inputs (objects 30 and 32) are supported as defined by the preceding table. 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, 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 is scaled by 10. 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.

In standard mode, analog inputs are scanned at approximately a 1-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 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 lower byte 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) do not contain valid data. 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 above. The Trip/Close bits take precedence over the control field. The control field is interpreted as follows:

Index	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
0–7	Set	Clear	Set	Clear	Pulse	Clear
8–14	Pulse	Do nothing	Pulse	Do nothing	Pulse	Do nothing
15	Read Oldest	Read Newest*	Read Oldest	Read Newest*	Read Oldest	Read Newest*
16	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1	Pulse RB2	Pulse RB1
17	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3	Pulse RB4	Pulse RB3
18	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5	Pulse RB6	Pulse RB5
19	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7	Pulse RB8	Pulse RB7
20	Pulse CC	Pulse OC	Pulse CC	Pulse OC	Pulse CC	Pulse OC

* 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 through 6, the relay will not accept the value and will return a hardware error status.

Relay Summary Event Data

In standard mode (DNP) the Relay Event Summary data is 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 15. This will load the relay event summary analogs (points 105–113) 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 15 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 15. This will load the relay event summary analogs (points 105–113) 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 15 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 change. Events are detected every second 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 15 must be pulsed no faster than once every two seconds. If binary output 15 is pulsed faster, some data may not be recognized and processed by the DNP event scanner.

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 relay's 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 123 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 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<STX>
Analogs  =   112 28 17 35 1 56 57 58 59 60 61 62 63 64 65 \
   66 67 100 101 102 103
Binaries =   Default Map<ETX>
==>
```

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<STX>
Binaries = Map Corrupted<ETX>
==>
```

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 remapping is disabled for that type (i.e., the relay uses the default analog or binary map). For example, the first example remap could be produced with the following commands:

```
==>DNP A
Enter the new DNP Analog map
112 28 17 \<CR>
35 1 56 57 58 59 60 61 62 63 64 65 66 67 100 101 102 \<CR>
103<CR>

Save Changes (Y/N)? Y<CR>
==>DNP B
Enter the new DNP Binary map
<CR>

Save Changes (Y/N)? Y<CR>
==>
```

Settings Sheet—Standard Mode DNP Port—SET P

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	=	________
Class for event data (0 for no event, 1–3)	ECLASS	=	________
Minutes for Request Interval (0 for never, 1–32767)	TIMERQ	=	________
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)	MAXDLY	=	________
Transmission delay from RTS assertion, seconds (OFF,0.00–30.00)	PREDLY	=	________
Post-transmit RTS deassertion delay, seconds (0.00–30.00)	PSTDLY	=	________
Analog reporting dead band, counts (0–32767)	ANADB	=	________
Allow Unsolicited Reporting (Y, N, DIAL)	UNSOL	=	________
Enable unsolicited messages on power-up (Y/N)	PUNSOL	=	________
Address of master to Report to (0–65534)	REPADR	=	________
Number of events to transmit on (1–200)	NUMEVE	=	________
Age of oldest event to force 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	=	________

Settings Sheet—Extended Mode DNP Port—SET P

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	=	________________
Minutes for Request Interval (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)	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	=	________________
Address of master to Report to (0–65534)	REPADR	=	________________
Number of events to transmit on (1–200)	NUMEVE	=	________________
Age of oldest event to force 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	=	________________

APPENDIX I: MIRRORED BITS COMMUNICATIONS

OVERVIEW

MIRRORED BITS® communications 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-351P-3 Recloser Control supports two MIRRORED BITS channels, differentiated by the channel specifiers A and B. Bits transmitted are called TMB1*x* through 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* through 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-351P-3.

Message Decoding and Integrity Checks

The relay 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.

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-351P-3 talking to another SEL-351P-3 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-351P-3). 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-351P-3, 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-351P-3 will delay a bit by 1/4 cycle, because the SEL-351P-3 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 ROK*x* 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 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.

Loop-Back 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 Message Decoding and Integrity Checks)

Use the **COMM** command to generate a long or summary report of the communications errors.

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*. Note: The user typically will combine RBAD*x* with other alarm conditions using SELOGIC control equations.

When channel unavailability exceeds a user-settable threshold, the relay will assert a user accessible flag, hereafter called CBAD*x*. Note: The user typically will combine CBAD*x* with other alarm conditions using SELOGIC control equations.

MIRRORED BITS PROTOCOL FOR THE PULSAR 9600 BAUD MODEM

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 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. 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 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-351P-3 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.

```
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.

SEL-351P-3 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* L	Show a long format communications summary report for all events on MIRRORED BITS® channel *p* (where *p* = A or B).
COM *p n*	Show a communications summary for latest *n* event on MIRRORED BITS channel *p*.
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS channel *p*.
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)
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.
EVE *n*	Show event report number *n* with 1/4-cycle resolution.
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 C *n*	Show compressed event report number *n* for use with SEL-5601 Analytic Assistant.
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 *n*	Show the latest *n* rows in the Load Profile report.
LDP *m n*	Show rows *m* through *n* in the Load Profile report.
LDP d1	Show rows in the Load Profile report from date d1.
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).
MET *k*	Display instantaneous metering data. Enter *k* for repeat count.
MET X *k*	Display same as **MET** command with phase-to-phase voltages. 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.
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
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).
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 R	Reset the front-panel tripping targets.
TAR *n k*	Display Relay Word row. If *n* = 0 through 59, display row *n*. If *n* is an element name (e.g., 50A1) display the row containing element *n*. Enter *k* for repeat count.
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.

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 W	Preload breaker/recloser contact wear.
BRE W A	Preload breaker/recloser contact wear and trip operation counters.
BRE R	Reset 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 password jumper is not in place, the control prompts you for 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 RB*n*. 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*.
LOO	Set MIRRORED BITS port to loopback.
PAS	Show existing Access Level 1, E (EZ), B, 2, and C passwords.
PAS 1 xxxxxx	Change Access Level 1 password to xxxxxx.
PAS E xxxxxx	Change Access Level E (EZ) password to xxxxxx.
PAS B xxxxxx	Change Access Level B password to xxxxxx.
PAS 2 xxxxxx	Change Access Level 2 password to xxxxxx.
PAS C xxxxxx	Change Access Level C password to xxxxxx.

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.

Key Stroke Commands

<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

<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-351P-3 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* L	Show a long format communications summary report for all events on MIRRORED BITS® channel *p* (where *p* = A or B).
COM *p n*	Show a communications summary for latest *n* event on MIRRORED BITS channel *p*.
COM *p m n*	Show a communications summary report for events *n* through *m* on MIRRORED BITS channel *p*.
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)
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.
EVE *n*	Show event report number *n* with 1/4-cycle resolution.
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 C *n*	Show compressed event report number *n* for use with SEL-5601 Analytic Assistant.
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 *n*	Show the latest *n* rows in the Load Profile report.
LDP *m n*	Show rows *m* through *n* in the Load Profile report.
LDP d1	Show rows in the Load Profile report from date d1.
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).
MET *k*	Display instantaneous metering data. Enter *k* for repeat count.
MET X *k*	Display same as **MET** command with phase-to-phase voltages. 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.
QUI	Quit. Returns to Access Level 0. Terminates SEL Distributed Port Switch Protocol (LMD) protocol connection.
SER *n*	Show the latest *n* rows in the Sequential Events Recorder (SER) event report.
SER *m n*	Show rows *m* through *n* in the Sequential Events Recorder (SER) event report.
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).
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 R	Reset the front-panel tripping targets.
TAR *n k*	Display Relay Word row. If *n* = 0 through 59, display row *n*. If *n* is an element name (e.g., 50A1) display the row containing element *n*. Enter *k* for repeat count.
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.
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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 W	Preload breaker/recloser contact wear.
BRE W A	Preload breaker/recloser contact wear and trip operation counters.
BRE R	Reset 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.

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CON *n*	Control Relay Word bit RB*n*, Remote Bit *n* where *n* = 1–16. Execute **CON *n*** and the control responds: CONTROL RB*n*. 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].
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PAS	Show existing Access Level 1, E (EZ), B, 2, and C passwords.
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PAS E xxxxxx	Change Access Level E (EZ) password to xxxxxx.
PAS B xxxxxx	Change Access Level B password to xxxxxx.
PAS 2 xxxxxx	Change Access Level 2 password to xxxxxx.
PAS C xxxxxx	Change Access Level C password to xxxxxx.

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).
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END **<Enter>**	Exits setting editing session, then prompts user to save settings.
<Ctrl> X	Aborts setting editing session without saving changes.