GE Power Management

750/760

FEEDER MANAGEMENT RELAY®

Instruction Manual

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WARNING

These instructions do not purport to cover all details or variations in equipment nor provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the General Electric Company.

To the extent required the products described herein meet applicable ANSI, IEEE, and NEMA standards; but no such assurance is given with respect to local codes and ordinances because they vary greatly.

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B.1 EU DECLARATION OF CONFORMITY

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C.1 WARRANTY INFORMATION

C.1.1 WARRANTY C-1

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The 750 and 760 Feeder Management Relays® are microprocessor-based units intended for the management and primary protection of distribution feeders, as well as for the management and backup protection of buses, transformers, and transmission lines. The 760 relay is particularly suited to overhead feeders, where automatic reclosing is normally applied.

Each relay provides protection, control, and monitoring functions with both local and remote human interfaces. They also display the present trip/alarm conditions, and most of the more than 35 measured system parameters. Recording of past trip, alarm or control events, maximum demand levels, and energy consumption is also performed.

These relays contain many innovative features. To meet diverse utility standards and industry requirements, these features have the flexibility to be programmed to meet specific user needs. This flexibility will naturally make a piece of equipment difficult to learn. To aid new users in getting basic protection operating quickly, setpoints are set to typical default values and advanced features are disabled. These settings can be reprogrammed at any time.

Programming can be accomplished with the front panel keys and display. Due to the numerous settings, this manual method can be somewhat laborious. To simplify programming and to provide a more intuitive interface, programming can be accomplished with a personal computer running the 750/760 PC program provided with each relay. Even with minimal computer knowledge, this menu-driven program provides easy access to all front panel functions. Actual values can be displayed and setpoints can be displayed, altered, stored, and printed. If settings are stored in a setpoint file, they can be downloaded at any time to the front panel program port of the relay via a computer cable connected to the serial port of any personal computer.

A summary of the available functions is contained in the following list, and a one-line diagram of the most important protection and control features follows. For a complete understanding of each features operation, refer to the Chapter 7: SETPOINTS of this manual. The logic diagrams include a reference to every setpoint related to a feature and show all logic signals passed between individual features. Information related to the selection of settings for each setpoint is also provided.

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PROTECTION

- Two Phase Time Overcurrent Elements with Voltage Restraint
- Two Phase Instantaneous Overcurrent Elements
- Two Neutral Time Overcurrent Elements
- Two Neutral Instantaneous Overcurrent Elements
- Ground Time and Instantaneous Overcurrent
- Sensitive Ground Time and Instantaneous Overcurrent
- Negative Sequence Time and Instantaneous Overcurrent
- Phase, Neutral, Ground, Sensitive Ground, and Negative Sequence Directional Control
- Negative Sequence Voltage
- Neutral Displacement
- Two Bus Undervoltage Elements
- Two Line Undervoltage Elements
- Two Overvoltage Elements
- Two Underfrequency Elements
- Frequency Decay
- Breaker Failure with Current Supervision

INPUTS

- 5 - AC Currents
- 4 - AC Voltages
- 20 Programmable Logic Inputs
  (14 contact and / or virtual)
  (6 virtual)
- 1 Analog Input

OUTPUTS

- 8 Electro-Mechanical Relays
- 1 Solid-State Trip
- 8 Analog Transducers

MONITORING

- Phase and Neutral Current Level
- Power Factor
  (Two Independent Stages)
- Fault Locator
- Demand
  (I_a, I_b, I_c, MW, Mvar, MVA)
- Analog Input
  (Two Threshold Stages)
  (Two Rate Stages)
- Overfrequency
- Trip Counter Limit
- Total Breaker Arcing Current
  (Per Phase)
- Breaker Operation Failure
- Trip and Close Coil Monitors
- VT Failure
- Pulsed Output

METERING

- Average Current
- Phase, Neutral, Ground, and Sensitive Ground Current Phasors
- Average Line and Phase Voltage
- Line and Phase Voltage Phasors
- Symmetrical Component Phasors
  (Current and Voltage)
- Frequency Magnitude and Rate
- Synchronizing Voltage Phasor
- Synchronizing Voltage Frequency
- Synchronizing $\Delta\Phi$, ΔkV, ΔHz
- Single and Three Phase Power
  (MW, Mvar, MVA, PF)
- Energy
  (MWh, Mvarh)
- Last and Maximum Demand
  (I_a, I_b, I_c, MW, Mvar, MVA)
- Analog Input Magnitude
- Analog Input Rate
  (per minute, per hour)

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COMMUNICATIONS

- Front Panel RS232 Serial Port
- Two Rear Terminal Serial Ports
  (COM1 - RS485 or RS422)
  (COM2 - RS485 Only)
- Modbus or DNP 3.0 Protocol

CONTROL

- Four Protection Setpoint Groups
- Synchrocheck
  (With Dead-Source Bypassing)
- Manual Close Blocking
- Cold Load Pickup Blocking
- Automatic Restoration after Undervoltage Tripping
- Automatic Restoration after Underfrequency Tripping
- Transfer
- Automatic Reclosing (760 Only)
  (Up To 4 Shots)
  (With Protection Modification and Current Supervision and Zone Coordination)
- Breaker Open & Close

OTHER

- Data Logger (8 Channels)
- Event Recorder (128 Events)
- Waveform Capture
  (16 Samples Per Cycle)
- Real Time Clock
- IRIG-B Time Synchronization

USER INTERFACE

- 40 Character Vacuum Fluorescent Display
- LED Indicators On Faceplate
- Clear English Language Messages
- Context-Sensitive Help Messages
- Intuitive Message Structure
- Full Numeric Keypad
- Faceplate Breaker Control Keys
- Access Security
  (Keyswitch and Passcode)
- Prefault, Fault and Postfault Simulation
- Product Firmware in Flash Memory
  (Upgrades via RS232 Port)

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1

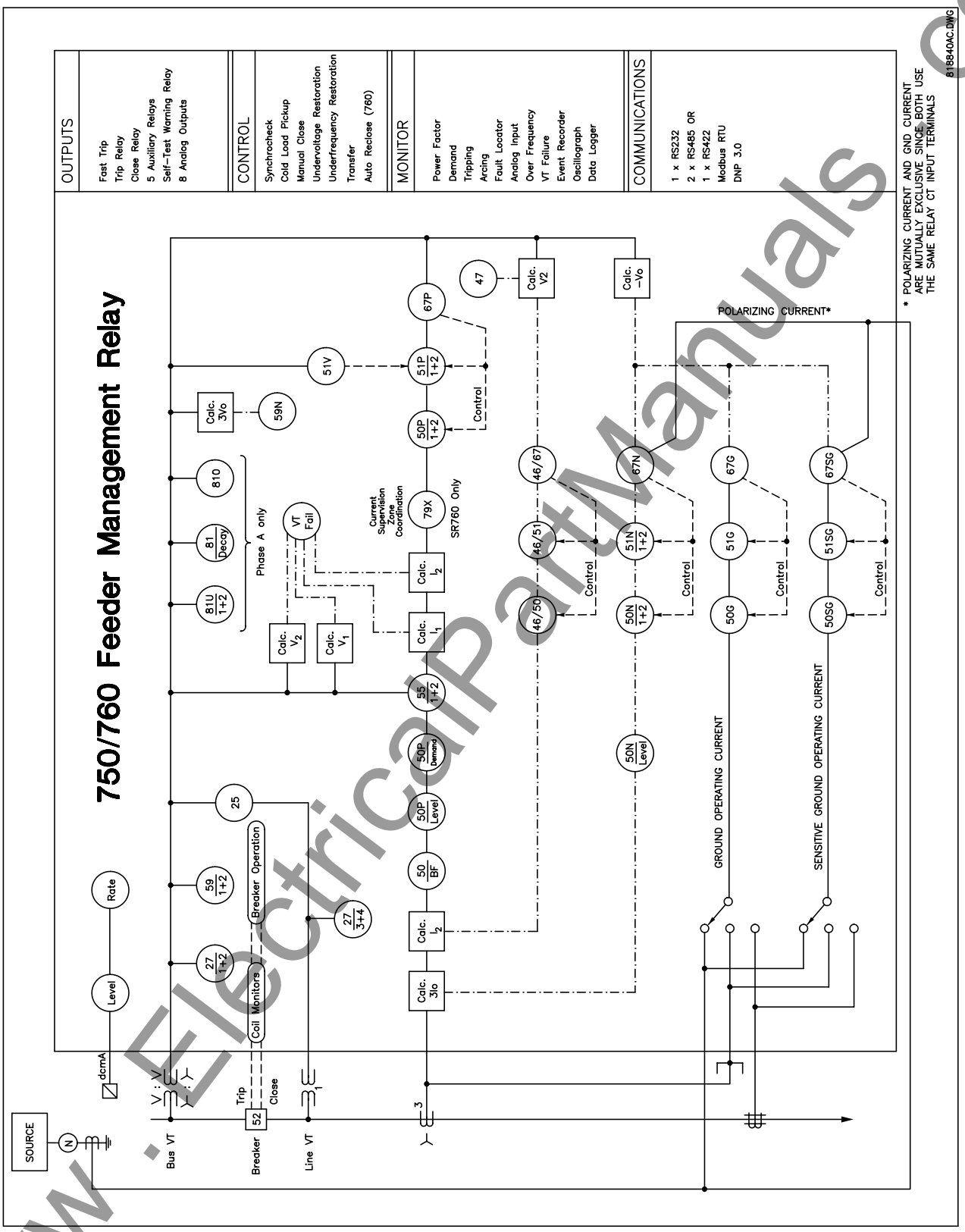


Figure 1–1: PROTECTION ONE LINE DIAGRAM

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1.1.3 USING THIS MANUAL

Reading a lengthy instruction manual on a new product is not a task most people enjoy. To speed things up, Chapter 2: GETTING STARTED provides a step-by-step tutorial for a simple feeder application. Important wiring considerations and precautions discussed in Chapter 3: INSTALLATION should be observed for reliable operation. Detailed information regarding accuracy, output relay contact ratings, and so forth are detailed in Section 1.2: TECHNICAL SPECIFICATIONS of this chapter. The remainder of this manual should be read and kept for reference to ensure maximum benefit from the 750 and 760. For further information, please consult your local sales representative or the factory. Comments about new features or modifications for your specific requirements are welcome.

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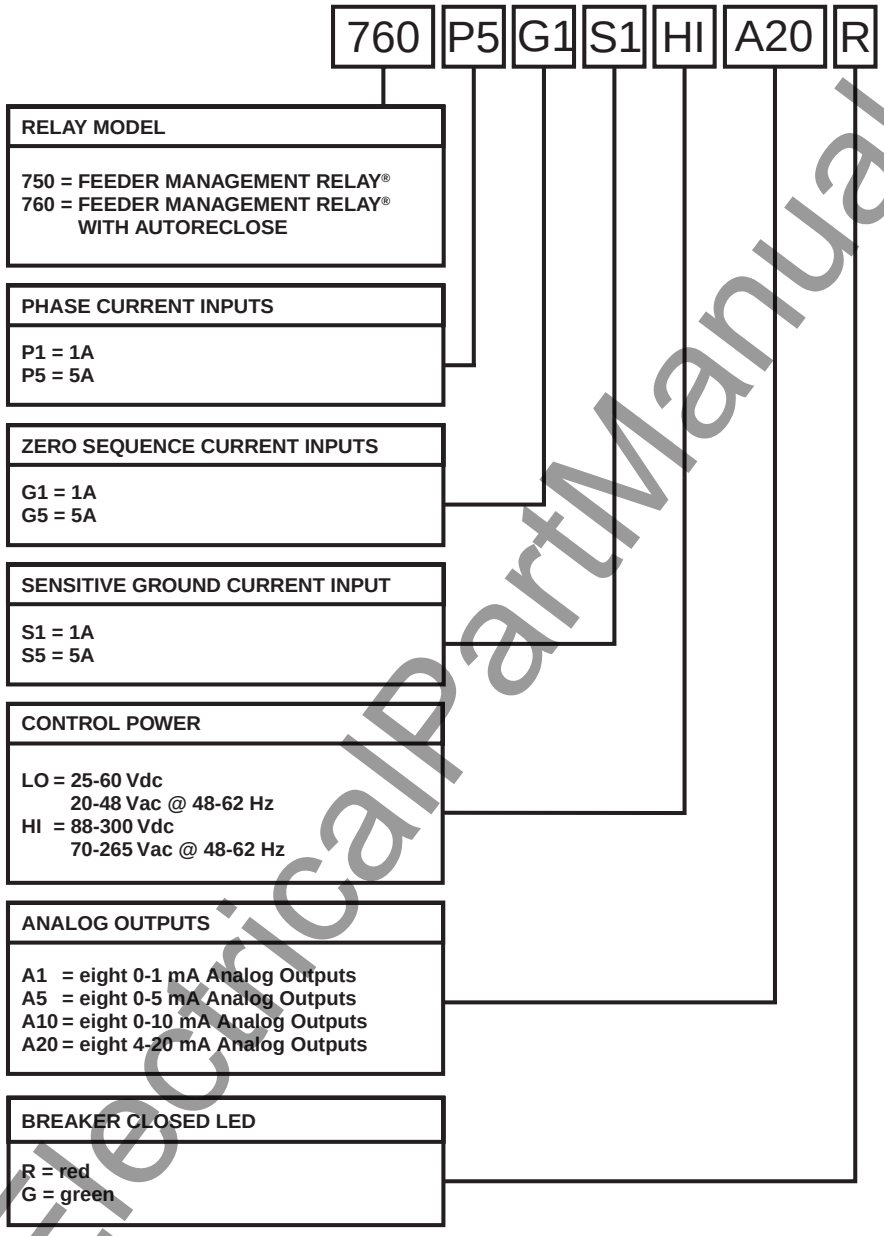
1.1.4 SHIPPING CONTENTS

- 750 Feeder Management Relay® or 760 Feeder Management Relay® with autoreclosure.
- 750/760 Instruction Manual with Warranty Card.
- 750/760 PC program and Firmware on CD, Service Sticker, and GE Power Management Screwdriver.

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1.1.5 ORDER CODE

The relay model number will be indicated on the side of the drawout unit. This identification label can be interpreted with the following order code.



OTHER ACCESSORIES

DEMO:	Metal carry case in which 750/760 unit may be mounted.
SR 19-1 PANEL:	Single cutout 19" panel.
SR 19-2 PANEL:	Dual cutout 19" panel.
RS-232/485:	RS232 to RS485 converter box for harsh industrial environments.
5A PHASE CT:	50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 600, 750,1000.
1A PHASE CT:	50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 600, 750,1000.
SR 1 3/8" COLLAR:	For shallow switchgear, reduces the depth of the relay by 1 3/8".
SR 3" COLLAR:	For shallow switchgear, reduces the depth of the relay by 3".

760ORDER.CDR

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1.2.1 APPLICABILITY

Systems: 3 or 4 wire, 600 kV maximum, 5000 Amp maximum

Frequency: 25 to 60 Hz nominal (frequency tracking allows operation from 16-65 Hz)

1.2.2 INPUTS

CONTROL POWER

Options: LO/HI (specified when ordering)

LO Range: DC = 20 to 60 V
AC = 20 to 48 V @ 48 to 62 Hz.

HI Range: DC = 88 to 300 V
AC = 70 to 265 V @ 48 to 62 Hz.

Power: 25 VA nominal, 35 VA maximum

Voltage Loss Hold-Up Time: 30 ms

PHASE CURRENT INPUT

Source CT: 1 to 50000 A primary,
1 or 5 A secondary

Relay Input: 1 A or 5 A (specified when ordering)

Burden: Less than 0.2 VA at 1 or 5 A

Conversion Range: 0.01 to 20 x CT
(fundamental frequency only)

Accuracy: at < 2 x CT: ± 0.5% of 2 x CT
at ≥ 2 x CT: ± 1% of 20 x CT

Overload Withstand: 1 second @ 80 times rated current
continuous @ 3 times rated current

Calculated Neutral Current Errors: 3 x phase inputs

GROUND CURRENT INPUT

Source CT: 1 to 50000 A primary,
1 or 5 A secondary

Relay Input: 1 A or 5 A (specified when ordering)

Burden: Less than 0.2 VA at 1 or 5 A

Conversion Range: 0.01 to 20 x CT
(fundamental frequency only)

Accuracy: at < 2 x CT: ± 0.5% of 2 x CT
at ≥ 2 x CT: ± 1% of 20 x CT

Overload Withstand: 1 second @ 80 times rated current
continuous @ 3 times rated current

SENSITIVE GROUND CURRENT INPUT

Source CT: 1 to 50000 A primary,
1 or 5 A secondary

Relay Input: 1 A or 5 A (specified when ordering)

Burden: Less than 0.2 VA at 1 or 5 A

Conversion Range: Low End: 0.005 x CT
Maximum: 500 A primary
(fundamental frequency only)

Accuracy: at < 0.1 x CT: ± 0.2% of 1 x CT
at ≥ 0.1 x CT: ± 1% of 1 x CT

Overload Withstand: 1 second @ 80 times rated current
continuous @ 3 times rated current

BUS AND LINE VOLTAGE INPUTS

Source VT: 0.12 to 600 kV / 50 to 240 V

Source VT Ratio: 1 to 5000 in steps of 0.1

Relay Input: 50 V to 240 V phase-neutral

Burden: Less than 0.025 VA at 120 V
or > 576 KΩ

Max. Continuous: 273 V phase-neutral (Full Scale) CT
(fundamental frequency only)

Accuracy (0°-40°C): ± 0.25% of full scale (10 to 130 V);
± 0.8% of full scale (130 to 273 V)

(for open delta, the calculated phase has errors 2 times those shown above)

LOGIC INPUTS

Inputs: 14 contact and / or virtual,
6 virtual only (Functions assigned to logic inputs)

Dry Contacts: 1000 Ω maximum ON resistance
(32 V DC @ 2 mA provided by relay)

Wet Contacts: 30 to 300 V DC @ 2.0 mA
(External DC voltage only)

ANALOG INPUT

Current Input: 0-1 mA, 0-5 mA, 0-10 mA, 0-20 mA,
or 4-20 mA (programmable)

Input Impedance: 375 Ω ± 10%

Conversion Range: 0 to 21 mA

Accuracy: ± 1% of full scale

TRIP AND CLOSE COIL MONITORING INPUTS

Acceptable Voltage Range: 20 to 250 V DC

Trickle Current: 2 mA to 5 mA

IRIG-B INPUT

Amplitude-Modulated: 2.5 to 6 Vp-p @ 3:1 signal ratio

DC Shift: TTL

Input Impedance: 20 kΩ ±10%

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(Accuracies based on less than 2 x CT and 50 to 130 V inputs)

* Full Scale = 2 x CT @ 1 x VT Full Scale x √3

GENERAL

The harmonic components of current and voltage are removed from the input voltage and current parameters, so all relay measurements based on these quantities respond to the fundamental component only. To minimize errors, the A/D process utilizes a sampling rate that is automatically adjusted to be 16 samples per power frequency cycle when a measurable voltage is available. To prevent overreaching of overcurrent elements, a digital filter removes the transient DC component of currents.

CURRENT

Phase A RMS Current Phasor

Phase B RMS Current Phasor

Phase C RMS Current Phasor

% of Load-To-Trip

Accuracy: ± 0.5% of full scale

VOLTAGE

A–N (A–B) RMS Voltage Phasor

B–N (B–C) RMS Voltage Phasor

C–N (C–A) RMS Voltage Phasor

Accuracy: ± 0.25% of full scale

FREQUENCY

A-N (A-B) Bus & Line Voltage

Range: 16 to 90 Hz

Accuracy: ± 0.02 Hz

SYMMETRICAL COMPONENTS

Current Level Accuracy: ± 1.5% of full scale

Voltage Level Accuracy: ± 0.75% of full scale

Current & Voltage

Angle Accuracy: ± 2°

3Φ POWER FACTOR

Range: 0.00 Lag to 1.00 to 0.00 Lead

Accuracy: ± 0.02

3Φ REAL POWER

Range: –3000.0 to 3000.0 MW

Accuracy: ± 1% of full scale

3Φ REACTIVE POWER

Range: –3000.0 to 3000.0 Mvar

Accuracy: ± 1% of full scale *

3Φ APPARENT POWER

Range: –3000.0 to 3000.0 MVA

Accuracy: ± 1% of full scale *

WATT-HOURS

Range: -2.1×10^8 to 2.1×10^8 MWh

Accuracy: ± 2% of full scale * per hour

VAR-HOURS

Range: -2.1×10^8 to 2.1×10^8 MVar

Accuracy: ± 2% of full scale * per hour

DEMAND

Phase A/B/C Current

Range: 0 to 65535 A

3Φ Real Power

Range: –3000.0 to 3000.0 MW

3Φ Reactive Power

Range: –3000.0 to 3000.0 Mvar

3Φ Apparent Power

Range: –3000.0 to 3000.0 MVA

Measurement Type: Thermal Exponential, 90% response time (programmed): 5, 10, 15, 20, 30, or 60 min.
Block Interval / Rolling Demand, time interval (programmed): 5, 10, 15, 20, 30, or 60 min.

Accuracy: ± 2% of full scale *

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PHASE / NEUTRAL / GROUND / NEGATIVE SEQUENCE TIME OVERCURRENT PROTECTION

Pickup Level:	0.05 to 20.00 in steps of 0.01 x CT
Dropout Level:	97 to 98% of Pickup
Curve Shape:	ANSI Extremely/Very/Moderately/ Normally Inverse
	Definite Time (0.1 s base curve)
	IEC Curve A/B/C and Short
	FlexCurve™ A/B (programmable curves)
	IAC Extreme/Very/Inverse/Short
Curve Multiplier:	0.00 to 100.00 in steps of 0.01
Reset Type:	Instantaneous/Linear
Level Accuracy:	Per current input (I_2 is 3 x input error)
Timing Accuracy:	at ≥ 1.03 x PU: ± 3% of trip time or ± 20 ms (whichever is greater)

SENSITIVE GROUND TIME OVERCURRENT PROTECTION

Pickup Level:	0.005 to 1.000 in steps of 0.001 x CT
Dropout Level:	97 to 98% of Pickup
Curve Shape:	ANSI Extremely/Very/Moderately/ Normally Inverse
	Definite Time (0.1 s base curve)
	IEC Curve A/B/C and Short
	FlexCurve™ A/B (programmable curves)
	IAC Extreme/Very/Inverse/Short
Curve Multiplier:	0.00 to 100.00 in steps of 0.01
Reset Type:	Instantaneous/Linear
Level Accuracy:	Per current input (I_2 is 3 x input error)
Timing Accuracy:	at ≥ 1.03 x PU: ± 3% of trip time or ± 20 ms (whichever is greater)

PHASE TIME OVERCURRENT VOLTAGE RESTRAINT

Pickup Adjustment:	Modifies pickup from 0.10 to 0.90 x VT nominal in a fixed line relationship

PHASE / NEUTRAL / GROUND / NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT PROTECTION

Pickup Level:	0.05 to 20.00 in steps of 0.01 x CT
Dropout Level:	97 to 98% of Pickup
Time Delay:	0.00 to 600.00 in steps of 0.01s
Level Accuracy:	Per phase / neutral / ground current input (I_2 is 3 x phase input error)
Timing Accuracy:	at 0 ms time delay (no intentional delay): relay contacts = 50 ms max; solid state output = 45 ms max
	at non-zero time delay: delay accuracy = 0 to +20 ms
Phases:	Any One/Any Two/All Three (programmable) phases have to operate for output (Not for I_2)

SENSITIVE GROUND INSTANTANEOUS OVERCURRENT PROTECTION

Pickup Level:	0.005 to 1.000 in steps of 0.001 x CT
Dropout Level:	97 to 98% of Pickup
Time Delay:	0.00 to 600.00 in steps of 0.01s
Level Accuracy:	Per phase / neutral / ground current input (I_2 is 3 x phase input error)
Timing Accuracy:	at 0 ms time delay (no intentional delay): relay contacts = 50 ms max; solid state output = 45 ms max
	at non-zero time delay: delay accuracy = 0 to +20 ms
Phases:	Any One/Any Two/All Three (programmable) phases have to operate for output (Not for I_2)

PHASE DIRECTIONAL CONTROL

Relay Connection:	90° (quadrature)
Polarizing Voltage:	Phase A: Vbc Phase B: Vca Phase C: Vab
MTA:	0 to 359° in steps of 1°
Angle Accuracy:	± 2°
Operation Delay:	25 to 40 ms

NEUTRAL DIRECTIONAL CONTROL

Polarized by voltage, current or both voltage and current (For voltage element polarizing, the source VTs must be connected in Wye).

Polarizing Voltage:	–Vo
Polarizing Current:	Ig
MTA:	0 to 359° in steps of 1°
Angle Accuracy:	± 2°
Operation Delay:	25 to 40 ms

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GROUND / SENSITIVE GROUND DIRECTIONAL CONTROL

Polarized by voltage, current or both voltage and current (For voltage element polarizing, the source VTs must be connected in Wye).

Polarizing Voltage:	-Vo
Polarizing Current:	Ig
MTA:	0 to 359° in steps of 1°
Angle Accuracy:	± 2°
Operation Delay:	25 to 40 ms

BUS UNDERVOLTAGE 1 / 2 AND LINE UNDERVOLTAGE 3 / 4

Minimum Voltage:	> programmable threshold from 0.00 to 1.25 x VT in steps of 0.01
Pickup Level:	0.00 to 1.25 in steps of 0.01 x VT
Dropout Level:	102 to 103% of Pickup
Curve:	definite time or inverse time
Time Delay:	0.0 to 6000.0 in steps of 0.1 s
Phases:	Any One/Any Two/All Three (programmed) to operate for output (bus undervoltage only)
Level Accuracy:	Per voltage input
Timing Accuracy:	± 100 ms

OVERVOLTAGE 1 / 2

Pickup Level:	0.00 to 1.25 in steps of 0.01 x VT
Dropout Level:	97 to 98% of Pickup
Time Delay:	0.0 to 6000.0 in steps of 0.1 s (definite time)
Phases:	Any One/Any Two/All Three (programmable) phases have to operate for output
Level Accuracy:	Per voltage input
Timing Accuracy:	± 100 ms

NEGATIVE SEQUENCE VOLTAGE

Pickup Level:	0.00 to 1.25 in steps of 0.01 x VT
Dropout Level:	97 to 98% of Pickup
Time Delay:	0.0 to 6000.0 in steps of 0.1 (definite or inverse time)
Level Accuracy:	3 x voltage input error
Timing Accuracy:	± 100 ms

UNDERFREQUENCY 1 / 2

Minimum Voltage:	0.00 to 1.25 in steps of 0.01 x VT in Phase A
Pickup Level:	20.00 to 65.00 in steps of 0.01 Hz
Dropout Level:	Pickup + 0.03 Hz
Time Delay:	0.00 to 600.00 in steps of 0.01 s (definite time)
Level Accuracy:	± 0.02 Hz
Timing Accuracy:	at 60 Hz: ± 25 ms at 50 Hz: ± 30 ms

BREAKER FAILURE

Pickup Level:	0.05 to 20.0 x CT in steps of 0.01
Dropout Level:	97 to 98% of Pickup
Time Delay:	0.03 to 1.00 s in steps of 10
Timing Accuracy:	± 20 ms error
Level Accuracy:	per CT input

NEUTRAL DISPLACEMENT

Pickup Level:	0.00 to 1.25 in steps of 0.01 x VT
Dropout Level:	97 to 98% of Pickup
Curve Shape:	ANSI Extremely/Very/Moderately/Normally Inverse Definite Time (0.1 s base curve) IEC Curve A/B/C and Short FlexCurve™ A/B (programmable curves) IAC Extreme/Very/Inverse/Short
Curve Multiplier:	0.00 to 100.00 in steps of 0.01
Reset Type:	Instantaneous/Linear
Level Accuracy:	3 x voltage input error
Timing Accuracy:	±50 ms

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PHASE / NEUTRAL CURRENT

Pickup Level:	0.05 to 20.00 in steps of 0.01 x CT
Dropout Level:	97 to 98% of Pickup
Time Delay:	0 to 60000 in steps of 1 s (definite time)
Level Accuracy:	Per current input
Timing Accuracy:	± 100 ms

POWER FACTOR 1 / 2

Required Voltage:	> 30% of nominal in all phases
Pickup Level:	0.50 Lag to 0.50 Lead in steps of 0.01
Dropout Level:	0.50 Lag to 0.50 Lead in steps of 0.01
Time Delay:	0 to 60 000 in steps of 1 s (definite time)
Level Accuracy:	± 0.02
Timing Accuracy:	± 100 ms

ANALOG IN THRESHOLD 1 / 2

Pickup Level:	0 to 65535 in steps of 1 unit
Dropout Level:	Programmable from 2 to 20% of Pickup (under or over)
Time Delay:	0 to 60000 in steps of 1 s
Level Accuracy:	± 1%
Timing Accuracy:	± 100 ms

ANALOG IN RATE 1 / 2

Pickup Level:	–1000 to 1000 µA/hr. in steps of 0.1
Dropout Level:	97 to 98% of Pickup
Time Delay:	0 to 60000.0 in steps of 1 s
Level Accuracy:	± 1%
Timing Accuracy:	± 100 ms

OVERFREQUENCY

Required Voltage:	> 30% of nominal in phase A
Pickup Level:	20.01 to 65.00 in steps of 0.01 Hz
Dropout Level:	Pickup - 0.03 Hz
Time Delay:	0.0 to 6000.0 in steps of 0.1 s
Level Accuracy:	± 0.02 Hz
Timing Accuracy:	at 60 Hz: ± 34 ms at 50 Hz: ± 40 ms

FAULT LOCATOR

Range:	–327.68 to 327.66 km/miles 0 to 65534 Ohms
Memory:	stores the 10 most recent faults

DEMAND

(accuracies based on less than 2 x CT and 50 to 130 V inputs)

Measured Values:	Phase A/B/C Current (A) 3Φ Real Power (MW) 3Φ Reactive Power (Mvar) 3Φ Apparent Power (MVA)
Measurement Type:	Thermal Exponential, 90% response time (programmed): 5, 10, 15, 20, 30, or 60 min. Block Interval / Rolling Demand, time interval (programmed): 5, 10, 15, 20, 30, or 60 min. Block Interval with Start Demand Interval Logic Input pulses
A Pickup Level:	10 to 10000 in steps of 1
MW Pickup Level:	0.1 to 3000.0 in steps of 0.1
Mvar Pickup Level:	0.1 to 3000.0 in steps of 0.1
MVA Pickup Level:	0.1 to 3000.0 in steps of 0.1
Level Accuracy:	± 2%

VT FAILURE

Programmable to inhibit dependent features.

BREAKER FAILURE TO OPERATE

Time Delay:	30 to 1000 ms in steps of 10
Timing Accuracy:	0 to +20 ms error

ACCUMULATED ARCING CURRENT

Pickup Level:	1 to 50 000 kA^2-seconds in steps of 1
Start Delay:	0 to 100 ms in steps of 1

TRIP / CLOSE COIL MONITORS

Detect open trip and close circuits.

PULSE OUTPUT

Pulse output is 1 second on time and one second off time after the programmed interval.

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SYNCHROCHECK

Voltage Difference: 0.01 to 100.00 kV in steps of 0.01

Phase Difference: 0 to 100° in steps of 2°

Frequency Difference: 0.00 to 5.00 Hz in steps of 0.02

Bypass Permissives: DB & DL (Dead Bus and Dead Line)
LL & DB (Live Line and Dead Bus)
DL & LB (Dead Line and Live Bus)
DL | DB (Dead Line or Dead Bus)
DL X DB (Dead Line or Dead Bus, but not both)

FOUR SETPOINT GROUPS

Can be changed from logic input or communications

Include protection features: Time O/C Curves, Phase O/C, Neutral O/C, Ground O/C, Negative Sequence O/C & Voltage, Phase Directional Control, Ground Directional Control, Over & Undervoltage, Underfrequency and Breaker Failure

UNDERVOLTAGE RESTORATION

Initiated By: Trip from Undervoltage 1, 2, 3 or 4

Minimum Voltage Level: 0.00 to 1.25 x VT in steps of 0.01

Time Delay: 0.1 to 100.0 in steps of 0.1 s

Incomplete Sequence Time: 1 to 10000 in steps of 1 min.

Phases: Any One/Any Two/All Three (programmable) phases have to operate for output

Level Accuracy: Per voltage input

Timing Accuracy: ± 100 ms

UNDERFREQUENCY RESTORATION

Initiated By: Trip from Underfrequency 1 or 2

Minimum Voltage Level: 0.00 to 1.25 x VT in steps of 0.01

Minimum Frequency Level: 20.00 to 60.00 in steps of 0.01 Hz.

Time Delay: 0.1 to 100.0 in steps of 0.1 s

Incomplete Sequence Time: 1 to 10000 in steps of 1 min.

Level Accuracy: Per voltage and frequency input

Timing Accuracy: ± 100 ms

MANUAL CLOSE FEATURE BLOCKING

Set to operate by a manual close command.

Programmable to block instantaneous overcurrent elements for a selectable period.

Programmable to raise pickup of time overcurrent elements for a selectable period.

COLD LOAD PICKUP FEATURE BLOCKING

Set to operate automatically or by a logic input command.

Programmable to block instantaneous overcurrent elements for a selectable period.

Programmable to raise pickup of time overcurrent elements for a selectable period.

TRANSFER SCHEME

Used for double-bus system with two normally-closed incoming and one normally-open bus tie circuit breaker.

Provides automatic closing of the bus tie breaker after a loss of one source, with bus decayed voltage permissive.

Provides trip of a pre-selected breaker after the third breaker is manually closed (prevent-parallel operation).

AUTORECLOSE (760 ONLY)

Up to four reclose attempts before lockout.

Each reclose shot can block instantaneous overcurrent, and raise pickup of time overcurrent elements.

Current supervision can adjust the maximum number of shots to be attempted.

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IRIG-B TIME SYNCHRONIZATION

Error: ± 1.0 millisecond

LAST TRIP DATA

Records cause of most recent trip, 4 RMS currents, and 3 RMS voltages with a 1 ms time stamp.

TRIP COUNTERS

Accumulates all ground, sensitive ground, neutral, negative sequence, and phase overcurrent trips.

EVENT RECORDER (128 EVENTS)

Records event cause, 3 phase current phasors, 1 ground current phasor, sensitive ground current phasors, 3 voltage phasors, system frequency, synchronizing voltage, synchronizing frequency, and analog input level with a 1 ms time stamp.

WAVEFORM CAPTURE

Data Channels:	4 currents, 3 voltages, 14 logic input states and 8 output relays
Sample Rate:	16 per cycle
Trigger Source:	Element pickup/trip/dropout, control/alarm event, logic input or manual command
Trigger Position:	0 to 100%
Storage capacity:	2 to 16 events with 2048 to 256 samples of data respectively

DATA LOGGER

Data Channels:	8 channels; same parameters as for analog outputs available
Sample Rate:	Per Cycle / Per second / Per Minute / Every 5,10,15, 20, 30, or 60 min.
Trigger Source:	Pickup/trip/dropout, control/alarm event, logic input, manual command, or continuous
Trigger Position:	0 to 100%
Storage capacity:	2 to 16 events with 2048 to 256 samples of data respectively (4096 if continuous)

SIMULATION

Programmable prefault, fault, and postfault parameters. Simulation of circuit breaker and selection of whether or not to operate outputs relays.

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1.2.8 OUTPUTS

ANALOG OUTPUTS

Type: Active

Outputs: 8 Channels; specify one of the following output ranges when ordering:

Output Range	Maximum Load
0-1 mA:	12 kΩ
0-5 mA:	2.4 kΩ
0-10 mA:	1.2 kΩ
4-20 mA:	600 Ω

Isolation: Fully isolated

Accuracy: ± 1% of full scale

Response Time: 100% indication in less than 6 power system cycles (100 ms @ 60 Hz)

SOLID STATE TRIP

Make and Carry 15 A @ 250 V DC for 500 ms

OUTPUT RELAYS

Configuration: 1 TRIP: Form A
2 CLOSE: Form A
3-7 AUXILIARY: Form C
8 SELF-TEST WARNING: Form C

Contact Material: silver alloy

Contact Ratings:

1 TRIP / 2 CLOSE:

Make: 30 A (per ANSI/IEEE C37.90)

Carry: 20 A continuous

Break: DC 300 W resistive
DC 150 W inductive (L/R = 40 ms)
AC 5000 VA resistive
AC 5000 VA inductive (PF = 0.4)

3-7 AUXILIARY / 8 SELF-TEST WARNING

Make: 30 A (per ANSI/IEEE C37.90)

Carry: 5 A continuous

Break: DC 150 W resistive
DC 90 W inductive (L/R = 40 ms)
AC 1250 VA resistive
AC 500 VA inductive (PF = 0.4)

Contact Durability: 100 000 operations (at 1800 operations/hour) at Rated Load

1.2.9 COMMUNICATIONS

ALL PORTS

300-19200 baud, programmable parity, Modbus RTU or DNP 3.0 protocol

EEPROM

100000 program/erase cycles max.

1.2.10 CLOCK

Resolution: 1 ms

Accuracy with IRIG-B: ± 1 ms

Accuracy without IRIG-B: ± 1 minute/month

Backup Battery Life: 10 years continuous use

1.2.11 PHYSICAL SPECIFICATIONS

ENVIRONMENT

Operating Temperature Range: –40 °C to +60 °C

Ambient Storage Temperature: –40 °C to +80 °C

Ambient Shipping Temperature: -40 °C to +80 °C

Humidity: up to 90% noncondensing

Pollution Degree: 2

IP Rating: 40-X

CASE

Fully drawout unit (automatic CT shorts)

Meets CE drawout specifications

Seal provision

Dust tight door

Panel or 19" rack mount

Weight (Case and Relay): 7.9 kg

Shipping Weight: 9.4 kg

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1.2.12 TESTING

TYPE WITHSTAND TESTS

Fast Transient:	Per ANSI/IEEE C37.90.1 and IEC 801.4 (Level 4) (5 kV @ 5x50 ns, Ri = 50 Ω)
Insulation Resistance:	Per IEC 255-5 (500 Vdc, 2000 MΩ)
Dielectric Strength:	Per IEC 255-5 and ANSI/IEEE C37.90 (2 kV @ 60 Hz for 1 minute)
Surge Withstand Capability:	Per IEC 255-22-1 and 255-4 Class 3 (fast transient common mode 2.5 kV, differential modes 1 kV)
	Per IEC 255-4 and ANSI/IEEE C37.90.1 (2.5 kV @ 1 MHz, 400/sec. for 2 sec., Ri = 200Ω)
Electrostatic Discharge:	Per IEC 801.2 Class 4 (15 kV, 150 pF, 150 Ω)
Impulse Voltage:	Per IEC 255-5 0.5 Joule 5kV
	(5 kV @ 1.2 x 50 µs, 0.5 J, Ri = 500 Ω common and differential modes)
Current Withstand:	Per ANSI/IEEE C37.90 (40 x rated Amp for 2 sec., 80 x Ir for 1 sec.)
RFI:	Per Ontario Hydro
	(150 & 450 MHz, 5 W transmitter@25 cm and 50 MHz, 15 W mobile transmitter@25 cm)
EMI:	Per ANSI/IEEE C37.90.2 Electromagnetic Interference @ 150 MHz and 450 MHz, 10V/m
Static:	Per IEC 801-2 Static Discharge
Stress Vibration:	Per IEC 68-2-6 and IEC 255-21-1

PRODUCTION TESTS

Thermal Cycling:	Operational test at ambient, reducing to -40 °C and then increasing to 60 °C
Dielectric Strength:	On CT inputs, VT inputs, Control Power inputs, Switch inputs, Coil Supervision outputs, and Relay outputs (2 kVac for 1 minute) to Safety Ground.

1.2.13 APPROVALS

UL
Recognized under E83849

CSA
Approved under LR 41286-56

CE
Conforms to IEC 947-1, IEC 1010-1

ISO
Manufactured to an ISO9001 registered program.

Specifications subject to change without notice.

It is recommended that all relays must be powered up at least once per year to avoid deterioration of electrolytic capacitors and subsequent relay failure.

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1.3.1 DESCRIPTION

Relay functions are controlled by two processors. A Motorola 68332 32-bit microprocessor measures all analog signals and logic inputs, outputs all analog signals, and controls all output relays. An Intel 80C186 16-bit microprocessor reads all user input including communications, and outputs to the faceplate display and LEDs. The processors pass information to each other via an RS485 serial communications channel. Consult Figure 1–3: HARDWARE BLOCK DIAGRAM on page 1–18 for the role of each processor. The remainder of this section describes the algorithms and operations that are critical to protection elements.

1.3.2 CURRENT AND VOLTAGE WAVEFORM CAPTURE

Current transformers (CTs) and voltage transformers (VTs) are used to scale-down the incoming current and voltage signals from the source instrument transformers. Both current and voltage signals are then passed through a 400 Hz low pass anti-aliasing filter. All signals are then simultaneously captured by sample and hold buffers to ensure there are no phase shifts. The signals are then converted to digital values by a 12 bit A/D converter before finally being passed on to the 68332 CPU for analysis.

Both current and voltage are sampled sixteen times per power frequency cycle with frequency tracking control. These 'raw' samples are calibrated in software and then placed into the waveform capture buffer thus emulating a fault recorder. The waveforms can be retrieved from the relay via the 750/760 PC Program for display and diagnostics.

1.3.3 FREQUENCY TRACKING

Frequency measurement is done by measuring the time between zero crossings of the 'BUS VT A' and 'LINE VT' voltage inputs. Both signals are passed through a 72 Hz low pass filter to prevent false zero crossings. Frequency readings are discarded if the rate of change between two successive cycles is greater than 10 Hz/s. This prevents momentary false frequency readings due to noise, phase reversals, or faults.

Frequency tracking utilizes the measured frequency to set the sampling rate for current and voltage which results in better accuracy for the FFT algorithm for off-nominal frequencies. Also, sampling is synchronized to the Va-x voltage zero crossing which results in better co-ordination for multiple 750/760 relays on the same bus. If a stable frequency signal is not available then the sampling rate defaults to the nominal system frequency.

1.3.4 PHASORS, TRANSIENTS, AND HARMONICS

Current waveforms are processed once every cycle with a DC Offset Filter and a Fast Fourier Transform (FFT) to yield phasors at the fundamental power system frequency. The resulting phasors have fault current transients and all harmonics removed. This results in an overcurrent relay that is extremely secure and reliable and one that will not overreach. The following diagram illustrates the signal processing performed on the AC current inputs:

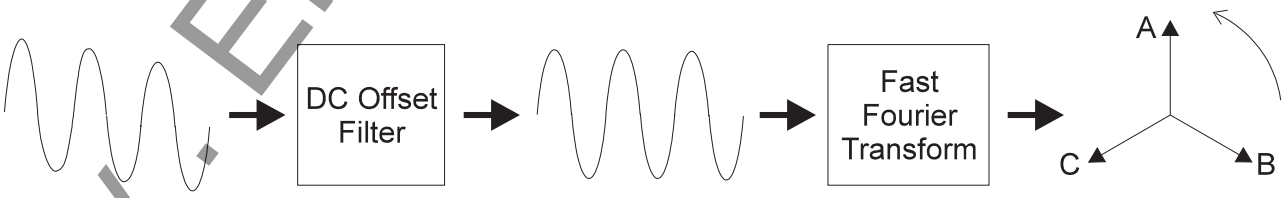


Figure 1–2: SIGNAL PROCESSING OF AC CURRENT INPUTS

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The DC Offset Filter is an infinite impulse response (IIR) digital filter which removes the DC component from the asymmetrical current present at the moment a fault occurs. This is done for all current signals used for overcurrent protection; voltage signals bypass the DC Offset Filter. The filter results in no overreach of the overcurrent protection; unfortunately, the filter also causes slower overcurrent response times (0 to 50 ms) for faults marginally over the pickup level.

The Fast Fourier Transform (FFT) uses exactly one cycle of samples to calculate a phasor quantity which represents the signal at the fundamental frequency only; all harmonic components are removed. Further explanation of the FFT is beyond the scope of this document but can be found in any text on signal analysis. All subsequent calculations (e.g. RMS, power, demand, etc.) are based upon the current and voltage phasors so the resulting values do not have any harmonic components either.

1.3.5 PROTECTION ELEMENTS

All protection elements are processed once every cycle to determine if a pickup has occurred or a timer has expired. The protection elements use RMS current/voltage based on the magnitude of the phasor; hence, protection is impervious to both harmonics and DC transients. Timing is not affected by system frequency.

1.3.6 LOGIC INPUTS

Contact inputs are debounced to eliminate false operations due to noise. The inputs must be in the same state for three consecutive readings spaced evenly over one power frequency cycle before a new state is recognized.

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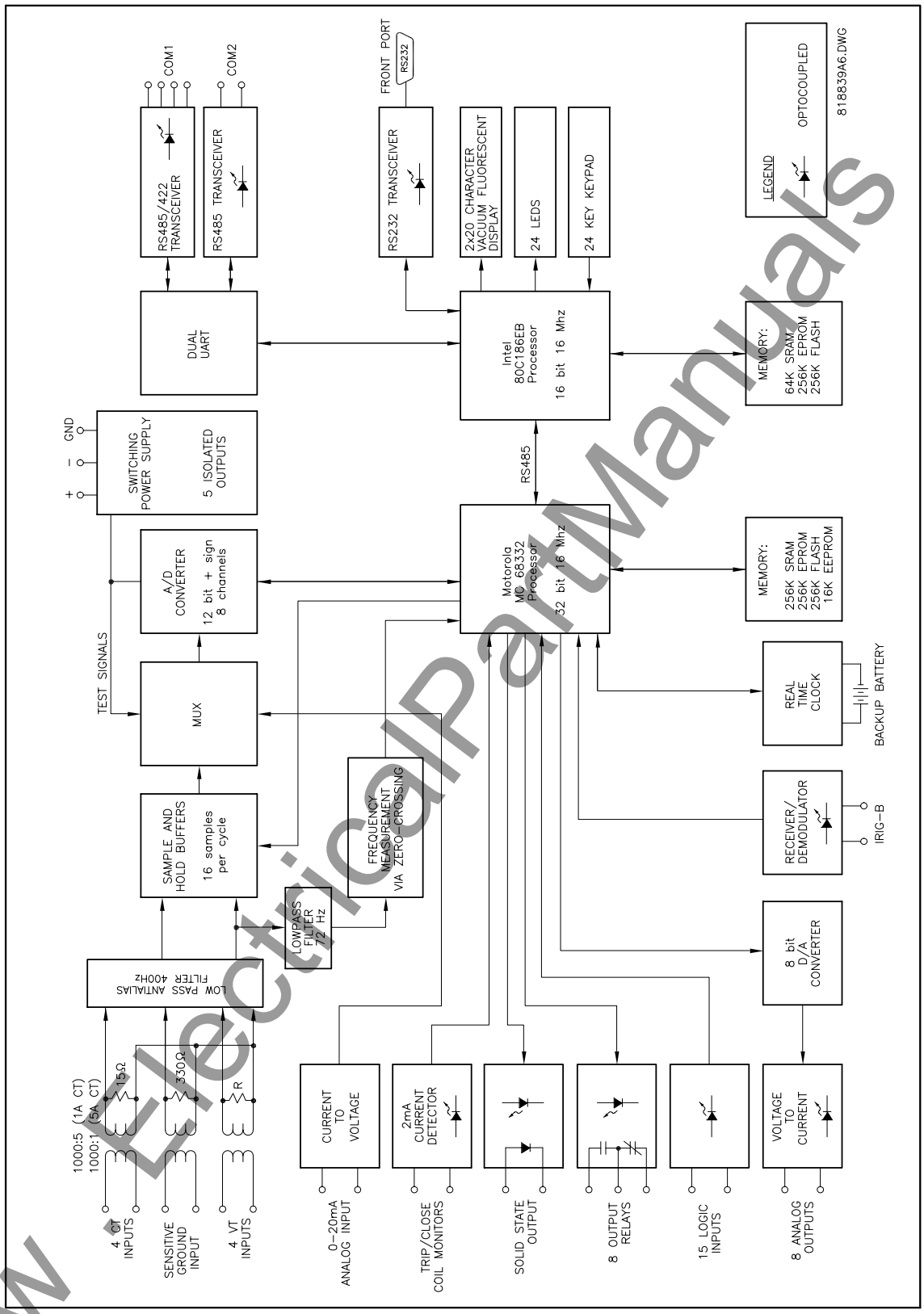


Figure 1–3: HARDWARE BLOCK DIAGRAM

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2.1.1 DESCRIPTION

The relay has five types of display messages: actual value, setpoint, diagnostic, flash, and help. Actual values are values that are measured by the relay such as current and voltage. Setpoints are programmable settings entered by the user. These types of messages are located within a menu structure that groups the information into categories. Navigating the menu structure is described below. A summary of the menu structure for actual values and setpoints can be found in Sections 6.1: OVERVIEW on page 6–1 and 7.1: OVERVIEW on page 7–1, respectively.



Press the ACTUAL key to display the header for the first actual values page. The actual values pages are numbered, have an 'A' prefix for easy identification and have a name which gives a general idea of the information available in that page. Repeatedly pressing the ACTUAL key will scroll through all the available actual values page headers.



Press the SETPOINT key to display the header for the first setpoints page. The setpoint pages are numbered, have an 'S' prefix for easy identification and have a name which gives a general idea of the settings available in that page. Repeatedly pressing the SETPOINT key will scroll through all the available setpoint page headers.



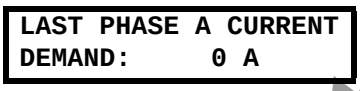
Press the ACTUAL key until the page **A2 METERING** appears. Now press the MESSAGE ▼ key and the first sub-page heading for page 2 of actual values appears. Pressing the MESSAGE ▼ and MESSAGE ▲ keys will scroll the display up and down through the sub-page headers.



Press the MESSAGE ▼ key until the **DEMAND** sub-page heading appears. Press ENTER to display the messages in this sub-page.



Note that all heading messages have the ■ symbol preceding them and that only some sub-pages have a subsequent second sub-page.



Press the ENTER key to display the actual values of this second sub-page. Actual values messages and setpoints always have a colon separating the name of the value and the actual value or setpoint. This particular message displays the last phase A current demand as measured by the relay. The menu path to this particular message is referred to as **A2 METERING \ DEMAND \ PHASE A CURRENT \ LAST PHASE A CURRENT DEMAND**. Messages are referred to in this manner throughout the manual.



Press the MESSAGE ▼ key and the next actual value display message will appear. Pressing the MESSAGE ▲ and MESSAGE ▼ keys will scroll the display up and down through all the actual value displays in this second sub-page.



Pressing the ESCAPE key reverses the process described above and returns the display to the previous level. Press the ESCAPE key twice to return to the **A2 METERING \ DEMAND** sub-page header.

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The following figure gives a specific example of how to use the Front Panel keys to navigate through the menu structure. Specific locations are referred to throughout this manual by using a path. The example shown in the figure gives the key presses required to reach the point given by the path **A3 MAINTENANCE \ ARCING CURRENT \ TOTAL ARCING CURRENT ØB**.

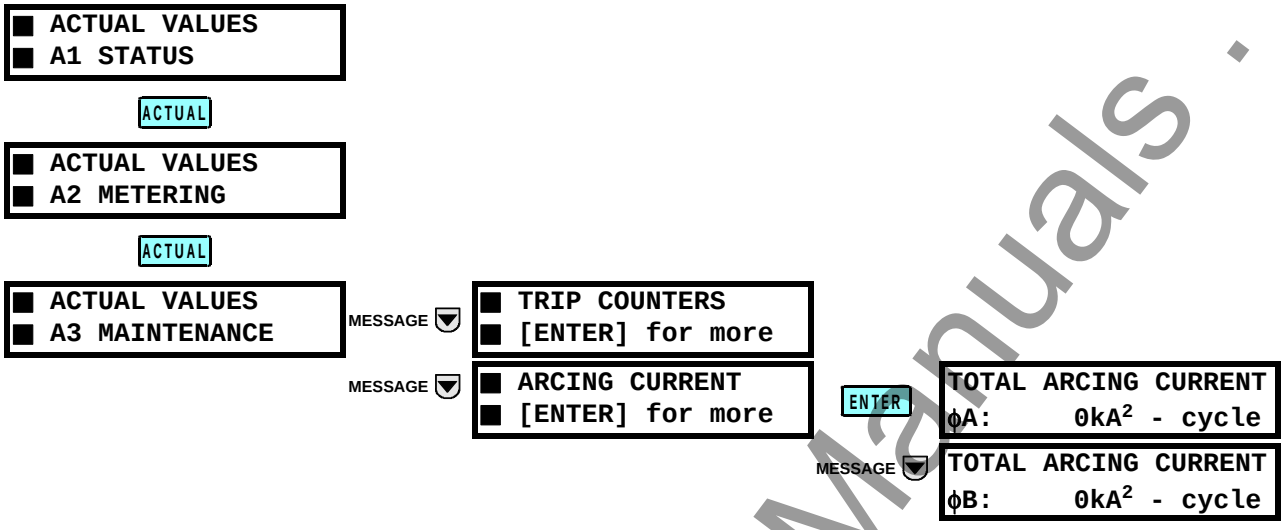


Figure 2–1: PANEL KEYING EXAMPLE

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2.2.1 DESCRIPTION

There are several different classes of setpoints, each distinguished by the way their values are displayed and edited. Now that we have become more familiar with maneuvering through messages, we can learn how to edit the values used by all setpoint classes.

2.2.2 INSTALLING THE SETPOINT ACCESS JUMPER

Hardware and passcode security features are designed to provide protection against unauthorized setpoint changes. Since we will be programming new setpoints using the front panel keys, a hardware jumper must be installed across the setpoint access terminals (C10 and C11) on the back of the relay case. Attempts to enter a new setpoint without this electrical connection will result in an error message.

2.2.3 HELP KEY

Pressing the HELP key will display context sensitive information about setpoints such as the range of values and the method of changing the setpoint. Help messages will automatically scroll through all messages currently appropriate.

2.2.4 NUMERICAL SETPOINTS

Each numerical setpoint has its own minimum, maximum, and step value associated with it. These parameters define what is acceptable for the setpoint. Two methods of editing and storing a numerical setpoint value are available.

The 750/760 numeric keypad works the same as any electronic calculator. A number is entered one digit at a time with the 0 to 9 and decimal keys. The leftmost digit is entered first and the rightmost digit is entered last. Pressing the ESCAPE key before the ENTER key returns the original value to the display.

The VALUE ▲ key increments the displayed value by the step value, up to a maximum allowed and then wraps around to the minimum value. The VALUE ▼ key decrements the displayed value by the step value, down to a minimum value and then wraps around to the maximum value.

```
NOMINAL VT SECONDARY
VOLTAGE: 120.0 V
```

Move to message **S2 SYSTEM SETUP \ BUS VT SENSING \ NOMINAL VT SECONDARY VOLTAGE**.

```
NOMINAL VT SECONDARY
VOLTAGE:  63.9 V
```

Press the 6, 6, decimal, and 3 keys. The display message will change as shown.

```
■ NEW SETPOINT
■ HAS BEEN STORED
```

Until the ENTER key is pressed, editing changes are not registered by the relay. Therefore, press the ENTER key to store the new value in memory. This flash message will momentarily appear as confirmation of the storing process. If 69.28 were entered, it would be automatically rounded to 69.3

2.2.5 ENUMERATION SETPOINTS

Enumeration setpoints have data values which are part of a set whose members are explicitly defined by a name. A set is comprised of two or more members. Enumeration values are changed using the VALUE ▲ and VALUE ▼ keys.

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VT CONNECTION TYPE Wye	Move to message **S2 SYSTEM SETUP \ BUS VT SENSING \ VT CONNECTION TYPE.**
VT CONNECTION TYPE Delta	Press the VALUE ▲ key until the *Delta* selection is displayed as shown.
■ NEW SETPOINT ■ HAS BEEN STORED	Press the ENTER key to store this change into memory. As before, confirmation of this action will momentarily flash on the display.

2.2.6 OUTPUT RELAY SETPOINTS

Each output relay setpoint has the 3 to 7 AUXILIARY output relays associated with it. Each can be toggled on or off individually, so that any combination of relays can be activated upon detection of the initiating condition. Output relay configuration type values are changed by using the 3 to 7 keys. Each key toggles the display between the corresponding number and a hyphen.

PHASE TIME O/C 1 RELAYS (3-7): -----	Move to message **S5 PROTECTION \ PHASE CURRENT \ PHASE TIME O/C 1 \ PHASE TIME O/C 1 RELAYS (3-7):**.
PHASE TIME O/C 1 RELAYS (3-7): 3----	If an application requires the **PHASE TIME O/C 1** protection element to operate output relay 3 AUXILIARY, select this output relay by pressing the 3 key.
■ NEW SETPOINT ■ HAS BEEN STORED	Press the ENTER key to store this change into memory. As before, confirmation of this action will momentarily flash on the display.

2.2.7 TEXT SETPOINTS

Text setpoints have data values which are fixed in length, but user defined in character. They may be comprised of upper case letters, lower case letters, numerals, and a selection of special characters. The editing and storing of a text value is accomplished with the use of the ENTER, VALUE ▼, VALUE ▲, and ESCAPE keys.

USER INPUT A NAME: User Input A	Move to message **S3 LOGIC INPUTS \ USER INPUT A \ USER INPUT A NAME:**. The name of this user defined input is going to be changed in this section.
USER INPUT A NAME: ■ser Input A	If an application is to be using the relay as a substation monitor, it is more informative to rename this input 'Substation Monitor'. Press the ENTER key and a solid cursor (■) will appear in the first character position.
USER INPUT A NAME: Substation Monitor	Press the VALUE ▼ or VALUE ▲ key until the character 'S' is displayed in the first position. Now press the ENTER key to store the character and advance the cursor to the next position. Change the second character to a 'u' in the same manner. Continue entering characters in this way until all characters in *Substation Monitor* are entered. Note that a space is selected like a character. If a character is entered incorrectly, press the ENTER key repeatedly until the cursor returns to the position of the error. Re-enter the character as required. Once complete, press the ESCAPE key to remove the solid cursor and view the result.

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2.3.1 APPLICATION EXAMPLE

The 750 and 760 relays contain many features designed to accommodate a wide range of applications. This chapter is provided to guide you, the first time user, through a real-world application. The following step-by-step installation example, provides you with a quick and convenient way of becoming familiar with the relay. To start, simply power on the unit, and follow the instructions in this tutorial. The example assumes the following system characteristics. It also assumes that relay setpoints are unaltered from their factory default values.

POWER SYSTEM DATA

System:	3Φ, 4 wire
Frequency:	60 Hz
Line Voltage:	13.8 kV
Maximum Current:	600 A

CONTROL SYSTEM REQUIREMENTS

All protection elements used are to trip the breaker.

Breaker position monitoring via 52b contact only.

Only current metering is required.

Contact Inputs:	remote open and close contacts from RTU. remote/local selection from panel hand switch. reset from RTU. alarm after 100 s delay from substation monitor
Contact Outputs:	trip and close to breaker control circuit *(trip and close relays)* relay failure alarm to RTU *(self-test warning relay, no programming required)* alarm contact to RTU *(setup in User Function for "Substation Monitor")*

No data communications to other equipment.

INSTRUMENT TRANSFORMER DATA

Bus VTs:	3 x Wye connected, ratio (14.4 kV:120 V)
Phase CTs:	3 x Wye connected, ratio 600:5 Amp

PHASE PROTECTION SETTINGS

Time O/C 1:	curve shape = Moderately Inverse pickup = 840 A multiplier = 20.2
Instantaneous O/C 1:	pickup = 840 A phases required = Any Two delay = 0 s
Instantaneous O/C 2:	pickup = 10100 A phases required = Any Two delay = 0 s

NEUTRAL PROTECTION SETTINGS

Time O/C 1:	curve shape = Moderately Inverse pickup = 120 A multiplier = 10
Instantaneous O/C 1:	pickup = 120 A delay = 0 s
Instantaneous O/C 2:	pickup = 2000 A delay = 0 s

You should now be familiar with maneuvering through and editing setpoint messages. As such, we will now limit our discussion to just the values that must be programmed, in order to meet the requirements of the example application. Any setpoints not explicitly mentioned should be left at the factory default value.

2.3.2 S2 SYSTEM SETPOINTS

The S2 setpoints page contains setpoints for entering the characteristics of the equipment on the feeder electrical system. In our example, these characteristics are specified under **POWER SYSTEM DATA** and **INSTRUMENT TRANSFORMER DATA**. From this information and the resulting calculations, program S2 setpoints as indicated.

a) CURRENT TRANSFORMERS

S2 SYSTEM SETUP \ CURRENT SENSING \ PHASE CT PRIMARY: *600 A*

b) VOLTAGE TRANSFORMERS

**S2 SYSTEM SETUP \ BUS VT SENSING **

VT CONNECTION TYPE:	*Wye*	
NOMINAL VT SECONDARY VOLTAGE:	*66.4 V*	(13.8kV ø- ø ≡ 7.97kV ø-N; 7.97kV / 120 = 66.4V s)
VT RATIO:	*120:1*	(14.4KV VTpri / 120V VTsec)

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c) POWER SYSTEM

S2 SYSTEM SETUP \ POWER SYSTEM \ NOMINAL FREQUENCY: *60 Hz*

2.3.3 S3 LOGIC INPUTS SETPOINTS

S3, the third setpoints page, contains setpoints for entering the characteristics of the logic inputs. In our example, these characteristics are specified under the Control System Requirements heading. Program S3 setpoints as indicated.

a) BREAKER POSITION MONITORING

**S3 LOGIC INPUTS \ LOGIC INPUTS SETUP **

INPUT 2 NAME:	*Brkr Position (52b)*
INPUT 2 ASSERTED LOGIC:	*Contact Close*

S3 LOGIC INPUTS \ BREAKER FUNCTIONS \ 52b CONTACT: *Input 2*

b) REMOTE OPEN/CLOSE AND RESET RTU CONTACTS

**S3 LOGIC INPUTS \ LOGIC INPUTS SETUP **

INPUT 3 NAME:	*Local Mode*
INPUT 3 ASSERTED LOGIC:	*Contact Close*
INPUT 4 NAME:	*Remote Open*
INPUT 4 ASSERTED LOGIC:	*Contact Close*
INPUT 5 NAME:	*Remote Close*
INPUT 5 ASSERTED LOGIC:	*Contact Close*
INPUT 6 NAME:	*Reset*
INPUT 6 ASSERTED LOGIC:	*Contact Close*

**S3 LOGIC INPUTS \ CONTROL FUNCTIONS **

LOCAL MODE:	*Input 3*
RESET:	*Input 6*
REMOTE OPEN:	*Input 4*
REMOTE CLOSE:	*Input 5*

c) ALARM-AFTER-DELAY INPUT

**S3 LOGIC INPUTS \ USER INPUT A **

USER INPUT A NAME:	*Substation Monitor*
USER INPUT A SOURCE:	*Input 1*
USER INPUT A FUNCTION:	*Alarm*
USER INPUT A RELAYS (3-7):	*3----*
USER INPUT A DELAY:	*100.00 s*

2.3.4 S5 PROTECTION SETPOINTS

S5 PROTECTION, the fifth setpoints page, contains setpoints for entering the characteristics of the protection elements. In our example, these characteristics are specified under **PHASE PROTECTION SETTINGS** and **NEUTRAL PROTECTION SETTINGS**. From this data and the resulting calculations, program S5 setpoints as indicated.

a) PHASE TIME O/C 1

**S5 PROTECTION \ PHASE CURRENT \ PHASE TIME OC 1 **

PHASE TIME OC 1 FUNCTION:	*Trip*	
PHASE TIME OC 1 PICKUP:	*1.40 x CT*	(840A pickup / 600A CT pri)

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PHASE TIME OC 1 CURVE:	*Mod Inverse*
PHASE TIME OC 1 MULTIPLIER:	*20.20*
PHASE TIME OC 1 RESET:	*Instantaneous*

b) PHASE INSTANTANEOUS O/C 1

**S5 PROTECTION \ PHASE CURRENT \ PHASE INST OC 1 **

PHASE INST OC 1 FUNCTION:	*Trip*	
PHASE INST OC 1 PICKUP:	*1.40 x CT*	(840A pickup / 600A CT pri)
PHASE INST OC 1 DELAY:	*0.00 s*	
PHASES REQUIRED FOR OPERATION:	*Any Two*	

c) PHASE INSTANTANEOUS O/C 2

**S5 PROTECTION \ PHASE CURRENT \ PHASE INST OC 2 **

PHASE INST OC 2 FUNCTION:	*Trip*	
PHASE INST OC 2 PICKUP:	*16.83 x CT*	(10100A pickup / 600 A pri)
PHASE INST OC 2 DELAY:	*0.00 s*	
PHASES REQUIRED FOR OPERATION:	*Any Two*	

d) NEUTRAL TIME O/C 1

**S5 PROTECTION \ NEUTRAL CURRENT \ NEUTRAL TIME OC 1 **

NEUTRAL TIME OC 1 FUNCTION:	*Trip*	
NEUTRAL TIME OC 1 PICKUP:	*0.20 x CT*	(120A pickup / 600A pri)
NEUTRAL TIME OC 1 CURVE:	*Mod Inverse*	
NEUTRAL TIME OC 1 MULTIPLIER:	*10.00*	
NEUTRAL TIME OC 1 RESET:	*Instantaneous*	

e) NEUTRAL INSTANTANEOUS O/C 1

**S5 PROTECTION \ NEUTRAL CURRENT \ NEUTRAL INST OC 1 **

NEUTRAL INST OC 1 FUNCTION:	*Trip*	
NEUTRAL INST OC 1 PICKUP:	*0.20 x CT*	(120A pickup / 600A pri)
NEUTRAL INST OC 1 DELAY:	*0.00 s*	

f) NEUTRAL INSTANTANEOUS O/C 2

**S5 PROTECTION \ NEUTRAL CURRENT \ NEUTRAL INST OC 2 **

NEUTRAL INST OC 2 FUNCTION:	*Trip*	
NEUTRAL INST OC 2 PICKUP:	*3.33 x CT*	(2000A pickup / 600A pri)
NEUTRAL INST OC 2 DELAY:	*0.00 s*	

g) GROUND TIME OVERCURRENT

S5 PROTECTION \ GROUND CURRENT \ GROUND TIME OC \ GROUND TIME O/C FUNCTION: *Disabled*

h) GROUND INSTANTANEOUS OVERCURRENT

S5 PROTECTION \ GROUND CURRENT \ GROUND INST OC \ GROUND INST O/C FUNCTION: *Disabled*

i) NEGATIVE SEQUENCE TIME OVERCURRENT

S5 PROTECTION \ NEGATIVE SEQUENCE \ NEG SEQ TIME OC \ NEG SEQ TIME OC FUNCTION:*Disabled*

j) NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT

S5 PROTECTION \ NEGATIVE SEQUENCE \ NEG SEQ INST OC \ NEG SEQ INST O/C FUNCTION:*Disabled*

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2.4.1 DESCRIPTION

Now that programming for the sample application is complete, the relay should be put in the *Ready* state. Note that the relay is defaulted to the *Not Ready* state before it leaves the factory. This minor self-test warning, diagnostic message, warns that the 750/760 has not been programmed for its intended application. If this warning is ignored, protection is active and will be using factory default setpoints. The RELAY IN SERVICE indicator will be on.

■ **SELF-TEST WARNING:** ■ **Relay Not Ready**

This diagnostic message indicates that the relay is in the *Not Ready* state.

760 OPERATION **Not Ready**

Move to the message **S1 RELAY SETUP \ INSTALLATION \ 760 OPERATION**. To put the relay in the *Ready* state, press the VALUE ▲ key until the *Ready* message is displayed and press ENTER. Enter *Yes* for the "Are You Sure?" prompt. The front panel RELAY IN SERVICE indicator will now turn on and the *Relay Not Ready* diagnostic message will disappear.

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3.1.1 DESCRIPTION

The 750/760 is packaged in the standard SR series arrangement which consists of a drawout relay and a companion case. The case provides mechanical protection for the drawout portion and is used to make permanent electrical connections to external equipment. Where required, case connectors are fitted with mechanisms, such as automatic CT shorting, to allow the safe removal of the relay from an energized panel. There are no electronic components in the case.

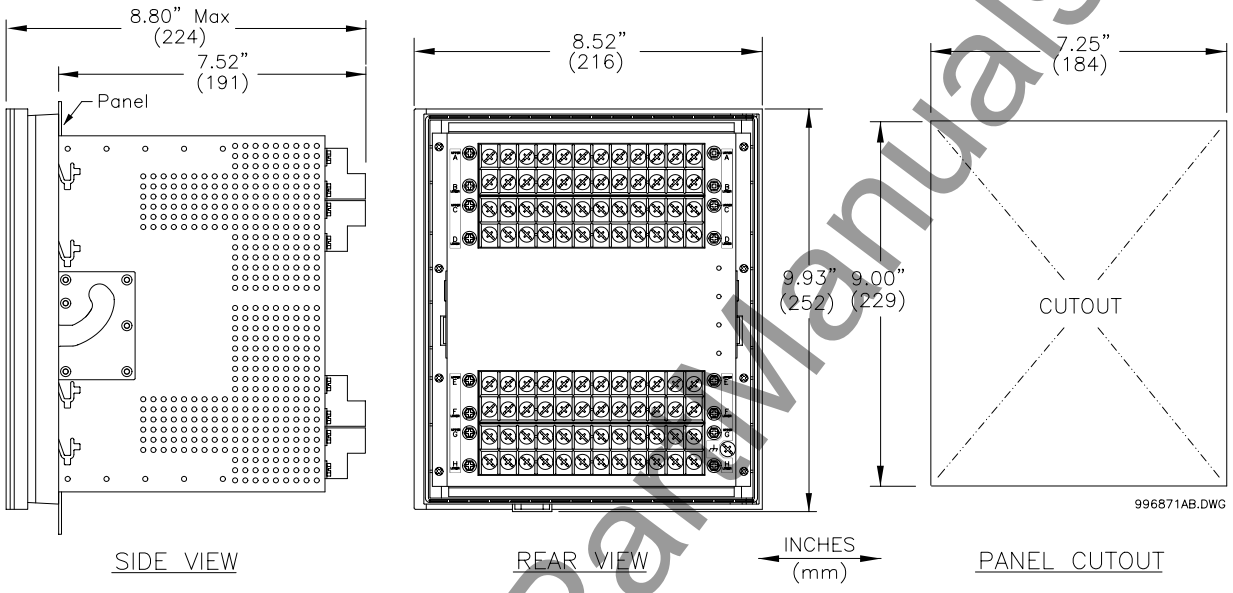


Figure 3–1: CASE DIMENSIONS

To prevent unauthorized removal of the drawout relay, a wire lead seal can be installed through the slot provided in the middle of the locking latch. With this seal in place, the relay cannot be removed from the case. Even though a passcode or setpoint access jumper can be used to prevent entry of setpoints and still allow monitoring of actual values, access to the front panel controls may still need to be restricted. As such, a separate seal can be installed on the outside of the door to prevent it from being opened.



Figure 3–2: DRAWOUT CASE SEAL

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3.1.2 CASE INSTALLATION

An 750 or 760 can be mounted alone or adjacent to another SR series unit on a standard 19" rack panel. Panel cutout dimensions for both conditions shown below. When planning the location of your panel cutout, ensure provision is made for the front door to swing open without interference to or from adjacent equipment.

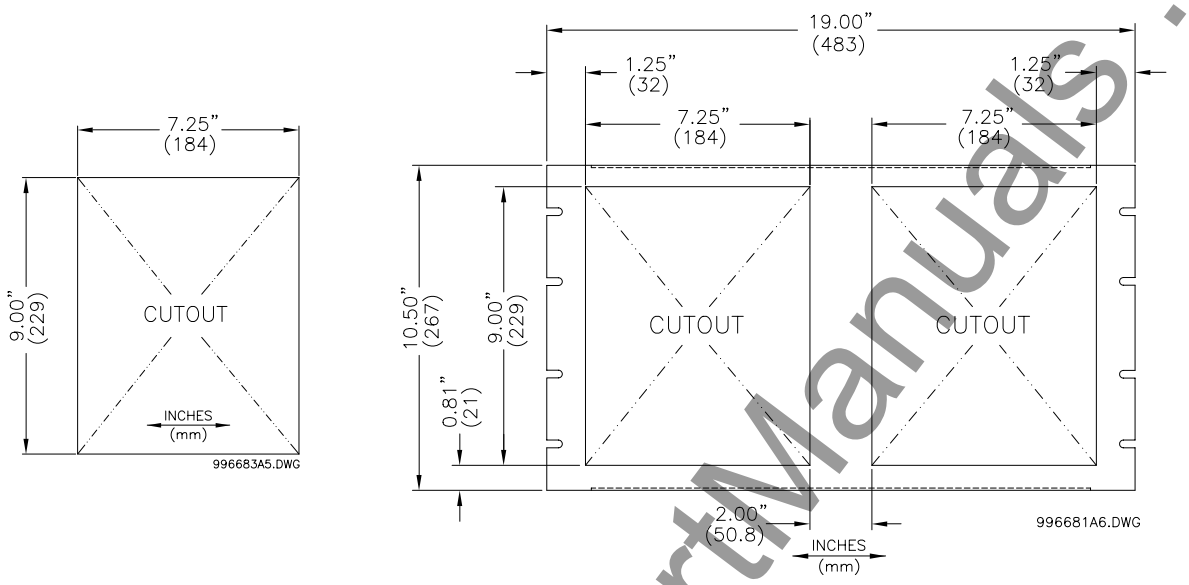


Figure 3–3: SINGLE AND DOUBLE UNIT PANEL CUTOUTS

Before mounting the SR unit in the supporting panel, remove the unit from the case. From the front of the panel, slide the empty case into the cutout. To ensure the case's front bezel sits flush with the panel, apply pressure to the bezel's front while bending the retaining tabs 90 degrees. These tabs are located on the sides and bottom of the case and appear as shown in the illustration. After bending all tabs, the case will be securely mounted so that its relay can be inserted. The SR unit is now ready for panel wiring.

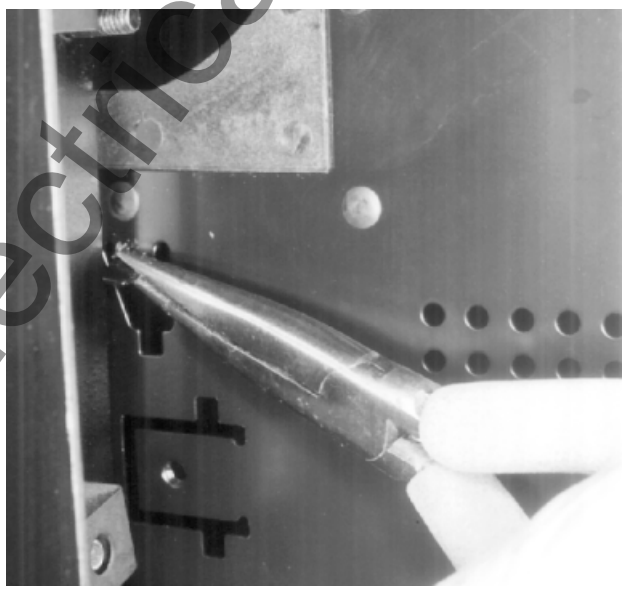


Figure 3–4: CASE MOUNTING TABS

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CAUTION

TURN OFF CONTROL POWER BEFORE DRAWING OUT OR RE-INSERTING THE RELAY TO PREVENT MALOPERATION!

CAUTION

If an attempt is made to install a relay into a non-matching case, the case's configuration pin will prevent full insertion. Applying a strong force in this instance will result in damage to the relay and case.

To remove the unit from the case:

1. Open the door by pulling from the top or bottom of its right side. It will rotate to the left about its hinges.
2. Press upward on the locking latch, which is located below the handle, and hold in its raised position. The tip of a small screwdriver may prove helpful in this operation.



Figure 3–5: PRESS LATCH UP AND PULL HANDLE

3. With the latch raised, pull the center of the handle outward. Once disengaged, continue rotating the handle up to the stop position.

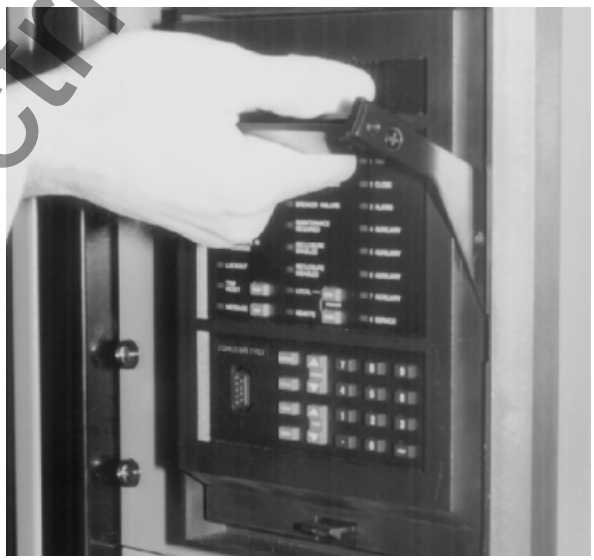


Figure 3–6: ROTATING HANDLE TO STOP POSITION

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4. When the stop position is reached, the locking mechanism will release. The relay will now slide out of the case when pulled from its handle. To free the relay, it may sometimes be necessary to adjust the handle position slightly.



Figure 3–7: SLIDING THE UNIT OUT OF THE CASE

To insert the unit into the case:

1. Ensure that the model number on the left side of the relay matches the requirements of the installation.
2. Raise the locking handle to the highest position.
3. Hold the unit immediately in front of the case and align the rolling guide pins (near the hinges of the relay's handle) with the case's guide slots.
4. Slide the unit into the case until the guide pins on the unit have engaged the guide slots on either side of the case.
5. Once fully inserted, grasp the handle from its center and rotate it down from the raised position towards the bottom of the relay.
6. Once the unit is fully inserted the latch will be heard to click, locking the handle in the final position. The unit is mechanically held in the case by the handle's rolling pins, which cannot be fully lowered to the locked position until the electrical connections are completely mated.

NOTE

No special ventilation requirements need to be observed during the installation of the unit.

NOTE

The unit does not require cleaning.

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3.2.1 DESCRIPTION

Due to the many features built into the 750 and 760 relays, a broad range of applications are available to the user. As such, it is not possible to present typical connections for all possible schemes. The information in this section will cover the important aspects of interconnections, in the general areas of instrument transformer inputs, other inputs, outputs, communications and grounding. Figure 3–8: REAR TERMINAL LAYOUT below shows the rear terminal layout of the 750/760.

WARNING

Relay contacts must be considered unsafe to touch when system is energized!! If the customer requires the relay contacts for low voltage accessible applications, it is their responsibility to ensure proper insulation levels!

WARNING

HAZARD may result if the product is not used for its intended purposes.

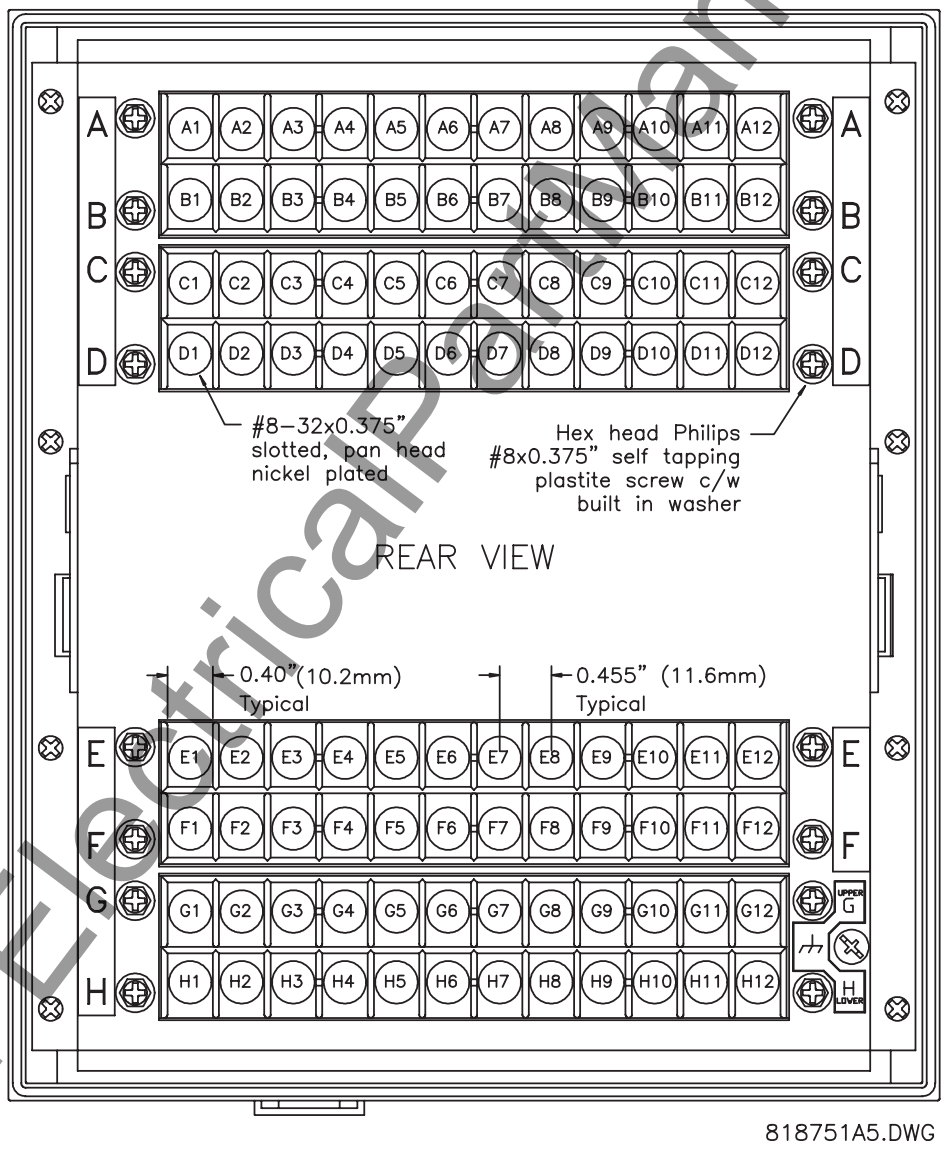


Figure 3–8: REAR TERMINAL LAYOUT

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3.2.2 REAR TERMINAL ASSIGNMENTS

ANALOG INPUT / OUTPUTS		OUTPUT RELAYS	
A1	ANALOG INPUT +	E1	SOLID STATE TRIP OUT +
A2	ANALOG INPUT -	E2	1 TRIP RELAY NO
A3	SHIELD (GROUND)	E3	2 CLOSE RELAY NO
A4	ANALOG OUTPUT -	E4	3 AUXILIARY RELAY NO
A5	ANALOG OUTPUT 1 +	E5	3 AUXILIARY RELAY NC
A6	ANALOG OUTPUT 2 +	E6	4 AUXILIARY RELAY NC
A7	ANALOG OUTPUT 3 +	E7	5 AUXILIARY RELAY NC
A8	ANALOG OUTPUT 4 +	E8	5 AUXILIARY RELAY NO
A9	ANALOG OUTPUT 5 +	E9	6 AUXILIARY RELAY NC
A10	ANALOG OUTPUT 6 +	E10	7 AUXILIARY RELAY NC
A11	ANALOG OUTPUT 7 +	E11	7 AUXILIARY RELAY NO
A12	ANALOG OUTPUT 8 +	E12	8 SELF-TEST WARNING RELAY NC
COMMUNICATION		**OUTPUT RELAYS**	
B1	COM1 RS485 +	F1	SOLID STATE TRIP OUT -
B2	COM1 RS485 -	F2	1 TRIP RELAY COM
B3	COM1 RS485 COM	F3	2 CLOSE RELAY COM
B4	COM1 RS422 TX +	F4	3 AUXILIARY RELAY COM
B5	COM1 RS422 TX -	F5	4 AUXILIARY RELAY NO
B6	COM2 RS485 +	F6	4 AUXILIARY RELAY COM
B7	COM2 RS485 -	F7	5 AUXILIARY RELAY COM
B8	COM2 RS485 COM	F8	6 AUXILIARY RELAY NO
B9	SHIELD (GROUND)	F9	6 AUXILIARY RELAY COM
B10	IRIG-B +	F10	7 AUXILIARY RELAY COM
B11	IRIG-B -	F11	8 SELF-TEST WARNING RELAY NO
B12	RESERVED	F12	8 SELF-TEST WARNG RELAY COM
LOGIC INPUTS		**CT and VT INPUTS / GROUND**	
C1	LOGIC INPUT 1	G1	COIL MONITOR 1 +
C2	LOGIC INPUT 2	G2	COIL MONITOR 2 +
C3	LOGIC INPUT 3	G3	SENSITIVE GROUND CT ■
C4	LOGIC INPUT 4	G4	SYNCHRO VT ■ *(LINE)*
C5	LOGIC INPUT 5	G5	PHASE A VT ■ *(BUS)*
C6	LOGIC INPUT 6	G6	PHASE C VT ■ *(BUS)*
C7	LOGIC INPUT 7	G7	PHASE A CT ■
C8	RESERVED	G8	PHASE B CT ■
C9	RESERVED	G9	PHASE C CT ■
C10	SETPOINT ACCESS –	G10	GROUND CT ■
C11	SETPOINT ACCESS +	G11	FILTER GROUND
C12	+32 VDC	G12	SAFETY GROUND
LOGIC INPUTS		**CT and VT INPUTS / POWER**	
D1	LOGIC INPUT 8	H1	COIL MONITOR 1 -
D2	LOGIC INPUT 9	H2	COIL MONITOR 2 -
D3	LOGIC INPUT 10	H3	SENSITIVE GROUND CT
D4	LOGIC INPUT 11	H4	SYNCHRO VT *(LINE)*
D5	LOGIC INPUT 12	H5	PHASE B VT ■ *(BUS)*
D6	LOGIC INPUT 13	H6	PHASE VT NEUTRAL *(BUS)*
D7	LOGIC INPUT 14	H7	PHASE A CT
D8	RESERVED	H8	PHASE B CT
D9	RESERVED	H9	PHASE C CT
D10	RESERVED	H10	GROUND CT
D11	RESERVED	H11	CONTROL POWER -
D12	DC NEGATIVE	H12	CONTROL POWER +

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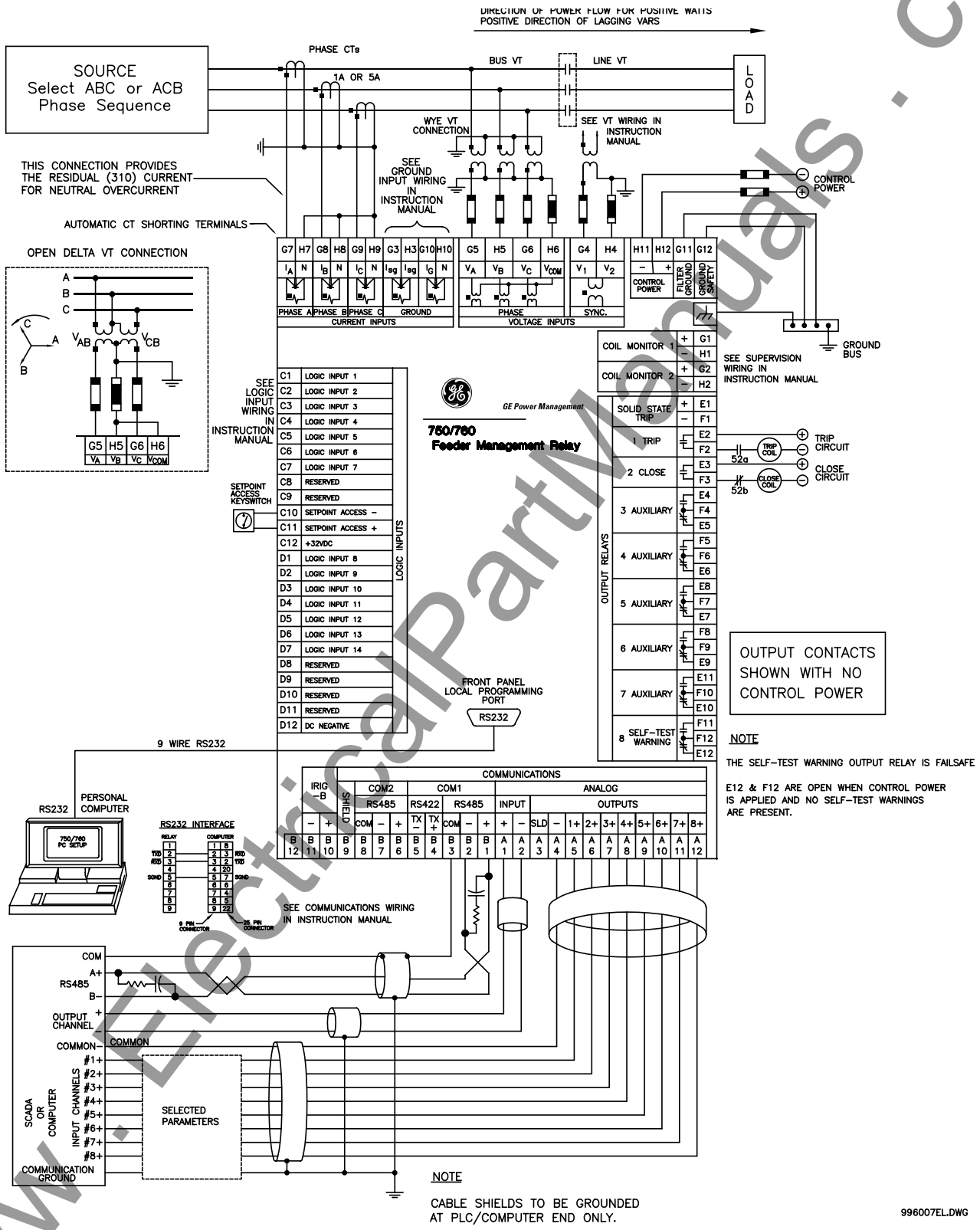


Figure 3–9: TYPICAL WIRING DIAGRAM

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3.2.4 PHASE SEQUENCE AND TRANSFORMER POLARITY

For the correct operation of many relay features, the instrument transformer polarities shown above in Figure 3–9: TYPICAL WIRING DIAGRAM must be followed. Note the solid square markings shown with all instrument transformer connections. When the connections adhere to this drawing, the arrow shows the direction of power flow for positive watts and the positive direction of lagging vars. The phase sequence is user programmable to be either ABC or ACB rotation.

3.2.5 AC CURRENT TRANSFORMER INPUTS

The 750 and 760 have five channels for AC current inputs, each with an isolating transformer and an automatic shorting mechanism that acts when the relay is withdrawn from its case. There are no internal ground connections on the current inputs. Current transformers with 1 to 50000 A primaries may be used.

CAUTION

Verify that the relay's nominal input current of 1 A or 5 A matches the secondary rating of the connected CTs. Unmatched CTs may result in equipment damage or inadequate protection.

CAUTION

IMPORTANT: The phase and ground current inputs will correctly measure to 20 times the current input's nominal rating. Time overcurrent curves become horizontal lines for currents above the 20 × CT rating. This becomes apparent if the pickup level is set above the nominal CT rating.

3.2.6 GROUND AND SENSITIVE GROUND CT INPUTS

There are two dedicated ground inputs referred throughout this manual as the 'Ground Current' and the 'Sensitive Ground Current' inputs. Before making ground connections, consider that the relay automatically calculates the neutral (residual) current from the sum of the three phase current phasors. The following figures show three possible ground connections using the ground current input (terminals G10, H10) and three possible sensitive ground connections using the sensitive ground current input (terminals G3, H3).

The ground input (terminals G10, H10) is used in conjunction with a zero sequence CT as source, or in the neutral of wye-connected source CTs. The ground current input can be used to polarize both the neutral and sensitive ground directional elements. When using the residual connection set the Ground CT Primary setpoint to a value equal to the Phase CT Primary setpoint.

The sensitive ground current input is intended for use either with a CT in a source neutral of a high-impedance grounded system, or on ungrounded systems. On ungrounded systems it is connected residually with the phase current inputs. In this case, the Senstv Gnd CT Primary setpoint should be programmed to a value equal to the Phase CT Primary setpoint. The sensitive ground current input can be connected to a zero-sequence CT for increased sensitivity and accuracy when physically possible in the system.

NOTE

Units that do not have the Sensitive Ground input (such as older units which have been upgraded with new firmware) will use the G3, H3 terminals as the polarizing input. Terminals G10, H10 are used for the Ground input. These connections will be shown on the terminal assignment label on the back of the relay's case.

NOTE

The Sensitive Ground input (G3, H3 terminals) must only be used on systems where the maximum ground current does not exceed 500 A.

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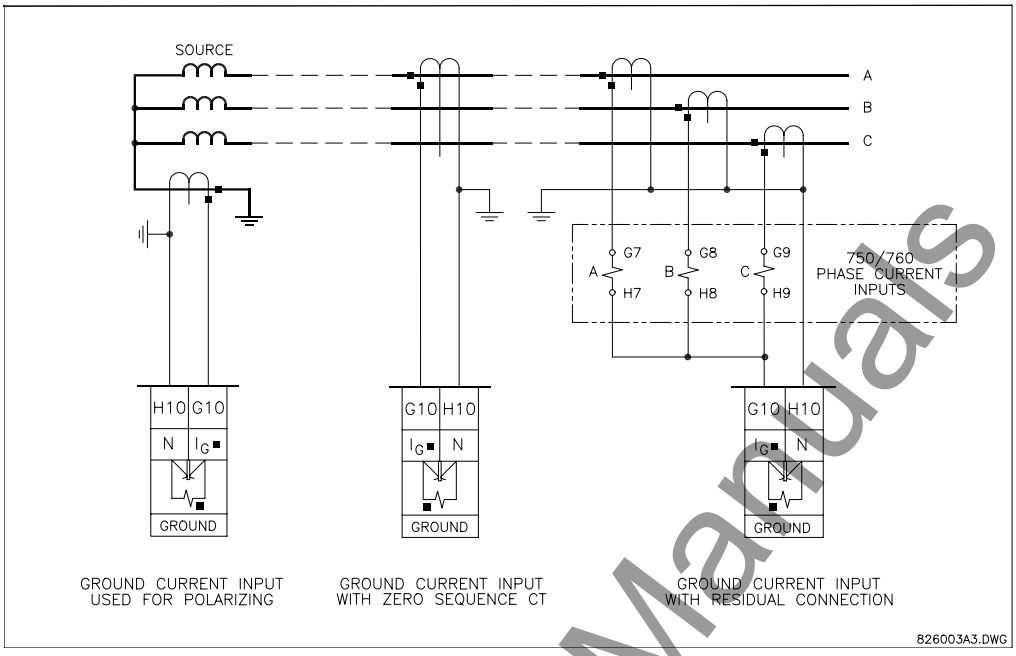


Figure 3–10: GROUND INPUTS

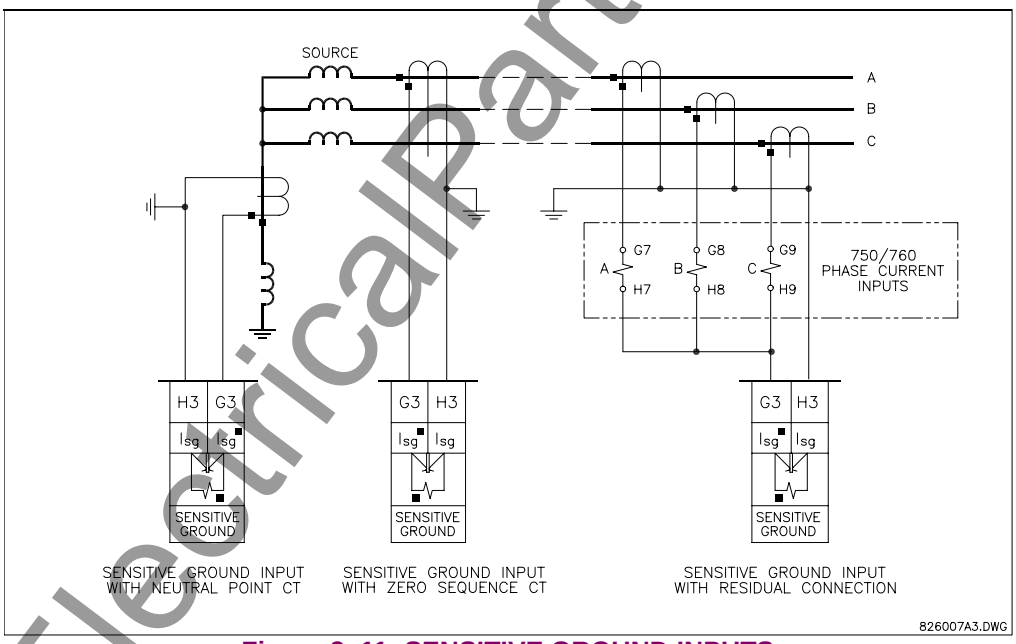


Figure 3–11: SENSITIVE GROUND INPUTS

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3.2.7 RESTRICTED EARTH FAULT INPUTS

Restricted Earth Fault protection is often applied to transformers having grounded wye windings to provide sensitive ground fault detection for faults near the transformer neutral. The Sensitive Ground input (terminals G3, H3) can be used.

NOTE

Although the 750/760 is designed for feeder protection, it can provide Restricted Earth Fault protection on transformers that do not have dedicated protection. To use the 750/760 for this type of protection, a stabilizing resistor and possibly a non-linear resistor will be required. For more details see Section 12.5.6: RESTRICTED EARTH FAULT on page 12–37.

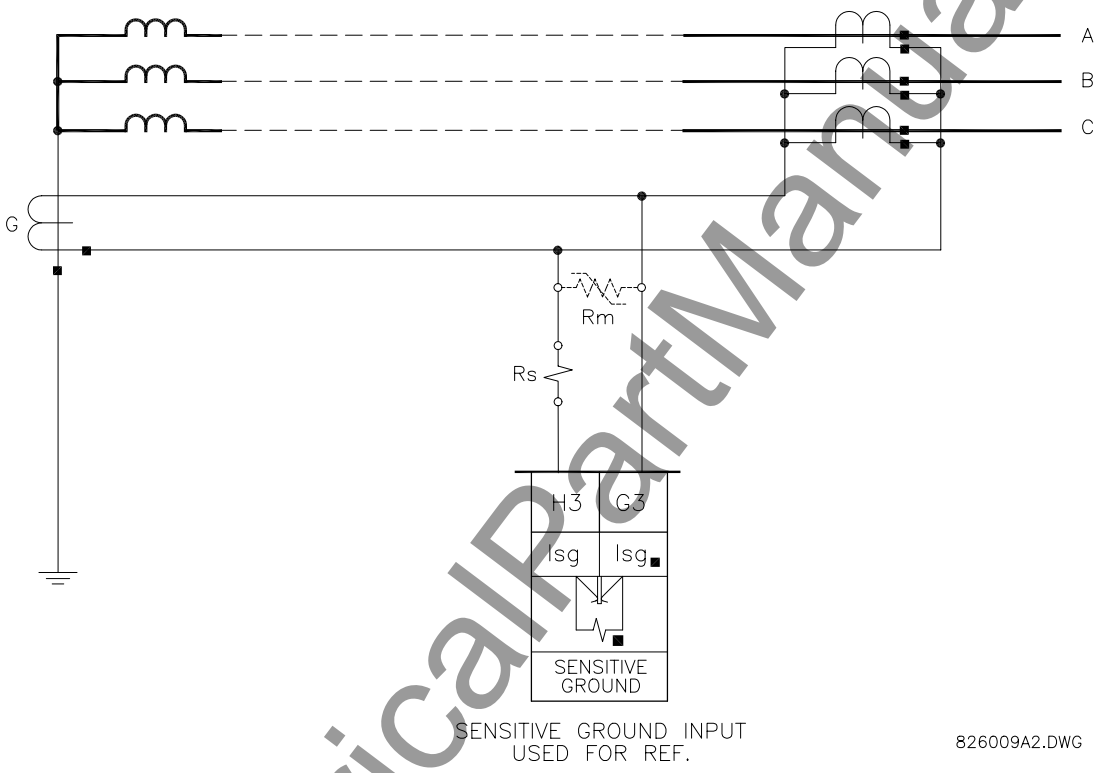


Figure 3–12: RESTRICTED EARTH FAULT INPUTS

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3.2.8 ZERO SEQUENCE CT INSTALLATION

The various CT connections and the exact placement of a zero sequence CT, so that ground fault current will be detected, are shown in the figure below. Twisted pair cabling on the zero sequence CT is recommended.

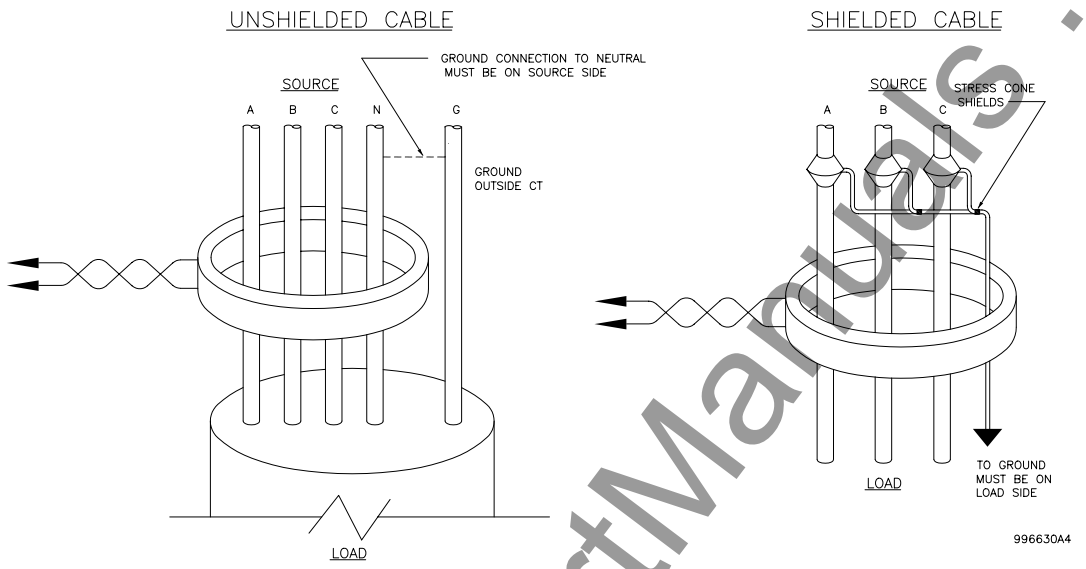


Figure 3–13: ZERO SEQUENCE (CORE BALANCE) CT INSTALLATION

3.2.9 AC VOLTAGE TRANSFORMER INPUTS

The 750 and 760 have four channels for AC voltage inputs, each with an isolating transformer. Voltage transformers up to a maximum 5000:1 ratio may be used. The nominal secondary voltage must be in the 50 to 240 V range.

The three phase inputs are designated as the "bus voltage". The bus VT connections most commonly used, wye and delta (or open delta), are shown in the typical wiring diagram. Be aware that these voltage channels are internally connected as wye. This is why the jumper between the phase B terminal and the Vcom terminal must be installed with a delta connection.

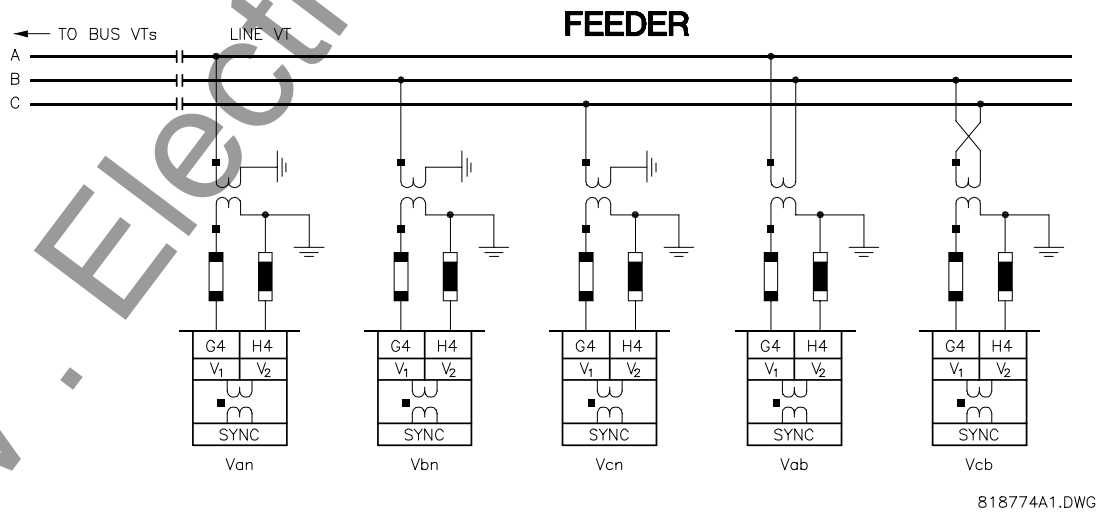


Figure 3–14: LINE VT CONNECTIONS

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NOTE

If delta VTs are used, zero sequence voltage (V_0) and neutral/sensitive ground polarizing voltage ($-V_0$) will be zero. Also with this delta VT connection, the phase-neutral voltage cannot be measured and will not be displayed.

The single phase input is designated as the “line voltage”. The line VT input channel, used for the synchrocheck feature, can be connected for phase-neutral voltages V_{an}, V_{bn}, or V_{cn}; or for phase-phase voltages V_{ab} or V_{cb} as shown below.

3.2.10 CONTROL POWER

CAUTION

Control power supplied to the relay must match the installed power supply range. If the applied voltage does not match, damage to the unit may occur. All grounds MUST be connected for normal operation regardless of control power supply type.

The label found on the left side of the relay specifies its order code or model number. The installed power supply’s operating range will be one of the following.

LO: 20 to 60 V DC or 20 to 48 V AC

HI: 88 to 300 V DC or 70 to 265 V AC

CAUTION

The relay should be connected *directly* to the ground bus, using the shortest practical path. A tinned copper, braided, shielding and bonding cable should be used. As a minimum, 96 strands of number 34 AWG should be used. Belden catalog number 8660 is suitable.

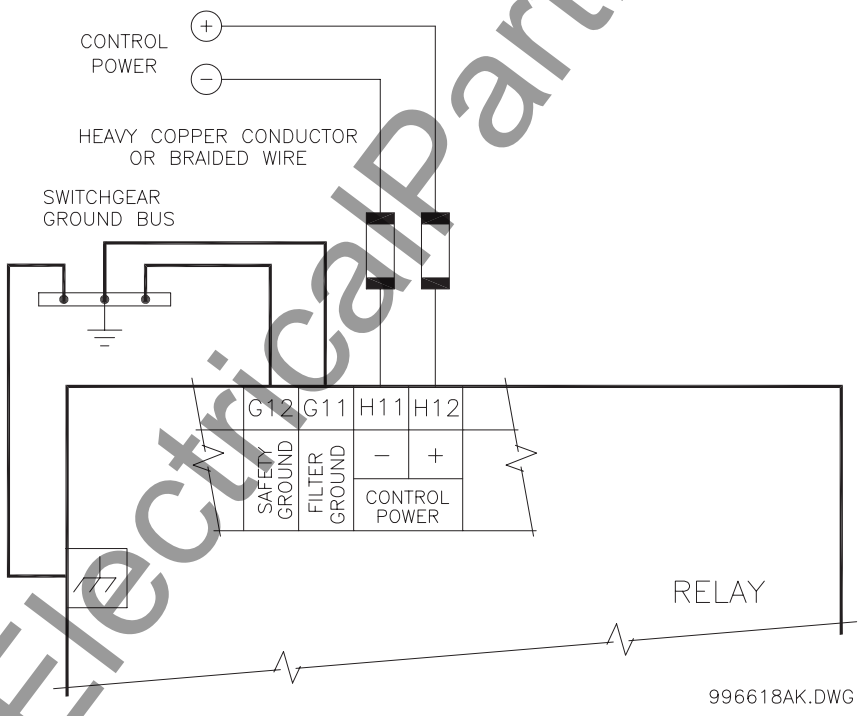


Figure 3–15: CONTROL POWER CONNECTION

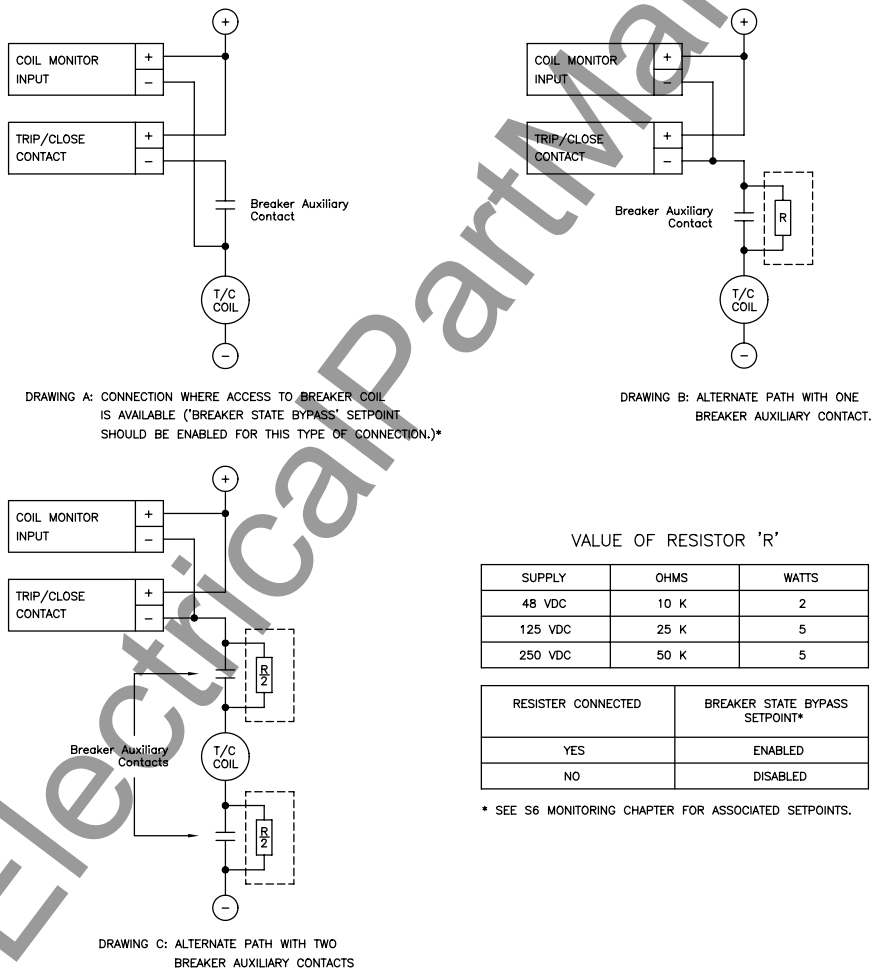
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3.2.11 TRIP / CLOSE COIL SUPERVISION

Supervision of a breaker trip coil requires the relay supervision circuit to be wired in parallel with the 1 TRIP contact. Likewise, supervision of the close coil requires the supervision circuit to be wired in parallel with the 2 CLOSE contact. Each connection places an impedance across the associated contact, which allows a small trickle current to flow through the related trip and close coil supervision circuitry. For external supply voltages in the 30 to 250 V DC range, this current draw will be between 2 to 5 mA. If either the trip or close coil supervision circuitry ceases to detect this trickle current, the appropriate failure will be declared by the relay.

When the **BREAKER STATE BYPASS** setpoints are disabled, the logic only allows a trip circuit to be monitored when the breaker is closed and a close circuit to be monitored when the breaker is open.

Circuit breakers equipped with standard control circuits have a 52a auxiliary contact which only allows tripping of the breaker when it is closed. In this breaker state, the 52a contact is closed and a trickle current will flow through the trip circuitry. When the breaker is open, the 52a auxiliary contact is also open and no trickle current will flow. When the breaker position monitoring inputs detect an open breaker, the trip coil supervision monitoring function will be disabled.



VALUE OF RESISTOR 'R'

SUPPLY	OHMS	WATTS
48 VDC	10 K	2
125 VDC	25 K	5
250 VDC	50 K	5

RESISTER CONNECTED	BREAKER STATE BYPASS SETPOINT*
YES	ENABLED
NO	DISABLED

* SEE S6 MONITORING CHAPTER FOR ASSOCIATED SETPOINTS.

Figure 3–16: TRIP / CLOSE COIL SUPERVISION CONNECTION

In a similar manner, the 52b auxiliary contact only allows closing of the breaker when it is open. In this breaker state, the 52b contact is shorted and a trickle current will flow through the breaker's close circuitry. When the breaker is closed, the 52b auxiliary contact is open and no trickle current will flow. When the breaker position monitoring inputs detect a closed breaker, the close coil supervision monitoring function will be disabled.

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When the **BREAKER STATE BYPASS** setpoints are enabled, the trip and close coil supervision circuits can be arranged to monitor the trip and close circuits continuously, unaffected by breaker state. This application requires that an alternate path around the 52a or 52b contacts in series with the operating coils be provided, with modifications to the standard wiring as shown on drawing 818730. With these connections, trickle current can flow at all times. If access to the breaker coil is available, as shown in drawing A above, continuous coil monitoring regardless of breaker state is possible without using a resistor to bypass the 52a/b contact.

3.2.12 SOLID STATE TRIP OUTPUT

A high speed solid state (SCR) output is also provided. This output is intended for applications where it is required to key a communications channel.

3.2.13 LOGIC INPUTS

CAUTION

Ensure correct polarity on logic input connections and do not connect any logic input circuits to ground or else relay hardware may be damaged.

External contacts can be connected to the relay's 14 logic inputs. As shown, these contacts can be either dry or wet. It is also possible to use a combination of both contact types.

A dry contact has one side connected to terminal C12. This is the +32 VDC voltage rail. The other side of the dry contact is connected to the required logic input terminal. When a dry contact closes, a current of approximately 2 mA will flow through the associated circuit.

A wet contact has one side connected to the positive terminal of an external DC power supply. The other side of this contact is connected to the required logic input terminal. In addition, the negative side of the external source must be connected to the relay's DC NEGATIVE rail at terminal D12. The maximum external source voltage for this arrangement is 300 V DC.

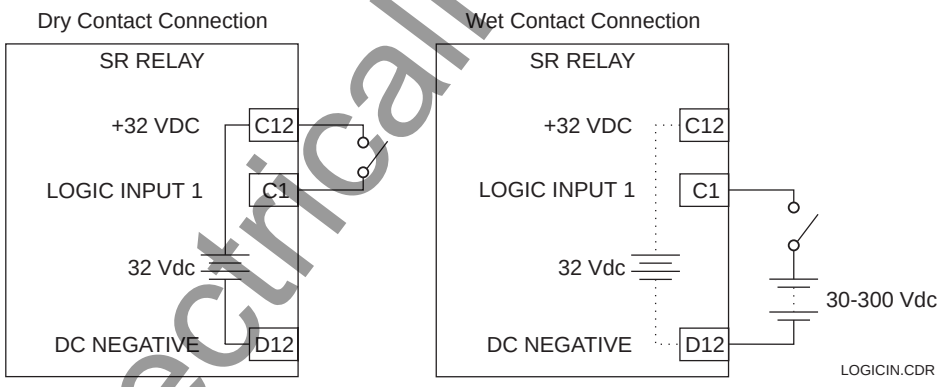


Figure 3–17: DRY AND WET CONTACT CONNECTIONS

3.2.14 ANALOG INPUT

Terminals A1 (+) and A2 (–) are provided for the input of a current signal from a wide variety of transducer outputs - refer to technical specifications for complete listing. This current signal can represent any external quantity, such as transformer winding temperature, bus voltage, battery voltage, station service voltage, or transformer tap position. Be sure to observe polarity markings for correct operation. Both terminals are clamped to within 36 volts of ground with surge protection. As such, common mode voltages should not exceed this limit. Shielded wire, with only one end of the shield grounded, is recommended to minimize noise effects.

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The 750 and 760 provide 8 analog output channels whose full scale range was specified at the time of ordering. Refer to Section 1.2: TECHNICAL SPECIFICATIONS on page 1–7 for complete listing.

Each analog output channel can be programmed to represent one of the parameters measured by the relay. For details, see Section 13.6: ANALOG OUTPUTS on page 13–24.

As shown in the typical wiring diagram, the analog output signals originate from terminals A5 to A12 and share A4 as a common return. Output signals are internally isolated and allow connection to devices which sit at a different ground potential. Each analog output terminal is clamped to within 36 volts of ground. To minimize the affect of noise, external connections should be made with shielded cable and only one end of the shield should be grounded.

If a voltage output is required, a burden resistor must be connected at the input of the external measuring device. Ignoring the input impedance, we have

$$R_{LOAD} = \frac{V_{FULL\ SCALE}}{I_{MAX}}$$

If a 5V full scale output is required with a 0 to 1 mA output channel:

$$R_{LOAD} = \frac{V_{FULL\ SCALE}}{I_{MAX}} = \frac{5\ \text{V}}{0.001\ \text{A}} = 5\ \text{k}\Omega$$

For a 0 to 5 mA channel this resistor would be 1 kΩ and for a 4 to 20 mA channel this resistor would be 250 Ω.

The Analog Output connection diagram is shown below.

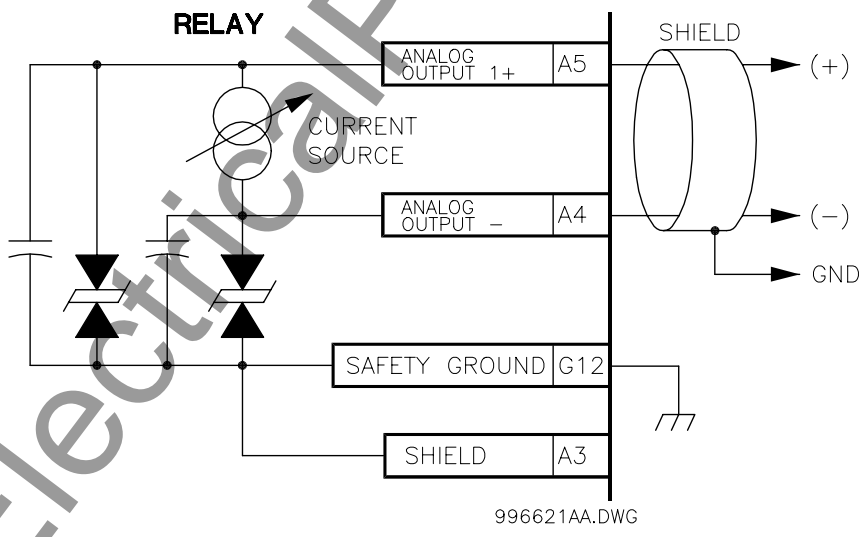


Figure 3–18: ANALOG OUTPUT CONNECTION

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3.2.16 RS485 / RS422 COMMUNICATION PORTS

The 750 and 760 provide the user with two rear communication ports which may be used simultaneously. Both support a subset of the AEG Modicon Modbus protocol as well as the Harris Distributed Network Protocol (DNP) as discussed in the communications chapter. Through the use of these ports, continuous monitoring and control from a remote computer, SCADA system or PLC is possible.

The first port, COM1, can be used in a two wire RS485 mode or a four wire RS422 mode, but will not operate in both modes at the same time. In the RS485 mode, data transmission and reception are accomplished over a single twisted pair with transmit and receive data alternating over the same two wires. These wires should be connected to the terminals marked RS485. The RS422 mode uses the COM1 terminals designated as RS485 for receive lines, and the COM1 terminals designated as RS422 for transmit lines. The second port, COM2, is intended for the two wire RS485 mode only.

To minimize errors from noise, the use of shielded twisted-pair wire is recommended. Correct polarity should also be observed. For instance, SR type relays must be connected with all B1 terminals (labeled COM1 RS485 +) connected together, and all B2 terminals (labeled COM1 RS485 –) connected together. Terminal B3 (COM1 RS485 COM) should be connected to the common wire inside the shield. To avoid loop currents, the shield should be grounded at one point only. Each relay should also be daisy-chained to the next one in the link. A maximum of 32 devices can be connected in this manner without exceeding driver capability. For larger systems, additional serial channels must be added. It is also possible to use commercially available repeaters to add more than 32 relays on a single channel. Star or stub connections should be avoided entirely.

Lightning strikes and ground surge currents can cause large momentary voltage differences between remote ends of the communication link. For this reason, surge protection devices are internally provided at both communication ports. An isolated power supply with an optocoupled data interface also acts to reduce noise coupling. To ensure maximum reliability, all equipment should have similar transient protection devices installed.

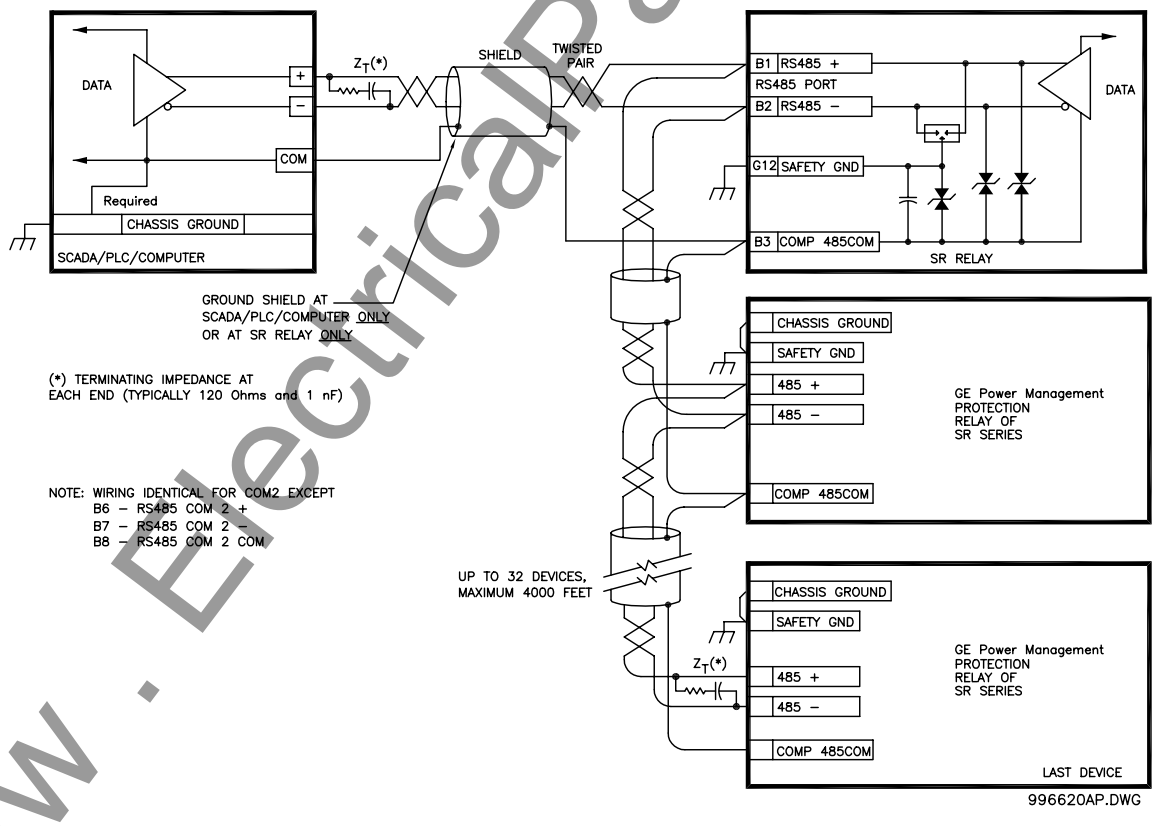


Figure 3–19: RS485 CONNECTION

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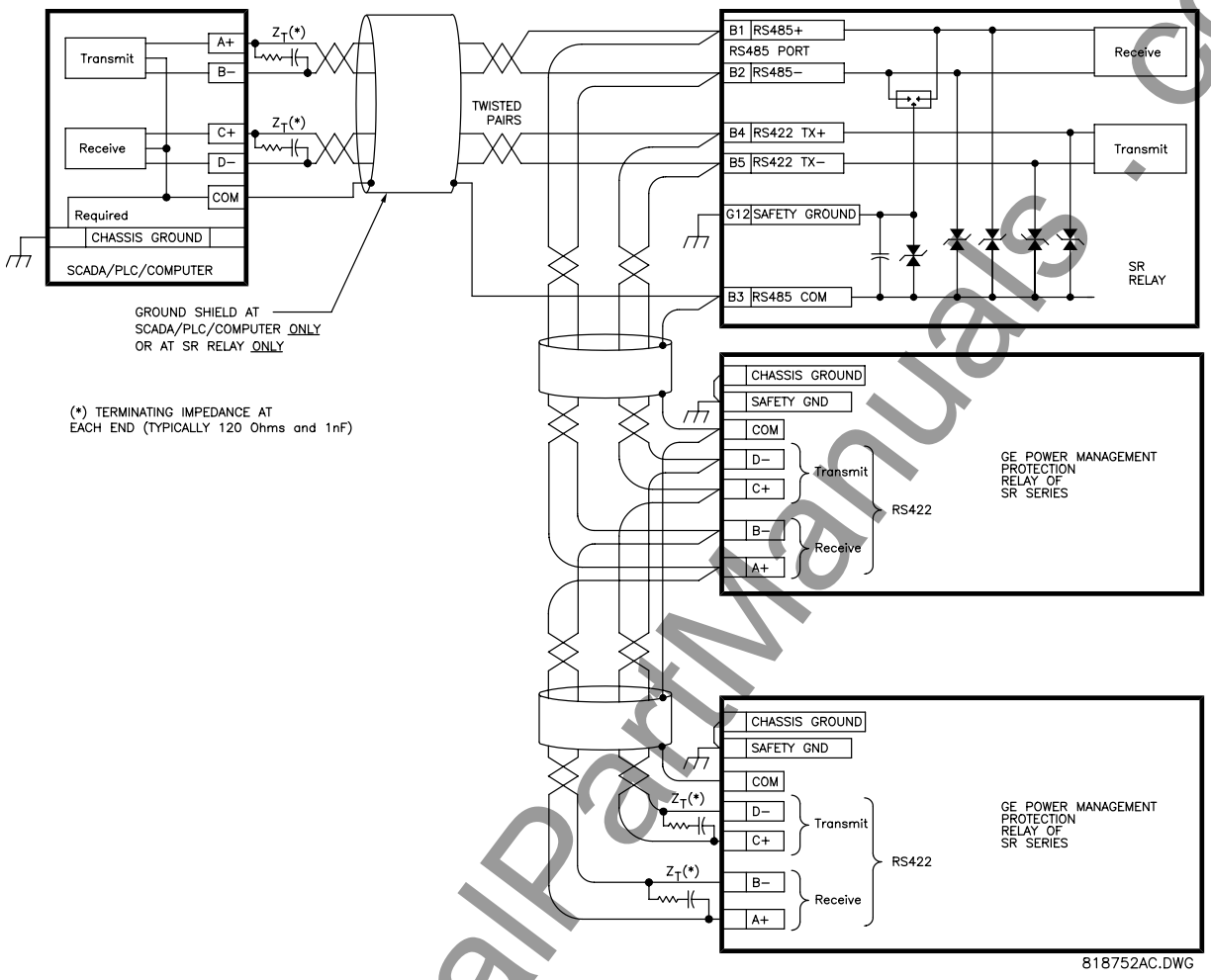


Figure 3–20: RS422 CONNECTION

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3.2.17 RS232 FRONT PANEL PROGRAM PORT

The 9-pin RS232C serial port located on the front panel is used in conjunction with the 750/760 PC Program for programming setpoints and upgrading relay firmware. A standard 9-pin RS232 cable is used to connect the relay to a personal computer as shown below. When downloading new firmware, make sure the relay address is set to 1 and the baud rate is set to 9600.

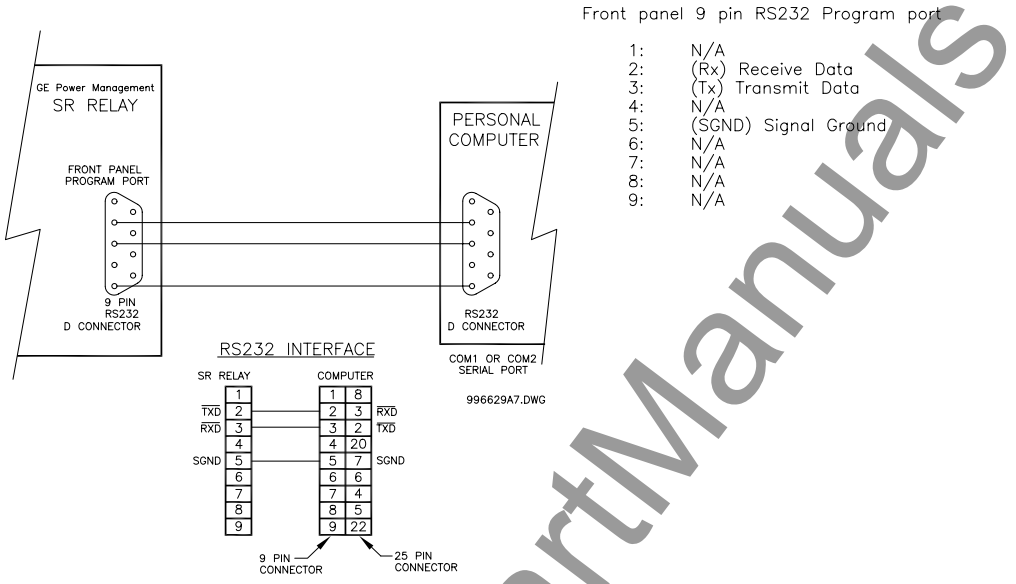


Figure 3–21: RS232 CONNECTION

3.2.18 IRIG-B

IRIG-B is a standard time code format that allows time stamping of events to be synchronized among connected devices within 1 millisecond. The IRIG time code formats are serial, width-modulated codes which can be either DC level shift or amplitude modulated (AM) form. Third party equipment is available for generating the IRIG-B signal; this equipment may use a GPS satellite system to obtain the time reference so that devices at different geographic locations can also be synchronized.

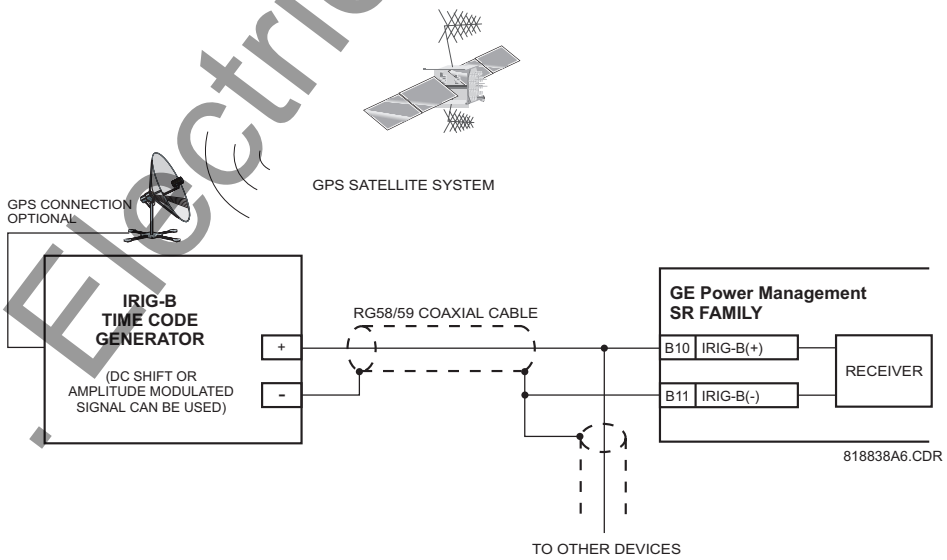


Figure 3–22: IRIG-B CONNECTION

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4.1.1 DESCRIPTION

The 750/760PC PROGRAM may be used for training or testing purposes from any computer running Microsoft Windows 3.1/95/98. Setpoints may be edited and printed, actual values may be read, and relay operation may be simulated. The 750/760 PC Program, provided with every 750/760 relay, allows easy access to all relay setpoints and actual values via a personal computer running Windows® 3.1/3.11, Windows® 95/98, Windows® NT or higher and one of the PC's RS232 ports – COM1 or COM2. The user can:

- Program/modify setpoints
- Load/save setpoint files from/to disk
- Read actual values
- Monitor status
- Plot/print/view trending graphs of selected actual values
- Perform waveform capture (oscillography)
- Download and "playback" waveforms (Simulation Mode)
- View the Event Recorder
- Get help on any topic

The 750/760 PC Program can be used "stand-alone", without an 750/760 relay, to create or edit 750/760 setpoint files.

4.1.2 HARDWARE AND SOFTWARE REQUIREMENTS

The configuration listed is for both a minimum configured and an optimal configured system. Running on a minimum configuration causes the performance of the PC program to slow down.

- Processor: minimum 486, Pentium recommended
- Memory: minimum 4 Mb, 16 Mb recommended, minimum 540 K of conventional memory
- Hard Drive: 20 Mb free space required before installation of PC program.
- O/S: Windows 3.1, Windows 3.11 for Workgroups, Windows 95, Windows NT

ADDITIONAL WINDOWS 3.1/3.11 CONSIDERATIONS:

- Installation of SHARE.EXE required.
- Close other applications (spreadsheet or word processor) before running the PC program to eliminate any problems because of low memory.

4.1.3 HARDWARE CONFIGURATION

The 750/760 PC Program communicate with the 750/760 via the front panel RS232 port or the rear terminal RS485 ports. To communicate with the relay via the front RS232 port, a standard "straight through" serial cable is used. The DB-9 male end is connected to the relay and the DB-9 or DB-25 female end is connected to the computer for COM1 or COM2 respectively.

To communicate with the relay via the rear RS485 ports, the GE Power Management F485 RS232/RS485 Converter box is needed. The F485 converter box is connected to the converter using a "straight-through" serial cable. A shielded twisted pair (20, 22 or 24 AWG) cable is used to connect the converter box to the 750/760 rear terminals. The converter box (+, –, GND) terminals are connected to the (B1, B2, B3) relay terminals for relay COM1 respectively. The line should also be terminated in an RC network (i.e. 120 Ω, 1 nF) as described in Section 3.2: TYPICAL WIRING on page 3–5.

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4.2.1 750/760 PC PROGRAM UPGRADING

To determine if the currently installed PC Program needs to be upgraded:

1. Obtain the version number from the installation disks or the GE Power Management CD-ROM. To determine the most recent version, visit the GE Power Management website at www.GEindustrial.com/pm.
2. Run 750/760 PC Program
3. Select the **Help > About 750PC** menu item.
4. Compare the PC Program version shown in the **About 750PC** dialog box with the version shown on the CD-ROM or website. If it is higher (or does not suppose the revision of firmware that is required) then 750/760PC needs to be upgraded.

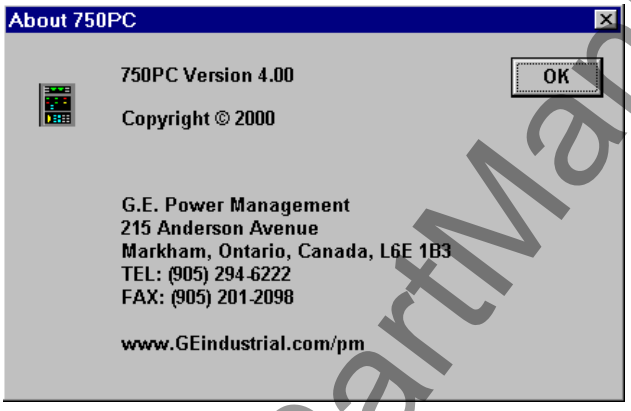


Figure 4–1: ABOUT 750PC SCREEN

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1. Insert the GE Power Management Product CD into the appropriate drive or proceed to the GE Power Management website at www.GEindustrial.com/pm. Since the Products CD is a “snapshot” of the website, the installation procedure for both sources is the same.
2. The GE Power Management main menu loads into the default web browser. This is shown in Figure 4–2: GE POWER MANAGEMENT WELCOME SCREEN below.

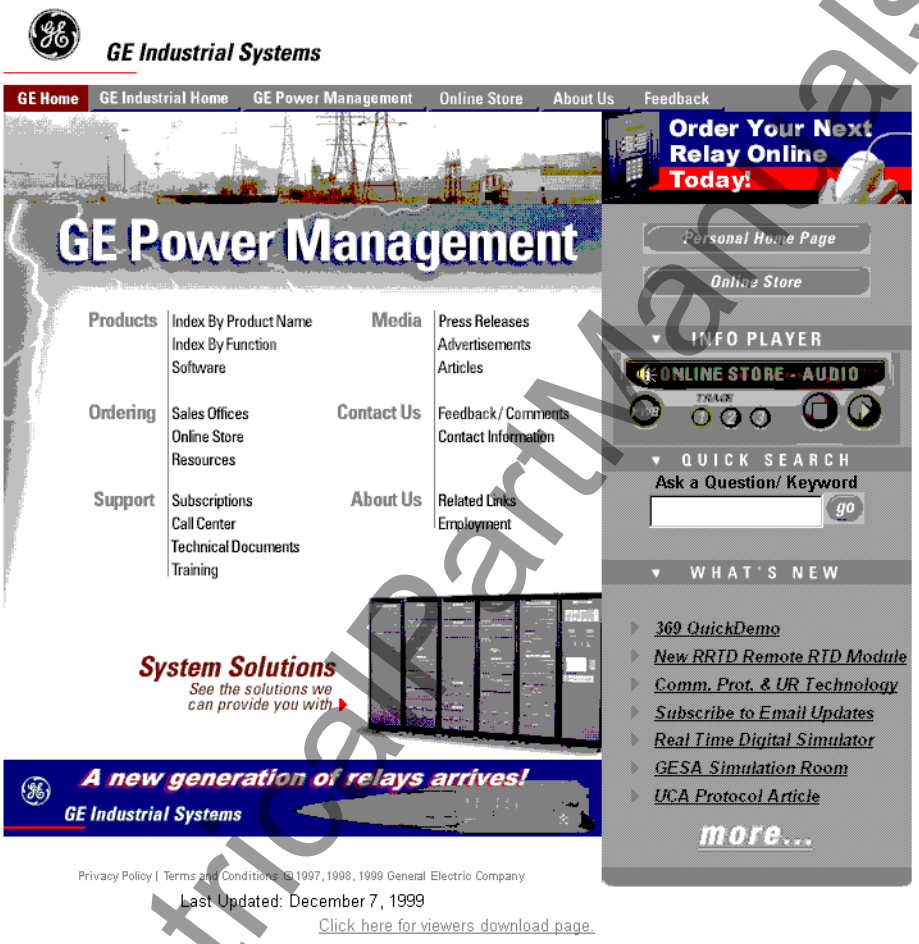


Figure 4–2: GE POWER MANAGEMENT WELCOME SCREEN

3. Select the **Products: Software** menu item.
4. Select either the 750 or 760 from the list of products. Both links lead to the same software selection
5. Follow the on-screen instructions to complete the installation of the PC Program. The **Typical** installation will include the PC Program and the relay firmware files.

The 750/760 PC Program installs the relay firmware files to the hard drive in a subdirectory of the PC Program called firmware. These firmware files can then be used to upgrade the relay. See Section 4.4.2: UPGRADING RELAY FIRMWARE on page 4–7 for more details.

If 3.5” floppy disks are required, they can be created from the installation program or ordered directly from the factory.

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4.3.1 MAIN WINDOW SCREEN

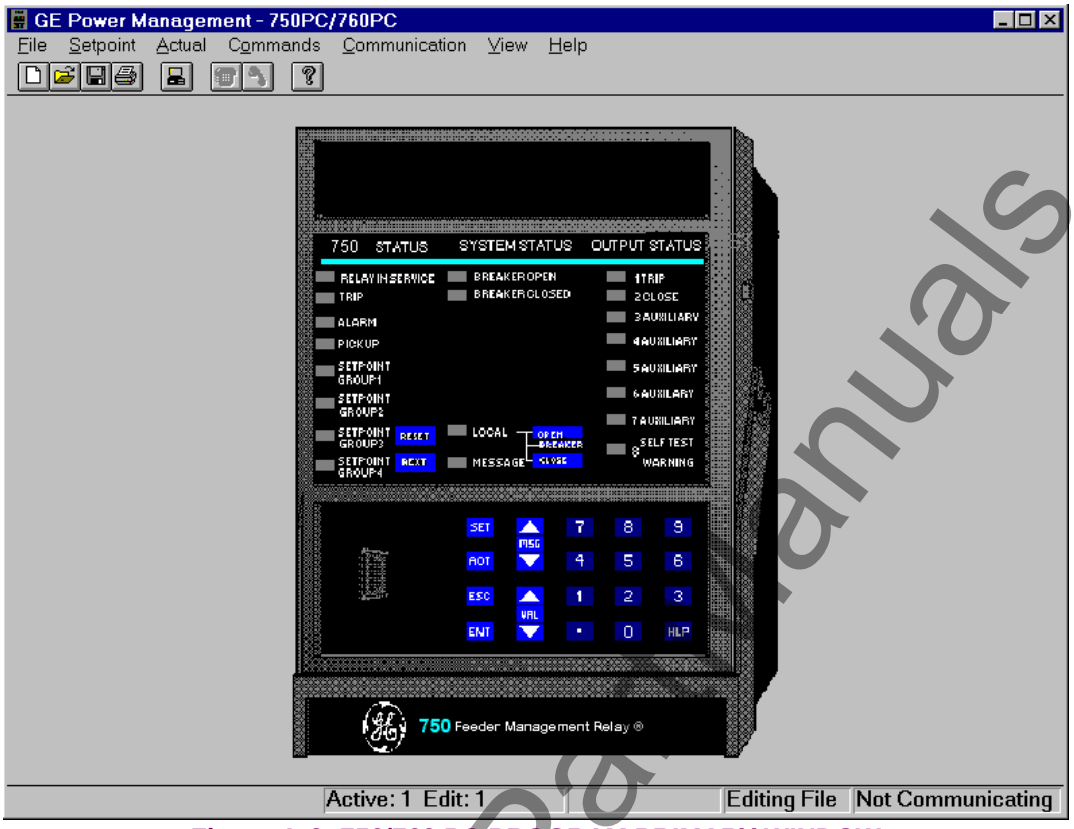
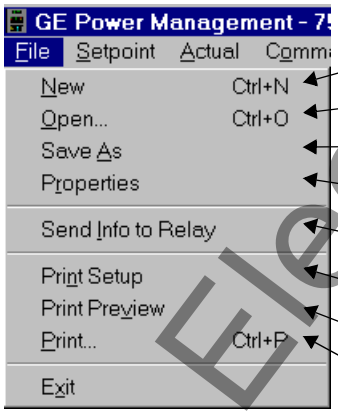


Figure 4–3: 750/760 PC PROGRAM PRIMARY WINDOW

4.3.2 TOP LEVEL MENU SUMMARY

The **File** menu provides options for working with setpoint files.



New: Creates a new setpoint file containing factory default settings.

Open: Opens an existing setpoint file.

Save As: Saves the current setpoints or setpoint file.

Properties: Selects the properties for the setpoint file.

Send Info to Relay: Sends the setpoint file to the relay.

Print Setup: Selects content and format of output.

Print Preview: Displays full pages as they will be printed.

Print: Print setpoints or setpoint file.

The **Setpoint** menu contains the same setpoint pages as seen in the relay. This provides a means to view and modify relay setpoints or a setpoint file.

The **Actual** menu contains the same actual values pages as seen in the relay. This menu also contains the additional selections: Waveform Capture, Data Logger, and Active Conditions.

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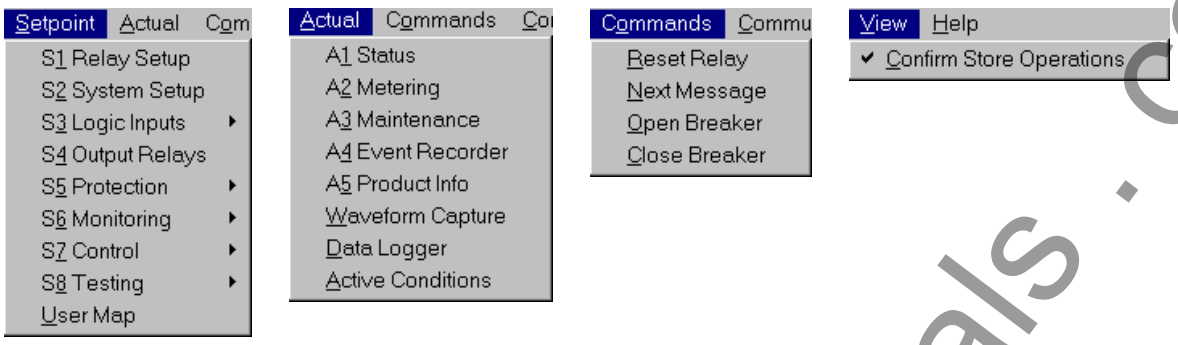
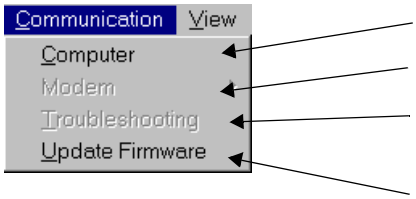


Figure 4–4: SETPOINT, ACTUAL, COMMANDS, AND VIEW MENUS

The **Commands** menu provides the functionality of the Reset, Next, Open Breaker and Close Breaker push-buttons on the front panel of the relay.

The **View** menu allows the user to set the "prompt on save" dialog boxes to ON or OFF.

The **Communication** menu contains the options for communications between the software and the 750/760.



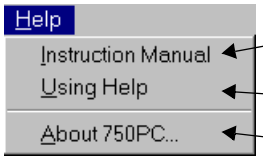
Computer: Contains the computer communication parameters.

Modem: Allows a phone number to be dialed using a modem.

Troubleshooting: Inspect/Insert data into the memory map using MODBUS address.

Update Firmware: Update the relay firmware.

The **Help** menu contains:

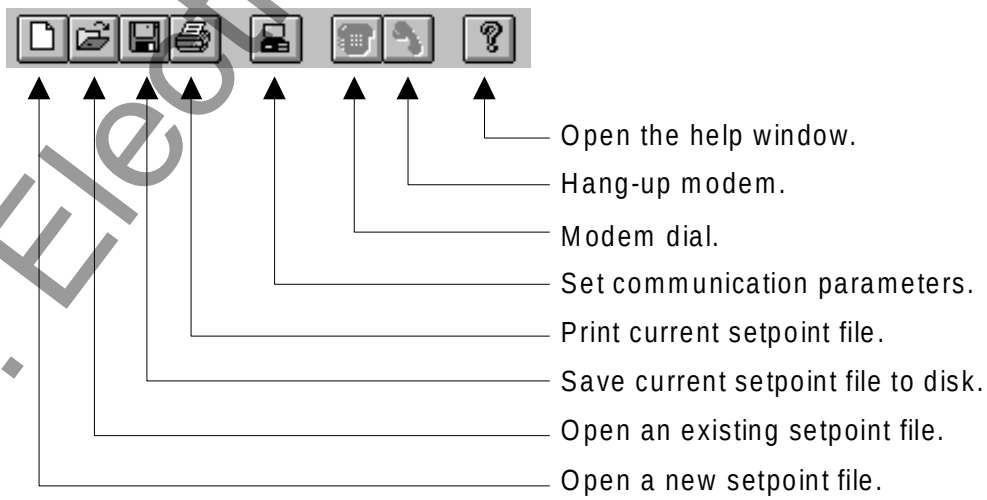


Instruction Manual: View and search the 750/760 Product Instruction Manual.

Using Help: Displays Instructions about using Help.

About 750PC: Displays the latest software version along with contact information and the GE Power Management website address.

4.3.3 TOOLBAR SUMMARY



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4.4.1 COMMUNICATIONS CONFIGURATION

Connect the computer to the 750/760 via one of the RS485 ports or via the front RS232 port. Following are the steps to begin communicating with the 750/760 using the PC Program.

1. Run the 750/760 PC Program using the icon installed during the installation process.
2. The main window will come up once the program has finished loading. The communications status of the 750/760 with the PC is displayed on the bottom right corner of the screen. If communications are established, the relay displayed will show the same LEDs and display as on the connected relay.
3. If the software is unable to establish communications, it is necessary to edit the communications settings.
4. Select the **Communication > Computer** menu item to open the **COMMUNICATION / COMPUTER** dialog box. These communications settings should be modified as follows:

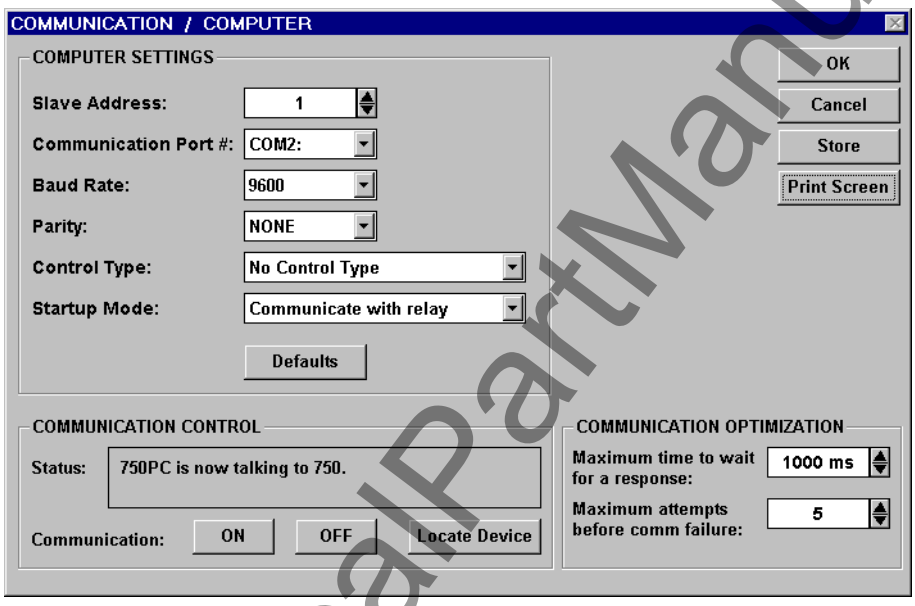


Figure 4–5: COMMUNICATION / COMPUTER DIALOG BOX

- **Slave Address**: This setting should be the same as **S1 RELAY SETUP / COMMUNICATIONS / SLAVE ADDRESS**.
- **Communication Port #**: This setting should be the COM port *on your computer* that is connected to the 750/760 (i.e. COM1 or COM2). On most PCs COM1 is used by the mouse device and so COM2 is usually available for communications.
- **Baud Rate**: This setting should be the same as **S1 RELAY SETUP / COMMUNICATIONS / BAUD RATE**.
- **Parity**: This setting should be the same as **S1 RELAY SETUP / COMMUNICATIONS / PARITY.**
- **Control Type**: Set to match the type of RS232/RS485 converter control type. If you are connected to the 750/760 front panel RS232 port, select **No Control Type**. If using a GE Power Management F485 converter, select **Multilin 232/485 Converter**. If you are connected to a modem, select **Modem**. If you are connected to a third party's converter box, use the manufacturer's specifications to select the appropriate control type from the available list.
- **Startup Mode**: Set the Startup Mode based on user preference. In the **Communicate with relay** mode the software will attempts to establish communications immediately upon startup. While in the **File mode / w default settings** the program waits for the user to click the **ON** button before attempting to establish communications – this is preferred when the 750/760 PC Program is being used without a relay.

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To begin communications click the **ON** button in the COMMUNICATION CONTROL section of the dialog box. The Status section of the dialog box will indicate the communication status. If communication is established the message ***750PC is now talking to 750*** will be displayed and the status at the bottom right hand corner of the screen will indicate ***Communicating***.

4.4.2 UPGRADING RELAY FIRMWARE

Prior to downloading new firmware into the 750/760, **save** the relay's setpoints to a file (see Section 4.4.5: SAVING SETPOINTS TO A FILE on page 4–9). Loading new firmware into the 750/760's *flash* memory via the front panel port is accomplished as follows:

1. From the **Communications** menu select **Update Firmware** (Note that units that do not have a bootware revision 3.00 or newer must be set to a baud rate of 9600 and a slave address of 1 before downloading new firmware. Check the bootware revision of the relay shown on page A5 Revision Codes).
2. The following warning message will pop-up. Click on the **Yes** button to proceed or **No** to abort.



Figure 4–6: UPGRADE RELAY FIRMWARE WARNING

3. The following dialog box will then appear requesting the name of the file containing the new analog board firmware to be loaded.

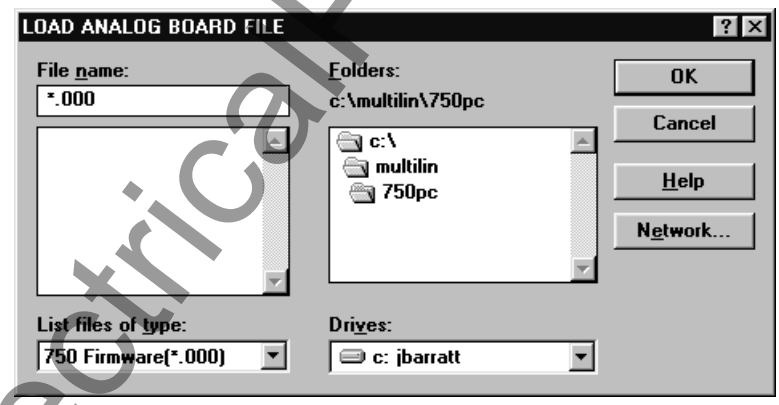
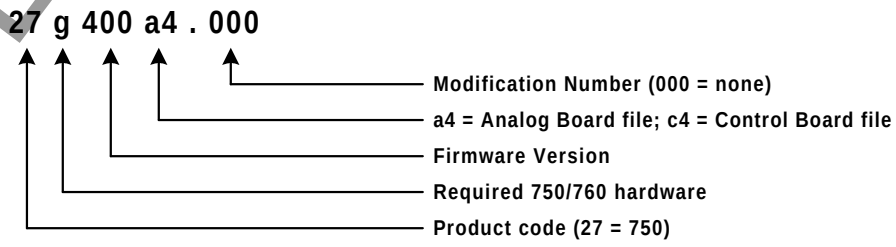


Figure 4–7: ANALOG BOARD FIRMWARE DIALOG BOX

4. Locate the appropriate file(s) by changing drives and/or directories until a list of file names appears in the file list box. File names for released 750/760 firmware have the following format:



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5. The 750/760 PC Program will automatically list file names ending with ***.000** Click on the appropriate file name such that it appears in the **File Name** box. Click on **OK** to continue.
6. A similar dialog box as in step 3 will appear asking for the control board firmware file. Locate this file and click on **OK** to continue.
7. Another warning message will appear to ensure you want to continue. Click on the **Yes** button to continue.
8. Upon completion, the program will put the relay back to “normal mode”.
9. The setpoint file saved in step 1 can now be loaded into the relay. (see Section 4.4.6: LOADING SETPOINTS FROM A FILE on page 4–10).

4.4.3 ENTERING SETPOINTS

The following example illustrates entering setpoints for **S2 SYSTEM SETUP / POWER SYSTEM** using the 750/760 PC Program.

1. From the **Setpoint** menu select **System Setup**
2. From the **System Setup** window select the **Sensing** tab.

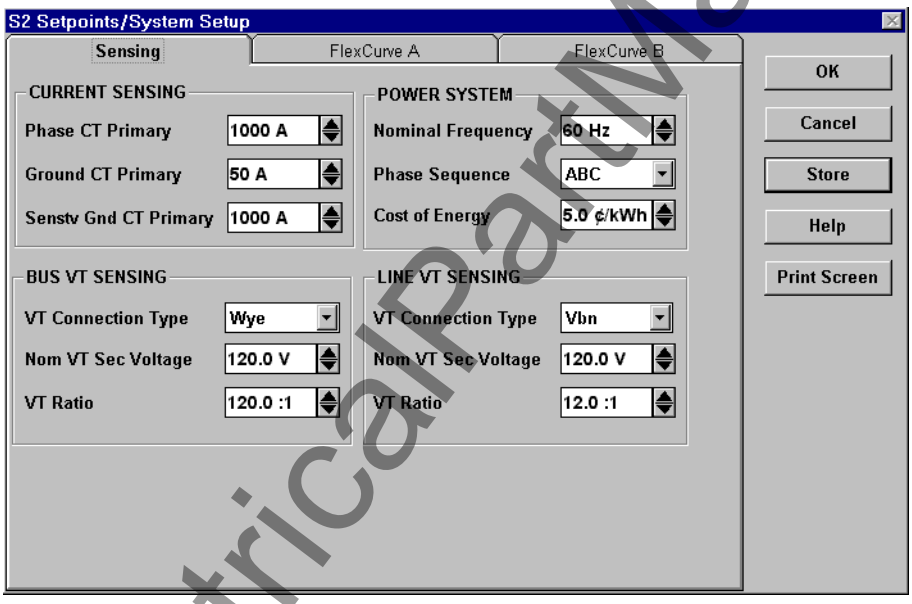


Figure 4–8: S2 SETPOINTS ENTRY DIALOG BOX

- For setpoints requiring numerical values (i.e. Nominal Frequency) click the mouse anywhere inside the setpoint box. This displays a numerical keypad showing the OLD value, RANGE and INCREMENT of the setpoint being modified. The up/down arrows can also be used to increment/decrement the value.
- For setpoints requiring non-numerical values (i.e. Phase Sequence) clicking anywhere inside the setpoint box or using the down arrow will cause a selection menu to be displayed.

3. Click on **OK** when done. You will be prompted to store the setpoints.
   - Click on **Cancel** to retain the previous value.
   - Click on **Store** to send the values to the 750/760 (if connected)
   - Click on **Help** to display help related to setpoints seen in this window

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4.4.4 VIEWING ACTUAL VALUES

The following example illustrates how any of the measured or monitored values can be displayed. In the following example voltage actual values are viewed using the PC Program:

1. From the **Actual** menu select **A2 Metering**.
2. From the **Metering** menu select the **Current** tab.
3. The following display box will be shown displaying the voltage actual values.

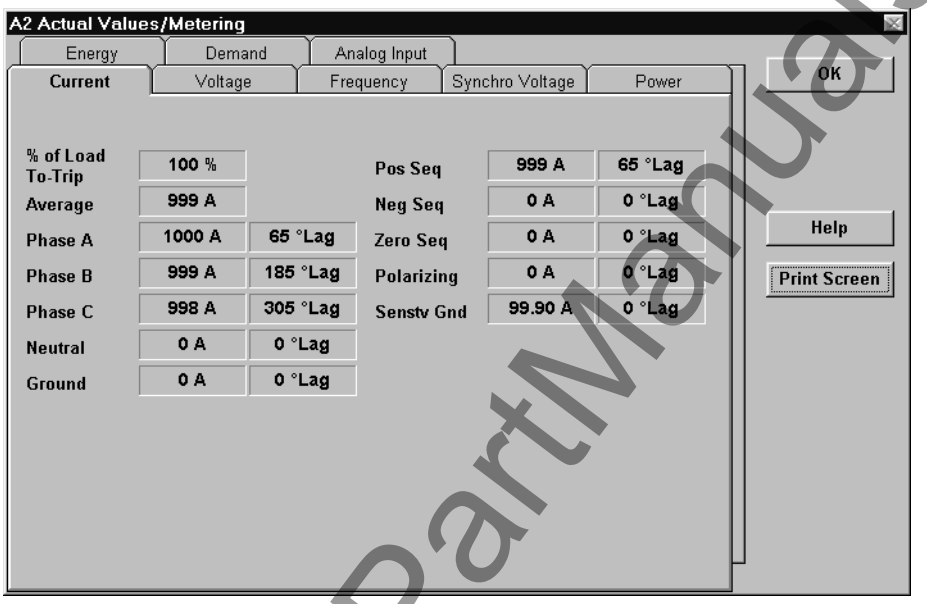
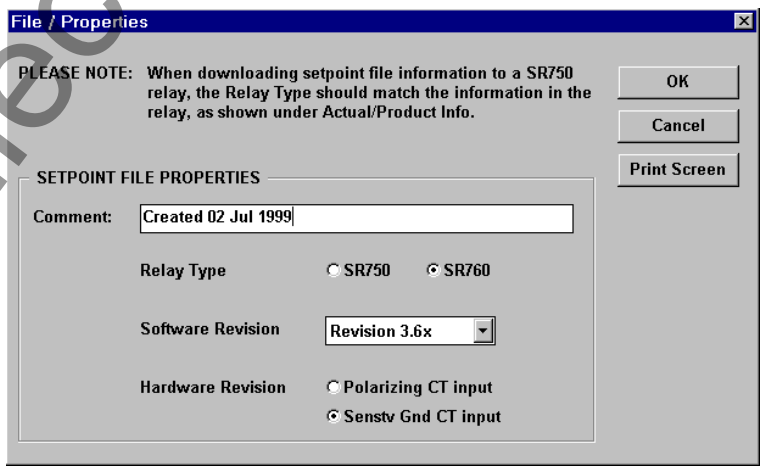


Figure 4–9: A2 METERING DIALOG BOX

4.4.5 SAVING SETPOINTS TO A FILE

Saving setpoints to a file on your PC is accomplished as follows:

1. If the 750/760PC software is not connected to a relay, select **Properties** from the **File** menu. The dialog box shown below will appear, allowing you to configure the software to match the options of a particular 750/760 relay. The software needs to know the correct options when creating a setpoint file so that when you download the file to the relay, setpoints not available for that particular relay will not be written.



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2. After configuring the setpoints (see Section 4.4.3: ENTERING SETPOINTS on page 4–8) select the **File > Save As** menu item. If the 750/760 PC Program is communicating with a relay, selecting **Save As** will save the setpoints of the connected relay to a file.

3. The following dialog box will pop-up. Enter the file name under which the file will be saved in the File Name box or click on any of the file names displayed in the box below. All 750 setpoint files should have the extension **.750**. All 760 setpoint files should have the extension **.760**. Click on **OK** to proceed:

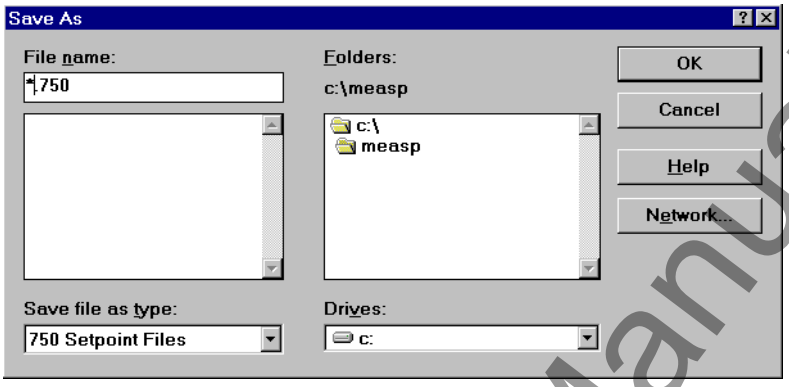


Figure 4–10: SAVE AS DIALOG BOX

4. The program will then read all the relay setpoint values and store them to the selected file.

4.4.6 LOADING SETPOINTS FROM A FILE

The following steps show how to download a setpoint file to a relay:

1. From the **File** menu select **Open**.

2. The following dialog box will pop-up. The program will display all filenames with the extension ***.750** for 750 file type and ***.760** for 760 file type. Select the file name of the setpoint file to download to the 750/760 – the selected file name will appear in the file name box. Click the **OK** button to continue.

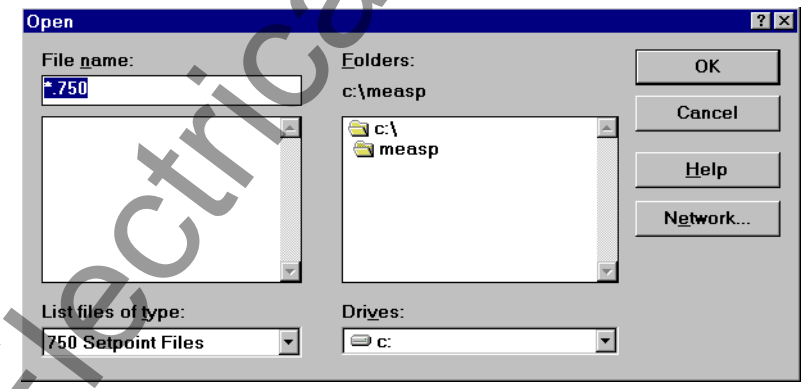


Figure 4–11: OPEN FILE DIALOG BOX

3. From the **File** menu select **Properties**. Change the file properties, if necessary, to be consistent with the relay that this setpoint file is going to be loaded into.

4. From the **File** menu select **Send Info to Relay**. The program will then prompt you to confirm or abort the process - click on **Yes** to download the setpoints to the relay or **No** to abort.

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4.4.7 USER MAP

The 750/760 PC Program provides a means to program the 750/760 User Map (MODBUS addresses 0x0180 to 01F7). Refer to section 16.4: MODBUS MEMORY MAP on page 16–18 for more information.

Selecting **Setpoint > User Map** opens the window below. This window allows the desired addresses to be written to User Map locations. The User Map values that correspond to these addresses are then displayed.

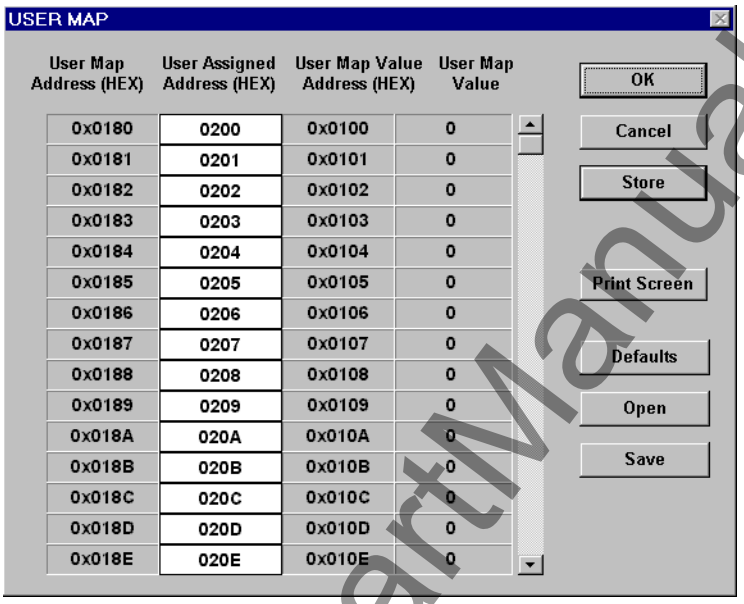


Figure 4–12: USER MAP VALUES WINDOW

4.4.8 WAVEFORM CAPTURE (TRACE MEMORY)

The 750/760 PC Program can be used to view Waveform Capture or Trace Memory data stored by the relay. Data is captured for analog current and voltage inputs (*Ia*, *Ib*, *Ic*, *Ig*, *Isg*, *Va*, *Vb*, *Vc*, *Vs*) as well as digital data for the output relays and the contact inputs states.

To use the Waveform Capture function, run the 750/760 PC Program and establish communications with a connected 750/760 relay.

Select **Actual > Waveform Capture** from the main window to open the Waveform Capture window. The window shown below will appear, showing the Phase A current of the last captured waveform. The red vertical line shows the trigger point of the waveform.

The cursors (shown by a solid and dotted green line) can be moved to different points on the waveform to see magnitude and delta time information. Waveform data can be saved to a CSV (Comma delimited) file by pressing the **Save** button. The **Open** button can open waveform data that has been stored to a CSV file.

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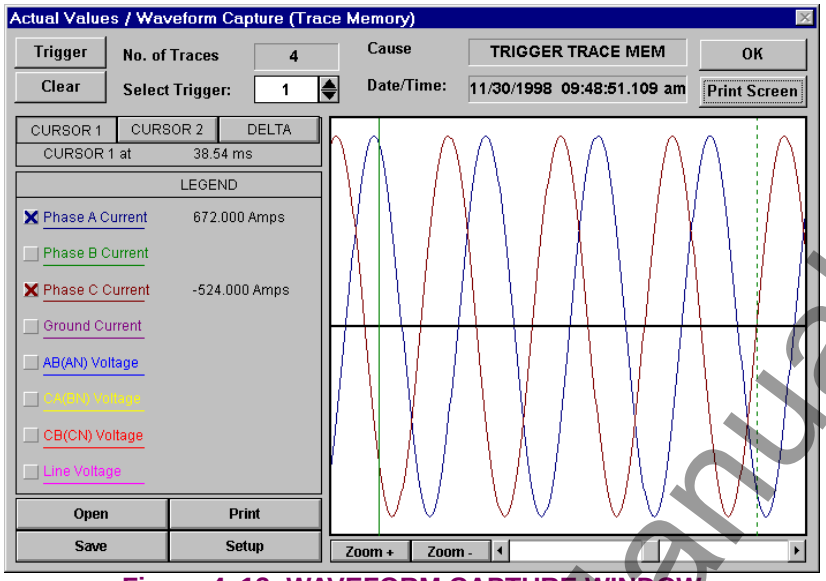


Figure 4–13: WAVEFORM CAPTURE WINDOW

Pressing **Setup** will enter the Graph Attributes window. The displayed waveform can be selected under the **Description** heading. Change **Color**, **Style**, **Width**, **Scaling Group**, and **Spline** as desired. Select the same **Scaling Group** for all parameters to be scaled together. Using **Spline** will result in a "smoothing" of the waveform.

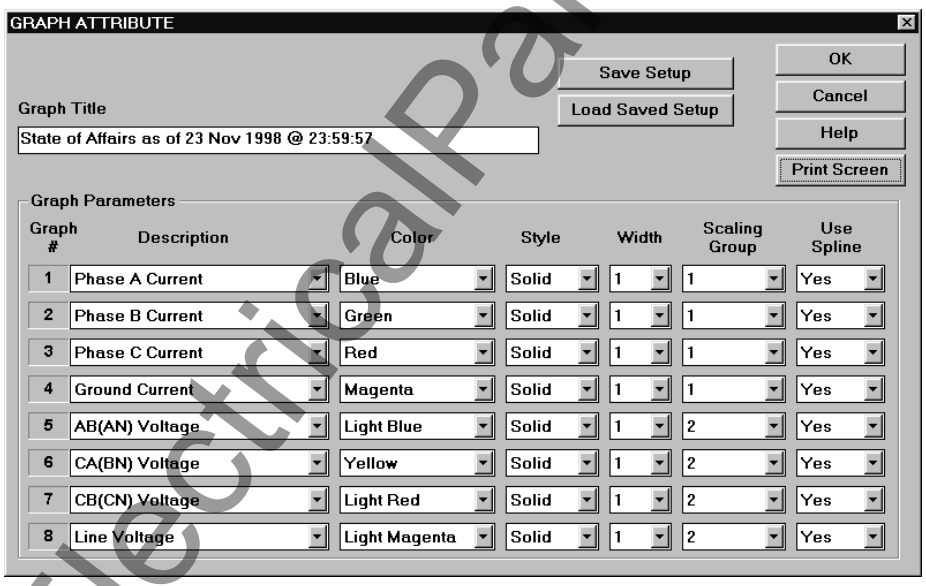


Figure 4–14: GRAPH ATTRIBUTES DIALOG BOX

4.4.9 DATA LOGGER

The data logger feature is used to sample and record up to eight actual values at an interval that is defined by the user. Refer to Section 8.7: DATA LOGGER on page 8–7 for more details. The Data Logger window behaves in the same manner as the Waveform Capture described above.

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5.1.1 DESCRIPTION

The front panel provides local operator interface with a vacuum florescent display, LED status indicators, control keys, and program port. The display and status indicators update alarm and status information automatically. The control keys are used to select the appropriate message for entering setpoints or displaying measured values. The RS232 program port is also provided for connection with a computer running the 750/760 PC program.

The 40-character vacuum fluorescent display, provides English messages that are visible under varied lighting conditions. While the keypad and display are not being used, the screen will display system information by scrolling through a maximum of 30 user-selected default messages. These default messages will only appear after a user programmed period of inactivity. Pressing any key during default message scrolling will return the display to the last message shown before the default messages appeared. Trip and alarm condition messages will automatically override default messages.

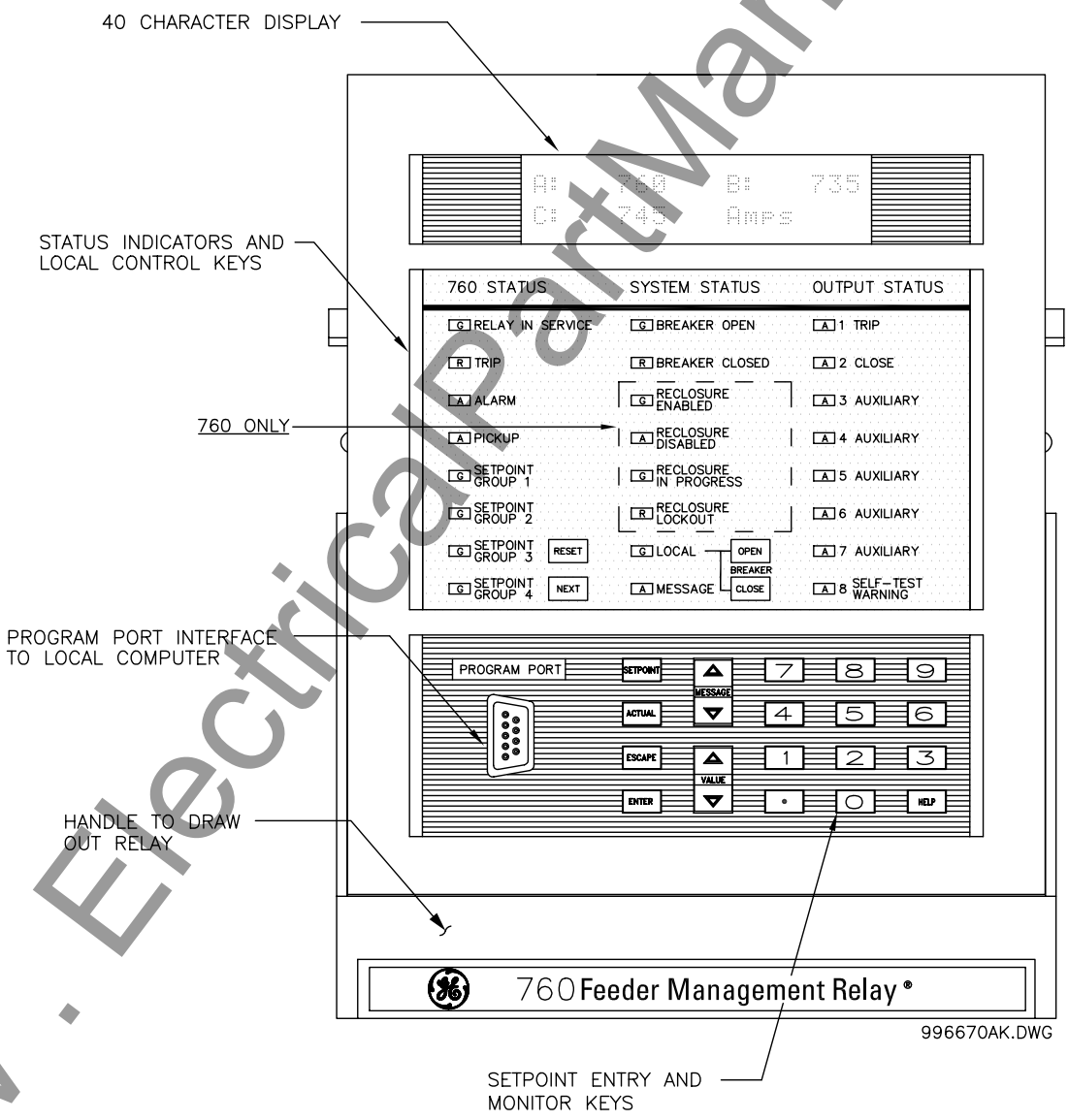


Figure 5–1: FRONT PANEL DESCRIPTION

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5.2.1 DESCRIPTION

The front panel indicators are grouped into three columns. The 750/760 STATUS column indicates the state of the relay, the SYSTEM STATUS column indicates the state of the breaker and the system, and the OUTPUT STATUS column indicates the state of the output relays. These LED indicators can be tested by pressing NEXT when no trips or alarms are active. As shown below, the color of each indicator conveys its importance.

G = Green	General Condition
A = Amber	Alert Condition
R = Red	Serious Alarm or Important Status

5.2.2 750/760 STATUS INDICATORS

RELAY IN SERVICE: This indicator will be on continuously if the relay is functioning normally and no major self-test errors have been detected. During operation the relay continuously performs various self tests and if a major self-test fails, the indicator will be turned off, all output relays will be de-energized, and the 8 SELF-TEST WARNING status indicator will be turned on. This indicates a complete loss of protection. See the self-test warning section later in this chapter.

TRIP: This indicator flashes when the relay detects a trip condition and operates the 1 TRIP relay to open the breaker. After the initiating fault has been cleared, this LED can be turned off with a reset.

ALARM: While the relay is detecting an alarm condition, this indicator will flash. Even if latched output relays are programmed to operate with the alarm, the indicator will automatically turn off if the alarm condition clears. Such output relays will remain in the operated state until a reset is performed.

Note: Latched Alarm – While the relay is detecting an alarm condition, this indicator will flash. After the alarm condition clears, the indicator remains illuminated and can be turned off with a reset.

PICKUP: For the purpose of testing and calibration verification, this indicator will light steady when any protection feature has its pickup threshold exceeded. Eventually, if the fault condition persists, a trip will be issued by the relay. If the measured parameter drops below its pickup level, the indicator will turn off.

SETPOINT GROUP 1-4: These indicators are flashing if the corresponding group is selected for editing and/or display; they are continuously on if the corresponding group is providing settings for the protection elements.

5.2.3 SYSTEM STATUS INDICATORS

NOTE

THE OPEN AND CLOSED STATUS INDICATOR COLORS ARE INTERCHANGEABLE AT THE TIME OF PLACING A 750/760 ORDER.

BREAKER OPEN: When the breaker is open, this indicator will be on continuously.

BREAKER CLOSED: When the breaker is closed, this indicator will be on continuously.

Breaker status indication is based on the breaker 52a and 52b contacts. With both contacts wired to the relay, the closed status is determined by a closed 52a contact and the open status is determined by a closed 52b contact. If both 52a and 52b contacts are open, due to a breaker being racked out of the switchgear, both the BREAKER OPEN and BREAKER CLOSED indicators will be off.

With a single 52a contact, it is impossible to distinguish between a breaker open state and a racked out breaker. In both situations, the 52a contact will be open. With a single 52b contact, you cannot distinguish between a breaker closed state and a racked out breaker. Likewise, the 52b contact will be open for both situations. To clarify this ambiguity, the breaker connected function should be programmed to an additional logic input. When this additional input is closed, a single 52a or 52b contact will show both breaker states. When the breaker is racked out, this additional breaker connected input should be open. In this case, both breaker status indicators will be off.

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RECLOSURE ENABLED (760 ONLY): This indicator will be on continuously when autoreclosure is allowed to operate as programmed. This is when the autoreclose function setpoint is enabled, and if used, the block reclosure logic input is not asserted. Otherwise, this indicator will be off. Note that this indicator will always be in the opposite state of the RECLOSURE DISABLED indicator.

RECLOSURE DISABLED (760 ONLY): This indicator will be on continuously when autoreclosure is not allowed to operate as programmed. This is when the autoreclose function setpoint is disabled, or if used, the block reclosure logic input is asserted. Otherwise, this indicator will be off. Note that this indicator will always be in the opposite state of the RECLOSURE ENABLED indicator.

RECLOSURE IN PROGRESS (760 ONLY): If a trip initiates a reclosing sequence, this indicator will go on continuously during each of the programmed dead times.

RECLOSURE LOCKOUT (760 ONLY): If the programmed reclose sequence has progressed to a final lockout condition, this indicator will be on continuously. Lockout can be cleared by performing a reset.

LOCAL: This indicator turns on if the local mode function has been assigned a logic input which is asserted. In local mode, the front panel OPEN and CLOSE keys operate while the Remote Open and Remote Close logic input functions will not operate. As well, the communication open and close commands have no effect.

MESSAGE: Under normal conditions, the default messages selected during setpoint programming are displayed. If any alarm or trip condition is generated, a diagnostic message overrides the displayed message and this indicator flashes. If there is more than one condition present, NEXT can be used to scroll through the messages. Pressing any other key return to the normally displayed messages. While viewing normally displayed messages, the MESSAGE indicator continues to flash if any diagnostic message is active. To return to the diagnostic messages from the normally displayed messages, press NEXT. Note that diagnostic messages for alarms disappear with the condition while diagnostic messages for trips remain until cleared by a reset.

5.2.4 OUTPUT STATUS INDICATORS

The 750 and 760 have eight output relays. 1 TRIP, 2 CLOSE, and 8 SELF-TEST WARNING have fixed operation while 3-7 AUXILIARY are configurable. Regardless of the mode of operation, the corresponding front panel indicator turns on while the output relay is signaling. If the non-operated state of an output relay is programmed as de-energized, the corresponding indicator will be on when the normally open contacts are closed. If the non-operated state of an output relay is programmed as energized, the corresponding indicator will be on when the normally open contacts are open.

1 TRIP: A trip sequence can be initiated by a protection element, a logic input element, a remote open command, a serial open command, or a front panel open command. When started, the 1 TRIP indicator turns on briefly while the 1 TRIP relay is energized. After the auxiliary breaker contacts indicate that the breaker has opened, the 1 TRIP relay and indicator stop operating. If both 52a and 52b auxiliary contacts are not installed, the 1 TRIP relay and indicator will de-energize 100 ms after the trip condition clears, or after two seconds.

2 CLOSE: A close sequence can be initiated by a 760 reclosure or a remote, serial, or front panel close command. When started, the 2 CLOSE indicator turns on briefly while the 2 CLOSE relay energizes. After the auxiliary breaker contacts indicate that the breaker has closed, the 2 CLOSE relay and indicator stop operating. If both 52a and 52b auxiliary contacts are not installed, the 2 CLOSE relay and indicator operate for 200 ms.

3-7 AUXILIARY: These relays are intended for customer specific requirements that can be initiated by any protection element or function whose RELAYS (3-7) setpoint has “3”, "4", "5", "6", or "7" selected. The 3-7 AUXILIARY indicators will turn on while the corresponding relays are operating.

8 SELF-TEST WARNING: During normal operation, this indicator is off with the fail-safe 8 SELF-TEST WARNING relay energized. If any abnormal condition is detected during self monitoring (such as a hardware failure) the indicator turns on and the relay de-energizes. If control power is lost or the relay is drawn out of its case, the 8 SELF-TEST WARNING relay signals loss of protection by de-energizing, but the electronic LED indicator remains off. Since there are no shorting contacts across the 8 SELF-TEST WARNING relay, both the normally open and normally closed contacts are open when the relay is drawn out.

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5.3.1 DESCRIPTION

The 750/760 display messages are organized into pages under the headings Setpoints and Actual Values. The SETPOINT key navigates through the page headers of programmable parameters (Setpoints). The ACTUAL key navigates through the page headers of measured parameters (Actual Values). Each page is broken down further into logical subpages of messages. The MESSAGE ▼ and MESSAGE ▲ keys are used to navigate through the subpages. A summary of the setpoints and actual values pages can be found in the Chapters 7: SETPOINTS and 6: ACTUAL VALUES, respectively.

The ENTER key is dual purpose. It is used to enter the subpages and to store altered setpoint values into memory to complete the change. The ESCAPE key is also dual purpose. It is used to exit from subpages and also to abort a setpoint change.

The VALUE ▼ and VALUE ▲ keys are used to scroll through the possible choices of an enumerated setpoint. They also decrement and increment numerical setpoints. Numerical setpoints may also be entered through the numeric keypad.

The HELP key may be pressed at any time to display a list of context sensitive help messages. Continue to press the HELP key to display all the help messages and return to the original display.

The RESET key will reset any latched conditions that are not presently active. This includes resetting latched output relays, latched TRIP indicators, breaker operation failure, and trip / close coil failures. The 760 autoreclose scheme is also reset with the shot counter being returned to zero and the lockout condition being cleared.

The NEXT key scrolls through any active conditions in the relay. Diagnostic messages are displayed indicating the state of protection and monitoring elements that are picked up, operating, or latched. When the MESSAGE indicator light is on there are messages to be viewed with the NEXT key.

Pressing the OPEN key will attempt to open the breaker connected to the 1 TRIP relay by closing the contact. Likewise, the CLOSE key will attempt to close the breaker connected to the 2 CLOSE relay by closing the contact. The OPEN and CLOSE keys only operate when the relay is in local mode; local mode can be enabled with a user programmed logic input.

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5.4.1 DIAGNOSTIC MESSAGES

Diagnostic messages are automatically displayed for any active conditions in the relay such as trips, alarms, or asserted logic inputs. These messages provide a summary of the present state of the relay. The MESSAGE indicator flashes when there are diagnostic messages available; press the NEXT key to scroll through the messages. The following shows the format of the various diagnostic messages.

■ PICKUP: <Φ> ■ < Cause >	These messages show any elements that are presently picked up.
■ TRIP: <Φ> ■ < Cause >	These messages indicate that an element has tripped. The message remains in the diagnostic queue until the relay is reset.
■ ALARM: <Φ> ■ < Cause >	These messages show any elements that are presently operating and have been programmed to have an alarm function. When an element is programmed to Latched Alarm, this message remains in the diagnostic queue after the alarm condition clears until the relay is reset.
■ SELF-TEST WARNING: ■ < Cause >	These messages show any self-test warnings.

5.4.2 SELF-TEST WARNINGS

The relay performs self diagnostics at initialization (after power-up), and continuously as a background task to ensure that every testable unit of the hardware and software is alive and functioning correctly. There are two types of self-test warnings indicating either a minor or major problem. Minor problems indicate a problem with the relay that does not compromise protection of the power system. Major problems indicate a very serious problem with the relay which comprises all aspects of relay operation.



SELF-TEST WARNINGS MAY INDICATE A SERIOUS PROBLEM WITH THE RELAY HARDWARE!

Upon detection of either a minor or major problem, the relay will:

- De-energize the 8 SELF-TEST WARNING relay.
- Indicate the failure in the diagnostic message queue.
- Record the failure in the EVENT RECORDER.

Upon detection of a major problem, the relay will (if possible) also:

- Turn off the RELAY IN SERVICE indicator.
- Inhibit operation of all output relays.

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Table 5–1: SELF-TEST WARNINGS

ERROR	SEVERITY	DESCRIPTION
A/D Virtual Ground	Major	This warning is caused by a failure of the analog to digital converter. The integrity of system input measurements is affected by this failure.
Analog Output +32V	Minor	Caused by the loss of the +32 V DC power supply used to power analog outputs. Analog output currents are affected by this failure.
Clock Not Set	Minor	Occurs if the clock has not been set.
Dry Contact +32V	Minor	Caused by the loss of the +32 V DC power supply used to power dry contacts of logic inputs. Logic inputs using internal power are affected by this failure.
EEPROM Corrupt	Major	This warning is caused by detection of corrupted location(s) in the relay data memory which cannot be self-corrected. Any function of the relay is susceptible to malfunction from this failure.
Factory Service	Major	This warning occurs when the relay is in factory service mode.
FLASH Corrupt	Major	This warning is caused by detection of a corrupted location in the program memory as determined by a CRC error checking code. Any function of the relay is susceptible to malfunction from this failure.
Force Analog Out	Minor	Occurs when the setpoint **FORCE ANALOG OUTPUTS FUNCTION** is set to *Enabled*.
Force Relays	Minor	Occurs when the setpoint **FORCE OUTPUT RELAYS FUNCTION** is set to *Enabled*.
Internal RS485	Minor	Caused by a failure of the internal RS485 communication link. Attempts to read Actual Values or write Setpoints will produce unpredictable results.
Internal Temp	Minor	Caused by the detection of unacceptably low (less than –40°C) or high (greater than +85°C) temperatures detected inside the unit.
IRIG-B Failure	Minor	This warning is caused when IRIG-B time synchronization has been enabled but the signal cannot be decoded.
Not Calibrated	Minor	This warning occurs when the relay has not been factory calibrated.
Pickup Test	Minor	Occurs when the setpoint **PICKUP TEST FUNCTION** is set to *Enabled*.
Prototype Software	Minor	Occurs when prototype software has been loaded into the relay.
Relay Not Ready	Minor	This warning occurs when the installation setpoint **750/760 OPERATION** has not been set to *Ready*.
RTC Crystal	Minor	This warning is caused by a failure of the Real Time Clock circuit. The ability of the relay to maintain the current date and time is lost.
Simulation Mode	Minor	This warning occurs when the simulation feature of the relay is active.

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5.5.1 DESCRIPTION

Flash messages are warning, error, or general information messages displayed in response to certain key presses. The length of time these messages remain displayed can be programmed in **S1 RELAY SETUP \ FRONT PANEL \ FLASH MESSAGE TIME**. The factory default flash message time is 4 seconds.

■ ADJUSTED VALUE ■ HAS BEEN STORED	This flash message is displayed in response to the ENTER key, while on a setpoint message with a numerical value. The edited value had to be adjusted to the nearest multiple of the step value before it was stored.
■ COMMAND IS BEING ■ EXECUTED	This flash message is displayed in response to executing a command message. Entering *Yes* at a command message will display the message "ARE YOU SURE?". Entering *Yes* again will perform the requested command and display this flash message.
■ DEFAULT MESSAGE ■ HAS BEEN ADDED	This flash message is displayed in response to pressing the . key, followed by the ENTER key twice, on any setpoint or actual value message in the subgroup **S1 \ RELAY SETUP \ DEFAULT MESSAGES**
■ DEFAULT MESSAGE ■ HAS BEEN REMOVED	This flash message is displayed in response to pressing the . key, followed by the ENTER key twice, on one of the selected default messages in the subgroup **S1 \ RELAY SETUP \ DEFAULT MESSAGES**
■ ENTER PASSCODE ■ IS INVALID	This flash message is displayed in response to an incorrectly entered passcode when attempting to enable or disable setpoint access.
■ ENTRY MISMATCH - ■ CODE NOT STORED	This flash message is displayed while changing the programmed password from the command message **S1 RELAY SETUP \ PASSCODE \ CHANGE PASSCODE?**. If the passcode entered at the stage "PLEASE RE-ENTER A NEW PASSCODE" is different from the one entered at the stage "PLEASE ENTER A NEW PASSCODE:", the relay will not store the entered passcode and display this flash message
■ INVALID KEY: MUST ■ BE IN LOCAL MODE	This flash message is displayed in response to pressing the OPEN or CLOSE keys while the relay is in REMOTE mode. The relay must be put into LOCAL mode in order for these keys to be operational.
■ NEW PASSCODE HAS ■ BEEN STORED	This flash message is displayed in response to changing the programmed passcode from the command message **S1 RELAY SETUP \ PASSCODE \ CHANGE PASSCODE?**. The directions to change the passcode were followed correctly and the new passcode was stored as entered.
■ NEW SETPOINT HAS ■ BEEN STORED	This flash message is displayed in response to the ENTER key while on any setpoint message. The edited value was stored as entered.
■ NO CONDITIONS ARE ■ CURRENTLY ACTIVE	This flash message is displayed in response to the NEXT key while the MESSAGE indicator is off. There are no active conditions to display in the diagnostic message queue.

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■ OUT OF RANGE - ■ VALUE NOT STORED	This flash message is displayed in response to the ENTER key while on a setpoint message or numerical value. The edited value was either less than the minimum or greater than the maximum acceptable values for the edited setpoint and as a result was not stored.
■ PLEASE ENTER A ■ NON-ZERO PASSCODE	This flash message is displayed while changing the passcode from the command message **S1 RELAY SETUP \ PASSCODE \ CHANGE PASSCODE?**. An attempt was made to change the passcode to "0" when it was already "0".
■ PRESS [ENTER] TO ■ ADD AS DEFAULT	This flash message is displayed for 5 seconds in response to pressing the . key, followed by the ENTER key while displaying any setpoint or actual value message except those in the subgroup **S1 RELAY SETUP \ DEFAULT MESSAGES**. Pressing the ENTER key again while this message is displayed adds the setpoint or actual value message to the default list.
■ PRESS [ENTER] TO ■ BEGIN TEXT EDIT	This flash message is displayed in response to the VALUE ▼ and VALUE ▲ keys while on a setpoint message with a text entry value. The ENTER key must be pressed to begin editing.
■ PRESS [ENTER] TO ■ REMOVE MESSAGE	This flash message is displayed for 5 seconds in response to pressing the . key, followed by the ENTER key while displaying one of the selected default messages in the subgroup **S1 RELAY SETUP \ DEFAULT MESSAGES**. Pressing the ENTER key again while this message is displayed removes the default message from the list.
■ PRESSED KEY ■ IS INVALID HERE	This flash message is displayed in response to any pressed key that has no meaning in the current context.
■ RESETTING LATCHED ■ CONDITIONS	This flash message is displayed in response to the NEXT key. All active latched conditions (trips, alarms, or latched relays) for which the activating condition is no longer present will be cleared.
■ SETPOINT ACCESS ■ DENIED (PASSCODE)	This flash message is displayed in response to the ENTER key while on any setpoint message. Setpoint access is restricted because the programmed passcode has not been entered to allow access.
■ SETPOINT ACCESS ■ DENIED (SWITCH)	This flash message is displayed in response to the ENTER key while on any setpoint message. Setpoint access is restricted because the setpoint access terminals have not been connected.
■ SETPOINT ACCESS ■ IS NOT ALLOWED	This flash message is displayed in response to correctly entering the programmed passcode at the command message **S1 RELAY SETUP \ PASSCODE \ ALLOW ACCESS TO SETPOINTS?**. The command to allow access to setpoints has been successfully executed and setpoints can be changed and entered.
■ SETPOINT ACCESS ■ IS NOW RESTRICTED	This flash message is displayed in response to entering the correct programmed passcode at the message **S1 RELAY SETUP \ PASSCODE \ RESTRICT ACCESS TO SETPOINTS?**. The command to restrict access to setpoints has been successfully executed and setpoints cannot be changed.

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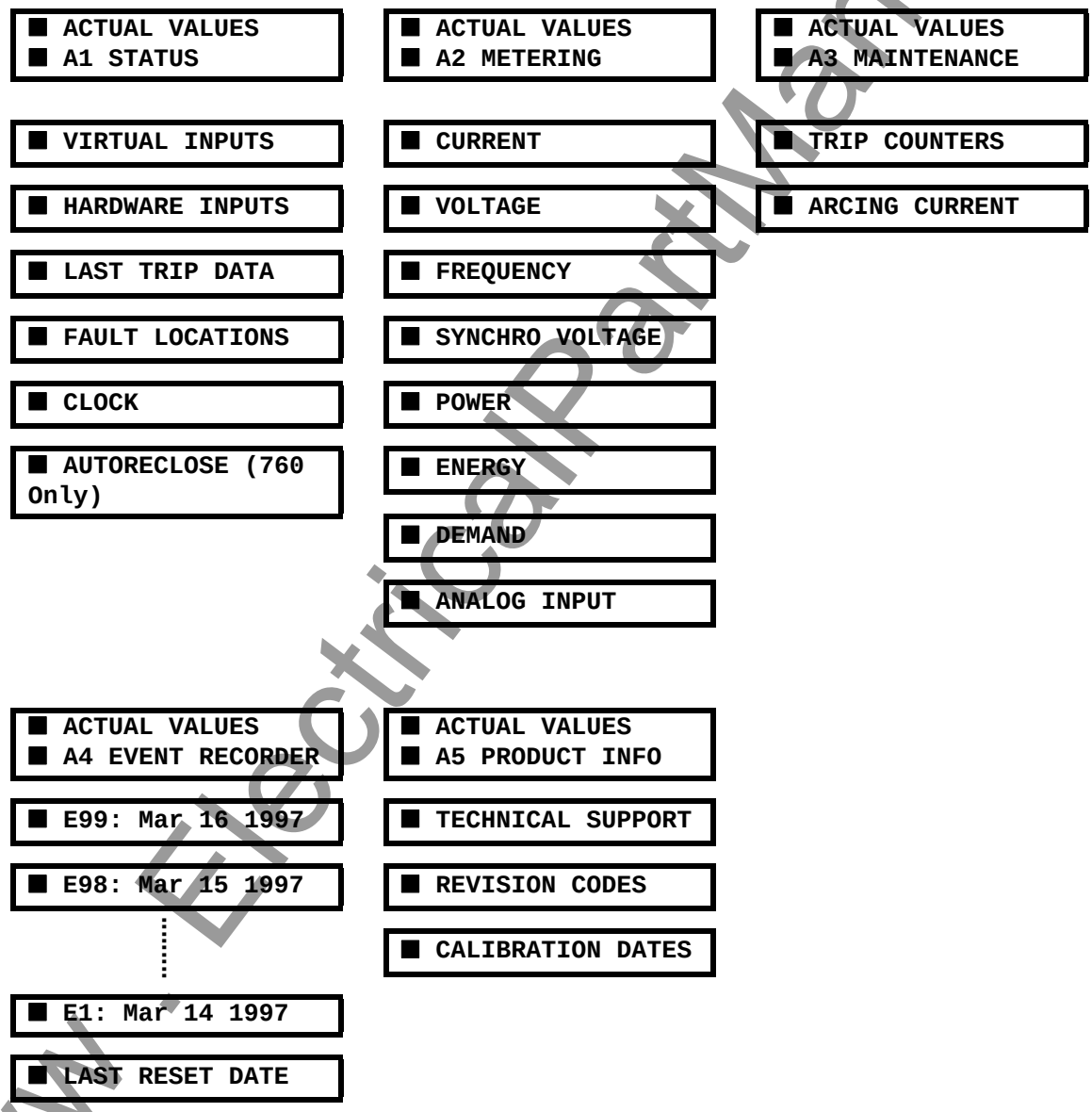
6.1.1 DESCRIPTION

Measured values, maintenance, and fault analysis information are accessed in the actual values mode. Actual value messages are organized into logical groups, or pages, for easy reference as shown in the summary below. All actual value messages are illustrated and described in blocks throughout this chapter.

Actual values may be accessed by any of the following methods.

1. Front panel, using the keys and display.
2. Front program port, and a portable computer running the 750/760 PC program supplied with the relay.
3. Rear RS485/RS422 COM 1 port or RS485 COM 2 port with a SCADA system running user written software.

Table 6–1: ACTUAL VALUES MESSAGE SUMMARY



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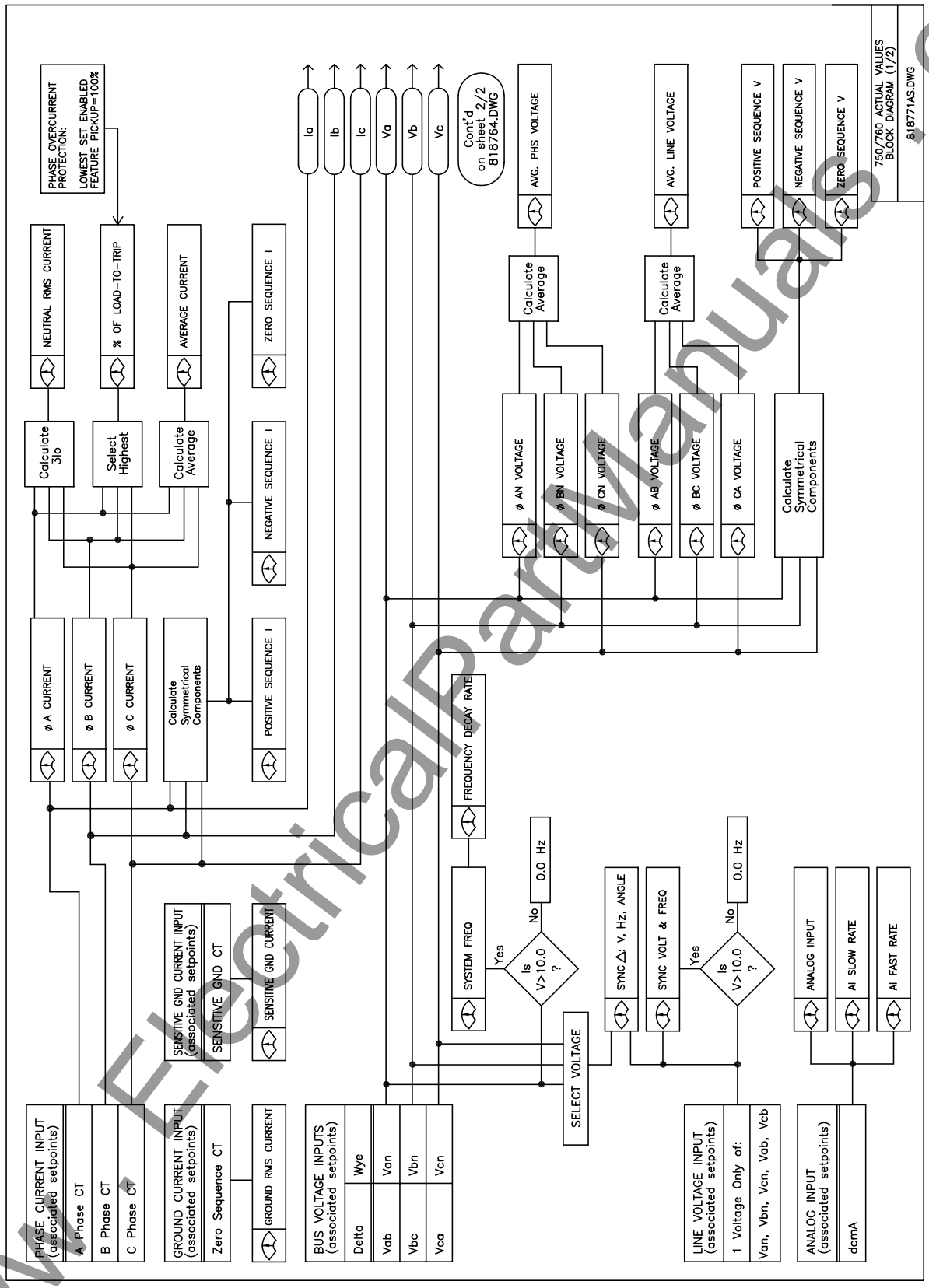


Figure 6–1: ACTUAL VALUES BLOCK DIAGRAM (1 OF 2)

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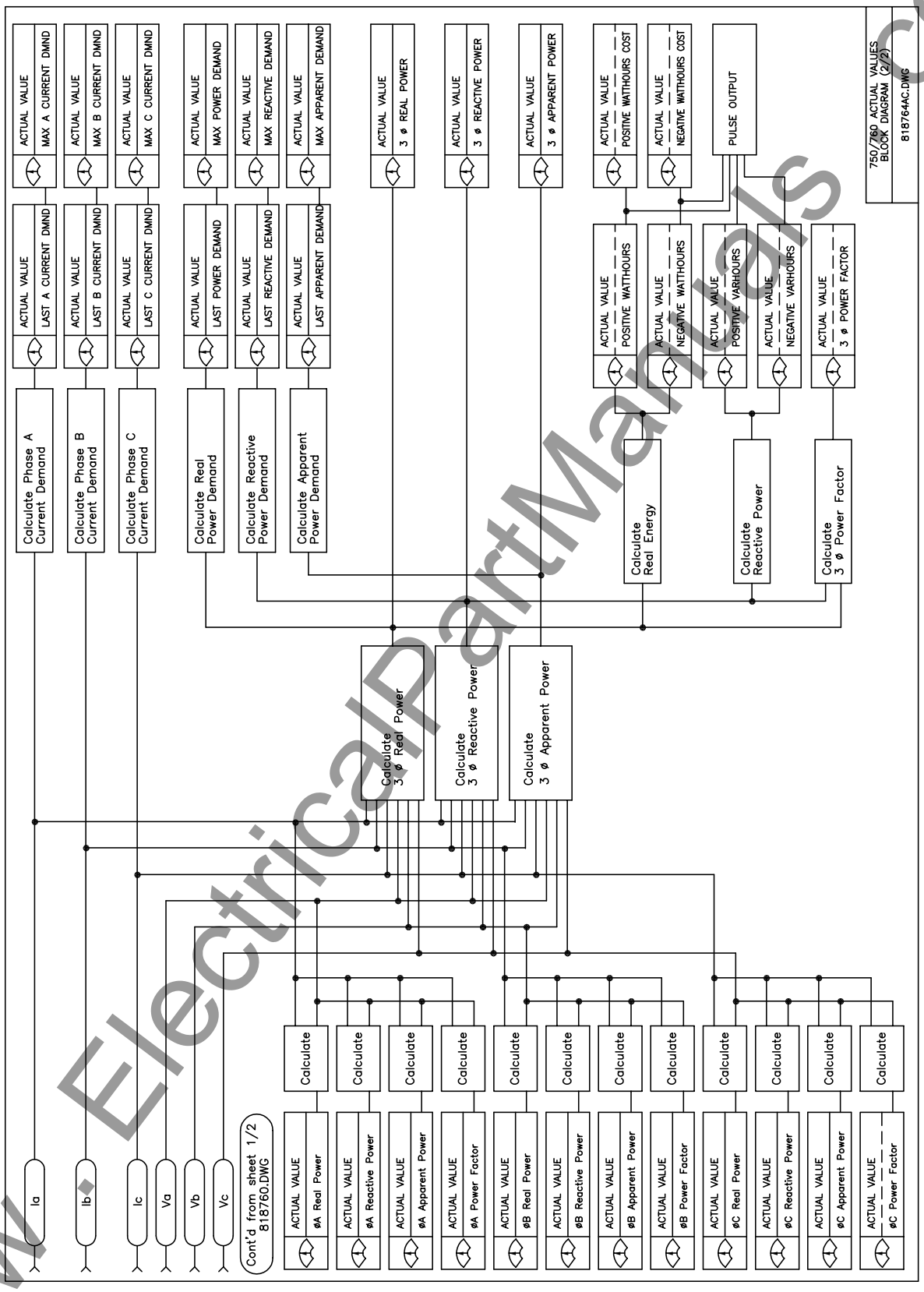


Figure 6–2: ACTUAL VALUES BLOCK DIAGRAM (2 OF 2)

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6.2.1 DESCRIPTION

Some status information is displayed by the front panel indicators. More status details can be viewed from the first page of actual values. This information includes time and date, the state of virtual and hardware logic inputs, data captured at the time of the last trip, fault locator data, and autoreclosure scheme data for 760 users.

6.2.2 VIRTUAL INPUTS

The state of all active virtual inputs as well as the ability to set their state is displayed here. In some applications, these displays can be used instead of panel switches for controlling operations within the relay. The ability to have user defined names for the inputs allows the operator interface to be easily understood. See Chapter 10: S3 LOGIC INPUTS for complete details on virtual inputs, their setpoints and application.

■ VIRTUAL INPUTS ■ [ENTER] for more	The Virtual Inputs path is: **\ ACTUAL VALUES \ A1 STATUS \ VIRTUAL INPUTS**
2 VIRTUAL INPUTS ARE ACTIVE	This message displays how many logic inputs have a virtual condition selected as part of their asserted logic. Refer to setpoint messages under **S3 LOGIC INPUTS \ LOGIC INPUT SETUP.**
Logic Input 1 Off	*Range: On, Off* Displays and allows setting the state of virtual input 1. The **Logic Input 1** display heading is user programmable. Only 'active' virtual inputs are displayed; active virtual inputs are those that have their **INPUT X ASSERTED LOGIC** setpoint programmed to monitor the state of the virtual input. There are subsequent displays for the remaining virtual inputs.

6.2.3 HARDWARE INPUTS

These messages display the state of all hardware inputs.

■ HARDWARE INPUTS ■ [ENTER] for more	The Hardware Inputs actual values path is: **\ ACTUAL VALUES \ A1 STATUS \ HARDWARE INPUTS**
CONTACT 1 STATE: Open	This message displays the state of contact input #1. Similar messages appear sequentially for contact inputs 2 through 14.
SETPOINT ACCESS STATE: Open	This message displays the state of the setpoint access jumper.
Trip Coil Monitor STATE: Open	This message displays the state of the trip or close coil circuit connected to the Coil Monitor 1 input. Note: the name programmed under **S6 MONITORING \ EQUIPMENT \ COIL 1 MONITOR \ COIL 1 MONITOR NAME** will be displayed on the top line.
Close Coil Monitor STATE: Open	This message displays the state of the trip or close coil circuit connected to the Coil Monitor 2 input. Note: the name programmed under **S6 MONITORING \ EQUIPMENT \ COIL 2 MONITOR \ COIL 2 MONITOR NAME** will be displayed on the top line.

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6.2.4 LAST TRIP DATA

Independent of the event recorder, the relay captures the system information at the time of the last trip event. This information includes a time and date stamp, trip cause, phase current, ground current, sensitive ground current, neutral current, voltages, system frequency, and the analog input. If more than one protection element trips for a fault (e.g. both phase and neutral instantaneous overcurrent 1) then only the first trip event detected by the relay will have Last Trip Data captured. This information cannot be cleared; data for a new trip overwrites the previous trip data.

■ LAST TRIP DATA ■ [ENTER] for more	The Last Trip Data actual values path is: **\ ACTUAL VALUES \ A1 STATUS \ LAST TRIP DATA**
DATE OF LAST TRIP: Mar 16 1997	This message displays the date of the event.
TIME OF LAST TRIP 12:34:56.789	This message displays the time of the event.
TRIP: <Φ> < Cause >	This message displays the cause of the last trip along with the phases that were involved. See Section 6.5: A4 EVENT RECORDER on page 6–18 for more details on causes of events.
A: 0 B: 0 C: 0 Amps	This message displays the values of the three phase currents at the moment of the event.
GROUND CURRENT: 0 A	This messages displays the value of the ground current, measured via the ground current input, at the moment of the event.
SENSTV GND CURRENT: 0.00 A	This message displays the value of the sensitive ground current, measured via the sensitive ground current input, at the moment of the event.
NEUTRAL CURRENT: 0 A	This message displays the calculated value of the neutral current at the moment of the event.
AN: 0.00 BN: 0.00 CN: 0.00 kVolts	This message displays the value of the three phase voltages at the moment of the event. This message is displayed only if **S2 SYSTEM SETUP \ BUS VT SENSING \ VT CONNECTION TYPE** is “Wye.”
AB: 0.00 BC: 0.00 CA: 0.00 kVolts	This message displays the value of the three line voltages at the moment of the event. If **S2 SYSTEM SETUP \ BUS VT SENSING \ VT CONNECTION TYPE** is *None*, this message displays 0 for all voltages. If **S2 SYSTEM SETUP \ BUS VT SENSING \ VT CONNECTION TYPE** is *Wye*, this message is not displayed
NEUTRAL VOLTAGE: 0.00 kV	This message displays the calculated value of neutral voltage at the moment of the event.
SYSTEM FREQUENCY: 0.00 Hz	This message displays the value of the system frequency at the moment of the event.
ANALOG INPUT 0 µA	This message displays the value of the analog input current at the moment of the event.

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6.2.5 FAULT LOCATIONS

The data for each of ten faults detected by overcurrent elements is stored under headings beginning with FAULT LOCATION 0. This information cannot be cleared; data for new events is always stored as fault 0. The data for each previous fault is shifted to the next highest number, and event 9 is discarded.

■ FAULT LOCATIONS ■ [ENTER] for more	The Fault Locations actual values path is: **\ ACTUAL VALUES \ A1 STATUS \ FAULT LOCATIONS**
■ FAULT LOCATION 0 ■ [ENTER] FOR MORE	The Fault Location 0 actual values path is: **\ ACTUAL VALUES \ A1 STATUS \ FAULT LOCATION 0**
DATE OF FAULT 0 Mar 16 1997	This message displays the date stamp of fault location 0.
TIME OF FAULT 0 12:34:56.789	This message displays the time stamp of fault location 0.
TYPE OF FAULT: n/a	This message displays the type of fault as determined by the fault locator. The message is displayed only if a fault location calculation has been performed.
DISTANCE TO FAULT: 0.00 km	This message displays the calculated distance to the fault, as determined by the fault locator, in the units selected. The message can only be displayed if a fault location calculation has been performed.
Zpos (INDUCTIVE): OHM TO FAULT: 0.00	This message displays the calculated impedance from the relay location to the fault, as determined by the fault locator, in actual Ohms. The message can only be displayed if a fault location calculation has been performed.

6.2.6 CLOCK

■ CLOCK ■ [ENTER] for more	The Clock actual values path is: **\ ACTUAL VALUES \ A1 STATUS \ CLOCK**
CURRENT DATE: November 23 1998	The current date is displayed. If the date has never been programmed, this message will display “Unavailable”.
CURRENT TIME: 16:30:00	The current time is displayed. If the time has never been programmed, the message will display “Unavailable”.

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6.2.7 AUTORECLOSE (760 ONLY)

■ AUTORECLOSE ■ [ENTER] for more	The Autoreclose actual values path is: **\ ACTUAL VALUES \ A1 STATUS \ AUTORECLOSE**
AUTORECLOSE SHOT NUMBER IN EFFECT: 0	The present shot number which the autoreclose scheme is using to control protection settings is displayed in this message. If the scheme has reached Lockout, the display is the shot number after which a trip caused lockout.
AUTORECLOSE SHOTS REMAINING	This message displays the number of reclose shots that can still be performed. After this point, the reclose system will be either reset or locked-out. The value displayed in this message is the value contained in the Shot Limit memory. Each time a reclose shot is performed, in a given sequence, this Shot Limit is reduced by one. The Shot Limit can also be reduced to any given value less than the programmed value by the current supervision function.
AUTORECLOSE SHOT RATE: 0 /hr	The number of reclosures in the past hour. This value will be cleared by a **RESET AR RATE DATA** command via the front panel or communications.
AUTORECLOSE SHOT COUNT: 0	The total number of reclosures since the **AR SHOT COUNT LAST RESET** date.
AR SHOT COUNT LAST RESET: Oct 25 1998	This message displays the last date the Autoreclose counter data was cleared. If the date has never been programmed, this message will display “Unavailable.”

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6.3.1 DESCRIPTION

The relay measures all RMS currents and voltages, frequency, and an auxiliary analog input. Other values like average & neutral current, average line & phase voltage, symmetrical components, frequency decay rate, synchrocheck delta, power factor, power (real, reactive, apparent), energy (real, reactive), running & maximum demands (current, real power, reactive power, apparent power), and analog input rate of change are derived. All quantities are recalculated every power system cycle and perform protection and monitoring functions. Displayed metered quantities are updated approximately 3 times a second for readability. All phasors and symmetrical components are referenced to the A-N voltage phasor for wye-connected VTs; to the A-B voltage phasor for delta-connected VTs; or to the phase A current phasor when no voltage signals are present.

6.3.2 CURRENT

Phase current magnitudes, phasors, and sequence components are displayed as shown below.

■ CURRENT ■ [ENTER] for more	The Current actual values path is: **\ ACTUAL VALUES \ A2 METERING \ CURRENT**
A: 0 B: 0 C: 0 Amps	Displays the RMS magnitudes of phase A, B, and C currents together in one message.
% OF LOAD-TO-TRIP: 0 %	Displays the ratio of highest phase current to lowest overcurrent pickup level.
AVERAGE CURRENT: 0 A	Displays the calculated average of the phase A, B, and C RMS currents. $I_{avg} = \frac{(\lvert I_a \rvert + \lvert I_b \rvert + \lvert I_c \rvert)}{3}$
PHASE A CURRENT: 0 A 0° Lag	Displays the measured phase A current RMS phasor
PHASE B CURRENT: 0 A 0° Lag	Displays the measured phase B current RMS phasor
PHASE C CURRENT: 0 A 0° Lag	Displays the measured phase C current RMS phasor
NEUTRAL CURRENT: 0 A 0° Lag	Displays the calculated neutral current RMS phasor: $3I_0 = I_a + I_b + I_c$
GROUND CURRENT: 0 A 0° Lag	Displays the measured ground current RMS phasor.
SENSTV GND CURRENT: 0.00 A 0° Lag	Displays the measures sensitive ground current RMS phasor.
POS SEQ CURRENT: 0 A 0° Lag	Displays the calculated positive sequence current RMS phasor. $I_{a1} = \frac{I_a + aI_b + a^2I_c}{3}$ for ABC phase sequence $I_{a1} = \frac{I_a + a^2I_b + aI_c}{3}$ for ACB phase sequence

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NEG SEQ CURRENT: **0 A 0° Lag**	Displays the calculated negative sequence current RMS phasor. $I_{a2} = \frac{I_a + a^2 I_b + a I_c}{3}$ for ABC phase sequence $I_{a2} = \frac{I_a + a I_b + a^2 I_c}{3}$ for ACB phase sequence
ZERO SEQ CURRENT: **0 A 0° Lag**	Displays the calculated zero sequence current RMS phasor. $I_{a0} = \frac{I_a + I_b + I_c}{3}$
POLARIZING CURRENT: **0 A 0° Lag**	Displays the measured polarizing current RMS phasor.

6.3.3 VOLTAGE

Line and phase voltage magnitudes and phasors for the bus VT inputs are displayed along with sequence components. All messages pertaining to phase voltages A-N, B-N, and C-N are only displayed if the **VT CONNECTION TYPE** setpoint is programmed to *wye*.

■ **VOLTAGE** ■ **[ENTER] for more**	The Voltage actual values path is: **\ ACTUAL VALUES \ A2 METERING \ VOLTAGE**
AB: 0.00 BC: 0.00 **CA: 0.00 kVolts**	Displays the RMS line voltage magnitudes together in one message.
AVERAGE LINE **VOLTAGE: 0.00 kV**	Displays the calculated average of the RMS line voltages. $V_{avg} = \frac{\lvert V_{ab}\rvert + \lvert V_{bc}\rvert + \lvert V_{ca}\rvert}{3}$
AN: 0.00 BN: 0.00 **CN: 0.00 kVolts**	Displays the RMS phase voltage magnitudes together in one message.
AVERAGE PHASE **VOLTAGE: 0.00 kV**	Displays the calculated average of the RMS line voltages. $V_{avg} = \frac{\lvert V_{an}\rvert + \lvert V_{bn}\rvert + \lvert V_{cn}\rvert}{3}$
LINE A-B VOLTAGE: **0.00 kV 0° Lag**	Displays the measured A-B RMS voltage phasor
LINE B-C VOLTAGE: **0.00 kV 0° Lag**	Displays the measured B-C RMS voltage phasor
LINE C-A VOLTAGE: **0.00 kV 0° Lag**	Displays the measured C-A RMS voltage phasor
PHASE A-N VOLTAGE: **0.00 kV 0° Lag**	Displays the measured A-N RMS voltage phasor
PHASE B-N VOLTAGE: **0.00 kV 0° Lag**	Displays the measured B-N RMS voltage phasor
PHASE C-N VOLTAGE: **0.00 kV 0° Lag**	Displays the measured C-N RMS voltage phasor

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NEUTRAL VOLTAGE: 0.00 kV 0° Lag	Displays the calculated neutral RMS phasor. $3V_0 = V_a + V_b + V_c$
POS SEQ VOLTAGE: 0 A 0° Lag	Displays the calculated positive sequence voltage RMS phasor. $V_{a1} = \frac{V_a + aV_b + a^2V_c}{3}$ for ABC phase sequence $V_{a1} = \frac{V_a + a^2V_b + aV_c}{3}$ for ACB phase sequence
NEG SEQ VOLTAGE: 0 A 0° Lag	Displays the calculated negative sequence voltage RMS phasor. $V_{a2} = \frac{V_a + a^2V_b + aV_c}{3}$ for ABC phase sequence $V_{a2} = \frac{V_a + aV_b + a^2V_c}{3}$ for ACB phase sequence
ZERO SEQ VOLTAGE: 0 A 0° Lag	Displays the calculated zero sequence current RMS phasor. $V_{a0} = \frac{V_a + V_b + V_c}{3}$

6.3.4 FREQUENCY

Frequency is measured with a zero-crossing detector from the Va voltage. Frequency and frequency decay will read zero if the potential across the Va input terminals is less than 10 Volts.

■ FREQUENCY ■ [ENTER] for more	The Frequency actual values path is: **\ ACTUAL VALUES \ A2 METERING \ FREQUENCY**
SYSTEM FREQUENCY 0.00 Hz	Displays the frequency of the power system. This is the frequency used for frequency tracking as discussed in Section 1.3.3: FREQUENCY TRACKING on page 1–16.
FREQUENCY DECAY RATE: 0.00 Hz/s	Displays the frequency decay rate. When the value is positive, the frequency is decreasing; when the value is negative, the frequency is increasing.

6.3.5 SYNCHRONIZING VOLTAGE

The voltage magnitude, phase angle, frequency, and delta values for the line VT synchronizing voltage input are displayed as shown below.

■ SYNCHRO VOLTAGE ■ [ENTER] for more	The Synchronizing Voltage actual values path is: **\ ACTUAL VALUES \ A2 METERING \ SYNCHRO VOLTAGE**
SYNCHRO VOLTAGE: 0.00 kV 0° Lag	Displays the measured RMS voltage phasor of the line VT input.
SYNCHRO FREQUENCY: 0.00 Hz	Displays the measured frequency of the line VT input. The display will read zero if the potential across the line VT input terminals is less than 10.0 volts.
SYNCHRO DELTA: 0° 0.00 kV 0.00 Hz	Displays the differences of phase position, voltage magnitude, and frequency between the line VT input and its corresponding bus VT input

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6.3.6 POWER

The relay calculates and displays the real, reactive, and apparent power of the system. Both three phase and single phase quantities are given. The relationship of these power quantities is illustrated in the power plane, as shown in the power quantity relationships figure that follows. If the setpoint **VT CONNECTION TYPE** is set to *none*, all three phase quantities are displayed as zero and all single phase quantities disappear. All power quantities auto-range to show units appropriate to the nominal power which is defined as:

P_N = Phase CT Primary × VT Secondary Voltage × VT Ratio.

Table 6–2: POWER QUANTITIES

NOMINAL POWER (P_N)	POWER UNITS	RESOLUTION
P_N < 1 MVA	kW, kvar, kVA, kWhr, kvarhr	1
1 MVA ≤ P_N < 10 MVA	MW, Mvar, MVA, MWhr, Mvarh	0.01
10 MVA ≤ P_N	MW, Mvar, MVA, MWhr, Mvarh	0.1

■ POWER ■ [ENTER] for more	The Power actual values path is: **\ ACTUAL VALUES \ A2 METERING \ POWER**
3Φ REAL POWER: 0.0 MW	This message displays the three phase real power.
3Φ REACTIVE POWER: 0.0 Mvar	This message displays the three phase reactive power.
3Φ APPARENT POWER 0.0 MVA	This message displays the three phase apparent power.
3Φ POWER FACTOR: 0.00	This message displays the three phase power factor as lagging or leading.
ΦA REAL POWER 0.0 MW	This message displays phase A real power. Similar power messages appear for phase B and C.
ΦA REACTIVE POWER 0.0 Mvar	This message displays phase A reactive power. Similar power messages appear for phase B and C.
ΦA APPARENT POWER 0.0 MVA	This message displays phase A apparent power. Similar power messages appear for phase B and C.
ΦA POWER FACTOR: 0.00	This message displays phase A power factor as leading or lagging. Similar power messages appear for phase B and C.

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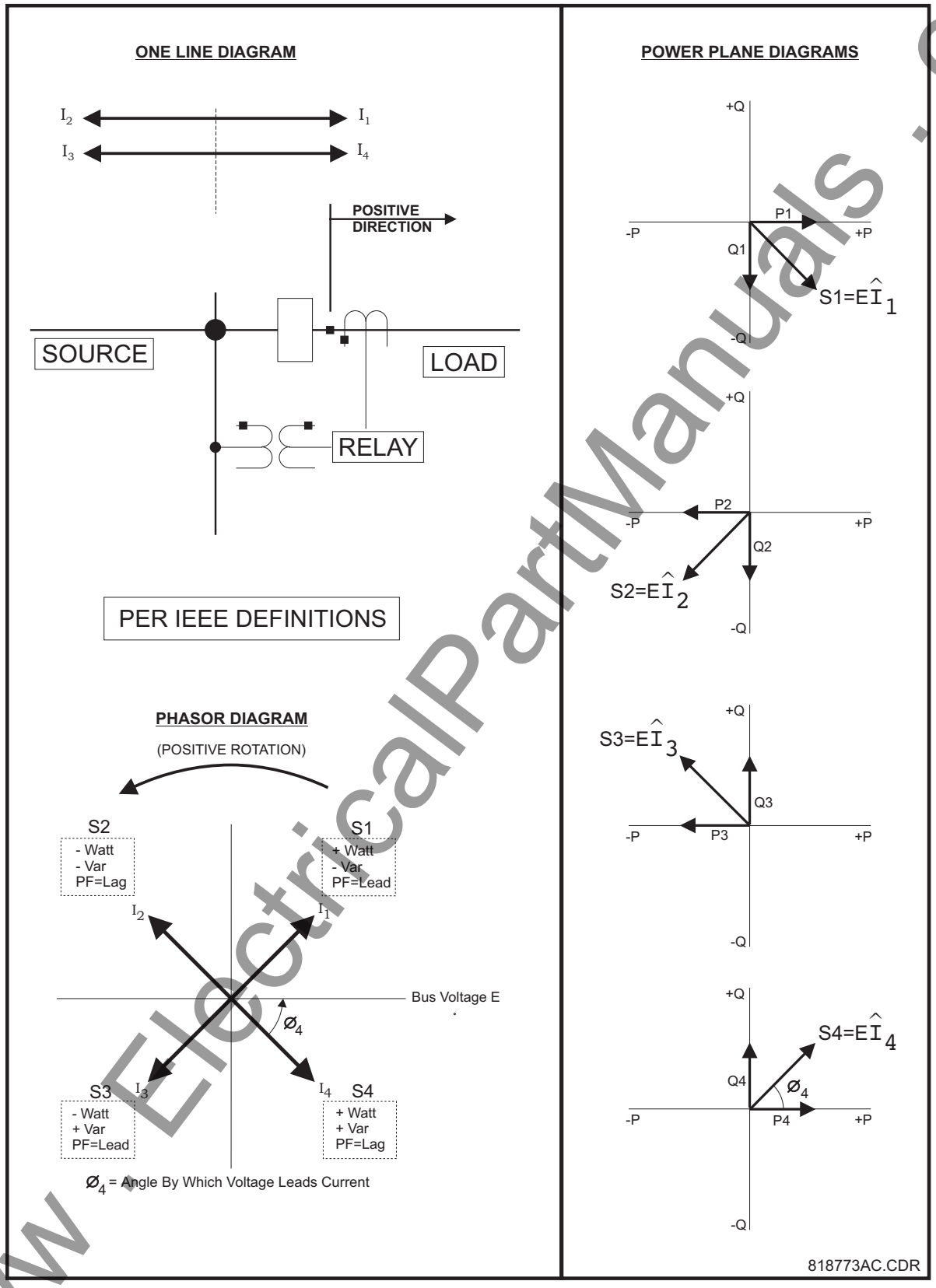


Figure 6–3: POWER QUANTITY RELATIONSHIPS

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6.3.7 ENERGY

The relay uses three phase power quantities to determine total energy consumption. All energy quantities can be reset to zero with the **CLEAR ENERGY USE DATA?** command found in setpoint heading **S1 RELAY SETUP \ CLEAR DATA**. Energy cost is also calculated based on the average billing rate programmed in the setpoint **S2 SYSTEM SETUP \ POWER SYSTEM \ COST OF ENERGY**. Although billing rate structures are usually more complex, these values provide approximate costs. Energy quantities auto-range to show units appropriate to the nominal power.

NOTE: The 750/760 is *not* a revenue class meter and cannot be used for billing purposes.

■ ENERGY ■ [ENTER] for more	The Energy actual values path is: **\ ACTUAL VALUES \ A2 METERING \ ENERGY**
POSITIVE WATTHOURS: 0.0 MWh	This message displays the positive watthours. Real power in the positive direction will add to this accumulated value. Real power opposite to this direction will add to the **NEGATIVE WATTHOURS** value.
POSTIVE WATTHOUR COST: $ 0	This message displays the approximate cost of the positive watthours.
NEGATIVE WATTHOURS: 0.0 MWh	This message displays the negative watthours. Real power in the negative direction will add to this accumulated value. Real power opposite to this direction will add to the **POSITIVE WATTHOURS** value.
NEGATIVE WATTHOUR COST: $ 0	This message displays the positive watthours. Real power in the positive direction will add to this accumulated value. Real power opposite to this direction will add to the **NEGATIVE WATTHOURS** value.
POSTIVE WATTHOUR COST: $ 0	This message displays the approximate cost of the negative watthours.
POSITIVE VARHOURS: 0.0 Mvarh	This message displays the positive varhours. Reactive power in the positive direction will add to this accumulated value. Reactive power opposite to this direction will add to the **NEGATIVE VARHOURS** value.
NEGATIVE VARHOURS: 0.0 Mvarh	This message displays the negative varhours. Reactive power in the negative direction will add to this accumulated value. Reactive power opposite to this direction will add to the **POSITIVE VARHOURS** value.
ENERGY USE DATA LAST RESET: Mar 16 1997	This message displays the last date the energy use data was cleared.

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6.3.8 DEMAND

The relay measures current demand on each phase, and average three phase demand for real, reactive, and apparent power. These parameters can be monitored to reduce supplier demand penalties or for statistical metering purposes. Demand calculations are based on the measurement type selected under **S6 MONITORING \ DEMAND**. For each quantity, the relay displays the demand over the most recent demand time interval, the maximum demand since the last maximum demand reset, and the time and date stamp of this maximum demand value. Maximum demand quantities can be reset to zero with the **CLEAR MAX DEMAND DATA?** command found under setpoint heading **S1 RELAY SETUP \ CLEAR DATA**.

a) PHASE A CURRENT DEMAND

■ DEMAND ■ [ENTER] for more	The Demand actual values path is: **\ ACTUAL VALUES \ A2 METERING \ DEMAND**
■ PHASE A CURRENT ■ [ENTER] for more	The Phase A Current Demand actual values path is: **\ ACTUAL VALUES \ A2 METERING \ DEMAND \ PHASE A CURRENT**
LAST PHASE A CURRENT DEMAND: 0 A	This message displays the phase A current demand over the most recent time interval.
MAX PHASE A CURRENT DEMAND: 0 A	This message displays the maximum phase A current demand since the **DEMAND DATA LAST RESET** date.
MAX PHASE A CURRENT DATE: Mar 16 1997	This message displays the date of the last maximum phase A current demand occurrence
MAX PHASE A CURRENT TIME: 16:30:00	This message displays the time of the last maximum phase A current demand occurrence.

Actual values displays for Phase B Current Demand, Phase C Current Demand, Real Power Demand, Reactive Power Demand, and Apparent Power Demand are not shown here. They are similar to those for Phase A Current Demand.

b) LAST RESET DATE

■ DEMAND ■ [ENTER] for more	The Demand actual values path is: **\ ACTUAL VALUES \ A2 METERING \ DEMAND**
■ LAST RESET DATE ■ [ENTER] for more	The Last Reset Date actual values path is: **\ ACTUAL VALUES \ A2 METERING \ DEMAND \ LAST RESET DATE**
DEMAND DATA LAST RESET: Mar 16 1997	This message displays the last date the maximum demand data was cleared. If the date has never been programmed, this relay will display 'Unavailable'.

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6.3.9 ANALOG INPUT

The relay provides the ability to monitor any external quantity via an auxiliary current input called the analog input.

■ ANALOG INPUT ■ [ENTER] for more	The Analog Input actual values path is: **\ ACTUAL VALUES \ A2 METERING \ ANALOG INPUT**
ANALOG INPUT: 0 µA	This message displays the scaled value of the analog input, as defined in **S6 MONITORING \ ANALOG INPUT \ ANALOG INPUT SETUP**. In this actual values display, the name programmed in setpoint message **S6 MONITORING \ ANALOG INPUT \ ANALOG INPUT SETUP \ ANALOG INPUT NAME** will be displayed instead of the factory default 'ANALOG INPUT'. The name of the units programmed in the setpoint message **S6 MONITORING \ ANALOG INPUT \ ANALOG INPUT SETUP \ ANALOG INPUT UNITS** will be displayed instead of the factory default 'µA'.
ANALOG INPUT: 0 µA /min	This message displays the analog input rate of change per minute.
ANALOG INPUT: 0 µA /hour	This message displays the analog input rate of change per hour.

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6.4.1 TRIP COUNTERS

Trip counters are used for scheduling inspections on equipment, for performing qualitative analysis of system problems, and for spotting trends. Any trip condition will increment the **BREAKER TRIPS** counter and one of the more specific trip counters available. A trip condition is generated by any feature or input which signals the 1 TRIP relay to operate. If the logic input assigned to the **BLOCK BREAKER STATISTICS** function is active, when a trip condition is generated, the trip counters will not be incremented. Trip counter data can be reset to zero with the **S1 RELAY SETUP \ INSTALLATION \ RESET TRIP COUNTER DATA?** command.

■ TRIP COUNTERS ■ [ENTER] for more	The Trip Counters actual values path is: **\ ACTUAL VALUES \ A3 MAINTENANCE \ TRIP COUNTERS**
BREAKER TRIPS: 0	The total number of breaker trips as detected by the 52a/b contacts since the **TRIP COUNTERS LAST RESET** date.
GROUND OC TRIPS: 0	The total number of ground overcurrent trips since the **TRIP COUNTERS LAST RESET** date.
SENSTV GND OC TRIPS 0	The total number of sensitive ground overcurrent trips since the **TRIP COUNTERS LAST RESET** date.
NEUTRAL OC TRIPS: 0	The total number of neutral overcurrent trips since the **TRIP COUNTERS LAST RESET** date.
NEG SEQ OC TRIPS: 0	The total number of negative sequence overcurrent trips since the **TRIP COUNTERS LAST RESET** date.
1ϕ PHASE OC TRIPS: 0	The total number of single phase overcurrent trips since the **TRIP COUNTERS LAST RESET** date.
2ϕ PHASE OC TRIPS: 0	The total number of two phase overcurrent trips since the **TRIP COUNTERS LAST RESET** date.
3ϕ PHASE OC TRIPS: 0	The total number of three phase overcurrent trips since the **TRIP COUNTERS LAST RESET** date.
TRIP COUNTERS LAST RESET: Mar 16 1997	This message displays the last date the trip counter data was cleared. If the date has never been programmed, this message will display 'Unavailable'.

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6.4.2 ARCING CURRENT

The relay calculates an estimate of the per-phase wear on the breaker contacts. Arcing current data can be reset to zero with the **S1 RELAY SETUP \ INSTALLATION \ RESET ARCING CURRENT DATA?** command.

■ ARCING CURRENT ■ [ENTER] for more	The Arcing Current actual values path is: **\ ACTUAL VALUES \ A2 MAINTENANCE \ ARCING CURRENT**
TOTAL ARCING CURRENT ΦA: 0 kA²-cycle	This message displays the total accumulated phase A arcing current, in kA^2-cycle, since the **ARCING CURRENT LAST RESET** date.
TOTAL ARCING CURRENT ΦB: 0 kA²-cycle	This message displays the total accumulated phase B arcing current, in kA^2-cycle, since the **ARCING CURRENT LAST RESET** date.
TOTAL ARCING CURRENT ΦC: 0 kA²-cycle	This message displays the total accumulated phase C arcing current, in kA^2-cycle, since the **ARCING CURRENT LAST RESET** date.
ARCING CURRENT LAST RESET: Mar 16 1997	This message displays the last date the total arcing current data was cleared. If the date has never been programmed, the relay will display 'Unavailable'.

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6.5.1 DESCRIPTION

The 750/760 has an event recorder which runs continuously, capturing and storing the last 128 events. All event recorder information is stored in non-volatile memory so the information is maintained after losing relay control power.

6.5.2 EVENT RECORDS

The last 128 events are displayed with the newest event first and the oldest event last. Each event has a header message which contains a summary of the event that occurred. Each event is assigned an event number equal to the number of events that have occurred since the recorder was cleared; the event number is incremented for each new event. Event recorder data can be cleared with the **S1 RELAY SETUP \ CLEAR DATA \ CLEAR EVENT RECORDER DATA?** command.

Event information is gathered at the instant the event occurs which means the current and voltage readings may reflect the transient nature of the event as opposed to steady state values. All messages pertaining to phase voltages A-N, B-N, and C-N are only displayed if the **VT CONNECTION TYPE** setpoint is programmed to *wye*. If the **VT CONNECTION TYPE** setpoint is programmed to *delta*, line voltages A-B, B-C, and C-A are displayed. The following example shows the display messages for a single event.

■ E1234: Mar 16 1997 ■ [ENTER] for more	This is the heading message for a single event; it displays the event number, date, and cause of the event that occurred. To view more information regarding the event press the ENTER key. To view other events press the MESSAGE ▲ and MESSAGE ▼ keys.
TIME OF EVENT: 16:30:00.000	Displays the time of the event with millisecond resolution.
<Type of Event>: <Cause of Event>	Displays the type and cause of event. See Section 6.5.4: EVENT TYPES on page 6–20 for more details on the format of this display message.
PHASE A CURRENT: 0 A 0° Lag	Displays the phase A current phasor at the moment of the event.
PHASE B CURRENT: 0 A 0° Lag	Displays the phase B current phasor at the moment of the event.
PHASE C CURRENT: 0 A 0° Lag	Displays the phase C current phasor at the moment of the event.
GROUND CURRENT: 0 A 0° Lag	Displays the ground current phasor at the moment of the event.
SENSTV GND CURRENT: 0 A 0° Lag	Displays the sensitive ground current phasor at the moment of the event.
LINE A-B VOLTAGE: 0.00 kV 0° Lag	Displays the A-B voltage phasor at the moment of the event.
LINE B-C VOLTAGE: 0.00 kV 0° Lag	Displays the B-C voltage phasor at the moment of the event.

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LINE C-A VOLTAGE: 0.00 kV 0° Lag	Displays the C-A voltage phasor at the moment of the event.
PHASE A-N VOLTAGE: 0.00 kV 0° Lag	Displays the A-N voltage phasor at the moment of the event.
PHASE B-N VOLTAGE: 0.00 kV 0° Lag	Displays the B-N voltage phasor at the moment of the event.
PHASE C-N VOLTAGE: 0 A 0° Lag	Displays the C-N voltage phasor at the moment of the event.
SYSTEM FREQUENCY: 0.00 Hz	Displays the value of the system frequency at the moment of the event.
SYNCHRO VOLTAGE: 0.00 kV 0° Lag	Displays the RMS voltage phasor of the line VT input at the moment of the event.
SYNCHRO FREQUENCY 0.00 Hz	Displays the frequency of the line VT input at the moment of the event.
ANALOG INPUT: 0 µA	Displays the value of the analog input at the moment of the event.

6.5.3 LAST RESET DATE

After the header message for the last event is a message indicating when the event recorder was last cleared.

■ LAST RESET DATE ■ [ENTER] for more	The event recorder Last Reset Date actual values path is: **\ ACTUAL VALUES \ A4 EVENT RECORDER \ LAST RESET DATE**
EVENT RECORDER LAST RESET: Mar 16 1997	Displays the date the event recorder was last cleared

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6.5.4 EVENT TYPES

Events are organized into several different types as shown in the following table of Event Messages. Several of the event types can be filtered out in order to save space in the event recorder. See **S1 RELAY SETUP \ EVENT RECORDER** and chapter 7 for more details on event filtering. For every event type there are a number of possible causes. The Event Cause tables list all the event causes according to which event types they can generate.

The following symbols are used in the description of the event messages:

< Cause > This represents the cause of an event from one of the following event cause tables.

< Φ > This represents the phases involved (e.g. ϕBC) in the event if applicable.

(CV) This indicates whether a contact (C) and/or virtual (V) input triggered the logic input.

< ON > This represents whether the logic input is asserted (ON) or not asserted (OFF).

< User Text > This represents user defined text which is programmed by the user for logic inputs.

The Event Messages are shown below:

< Cause >	**General Events** These are events that occur when a specific operation takes place
PICKUP: <Φ> **< Cause >**	**Pickup Events** These are events that occur when a protection element picks up and starts timing
TRIP: <Φ> **< Cause >**	**Trip Events** These are events that occur when an element whose function has been programmed to *Trip* or *Trip & AR* operates.
ALARM: <Φ> **< Cause >**	**Alarm Events** These are events that occur when an element whose function has been programmed to *Alarm* operates or drops out.
CONTROL: <Φ> **< Cause >**	**Control Events:** These are events that occur when an element whose function has been programmed to Control operates or drops out.
DROPOUT: **< Cause >**	**Dropout Events** These are events that occur when a protection element drops out after a corresponding pickup event.
INPUT(CV) <ON>: **< Cause >**	**Contact / Virtual Input Events** These are events that occur when an input is either asserted or de-asserted. The letter(s) in parentheses indicate whether the event was caused by an input contact (C), a virtual input (V) or both (CV). The cause is equal to the name of the function that is invoked by the logic input.
SELF-TEST WARNING **< Cause >**	**Self-Test Warning Events** These are events that occur when a self-test warning is detected or one of the manual testing features is enabled.

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a) GENERAL EVENT CAUSES

Control Power Off	Clear Energy Use	Reclosure 1	Transfer Initiated
Control Power On	Clear Max Demand	Reclosure 2	Transfer Not Ready
Breaker Opened	Clear Event Record	Reclosure 3	Cls From Transfer
Breaker Closed	Reset Trip Counter	Reclosure 4	Trip From Transfer
Breaker Not Connected	Reset Arc Current	Reclosure Lockout	Group 1 Active
Reset	Display Message	Shots Reduced to 3	Group 2 Active
Open Breaker	Trigger Trace	Shots Reduced to 2	Group 3 Active
Close Breaker	Trigger Data Log	Shots Reduced to 1	Group 4 Active
Set Time	Reset AR Count	Shots Reduced to L/O	
Set Date	Reset AR Shot Rate	Autoreclose Reset	

b) PICKUP / TRIP / ALARM / LATCHED ALARM / CONTROL EVENT

Phase Time OC 1	Phase Dir Reverse	Phase Current Level	Analog Threshold 1
Phase Time OC 2	Neutral Dir Reverse	Neutral Current Level	Analog Threshold 2
Phase Inst OC 1	Neg Seq Dir Reverse	Overfrequency	Analog Rate 1
Phase Inst OC 2	Sens Gnd Dir Reverse	Out of Sync	Analog Rate 2
Ground Time OC	Ground Dir Reverse	Power Factor 1	Trip Counter
Ground Inst OC	Bus Undervoltage 1	Power Factor 2	Arcing Current
Senstv Gnd Time OC	Bus Undervoltage 2	Current Demand	Breaker Failure
Senstv Gnd Inst OC	Line Undervoltage 3	Real Power Demand	Breaker Operation
Neutral Time OC 1	Line Undervoltage 4	Reactive Power Demand	*** Trip Coil Monitor
Neutral Time OC 2	Overvoltage 1	Apparent Power Demand	*** Close Coil Monitor
Neutral Inst OC 1	Overvoltage 2	Neutral Displacement	** Pulse Output
Neutral Inst OC 2	Underfrequency 1	UVolt Restore Init	VT Failure
Neg Seq Time OC	Underfrequency 2	UFreq Restore Init	* User Input A -T
Neg Seq Inst OC	Frequency Decay	Manual Close Block	Autoreclose Rate
	Neg Seq Voltage	Cold Load P/U Block	

***** For user inputs A -T the user defined name is displayed.
****** The pulse output quantity name is displayed.
******* The coil monitor name is displayed.

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c) LOGIC INPUT EVENT CAUSES

52a Contact	Block 1 TRIP	Block Neutral OC	Selected To Trip
52b Contact	Block 2 CLOSE	Block Phase Time OC 1	UV On Other Source
Breaker Connected	Block Reset	Block Phase Time OC 2	Incomer 1 Closed
Local Mode	Block Undervolt 1	Block Phase Inst OC 1	Incomer 2 Closed
Remote Reset	Block Undervolt 2	Block Phase Inst OC 2	Bus Tie Connected
Remote Open	Block Undervolt 3	Block Gnd Time OC	Bus Tie Closed
Remote Close	Block Undervolt 4	Block Gnd Inst OC	Block Transfer
Cold Load Pickup	Block Underfreq 1	Block Neutral Time OC 1	Xmfr Lockout
	Block Underfreq 2	Block Neutral Time OC 2	Source Trip
Setpoint Group 2	Block Freq Decay	Block Neutral Inst OC 1	Cls From Incomer 1
Setpoint Group 3	Block Neg Seq Volt	Block Neutral Inst OC 2	Cls From Incomer 2
Setpoint Group 4	Block Restoration	Block Neg Seq Inst	Simulate Fault
Trigger Data Log	Block Trip Count	Block Neg Seq Time	Initiate Reclosure
Trigger Trace	Bypass Synchrochk	Block Sens Gnd OC	Cancel Reclosure
*User Input A -T	Block All OC	Block Sens Gnd Time OC	Block Reclosure
	Block Phase OC	Block Sens Gnd Inst OC	Block Neutral Disp
Start Demand Interval	Block Ground OC		

* For user inputs A-T, the user defined name is displayed.

d) WARNING EVENT CAUSES

Force Relays	A/D Virtual Ground	Dry Contact +32V	Relay Not Ready
Force Analog Out	EEPROM Corrupt	Clock Not Set	Not Calibrated
Simulation Mode	FLASH Corrupt	Prototype Software	RTC Crystal
Pickup Test	Factory Service	Internal RS485	
IRIG-B Failure	Analog Output +32V	Internal Temp	

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6.6.1 DESCRIPTION

This page specifies product information including hardware revision and configuration, software revision, and serial number. Also included are the manufacturing and calibration dates. This information is intended for GE Power Management service personnel. It also has information on where to obtain Technical Support.

6.6.2 TECHNICAL SUPPORT

■ TECHNICAL SUPPORT ■ [ENTER] for more	The Technical Support actual values path is: **\ ACTUAL VALUES \ A5 PRODUCT INFO \ TECHNICAL SUPPORT**
GE Power Management 215 Anderson Ave	This message displays the manufacturer's address.
Markham, Ontario. Canada, L6E 1B3	This message displays the manufacturer's address.
Tel: (905) 294-6222 Fax: (905) 201-2098	This message displays the manufacturer's telephone and fax number.
Internet Address: GEindustrial.com/pm	This message displays the GE Power Management internet address.

6.6.3 REVISION CODES

■ REVISION CODES ■ [ENTER] for more	The Revision Codes actual values path is: **\ ACTUAL VALUES \ A5 PRODUCT INFO \ REVISION CODES**
GE Power Management 750 REVISION 4.00	This message displays the product name and software revision.
HARDWARE REVISION: H	This message displays the hardware revision of the relay.
SOFTWARE REVISION: 400	This message displays the software revision of the relay.
VERSION NUMBER: 000	This message displays the version number of the relay, indicating any special modification number.
ORDER CODE: 760- P5-G5-S5-HI-A20-R	This message displays the installed options and is the order code of the relay.
BOOTWARE REVISION: 300	This message displays the revision number of the boot software.
SERIAL NUMBER: A2872001	The product serial number is an eight digit alphanumeric value.
MANUFACTURING DATE: Oct 25 1997	This is the date the relay passed the final test at the factory.

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6.6.4 CALIBRATION DATES

■ CALIBRATION DATES ■ [ENTER] for more	The Calibration Dates actual values path is: **\ ACTUAL VALUES \ A5 PRODUCT INFO \ CALIBRATION DATES**
FACTORY CALIBRATION DATE: Oct 25 1997	This message displays the date the relay was calibrated at the factory.
LAST CALIBRATION DATE: Oct 25 1997	This message displays the date calibration parameters were last modified.

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7.1.1 MESSAGE SUMMARY

The 750/760 has a considerable number of programmable setpoints which makes it extremely flexible. The setpoints have been grouped into a number of pages and sub-pages as shown below. Each page of setpoints (e.g. **S2 SYSTEM SETUP**) has a chapter which describes in detail all the setpoints found on that page.

Table 7–1: SETPOINTS MESSAGE SUMMARY

SETPOINTS S1 RELAY SETUP	SETPOINTS S2 SYSTEM SETUP	SETPOINTS S3 LOGIC INPUTS	SETPOINTS S4 OUTPUT RELAYS
PASSCODE	CURRENT SENSING	LOGIC INPUTS SETUP	1 TRIP RELAY
COMMUNICATIONS	BUS VT SENSING	BREAKER FUNCTIONS	2 CLOSE RELAY
CLOCK	LINE VT SENSING	CONTROL FUNCTIONS	3 AUXILIARY
EVENT RECORDER	POWER SYSTEM	USER INPUTS	4 AUXILIARY
TRACE MEMORY	FLEXCURVE A	BLOCK FUNCTIONS	5 AUXILIARY
DATA LOGGER	FLEXCURVE B	BLOCK OC FUNCTIONS	6 AUXILIARY
FRONT PANEL		TRANSFER FUNCTIONS	7 AUXILIARY
DEFAULT MESSAGES		RECLOSE FUNCTIONS †	
USER TEXT MESSAGES		MISC FUNCTIONS	
CLEAR DATA			
INSTALLATION			

SETPOINTS S5 PROTECTION	SETPOINTS S6 MONITORING	SETPOINTS S7 CONTROL	SETPOINTS S8 TESTING
PHASE CURRENT	PHASE CURRENT	SETPOINT GROUPS	OUTPUT RELAYS
NEUTRAL CURRENT	POWER FACTOR	SYNCHROCHECK	PICKUP TEST
GROUND CURRENT	FAULT LOCATOR	MANUAL CLOSE	ANALOG OUTPUTS
SENSTV GND CURRENT	DEMAND	COLD LOAD PICKUP	SIMULATION
NEGATIVE SEQUENCE	ANALOG INPUT	UNDERVOLT RESTORE	FACTORY SERVICE
VOLTAGE	ANALOG OUTPUTS	UNDERFREQ RESTORE	
FREQUENCY	OVERFREQUENCY	TRANSFER	
BREAKER FAILURE	EQUIPMENT	AUTORECLOSE †	
	PULSE OUTPUT		

† 760 only

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7.2.1 DESCRIPTION

Prior to operating the relay on a feeder, setpoints defining system characteristics, inputs, relay outputs, and protection settings must be entered, via one of the following methods:

1. Front panel, using the keys and display.
2. Front program port, and a portable computer running the 750/760 PC program supplied with the relay.
3. Rear RS485/RS422 COM1 port or RS485 COM2 port and a SCADA system running user-written software.

Any of these methods can be used to enter the same information. A computer, however, makes entry much easier. Files can be stored and downloaded for fast, error free entry when a computer is used. To facilitate this process, a CD with the programming software 750/760 PC program is supplied with the relay.

The relay leaves the factory with setpoints programmed to default values, and it is these values that are shown in all the setpoint message illustrations. Many of these factory default values can be left unchanged.



At a minimum, the setpoints in page **S2 SYSTEM SETUP** must be entered for the system to function correctly. In order to safeguard against the installation of a relay whose setpoints have not been entered, the relay will display the *Relay Not Ready* self-test warning as shown below. In addition, the 8 SELF-TEST WARNING relay will be de-energized. Once the relay has been programmed for the intended application, setpoint **S1 RELAY SETUP \ INSTALLATION \ 760 OPERATION** should be changed from the factory default *Not Ready* to *Ready*.

```
■ SELF-TEST WARNING
■ Relay Not Ready
```

Some messages associated with disabled features are hidden. These context sensitive messages are illustrated with a dotted border on the message box. Before putting the relay in the *Ready* state, each page of setpoint messages should be worked through, entering values either by keypad or computer.

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7.3.1 DESCRIPTION

Hardware and passcode security features are designed into the relay to provide protection against unauthorized setpoint changes.

7.3.2 SETPOINT ACCESS JUMPER

To program new setpoints using the front panel keys a hardware jumper must be installed across the setpoint access terminals on the back of the relay. These terminals can be permanently wired to a panel mounted key switch if desired. Attempts to enter a new setpoint without the electrical connection across the setpoint access terminals will result in an error message. The jumper does not restrict setpoint access via serial communications.

7.3.3 PASSCODE SECURITY

The relay has a programmable passcode setpoint which may be used to disallow setpoint changes from both the front panel and the serial communications ports. This passcode consists of up to 8 alphanumeric characters.

The factory default passcode is “0”. When this specific value is programmed into the relay it has the effect of removing all setpoint modification restrictions. Therefore, only the setpoint access jumper can be used to restrict setpoint access via the front panel and there are no restrictions via the communications ports.

When the passcode is programmed to any other value, setpoint access is restricted for the front panel and all communications ports. Access is not permitted until the passcode is entered via the keypad (for the front panel) or is programmed into a specific register (via communications). Note that enabling setpoint access on one interface does not automatically enable access for any of the other interfaces (i.e., the passcode must be explicitly set in the relay via the interface from which access is desired).

A front panel command is available to disable setpoint access once all modifications are complete. For the communications ports, access may be disabled by writing an invalid passcode into the register previously used to enable setpoint access. In addition, setpoint access is automatically disabled on an interface if no activity is detected on that interface for a period of thirty minutes.

The 750/760 PC Program, included with the relay, incorporates a facility for programming the relay’s passcode as well as enabling/disabling setpoint access. For example, when an attempt is made to modify a setpoint but access is restricted, the program will prompt the user to enter the passcode and send it to the relay before the setpoint is actually written to the relay. If a SCADA system is used for relay programming, it is up to the programmer to incorporate appropriate security for the application.

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7.4.1 DESCRIPTION

To make the application of this device as simple as possible, similar methods of operation and therefore similar types of setpoints are incorporated in various features. Rather than repeat operation descriptions for this class of setpoint throughout the manual, a general description is presented in this overview. Details that are specific to a particular feature will be included in the discussion of the feature. The form and nature of these setpoints is described below.

(Feature Name) FUNCTION:	*Range: as shown for each feature* If Setting = *Disabled*: the feature is not operational If Setting = *Enabled*: the feature is operational. If Setting = *Trip*: the feature is operational. When an output is generated the feature will declare a "Trip" condition, which will operate the 1 TRIP relay and any other selected output relays, and display the appropriate trip message. If Setting = *Trip & AR* (Overcurrent features of 760 Only): the feature is operational. When an output is generated the feature will declare a "Trip" condition, which will operate the 1 TRIP relay and any other selected output relays; signal an "Initiate" to the autoreclose feature, and display the appropriate trip message. If Setting = *Alarm* or *Latched Alarm*: the feature is operational. When an output is generated the feature will declare an "Alarm" condition, which will operate any selected output relays, and display the appropriate alarm message. If Setting = *Control*: the feature is operational. When an output is generated the feature will operate any selected output relays.

The function settings of *Trip*, *Trip & AR*, *Alarm* and *Control* are also used to select those operations that will be stored in the Event Recorder.

(Feature Name) RELAYS (3-7):	*Range: Any Combination of the 3-7 AUXILIARY Relays* Selects the relays required to operate when the feature generates an output.
(Feature Name) PICKUP:	*Range: As shown for each feature.* Selects the threshold above (for over- elements) or below (for under- elements) which the measured parameter causes an output from the measuring element.
(Feature Name) DELAY:	*Range: As shown for each feature.* Selects a fixed time interval by which an input signal is delayed from appearing at the output.

From a contact input change of state to a contact closure of the 1 TRIP relay, the total delay is the time selected in this setpoint plus approximately 2 power frequency periods. From an AC parameter input level change measured by an instantaneous feature to a contact closure of the 1 TRIP relay, the total delay is the time selected in this setpoint plus approximately 2.5 power frequency periods. In both cases, auxiliary output relays are approximately 5 ms slower.

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(Feature Name) DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* This setpoint is available for overcurrent features which are subject to control from a directional element. If setting = *Disabled*: the element is allowed to operate for current flow in any direction. There is no supervision from the directional element. If setting = *Forward*: the element is allowed to operate for current flow in the forward direction only, as determined by the directional element. If setting = *Reverse*: the element is allowed to operate for current flow in the reverse direction only, as determined by the directional element.
PHASES REQUIRED FOR OPERATION: Any One	*Range: Any One, Any Two, All Three* This setpoint is available for those features which measure each phase parameter individually. If Setting = *Any One*: an output is generated if any one or more phase parameters are beyond the pickup setting. If Setting = *Any Two*: an output is generated if any combination of two or more phase parameters are beyond the pickup setting. If Setting = *All Three*: an output is generated if all three phase parameters are beyond the pickup setting.

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7.5.1 DESCRIPTION

The logic diagrams provided should be referred to for a complete comprehensive understanding of the operation of each feature. These sequential logic diagrams illustrate how each setpoint, input parameter, and internal logic is used in a feature to obtain an output. In addition to these logic diagrams, written descriptions are provided in the setpoints chapter which includes each feature.

7.5.2 SETPOINTS

- Shown as a block with a shaded heading labeled 'SETPOINT'.
- The location of setpoints is indicated by the path heading on the diagram.
- The exact wording of the displayed setpoint message identifies the setpoint.
- Major functional setpoint selections are listed below the name and are incorporated in the logic.

7.5.3 MEASUREMENT UNITS

- Shown as a block with an inset box labeled 'RUN'.
- The associated pickup or dropout setpoint is shown directly above.
- Element operation of the detector is controlled by the signal entering the 'RUN' inset. The measurement / comparison can only be performed if a logic '1' is provided at the 'RUN' input.
- Relationship between setpoint and input parameter is indicated by mathematical symbols: '<' (less than), '>' (greater than), etc.
- ANSI device number (if one exists) is indicated above the block.

7.5.4 TIME DELAYS

- Shown as a block with the following schematic symbol, |——|.
- If delay is adjustable, associated delay setpoint is shown directly above, and schematic symbol has an additional variability indication, an oblique bar.
- ANSI device number (62) is indicated above the block.

7.5.5 LED INDICATORS

- Shown as the following schematic symbol, ⊗.
- The exact wording of the front panel label identifies the indicator.

7.5.6 LOGIC

- Described using basic logic gates ('AND', 'OR', 'XOR', 'NAND', 'NOR', ...)
- The inverter symbol, a logical NOT, is shown as a circle, ❍.

7.5.7 CONDITIONS

- Shown as a rounded block with a shaded heading labeled 'CONDITION'.
- Conditions are mutually exclusive, i.e., only one condition can be active at any point in time.
- Conditions latch until another condition becomes active.
- The output of an active condition is 1 or logic high.

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8.1.1 DESCRIPTION

To program setpoints, besides the setpoint access jumper that must be installed on the rear terminals, a passcode must also be entered if the passcode security feature is enabled. When the relay is shipped from the factory the passcode is defaulted to '0'. When the passcode is '0', the passcode security feature is always disabled and only the setpoint access jumper is required for changing setpoints from the front panel.

8.1.2 SETTINGS

■ PASSCODE ■ [ENTER] for more	The PASSCODE setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ PASSCODE**
SETPOINT ACCESS: Allowed	*Range: Allowed, Restricted (Cannot Be Edited)* This indicates whether passcode protection is currently enabled.
RESTRICT ACCESS TO SETPOINTS? No	*Range: Yes, No* This message is only displayed when setpoint access is allowed and the current passcode is not '0'. Select *Yes* and follow directions to restrict setpoint access.
ALLOW ACCESS TO SETPOINTS? No	*Range: Yes, No* This message is only displayed when setpoint access is restricted. In this state, new setpoints cannot be entered. In order to regain setpoint access, select *Yes* and follow directions to enter the passcode that was previously programmed. If the passcode is correctly entered, entering new setpoints will be allowed. If no keys are pressed for longer than 30 minutes, setpoint access will automatically become restricted. Removing the setpoint access jumper will immediately restrict setpoint access. If passcode protection is active but the passcode is not known, the factory should be contacted with the encrypted passcode value.
CHANGE PASSCODE? No	*Range: Yes, No* To change the current passcode, select *Yes* and follow directions. Note that changing the passcode to '0', as it is when shipped from the factory, will disable the passcode security feature.
ENCRYPTED PASSCODE: AIKFBAIK	*Range: (Cannot Be Edited)* If the programmed passcode is not known, consult the factory service department with the 8 character word displayed.

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8.2.1 DESCRIPTION

Up to 32 devices can be daisy-chained with one of them a computer or programmable controller. Either COM1, the two wire RS485 or the four wire RS422 serial communication port, or COM2, the two wire RS485 port may be used. One relay can be connected directly to a personal computer via the front panel RS232 port with a standard, straight-through RS232 cable.

8.2.2 SETTINGS

■ PORT SETUP ■ [ENTER] for more	The Communications setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ COMMUNICATIONS \ PORT SETUP**
SLAVE ADDRESS: 1	*Range: 1 to 254 in steps of 1* Selects the serial communications slave address of the relay. Both COM1 and COM2 use this same address. The front panel RS232 port will accept any address for normal communications, but must be set to 1 when upgrading the relay firmware. Each relay on the same RS485/422 communications link must have a unique address.
COM1 RS485/422 BAUD RATE: 9600	*Range: 300, 1200, 2400, 4800, 9600, 19200* Select the baud rate for COM1, the RS485/RS422 communication port. All relays on the communication link, and the computer connecting them, must run at the same baud rate. The fastest response will be obtained at *19200* Baud. Slower baud rates should be used if noise becomes a problem. The data frame is fixed at 1 start, 8 data, and 1 stop bit.
COM1 RS485/422 PARITY: None	*Range: None, Odd, Even* Selects the parity for COM1.
COM1 RS485/422 HARDWARE: RS485	*Range: RS485, RS422* Selects the COM1 hardware configuration to be either two wire RS485 or four wire RS422 communications.
COM2 RS485/422 BAUD RATE: 9600	*Range: 300, 1200, 2400, 4800, 9600, 19200* Selects the baud rate for COM2, the rear terminal RS485 communication port.
COM2 RS485/422 PARITY: None	*Range: None, Odd, Even* Selects the parity for COM2.
FRONT RS232 BAUD RATE: 9600	*Range: 300, 1200, 2400, 4800, 9600, 19200* Selects the baud rate for front panel RS232 serial communications port. When upgrading the relay firmware, this rate should be set to *9600* Baud.
FRONT RS232 PARITY: None	*Range: None, Odd, Even* Selects the parity for the front RS232 port.

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8.3.1 DESCRIPTION

The relay can be programmed to communicate using the DNP Protocol through one of its ports. Refer to Section 16.5: DNP 3.0 DEVICE PROFILE on page 16–84 for details. The following setpoints configure the DNP Protocol within the relay.

8.3.2 SETTINGS

■ DNP CONFIGURATION ■ [ENTER] for more	The Communications setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ COMMUNICATIONS \ DNP CONFIGURATION**
DNP PORT: None	*Range: None, COM1, COM2, Front* Select which communications port will use the DNP protocol for communication. The default is to use the MODBUS protocol on all ports.
DNP POINT MAPPING Disabled	*Range: Enabled, Disabled* Select whether the User Map will be available through DNP. When enabled, the 120 User Map Values are included in the DNP Object 30 point list. See Section 16.5: DNP 3.0 DEVICE PROFILE on page 16–84.
TRANSMISSION DELAY: 0 ms	*Range: 0 to 65000 in steps of 1 ms* Select the minimum time from when a DNP request is received and a response issued. A value of zero causes the response to be issued as quickly as possible.
DATA LINK CONFIRM MODE: Never	*Range: Never, Sometimes, Always* Select the data link confirmation mode desired for responses sent by the 750/760. When *Sometimes* is selected, data link confirmation is only requested when the response contains more than one frame.
DATA LINK CONFIRM TIMEOUT: 1000 ms	*Range: 0 to 65000 in steps of 1 ms* Select a desired timeout. If no confirmation response is received within this time, the 750/760 will resend the frame if retries are still available.
DATA LINK CONFIRM RETRIES: 3	*Range: 0 to 100 in steps of 1* Select the number of retries that will be issued for a given data link frame.
SELECT/OPERATE ARM TIMEOUT: 10000 ms	*Range: 1 to 65000 in steps of 1 ms* Select the duration of the select / operate arm timer.
WRITE TIME INTERVAL: 0 min	*Range: 0 to 65000 in steps of 1 min* Select the time that must elapse before the 750/760 will set the “need time” internal indication (IIN). After the time is written by a DNP master, the IIN will be set again after this time elapses. A value of zero disables this feature.
COLD RESTART INHIBIT: Disabled WARNING	*Range: Enabled, Disabled* When disabled, a cold restart request from a DNP master will cause the 750/760 to be reset. Enabling this setpoint will cause the cold start request to initialize only the DNP sub-module. **When *Disabled* is selected, a cold restart request will cause loss of protection until the 750/760 reset completes.**

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8.4.1 DESCRIPTION

The relay has an internal real time clock that is used to perform time and date stamping for various relay features such as event, maximum demand, and last trip data recording. Time stamping on multiple relays can be synchronized to ±1 ms with the use of an IRIG-B input. The clock has a battery back up so that the time and date are maintained on the loss of relay control power. The time and date are preset at the factory, but should be changed to correspond to the appropriate time zone.

8.4.2 SETTINGS

■ CLOCK ■ [ENTER] for more	The Clock setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ CLOCK**
DATE (MM/DD/YYYY): 03/16/1997	*Range: Month = 1 to 12, Day = 1 to 31, Year = 1990 to 2089* Enter the current date, using two digits for the month, two digits for the day, and four digits for the year. For example, July 15, 1998 would be entered as 07 15 1998. If entered from the front panel, the new date will take effect the moment the ENTER key is pressed.
TIME (HH:MM:SS): 16:30:00	*Range: Hour = 0 to 23, Minute = 0 to 59, Second = 0 to 59* Enter the current time, by using two digits for the hour in 24 hour time, two digits for the minutes, and two digits for the seconds. If entered from the front panel, the new time will take effect the moment the ENTER key is pressed. For example, 3:05 PM would be entered as 15 05 00, with the ENTER key pressed at exactly 3:05 PM.
IRIG-B SIGNAL TYPE: None	*Range: None, DC Shift, Amplitude Modulated* Enables the IRIG-B time synchronization and selects the type of IRIG-B signal to use. **NOTES:** 1. The IRIG-B signal contains all necessary time and date stamping data except for the year. The year must be entered with the date. 2. If IRIG-B is enabled and functioning properly, then setting the time and date (except for the year) as described in the previous message will have no effect. 3. If IRIG-B is enabled but the signal cannot be decoded, the self-test warning 'IRIG-B Failure' is generated.

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8.5.1 DESCRIPTION

The relay captures a wide variety of events and stores the last 128 in non-volatile memory. See Section 6.5: A4 EVENT RECORDER on page 6–18 for details. A single power system disturbance could conceivably fill half of the event recorder due to the various events that can be captured. Also, some events may happen on a regular basis as part of a control scheme (e.g. Power Factor events in a capacitor bank switching scheme). For this reason, certain event types can be 'filtered' from the event recorder to save room for other events. The following setpoints describe the events that can be filtered.

8.5.2 SETTINGS

■ EVENT RECORDER ■ [ENTER] for more	The Event Recorder setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ EVENT RECORDER**
EVENT RECORDER FUNCTION: Enabled	*Range: Enabled, Disabled* Enter *Disabled* for this setpoint to inhibit recording of all events. Disabling the event recorder will not clear any data in the event recorder.
RECORD PICKUP EVENTS: Enabled	*Range: Enabled, Disabled* Enter *Disabled* for this setpoint to inhibit recording of element pickup events.
RECORD DROPOUT EVENTS: Enabled	*Range: Enabled, Disabled* Enter *Disabled* for this setpoint to inhibit recording of element dropout events.
RECORD TRIP EVENTS: Enabled	*Range: Enabled, Disabled* Enter *Disabled* for this setpoint to inhibit recording of events that occur when an element that has been programmed to the *Trip* or *Trip & AR* function operates.
RECORD ALARM EVENTS: Enabled	*Range: Enabled, Disabled* Enter *Disabled* for this setpoint to inhibit recording of events that occur when an element that has been programmed to the *Alarm* function operates.
RECORD CONTROL EVENTS: Enabled	*Range: Enabled, Disabled* Enter *Enabled* for this setpoint to permit recording of events that occur when an element that has been programmed to the *Control* function operates.
RECORD LOGIC INPUT EVENTS: Enabled	*Range: Enabled, Disabled* Enter *Disabled* for this setpoint to inhibit recording of logic input events.
RECORD DATE/TIME EVENTS: Enabled	*Range: Enabled, Disabled* Enter *Disabled* for this setpoint to inhibit recording of set date and set time events.

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8.6.1 DESCRIPTION

The waveform capture feature is similar to a transient / fault recorder. It captures oscillography / waveform data in response to a variety of system events. Data is captured for the analog current and voltage inputs (I_a, I_b, I_c, I_g, I_{sg}, V_a, V_b, V_c, V_s) as well as digital data for the output relays and input contact states. The trace memory data can be downloaded to the 750/760 PC Program for display and diagnostics purposes. All data is stored in volatile RAM memory which means that the information is lost when power to the relay is lost. The amount of data to capture and the trigger point are configurable as described below.

8.6.2 SETTINGS

■ TRACE MEMORY ■ [ENTER] for more	The Trace Memory setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ TRACE MEMORY**
BUFFER ORGANIZATION: 16 x 256	*Range: 2 x 2048, 4 x 1024, 8 x 512, 16 x 256* Selects the partitioning of waveform capture data storage. The first number indicates the number of events that can be stored in memory. The second number indicates the number of data samples captured per channel for each event. Note that the relay captures 16 samples per cycle. When more waveform captures are triggered than the allowable number of events selected by this setpoint, the oldest data is discarded to make room for the new capture. For example, *4 x 1024* indicates that the last three events with 1024 data samples per channel (64 cycles) can be stored in memory. Note that one buffer must be reserved for capturing the next event. **Changing this setpoint will clear any data that is currently in memory.**
TRIGGER POSITION: 25%	*Range: 0 to 100 in steps of 1%* Selects the amount of data captured before the trigger point. For example, if **TRIGGER POSITION** is set to *25%* and **BUFFER ORGANIZATION** is set to *2 x 2048*, then there will be 512 samples (32 cycles) captured before the trigger point.
TRIGGER ON PICKUP: Enabled	*Range: Enabled, Disabled* Selects whether protection element pickup events trigger new waveform capture.
TRIGGER ON DROPOUT: Disabled	*Range: Enabled, Disabled* Selects whether protection element dropout events trigger new waveform capture.
TRIGGER ON TRIP: Enabled	*Range: Enabled, Disabled* Selects whether a trip operation event triggers a new waveform capture for protection elements programmed to *Trip* or *Trip & AR*.
TRIGGER ON ALARM: Disabled	*Range: Enabled, Disabled* Selects whether an alarm operation event triggers a new waveform capture for protection elements programmed to *Alarm*.
TRIGGER ON CONTROL: Disabled	Range: Enabled, Disabled Selects whether a control operation event triggers a new waveform capture for protection elements programmed to *Control*.

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8.7.1 DESCRIPTION

The data logger feature is used to sample and record up to eight actual values at an interval that is defined by the user. This recorded data may be downloaded to the 750/760 PC Program for display and diagnostics. All data is stored in volatile RAM memory which means that the information is lost when power to the relay is lost. There are two basic modes of operation:

Continuous Mode: At each sampling time the logger will record the actual value(s) programmed and store them in the log. Up to 4096 data samples per channel will be recorded after which the oldest data is replaced by newly sampled data.

Trigger Mode: The programmed actual value(s) for up to the last 15 events may be recorded in this mode, each in a separate buffer. The desired amount of pre-trigger data that is to be recorded in the buffer is also selectable. Before the trigger occurs, pre-trigger data is gathered as required. When the programmed trigger condition takes place, data is collected until the buffer is filled, pre-trigger data collection begins in the next buffer and the relay then waits for the next trigger. Once all buffers have been filled, the oldest data is overwritten when a new trigger occurs.

Changing any setpoint affecting data logger operation will clear any data that is currently in the log.

8.7.2 SETTINGS

■ DATA LOGGER ■ [ENTER] for more	The Data Logger setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ DATA LOGGER**
SAMPLE RATE: 1 cycle	*Range: 1 cycle, 1 second, 1 min, 5 min, 10 min, 15 min, 20 min, 30 min, 60 min* Select the time interval at which the actual value data will be recorded. This setpoint multiplied by the number of samples to accumulate determines the duration of the data log record. For example, if the sample rate is 15 minutes and continuous mode is enabled then the duration of the data log record is equal to 15 min x 4096 = 61440 min = 42 days.
CONTINUOUS MODE: Disabled	*Range: Enabled, Disabled* Select *Enabled* to operate the data logger in continuous mode. Select *Disabled* to operate the data logger in trigger mode.
BUFFER ORGANIZATION: 16 x 256	*Range: 2 x 2048, 4 x 1024, 8 x 512, 16 x 256* This setpoint is only applicable when the data logger is operating in trigger mode. It selects the number triggers stored and the number of samples per channel stored for each trigger. For example, *4 x 1024* indicates that the last three triggers with 1024 data samples per channel can be stored in memory. Note that one buffer must be reserved for capturing the next event.
TRIGGER POSITION: 25 %	*Range: 0 to 100 in steps of 1%* This setpoint is only applicable when the data logger is operating in trigger mode. Select the desired amount of each buffer that is to be allocated for pre-trigger data. If set to zero, data collection effectively starts once the trigger occurs. If set to *100%*, only pre-trigger data will be recorded in the buffer. Note: If a trigger occurs before the programmed amount of pre-trigger data is collected, the remainder of the buffer will be filled with post-trigger data until it is full. Actual values in the memory map provide information as to where the true trigger position is in each log buffer.

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TRIGGER ON PICKUP: Enabled	*Range: Enabled, Disabled* This setpoint is only applicable when the data logger is in trigger mode. Selects whether a protection element pickup triggers a new data log capture.
TRIGGER ON DROPOUT: Disabled	*Range: Enabled, Disabled* This setpoint is only applicable when the data logger is in trigger mode. Selects whether a protection element dropout triggers a new data log capture.
TRIGGER ON TRIP: Enabled	*Range: Enabled, Disabled* This setpoint is only applicable when the data logger is operating in trigger mode. Selects whether a trip operation triggers a new data log capture for protection elements programmed to *Trip* or *Trip & AR*.
TRIGGER ON ALARM: Disabled	*Range: Enabled, Disabled* This setpoint is only applicable when the data logger is operating in trigger mode. Selects whether an alarm operation triggers a new data log capture for protection elements programmed to *Alarm*.
TRIGGER ON CONTROL: Disabled	*Range: Enabled, Disabled* This setpoint is only applicable when the data logger is operating in trigger mode. Selects whether a control operation triggers a new data log capture for protection elements programmed to *Control*.
CHANNEL 1 SOURCE: Phase A Current	*Range: Any Value that may be Assigned as an Analog Output Function* Select the actual value that is to be recorded in channel 1 of the data log. Note: If all channel sources (1 through 8) are programmed to *Disabled*, then the data logger will not collect data in continuous mode or respond to triggers in trigger mode.
CHANNEL 2 SOURCE: Phase B Current	*Range: Any Value that may be Assigned as an Analog Output Function* Select the actual value that is to be recorded in channel 2 of the data log.
CHANNEL 3 SOURCE: Phase C Current	*Range: Any Value that may be Assigned as an Analog Output Function* Select the actual value that is to be recorded in channel 3 of the data log.
CHANNEL 4 SOURCE: Neutral Current	*Range: Any Value that may be Assigned as an Analog Output Function* Select the actual value that is to be recorded in channel 4 of the data log.
CHANNEL 5 SOURCE: Phase A-N Voltage	*Range: Any Value that may be Assigned as an Analog Output Function* Select the actual value that is to be recorded in channel 5 of the data log.
CHANNEL 6 SOURCE: Phase B-N Voltage	*Range: Any Value that may be Assigned as an Analog Output Function* Select the actual value that is to be recorded in channel 6 of the data log.
CHANNEL 7 SOURCE: Phase C-N Voltage	*Range: Any Value that may be Assigned as an Analog Output Function* Select the actual value that is to be recorded in channel 7 of the data log.
CHANNEL 8 SOURCE: Frequency	*Range: Any Value that may be Assigned as an Analog Output Function* Select the actual value that is to be recorded in channel 8 of the data log.

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8.8.1 DESCRIPTION

Some of the front panel relay characteristics can be modified to suit different situations.

8.8.2 SETTINGS

■ FRONT PANEL ■ [ENTER] for more	The Front Panel setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ FRONT PANEL**
FLASH MESSAGE TIME: 4.0 s	*Range: 0.5 to 10.0 in steps of 0.1 s* Flash messages are status, warning, error, or information messages displayed for several seconds in response to certain key presses during setpoint programming. The time these messages remain on the display, overriding the normal messages, can be changed to accommodate different user reading rates.
DEFAULT MESSAGE TIME: 300 s	*Range: 10 to 900 in steps of 1 s* If no keys are pressed for a period of time, the relay will automatically begin to display a programmed set of default messages. This time can be modified to ensure menu messages remain on the screen long enough during programming or reading of actual values. Once default scanning starts, pressing any key will restore the last message displayed on the screen.
DEFAULT MESSAGE INTENSITY: 25 %	*Range: 25 to 100 in steps of 25%* To extend the life of the phosphor in the vacuum fluorescent display, the brightness of the display can be attenuated when default messages are being displayed. When interacting with the display using the front panel keys, the display will always operate at full brightness.
DISPLAY FILTER CONSTANT: 0	*Range: 0 to 255 in steps of 1* This value is used for filtering the displayed values of current, voltage, and power. It determines how quickly the filter responds and how much the filter will 'smooth' the display values. Smaller values result in quicker response times, but with less smoothing. Larger values result in a slower response time, but with more smoothing. A value of *0* completely disables the filter. A value of *224* results in a reasonably smooth display value with a response time of about one second. A value of *255* results in a very smooth display value, but with a response time of about five seconds.
3 KEY MAX DEMAND CLEARING: Disabled	*Range: Disabled, Enabled.* For increased ease of Max Demand clearing, this setpoint enables the use of the key sequence SETPOINT, ▪, MESSAGE ▲ to force the max demand values to clear. This key sequence operates on any setpoint or actual values page. The keystrokes must be entered in the above order. Any other variation of the key sequence will not permit the clearing of the Max Demand Values.

NOTE

Firmware versions 3.70 and greater do not support a keypad beeper as did previous firmware versions. The PC software does not support keypad beeper operation.

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8.9.1 DESCRIPTION

Under normal conditions, if no front panel keys have been pressed for longer than the time specified in **S1 RELAY SETUP \ FRONT PANEL \ DEFAULT MESSAGE TIMEOUT**, the screen will begin to sequentially display up to 30 user-selected default messages. Any Actual Value or Setpoint message can be selected for default display. In addition, up to 5 user programmable text messages can be created for display as default messages. The relay, for example, could be set to sequentially display a text message identifying the feeder, the system status, the measured current in each phase, and phase time overcurrent pickup setting. The first message under this subheading states the number of messages currently selected. The messages that follow are copies of the default messages selected, in the sequence they will be displayed.

8.9.2 SETTINGS

■ DEFAULT MESSAGES ■ [ENTER] for more	The Default Messages setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ DEFAULT MESSAGES**
3 MESSAGES SELECTED 27 REMAIN UNASSIGNED	*Shows the number of default messages selected.*
GE Power Management 750 REVISION 4.00	*Shows the first selected default message.*
A: 0 B: 0 C: 0 Amps	*Shows the second selected default message.*
GROUND CURRENT: 0 A 0° Lag	*Shows the third selected default message.*

8.9.3 ADDING DEFAULT MESSAGES

Default messages can be added to the end of the default message list, as follows:

1. Allow access to setpoints by installing the setpoint access jumper and entering the correct passcode.
2. Select the Setpoint or Actual Value message to be entered as a default message, so that it is displayed.
3. Press the key followed by the ENTER key while the message is displayed. The screen will display 'PRESS [ENTER] TO ADD AS DEFAULT.' Press the ENTER key again while this message is being displayed. The message is now added to the default message list.

8.9.4 REMOVING DEFAULT MESSAGES

Default messages can be removed from the default message list, as follows:

1. Allow access to setpoints by installing the setpoint access jumper and entering the correct passcode.
2. Select the message under the subheading **S1 RELAY SETUP \ DEFAULT MESSAGES** that is to be removed from the default message list.
3. Press the key followed by the ENTER key. The screen will display 'PRESS [ENTER] TO REMOVE MESSAGE.' Press the ENTER key while this message is being displayed. The message is now removed from the default message list, and the messages that follow are moved up to fill the gap.

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8.10.1 DESCRIPTION

Up to 5 display messages can be programmed with user specific information. When these user text messages are selected as default messages, they can provide system identification information or operator instruction.

8.10.2 SETTINGS

■ USER TEXT MESSAGES ■ [ENTER] for more	The User Text Messages setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ USER TEXT MESSAGES**
Text 1	*Range: 2 lines x 20 ASCII characters* Enter any desired text message.

8.10.3 ADDING USER TEXT MESSAGES

1. Allow access to setpoints by installing the setpoint access jumper and entering the correct passcode.
2. Select the user text message to be edited under the subgroup **S1 RELAY SETUP \ USER TEXT MESSAGES**.
3. Press the ENTER key. A solid cursor will appear over the first character position.
4. Use the VALUE ▲ and VALUE ▼ keys to change the character. A space is selected like a character.
5. Press the ENTER key to store the character and advance the cursor to the next position. To skip over a character press the ENTER key.
6. Continue entering characters and spaces until the desired message is displayed. If a character is entered incorrectly, repeatedly press the ENTER key until the cursor returns to the position of the error and enter the correct character. You may also press the ESCAPE and ENTER keys to restart the editing process.
7. Press the MESSAGE ▲ or MESSAGE ▼ key when editing is complete. To select this message as a default message, follow the instructions in the section on adding default messages.

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8.11.1 DESCRIPTION

The following commands are used to clear specific memory functions after the data has been read by an operator.

8.11.2 SETTINGS

■ CLEAR DATA ■ [ENTER] for more	The Clear Data commands path is: **\ SETPOINTS \ S1 RELAY SETUP \ CLEAR DATA**
CLEAR ENERGY USE DATA? No	*Range: Yes, No* Enter *Yes* to clear all the accumulated power consumption data under the actual values subgroup **A2 METERING \ ENERGY. THE ENERGY USE DATA LAST RESET** date is updated to the current date upon issuing this command.
CLEAR MAX DEMAND DATA? No	*Range: Yes, No* Enter *Yes* to clear all maximum demand data values under the actual values subgroup **A2 METERING \ DEMAND**, namely, **MAX PHASE A CURRENT DEMAND**, **MAX PHASE B CURRENT DEMAND**, **MAX PHASE C CURRENT DEMAND**, **MAX REAL POWER DEMAND**, **MAX REACTIVE POWER DEMAND**, and **MAX APPARENT POWER DEMAND**. The **DEMAND DATA LAST RESET** date is updated to the current date upon issuing this command.
CLEAR EVENT RECORDER DATA? No	*Range: Yes, No* The event recorder saves the most recent 128 events, automatically overwriting the oldest event. Enter *Yes* to clear all recorded event data in actual values page **A4 EVENT RECORDER**. The **EVENT RECORDER LAST RESET** date is updated to the current date upon issuing this command.

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8.12.1 WARNING

WARNING

To warn against the installation of a relay whose setpoints have not been entered for the required application, a 'Relay Not Ready' SELF-TEST WARNING diagnostic message will be displayed until the relay is made 'Ready' via the S1 RELAY SETUP \ INSTALLATION \ 760 OPERATION setpoint. This setpoint is defaulted to 'Not Ready' when the relay leaves the factory.

8.12.2 SETTINGS

■ INSTALLATION ■ [ENTER] for more	The Installation setpoints path is: **\ SETPOINTS \ S1 RELAY SETUP \ INSTALLATION**
760 OPERATION: Not Ready	*Range: Ready, Not Ready* The 'Relay Not Ready' SELF-TEST WARNING message is displayed until the relay is put into the *Ready* state via this setpoint.
RESET TRIP COUNTER DATA? No	*Range: Yes, No* Enter *Yes* to clear all accumulated trip counter values under the actual values subgroup **A3 MAINTENANCE \ TRIP COUNTERS**. This command should be used on a new installation, or after new equipment has been installed. The **TRIP COUNTERS LAST RESET** date is updated to the current date upon issuing this command.
RESET ARCING CURRENT DATA? No	*Range Yes, No* Enter *Yes* to clear all accumulated arcing current values under the actual values subgroup **A3 MAINTENANCE \ ARCING CURRENT**. This command should be used on a new installation, or after new equipment has been installed. The **ARCING CURRENT LAST RESET** date is updated to the current date upon issuing this command.
RESET AR COUNT DATA? No	*Range Yes, No* Enter *Yes* to clear the Autoreclose Shot Count under the actual values subgroup **A1 STATUS \ AUTORECLOSE**. The **AR SHOT COUNT LAST RESET** date is updated to the current date upon issuing this command.
RESET AR RATE DATA? No	*Range Yes, No* Enter *Yes* to clear the Autoreclose Shot Rate under the actual values subgroup **A1 STATUS \ AUTORECLOSE**.

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9.1.1 DESCRIPTION

This group of setpoints is critical for all overcurrent protection features that have settings specified in multiples of CT rating. When the relay is ordered, the phase, ground, and sensitive ground CT inputs must be specified as either 1 Amp or 5 Amp.

As the phase CTs are connected in wye (star), the calculated phasor sum of the three phase currents ($I_a + I_b + I_c$ = Neutral Current = $3I_0$) is used as the input for the neutral overcurrent. In addition, a zero-sequence (core balance) CT which senses current in all of the circuit primary conductors, or a CT in a neutral grounding conductor may also be used. For this configuration, the ground CT primary rating must be entered. To detect low level ground fault currents, the sensitive ground input may be used. In this case, the sensitive ground CT primary rating must be entered. For additional details on CT connections, refer to Section 3.2: TYPICAL WIRING on page 3–5.

9.1.2 SETTINGS

■ CURRENT SENSING ■ [ENTER] for more	The Current Sensing setpoints path is: **\ SETPOINTS \ S2 SYSTEM SETUP \ CURRENT SENSING**
PHASE CT PRIMARY: 1000 A	*Range: 1 to 50000 in steps of 1 A* Enter the phase CT primary current value. For both 1000:5 or 1000:1 phase CTs, the entry would be *1000*. For correct operation, the CT secondary must match the relay as indicated on the relay identification label, e.g. 5 A for a xxx:5 CT.
GROUND CT PRIMARY 50 A	*Range: 1 to 50000 in steps of 1 A* Enter the ground CT primary current value. For both a 50:5 or 50:1 ground CT, the entry is *50*. Verify that the CT secondary rating matches the rating on the relay label.
SENSTV GND CT PRIMARY: 1000 A	*Range: 1 to 50000 in steps of 1 A* Enter the sensitive ground CT primary current value. For both 1000:5 or 1000:1 CTs, the entry would be *1000*. Verify that the CT secondary rating matches the rating on the relay label.

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9.2.1 DESCRIPTION

With bus VTs installed, the relay can be used to perform voltage measurements, power calculations, and directional control of overcurrent elements.

9.2.2 SETTINGS

■ BUS VT SENSING ■ [ENTER] for more	The Bus VT Sensing setpoints path is: **\ SETPOINTS \ S2 SYSTEM SETUP \ BUS VT SENSING**
VT CONNECTION TYPE: Wye	*Range: None, Wye, Delta* Enter *None* if Bus VTs are not to be used. If used, enter the VT connection made to the system as *Wye* or *Delta*. An open-delta connection would be entered as *Delta*. See Figure 3–9: TYPICAL WIRING DIAGRAM on page 3–7 for details.
NOMINAL VT SECONDARY VOLTAGE: 120.0 V	*Range: 50.0 to 240.0 in steps of 0.1 V* This setpoint is the voltage across the VT secondary winding when nominal voltage is applied to the primary. On a source of 13.8 kV line-line at nominal voltage, with a 14400:120 Volt VT in the delta connection, the voltage to be entered is 115 V. For the wye connection, the voltage to be entered is 115/√3 = 66.4 V.
VT RATIO: 120.0:1	*Range: 1.0 to 5000.0 in steps of 0.1* Enter the VT primary to secondary turns ratio with this setpoint. For a 14400:120 VT, the entry would be *120:1* (14400 / 120 = 120.0).

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9.3.1 DESCRIPTION

With a line VT installed, the relay can be used to check for a condition of synchronism between two voltages, either line-line or line-neutral.

9.3.2 SETTINGS

■ LINE VT SENSING ■ [ENTER] for more	The Line VT Sensing setpoints path is: **\ SETPOINTS \ S2 SYSTEM SETUP \ LINE VT SENSING**
VT CONNECTION: Vbn	*Range: V_{an}, V_{bn}, V_{cn}, V_{ab}, V_{cb}* Enter the line VT connection made to the system. This selection is critical to the operation of synchrocheck, as it instructs the relay which bus VT input voltage is to be compared to the line VT input voltage. See Figure 3–14: LINE VT CONNECTIONS on page 3–11 for the system connection to match this setpoint.
NOMINAL VT SECONDARY VOLTAGE: 120.0 V	*Range: 50.0 to 240.0 in steps of 0.1 V* This setpoint is the voltage across the VT secondary winding when nominal voltage is applied to the primary. On a source of 13.8 kV line-line at nominal voltage, with a 14400:120 Volt VT in the delta connection, the voltage to be entered is *115 V*. For the wye connection, the voltage to be entered is 115/√3 = *66.4 V*.
VT RATIO: 120.0:1	*Range: 1.0 to 5000.0 in steps of 0.1* Enter the VT primary to secondary turns ratio with this setpoint. For a 14400:120 VT, the entry would be *120.0:1* (14400 / 120 = 120.0).

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9.4.1 SETTINGS

■ POWER SYSTEM ■ [ENTER] for more	The Power System setpoints path is: **\ SETPOINTS \ S2 SYSTEM SETUP \ POWER SYSTEM**
NOMINAL FREQUENCY: 60 Hz	*Range: 25 to 60 in steps of 1 Hz* Enter the nominal power system frequency. This value is used as a default to set the optimal digital sampling rate if the system frequency cannot be measured as there is no voltage available at the bus voltage phase A input terminals.
PHASE SEQUENCE ABC	*Range: ABC, ACB* Enter the phase sequence of the power system.
COST OF ENERGY: 5.0 ¢/kWh	*Range: 1.0 to 25.0 in steps of 0.1 ¢/kWh* Kilowatt hour power usage is converted to a cost of energy using this setpoint. The cost of energy charged by a utility is usually a variable rate depending on total energy consumed or other factors. Enter an estimated average cost in cents per kWh. Approximate energy cost will be determined by the relay, providing a value useful for budgeting purposes.

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9.5.1 DESCRIPTION

Two user programmable FlexCurves™ can be stored in the relay. These can be used for time overcurrent protection in the same manner as ANSI, IAC, and IEC curves. The custom FlexCurve™ has setpoints for entering times to trip at the following current levels: 1.03, 1.05, 1.1 to 6.0 in steps of 0.1, and 6.5 to 20.0 in steps of 0.5. The relay then converts these points to a continuous curve by linear interpolation between data points.

9.5.2 SETTINGS

■ FLEXCURVE A ■ [ENTER] for more	The FlexCurve A setpoints path is: **\ SETPOINTS \ S2 SYSTEM SETUP \ FLEXCURVE A**
CURVE A TRIP TIME AT 1.03 x PU: 0 ms	*Range: 0 to 65535 in steps of 1 ms* Enter the required trip time for the listed current level. There are eighty more trip time settings following this one; see the table below for a complete listing.
■ FLEXCURVE B ■ [ENTER] for more	The FlexCurve B setpoints path is: **\ SETPOINTS \ S2 SYSTEM SETUP \ FLEXCURVE B**
CURVE B TRIP TIME AT 1.03 x PU: 0 ms	*Range: 0 to 65535 in steps of 1 ms* Enter the required trip time for the listed current level. There are eighty more trip time settings following this one; see the table below for a complete listing.

The following table shows all the pickup levels for which a trip time must be entered.

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Table 9–1: FLEXCURVE TRIP TIMES

Pickup (I/Ipu)	Trip Time (ms)	Pickup (I/Ipu)	Trip Time (ms)	Pickup (I/Ipu)	Trip Time (ms)	Pickup (I/Ipu)	Trip Time (ms)
1.03		2.90		4.90		10.5	
1.05		3.00		5.00		11.0	
1.10		3.10		5.10		11.5	
1.20		3.20		5.20		12.0	
1.30		3.30		5.30		12.5	
1.40		3.40		5.40		13.0	
1.50		3.50		5.50		13.5	
1.60		3.60		5.60		14.0	
1.70		3.70		5.70		14.5	
1.80		3.80		5.80		15.0	
1.90		3.90		5.90		15.5	
2.00		4.00		6.00		16.0	
2.10		4.10		6.50		16.5	
2.20		4.20		7.00		17.0	
2.30		4.30		7.50		17.5	
2.40		4.40		8.00		18.0	
2.50		4.50		8.50		18.5	
2.60		4.60		9.00		19.0	
2.70		4.70		9.50		19.5	
2.80		4.80		10.0		20.0	

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10.1.1 INTRODUCTION

The 750/760 relay has 20 logic inputs which can be used to operate a variety of logic functions for circuit breaker control, external trips, blocking of protection elements, etc. The relay has 'contact inputs' and 'virtual inputs' that are combined in a form of programmable logic to facilitate the implementation of various schemes.

The relay has 14 rear terminal contact inputs. These contacts can be either wet or dry (see Section 3.2.13: LOGIC INPUTS on page 3–14 for typical wiring of the logic input contacts). External contacts are either open or closed and are debounced for one power frequency cycle to prevent false operation from induced voltage. Because of debouncing, **momentary contacts must have a minimum dwell time greater than one power frequency cycle**.

The relay also has 20 virtual inputs which are analogous to software switches. They allow all the functionality of logic inputs to be invoked via serial communications or from the front panel. This has several advantages over only having contact inputs:

- The number of logic inputs can be increased without introducing additional hardware.
- Logic functions that must be invoked from a remote location can all be done over a single RS485 communications channel.
- The same logic function can be invoked both locally via contact input, front panel keypad, and/or remotely via communications.
- Panel switches can be replaced entirely by virtual switches to save cost and wiring.

Virtual inputs are simply memory locations in the relay which can be assigned a value via communications or from the front panel display menu **\ ACTUAL VALUES \ A1 STATUS \ VIRTUAL INPUTS**. If the value stored in memory is *0* then the virtual input is Off, otherwise the virtual input is On. The state of virtual inputs is written as if it were a setpoint; these values are non-volatile and are found in the Memory Map at locations 0090 to 00A4 hex. Momentary virtual inputs are simulated by first writing a '1' to the corresponding register followed by writing a '0'. Due to communications delay there will be a dwell time of 50 to 200 ms. Maintained virtual inputs are simulated by writing a '1' to the corresponding register.

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10.2.1 DESCRIPTION

Each logic input has two setpoints as shown below for Logic Input 1. The following points apply to all the logic inputs:

- The state of a contact input is either 'Open' or 'Closed' and is determined directly from the rear terminal inputs.
- The state of a virtual input is either 'On' or 'Off' and can be set by the user either from serial communications or from the **ACTUAL VALUES \ A1 STATUS \ VIRTUAL INPUTS** menu.
- The state of a logic input is either 'Asserted' or 'Not-Asserted'.
- The state of logic input X (X = 1 to 14) is determined by combining the state of contact input X with the state of virtual input X according to the **INPUT X ASSERTED LOGIC** setpoint; this is a limited form of programmable logic.
- The state of logic input Y (Y = 15 to 20) is determined by the state of virtual input Y according to the **INPUT Y ASSERTED LOGIC** setpoint; this is a limited form of programmable logic.
- A logic function is invoked when its corresponding logic input is ASSERTED.
- One logic input can invoke many logic functions if required.

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■ LOGIC INPUTS SETUP
■ [ENTER] for more

The Logic Inputs Setup setpoints path is:

\ SETPOINTS \ S3 LOGIC INPUTS \ LOGIC INPUTS SETUP

INPUT 1 NAME:
Logic Input 1

Range: Any Combination of 18 Alphanumeric Characters.

An 18 character field that will be displayed in the **ACTUAL VALUES \ A1 STATUS \ VIRTUAL INPUTS** menu. This allows a more operator friendly description to be used when replacing panel switches with a virtual switch.

LOGIC 1 ASSERTED
LOGIC: Contact Close

Range: See below.

This setpoint determines how to combine the state of the contact and virtual input to determine the state of the logic input.

For logic inputs 1 to 14 the setpoint has the following choices:

SETPOINT VALUE	LOGIC INPUT ASSERTED WHEN:
Disabled	Never
Contact Close	Contact is closed
Contact Open	Contact is open
Virtual On	Virtual input is on
Virtual Off	Virtual input is off
Closed & Von	Contact is closed AND virtual input is on
Closed & Voff	Contact is closed AND virtual input is off
Open & Von	Contact is open AND virtual input is on
Open & Voff	Contact is open AND virtual input is off
Closed | Von	Contact is closed OR virtual input is on
Closed | Voff	Contact is closed OR virtual input is off
Open | Von	Contact is open OR virtual input is on
Open | Voff	Contact is open OR virtual input is off
Closed X Von	Contact is closed XOR virtual input is on
Closed X Voff	Contact is closed XOR virtual input is off
Open X Von	Contact is open XOR virtual input is on
Open X Voff	Contact is open XOR virtual input is off

For logic inputs 15 to 20 the setpoint has the following choices:

SETPOINT VALUE	LOGIC INPUT ASSERTED WHEN:
Disabled	Never
Virtual On	Virtual Input is On
Virtual Off	Virtual Input is Off

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10.3.1 DESCRIPTION

The following logic functions are used to determine whether the circuit breaker is open, closed, or disconnected from the main power circuit, as monitored by auxiliary contacts on a drawout breaker racking mechanism, or on the associated isolating disconnect switches on a fixed circuit breaker.

If neither the 52a or 52b contacts are installed then the following functions cannot be performed:

- Monitoring of breaker position
- Breaker Operation Failure
- Feedback control of 1 TRIP and 2 CLOSE relays
- Trip / Close Coil Supervision Without Permissive
- Manual close feature blocking
- Autoreclose
- Transfer

CAUTION

1. It is strongly recommended that the Breaker Operation Failure alarm be enabled when either 52a or 52b breaker auxiliary contacts are installed.

2. Breaker logic functions must be assigned to logic inputs 1 to 14 as they must only be contacts.

10.3.2 SETTINGS

■ BREAKER FUNCTIONS ■ [ENTER] for more	The Breaker Functions setpoints path is: **\ SETPOINTS \ S3 LOGIC INPUTS \ BREAKER FUNCTIONS**
52a CONTACT: Disabled	*Range: Disabled, Input 1, Input 2,..., Input 20* Enter the input used to monitor the 52/a contact. See table below to determine how the 52/a contact affects the breaker state.
52b CONTACT: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Enter the input used to monitor the 52/b contact. See table below to determine how the 52/b contact affects the breaker state.
BREAKER CONNECTED: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* When asserted, this logic input indicates that the breaker is connected to the primary system. When the breaker is determined to be disconnected, the breaker state is shown to be neither open nor closed.

Table 10–1: 52A/B CONTACT INTERPRETATION

52/a CONTACT INSTALLED?	52/b CONTACT INSTALLED?	INTERPRETATION
Yes	Yes	52a closed indicates breaker is closed 52b closed indicates breaker is open
Yes	No	52a closed indicates breaker is closed 52a open indicates breaker is open
No	Yes	52b open indicates breaker is closed 52b closed indicates breaker is open
No	No	Breaker status unknown

For further information regarding operation with only one auxiliary breaker contact, see Section 5.2.3: SYSTEM STATUS INDICATORS on page 5–2.

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10.4.1 SETTINGS

■ CONTROL FUNCTIONS ■ [ENTER] for more	The Control Functions setpoints path is: **\ SETPOINTS \ S3 LOGIC INPUTS \ CONTROL FUNCTIONS**
LOCAL MODE: **Disabled**	*Range: Disabled, Input 1, Input 2, ..., Input 20* Places the relay in local mode. The relay will be in remote mode if not forced into local mode by this function.
RESET: **Disabled**	*Range: Disabled, Input 1, Input 2, ..., Input 20* Resets the last trip indicator, and latched relays. With the 760, it also resets autoreclose lockout.
REMOTE OPEN: **Disabled**	*Range: Disabled, Input 1, Input 2, ..., Input 20* Initiates a breaker opening via the 1 TRIP relay. Operates only when in the remote mode.
REMOTE CLOSE: **Disabled**	*Range: Disabled, Input 1, Input 2, ..., Input 20* Initiates a breaker closure via the 2 CLOSE relay. Operates only when in the remote mode.
COLD LOAD PICKUP: **Disabled**	*Range: Disabled, Input 1, Input 2, ..., Input 20* Initiates the Cold Load Pickup blocking feature.
SETPOINT GROUP 2: **Disabled**	*Range: Disabled, Input 1, Input 2, ..., Input 20* Signals setpoint control to make Group 2 the active group.
SETPOINT GROUP 3: **Disabled**	*Range: Disabled, Input 1, Input 2, ..., Input 20* Signals setpoint control to make Group 3 the active group.
SETPOINT GROUP 4: **Disabled**	*Range: Disabled, Input 1, Input 2, ..., Input 20* Signals setpoint control to make Group 4 the active group.

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10.5.1 DESCRIPTION

There are twenty general purpose user input functions (A through T) that generate outputs in response to an asserted logic input. These functions can be used to:

- Initiate a trip.
- Initiate a trip and a reclosure (760 Only).
- Log the operation of a contact in the event recorder.
- Convert an external contact into a self-resetting, latched or pulsed contact.
- Convert an external contact into a form-C contact.
- Provide a contact multiplier for an external contact by operating multiple relays.

10.5.2 SETTINGS

The setpoints for User Input A are shown below (User Input B – T setpoints are identical).

■ USER INPUT A ■ [ENTER] for more	The User Inputs A setpoints path is: **\ SETPOINTS \ S3 LOGIC INPUTS \ USER INPUTS \ USER INPUT A**
USER INPUT A NAME: User Input A	*Range: Any Combination of 18 Alphanumeric Characters.* An 18 character field that will be displayed as part of the diagnostic messages and event recorder when the logic input is asserted.
USER INPUT A SOURCE: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Selects the logic input that triggers User Input A.
USER INPUT A FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Selects the type of output function for User Input A.
USER INPUT A RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Selects the auxiliary relays that will operate in conjunction with User Input A.
USER INPUT A DELAY: 0.00 s	*Range: 0.00 to 600.00 in steps of 0.01 s* Selects the amount of time that the logic input must remain asserted before User Input A operates.

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10.6.1 DESCRIPTION

The following logic input functions block various operations within the relay. Protection elements will NOT detect faults, send messages, or illuminate indicators when blocked.

10.6.2 SETTINGS

■ BLOCK FUNCTIONS ■ [ENTER] for more	The Block Functions setpoints path is: **\ SETPOINTS \ S3 LOGIC INPUTS \ BLOCK FUNCTIONS**
BLOCK 1 TRIP RELAY: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks operation of the 1 TRIP relay. Protection features will still detect faults, display messages, and illuminate indicators.
BLOCK 2 CLOSE RELAY: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* A system condition monitor such as 'synchrocheck' or 'closing spring charged' can be connected for close supervision. If this function is selected, this input must be de-asserted to permit operation of the 2 CLOSE relay.
BLOCK RESET: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks any attempted reset.
BLOCK UNDERVOLT 1: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the Undervoltage 1 element from operating. This input can be used where automatic / manual modes are required.
BLOCK UNDERVOLT 2: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the Undervoltage 2 element from operating.
BLOCK UNDERVOLT 3: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the Undervoltage 3 element from operating.
BLOCK UNDERVOLT 4: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the Undervoltage 4 element from operating.
BLOCK UNDERFREQ 1: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the Underfrequency 1 element from operating.
BLOCK UNDERFREQ 2: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the Underfrequency 2 element from operating.
BLOCK FREQUENCY DECAY: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the Frequency Decay element from operating.
BYPASS SYNCHROCHECK: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Provides a manual override of the synchrocheck monitor, so an operator can close the feeder breaker without the programmed synchrocheck condition.

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BLOCK BREAKER: STATISTICS: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the accumulation of breaker statistical data found on the **A3 MAINTENANCE \ TRIP COUNTERS** and **A3 MAINTENANCE \ ARCING CURRENT** pages of actual values. This data includes, breaker operation and trip counters along with breaker arcing current. This input could be used during testing to prevent maintenance operations from being accumulated.
BLOCK NEG SEQ: VOLTAGE: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the negative sequence voltage element from operating.
BLK NTR DISPLACEMNT: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the neutral displacement element from operating.
BLOCK RESTORATION: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks both undervoltage and underfrequency restoration features.

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10.7.1 DESCRIPTION

The following logic input functions allow overcurrent protection elements to be blocked. Overcurrent elements will NOT detect faults, send messages, or illuminate indicators when blocked. These functions can be used to:

- Block overcurrent operation from downstream relays for selective tripping schemes from external directional current/power or any other supervision.
- Block overcurrent operation during initial feeder loading when the inrush currents are not yet known.
- Block neutral operation during single-phase switching, or during fault burn-off attempts.
- Block timed phase and neutral operation during deliberate emergency overload operating situations.

10.7.2 SETTINGS

■ BLK OC FUNCTIONS ■ [ENTER] for more	The Block Overcurrent Functions setpoints path is: **\ SETPOINTS \ S3 LOGIC INPUTS \ BLOCK OC FUNCTIONS**
BLOCK ALL OC: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks all overcurrent elements.
BLOCK PHASE OC: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks all phase overcurrent elements.
BLOCK NEUTRAL OC: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks all neutral overcurrent elements.
BLOCK GROUND OC: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks all ground overcurrent elements.
BLOCK SENSTV GND OC: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks all sensitive ground overcurrent elements.
BLOCK PHASE TIME 1: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the phase time overcurrent 1 element.
BLOCK PHASE TIME 2: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the phase time overcurrent 2 element.
BLOCK PHASE INST 1: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the phase instantaneous 1 overcurrent element.
BLOCK PHASE INST 2: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the phase instantaneous 2 overcurrent element.
BLOCK NEUTRL TIME 1: DECAY: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the neutral time overcurrent 1 element.
BLOCK NEUTRL TIME 2: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the neutral time overcurrent 2 element.
BLOCK NEUTRL INST 1: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the neutral instantaneous 1 overcurrent element.

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BLOCK NEUTRL INST 2: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the neutral instantaneous 2 overcurrent element.
BLK GROUND TIME: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the ground time overcurrent element.
BLOCK GROUND INST: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the ground instantaneous overcurrent element.
BLK SENSTV GND TIME: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the sensitive ground time overcurrent element.
BLK SENSTV GND INST: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the sensitive ground instantaneous overcurrent element.
BLOCK NEG SEQ TIME: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the negative sequence time overcurrent element.
BLOCK NEG SEQ INST: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Blocks the negative sequence instantaneous overcurrent element.

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10.8.1 DESCRIPTION

The following logic input functions are used exclusively for the bus transfer scheme. Refer to Section 14.7: TRANSFER on page 14–18 for more detail.

NOTE

If the bus transfer feature of the relay is required in an installation, all logic input functions necessary for the operation of this scheme must be assigned to contact inputs before any other functions. This is to ensure there are no conflicts.

10.8.2 SETTINGS

■ TRANSFER FUNCTIONS ■ [ENTER] for more	The Transfer Functions setpoints path is: **\ SETPOINTS \ S3 LOGIC INPUTS \ TRANSFER FUNCTIONS**
SELECT TO TRIP: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to select the breaker to trip on prevent-parallel operation.
UNDERVOLT ON OTHER SOURCE: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used for permission-to-transfer logic.
INCOMER 1 BREAKER CLOSED: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to track breaker state, for prevent-parallel or permission-to-transfer logic.
INCOMER 2 BREAKER CLOSED: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to track breaker state, for prevent-parallel or permission-to-transfer logic.
TIE BREAKER CONNECTED: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to inhibit transfers if the breaker cannot be used to pass current from the source to the load, such as when it is in the Test or Disconnected positions.
TIE BREAKER CLOSED: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to track breaker state, for prevent-parallel or permission-to-transfer logic.
BLOCK TRANSFER: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to disable the transfer scheme.
TRANSFORMER LOCKOUT: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to initiate a transfer as source 1 (2) is about to be lost.
SOURCE TRIP: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to initiate a transfer as source 1 (2) is about to be lost.
CLOSE FROM INCOMER1: DECAY: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to signal the bus tie breaker to begin a close operation.
CLOSE FROM INCOMER2: DECAY: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Used to signal the bus tie breaker to begin a close operation.

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10.9.1 DESCRIPTION

The following logic input functions are used in the autoreclose scheme. Refer to Section 14.8: AUTORECLOSE (760 ONLY) on page 14–30 for more detail.

10.9.2 SETTINGS

■ RECLOSE FUNCTIONS ■ [ENTER] for more	The Autoreclose Functions setpoints path is: **\ SETPOINTS \ S3 LOGIC INPUTS \ RECLOSE FUNCTIONS**
INITIATE RECLOSURE: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Initiates an autoreclose sequence leading to an operation of the 2 CLOSE relay. This input will NOT cause the 1 TRIP output relay of the 760 to operate. It is intended for use where the initiating device sends an independent trip to the breaker at the same time it sends an initiate reclosure to the 760.
CANCEL RECLOSURE: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Cancels a reclosure sequence in progress and blocks the autoreclose scheme from operating.
BLOCK RECLOSURE: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Cancels a reclosure sequence in progress and blocks the autoreclose scheme from operating.

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10.10.1 DESCRIPTION

The following logic input functions do not fall into any specific category and thus are listed together under miscellaneous functions.

10.10.2 SETTINGS

■ MISC FUNCTIONS ■ [ENTER] for more	The Miscellaneous Functions setpoints path is: **\ SETPOINTS \ S3 LOGIC INPUTS \ MISCELLANEOUS**
TRIGGER TRACE MEMORY: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Triggers a Trace Memory waveform capture.
TRIGGER DATA LOGGER: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* Triggers a Data Logger sample capture.
SIMULATE FAULT: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* This input function is operational only when the relay is in simulation testing mode, the breaker is closed (real or simulated breaker) and presently in the prefault state. When the assigned input is asserted, the relay is forced into the fault state where the programmed 'fault' values are used.
START DEMAND INTERVAL: Disabled	*Range: Disabled, Input 1, Input 2, ..., Input 20* This input begins the new demand interval for all Block Interval demand calculations.

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11.1.1 DESCRIPTION

The 750/760 relay is equipped with eight electromechanical output relays: three special purpose (1 TRIP, 2 CLOSE, and 8 SELF-TEST WARNING) and five general purpose (3, 4, 5, 6, and 7 AUXILIARY). The special purpose relays have fixed operating characteristics and the general purpose relays can be configured by the user. Logic diagrams for each output relay are provided for detailed explanation of their operation.

11.1.2 1 TRIP AND 2 CLOSE RELAY OPERATION

Operation of these breaker-control relays is designed to be controlled by the state of the circuit breaker as monitored by a 52a or 52b contact. Once a feature has energized one of these relays it will remain operated until the requested change of breaker state is confirmed by a breaker auxiliary contact and the initiating condition has reset. If the initiating feature resets but the breaker does not change state, the output relay will be reset after either the delay programmed in the Breaker Operation feature or a default interval of 2 seconds expires. If neither of the breaker auxiliary contacts 52a nor 52b is programmed to a logic input, the 1 TRIP relay is de-energized after either the delay programmed in the Breaker Failure feature or a default interval of 100 milliseconds after the initiating input resets and the 2 CLOSE relay is de-energized after 200 milliseconds. If a delay is programmed for the Trip or Close contact seal in time, then this delay is added to the reset time. Note that the default setting for the seal in time is 40 ms.

Table 11–1: BREAKER AUXILIARY CONTACTS AND RELAY OPERATION

52a CONTACT INSTALLED?	52b CONTACT INSTALLED?	RELAY OPERATION
Yes	Yes	1 TRIP relay remains operating until 52b indicates an open breaker. 2 CLOSE relay remains operating until 52a indicates a closed breaker.
Yes	No	1 TRIP relay remains operating until 52a indicates an open breaker. 2 CLOSE relay remains operating until 52a indicates a closed breaker.
No	Yes	1 TRIP relay remains operating until 52b indicates an open breaker. 2 CLOSE relay remains operating until 52b indicates a closed breaker.
No	No	1 TRIP relay operates until either the Breaker Failure delay expires (if the Breaker Failure element is enabled) or 100 ms after the feature causing the trip resets. 2 CLOSE relay operates for 200 ms.

11.1.3 3-7 AUXILIARY RELAY OPERATION

Operation of these relays is programmed by the user. Each relay can be selected to become either energized or de-energized when operated, and to operate as latched, self-resetting or pulsed.

Table 11–2: AUXILIARY RELAY OPERATION

OUTPUT TYPE	DESCRIPTION
Latched	Upon being operated by any programmed feature, the relay output contacts change state and remain in the new state. The relay can be returned to the non-operated state only by the RESET key, the reset logic input, or a computer reset command. This mode is used for alarms which must be acknowledged, or to provide a lockout function.
Self-resetting	Upon being operated by any programmed feature, the relay output contacts change state and remain in the new state until all features which operate the relay are no longer signaling it to operate. For a relay operated by a single feature, the output contacts follow the state of the feature.
Pulsed	Upon being operated by any programmed feature, the relay output contacts change state and remain in the new state for a programmed time interval called the **PULSED OUTPUT DWELL TIME**. The dwell timer is started when the first feature causes operation of the output relay.

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11.2.1 DESCRIPTION

A “Seal In Time” can be programmed for the 1 TRIP relay. This time is added to the reset time of the 1 TRIP relay, thus extending its pulse width. This is for use in applications where the 52 contacts reporting breaker state to the 750/760 are faster than the 52 contacts that are responsible for interrupting coil current.

11.2.2 SETTINGS

■ 1 TRIP RELAY ■ [ENTER] for more	The 1 TRIP RELAY setpoints path is: **\ SETPOINTS \ S4 OUTPUT RELAYS \ 1 TRIP RELAY**
TRIP RELAY SEAL IN TIME: 0.04s	*Range: 0.00 to 9.99 in steps of 0.01 sec.* Enter the extended reset time of the 1 TRIP RELAY

Similarly, a “Seal In Time” can be programmed for the 2 CLOSE relay. This time is added to the reset time of the 2 CLOSE relay, thus extending its pulse width. This is for use in applications where the 52 contacts reporting breaker state to the 750/760 are faster than the 52 contacts that are responsible for interrupting coil current.

■ 2 CLOSE RELAY ■ [ENTER] for more	The 1 TRIP RELAY setpoints path is: **\ SETPOINTS \ S4 OUTPUT RELAYS \ 2 CLOSE RELAY**
2 CLOSE RLY SEAL IN TIME:0.04s	*Range: 0.00 to 9.99 in steps of 0.01 sec.* Enter the extended reset time of the 2 CLOSE RELAY

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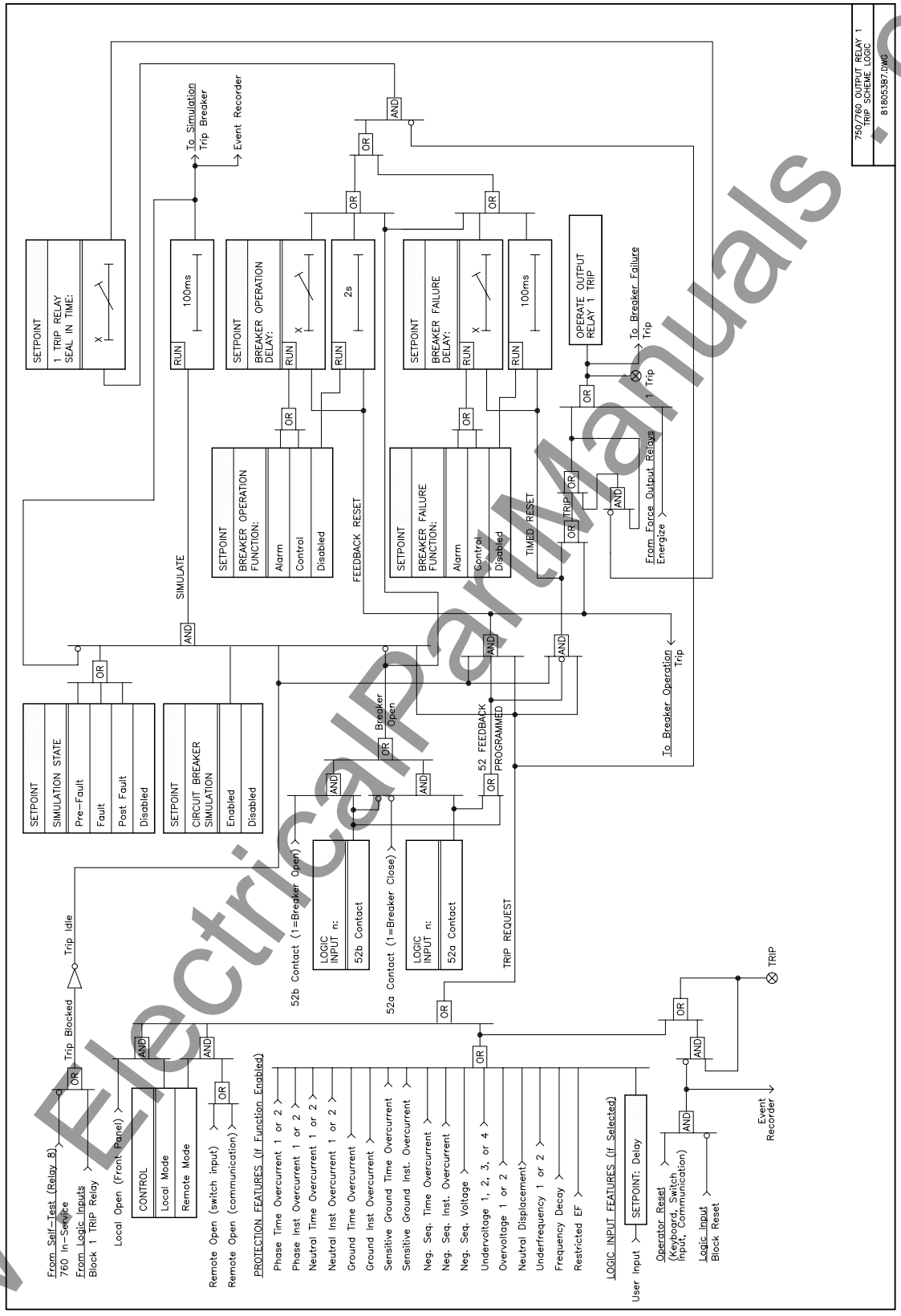


Figure 11–1: OUTPUT RELAY 1 TRIP

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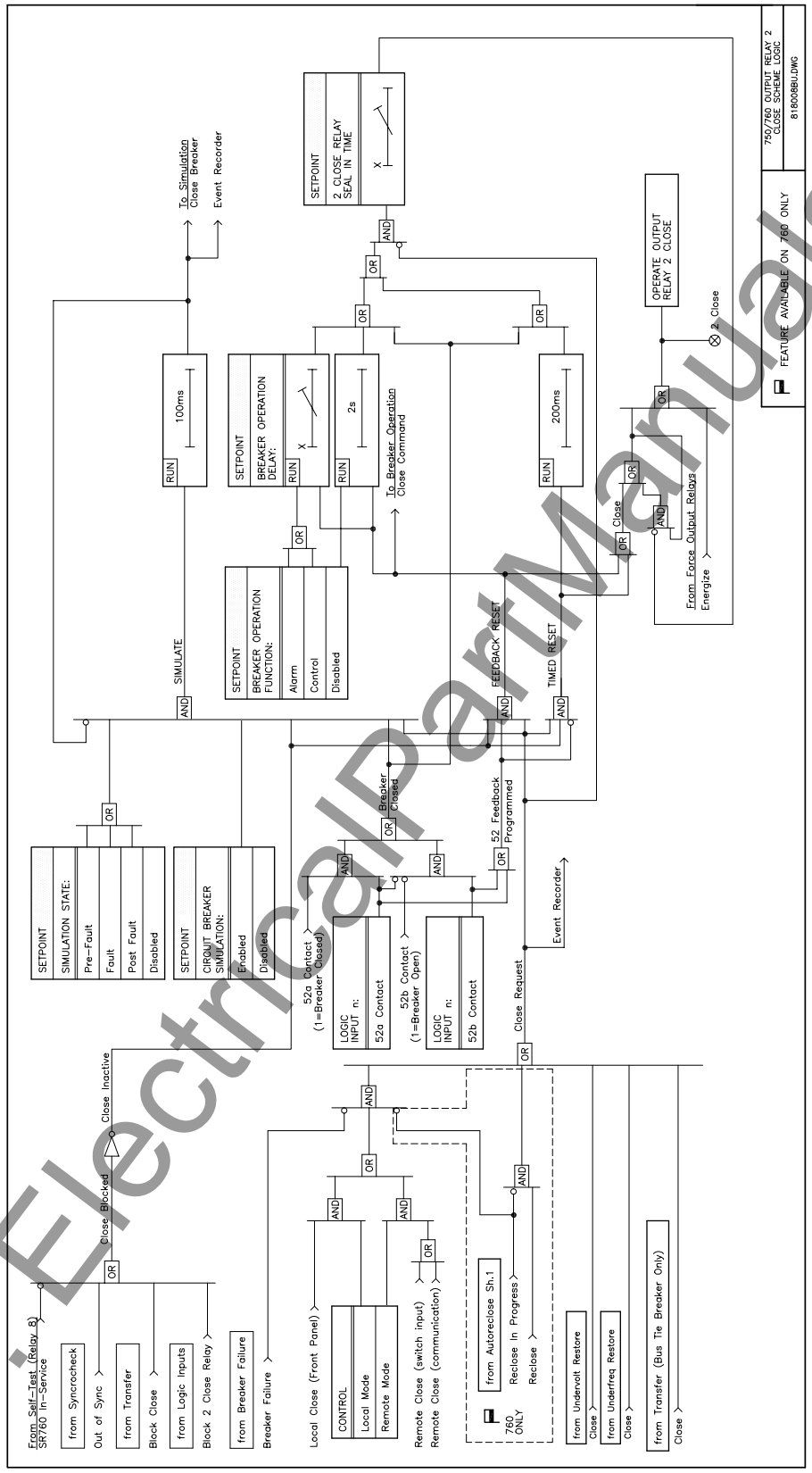


Figure 11–2: OUTPUT RELAY 2 CLOSE

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11.3.1 DESCRIPTION

Output relays 4 through 7 may be edited with setpoints similar to the ones shown for the 3 AUXILIARY relay.

11.3.2 SETTINGS

■ 3 AUXILIARY ■ [ENTER] for more	The 3 Auxiliary setpoints path is: **\ SETPOINTS \ S4 OUTPUT RELAYS \ 3 AUXILIARY**
RELAY 3 NAME: AUXILIARY	*Range: Any Combination of 16 Alphanumeric Characters.* Enter the name of the relay. The name entered here will be displayed instead of the default name in the heading message of the output relay.
RELAY 3 NON-OPERATED STATE: De-energized	*Range: Energized, De-energized* Figure 3–9: TYPICAL WIRING DIAGRAM on page 3–7 shows relay contacts with no control power applied. If the non-operated state of the relay is programmed to be *De-energized*, then the state of the relay contacts will be as shown in the wiring diagram. If the non-operated state is programmed to be *Energized*, then the state of the relay contacts will be opposite to that shown in the wiring diagram.
RELAY 3 OUTPUT TYPE: Self-Resetting	*Range: Self-Resetting, Latched, Pulsed* Three types of output relay operation are available.
PULSED OUTPUT DWELL TIME: 0.1 s	*Range: 0.1 to 6000.0 in steps of 0.1 s* This message is only displayed if the **RELAY 3 OUTPUT TYPE** is selected as *Pulsed*. This setpoint determines the time interval that the pulsed contacts remain in the operated state.

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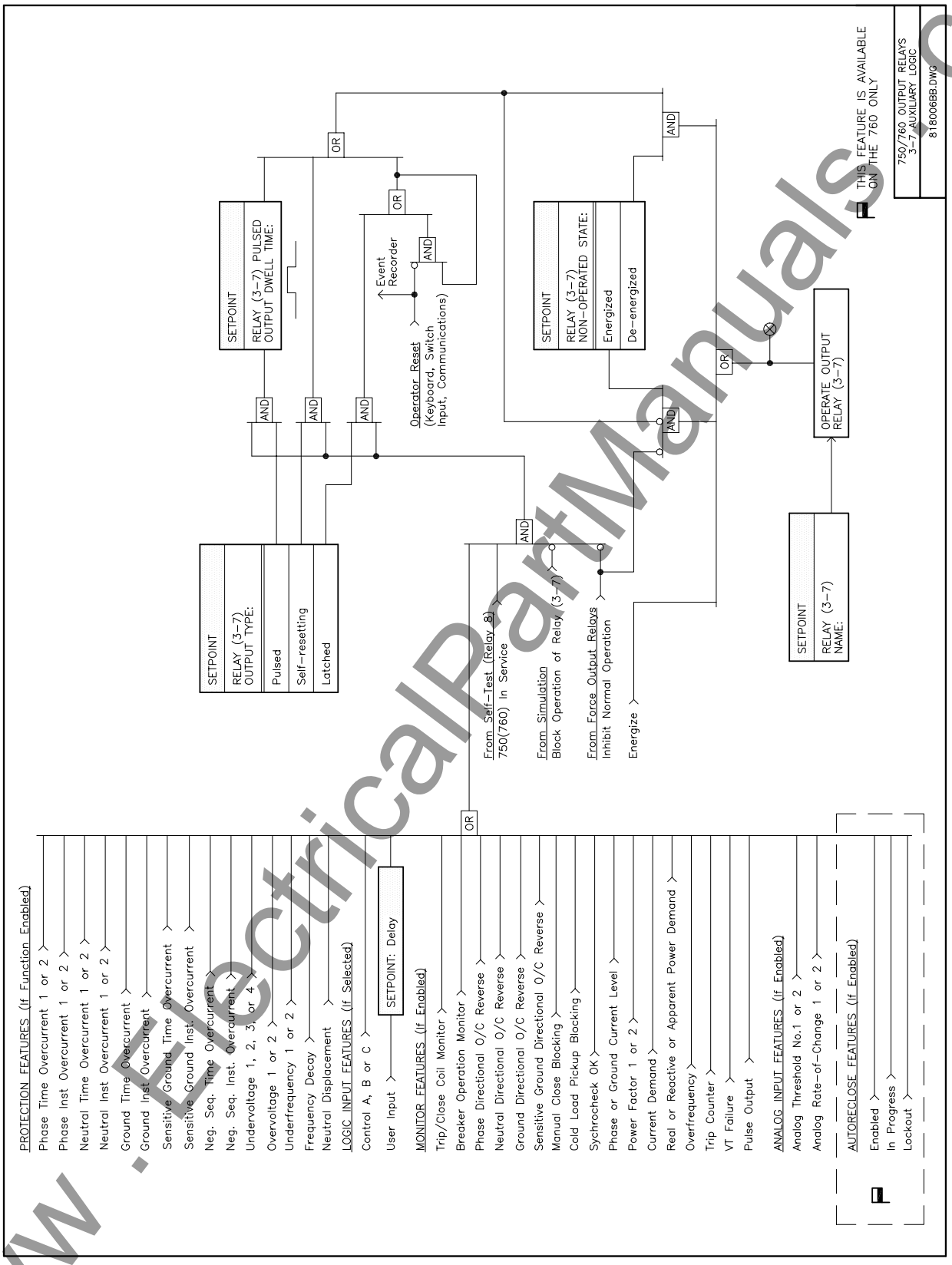


Figure 11–3: OUTPUT RELAYS 3-7 AUXILIARY

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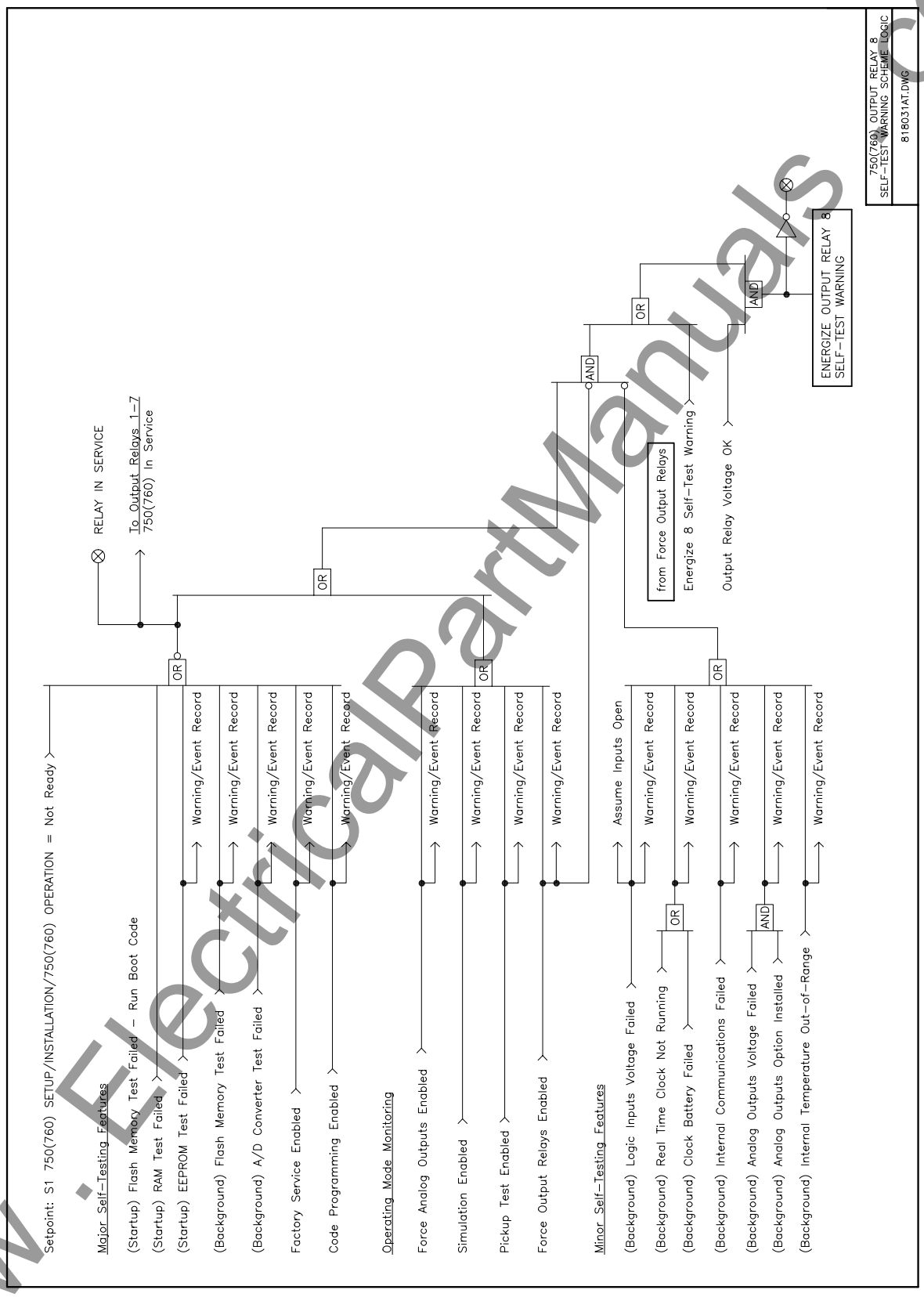


Figure 11–4: OUTPUT RELAY 8 SELF-TEST WARNING

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12.1.1 DESCRIPTION

The relay has a total of six phase, two neutral, one ground, one sensitive ground, and one negative sequence time overcurrent elements. The programming of the time-current characteristics of these elements is identical in all cases and will only be covered in this general section. The required curve is established by programming a Pickup Current, Curve Shape, Curve Multiplier, and Reset Time. The Curve Shape can be either a standard shape or a user-defined shape programmed with the FlexCurve™ feature.

Accurate coordination may require changing the time overcurrent characteristics of particular elements under different conditions. For manual closing or picking up a cold load, a different time-current characteristic can be produced by increasing the pickup current setting. In the 760, the pickup current can also be raised between autoreclose shots. The following setpoints are used to program the time-current characteristics.

[Element Name]
PICKUP: 1.00 x CT

Range: As Shown For Each Element

The pickup current is the threshold current at which the time overcurrent element starts timing. There is no intentional 'dead band' when the current is above the pickup level. However, accuracy is only guaranteed above a 1.03 per unit pickup level. The dropout threshold is 98% of the pickup threshold. Enter the pickup current corresponding to 1 per unit on the time overcurrent curves as a multiple of the source CT. For example, if 100: 5 CTs are used and a pickup of 90 amps is required for the time overcurrent element, enter *0.9 x CT*.

[Element Name]
CURVE: Ext Inverse

Table 12–1: CURVE RANGE

ANSI	GE Type IAC	IEC	Other
Extremely Inverse	Extremely Inverse	Curve A (BS142)	Definite Time
Very Inverse	Very Inverse	Curve B (BS142)	FlexCurve™ A
Normally Inverse	Inverse	Curve C (BS142)	FlexCurve™ B
Moderately Inverse	Short Inverse	IEC Short Inverse	

Select the desired curve shape. If none of the standard curve shapes is appropriate, a custom FlexCurve™ can be created by entering the trip times at 80 different current values. See **S2 SYSTEM SETUP \ FLEXCURVE A**. Curve formulas are given for use with computer based coordination programs **(NOTE: Calculated trip time values are only valid for $I / I_{pu} > 1$)**. Select the appropriate curve shape and multiplier, thus matching the appropriate curve with the protection requirements.

[Element Name]
MULTIPLIER: 1.00

Range: 0.00 to 100.00 in steps of 0.01

A multiplier setpoint allows shifting of the selected base curve in the vertical time direction. Unlike the electromechanical time dial equivalent, trip times are directly proportional to the value of the time multiplier setting. For example, all trip times for a multiplier of 10 are 10 times the multiplier 1 or base curve values. Setting the multiplier to zero results in an instantaneous response to all current levels above pickup.

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[Element Name] RESET: Instantaneous	*Range: Instantaneous, Linear* Time overcurrent tripping time calculations are made with an internal 'energy capacity' memory variable. When this variable indicates that the energy capacity has reached 100%, a time overcurrent trip is generated. If less than 100% is accumulated in this variable and the current falls below the dropout threshold of 97 to 98% of the pickup value, the variable must be reduced. Two methods of this resetting operation are available, *Instantaneous* and *Linear*. The *Instantaneous* selection is intended for applications with other relays, such as most static units, which set the energy capacity directly to zero when the current falls below the reset threshold. The *Linear* selection can be used where the relay must coordinate with electromechanical units. With this setting, the energy capacity variable is decremented according to the following equation. $T_{RESET} = E \times M \times C_R$ where: T_{RESET} = reset time in seconds E = energy capacity reached (per unit) M = curve multiplier C_R = characteristic constant (5 for ANSI, IAC, Definite Time, and FlexCurves™; 8 for IEC)

NOTE

Graphs of standard time-current curves on 11" × 17" log-log graph paper are available upon request. Requests may be placed with our literature department.

12.1.2 DEFINITE TIME CURVE

The Definite Time curve shape causes a trip as soon as the pickup level is exceeded for a specified period of time. The base Definite Time curve has a delay of 0.1 seconds. The curve multiplier makes this delay adjustable from 0.00 to 10.00 seconds in steps of 0.01 seconds.

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The ANSI time overcurrent curve shapes conform to industry standard curves and fit into the ANSI C37.90 curve classifications for extremely, very, normally, and moderately inverse. The 750/760 curves are derived from the formula:

$$T = M \times \left[A + \frac{B}{\left(\frac{I}{I_{pu}} - C\right)} + \frac{D}{\left(\frac{I}{I_{pu}} - C\right)^2} + \frac{E}{\left(\frac{I}{I_{pu}} - C\right)^3} \right]$$

where T = Trip Time (seconds)
M = Multiplier Setpoint
I = Input Current
I_{pu} = Pickup Current Setpoint
A, B, C, D, E = Constants

Table 12–2: ANSI CURVE CONSTANTS

ANSI CURVE CONSTANTS	A	B	C	D	E
EXTREMELY INVERSE	0.0399	0.2294	0.5000	3.0094	0.7222
VERY INVERSE	0.0615	0.7989	0.3400	-0.2840	4.0505
NORMALLY INVERSE	0.0274	2.2614	0.3000	-4.1899	9.1272
MODERATELY INVERSE	0.1735	0.6791	0.8000	-0.0800	0.1271

Table 12–3: ANSI CURVE TRIP TIMES (IN SECONDS)

Multiplier	Current (I / Ipu)									
(M)	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
ANSI EXTREMELY INVERSE										
0.5	2.000	0.872	0.330	0.184	0.124	0.093	0.075	0.063	0.055	0.049
1.0	4.001	1.744	0.659	0.368	0.247	0.185	0.149	0.126	0.110	0.098
2.0	8.002	3.489	1.319	0.736	0.495	0.371	0.298	0.251	0.219	0.196
4.0	16.004	6.977	2.638	1.472	0.990	0.742	0.596	0.503	0.439	0.393
6.0	24.005	10.466	3.956	2.208	1.484	1.113	0.894	0.754	0.658	0.589
8.0	32.007	13.955	5.275	2.944	1.979	1.483	1.192	1.006	0.878	0.786
10.0	40.009	17.443	6.594	3.680	2.474	1.854	1.491	1.257	1.097	0.982
ANSI VERY INVERSE										
0.5	1.567	0.663	0.268	0.171	0.130	0.108	0.094	0.085	0.078	0.073
1.0	3.134	1.325	0.537	0.341	0.260	0.216	0.189	0.170	0.156	0.146
2.0	6.268	2.650	1.074	0.682	0.520	0.432	0.378	0.340	0.312	0.291
4.0	12.537	5.301	2.148	1.365	1.040	0.864	0.755	0.680	0.625	0.583
6.0	18.805	7.951	3.221	2.047	1.559	1.297	1.133	1.020	0.937	0.874
8.0	25.073	10.602	4.295	2.730	2.079	1.729	1.510	1.360	1.250	1.165
10.0	31.341	13.252	5.369	3.412	2.599	2.161	1.888	1.700	1.562	1.457
ANSI NORMALLY INVERSE										
0.5	2.142	0.883	0.377	0.256	0.203	0.172	0.151	0.135	0.123	0.113
1.0	4.284	1.766	0.754	0.513	0.407	0.344	0.302	0.270	0.246	0.226
2.0	8.568	3.531	1.508	1.025	0.814	0.689	0.604	0.541	0.492	0.452
4.0	17.137	7.062	3.016	2.051	1.627	1.378	1.208	1.082	0.983	0.904
6.0	25.705	10.594	4.524	3.076	2.441	2.067	1.812	1.622	1.475	1.356
8.0	34.274	14.125	6.031	4.102	3.254	2.756	2.415	2.163	1.967	1.808
10.0	42.842	17.656	7.539	5.127	4.068	3.445	3.019	2.704	2.458	2.260
ANSI MODERATELY INVERSE										
0.5	0.675	0.379	0.239	0.191	0.166	0.151	0.141	0.133	0.128	0.123
1.0	1.351	0.757	0.478	0.382	0.332	0.302	0.281	0.267	0.255	0.247
2.0	2.702	1.515	0.955	0.764	0.665	0.604	0.563	0.533	0.511	0.493
4.0	5.404	3.030	1.910	1.527	1.329	1.208	1.126	1.066	1.021	0.986
6.0	8.106	4.544	2.866	2.291	1.994	1.812	1.689	1.600	1.532	1.479
8.0	10.807	6.059	3.821	3.054	2.659	2.416	2.252	2.133	2.043	1.972
10.0	13.509	7.574	4.776	3.818	3.324	3.020	2.815	2.666	2.554	2.465

Graphs of standard time-current curves on 11" × 17" log-log graph paper are available upon request. Requests may be placed with our literature department.

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The curves for the General Electric type IAC relay family are derived from the formula:

$$T = M \times \left[A + \frac{B}{\left(\frac{I}{I_{pu}} - C\right)} + \frac{D}{\left(\frac{I}{I_{pu}} - C\right)^2} + \frac{E}{\left(\frac{I}{I_{pu}} - C\right)^3} \right]$$

where T = Trip Time (seconds)
M = Multiplier Setpoint
I = Input Current
I_{pu} = Pickup Current Setpoint
A, B, C, D, E = Constants

Table 12–4: IAC CURVE CONSTANTS

IAC CURVE CONSTANTS	A	B	C	D	E
IAC EXTREME INVERSE	0.0040	0.6379	0.6200	1.7872	0.2461
IAC VERY INVERSE	0.0900	0.7955	0.1000	-1.2885	7.9586
IAC INVERSE	0.2078	0.8630	0.8000	-0.4180	0.1947
IAC SHORT INVERSE	0.0428	0.0609	0.6200	-0.0010	0.0221

Table 12–5: IAC CURVE TRIP TIMES (IN SECONDS)

Multiplier	Current (I / Ipu)									
(M)	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IAC EXTREMELY INVERSE										
0.5	1.699	0.749	0.303	0.178	0.123	0.093	0.074	0.062	0.053	0.046
1.0	3.398	1.498	0.606	0.356	0.246	0.186	0.149	0.124	0.106	0.093
2.0	6.796	2.997	1.212	0.711	0.491	0.372	0.298	0.248	0.212	0.185
4.0	13.591	5.993	2.423	1.422	0.983	0.744	0.595	0.495	0.424	0.370
6.0	20.387	8.990	3.635	2.133	1.474	1.115	0.893	0.743	0.636	0.556
8.0	27.183	11.987	4.846	2.844	1.966	1.487	1.191	0.991	0.848	0.741
10.0	33.979	14.983	6.058	3.555	2.457	1.859	1.488	1.239	1.060	0.926
IAC VERY INVERSE										
0.5	1.451	0.656	0.269	0.172	0.133	0.113	0.101	0.093	0.087	0.083
1.0	2.901	1.312	0.537	0.343	0.266	0.227	0.202	0.186	0.174	0.165
2.0	5.802	2.624	1.075	0.687	0.533	0.453	0.405	0.372	0.349	0.331
4.0	11.605	5.248	2.150	1.374	1.065	0.906	0.810	0.745	0.698	0.662
6.0	17.407	7.872	3.225	2.061	1.598	1.359	1.215	1.117	1.046	0.992
8.0	23.209	10.497	4.299	2.747	2.131	1.813	1.620	1.490	1.395	1.323
10.0	29.012	13.121	5.374	3.434	2.663	2.266	2.025	1.862	1.744	1.654
IAC NORMALLY INVERSE										
0.5	0.578	0.375	0.266	0.221	0.196	0.180	0.168	0.160	0.154	0.148
1.0	1.155	0.749	0.532	0.443	0.392	0.360	0.337	0.320	0.307	0.297
2.0	2.310	1.499	1.064	0.885	0.784	0.719	0.674	0.640	0.614	0.594
4.0	4.621	2.997	2.128	1.770	1.569	1.439	1.348	1.280	1.229	1.188
6.0	6.931	4.496	3.192	2.656	2.353	2.158	2.022	1.921	1.843	1.781
8.0	9.242	5.995	4.256	3.541	3.138	2.878	2.695	2.561	2.457	2.375
10.0	11.552	7.494	5.320	4.426	3.922	3.597	3.369	3.201	3.072	2.969
IAC SHORT INVERSE										
0.5	0.072	0.047	0.035	0.031	0.028	0.027	0.026	0.026	0.025	0.025
1.0	0.143	0.095	0.070	0.061	0.057	0.054	0.052	0.051	0.050	0.049
2.0	0.286	0.190	0.140	0.123	0.114	0.108	0.105	0.102	0.100	0.099
4.0	0.573	0.379	0.279	0.245	0.228	0.217	0.210	0.204	0.200	0.197
6.0	0.859	0.569	0.419	0.368	0.341	0.325	0.314	0.307	0.301	0.296
8.0	1.145	0.759	0.559	0.490	0.455	0.434	0.419	0.409	0.401	0.394
10.0	1.431	0.948	0.699	0.613	0.569	0.542	0.524	0.511	0.501	0.493

Graphs of standard time-current curves on 11" × 17" log-log graph paper are available upon request. Requests may be placed with our literature department.

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For European applications, the relay offers the four standard curves defined in IEC 255-4 and British Standard BS142. These are defined as IEC Curve A, IEC Curve B, IEC Curve C, and Short Inverse. The formula is:

$$T = M \times \left[\frac{K}{\left(\frac{I}{I_{pu}} \right)^{E} - 1} \right]$$

where T = Trip Time (seconds)
M = Multiplier Setpoint
I = Input Current
I_{pu} = Pickup Current Setpoint
K, E = Constants

Table 12–6: IEC CURVE CONSTANTS

IEC CURVE CONSTANTS	K	E
IEC CURVE A	0.140	0.020
IEC CURVE B	13.500	1.000
IEC CURVE C	80.000	2.000
SHORT INVERSE	0.050	0.040

Table 12–7: IEC CURVE TRIP TIMES (IN SECONDS)

Multiplier	Current (I / Ipu)									
(M)	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEC CURVE A										
0.05	0.860	0.501	0.315	0.249	0.214	0.192	0.176	0.165	0.156	0.149
0.10	1.719	1.003	0.630	0.498	0.428	0.384	0.353	0.330	0.312	0.297
0.20	3.439	2.006	1.260	0.996	0.856	0.767	0.706	0.659	0.623	0.594
0.40	6.878	4.012	2.521	1.992	1.712	1.535	1.411	1.319	1.247	1.188
0.60	10.317	6.017	3.781	2.988	2.568	2.302	2.117	1.978	1.870	1.782
0.80	13.755	8.023	5.042	3.984	3.424	3.070	2.822	2.637	2.493	2.376
1.00	17.194	10.029	6.302	4.980	4.280	3.837	3.528	3.297	3.116	2.971
IEC CURVE B										
0.05	1.350	0.675	0.338	0.225	0.169	0.135	0.113	0.096	0.084	0.075
0.10	2.700	1.350	0.675	0.450	0.338	0.270	0.225	0.193	0.169	0.150
0.20	5.400	2.700	1.350	0.900	0.675	0.540	0.450	0.386	0.338	0.300
0.40	10.800	5.400	2.700	1.800	1.350	1.080	0.900	0.771	0.675	0.600
0.60	16.200	8.100	4.050	2.700	2.025	1.620	1.350	1.157	1.013	0.900
0.80	21.600	10.800	5.400	3.600	2.700	2.160	1.800	1.543	1.350	1.200
1.00	27.000	13.500	6.750	4.500	3.375	2.700	2.250	1.929	1.688	1.500
IEC CURVE C										
0.05	3.200	1.333	0.500	0.267	0.167	0.114	0.083	0.063	0.050	0.040
0.10	6.400	2.667	1.000	0.533	0.333	0.229	0.167	0.127	0.100	0.081
0.20	12.800	5.333	2.000	1.067	0.667	0.457	0.333	0.254	0.200	0.162
0.40	25.600	10.667	4.000	2.133	1.333	0.914	0.667	0.508	0.400	0.323
0.60	38.400	16.000	6.000	3.200	2.000	1.371	1.000	0.762	0.600	0.485
0.80	51.200	21.333	8.000	4.267	2.667	1.829	1.333	1.016	0.800	0.646
1.00	64.000	26.667	10.000	5.333	3.333	2.286	1.667	1.270	1.000	0.808
IEC SHORT TIME										
0.05	0.153	0.089	0.056	0.044	0.038	0.034	0.031	0.029	0.027	0.026
0.10	0.306	0.178	0.111	0.088	0.075	0.067	0.062	0.058	0.054	0.052
0.20	0.612	0.356	0.223	0.175	0.150	0.135	0.124	0.115	0.109	0.104
0.40	1.223	0.711	0.445	0.351	0.301	0.269	0.247	0.231	0.218	0.207
0.60	1.835	1.067	0.668	0.526	0.451	0.404	0.371	0.346	0.327	0.311
0.80	2.446	1.423	0.890	0.702	0.602	0.538	0.494	0.461	0.435	0.415
1.00	3.058	1.778	1.113	0.877	0.752	0.673	0.618	0.576	0.544	0.518

Graphs of standard time-current curves on 11" × 17" log-log graph paper are available upon request. Requests may be placed with our literature department.

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12.2.1 DESCRIPTION

Directional overcurrent relaying is necessary for the protection of multiple source feeders, when it is essential to discriminate between faults in different directions. It would be impossible to obtain correct relay selectivity through the use of a non-directional overcurrent relay in such cases. Fault directional control (ANSI device 67) is incorporated into the relay for all phase, neutral, sensitive ground, and negative sequence overcurrent elements. If directional control is selected, it will determine whether current flow in each phase is in the forward or reverse direction, as determined by the connection of the phase source CTs, selected MTA angle, voltage and current phasors. Each overcurrent element can be individually programmed to operate for flow only in specific directions. For increased security, all overcurrent elements under directional control add one power frequency cycle of intentional delay to prevent operational errors on current 'swings'.

Some terms commonly used in directional relaying are defined as:

- ***Operating Current***: the quantity whose directionality is to be tested.
- ***Polarizing Voltage***: a voltage whose phase will remain reasonably constant between a non-faulted and a faulted system, used as a phase reference for the operating current.
- ***Relay Connection***: for phase directional relaying, the characteristic angle between the operating current and the polarizing voltage in the non-faulted system.
- ***Zero Torque Line***: the boundary line between operating and blocking regions in the complex plane; in an electromechanical directional relay, an operating current near this line generates minimum torque.
- ***Maximum Torque Line***: the line perpendicular, through the origin, to the Zero Torque Line in the complex plane; in an electromechanical directional relay, an operating current near this line will generate a maximum amount of torque.
- ***Maximum Torque Angle (MTA)***: the angle by which the Maximum Torque Line is rotated from the Polarizing Voltage.

The following diagram specifically shows the phasors involved for phase A directional polarization, but the general principles can be applied to all directional elements.

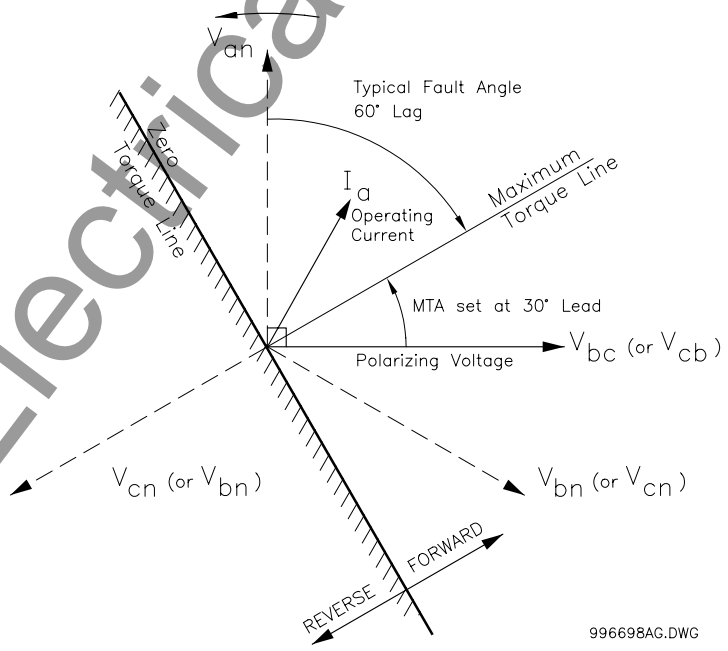


Figure 12–1: PHASE A DIRECTIONAL OVERCURRENT POLARIZING

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12.2.2 PHASE OVERCURRENT

Phase overcurrent protection comprises two time overcurrent, two instantaneous overcurrent, and a phase directional element. The directional element determines whether current flow is in the forward or reverse direction, as determined by the connected polarity of the input CTs and the Maximum Torque Angle selected for the phase directional element. Each phase overcurrent element can be programmed to either disable directionality or provide a trip for current flow in the forward/reverse direction only. Two elements allow the use of 'Loset' and 'Hiset' detectors in autoreclose applications, zone-selective (blocking) schemes, and distinct settings for faults in different directions. Phase overcurrent protection elements can be blocked individually or by logic inputs.

12.2.3 PHASE TIME OVERCURRENT

Phase time overcurrent 1 and 2 are identical elements. Each consists of the equivalent of three separate time overcurrent relays, ANSI device 51P, with identical characteristics. These elements can be controlled by the phase directional element, providing operation for current flow in the permitted direction only. Voltage restrained operation which reduces the pickup level with reduced voltage is also available.

■ PHASE TIME OC 1 ■ [ENTER] for more	The Phase Time Overcurrent 1 setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ PHASE CURRENT \ PHASE TIME OC 1**
PHASE TIME OC 1 FUNCTION: Trip	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
PHASE TIME OC 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
PHASE TIME OC 1 PICKUP: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Select the current level required.
PHASE TIME OC 1 CURVE: Ext Inverse	*Range: Ext Inverse, Very Inverse, Norm Inverse, ..., FlexCurve B* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
PHASE TIME OC 1 MULTIPLIER: 1.00	*Range: 0.00 to 100.00 in steps of 0.01* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
PHASE TIME OC 1 RESET: Instantaneous	*Range: Instantaneous, Linear* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
PHASE TIME OC 1 DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.
PHASE TIME OC 1 VOLT RESTRAINT: Disabled	*Range: Enabled, Disabled* Select *Disabled* for this setpoint if voltage restraint is not required. When set to *Enabled*, this feature lowers the pickup value of each individual phase time OC element in a fixed relationship with the corresponding phase input voltage. When voltage restraint is enabled, it is not allowed to change the pickup current setting if the manual close blocking, cold load pickup blocking or autoreclose features are controlling the protection. If the **BUS INPUT VT TYPE** is selected to *None*, this feature is automatically disabled.

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Figure 12–2: VOLTAGE RESTRAINT CHARACTERISTIC FOR PHASE-TIME OVERCURRENT

NOTE

If voltage restraint is enabled, the adjusted pickup, calculated by adjusting the pickup value by the multiplier, will not fall below 0.05 × CT, which is the lowest setting for the PHASE TIME OC PICKUP.

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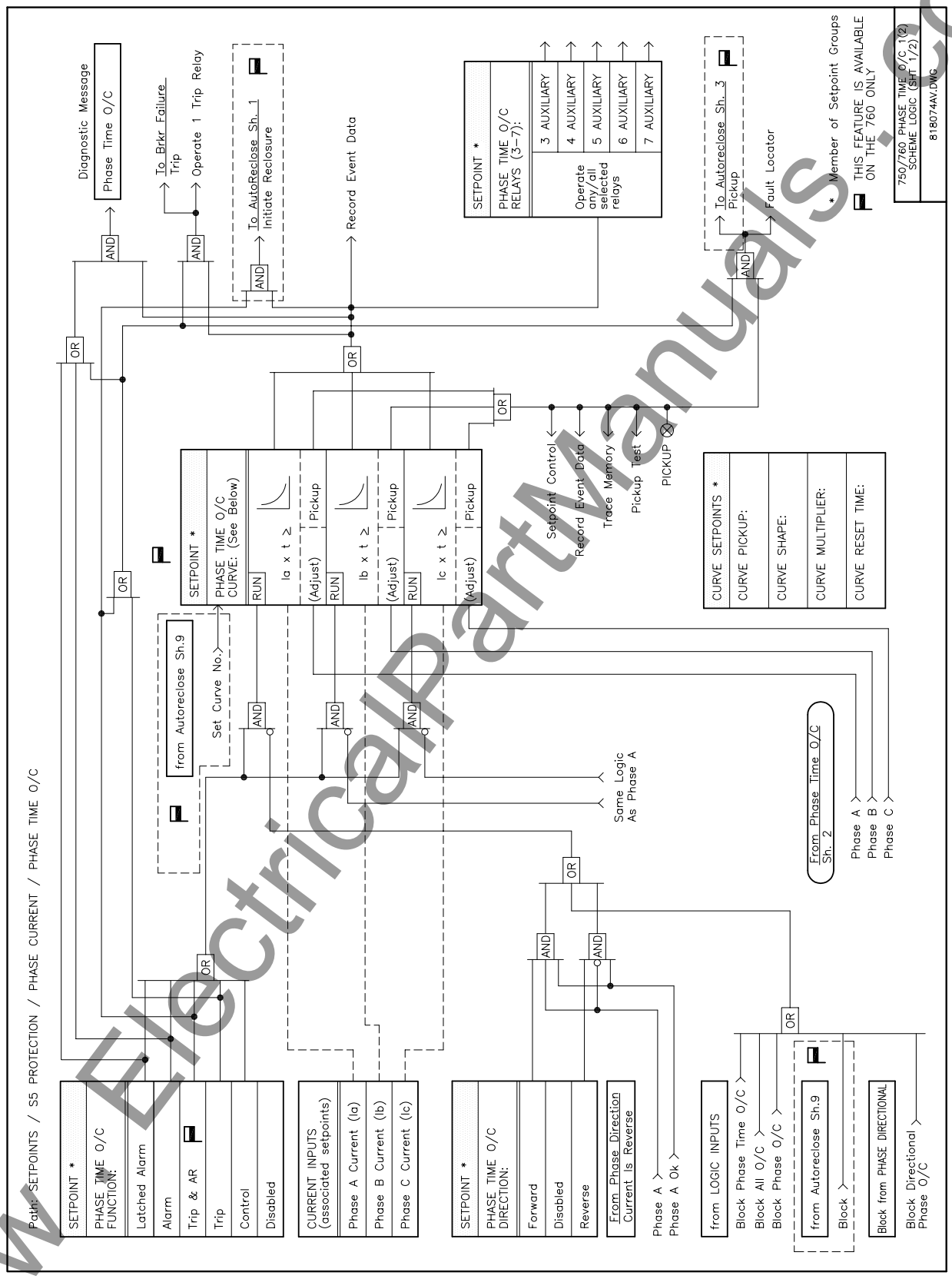


Figure 12–3: PHASE TIME OVERCURRENT LOGIC DIAGRAM (1 OF 2)

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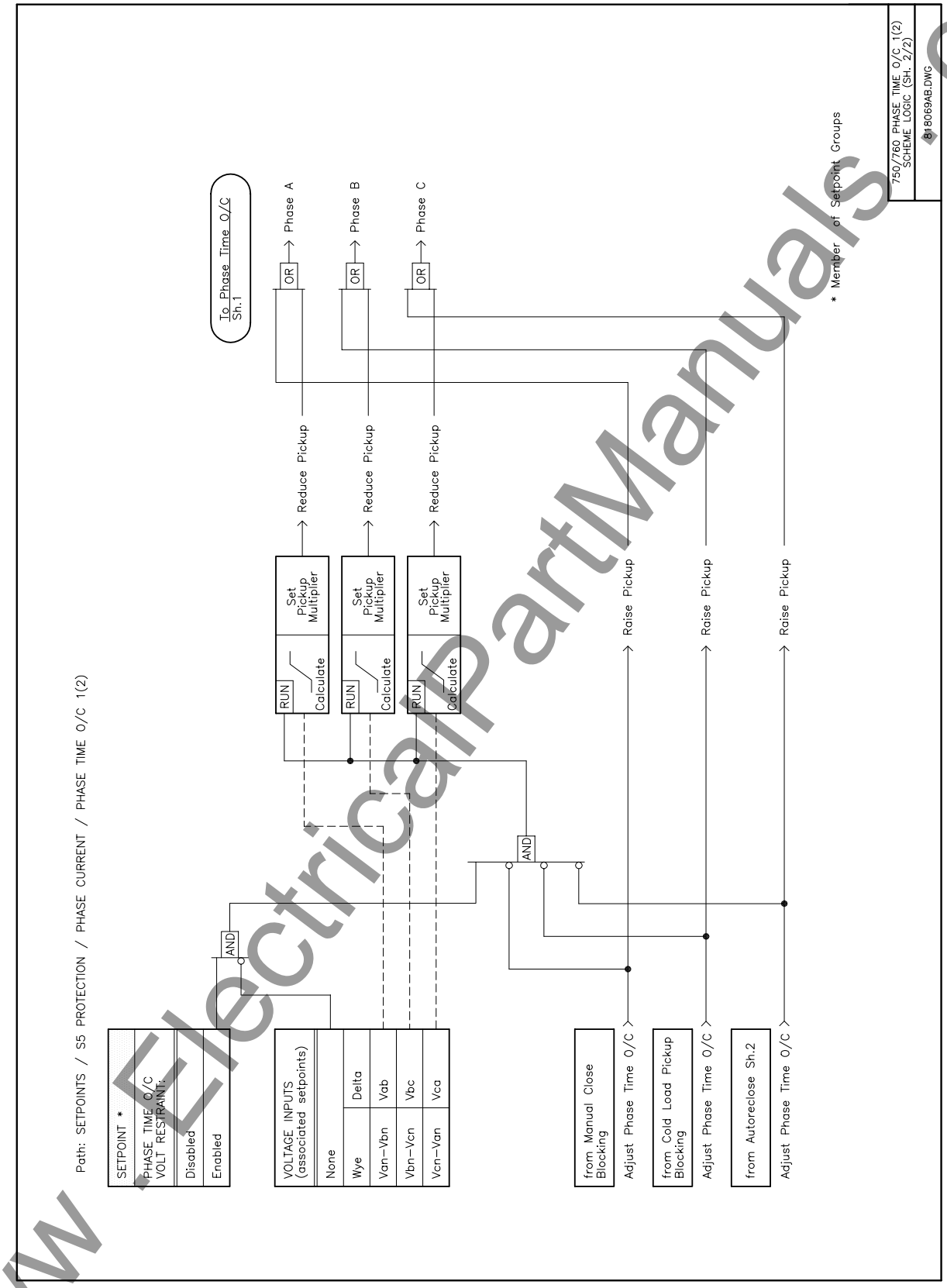


Figure 12–4: PHASE TIME OVERCURRENT LOGIC DIAGRAM (2 OF 2)

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12.2.4 PHASE INSTANTANEOUS OVERCURRENT

Phase instantaneous overcurrent 1 and 2 are identical elements. Each consists of the equivalent of three separate instantaneous overcurrent relays, ANSI device 50P, all with identical characteristics. These elements can be controlled by the phase directional element, providing operation for current flow in the permitted direction only.

■ PHASE INST OC 1 ■ [ENTER] for more	The Phase Instantaneous Overcurrent 1 setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ PHASE CURRENT \ PHASE INST OC 1**
PHASE INST OC 1 FUNCTION: Trip	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
PHASE INST OC 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
PHASE INST OC 1 PICKUP: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Enter the pickup in terms of the CT rating. For example, if 100:5 phase CTs are installed, enter *10.0 x CT* for an overcurrent trip of 1000 A.
PHASE INST OC 1 DELAY: 0.00 s	*Range: 0.00 to 600.00 in steps of 0.01 s* Select the delay required.
PHASES REQUIRED FOR OPERATION: Any One	*Range: Any One, Any Two, All Three* Select the type of operation required.
PHASE INST OC 1 DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.

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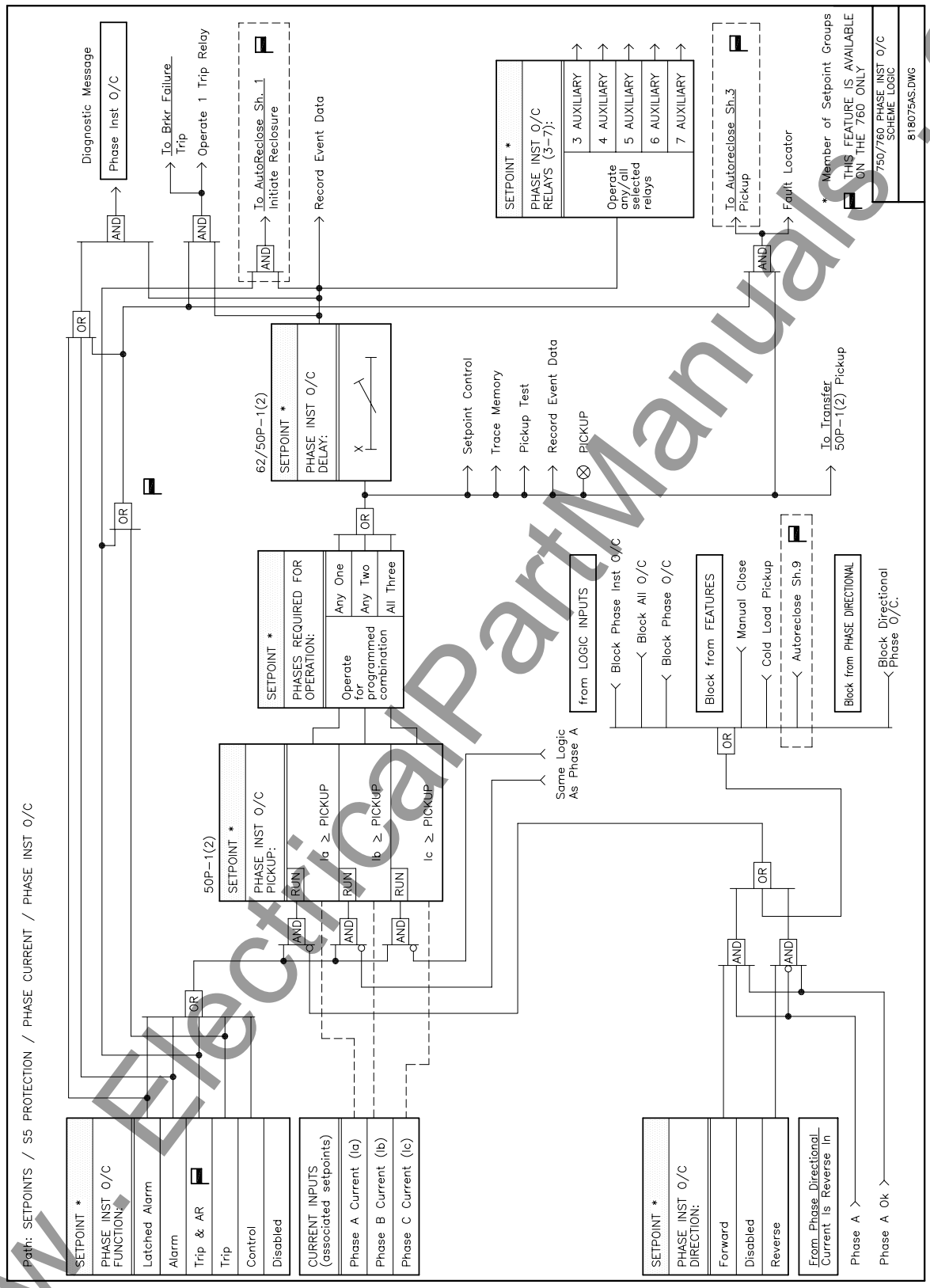


Figure 12–5: PHASE INSTANTANEOUS OVERCURRENT LOGIC DIAGRAM

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The 750/760 uses the secure 90° or quadrature connection exclusively for phase directional polarization. An MTA setting of 90° represents a phase current in-phase with its phase voltage, which is leading the polarizing voltage by 90°. The table below shows the operating currents and polarizing voltages used for phase directional control. Refer to Section 12.2.1: DESCRIPTION on page 12–6 for more information.

Table 12–8: PHASE DIRECTIONAL CONTROL OPERATING CHARACTERISTICS

QUANTITY	OPERATING CURRENT	POLARIZING VOLTAGE (ABC Phase Sequence)	POLARIZING VOLTAGE (ACB Phase Sequence)
Phase A	I_a	V_{bc}	V_{cb}
Phase B	I_b	V_{ca}	V_{ac}
Phase C	I_c	V_{ab}	V_{ba}

To increase security for three phase faults very close to the location of the VTs used to measure the polarizing voltage, a **voltage memory** feature is incorporated. This feature remembers the last measurement of the polarizing voltage which is greater than the **MINIMUM POLARIZING VOLTAGE** setting and uses it to determine direction. The voltage memory remains valid for one second after the voltages have collapsed. Once the voltage memory has expired, after one second, the phase overcurrent elements under directional control can be set to block or trip on overcurrent. When set to *Enabled*, the setpoint **BLOCK OC WHEN VOLT MEM EXPIRES** will block the operation of any phase overcurrent element under directional control when voltage memory expires. When set to *Disabled*, directional blocking of any phase overcurrent element will be inhibited. The voltage memory is updated immediately when the polarizing voltage is restored.

To complement the voltage memory feature, a 'Close Into Fault' (CIF) feature allows close-in faults to be cleared when energizing a line. When the **BLOCK OC WHEN VOLT MEM EXPIRES** setpoint is *Disabled*, the CIF feature permits operation of any phase overcurrent element if current appears without any voltage. When set to *Enabled* the CIF feature inhibits operation of any phase overcurrent element under directional control under these conditions. In both cases, directional blocking will be permitted to resume when the polarizing voltage becomes greater than the 'minimum polarizing voltage' setting.

CAUTION

Setting the BLOCK OC WHEN VOLT MEM EXPIRES to *Enabled* will block all phase overcurrent elements under directional control (phase overcurrent element set to trip in either the forward or reverse direction) from operating.

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12.2.6 PHASE DIRECTIONAL SETPOINTS

■ PHASE DIRECTIONAL ■ [ENTER] for more	The Phase Directional setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ PHASE CURRENT \ PHASE DIRECTIONAL**
PHASE DIRECTIONAL FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
PHASE DIRECTIONAL RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
PHASE DIRECTIONAL MTA: 30° LEAD	*Range: 0 to 359° in steps of 1°* Enter the maximum torque angle from 0 to 359°, by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity. The factory default value for maximum torque angle is 30°. This is an appropriate angle for an inductive fault angle of 60°, which is typical of the upper voltage range of distribution feeders. See Figure 12–1: PHASE A DIRECTIONAL OVERCURRENT POLARIZING on page 12–6 for more information.
MINIMUM POLARIZING VOLTAGE: 0.05 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT*
BLK OC WHEN VOLT MEM EXPIRES: Disabled	*Range: Disabled, Enabled* Select the required operation upon expiration of voltage memory. When this setpoint is set to *Enabled*, all phase overcurrent elements under directional control will be blocked from operating when voltage memory expires. When set to *Disabled*, all phase overcurrent elements will not be inhibited by directional control. This setpoint also determines the operation of the phase overcurrent elements under directional control upon 'Close Into Fault' (CIF).

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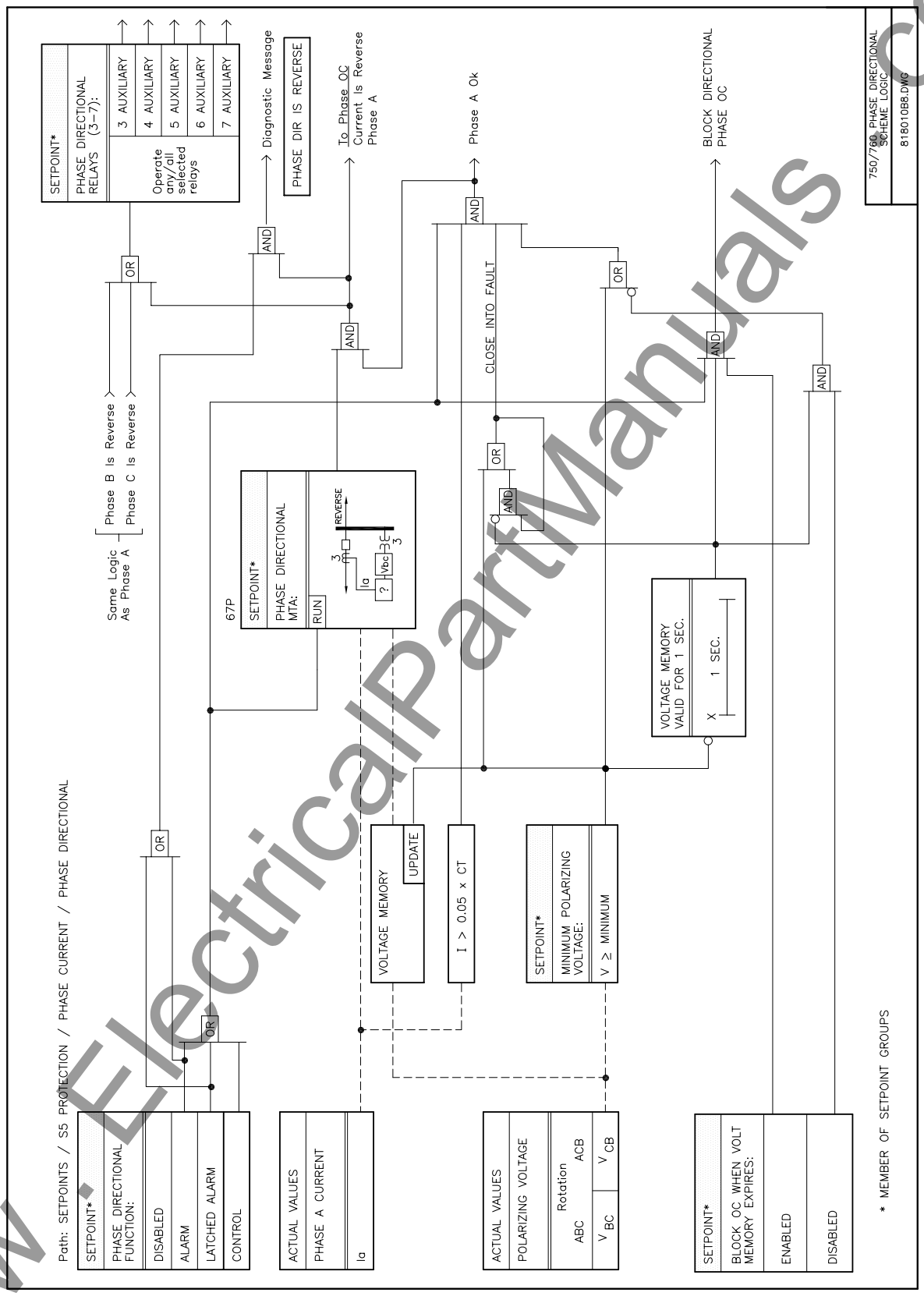


Figure 12–6: PHASE DIRECTIONAL LOGIC DIAGRAM

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12.3.1 DESCRIPTION

Four neutral overcurrent protection elements are provided. Two time overcurrent elements and two instantaneous overcurrent elements. They all monitor the calculated neutral current ($3I_o = I_a + I_b + I_c$) which has DC offset and harmonic components removed. Neutral overcurrent elements can be controlled by the neutral directional element allowing operation for faults in the permitted direction only. Also, the elements can be blocked individually or as a group by logic inputs.

12.3.2 NEUTRAL TIME OVERCURRENT

Neutral time overcurrent elements 1 and 2 are programmed in this subgroup. They are two identical protection elements each equivalent to a single ANSI device 51N neutral time overcurrent relay.

■ NEUTRAL TIME OC 1 ■ [ENTER] for more	The Neutral Time Overcurrent 1 setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ NEUTRAL CURRENT \ NEUTRAL TIME OC 1**
NEUTRAL TIME OC 1 FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
NEUTRAL TIME OC 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NEUTRAL TIME OC 1 PICKUP: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Select the current level required.
NEUTRAL TIME OC 1 CURVE: Ext Inverse	*Range: Ext Inverse, Very Inverse, Norm Inverse, ..., Flex Curve B* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
NEUTRAL TIME OC 1 MULTIPLIER: 1.00	*Range: 0.00 to 100.00 in steps of 0.01* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
NEUTRAL TIME OC 1 RESET: Instantaneous	*Range: Instantaneous, Linear* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
NEUTRAL TIME OC 1 DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.

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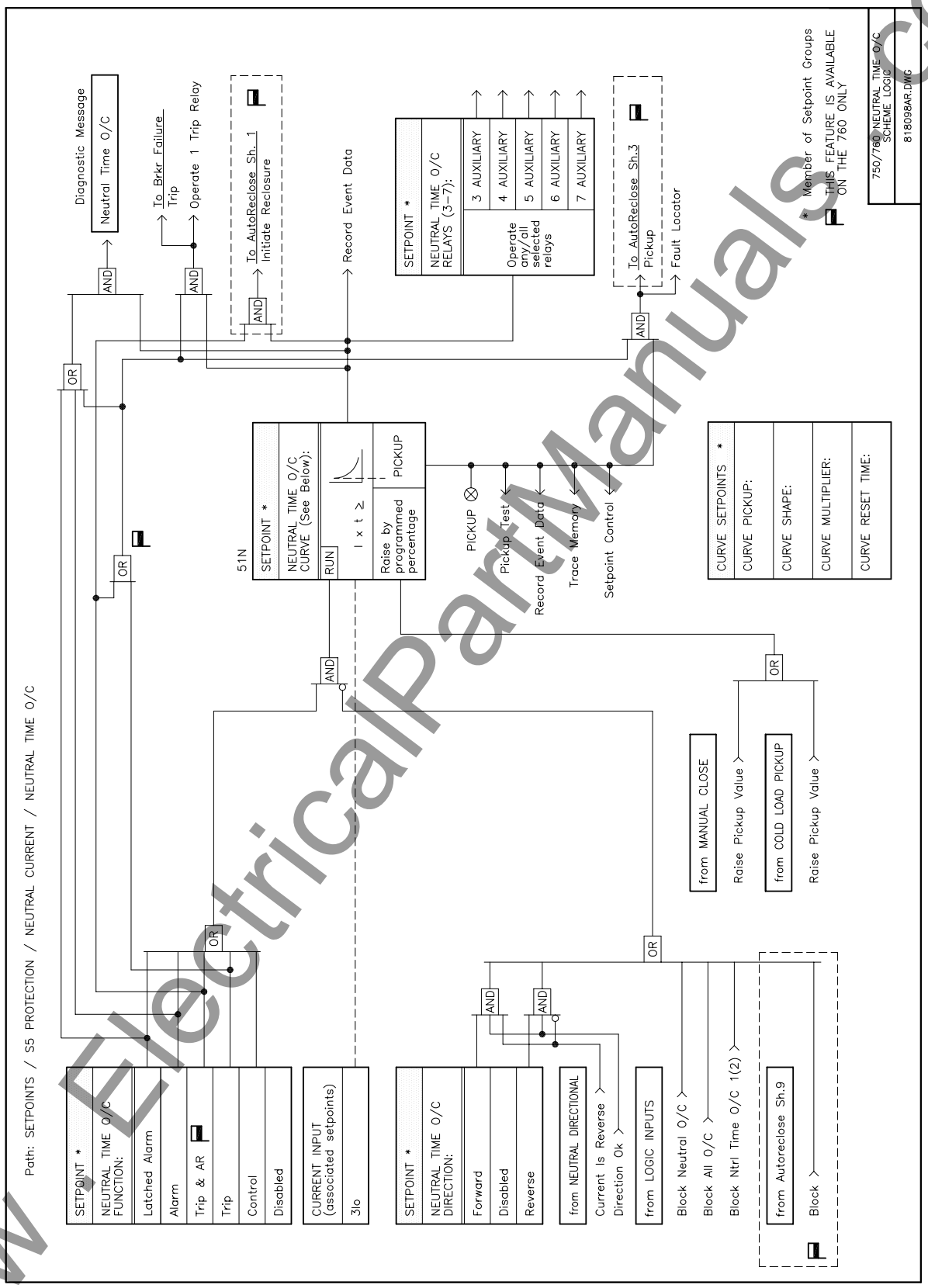


Figure 12–7: NEUTRAL TIME OVERCURRENT LOGIC DIAGRAM

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12.3.3 NEUTRAL INSTANTANEOUS OVERCURRENT

Neutral instantaneous overcurrent elements 1 and 2 are programmed in this subgroup. They are two identical protection elements each equivalent to a single ANSI device 50N neutral instantaneous overcurrent relay.

■ NEUTRAL TIME OC 1 ■ [ENTER] for more	The Neutral Instantaneous Overcurrent 1 setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ NEUTRAL CURRENT \ NEUTRAL INST OC 1**
NEUTRAL INST OC 1 FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
NEUTRAL INST OC 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NEUTRAL INST OC 1 PICKUP: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Enter the pickup in terms of the CT rating. For example, if a pickup of 1000 A is required, enter *5.0 x CT* with a 200:5 phase CT installed.
NEUTRAL INST OC 1 DELAY: 0.00 s	*Range: 0.00 to 600.00 in steps of 0.01 s* Select the delay required.
NEUTRAL INST OC 1 DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.

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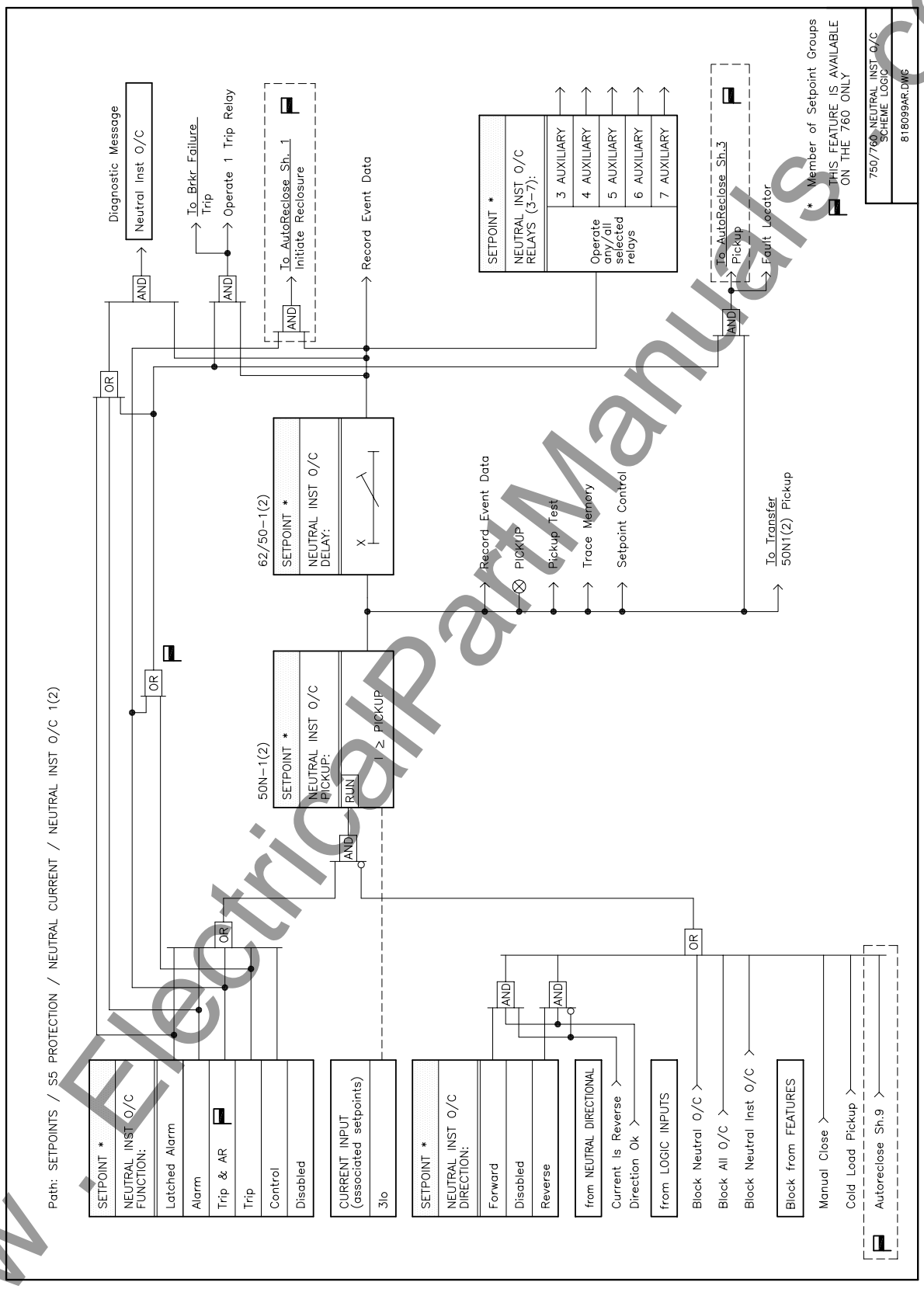


Figure 12–8: NEUTRAL INSTANTANEOUS OVERCURRENT LOGIC DIAGRAM

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The neutral directional feature controls the operation of all neutral overcurrent elements and allows them to discriminate between forward or reverse faults. Refer to Section 12.2: DIRECTIONAL OVERCURRENT CHARACTERISTICS on page 12–6 for more details on directional principles. Neutral directional can be either voltage, current, or dual polarized. The calculated neutral current is always the operating current.

When voltage polarized, the polarizing quantity is the zero sequence voltage which is calculated from the bus input voltages. The **VT CONNECTION TYPE** must be *wye* in this case. If the polarizing voltage drops below the **MINIMUM OPERATING VOLTAGE** setting the direction defaults to forward. The following table shows the operating current and polarizing voltage used for neutral directional control

Table 12–9: NEUTRAL DIRECTIONAL OPERATING CHARACTERISTICS

QUANTITY	OPERATING CURRENT	POLARIZING VOLTAGE (VT connection = Wye)	POLARIZING CURRENT
Neutral	$3I_0 = I_a + I_b + I_c$	$-V_0 = -(V_a + V_b + V_c) / 3$	I_g †

† Note: On relays with bootware revision 3.00 or newer, the polarizing current is input via the ground CT input. Otherwise, the polarizing current is input via a dedicated polarizing CT input. See Section 3.2: TYPICAL WIRING on page 3–5 for more details.

When current polarized the Ground CT Input (terminals G10, H10) is used to determine neutral current direction. The polarizing current comes from a source CT measuring the current flowing from the ground return into the neutral of a ground fault current source which is usually a transformer. The direction is *Forward* when the neutral current is within ±90° of the polarizing current. Otherwise, the direction is *Reverse*. If the polarizing current is less than 5% of CT nominal then the direction defaults to forward.

Dual polarization provides maximum security and reliability. If the polarizing voltage magnitude is insufficient then current polarizing takes control. If the polarizing current magnitude is insufficient then the voltage polarizing takes control. If neither voltage nor current polarizing is possible then the direction defaults to forward.

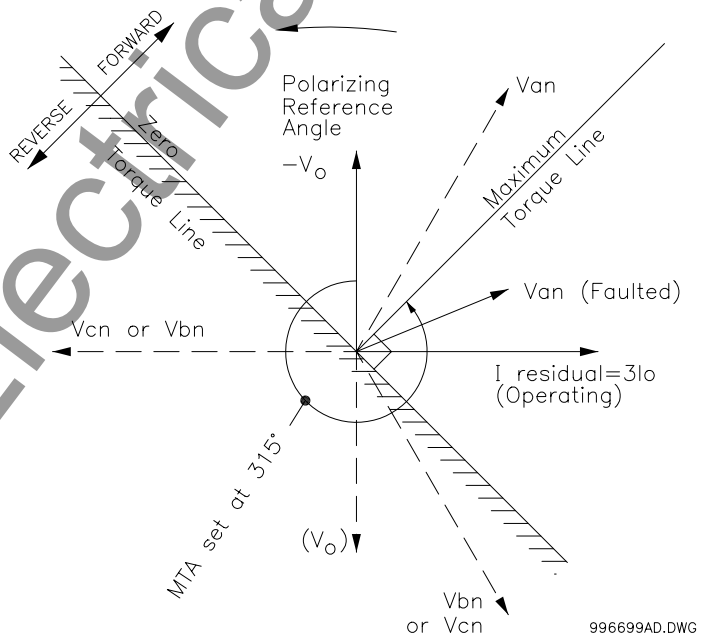


Figure 12–9: NEUTRAL DIRECT VOLTAGE POLARIZING

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The setpoints for Neutral Directional are as follows:

■ NEUTRAL DIRECTION ■ [ENTER] for more	The Neutral Time Overcurrent 1 setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ NEUTRAL CURRENT \ NEUTRAL DIRECTION**
NEUTRAL DIRECTIONAL FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
NEUTRAL DIRECTIONAL RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NEUTRAL POLARIZING: Voltage	*Range: Voltage, Current, Dual* If neutral directional control with both voltage and current polarized elements is desired, enter *Dual*. If neutral directional control with only the voltage polarized element is desired, enter *Voltage*. If neutral directional control with only the current polarized element is desired, enter *Current*.
NEUTRAL DIRECTIONAL MTA: 315° Lead	*Range: 0 to 359 Lead in steps of 1°* Enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity. This setting affects voltage polarizing only. See Figure 12–9: NEUTRAL DIRECT VOLTAGE POLARIZING on page 12–20 for more information.
MINIMUM POLARIZING VOLTAGE: 0.05 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* This setting affects the voltage element only. As the system zero sequence voltage is used as the polarizing voltage for this element, a minimum level of voltage must be selected to prevent operation caused by system unbalanced voltages or VT ratio errors. For well-balanced systems and 1% accuracy VTs, this setpoint can be as low as 2% of VT nominal voltage. For systems with high-resistance grounding or floating neutrals, this setpoint can be as high as 20%. The default value of *0.05 x VT* is appropriate for most solidly grounded systems.

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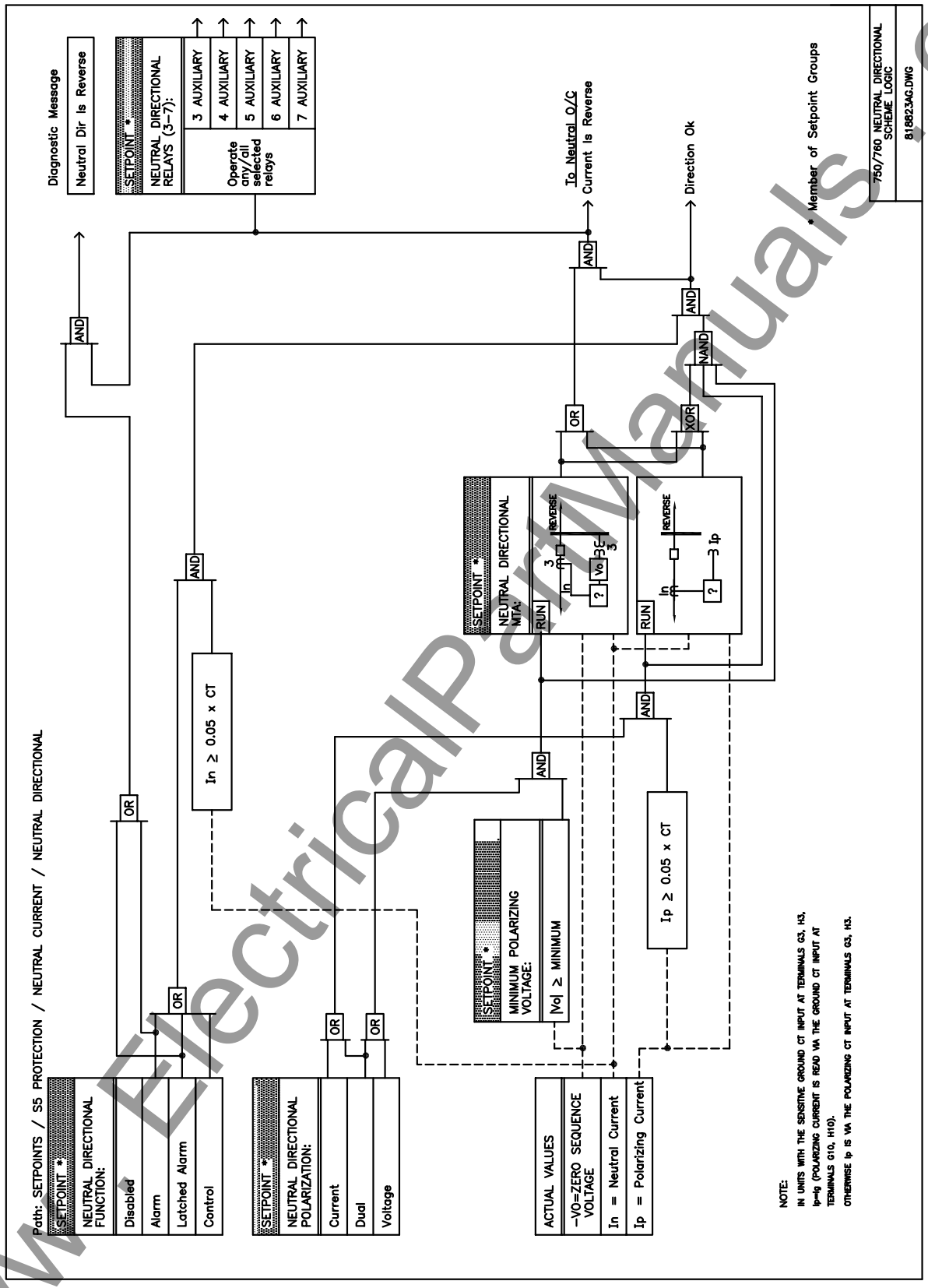


Figure 12–10: NEUTRAL DIRECTIONAL LOGIC DIAGRAM

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12.4.1 DESCRIPTION

Separate protection is provided for ground time overcurrent and ground instantaneous overcurrent. These elements monitor the ground current input on terminals G10 and H10. Ground overcurrent elements can be blocked individually or as a group by logic inputs. Ground overcurrent elements can be controlled by the ground directional element allowing operation for faults in the permitted direction only.

12.4.2 GROUND TIME OVERCURRENT

The equivalent of a single ground time overcurrent relay, ANSI device 51G, is programmed in this subgroup.

■ GROUND TIME OC ■ [ENTER] for more	The Ground Time Overcurrent setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ GROUND CURRENT \ GROUND TIME OC**
GROUND TIME OC FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
GROUND TIME OC RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
GROUND TIME OC PICKUP: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Select the current level required.
GROUND TIME OC CURVE: Ext Inverse	*Range: Ext Inverse, Very Inverse, Norm Inverse, ..., Flex Curve B* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
GROUND TIME OC MULTIPLIER: 1.00	*Range: 0.00 to 100.00 in steps of 0.01* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
GROUND TIME OC RESET: Instantaneous	*Range: Instantaneous, Linear* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
GROUND TIME OC DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.

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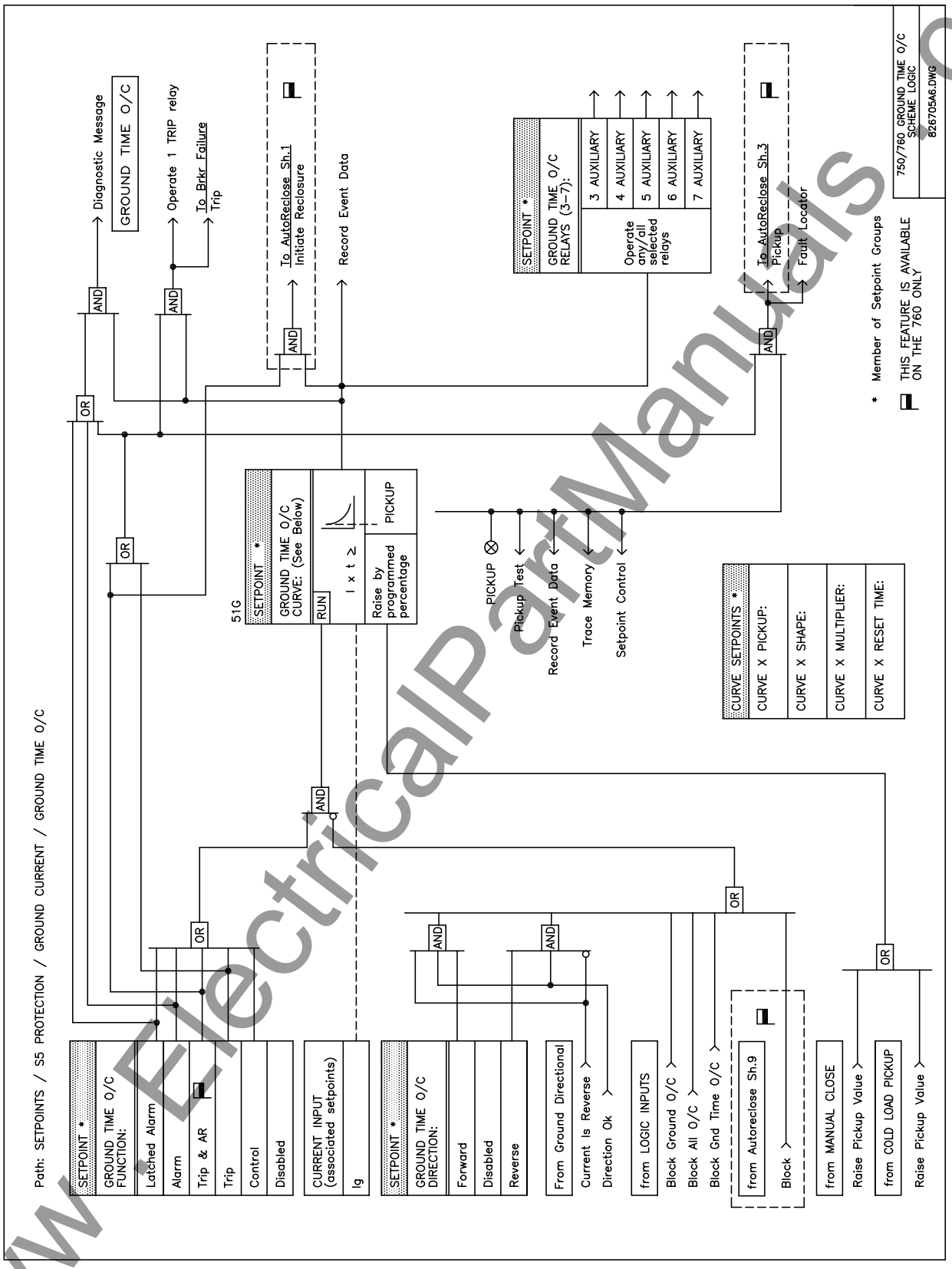


Figure 12–11: GROUND TIME OVERCURRENT LOGIC DIAGRAM

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12.4.3 GROUND INSTANTANEOUS OVERCURRENT

The equivalent of a single ground instantaneous relay, ANSI device 50G, is programmed in this subgroup.

■ GROUND INST OC ■ [ENTER] for more	The Ground Instantaneous Overcurrent setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ GROUND CURRENT \ GROUND INST OC**
GROUND INST OC FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
GROUND INST OC RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
GROUND INST OC PICKUP: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Enter the pickup in terms of the CT rating. For example, if a pickup of 1000A is required, enter *5.00 x CT* with a 200:5 ground CT installed.
GROUND INST OC DELAY: 0.00 s	*Range: 0.00 to 600.00 in steps of 0.01 s* Select the delay required.
GROUND INST OC DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.

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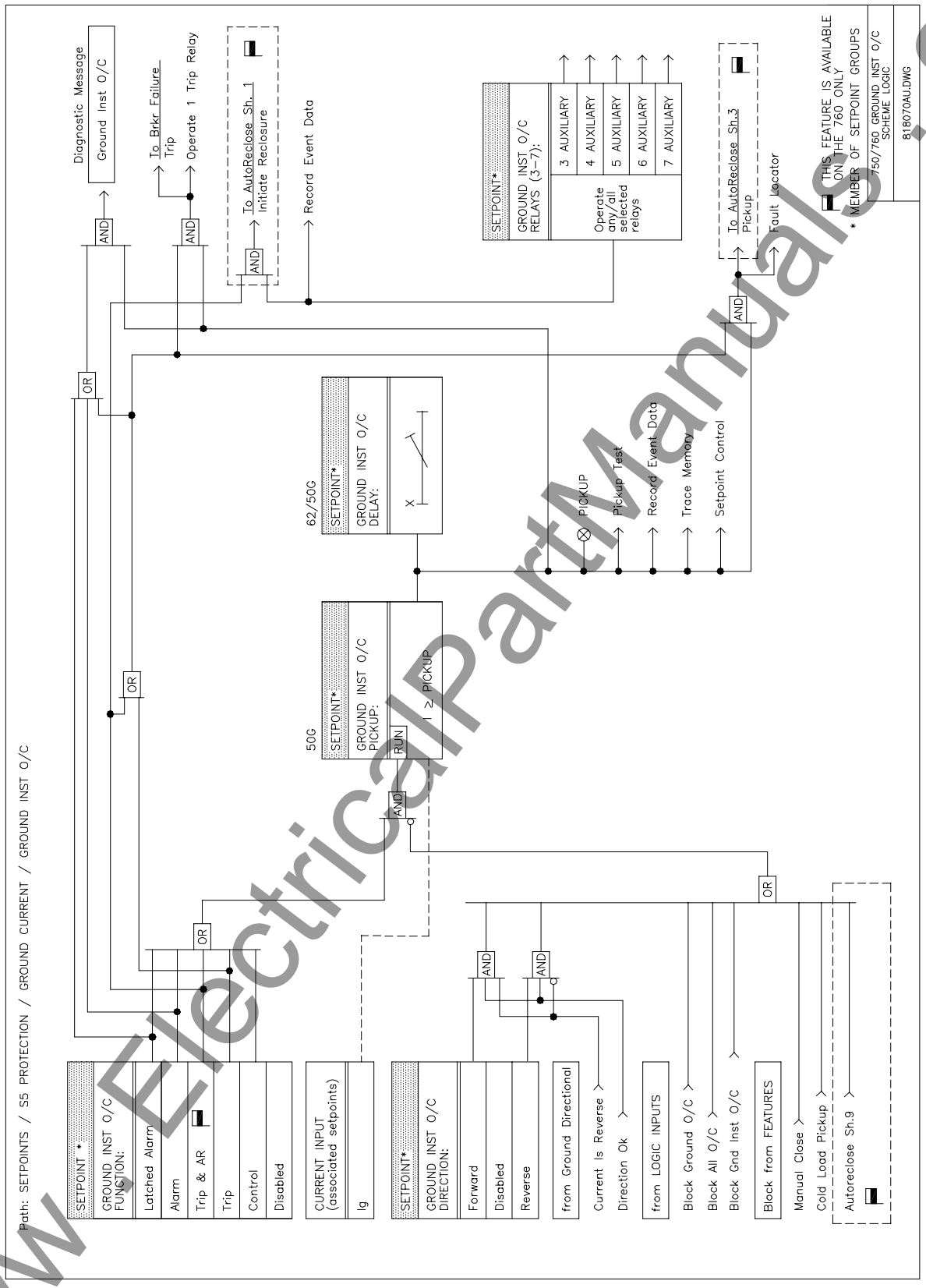


Figure 12–12: GROUND INSTANTANEOUS OVERCURRENT LOGIC DIAGRAM

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The ground directional feature controls the operation of all ground overcurrent elements and allows them to discriminate between forward or reverse faults. Refer to Section 12.2: DIRECTIONAL OVERCURRENT CHARACTERISTICS on page 12–6 for more details on directional principles. Ground directional can be either voltage, current, or dual polarized. The ground current input is always the operating current.

When voltage polarized, the polarizing quantity is the zero sequence voltage which is calculated from the bus input voltages. The **VT CONNECTION TYPE** must be *Wye* in this case. If the polarizing voltage drops below the **MINIMUM OPERATING VOLTAGE** setting the direction defaults to forward. The following table shows the operating current and polarizing quantities used for ground directional control.

Table 12–10: GROUND DIRECTIONAL CONTROL CHARACTERISTICS

QUANTITY	OPERATING CURRENT	POLARIZING VOLTAGE (VT connection = Wye)	POLARIZING CURRENT
Ground	I_g	$-V_0 = -(V_a + V_b + V_c) / 3$	I_{pol} †

† Note: On relays with bootware revision 3.00 or newer, the ground directional element may only be voltage polarized since these relays do not have a polarizing current input. Otherwise, the polarizing current is input via a dedicated polarizing CT input. See Section 3.2: TYPICAL WIRING on page 3–5 for more details.

When current polarized, the 'Polarizing CT Input' is used to determine ground current direction. The polarizing current comes from a source CT measuring the current flowing from the ground return into the neutral of a ground fault current source which is usually a transformer. The direction is *Forward* when the sensitive ground current is within ±90° of the polarizing current. Otherwise, the direction is *Reverse*. If the polarizing current is less than 5% of CT nominal then the direction defaults to forward.

Dual polarization provides maximum security and reliability. If the polarizing voltage magnitude is insufficient then the current polarizing takes control. If the polarizing current magnitude is insufficient then the voltage polarizing takes control. If neither voltage nor current polarizing is possible then the direction defaults to forward.

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■ GROUND DIRECTION ■ [ENTER] for more	The Ground Directional setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ GROUND CURRENT \ GROUND DIRECTION**
GROUND DIRECTIONAL FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
GROUND DIRECTIONAL RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
GROUND POLARIZING: Voltage	*Range: Current, Voltage, Dual* If ground directional control with both voltage and current polarized elements is desired, enter *Dual*. If ground directional control with only the voltage polarized element is desired, enter *Voltage*. If ground directional control with only the current polarized element is desired, enter *Current*.
GROUND DIRECTIONAL MTA: 315° Lead	*Range: 0 to 359 Lead in steps of 1°* Enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity. This setting affects voltage polarizing only.
MINIMUM POLARIZING VOLTAGE: 0.05 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* This setting affects the voltage element only. As the system zero sequence voltage is used as the polarizing voltage for this element, a minimum level of voltage must be selected to prevent operation caused by system unbalanced voltages or VT ratio errors. For well-balanced systems and 1% accuracy VTs, this setpoint can be as low as 2% of VT nominal voltage. For systems with high-resistance grounding or floating neutrals, this setpoint can be as high as 20%. The default value of *0.05 x VT* is appropriate for most solidly grounded systems.

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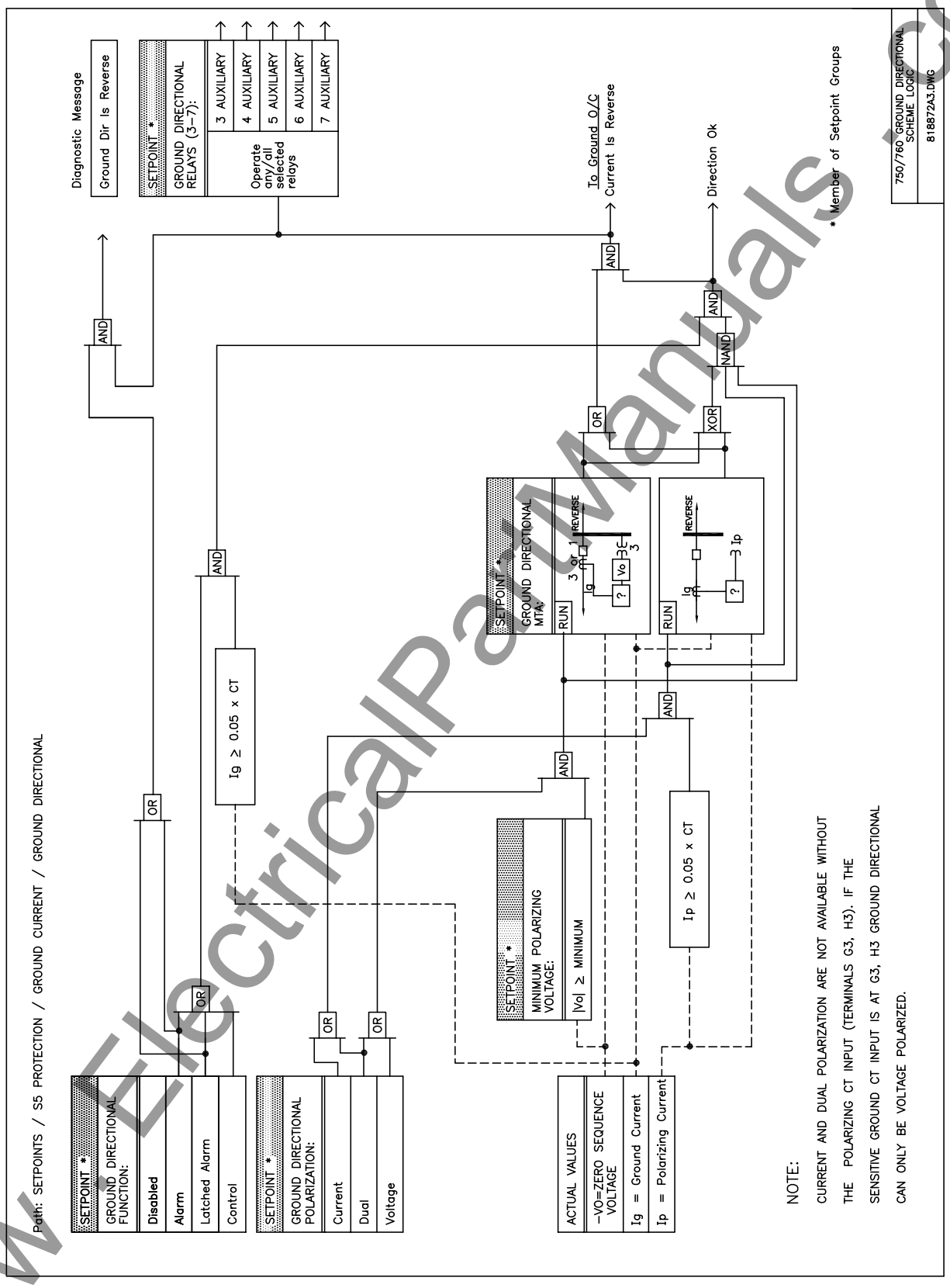


Figure 12–13: GROUND DIRECTIONAL LOGIC DIAGRAM

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12.5.1 DESCRIPTION

Two sensitive ground overcurrent protection elements are provided. One time overcurrent element and one instantaneous element. Sensitive ground overcurrent elements can be controlled by the sensitive ground directional element allowing operation for faults in the permitted direction only. Also, the elements can be blocked individually or as a group by logic inputs.

12.5.2 SENSITIVE GROUND TIME OVERCURRENT

The sensitive ground time overcurrent element, ANSI device 51SG is programmed in this subgroup.

■ SENSTV GND TIME OC ■ [ENTER] for more	The Sensitive Ground Time Overcurrent setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ SENSTV GND CURRENT \ SENSTV GND TIME OC**
SENSTV GND TIME OC FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
SENSTV GND TIME OC RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
SENSTV GND TIME OC PICKUP: 1.00 x CT	*Range: 0.005 to 1.000 in steps of 0.001 x CT* Select the sensitive ground current level required for pickup.
SENSTV GND TIME OC CURVE: Ext Inverse	*Range: Ext Inverse, Very Inverse, Norm Inverse, ..., Flex Curve B* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
SENSTV GND TIME OC MULTIPLIER: 1.00	*Range: 0.00 to 100.00 in steps of 0.01* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
SENSTV GND TIME OC RESET: Instantaneous	*Range: Instantaneous, Linear* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
SENSTV GND TIME OC DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.

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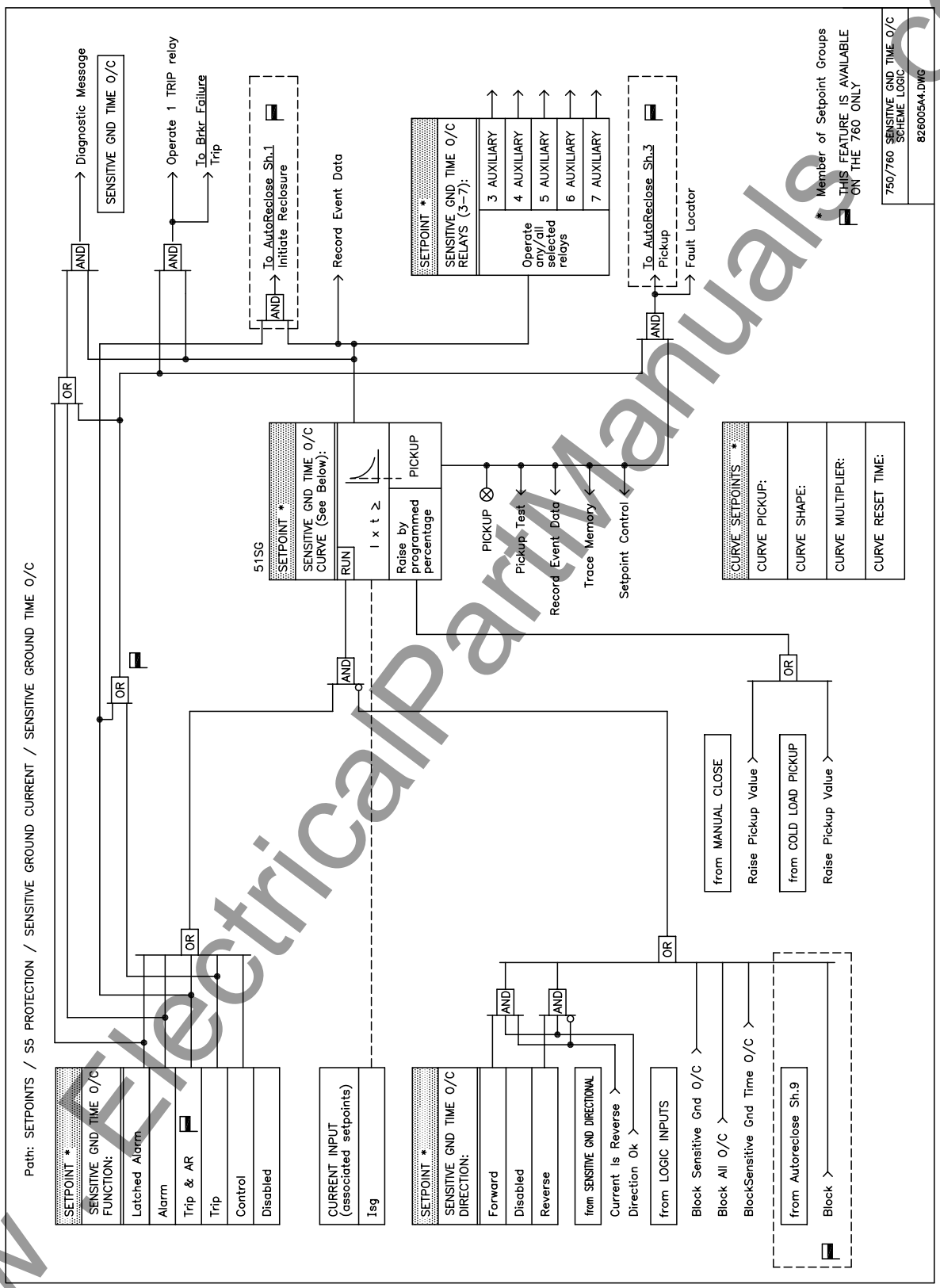


Figure 12–14: SENSITIVE GROUND TIME OVERCURRENT LOGIC DIAGRAM

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12.5.3 SENSITIVE GROUND INSTANTANEOUS OVERCURRENT

The sensitive ground instantaneous overcurrent element, ANSI device 50SG is programmed in this subgroup.

■ SENSTV GND INST OC ■ [ENTER] for more	The Sensitive Ground Instantaneous Overcurrent setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ SENSTV GND CURRENT \ SENSTV GND INST OC**
SENSTV GND INST OC FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
SENSTV GND INST OC RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
SENSTV GND INST OC PICKUP: 1.00 x CT	*Range: 0.005 to 1.000 in steps of 0.001 x CT* Enter the pickup in terms of the CT rating.
SENSTV GND INST OC DELAY: 0.00 s	*Range: 0.00 to 600.00 in steps of 0.01 s* Select the delay required.
SENSTV GND INST OC DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.

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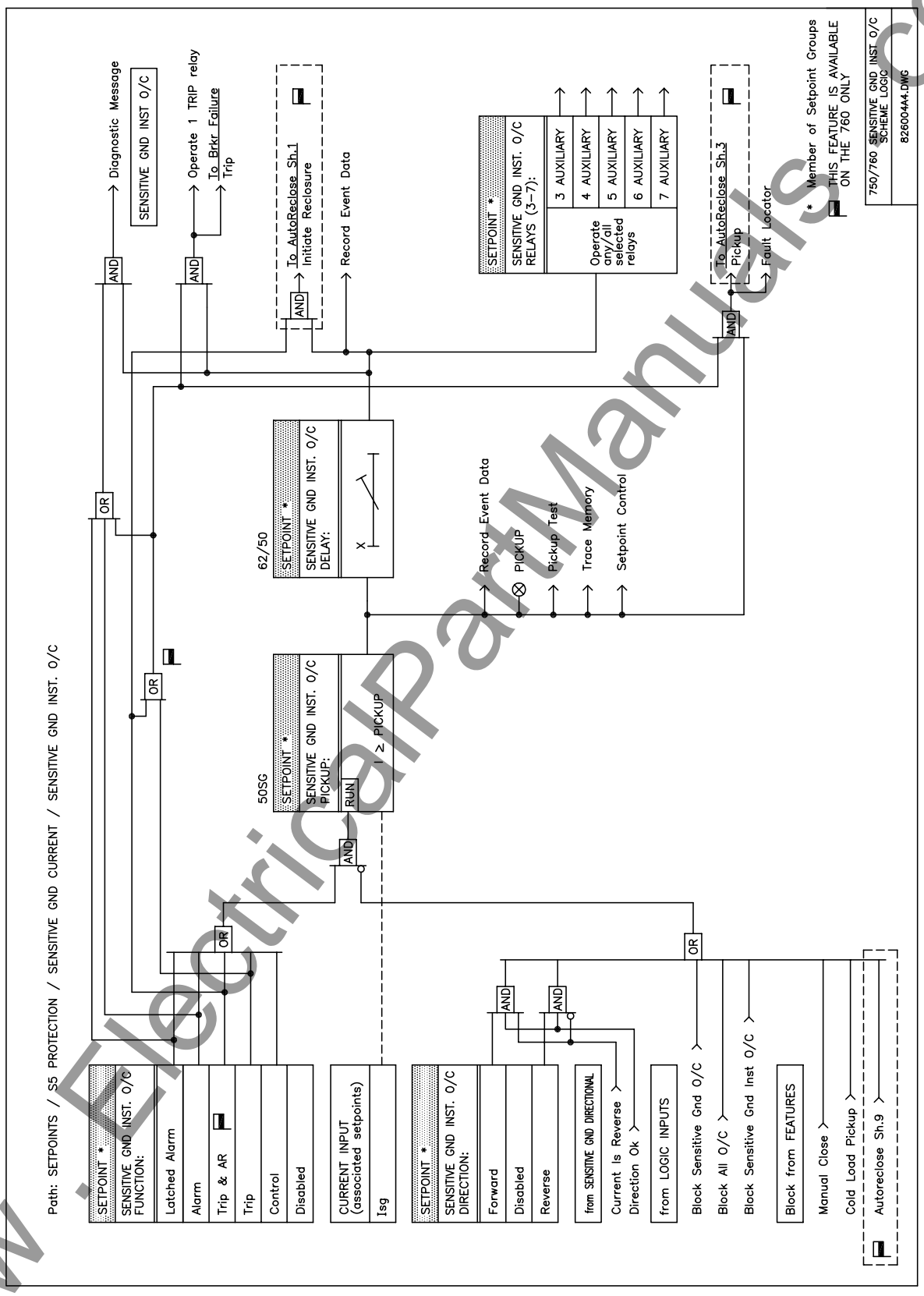


Figure 12–15: SENSITIVE GROUND INSTANTANEOUS OVERCURRENT LOGIC DIAGRAM

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12.5.4 SENSITIVE GROUND DIRECTIONAL

The sensitive ground directional feature controls the operation of all sensitive ground overcurrent elements and allows them to discriminate between forward or reverse faults. Refer to Section 12.2: DIRECTIONAL OVERCURRENT CHARACTERISTICS on page 12–6 for more details on directional principles. Sensitive ground directional can be either voltage, current, or dual polarized. The sensitive ground current input is always the operating current.

When voltage polarized, the polarizing quantity is the zero sequence voltage which is calculated from the bus input voltages. The **VT CONNECTION TYPE** must be *Wye* in this case. If the polarizing voltage drops below the **MINIMUM OPERATING VOLTAGE** setting the direction defaults to forward. The following table shows the operating current and polarizing quantities used for sensitive ground directional control.

Table 12–11: SENSITIVE GROUND DIRECTIONAL CHARACTERISTICS

QUANTITY	OPERATING CURRENT	POLARIZING VOLTAGE (VT connection = Wye)	POLARIZING CURRENT
Sensitive Ground	I_{sg}	$-V_o = -(V_a + V_b + V_c) / 3$	I_g †

† NOTE: On relays with bootware revision 3.00 or newer, the polarizing current is input via the ground CT input. Otherwise, the polarizing current is input via a dedicated polarizing CT input. See Section 3.2: TYPICAL WIRING on page 3–5 for more details.

When current polarized, the **GROUND CURRENT CT INPUT** is used to determine sensitive ground current direction. The polarizing current comes from a source CT measuring the current flowing from the ground return into the neutral of a ground fault current source which is usually a transformer. The direction is *Forward* when the sensitive ground current is within ±90° of the polarizing current. Otherwise, the direction is *Reverse*. If the polarizing current is less than 5% of CT nominal then the direction defaults to forward.

Dual polarization provides maximum security and reliability. If the polarizing voltage magnitude is insufficient then the current polarizing takes control. If the polarizing current magnitude is insufficient then the voltage polarizing takes control. If neither voltage nor current polarizing is possible then the direction defaults to forward.

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■ SENSTV GND DIRECTN ■ [ENTER] for more	The Sensitive Ground Directional setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ SENSTV GND CURRENT \ SENSTV GND DIRECTN**
SENSTV GND DIRECTN FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
SENSTV GND DIRECTN RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
SENS GND POLARIZING: Voltage	*Range: Voltage, Current, Dual* If sensitive ground directional control with both voltage and current polarized elements is desired, enter *Dual*. With this setting, both polarizing quantities must agree that the operating current is in the reverse direction for the sensitive ground directional element to operate the selected output relays. If sensitive ground directional control with only the voltage polarized element is desired, enter *Voltage*. If sensitive ground directional control with only the current polarized element is desired, enter *Current*.
SENSTV GND DIRECTN MTA: 315° Lead	*Range: 0 to 359 Lead in steps of 1°* Enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity. This setting affects voltage polarizing only.
MINIMUM POLARIZING VOLTAGE: 0.05 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* This setting affects the voltage element only. As the system zero sequence voltage is used as the polarizing voltage for this element, a minimum level of voltage must be selected to prevent operation caused by system unbalanced voltages or VT ratio errors. For well-balanced systems and 1% accuracy VTs, this setpoint can be as low as 2% of VT nominal voltage. For systems with high-resistance grounding or floating neutrals, this setpoint can be as high as 20%. The default value of *0.05 x VT* is appropriate for most solidly grounded systems.

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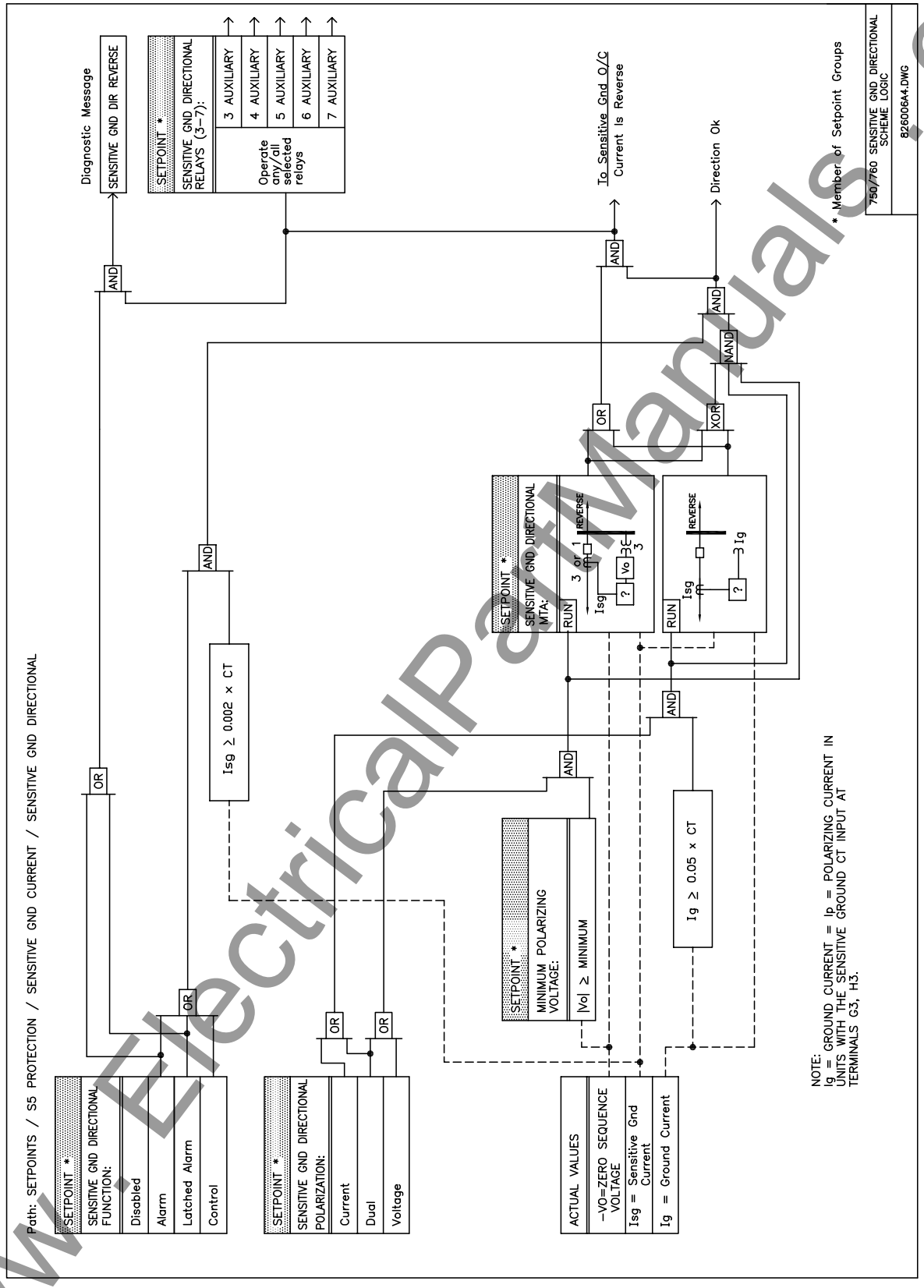


Figure 12–16: SENSITIVE GROUND DIRECTIONAL CURRENT

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Restricted Earth Fault protection is often applied to transformers having grounded wye windings, to provide sensitive ground fault detection for faults near the transformer neutral. The Sensitive Ground Input (terminals G3, H3) can be used.

Although the 750/760 is designed for feeder protection, it can provide Restricted Earth Fault protection on transformers that do not have dedicated protection. To use the 750/760 for this type of protection, a stabilizing resistor and possibly a non-linear resistor will be required.

The inclusion of a stabilizing resistor encourages the circulating fault current to flow via the magnetizing impedance of the saturated current transformer thus minimizing spill current in the REF relay. A non-linear resistor will be required where the voltage across the inputs would be greater than 2000 volts. Refer to Section 3.2.7: RESTRICTED EARTH FAULT INPUTS on page 3–10 for the connections required to use the 750/760 to perform Restricted Earth Fault protection.

a) STABILIZING RESISTOR

To determine the appropriate value for the Stabilizing Resistor, use the following equation:

$$R_s = \frac{V_s}{I_s} = \frac{I_F \cdot (R_{CT} + 2R_L)}{I_s}$$

where:

R_S = resistance value of the stabilizing resistor

V_S = voltage at which the 750/760 will operate

I_S = current flowing through the stabilizing resistor and the 750/760

I_F = maximum secondary fault current magnitude

R_{CT}= internal resistance of the current transformer

R_L = resistance of attached wire leads

b) NON-LINEAR RESISTOR

A non-linear resistor is recommended if the peak fault voltage may be above the relays maximum of 2000 V. The following calculation is done to determine if a non-linear resistor is required. When required, this should be provided by the end-user.

It is assumed that the ratio of the CT kneepoint (V_K) V_S is to 2 for stability. Thus,

$$V_K = 2V_S$$

Next, the voltage that would result from a fault must be determined, neglecting saturation,

$$V_f = I_f \cdot (R_{CT} + 2R_L + R_S)$$

The peak value of this fault voltage would be:

$$V_P = 2\sqrt{2} \cdot \sqrt{V_k \cdot (V_f - V_K)}$$

If V_P is greater than 2000V, then a non-linear resistor must be used.

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c) SAMPLE APPLICATION

The **CTs** used in this example are **3000/1, 10P10, 15 VA**, and the **transformer** used in the example is an **11 kV / 400V, 2000kVA**. At 10P10 the voltage at which the CT will saturate will be 10 x 15 = 150 V. An equivalent IEEE description for this CT would be 3000/1, C150.

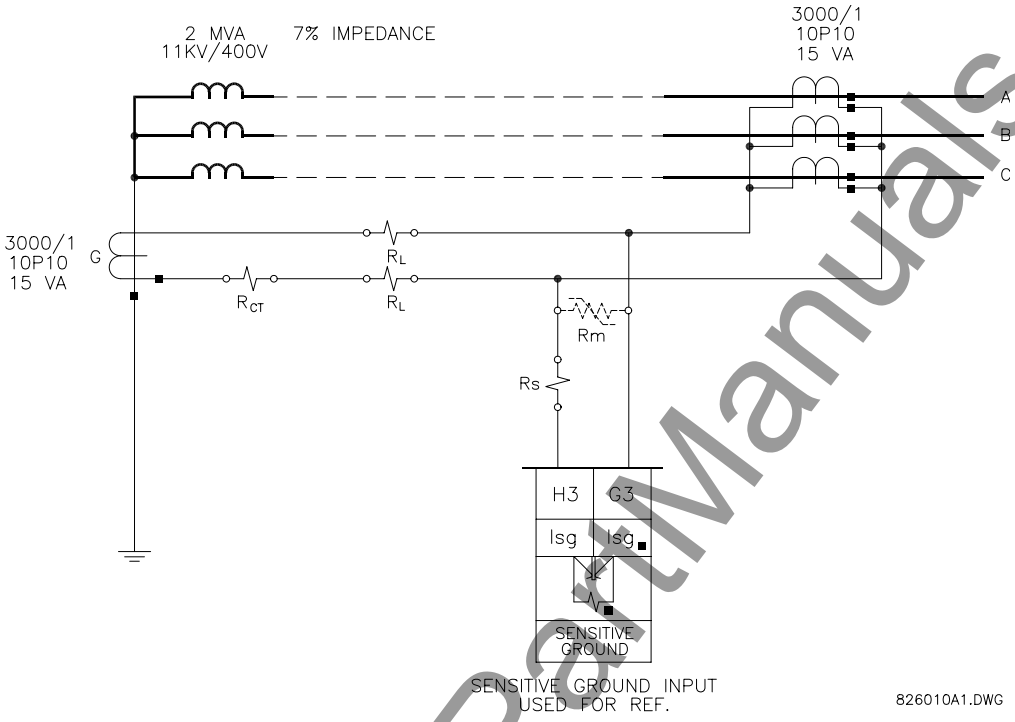


Figure 12–17: SAMPLE APPLICATION

R_{CT} = 3.7Ω
R_L = 0.954Ω assuming 600 feet of #12 wire
$X(\%)$ = impedance of transformer = 7% = 0.07

Rated transformer current through wye windings:

$$I_P = \frac{2000\ \text{kVA}}{\sqrt{3} \cdot 400\ \text{V}} = 2887\ \text{A}$$

Maximum fault current is:

$$I_{MAXf} = \frac{I_P}{X(\%)} = \frac{2887\ \text{A}}{0.07} = 41243\ \text{A}$$

Therefore, the secondary full load current is:

$$I_{SFLC} = \frac{2887\ \text{A}}{3000} = 0.962\ \text{A}$$

and the maximum secondary fault current is:

$$I_{Smax} = \frac{0.962\ \text{A}}{0.07} = 13.74\ \text{A} = I_f$$

A V_K / V_S ratio of 2 is assumed to ensure operation.

$V_S = I_f(R_{CT} + 2R_L)$ = 77.05 V

$V_K = 2V_S$ = 154.1 V

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d) CALCULATING THE STABILIZING RESISTOR

Assume I_{PICKUP} to be 30% rated transformer current, that is:

$$I_{PICKUP} = 0.3 \times 2887 \text{ A} = 866 \text{ A (Primary)}$$

This means also (assuming 1% for CT magnetizing current):

$$I_{RELAY\ PICKUP} = \frac{866 \text{ A}}{3000} - (4 \times 0.01) = 0.248 \text{ A} = I_S$$

and therefore:

$$R_s = \frac{V_s}{I_s} = \frac{77.05\ \Omega}{0.248 \text{ A}} = 311\ \Omega$$

e) DETERMINING THE USE OF A NON-LINEAR RESISTOR

We have:

$$V_f = I_f \cdot (R_{CT} + 2R_L + R_s) = 13.748 \text{ A} \times (3.7\ \Omega + (2 \times 0.954\ \Omega) + 311\ \Omega) = 4353 \text{ V}$$

$$V_P = 2\sqrt{2} \cdot \sqrt{V_K \cdot (V_F - V_K)} \quad \rightarrow \text{use 150 V as value for } V_K$$

$$= 2\sqrt{2} \cdot \sqrt{150 \text{ V} \times (4353 \text{ V} - 150 \text{ V})} = 2246 \text{ V}$$

A non-linear resistor is recommended as the peak fault voltage is above relay voltage maximum of 2000 V.

The setpoints for Restricted Earth Fault are as follows:

■ RESTRICTED EF ■ [ENTER] for more	The Restricted Earth Fault setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ SENSTV GND CURRENT \ RESTRICTED EF**
RESTRICTED EARTH FLT FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
RESTRICTED EARTH FLT RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
RESTRICTED EARTH FLT PICKUP: 0.100 x CT	*Range: 0.005 to 1.000 in steps of 0.001 x CT* Enter the pickup in terms of the CT rating.
RESTRICTED EARTH FLT DELAY: 0.00 s	*Range: 0.00 to 600.00 in steps of 0.01 s* Select the delay required.

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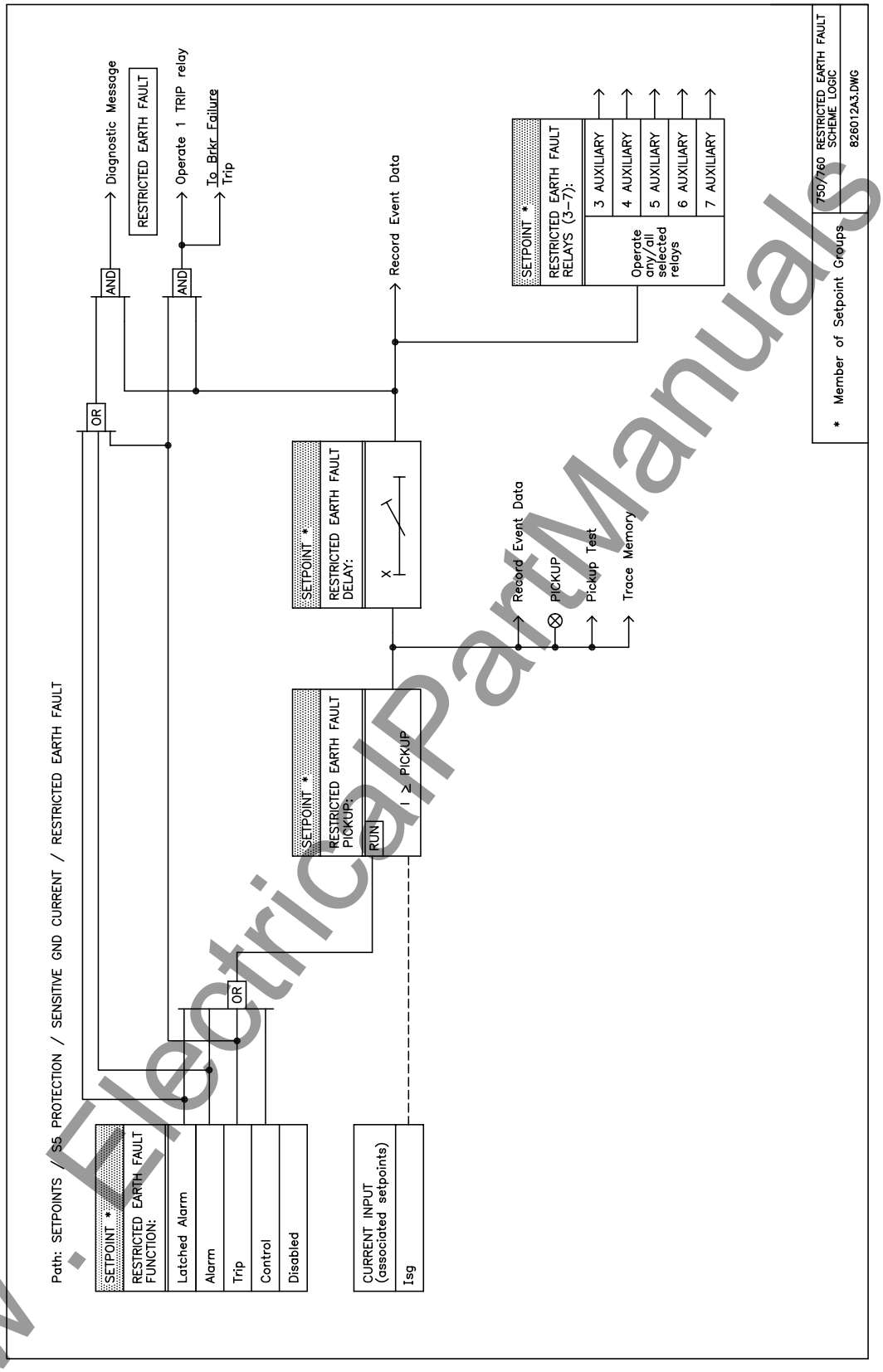


Figure 12–18: RESTRICTED EARTH FAULT LOGIC DIAGRAM

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12.6.1 DESCRIPTION

Separate protection is provided for the calculated negative sequence time overcurrent, instantaneous overcurrent and voltage. Each of these features can be individually blocked by logic inputs.

12.6.2 NEGATIVE SEQUENCE TIME OVERCURRENT

A time overcurrent element operating on the negative sequence component of current, ANSI device 46 is programmed in this subgroup.

■ NEG SEQ TIME OC ■ [ENTER] for more	The Negative Sequence Time Overcurrent setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ NEGATIVE SEQUENCE \ NEG SEQ TIME OC**
NEG SEQ TIME OC FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
NEG SEQ TIME OC RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NEG SEQ TIME OC PICKUP: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Select the current level required.
NEG SEQ TIME OC CURVE: Ext Inverse	*Range: Ext Inverse, Very Inverse, Norm Inverse, ..., Flex Curve B* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
NEG SEQ TIME OC MULTIPLIER: 1.00	*Range: 0.00 to 100.00 in steps of 0.01* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
NEG SEQ TIME OC RESET: Instantaneous	*Range: Instantaneous, Linear* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.
NEG SEQ TIME OC DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.

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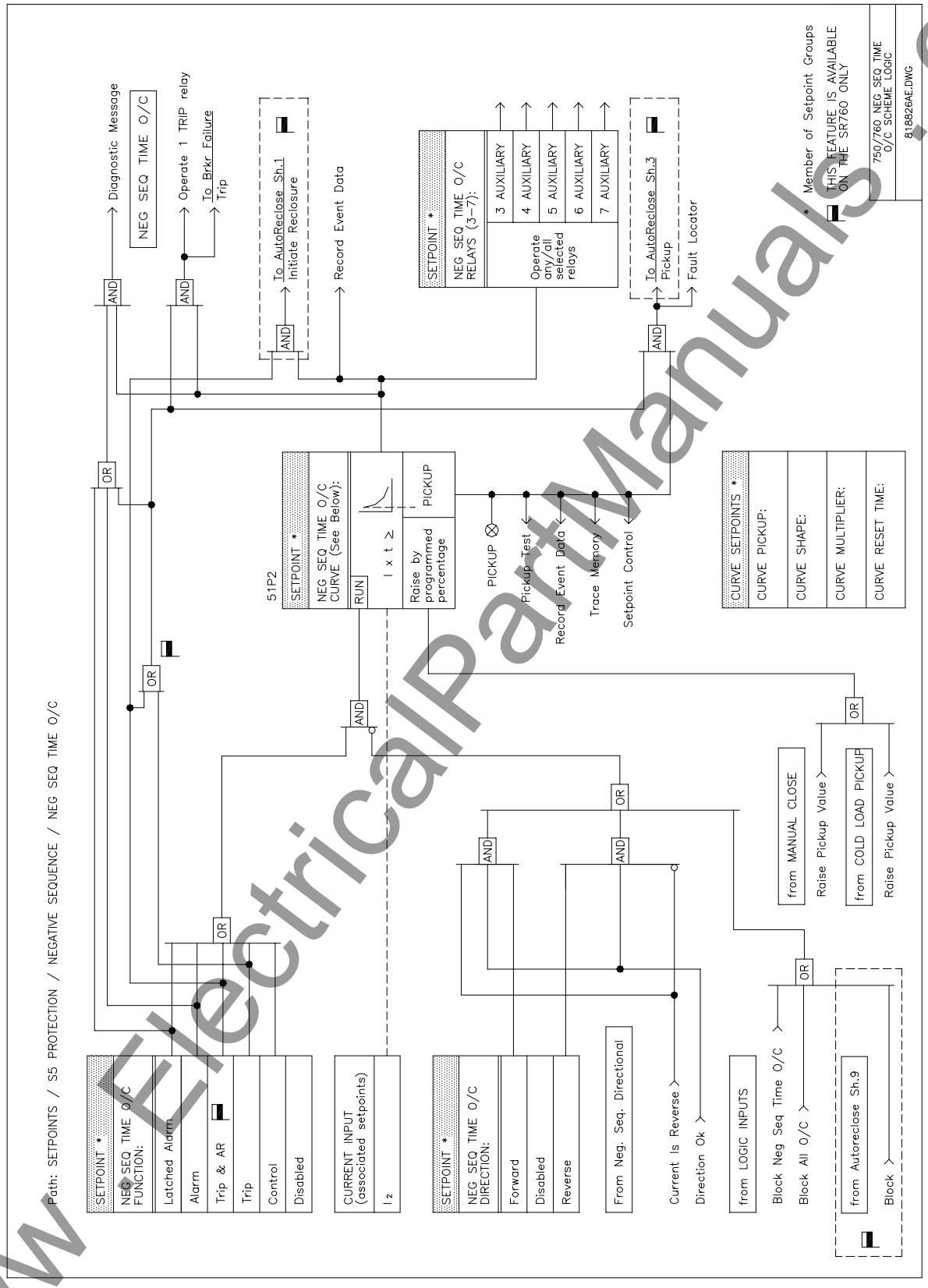


Figure 12–19: NEGATIVE SEQUENCE TIME OVERCURRENT LOGIC DIAGRAM

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12.6.3 NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT

A instantaneous overcurrent element operating on the negative sequence component of current, ANSI device 46 is programmed in this subgroup.

■ NEG SEQ INST OC ■ [ENTER] for more	The Negative Sequence Instantaneous Overcurrent setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ NEGATIVE SEQUENCE \ NEG SEQ INST OC**
NEG SEQ INST OC FUNCTION: Disabled	*Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control* Select the required function.
NEG SEQ INST OC RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NEG SEQ INST OC PICKUP: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Select the current level in terms of the CT rating. For example, if 100:5 phase CTs are installed, enter *1.00 x CT* for a negative sequence instantaneous over-current trip of 100 A.
NEG SEQ INST OC DELAY: 0.00 s	*Range: 0.00 to 600.00 in steps of 0.01 s* Select the delay required.
NEG SEQ INST OC DIRECTION: Disabled	*Range: Disabled, Forward, Reverse* Select the direction(s) of current flow for which operation is permitted.

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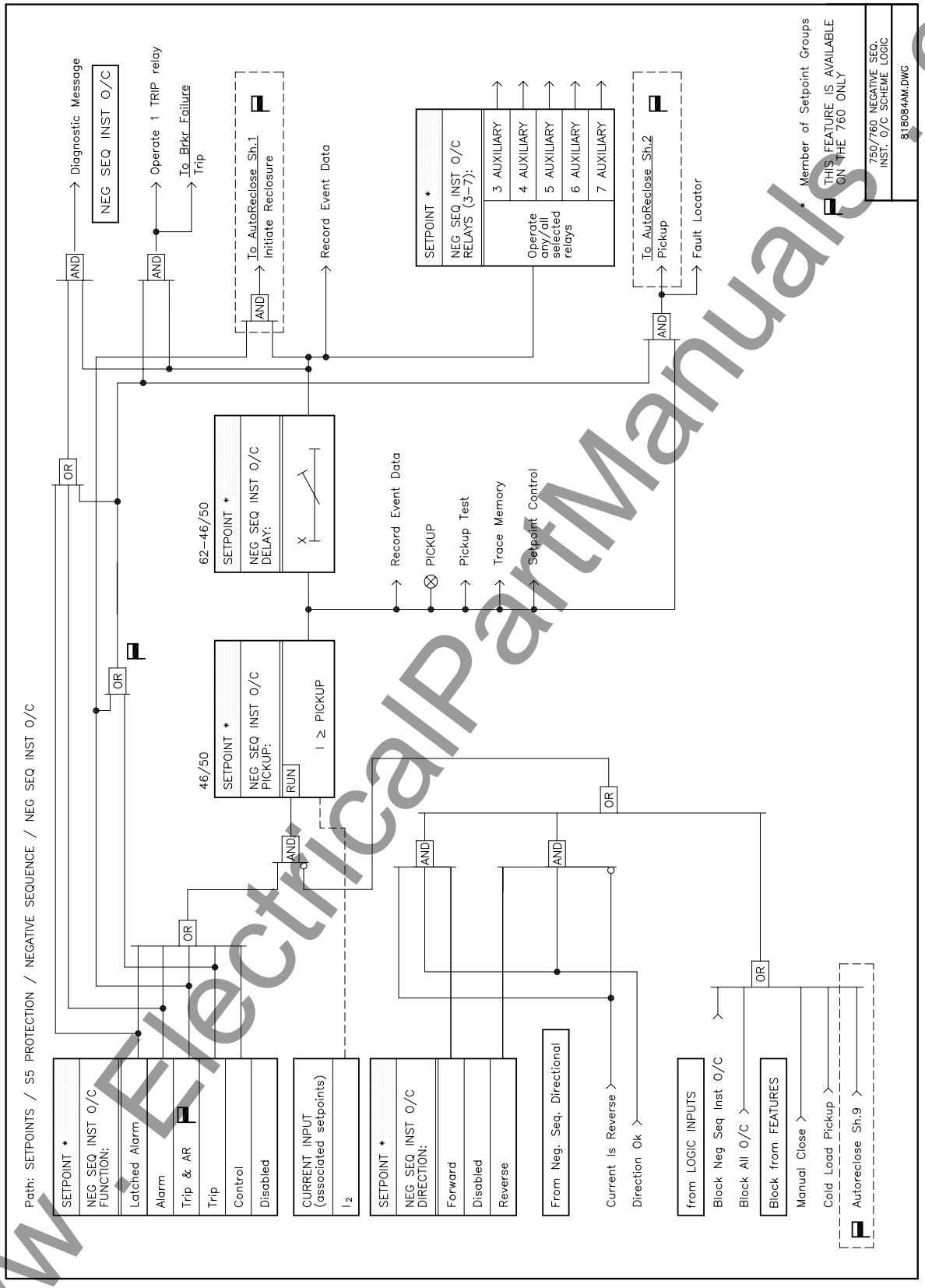


Figure 12–20: NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT LOGIC DIAGRAM

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12.6.4 NEGATIVE SEQUENCE DIRECTIONAL

The negative sequence directional feature controls the operation of all negative sequence overcurrent elements and allows them to discriminate between forward or reverse faults. Refer to Section 12.2: DIRECTIONAL OVERCURRENT CHARACTERISTICS on page 12–6 for more details on directional principles. The operating current and polarizing voltage is shown in the following table. If the polarizing voltage drops below the 'Minimum Operating Voltage' setting the direction defaults to forward.

Table 12–12: NEGATIVE SEQUENCE DIRECTIONAL CHARACTERISTICS

QUANTITY	OPERATING CURRENT	POLARIZING VOLTAGE
Negative Sequence (ABC phase sequence)	$I_{a2} = \frac{I_a + a^2 I_b + a I_c}{3}$	$-V_{a2} = -\frac{V_a + a^2 V_b + a V_c}{3}$
Negative Sequence (ACB phase sequence)	$I_{a2} = \frac{I_a + a I_b + a^2 I_c}{3}$	$-V_{a2} = -\frac{V_a + a V_b + a^2 V_c}{3}$

The setpoints for Negative Sequence Directional are as follows.

■ NEG SEQ DIRECTION ■ [ENTER] for more	The Negative Sequence Directional setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ NEGATIVE SEQUENCE \ NEG SEQ DIRECTION**
NEG SEQ DIRECTIONAL FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
NEG SEQ DIRECTIONAL RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays to operate.
NEG SEQ DIRECTIONAL MTA: 315° Lead	*Range: 0 to 359 Lead in steps of 1°* Enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity.
MINIMUM POLARIZING VOLTAGE: 0.05 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* As the system negative sequence voltage is used as the polarizing voltage for this element, a minimum level of voltage must be selected to prevent operation caused by system unbalanced voltages or VT ratio errors. For well-balanced systems and 1% accuracy VTs, this setpoint can be as low as 2% of VT nominal voltage. For systems with high-resistance grounding or floating neutrals, this setpoint can be as high as 20%. The default value of *0.05 x VT* is appropriate for most solidly grounded systems.

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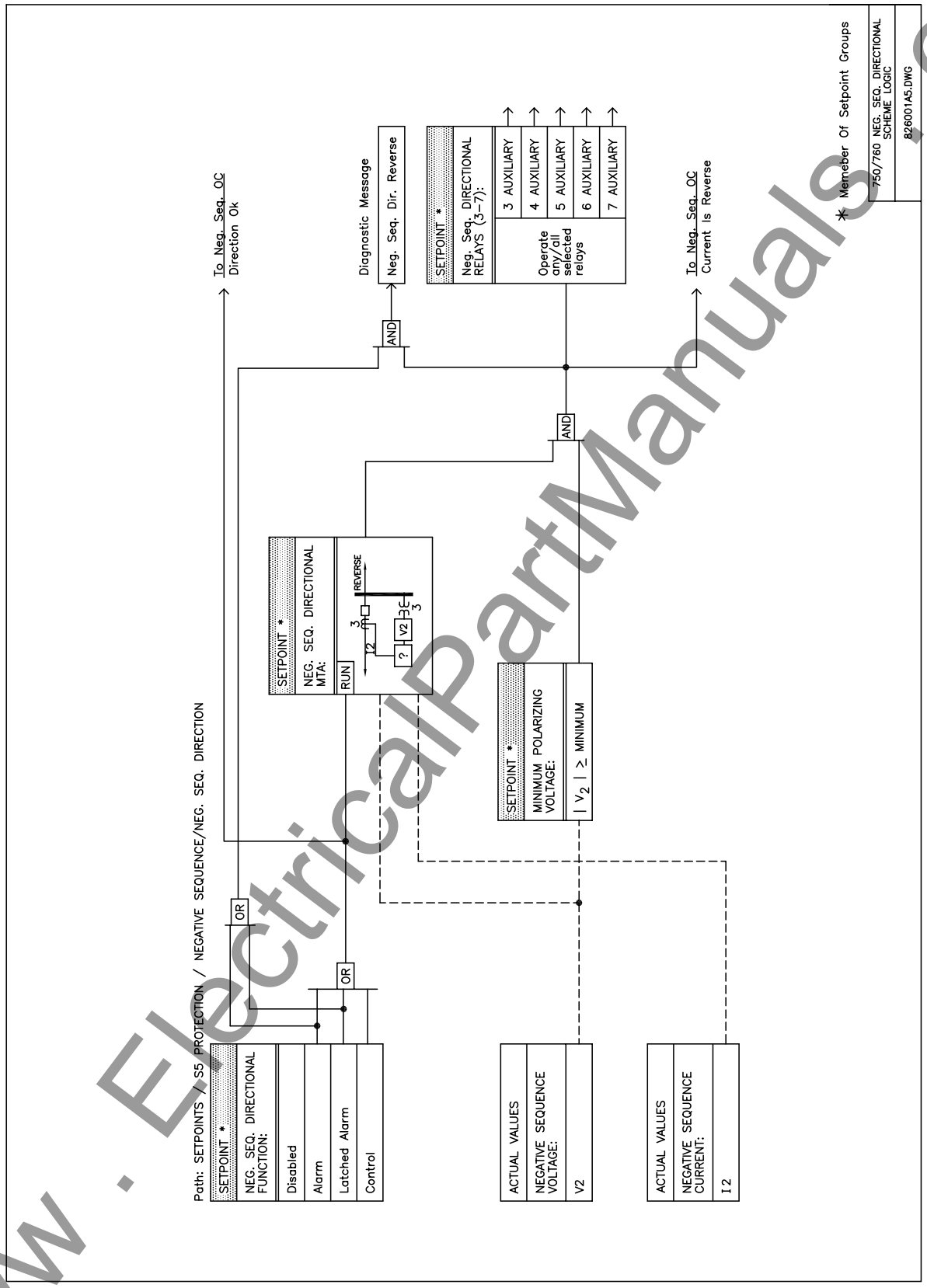


Figure 12–21: NEGATIVE SEQUENCE DIRECTIONAL LOGIC DIAGRAM

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12.6.5 NEGATIVE SEQUENCE VOLTAGE

To protect against loss of one or two source phases, or against a reversed phase sequence of voltage, the negative sequence voltage element can be used to either cause a trip or generate an alarm when the negative sequence voltage exceeds the specified threshold for a specified time delay.

■ NEG SEQ VOLTAGE ■ [ENTER] for more	The Negative Sequence Voltage setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ NEGATIVE SEQUENCE \ NEG SEQ VOLTAGE**
NEG SEQ VOLTAGE FUNCTION: Disabled	*Range: Disabled, Trip, Alarm, Latched Alarm, Control* Select the required function.
NEG SEQ VOLTAGE RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NEG SEQ VOLTAGE PICKUP: 0.10 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the pickup as a fraction of the bus VT nominal voltage.
NEG SEQ VOLTAGE DELAY: 2.0 s	*Range: 0.0 to 6000.0 in steps of 0.1 s* Select the delay required.

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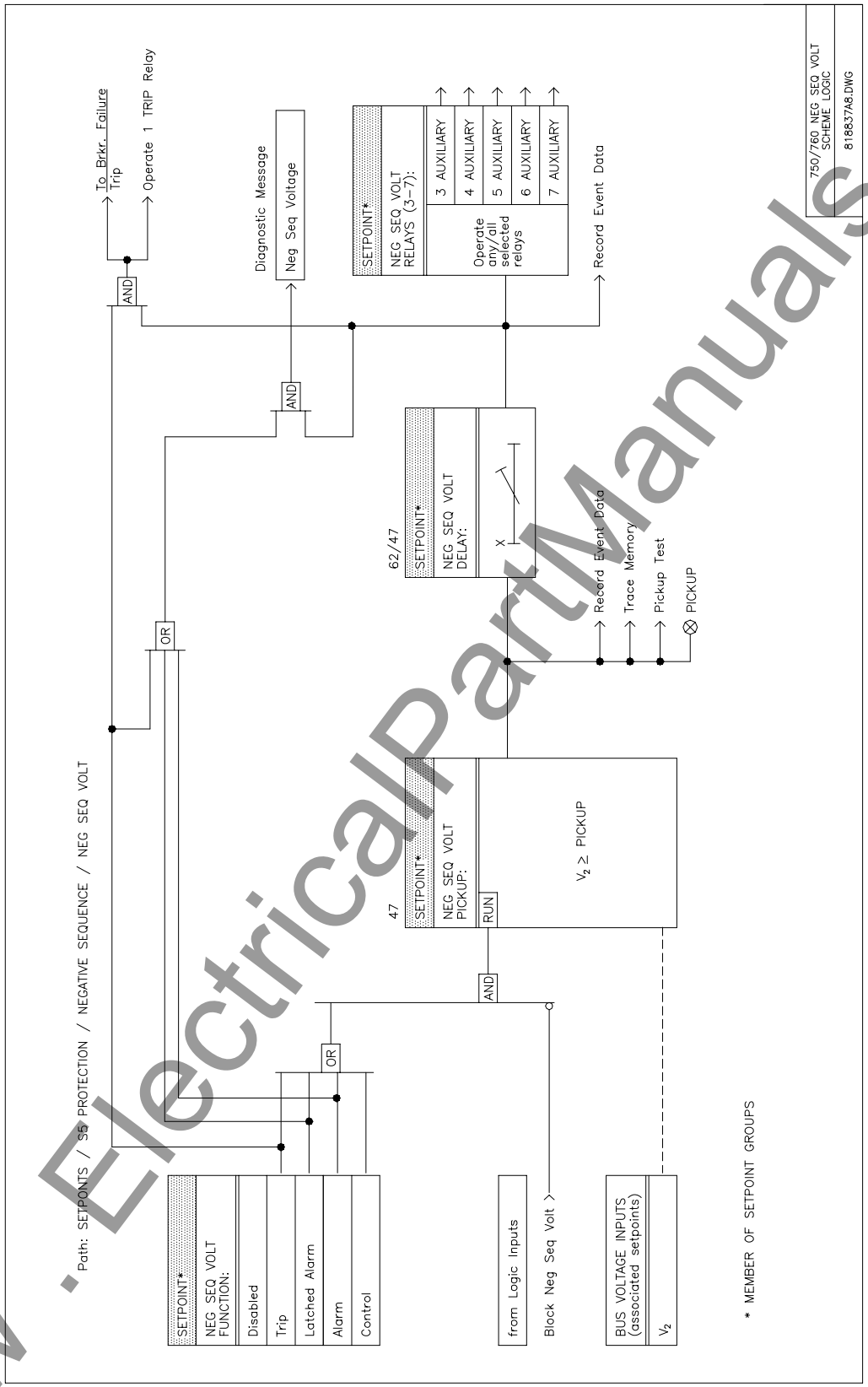


Figure 12–22: NEGATIVE SEQUENCE VOLTAGE LOGIC DIAGRAM

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12.7.1 DESCRIPTION

There are four undervoltage protection elements which can be used for a variety of applications:

- ***Undervoltage Protection:*** For voltage sensitive loads, such as induction motors, a drop in voltage will result in an increase in the drawn current, which may cause dangerous overheating in the motor. The undervoltage protection feature can be used to either cause a trip or generate an alarm when the voltage drops below a specified voltage setting for a specified time delay.
- ***Permissive Functions:*** The undervoltage feature may be used to block the functioning of external devices by operating an output relay, when the voltage falls below the specified voltage setting. Note that all internal features that are inhibited by an undervoltage condition, such as underfrequency and overfrequency, have their own inhibit functions independent of the undervoltage protection features.
- ***Source Transfer Schemes:*** In the event of an undervoltage, a transfer signal may be generated to transfer a load from its normal source to a standby or emergency power source.

12.7.2 BUS UNDERVOLTAGE

Bus undervoltage 1 & 2 are identical elements that generate outputs in response to undervoltage conditions on the bus voltage inputs. The time delay characteristic can be programmed as definite time or inverse time. A minimum operating voltage level is programmable to prevent undesired operation before voltage becomes available. The setpoints for Undervoltage 1 are shown below. Undervoltage 2 setpoints are identical.

■ BUS UNDERVOLTAGE 1 ■ [ENTER] for more	The Bus Undervoltage 1 setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ VOLTAGE \ BUS UNDERVOLTAGE 1**
BUS UNDERVOLTAGE 1 FUNCTION: Disabled	*Range: Disabled, Trip, Alarm, Latched Alarm, Control* Select the required function.
BUS UNDERVOLTAGE 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
BUS UNDERVOLTAGE 1 PICKUP: 0.75 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Selects the pickup as a fraction of the nominal bus VT Secondary Voltage. For example, if the nominal VT secondary voltage is 120 V, and an alarm is required whenever the voltage goes below 110 V, enter (110/120) = *0.92 x VT* for the pickup.
BUS UNDERVOLTAGE 1 CURVE: Definite Time	*Range: Definite Time, Inverse Time* Selects the shape of the undervoltage time curve to be used. *Definite Time:* Time delay equal to the **BUS UNDERVOLTAGE 1 DELAY** setpoint. *Inverse Time:* See Section 12.1.4: IAC CURVES on page 12–4.
BUS UNDERVOLTAGE 1 DELAY: 2.0 s	*Range: 0.0 to 6000.0 in steps of 0.1 s* Selects the minimum operating time of Bus Undervoltage 1.
PHASES REQUIRED FOR OPERATION: All Three	*Range: Any One, Any Two, All Three* Select the type of operation required.
MINIMUM OPERATING VOLTAGE: 0.30 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Inhibits the Bus Undervoltage 1 element for voltages below this level. Setting to *0.00 x VT* will allow a dead bus to be considered a fault condition.

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12.7.3 UNDERVOLTAGE INVERSE TIME DELAY CHARACTERISTICS

The undervoltage elements can be programmed to have an inverse time delay characteristic. The undervoltage delay setpoint defines a family of curves as illustrated by the following equation and figure.

$$T = \frac{D}{1 - V / V_{pu}}$$

where T = Operating Time
D = Undervoltage Delay Setpoint
V = Voltage as a fraction of the nominal VT Secondary Voltage
V_{pu} = Pickup Level

Note: At 0% of pickup the operating time equals the Undervoltage Delay Setting.

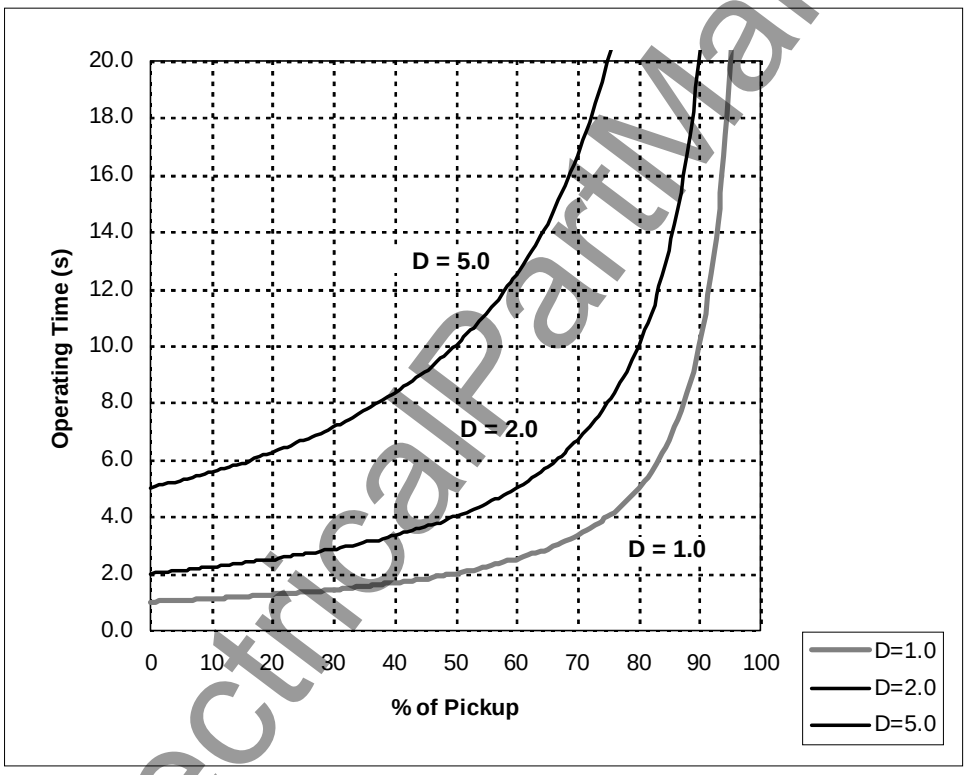


Figure 12–23: INVERSE TIME UNDERVOLTAGE CURVES

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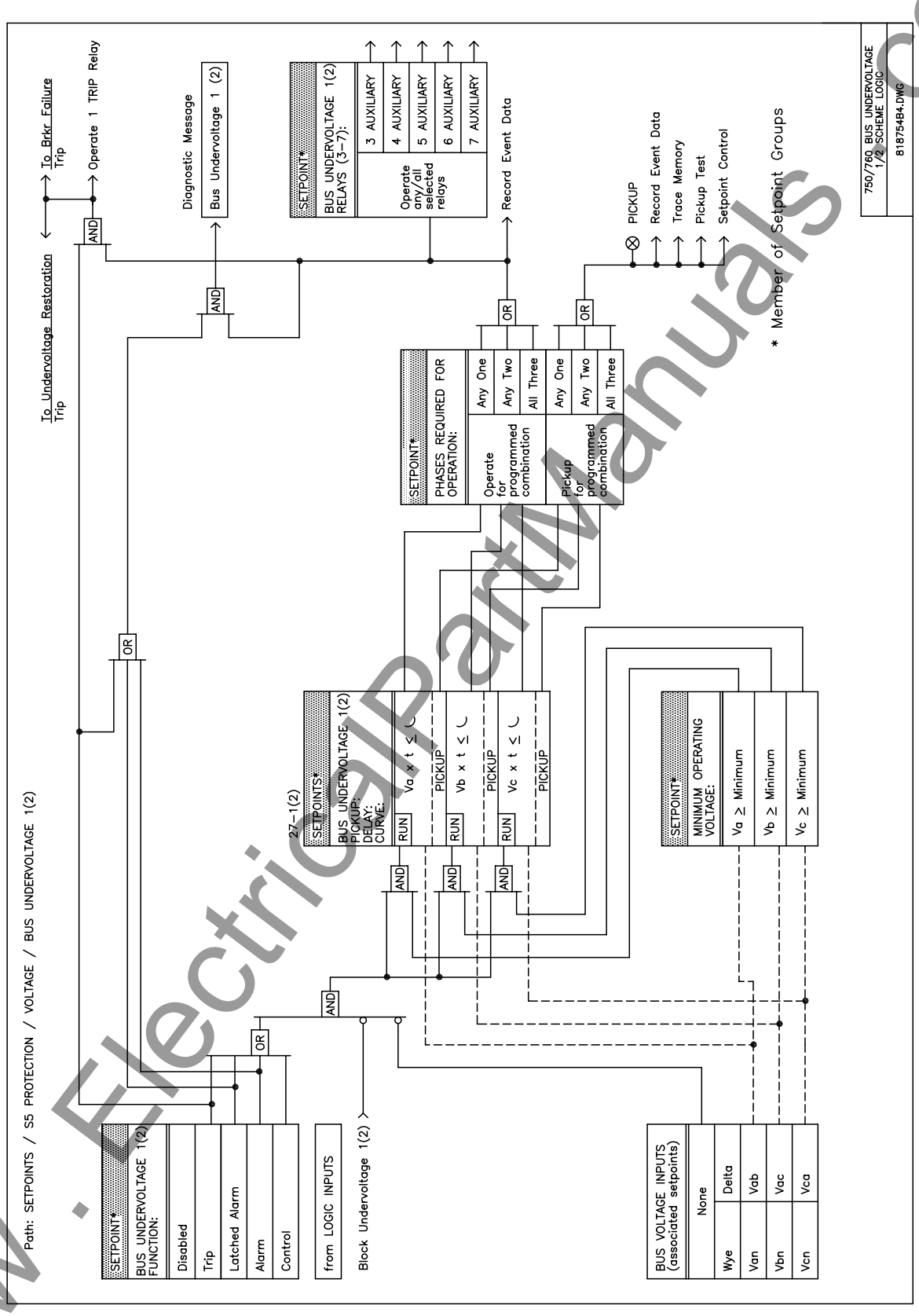


Figure 12–24: BUS UNDERVOLTAGE 1 / 2 LOGIC DIAGRAM

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Line undervoltage 3 and 4 are identical protection elements that generate outputs in response to an undervoltage condition on the line voltage input. The time delay characteristic can be programmed as either definite time or inverse time. A minimum operating voltage level is programmable to prevent undesired operation before voltage becomes available. The setpoints for the Undervoltage 3 element are shown below. Undervoltage 4 setpoints are identical.

■ LINE UNDERVOLT 3 ■ [ENTER] for more	The Line Undervoltage 3 setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ VOLTAGE \ LINE UNDERVOLTAGE 3**
LINE UNDERVOLTAGE 3 FUNCTION: Disabled	*Range: Disabled, Trip, Alarm, Latched Alarm, Control* Select the required function.
LINE UNDERVOLTAGE 3 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
LINE UNDERVOLTAGE 3 PICKUP: 0.75 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Selects the pickup as a fraction of the nominal bus VT Secondary Voltage. For example, if the nominal VT secondary voltage is 120 V, and an alarm is required whenever the voltage goes below 110 V, enter 110 / 120 = *0.92 x VT* for the pickup.
LINE UNDERVOLTAGE 3 CURVE: Definite Time	*Range: Definite Time, Inverse Time* Selects the shape of the undervoltage time curve to be used. *Definite Time:* Time delay equal to the Bus Undervoltage 1 Delay setpoint. *Inverse Time:* See Section 12.1.4: IAC CURVES on page 12–4.
LINE UNDERVOLTAGE 3 DELAY: 2.0 s	*Range: 0.0 to 6000.0 in steps of 0.1 s* Selects the minimum operating time of Line Undervoltage 3. If voltage is above the pickup level or below the minimum operating voltage the timer resets.
MINIMUM OPERATING VOLTAGE: 0.30 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* The Line Undervoltage 3 element is inhibited for voltages below this level. Setting this voltage to *0.00* will allow a dead bus to be considered a fault condition.

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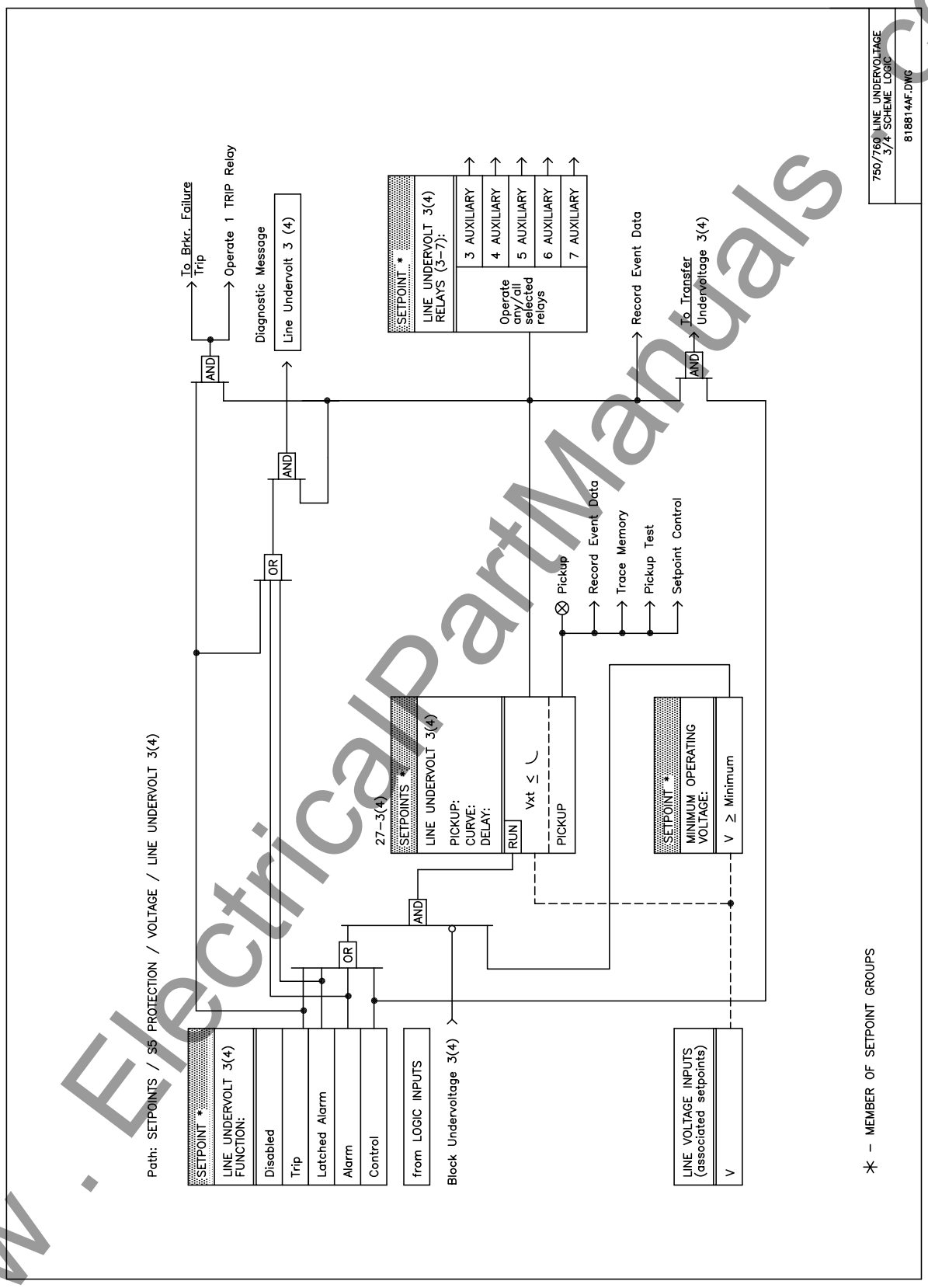


Figure 12–25: LINE UNDERVOLTAGE 3 / 4 LOGIC DIAGRAM

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12.7.5 OVERVOLTAGE

To protect voltage sensitive loads and circuits against sustained overvoltage conditions, the overvoltage 1 and 2 protection features can be used to either cause a trip or generate an alarm when the voltage exceeds a specified voltage setting for a specified time delay.

The following setpoints are repeated for both Overvoltage 1 and Overvoltage 2.

■ OVERVOLTAGE 1 ■ [ENTER] for more	The Overvoltage 1 setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ VOLTAGE \ OVERVOLTAGE 1**
OVERVOLTAGE 1 FUNCTION: Disabled	*Range: Disabled, Trip, Alarm, Latched Alarm, Control* Select the required function.
OVERVOLTAGE 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
OVERVOLTAGE 1 PICKUP: 1.25 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Selects the pickup as a fraction of the nominal bus VT Secondary Voltage. For example, if the nominal VT secondary voltage is 120 V, and an alarm is required whenever the voltage exceeds 130 V, enter 130 / 120 = *1.08* for the pickup.
OVERVOLTAGE 1 DELAY: 2.0 s	*Range: 0.0 to 6000.0 in steps of 0.1 s* Selects the delay required.
PHASES REQUIRED FOR OPERATION: All Three	*Range: Any One, Any Two, All Three* Select the type of operation required.

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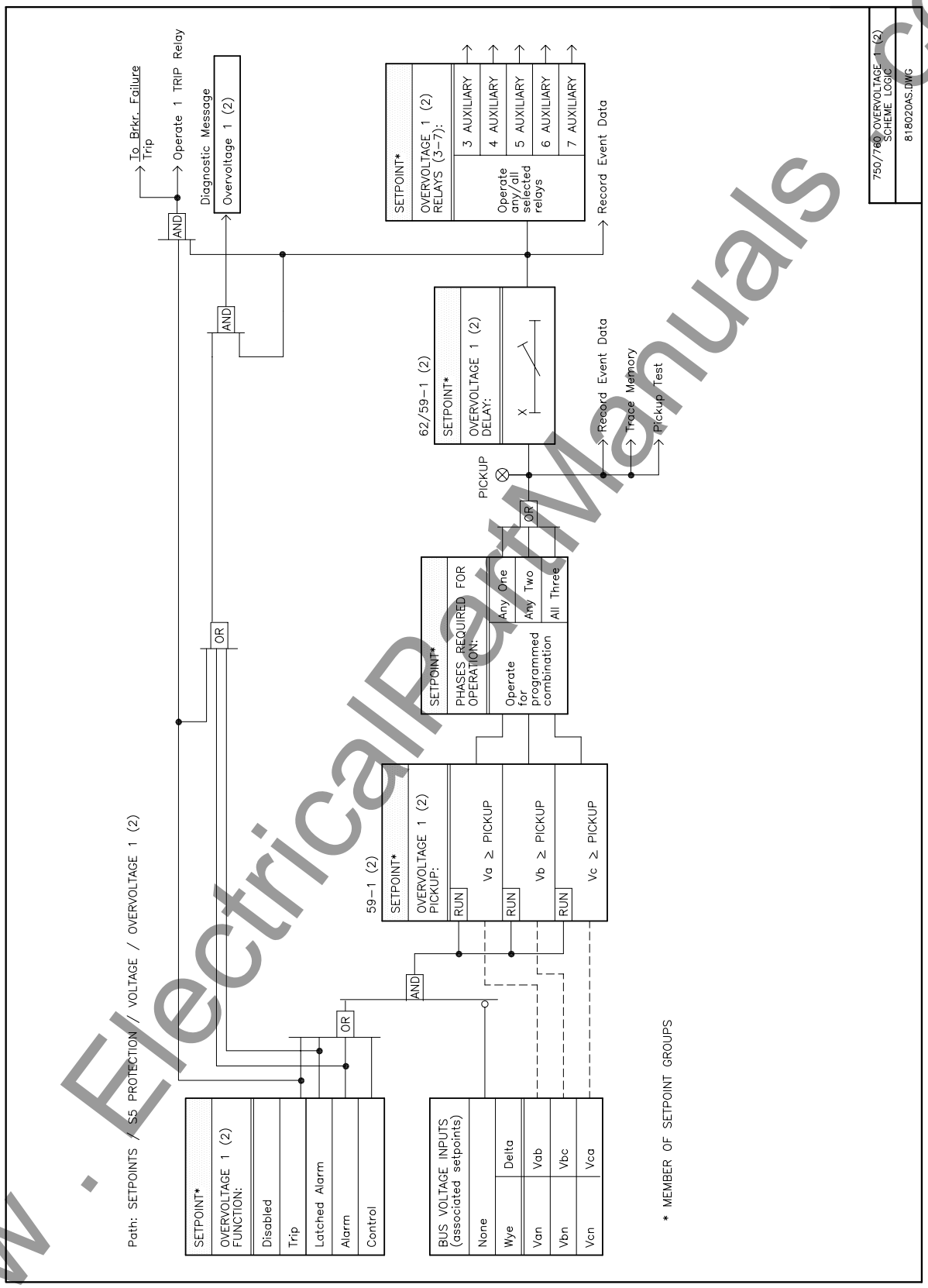


Figure 12–26: OVERVOLTAGE 1 / 2 LOGIC DIAGRAM

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12.7.6 NEUTRAL DISPLACEMENT

The 750/760 incorporates a Neutral Displacement element, which uses the internally derived $3V_0$ value. This protection element requires the three phase Bus VTs to be wye connected. When setting the pickup level for this element, it is important to consider the error in the VT ratio as well as the normal voltage unbalance on the system. The Neutral Displacement setpoints are as follows.

■ NTR DISPLACEMENT ■ [ENTER] for more	The Neutral Displacement setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ VOLTAGE \ NTR DISPLACEMENT**
NTR DISPLACEMENT FUNCTION: Disabled	*Range: Disabled, Trip, Alarm, Latched Alarm, Control* Select the required function.
NTR DISPLACEMENT RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NTR DISPLACEMENT PICKUP: 1.00 x CT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the pickup as a fraction of the bus VT nominal voltage. For example, if the nominal VT secondary voltage is 120 V, and an alarm is required whenever the voltage exceeds 130 V, enter 130 / 120 = *1.08* for the pickup.
NTR DISPLACEMENT CURVE: Ext Inverse	*Range: Ext Inverse, Very Inverse, Norm Inverse, ..., FlexCurve B* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.†
NTR DISPLACEMENT MULTIPLIER: 1.00	*Range: 0.00 to 100.00 in steps of 0.01* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.†
NTR DISPLACEMENT RESET: Instantaneous	*Range: Instantaneous, Linear* See description in Section 12.1: TIME OVERCURRENT CURVE CHARACTERISTICS on page 12–1.†

† NOTE: The same curves used for the time overcurrent elements are used for Neutral Displacement. When using the curve to determine the operating time of the Neutral Displacement element, substitute the ratio of neutral voltage to the pickup level for the current ratio shown on the horizontal axis of the curve plot.

The user should be aware that the neutral displacement feature should be applied with caution. It would normally be applied to give line to ground fault coverage on high impedance grounded or ungrounded systems, which are isolated. This constraint stems from the fact that a measurement of $3V_0$ cannot discriminate between a faulted circuit and an adjacent healthy circuit. Use of a time delayed back-up or an alarm mode allow other protections an opportunity to isolate the faulted element first.

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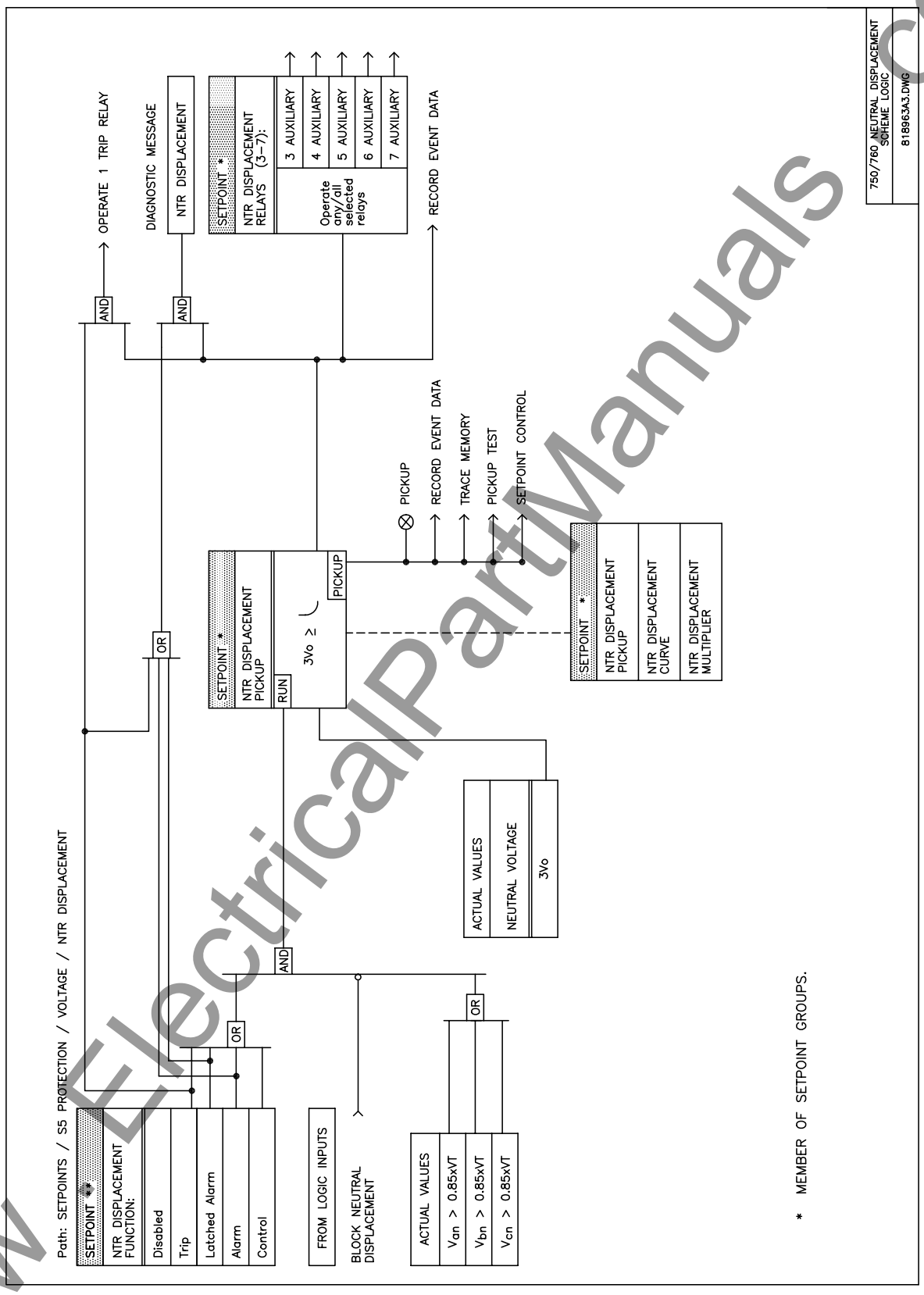


Figure 12–27: NEUTRAL DISPLACEMENT SCHEME LOGIC DIAGRAM

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12.8.1 DESCRIPTION

The 750/760 can be used as the primary detecting relay in automatic load shedding schemes based on underfrequency. The need for such a relay arises if during a system disturbance, an area becomes electrically isolated from the main system and suffers a generation deficiency due to the loss of either transmission or generation facilities. If reserve generation is not available in the area, conditions of low system frequency will occur which may lead to a complete collapse. The 750/760 provides two underfrequency and one rate-of-change of frequency protection elements which can automatically disconnect sufficient load to restore an acceptable balance between load and generation.

12.8.2 UNDERFREQUENCY

There are two identical underfrequency protection elements, ANSI devices 81U-1 and 81U-2. The setpoints for the Underfrequency 1 element are as follows. Underfrequency 2 setpoints are identical.

■ UNDERFREQUENCY 1 ■ [ENTER] for more	The Underfrequency 1 setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ FREQUENCY \ UNDERFREQUENCY 1**
UNDERFREQUENCY 1 FUNCTION: Disabled	*Range: Disabled, Trip, Alarm, Latched Alarm, Control* Select the required function.
UNDERFREQUENCY 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
UNDERFREQUENCY 1 PICKUP: 59.00 Hz	*Range: 20.00 to 65.00 in steps of 0.01 Hz* Enter the level at which the underfrequency element is to pickup. For example, if the system frequency is 60 Hz, and load shedding is required at 59.50 Hz, enter *59.5* for this setpoint.
UNDERFREQUENCY 1 DELAY: 2.00 s	*Range: 0.00 to 600.00 in steps of 0.01 s* Select the delay required.
MINIMUM OPERATING VOLTAGE: 0.70 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the minimum voltage required to allow the underfrequency element to operate. Used to prevent incorrect operation before energization of the source to the relay location, and during voltage dips.
MINIMUM OPERATING CURRENT: 0.20 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Enter the minimum value of current required on any phase to allow the underfrequency element to operate. Used to prevent underfrequency tripping during periods of light load, when this action would have an insignificant effect on the system.

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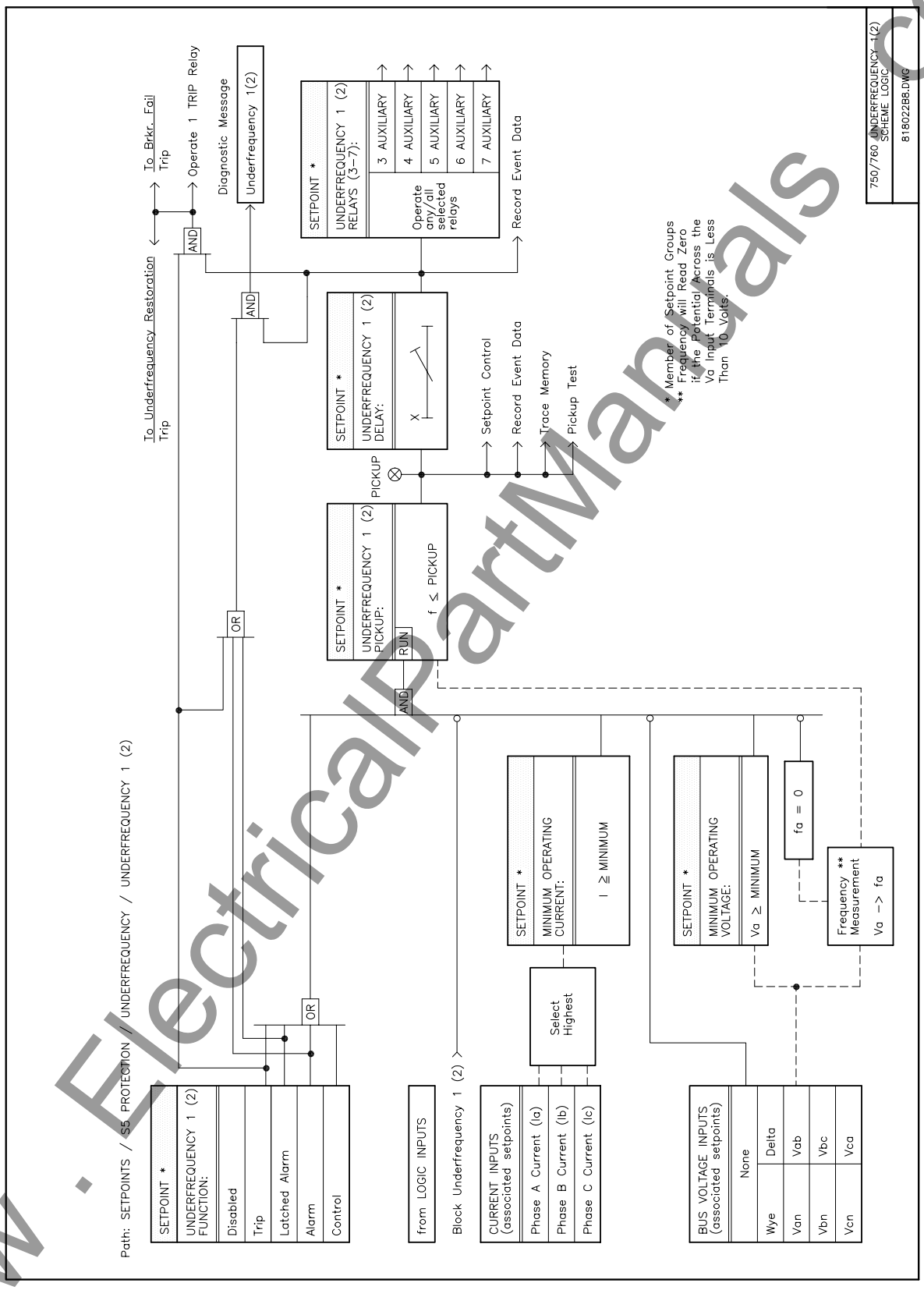


Figure 12–28: UNDERFREQUENCY 1 / 2 LOGIC DIAGRAM

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12.8.3 FREQUENCY DECAY

There is one frequency decay protection element, ANSI device 81D which can provide a faster response to system disturbances than the underfrequency elements. The setpoints for the Frequency Decay element are as follows.

■ FREQUENCY DECAY ■ [ENTER] for more	The Frequency Decay setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ FREQUENCY \ FREQUENCY DECAY**
FREQUENCY DECAY FUNCTION: Disabled	*Range: Disabled, Trip, Alarm, Latched Alarm, Control* Select the required function.
FREQUENCY DECAY RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
FREQUENCY DECAY RATE: 1.0 Hz/s	*Range: 0.1 to 5.0 in steps of 0.1 Hz/s* Enter the rate of frequency decay above which the element will operate.
FREQUENCY DECAY PICKUP: 59.00 Hz	*Range: 20.00 to 65.00 in steps of 0.01 Hz* Enter the frequency level below which the frequency decay element will operate.
FREQUENCY DECAY DELAY: 2.00 s	*Range: 0.00 to 600.00 in steps of 0.01 s* Select the delay required.
MINIMUM OPERATING VOLTAGE: 0.70 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the minimum voltage required to allow the frequency decay element to operate. Used to prevent incorrect operation before energization of the source to the relay location, and during voltage dips.
MINIMUM OPERATING CURRENT: 0.20 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Enter the minimum value of current required on any phase to allow the frequency decay element to operate. Used to prevent underfrequency tripping during periods of light load, when this action would have an insignificant effect on the system.

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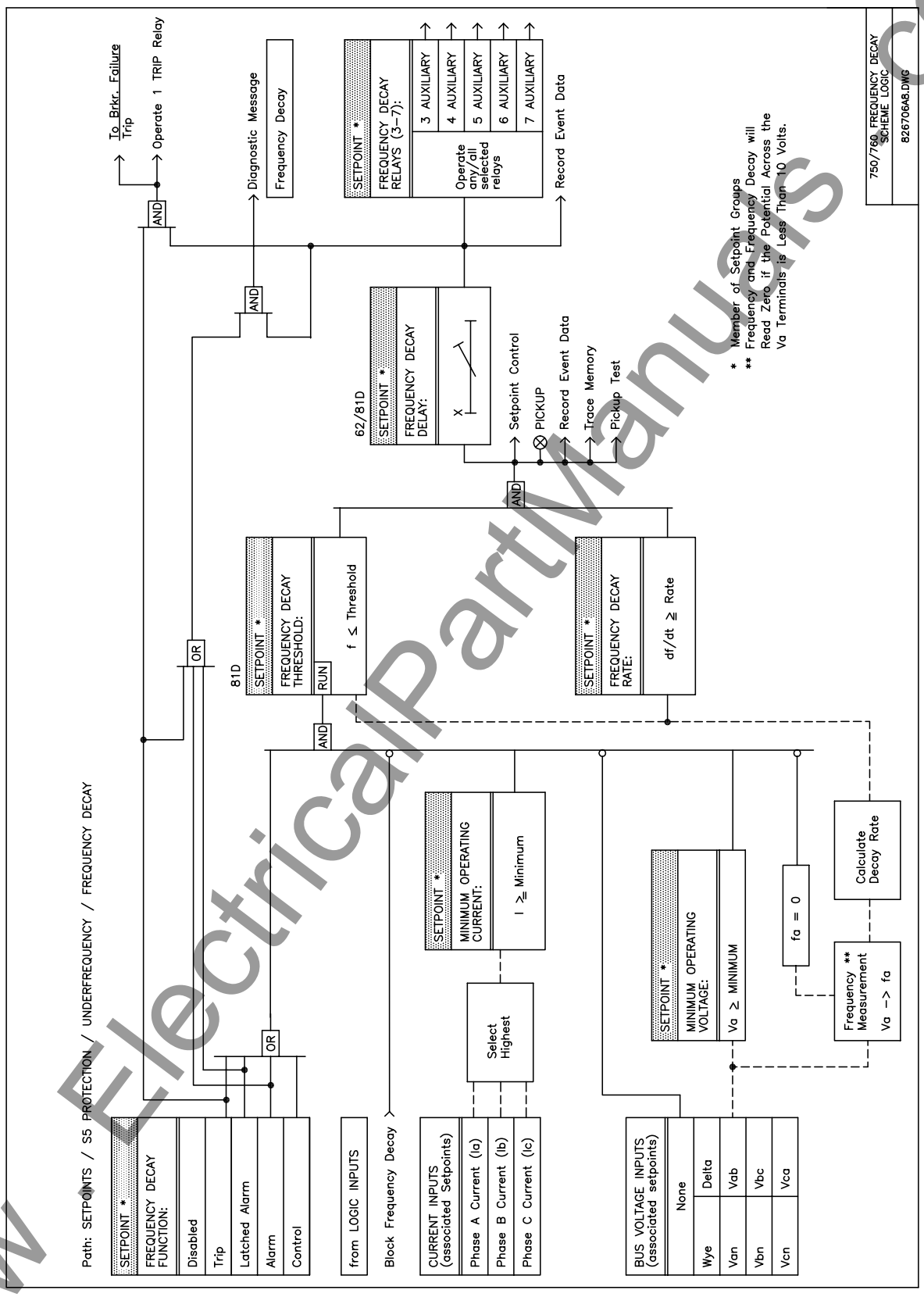


Figure 12–29: FREQUENCY DECAY LOGIC DIAGRAM

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12.9.1 DESCRIPTION

Breaker failure monitors the phase currents while a trip command exists. If any phase current is above the set level after the **BREAKER FAILURE DELAY** time expires, a breaker failure will be declared, which will operate the selected output relays and force the 760 autoreclose scheme to lockout.

To provide user flexibility, the 750/760 has included two programmable delays for the **BREAKER FAILURE FUNCTION**. The timers can be used singularly or in combination with each other. The difference between the two is their location in the logic diagram. Delay 1 starts counting down from the user programmed delay setpoint once a Trip condition is recognized. On the other hand, Delay 2 provides a delay where it does not begin counting down until a trip condition is present, Delay 1 has expired, and one of the phase currents is above the **BREAKER FAILURE CURRENT** setpoint. If one of the delays is not required, simply program the unwanted timer to its minimum value.

12.9.2 SETTINGS

■ BREAKER FAILURE ■ [ENTER] for more	The Breaker Failure setpoints path is: **\ SETPOINTS \ S5 PROTECTION \ BREAKER FAILURE**
BREAKER FAILURE FUNCTION: Disabled	*Range: Disabled, Trip, Alarm, Latched Alarm, Control* Select the required function.
BREAKER FAILURE RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
BREAKER FAILURE DELAY 1: 0.10 s	*Range: 0.03 to 1.00 in steps of 0.01 s* Enter the maximum time, during which a trip command exists, that it will take for the current measured by the relay to fall below the level programmed in the breaker failure current setpoint. If the current does not drop within this programmable delay time, a breaker failure condition will be declared. **NOTE:** The operation of the filter that reduces the overreaching effect of asymmetrical offset currents will cause the measured current to ramp down to zero after the breaker trips. It is strongly recommended that a margin of at least 1.5 power frequency cycles be added to the expected breaker time-to-trip for this setting.
BREAKER FAILURE DELAY 2: 0.00 s	*Range: 0.00 to 1.00 in steps of 0.01 s* Enter the maximum time, during which a trip command exists, that it will take for the current measured by the relay to fall below the level programmed in the breaker failure current setpoint. If the current does not drop within this programmable delay time, a breaker failure condition will be declared. NOTE The operation of the filter that reduces the overreaching effect of asymmetrical offset currents will cause the measured current to ramp down to zero after the breaker trips. It is strongly recommended that a margin of at least 1.5 power frequency cycles be added to the expected breaker time-to-trip for this setting.
BREAKER FAILURE CURRENT: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Select the level to which the current must fall within the breaker failure delay time.

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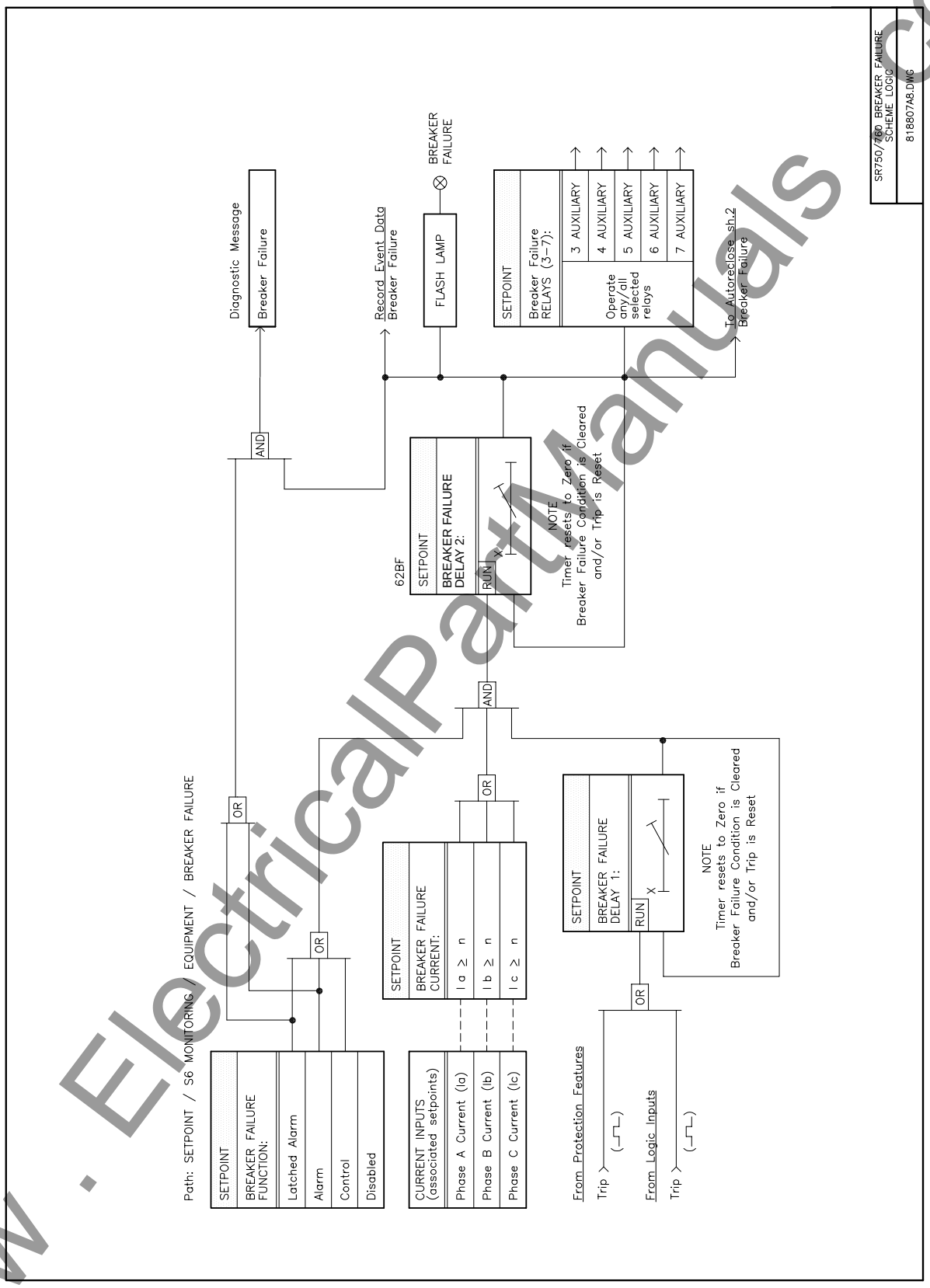


Figure 12–30: BREAKER FAILURE LOGIC DIAGRAM

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13.1.1 DESCRIPTION

In addition to the conventional overcurrent protection elements that are used for tripping, separate phase and neutral current level detectors are provided for alarm or control purposes. These elements allow longer time delays to be programmed.

13.1.2 PHASE CURRENT LEVEL

■ PHASE CURRENT ■ [ENTER] for more	The **PHASE CURRENT** Level setpoints path is: **\ SETPOINTS \ S6 MONITORING \ CURRENT LEVEL \ PHASE CURRENT**
PHASE CURRENT FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
PHASE CURRENT RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
PHASE CURRENT PICKUP: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Enter the pickup in terms of the CT rating. If 100:5 phase CTs are installed, enter *0.9 x CT* for an alarm level of 90 amps.
PHASE CURRENT DELAY: 2 s	*Range: 0 to 60000 in steps of 1 s* Select the delay required.

13.1.3 NEUTRAL CURRENT LEVEL

■ NEUTRAL CURRENT ■ [ENTER] for more	The **NEUTRAL CURRENT** Level setpoints path is: **\ SETPOINTS \ S6 MONITORING \ CURRENT LEVEL \ NEUTRAL CURRENT**
NEUTRAL CURRENT FUNCTION: Disabled	*Range: Disabled, Alarm, Control* Select the function required.
NEUTRAL CURRENT RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NEUTRAL CURRENT PICKUP: 1.10 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* Enter the pickup in terms of the CT rating. If 100:5 phase CTs are installed, enter *0.9 x CT* for an alarm level of 90 amps.
NEUTRAL CURRENT DELAY: 2 s	*Range: 0 to 60000 in steps of 1 s* Select the delay required.

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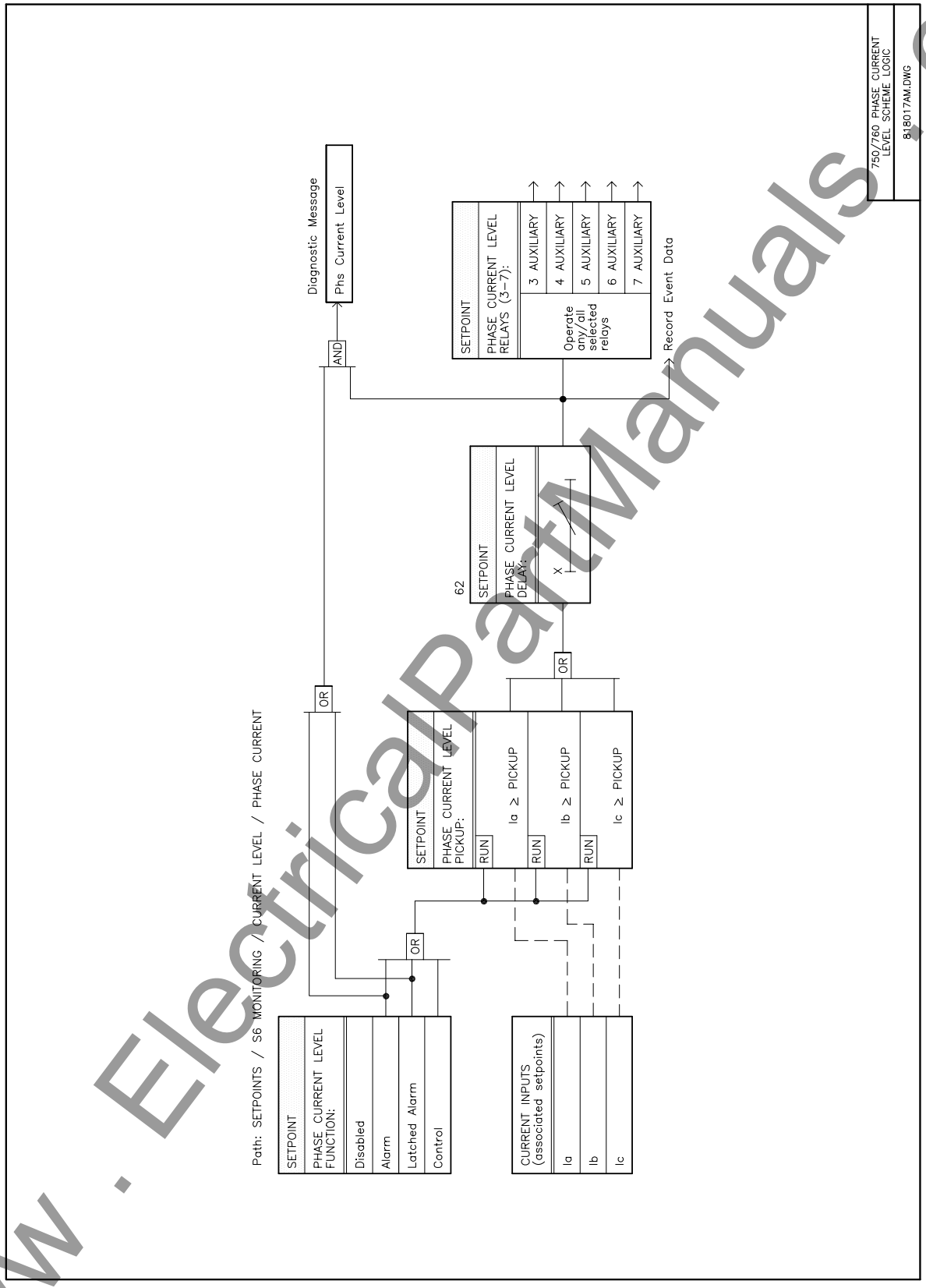


Figure 13–1: PHASE CURRENT LOGIC DIAGRAM

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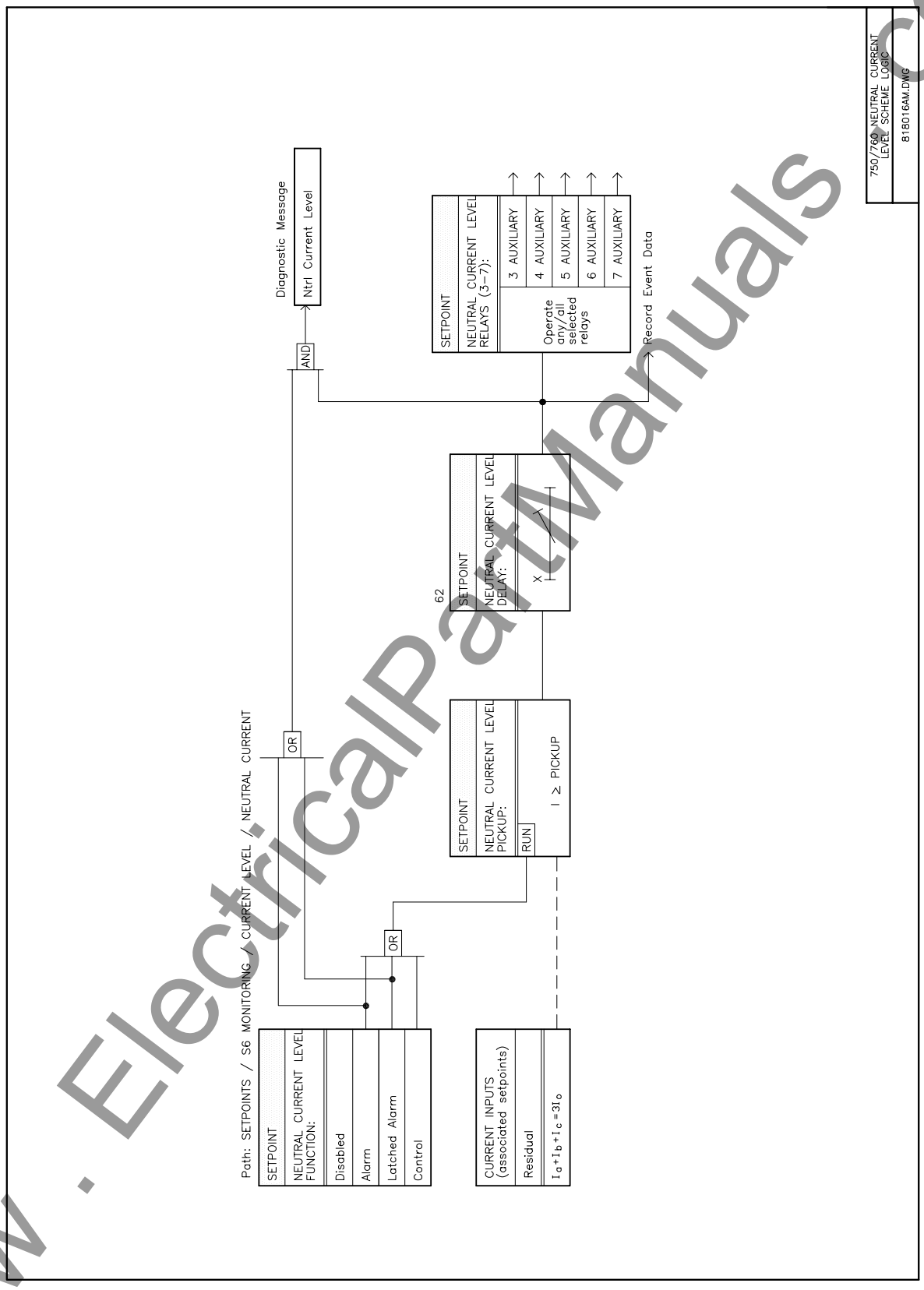


Figure 13–2: NEUTRAL CURRENT LOGIC DIAGRAM

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13.2.1 DESCRIPTION

It is generally desirable for a system operator to maintain the power factor as close to unity as possible to minimize both costs and voltage excursions. Since the power factor is variable on common non-dedicated circuits, it is advantageous to compensate for low (lagging) power factor values by connecting a capacitor bank to the circuit when required. The relay allows two stages of capacitance switching for power factor compensation.

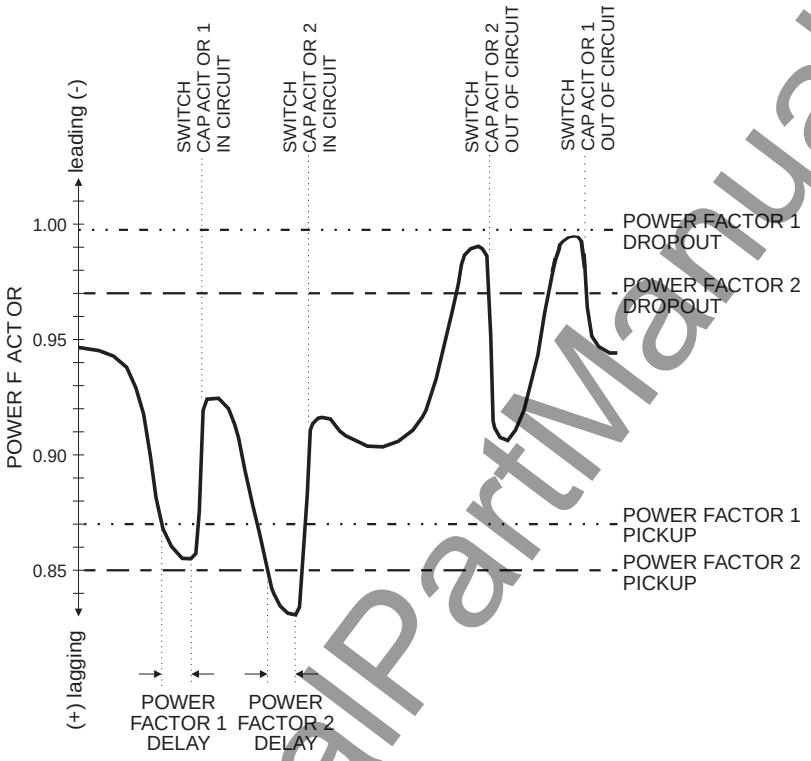


Figure 13–3: CAPACITOR BANK SWITCHING

The relay calculates the average power factor in the three phases, according to the following equation.

$$\text{Average Power Factor} = \frac{\text{Total 3 Phase Real Power}}{\text{Total 3 Phase Apparent Power}}$$

Two independent elements are available for monitoring power factor, **POWER FACTOR 1** and **POWER FACTOR 2**, each having a pickup and a dropout level. For each element, when the measured power factor becomes more lagging than the pickup level (i.e. numerically less than), the relay will operate a user-selected output contact. This output can be used to control a switching device which connects capacitance to the circuit, or to signal an alarm to the system operator. After entering this state, when the power factor becomes less lagging than the power factor dropout level for a time larger than the set delay, the relay will reset the output contact to the non-operated state.

Both **POWER FACTOR 1** and **2** features are inhibited from operating unless all three voltages are above 30% of nominal and one or more currents is above 0. **POWER FACTOR 1** and **2** delay timers will only be allowed to time when the 30% threshold is exceeded on all phases and the power factor remains outside of the programmed pickup and dropout levels. In the same way, when a power factor condition starts the **POWER FACTOR 1** or **2** delay timer, if all three phase voltages fall below the 30% threshold before the timer has timed-out, the element will reset without operating. A loss of voltage during any state will return both **POWER FACTOR 1** and **2** to the reset state.

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All of the following setpoints are repeated for **POWER FACTOR 2**.

■ POWER FACTOR 1 ■ [ENTER] for more	The **POWER FACTOR 1** setpoints path is: **\ SETPOINTS \ S6 MONITORING \ POWER FACTOR \ POWER FACTOR 1**
POWER FACTOR 1 FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
POWER FACTOR 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
POWER FACTOR 1 PICKUP: 0.80 Lag	*Range: –0.99 to 1.00 in steps of 0.01* *(positive values indicate lagging power factor)* Enter the level at which the power factor element is to pickup. When the power factor becomes more lagging than this value for longer than the **POWER FACTOR 1 DELAY**, the selected output relay(s) will operate.
POWER FACTOR 1 DROPOUT: 1.00	*Range: –0.99 to 1.00 in steps of 0.01* *(positive values indicate lagging power factor)* Enter the level at which the power factor element is to dropout. When the power factor becomes more leading than this value for longer than the **POWER FACTOR 1 DELAY**, the selected output relay(s) will reset.
POWER FACTOR 1 DELAY: 50 s	*Range: 0 to 60000 in steps of 1 s* Select the delay required.

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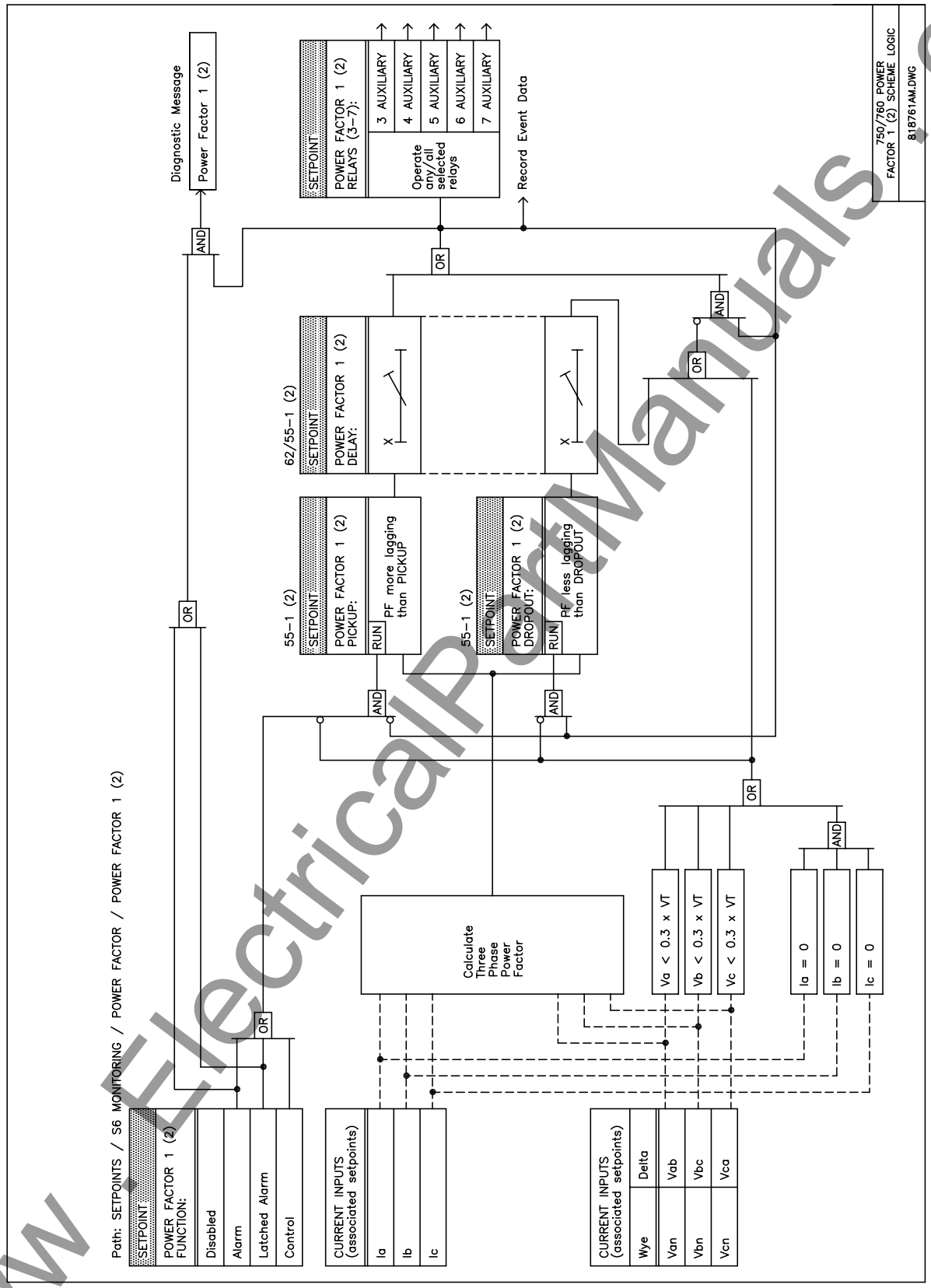


Figure 13–4: POWER FACTOR LOGIC DIAGRAM

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13.3.1 DESCRIPTION

The relay calculates the distance to fault with fault resistance compensation. For the fault location feature, a fault is defined as an event that has caused a current level greater than the pickup threshold of an overcurrent protection feature programmed to *Trip* or *Trip & AR* (760 Only), which has remained for sufficient time to cause the relay to produce a Trip command. After this has happened, the apparent distance to the fault is calculated in a background mode, maintaining all other features in operation. The distance calculation is based on the assumptions that:

(a) the feeder positive and zero sequence impedances are a constant per unit distance, and

(b) mutual compensation is not required.

If the feeder utilizes conductors of different sizes, or more than one physical arrangement of conductors, or shares poles or towers with a parallel feeder, these assumptions are incorrect and errors are introduced.

The algorithm uses prefault system data to reduce the error caused by variable fault resistance, so inaccuracy is introduced for a fault which occurs when no load current was present. Also, error is introduced if the feeder has sources at locations other than the location of the relay, due to infeed effects.

The algorithm contains three sets of equations that are used to perform the calculations for a specific fault type: phase to ground, phase to phase to ground, phase to phase, and three phase. Each of the sets (other than three-phase) consists of a subset which covers all combinations of phases. The algorithm therefore uses a fault identification procedure to select the appropriate equations to be used for calculation. This procedure uses both prefault and fault current phasors from memory to identify the type of fault. The prefault data is taken from a sample collected three power frequency cycles before the pickup of the overcurrent element to ensure the sample contains only load current. The after fault data is taken from samples collected 1.5 power frequency cycles after overcurrent pickup to ensure the current had existed for at least one complete sampling interval.

As well as the apparent distance to the fault, the locator records the feeder apparent reactance (with fault resistance removed if prefault current was available.) This parameter can be very useful in estimating the location of a fault on a feeder tap, where the apparent distance can be calculated as beyond the feeder end. The date, time, type of fault, and phases involved are also stored for the event. Non-volatile memory is provided for the past ten events, in a FIFO queue, available under **ACTUAL VALUES \ A1 STATUS \ FAULT LOCATIONS**.

NOTE

If the feeder has a source with a grounded neutral, and is therefore capable of providing ground fault current, the bus VTs must be both connected and selected as Wye in setpoint S2 SYSTEM SETUP \ BUS VT SENSING \ VT CONNECTION TYPE, to allow the fault locator to perform the calculations properly. If the fault classification results in a phase to ground fault, the program checks that the setpoint noted above is set to 'Wye' before the calculation is permitted.

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■ FAULT LOCATOR ■ [ENTER] for more	The **FAULT LOCATOR** setpoints path is: **\ SETPOINTS \ S6 MONITORING \ FAULT LOCATOR**
LENGTH OF FEEDER: 0.1 km	*Range: 0.1 to 99.9 in steps of 0.1 km/miles* Enter the total length of the feeder, in kilometers or miles.
UNITS OF LENGTH km	*Range: km, Miles* Enter the desired units of measurement, either kilometers or miles.
Zpos (RESISTIVE) OF FEEDER: 0.01 Ω	*Range: 0.01 to 99.99 in steps of 0.01 Ω* Enter the total real component of the feeder positive sequence impedance, in actual ohms.
Zpos (INDUCTIVE) OF FEEDER: 0.01 Ω	*Range: 0.01 to 99.99 in steps of 0.01 Ω* Enter the total imaginary component of the feeder positive sequence impedance, in actual ohms.
Zzero (RESISTIVE) OF FEEDER: 0.01 Ω	*Range: 0.01 to 99.99 in steps of 0.01 Ω* Enter the total real component of the feeder zero sequence impedance, in actual ohms.
Zzero (INDUCTIVE) OF FEEDER: 0.01 Ω	*Range: 0.01 to 99.99 in steps of 0.01 Ω* Enter the total imaginary component of the feeder zero sequence impedance, in actual ohms.
FAULT TYPE OUTPUT TO RELAYS 4-7: Disabled	*Range: Disabled, Enabled* Selects whether fault type indication on output relays 4 to 7 is enabled. When enabled, relays 4 to 7 will operate to indicate the type of the most recent fault i.e. Fault Location #0 Fault Type. The auxiliary relays are reset to their non-operated state after the relay is reset. Any combination of relays 4 to 7 may be operated and the outputs are designated as follows. Phase A faults operate the 4 AUXILIARY relay. Phase B faults operate the 5 AUXILIARY relay. Phase C faults operate the 6 AUXILIARY relay. Neutral faults operate the 7 AUXILIARY relay.
FAULT LOCATION AFTER TRIP: Disabled	*Range: Enabled, Disabled* Users utilizing the Fault Distance capability of the product may benefit from having a fault distance message displayed along with other active conditions in the relay. When set to *Enabled*, a fault distance message will be displayed when a trip has occurred within the relay. The fault distance message will be removed when the active conditions are reset. This message only appears after the first TRIP condition; any subsequent TRIPs will only update the fault distance value (if required).

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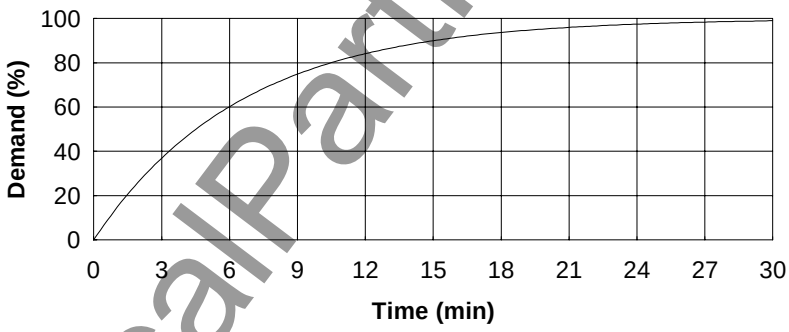
13.4.1 DESCRIPTION

The relay measures current demand on each phase, and three phase demand for real, reactive, and apparent power. Setpoints are provided to allow the user to emulate some common electrical utility demand measuring techniques, for statistical or control purposes.

NOTE

The relay is not approved as or intended to be a revenue metering instrument. If used in a peak load control system, the user must consider the accuracy rating and method of measurement employed, and the source VTs and CTs, in comparison with the electrical utility revenue metering system.

The relay can be set to calculate demand by any of three methods.

METHOD	DESCRIPTION
Thermal Exponential	This selection emulates the action of an analog peak recording thermal demand meter. The relay measures the quantity (RMS current, real power, reactive power, or apparent power) on each phase every second, and assumes the circuit quantity remains at this value until updated by the next measurement. It calculates the 'thermal demand equivalent' based on the following equation. $d(t) = D(1 - e^{-kt})$ where d = demand value after applying input quantity for time t (in minutes) D = input quantity (constant) k = 2.3 / thermal 90% response time  Figure 13–5: THERMAL DEMAND CHARACTERISTIC (FOR 15 MIN. RESPONSE) See the 90% thermal response time characteristic of 15 minutes above. A setpoint establishes the time to reach 90% of a steady-state value, just as the response time of an analog instrument. A steady state value applied for twice the response time will indicate 99% of the value.
Block Interval	This selection calculates a linear average of the quantity (RMS current, real power, reactive power, or apparent power) over the programmed demand time interval, starting daily at 00:00:00 (i.e. 12 am). The 1440 minutes per day is divided into the number of blocks as set by the programmed time interval. Each new value of demand becomes available at the end of each time interval.
Block Interval (*with Start Demand Interval Logic input*)	This selection calculates a linear average of the quantity (RMS current, real power, reactive power, or apparent power) over the interval between successive Start Demand Interval logic input pulses. Each new value of demand becomes available at the end of each pulse. See **S3 LOGIC INPUTS \ MISCELLANEOUS \ START DEMAND INTERVAL** to program the input for the new demand interval pulses.
Rolling Demand	This selection calculates a linear average of the quantity (RMS current, real power, reactive power, or apparent power) over the programmed demand time interval, in the same way as Block Interval. The value is updated every minute and indicates the demand over the time interval just preceding the time of update.

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13.4.2 CURRENT DEMAND

The current demand for each phase is calculated individually, and the demand for each phase is monitored by comparing to a single current demand pickup value. If the current demand pickup is exceeded by any phase, the relay can cause an alarm or signal an output relay.

■ CURRENT ■ [ENTER] for more	The **CURRENT** Demand setpoints path is: **\ SETPOINTS \ S6 MONITORING \ DEMAND \ CURRENT**
CURRENT DEMAND FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Selects the required function.
MEASUREMENT TYPE: Thermal Exponential	*Range: Thermal Exponential, Block Interval, Rolling Demand* Select one of three current demand calculation methods.
THERMAL 90% RESPONSE TIME: 15 min	*Range: 5 min, 10 min, 15 min, 20 min, 30 min, 60 min* This message is only displayed if the **MEASUREMENT TYPE** is selected as *Thermal Exponential*. Enter the time required for a steady state current to indicate 90% of the actual value. This setpoint allows the user to approximately match the response of the relay to analog instruments.
TIME INTERVAL: 20 min	*Range: 5 min, 10 min, 15 min, 20 min, 30 min, 60 min* This message is only displayed if the **MEASUREMENT TYPE** is selected as *Block Interval* or *Rolling Demand*. Enter the time period over which the current demand calculation is to be performed.
CURRENT DEMAND RELAYS (3-7):-----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
CURRENT DEMAND PICKUP: 1000 A	*Range: 10 to 10000 in steps of 1 A* Enter the threshold value for current demand. For example, if an action is required when the current demand is above 1000 A, enter *1000* for this setpoint. When the maximum current demand in any phase exceeds this setting, the programmed action will be performed.

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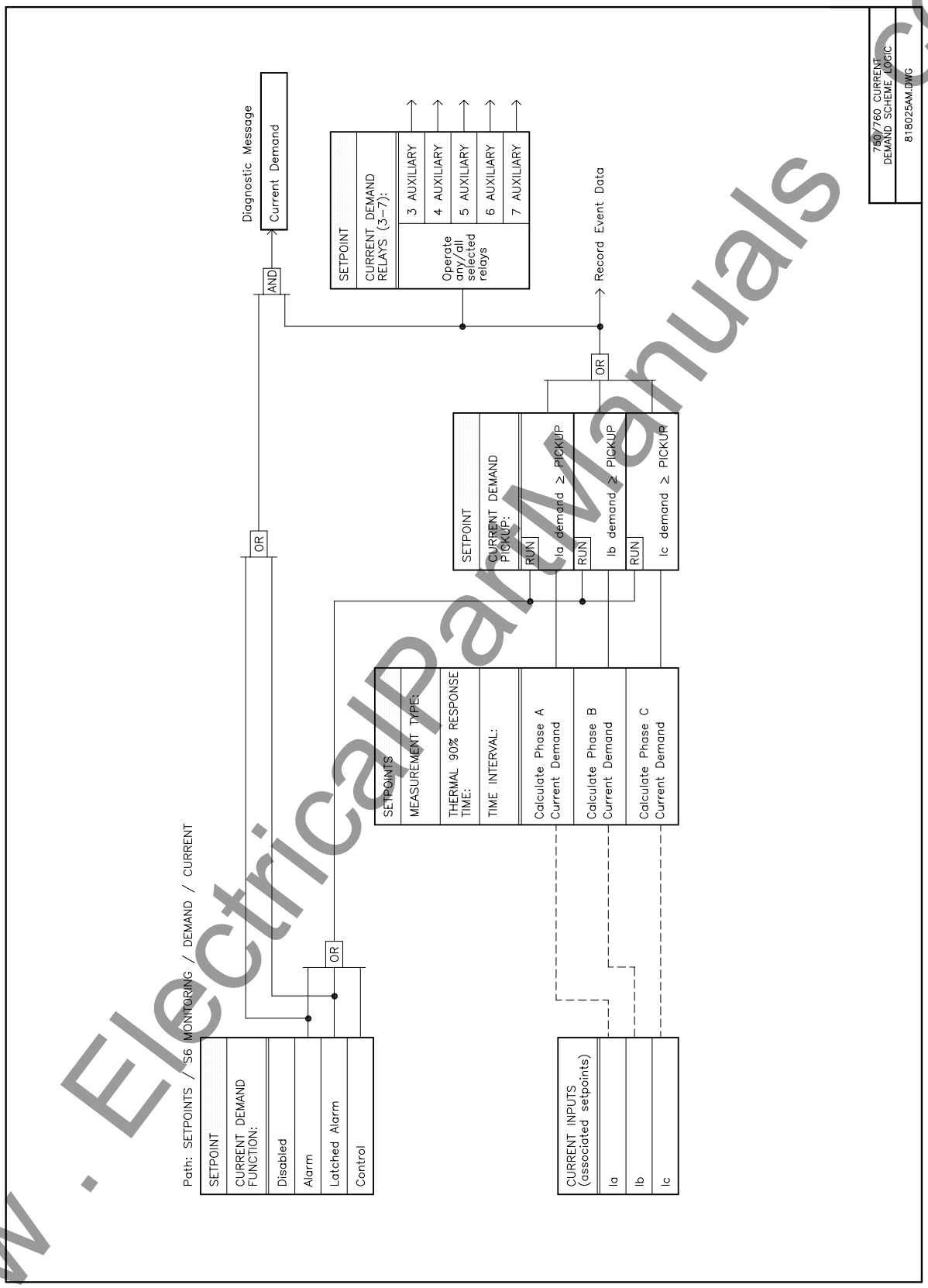


Figure 13–6: CURRENT DEMAND LOGIC DIAGRAM

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13.4.3 REAL POWER DEMAND

The real power demand is monitored by comparing to a pickup value. If the real power demand pickup is ever exceeded, the relay can be configured to cause an alarm or signal an output relay.

■ REAL POWER ■ [ENTER] for more	The **REAL POWER** Demand setpoints path is: **\ SETPOINTS \ S6 MONITORING \ DEMAND \ REAL POWER**
REAL POWER DEMAND FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Selects the required function.
MEASUREMENT TYPE: Block Interval	*Range: Thermal Exponential, Block Interval, Rolling Demand* Select one of three real power demand calculation methods.
THERMAL 90% RESPONSE TIME: 15 min	*Range: 5 min, 10 min, 15 min, 20 min, 30 min, 60 min* This message is only displayed if the **MEASUREMENT TYPE** is selected as *Thermal Exponential*. Enter the time required for a steady state real power to indicate 90% of the actual value. This setpoint allows the user to approximately match the response of the relay to analog instruments.
TIME INTERVAL: 20 min	*Range: 5 min, 10 min, 15 min, 20 min, 30 min, 60 min* This message is only displayed if the **MEASUREMENT TYPE** is selected as *Block Interval* or *Rolling Demand*. Enter the time period over which the real power demand calculation is to be performed.
REAL POWER DEMAND RELAYS (3-7):-----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
REAL POWER DEMAND PICKUP: 10.0 MW	*Range: 0.1 to 3000.0 in steps of 0.1 MW*[1] Enter the threshold value for real power demand. For example, if an action is required when the real power demand is above 1.5 MW, enter *1.5* for this setpoint. When the maximum real power demand exceeds this setting, the programmed action will be performed. [1] Power quantities auto-range to show units appropriate to the power system size.

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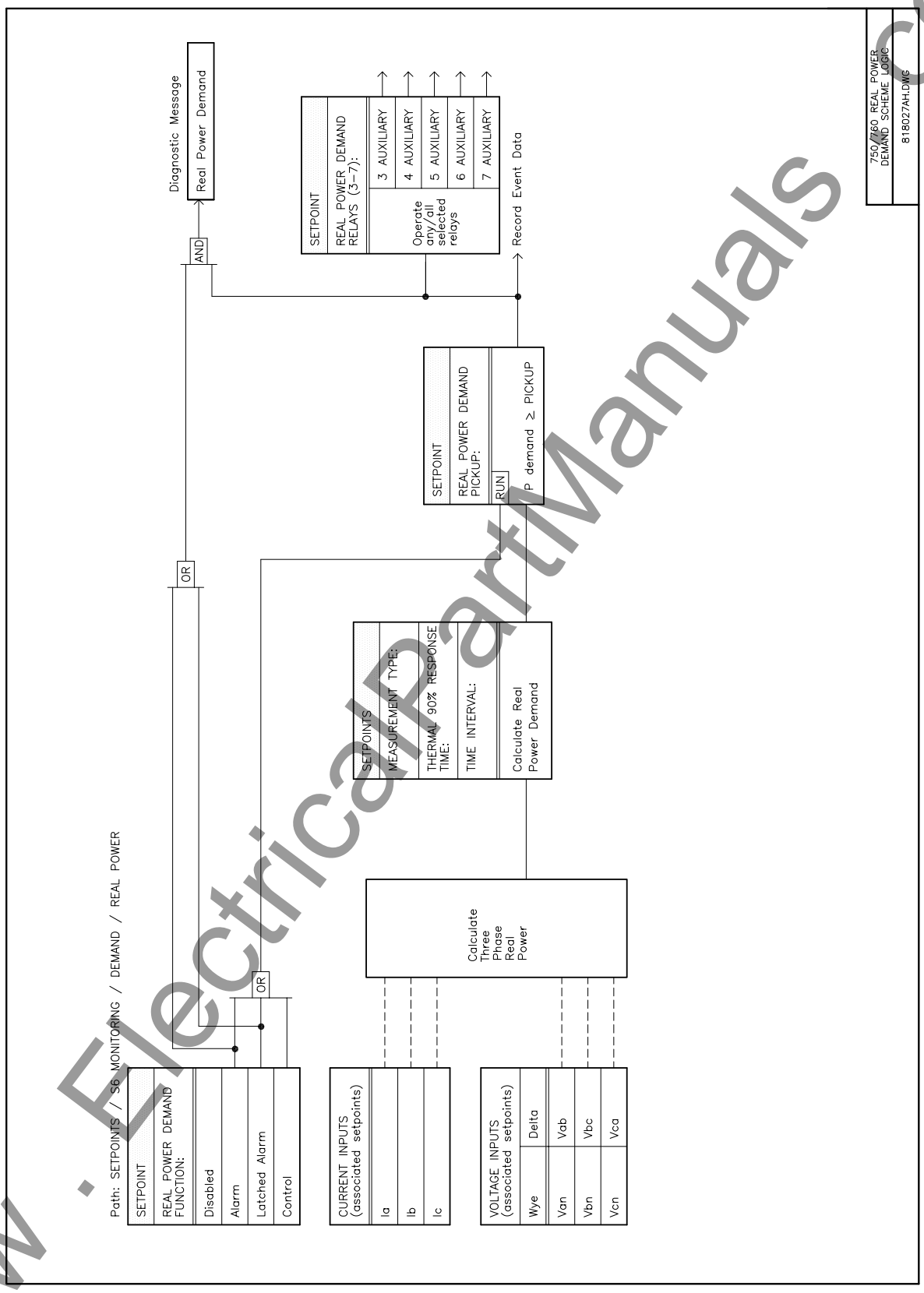


Figure 13–7: REAL POWER DEMAND LOGIC DIAGRAM

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13.4.4 REACTIVE POWER DEMAND

The reactive power demand is monitored by comparing to a pickup value. If the reactive power demand pickup is ever exceeded, the relay can be configured to cause an alarm or signal an output relay.

■ REACTIVE POWER ■ [ENTER] for more	The **REACTIVE POWER** Demand setpoints path is: **\ SETPOINTS \ S6 MONITORING \ DEMAND \ REACTIVE POWER**
REACTIVE PWR DEMAND FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Selects the required function.
MEASUREMENT TYPE: Block Interval	*Range: Thermal Exponential, Block Interval, Rolling Demand* Select one of three reactive power demand calculation methods.
THERMAL 90% RESPONSE TIME: 15 min	*Range: 5 min, 10 min, 15 min, 20 min, 30 min, 60 min* This message is only displayed if the **MEASUREMENT TYPE** is selected as *Thermal Exponential*. Enter the time required for a steady state reactive power to indicate 90% of the actual value. This setpoint allows the user to approximately match the response of the relay to analog instruments.
TIME INTERVAL: 20 min	*Range: 5 min, 10 min, 15 min, 20 min, 30 min, 60 min* This message is only displayed if the **MEASUREMENT TYPE** is selected as *Block Interval* or 'Rolling Demand'. Enter the time period over which the reactive power demand calculation is to be performed.
REACTIVE PWR DEMAND RELAYS (3-7):-----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
REACTIVE PWR DEMAND PICKUP: 10.0 MVar	*Range: 0.1 to 3000.0 in steps of 0.1 Mvar*[1] Enter the threshold value for reactive power demand. For example, if an action is required when the reactive power demand is above 1.5 Mvar, enter *1.5* for this setpoint. When the maximum reactive power demand exceeds this setting, the programmed action will be performed. [1] Power quantities auto-range to show units appropriate to the power system size.

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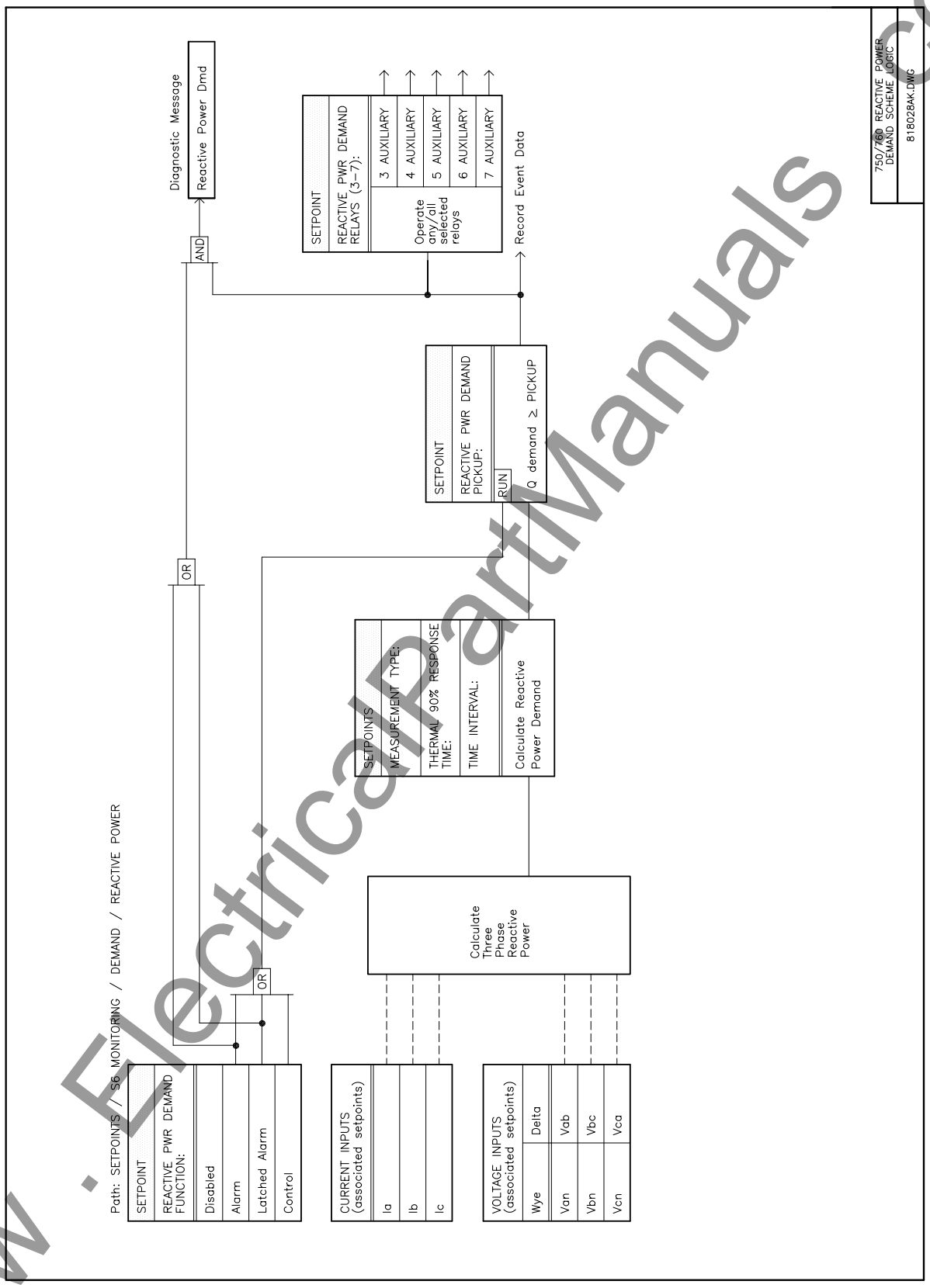


Figure 13–8: REACTIVE POWER DEMAND LOGIC DIAGRAM

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13.4.5 APPARENT POWER DEMAND

The apparent power demand is monitored by comparing to a pickup value. If the apparent power demand pickup is ever exceeded, the relay can be configured to cause an alarm or signal an output relay.

■ APPARENT POWER ■ [ENTER] for more	The **APPARENT POWER** Demand setpoints path is: **\ SETPOINTS \ S6 MONITORING \ DEMAND \ APPARENT POWER**
APPARENT PWR DEMAND FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Selects the required function.
MEASUREMENT TYPE: Block Interval	*Range: Thermal Exponential, Block Interval, Rolling Demand* Select one of three apparent power demand calculation methods.
THERMAL 90% RESPONSE TIME: 15 min	*Range: 5 min, 10 min, 15 min, 20 min, 30 min, 60 min* This message is only displayed if the **MEASUREMENT TYPE** is selected as *Thermal Exponential*. Enter the time required for a steady state apparent power to indicate 90% of the actual value. This setpoint allows the user to approximately match the response of the relay to analog instruments.
TIME INTERVAL: 20 min	*Range: 5 min, 10 min, 15 min, 20 min, 30 min, 60 min* This message is only displayed if the **MEASUREMENT TYPE** is selected as *Block Interval* or *Rolling Demand*. Enter the time period over which the apparent power demand calculation is to be performed.
APPARENT PWR DEMAND RELAYS (3-7):-----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
APPARENT PWR DEMAND PICKUP: 10.0 MVA	*Range: 0.1 to 3000.0 in steps of 0.1 MVA*[1] Enter the threshold value for apparent power demand. For example, if an action is required when the apparent power demand is above 1.5 MVA, enter *1.5* for this setpoint. When the maximum apparent power demand exceeds this setting, the programmed action will be performed. [1] Power quantities auto-range to show units appropriate to the power system size.

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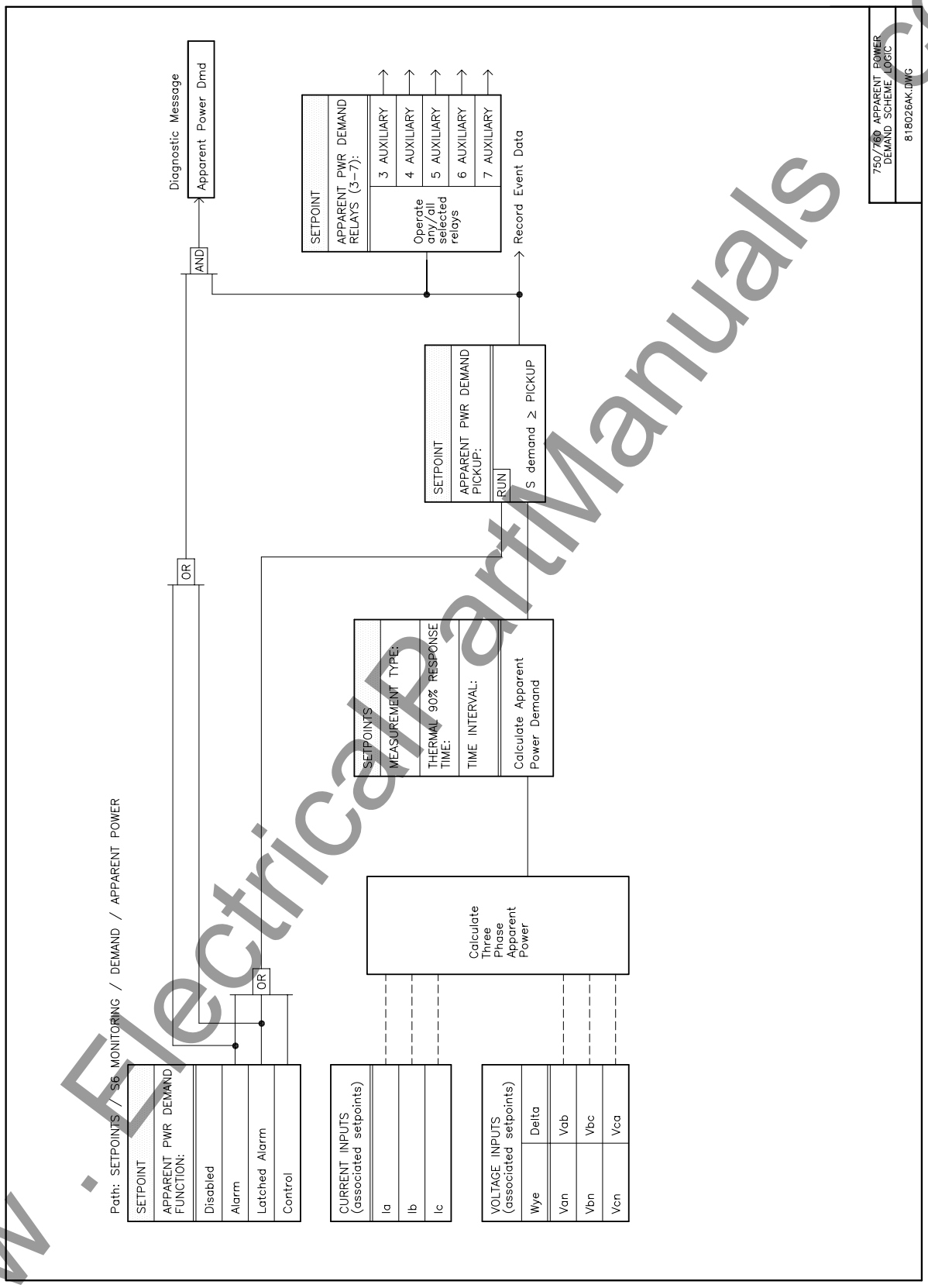


Figure 13–9: APPARENT POWER DEMAND LOGIC DIAGRAM

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13.5.1 DESCRIPTION

The relay can monitor any external quantity, such as transformer winding temperature, bus voltage, battery voltage, station service voltage, transformer tap position, etc., via an auxiliary current input called the analog input. Any one of the standard transducer output ranges 0-1 mA, 0-5 mA, 0-10 mA, 0-20 mA, or 4-20 mA can be connected to the analog input terminals.

Two independent elements are available for monitoring the analog input level, **ANALOG THRESHOLD 1(2)**, each having a user programmable name, pickup level, drop out ratio, and a time delay. For each element, when the measured analog input quantity exceeds the pickup level for longer than the associated time delay, the relay can be configured to cause a trip, an alarm, or signal an output contact. The element will drop out only when the user programmed drop out ratio has been met. There are also two elements which measure the analog input rate-of-change, **ANALOG IN RATE 1(2)**, which operate in a similar fashion.

13.5.2 ANALOG INPUT SETUP

Before the analog input can be used for monitoring, the value of the input must be converted to the quantity that is being measured. The relay simplifies this process by internally scaling the transducer output, and displaying and monitoring the actual measured parameter. Note the resolution that will result from the selection of the minimum and maximum setpoints. For example, if 0 to 20 µA is to be represented via the 0 to 20 mA analog input, an input of 4.5 mA will translate to a 5 µA actual value reading. This is due to the rounding up of the value, since the analog input actual value is an F1 format. If a range of 0 to 200 µA was programmed to be represented via the 0 to 20 mA input, 4.5 mA will result in a 45 µA actual value.

■ ANALOG INPUT SETUP ■ [ENTER] for more	The **ANALOG INPUT SETUP** setpoints path is: **\ SETPOINTS \ S6 MONITORING \ ANALOG INPUT \ ANALOG INPUT SETUP**
ANALOG INPUT NAME: ANALOG INPUT	*Range: Any Combination of 20 Alphanumeric Characters* Enter the name of the quantity being read. See Section 8.10: USER TEXT MESSAGES on page 8–11 for a description of entering text from the front panel. This name will be displayed instead of *ANALOG INPUT* (which is the factory default) in the actual value message **A2 METERING \ ANALOG INPUT \ ANALOG INPUT**. If the quantity being read is the transformer winding temperature, you may enter *TRANSFORMER TEMP* for this setpoint.
ANALOG INPUT UNITS: µA	*Range: Any Combination of 6 Alphanumeric Characters* Enter the units of the quantity being read. See Section 8.10: USER TEXT MESSAGES on page 8–11 for a description of entering text from the front panel. The 6 characters entered here will be displayed instead of *µA* (which is the factory default) wherever the analog input units are displayed. If the quantity being read is the transformer winding temperature in units of degrees Celsius, you may enter *°C* for this setpoint.
ANALOG INPUT RANGE: 0-20 mA	*Range: 0-1 mA, 0-5 mA, 4-20 mA, 0-20 mA, 0-10 mA* Enter the current output range of the transducer connected to the relay's analog input. Any of the standard transducer output ranges are accommodated.
ANALOG INPUT MINIMUM VALUE: 0 µA	*Range: 0 to 65535 in steps of 1* Enter the value of the quantity which corresponds to the minimum output value of the transducer. For example, if a temperature transducer which outputs 4 to 20 mA for temperatures 0 to 250°C is connected to the analog input, then enter *0*. The relay will therefore interpret 4 mA as representing 0°C. Intermediate values between the minimum and maximum will be scaled linearly.

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ANALOG INPUT MAXIMUM VALUE: 20000 µA	*Range: 0 to 65535 in steps of 1* Enter the value of the quantity measured which corresponds to the maximum output value of the transducer. For example, if a temperature transducer which outputs 4 to 20 mA for temperatures 0 to 250 °C has been connected to the analog input, then enter *250* for this setpoint. The relay will therefore interpret 20 mA as representing 250 °C. Intermediate values between the minimum and maximum will be scaled linearly.

13.5.3 ANALOG THRESHOLD

Monitoring of the analog input can be performed by two separate functions, each operating at different thresholds of analog input current and each having a selection to trip, alarm, or control. Control allows the element to signal its own output relay(s). For user flexibility, independent user names can also be programmed for each **ANALOG THRESHOLD**.

All of the following setpoints are repeated for **ANALOG THRESHOLD 2**.

■ **ANALOG THRESHOLD 1** ■ **[ENTER] for more**	The **ANALOG THRESHOLD 1** setpoints path is: **\ SETPOINTS \ S6 MONITORING \ ANALOG INPUT \ ANALOG THRESHOLD 1**
A/I THRESHLD 1 NAME: Analog Threshld 1	*Range: any combination of 18 alphanumeric characters.* Enter the name of threshold 1. See Section 8.10: USER TEXT MESSAGES on page 8–11 for a description of entering text from the front panel. This name will be displayed instead of *Analog Threshld 1* (the factory default) in the remaining setpoints in **SETPOINTS \ S6 MONITORING \ ANALOG INPUT \ ANALOG THRESHOLD 1**. This user name will also appear when an associated trip or alarm is generated as well as being stored in the event recorder if programmed to do so.
ANALOG THRESHOLD 1 FUNCTION: Disabled	*Range: Disabled, Trip, Alarm, Latched Alarm, Control, Blk Thrsh 1*† Select the required function. Note that a connected analog input will still be read and displayed in **A2 METERING \ ANALOG INPUT** if both the **ANALOG THRESHOLD 1** and **ANALOG THRESHOLD 2** functions are set to *Disabled*. † The *Blk Thrsh 1* value applies to the **ANALOG THRESHOLD 2 FUNCTION** setpoint only.
ANALOG THRESHOLD 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
ANALOG THRESHOLD 1 PICKUP: 100 µA	*Range: 0 to 65535 in steps of 1 unit* Enter the pickup value for this analog input monitoring element. The units displayed will be those entered in the analog input setup. For example, if a temperature transducer is connected to the analog input, and an alarm is required when the temperature exceeds 90°C, enter *90* for this setpoint. When the measured value of analog input exceeds this setting for a period longer than the delay setting, an output will occur and the user selected relays will signal an output.

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ANALOG THRESHOLD 1 DROP OUT RATIO: 5	*Range: 2 to 20 in steps of 1* Enter the drop out ratio for this analog input monitoring element. The value programmed here represents the value at which the element will effectively drop out. This is a percentage of the pickup value. If 5000 µA has been programmed as the pickup level and this setpoint is programmed for a drop out ratio of *10*, then the drop out current will be 4500 µA. $$\text{Drop Out} = \text{pickup} - \frac{\text{pickup} \times \text{dropout ratio}}{100}$$
ANALOG THRESHOLD 1 PICKUP TYPE: Over	*Range: Over, Under* Determines if pickup will occur when the analog input is over or under the programmed threshold. When set to Over, the Drop Out value is calculated as: $$\text{Drop Out} = \text{pickup} - \frac{\text{pickup} \times \text{dropout ratio}}{100}$$ When set to Under, the Drop Out value is calculated as: $$\text{Drop Out} = \text{pickup} + \frac{\text{pickup} \times \text{dropout ratio}}{100}$$
ANALOG THRESHOLD 1 DELAY: 100 s	*Range: 0 to 60000 in steps of 1 s* Select the delay required.

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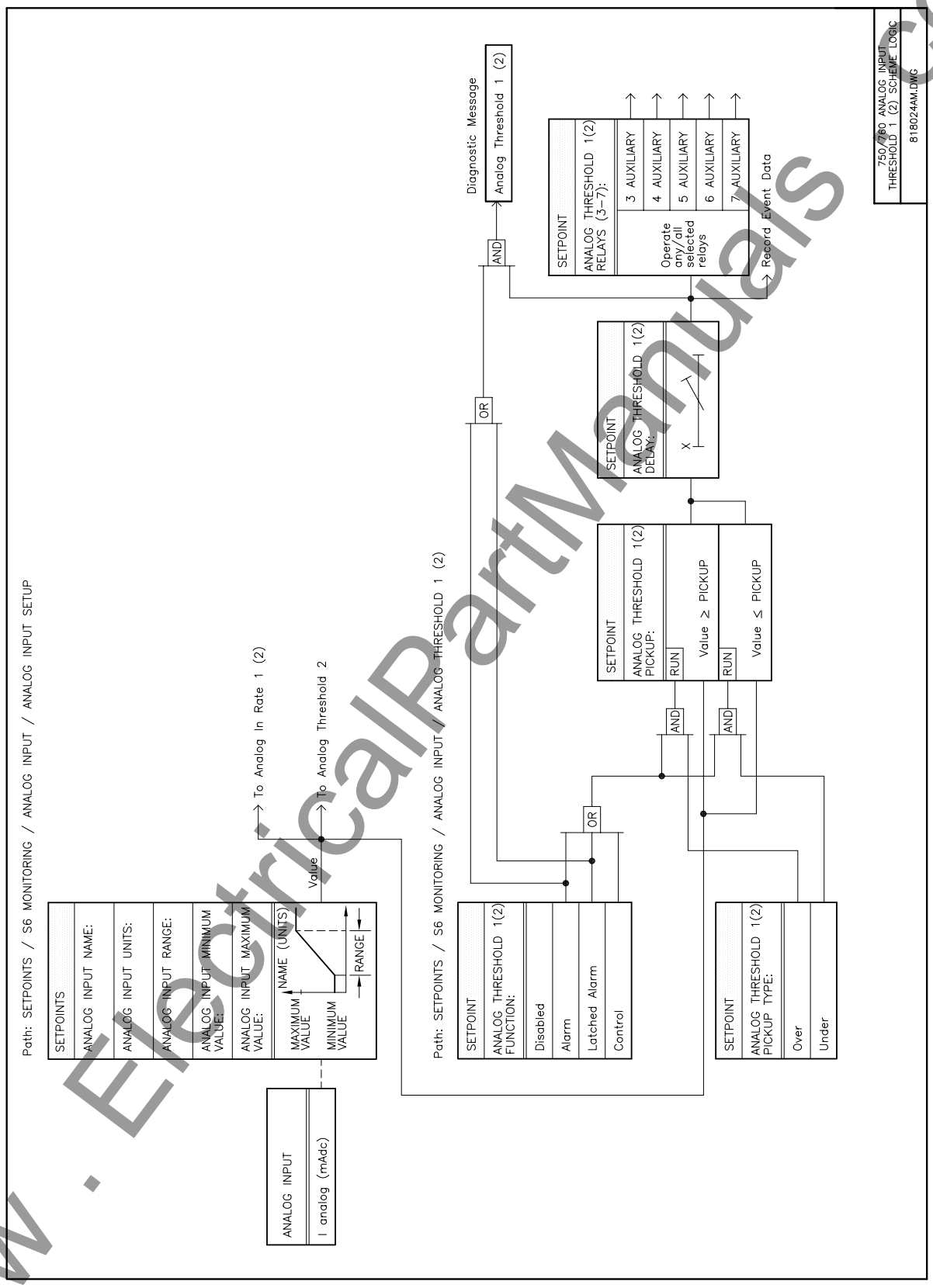


Figure 13–10: ANALOG INPUT THRESHOLD LOGIC DIAGRAM

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13.5.4 ANALOG INPUT RATE OF CHANGE

The relay has fast and slow analog input rates of change. The fast rate of change measures over the last one minute interval and detects a rapid increase or decrease in the input quantity. The slow rate of change measures over the last one hour interval and detects the long term trend of the input quantity. A positive rate indicates an increasing analog input and a negative rate indicates a decreasing analog input.

The fast (slow) analog input rate of change is calculated as follows. Every second (minute) the present analog input reading is captured and a new rate of change calculated for the previous minute (hour). The rate is calculated using the previous sixty analog input readings and the 'Least Squares Approximation' method that generates an equation for the best line through the sample points as shown below. The rate of change is equal to the slope of this line which is a stable quantity not unduly affected by noise or fluctuations from the input.

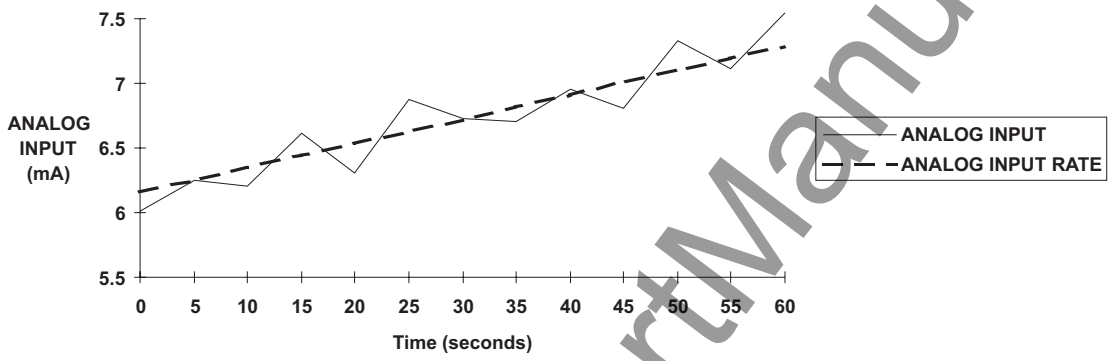


Figure 13–11: ANALOG INPUT RATE OF CHANGE MEASUREMENT

The following setpoints are also repeated for **ANALOG IN RATE 2**.

■ ANALOG IN RATE 1 ■ [ENTER] for more	The **ANALOG IN RATE 1** setpoints path is: **\ SETPOINTS \ S6 MONITORING \ ANALOG INPUT \ ANALOG IN RATE 1**
ANALOG IN RATE 1 FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function. Note that a connected analog input will still be read and displayed in **A2 METERING \ ANALOG INPUT** if both the analog threshold 1 and analog threshold 2 functions are set to 'Disabled'.
ANALOG IN RATE 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
A.I. RATE 1 PICKUP: 10.0 µA /hour	*Range: –1000.0 to 1000.0 in steps of 0.1* Enter the pickup value for this analog in rate monitoring element. When the measured value of analog in rate exceeds this setting for a period longer than the programmed delay, an alarm will occur and the user-selected relays will signal an output.
ANALOG IN RATE 1 DELAY: 0 s	*Range: 0 to 60000 in steps of 1 s* Select the delay required.

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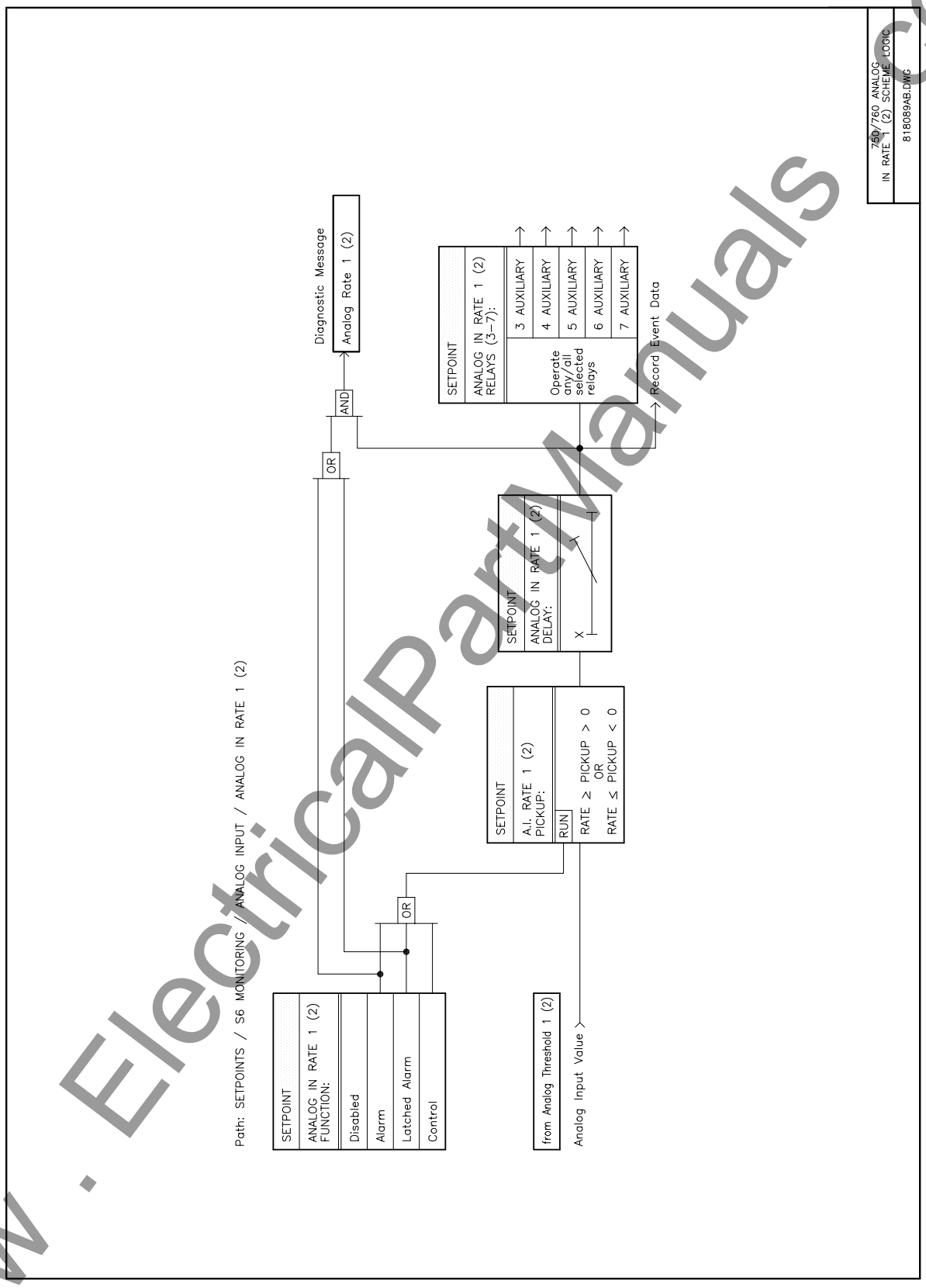


Figure 13–12: ANALOG INPUT RATE OF CHANGE LOGIC DIAGRAM

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The following setpoints are repeated for **ANALOG OUTPUT 1** through **ANALOG OUTPUT 8**.

■ ANALOG OUTPUT 1 ■ [ENTER] for more	The **ANALOG OUTPUT 1** setpoints path is: **\ SETPOINTS \ S6 MONITORING \ ANALOG OUTPUTS \ ANALOG OUTPUT 1**
ANALOG OUT 1 SOURCE: Disabled	*Range: See the list of Parameters in Table Below* Select the parameter which is required to be represented by the output channel. Once the parameter is entered for the function of the channel, the range for the channel minimum and maximum values is automatically set.
ANALOG OUT 1 MIN: -100.0 MW	*Range: As Per Function Selection* Enter the value of the selected parameter, which corresponds to the minimum analog output current. For example, if the channel is selected to represent real power with a range of –100 to +100 MW, enter *–100* for the minimum value.
ANALOG OUT 1 MAX: 100.0 MW	*Range: As Per Function Selection* Enter the value of the selected parameter, which corresponds to the maximum analog output current. For example, if the channel is selected to represent real power with a range of –100 to +100 MW, enter *+100* for the maximum value. Intermediate values between the minimum and maximum will be scaled linearly.

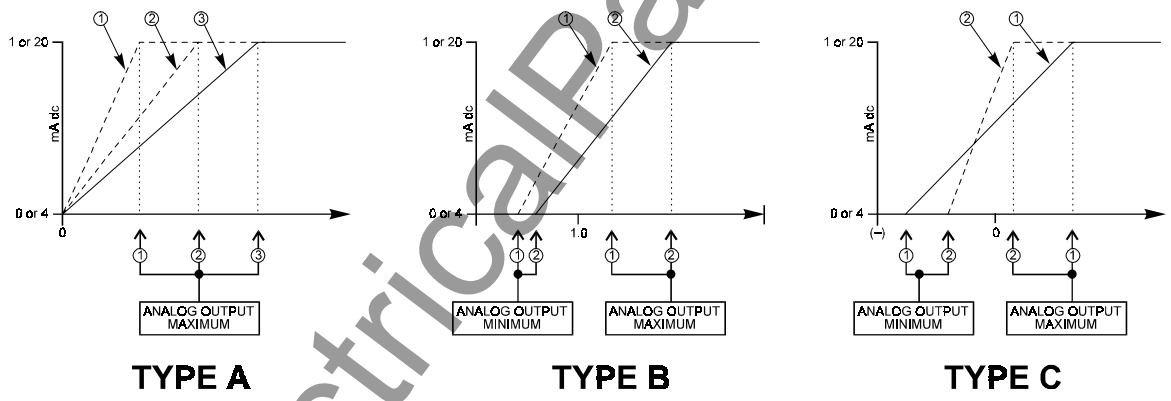


Figure 13–13: ANALOG OUTPUTS CHARACTERISTICS CHANNEL

Each channel can be programmed to represent a parameter from Table 13–1: ANALOG OUTPUT PARAMETER SELECTIONS on page 13–25. As shown in the last column, there are three types of channels, designated A, B and C. The characteristic of the type A channel is that the range of the parameter extends from a minimum of 0 units. The characteristic of the type B channel is that the range of the parameter is between definite boundaries. The characteristic of the type C channel is that the parameter includes direction of flow.

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13.6.2 ANALOG OUTPUT PARAMETER SELECTIONS

Table 13–1: ANALOG OUTPUT PARAMETER SELECTIONS (Sheet 1 of 2)

PARAMETER NAME	RANGE / UNITS	STEP	DEFAULTS		CHANNEL TYPE
			MIN.	MAX.	
Phase A/B/C Current	0 to 65535 Amps	1	0	2000	A
Phase A/B/C Current Angle	0 to 359° Lag	1	0	359	A
Average Current	0 to 65535 Amps	1	0	2000	A
% Of Load-To-Trip	0 to 2000%	1	0	1000	A
Neutral Current	0 to 65535 Amps	1	0	2000	A
Neutral Current Angle	0 to 359° Lag	1	0	359	A
Phase AN/BN/CN Voltage	0.00 to 655.35 kV	0.01	0.00	100.00	A
Phase AN/BN/CN Voltage Angle	0 to 359° Lag	1	0	359	A
Average Phase Voltage	0.00 to 655.35 kV	0.01	0.00	100.00	A
Line AB/BC/CA Voltage	0.00 to 655.35 kV	0.01	0.00	100.00	A
Line AB/BC/CA Voltage Angle	0 to 359° Lag	1	0	359	A
Average Line Voltage	0.00 to 655.35 kV	0.01	0.00	100.00	A
Frequency	20.00 to 65.00 Hz	0.01	47.00	63.00	B
3ϕ Real Power	–3000.0 to 3000.0 MW[1]	0.1	–100.0	100.0	C
3ϕ Reactive Power	–3000.0 to 3000.0 Mvar[1]	0.1	–100.0	100.0	C
3ϕ Apparent Power	0.0 to 3000.0 MVA[1]	0.1	0.0	100.0	A
3ϕ Power Factor	0.00 Lead to 0.00 Lag	0.01	0.99 Lag	0.50 Lag	B
Last Phase A/B/C Demand	0 to 65535 Amps	1	0	2000	A
Last Watt Demand	–3000.0 to 3000.0 MW[1]	0.1	–100.0	100.0	C
Last Var Demand	–3000.0 to 3000.0 Mvar[1]	0.1	–100.0	100.0	C
Last VA Demand	0.0 to 3000.0 MVA[1]	0.1	0.0	100.0	A
Analog Input	0 to 65535 Units	1	0	1000	A
Last Fault Distance	–327.67 to 327.67 km/miles	0.01	–50.00	50.00	C
Positive Watthours	0.0 to 6553.5 MWh[1]	0.1	0.0	1000.0	A
Negative Watthours	0.0 to 6553.5 MWh[1]	0.1	0.0	1000.0	A
Positive Varhours	0.0 to 6553.5 Mvarh[1]	0.1	0.0	1000.0	A
Negative Varhours	0.0 to 6553.5 Mvarh[1]	0.1	0.0	1000.0	A
Ground Current	0 to 65535 Amps	1	0	2000	A
Ground Current Angle	0 to 359° Lag	1	0	359	A
Polarizing Current	0 to 65535 Amps	1	0	2000	A
Polarizing Current Angle	0 to 359° Lag	1	0	359	A
ϕA/ϕB/ϕC Real Power	–3000.0 to 3000.0 MW[1]	0.1	–100.0	100.0	C
ϕA/ϕB/ϕC Reactive Power	–3000.0 to 3000.0 Mvar[1]	0.1	–100.0	100.0	C

[1] Power and energy quantities auto-range to display units appropriate to power system size.

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Table 13–1: ANALOG OUTPUT PARAMETER SELECTIONS (Sheet 2 of 2)

PARAMETER NAME	RANGE / UNITS	STEP	DEFAULTS		CHANNEL TYPE
			MIN.	MAX.	
ϕA/ϕB/ϕC Apparent Power	0.0 to 3000.0 MVA[1]	0.1	0.0	100.0	A
ϕA/ϕB/ϕC Power Factor	0.00 Lead to 0.00 Lag	0.01	0.99 Lag	0.50 Lag	B
Synchro Voltage	0.00 to 655.35 kV	0.01	0.00	100.00	A
Synchro Voltage Angle	0 to 359° Lag	1	0	359	A
Synchro Frequency	20.00 to 65.00 Hz	0.01	47.00	63.00	B
Frequency Decay Rate	–10.00 to 10.00 Hz/s	0.01	–0.50	0.50	C
Positive/Negative/Zero Sequence Current	0 to 65535 Amps	1	0	2000	A
Positive/Negative/Zero Sequence Current Angle	0 to 359° Lag	1	0	359	A
Positive/Negative/Zero Sequence Voltage	0.00 to 655.35 kV	0.01	0.00	100.00	A
Positive/Negative/Zero Sequence Voltage Angle	0 to 359° Lag	1	0	359	A
Synchro Voltage Difference	0.00 to 655.35 kV	0.01	0.00	100.00	A
Synchro Angle Difference	0 to 359° Lag	1	0	359	A
Synchro Frequency Difference	20.00 to 65.00 Hz	0.01	47.00	63.00	B
Sensitive Ground Current	0.00 to 655.35 A	0.01	0.00	20.00	A
Sensitive Ground Current Angle	0 to 359° Lag	1	0	359	A
Neutral Voltage	0.00 to 655.35 kV	0.01	0.00	100.00	A
Neutral Voltage Angle	0 to 359° Lag	1	0	359	A

[1] Power and energy quantities auto-range to display units appropriate to power system size.

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13.7.1 DESCRIPTION

A significant overfrequency condition, likely caused by a breaker opening and disconnecting load from a particular generation location, can be detected and used to quickly ramp the turbine speed back to normal. If this is not done, the over speed can lead to a turbine trip, which would then subsequently require a turbine start up before restoring the system. If the overfrequency turbine ramp down is successful, the system restoration can be much quicker. The overfrequency monitoring feature of the relay can be used for this purpose at a generating location.

The overfrequency feature is inhibited from operating unless the phase A voltage is above 30% of nominal. When the supply source is energized, the overfrequency delay timer will only be allowed to time when the 30% threshold is exceeded and the frequency is above the programmed pickup level. In the same way, when an overfrequency condition starts the overfrequency delay timer and the phase A voltage falls below the 30% threshold before the timer has expired, the element will reset without operating.

13.7.2 SETPOINTS

■ **OVERFREQUENCY** ■ **[ENTER] for more**	The **OVERFREQUENCY** setpoints path is: **\ SETPOINTS \ S6 MONITORING \ OVERFREQUENCY**
OVERFREQUENCY **FUNCTION: Disabled**	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function. Note that the system frequency will still be measured and displayed in **A2 METERING \ FREQUENCY** if both the overfrequency and underfrequency functions are set to *Disabled*.
OVERFREQUENCY **RELAYS (3-7): -----**	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
OVERFREQUENCY **PICKUP: 60.50 Hz**	*Range: 20.00 to 65.00 in steps of 0.01 Hz* Enter the level at which the overfrequency element is to pickup. For example, if the system frequency is 60 Hz and an alarm is required at 60.50 Hz, enter *60.50* for this setpoint. When the measured frequency exceeds this value for a period longer than the programmed delay, an alarm will occur and the selected relays will signal an output.
OVERFREQUENCY **DELAY: 5.0 s**	*Range: 0.0 to 6000.0 in steps of 0.1 s* Select the delay required.

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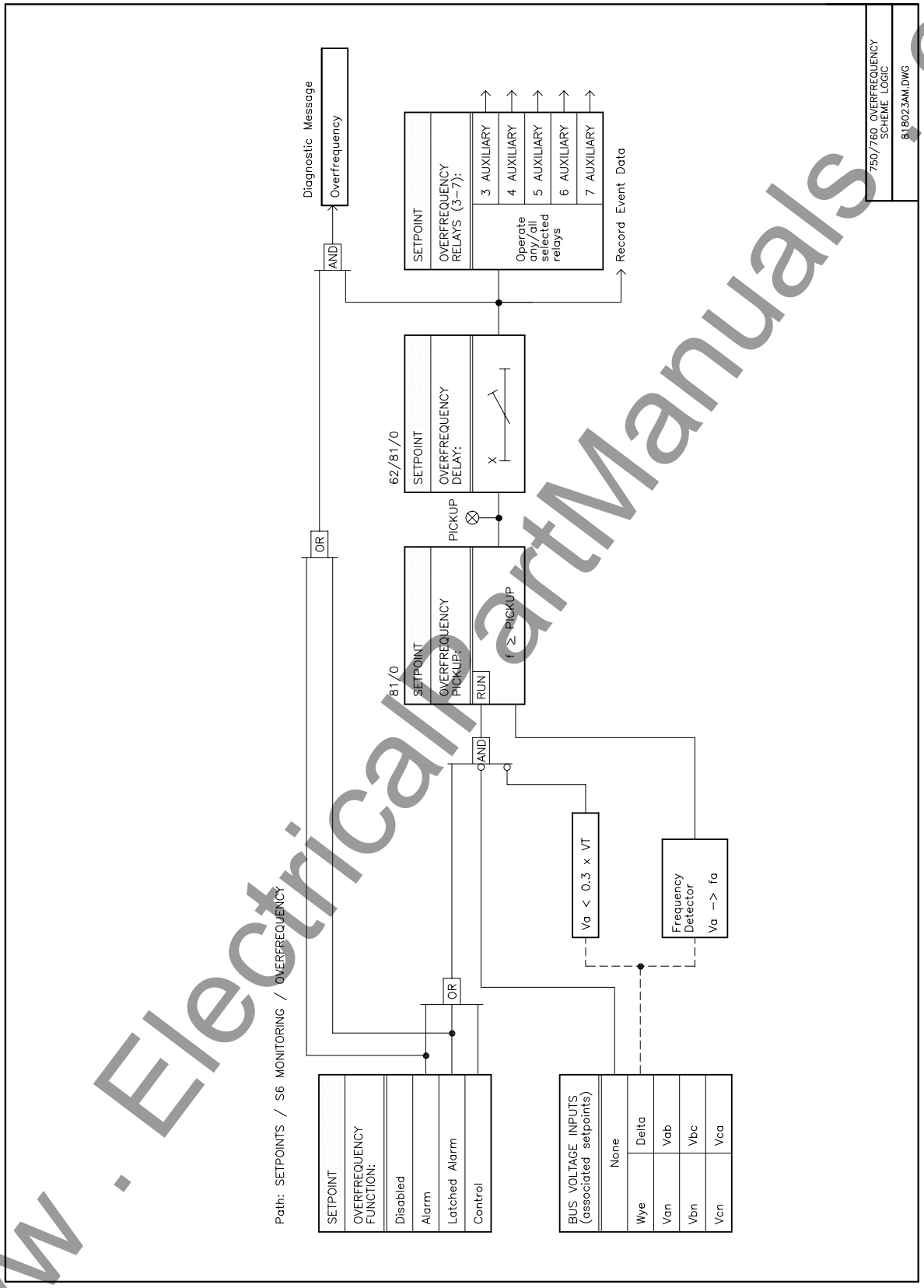


Figure 13–14: OVERFREQUENCY LOGIC DIAGRAM

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13.8.1 DESCRIPTION

The equipment monitoring features are provided to detect failures or unusual operating conditions of the feeder circuit breaker and the bus VTs.

13.8.2 TRIP COUNTER

■ TRIP COUNTER ■ [ENTER] for more	The Trip Counter setpoints path is: **\ SETPOINTS \ S6 MONITORING \ EQUIPMENT \ TRIP COUNTER**
TRIP COUNTER FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function. Note that the number of trips will still be counted and displayed under **A3 MAINTENANCE \ TRIP COUNTERS** if set to *Disabled*.
TRIP COUNTER RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
TRIP COUNTER LIMIT: 10000 Trips	*Range: 1 to 10000 in steps of 1* Enter the trip count at which this feature is to cause an alarm. For example, if an alarm is desired as soon as the number of trips reaches 100, enter *100* for this setpoint. When the total number of trips detected reaches this setting, an output will occur.

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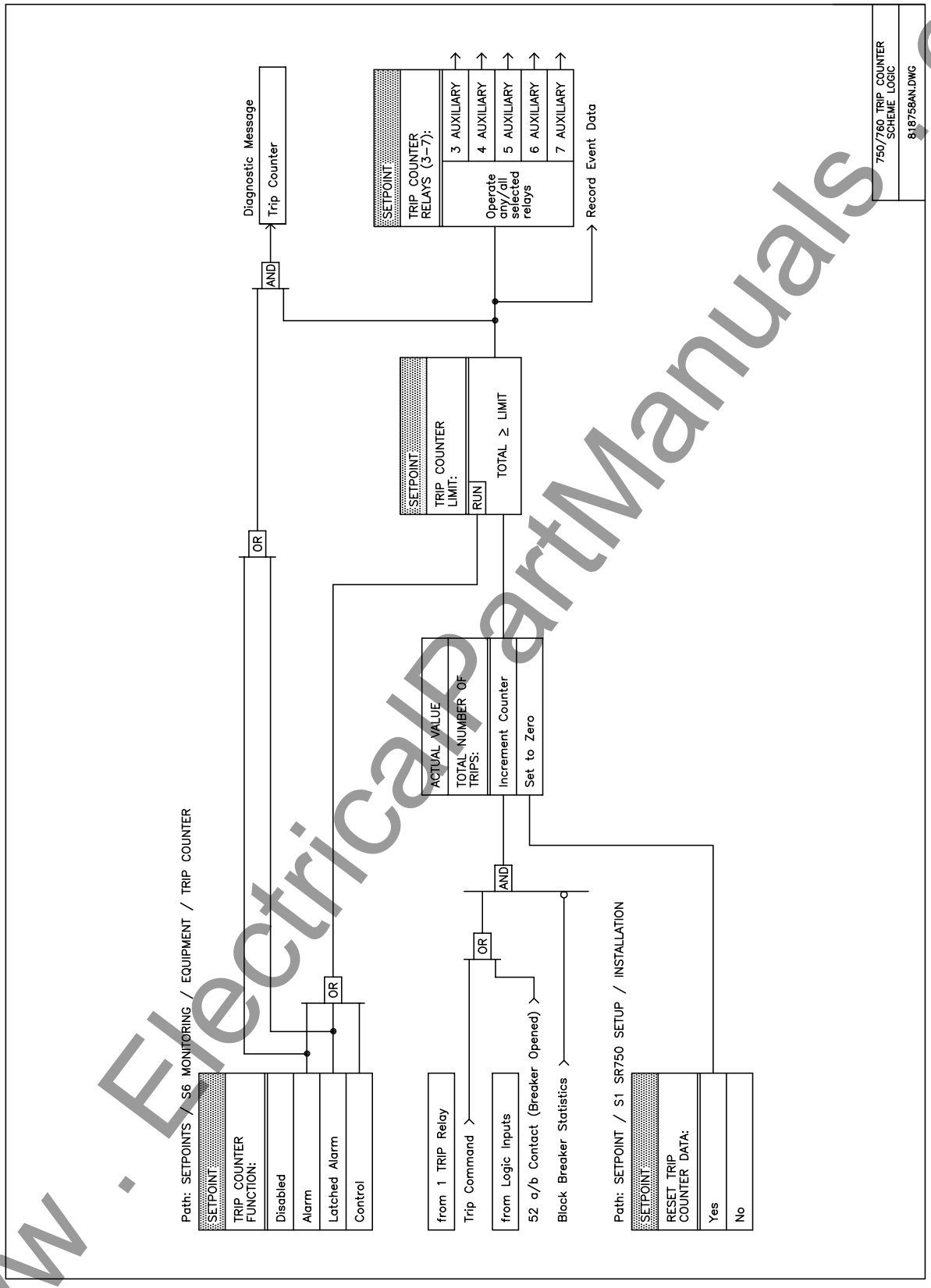


Figure 13–15: TRIP COUNTER LOGIC DIAGRAM

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13.8.3 ARCING CURRENT

The relay calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the arcing current squared passing through the contacts while they are opening. These per-phase values are added to accumulated totals for each phase and compared to a programmed threshold value. When the threshold is exceeded in any phase, the relay can be used to generate an alarm. The threshold value can be set to a maintenance specification provided by the breaker manufacturer.

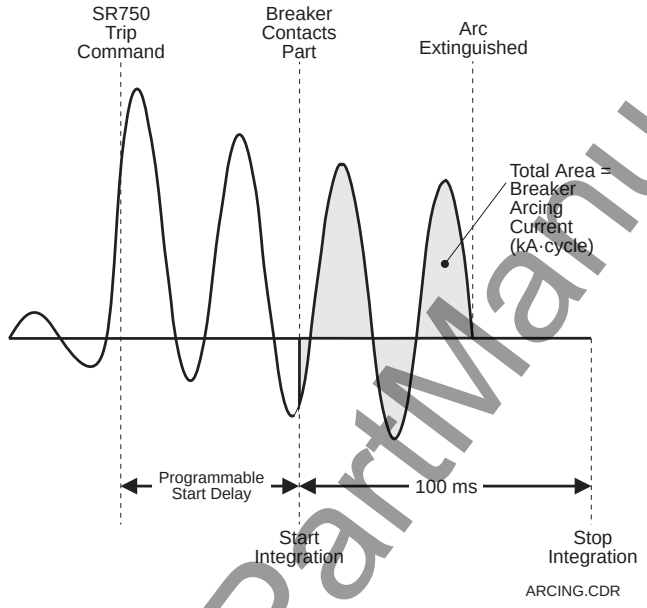


Figure 13–16: ARCING CURRENT MEASUREMENT

■ ARCING CURRENT ■ [ENTER] for more	The **ARCING CURRENT** setpoints path is: **\ SETPOINTS \ S6 MONITORING \ EQUIPMENT \ ARCING CURRENT**
TOTAL ARCING CURRENT FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function. Note that the total arcing current for each phase will still be available for display under **A3 MAINTENANCE \ ARCING CURRENT** if set to *Disabled*.
TOTAL ARCING CURRENT RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
TOTAL ARCING CURRENT START DELAY: 32 ms	*Range: 0 to 100 in steps of 1 ms* Enter the expected ms time delay, from the moment a trip command is issued, until the breaker contacts will actually begin to open. This setpoint is used by the relay to determine when to start integrating. The integration continues for 100 ms, by which time most modern breakers will have cleared a fault.
TOTAL ARCING CURRENT LIMIT: 1000 kA^2-cyc	*Range: 1 to 50000 in steps of 1* Enter the total arcing current in kA^2–cycle, at which this feature is to cause an alarm. For example, if an alarm is desired as soon as the total arcing current in any phase exceeds 1000 kA^2–cycle, enter *1000* for this setpoint. An output will occur when the total arcing current in any phase reaches this setting.

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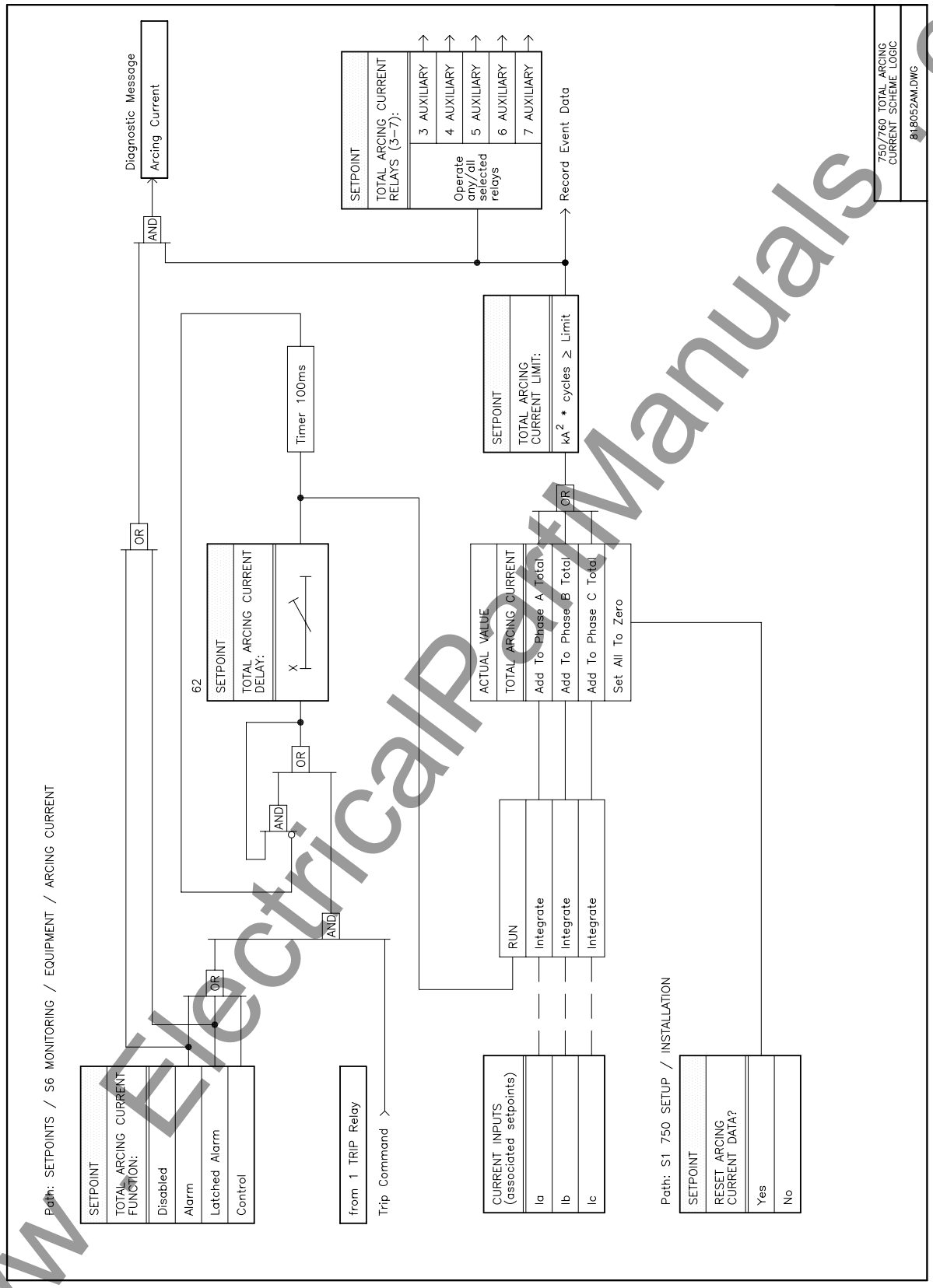


Figure 13–17: ARCING CURRENT LOGIC DIAGRAM

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13.8.4 BREAKER OPERATION

Circuit breakers typically have both a 52a (breaker tripped = open) contact and a 52b (breaker tripped = closed) contact. Either or both of these contacts can be connected to the relay logic inputs, from which breaker status is detected. Interpretation of breaker status depends on which 52 contacts are installed. See Sections 5.2.3: SYSTEM STATUS INDICATORS on page 5–2 and 10.3: BREAKER FUNCTIONS on page 10–4 for more information on 52a (52b) contacts. If neither 52a nor 52b contacts are installed, correct breaker operation will not be verified and a breaker operation alarm can never occur.

A breaker operation failure can be caused by either of the following conditions if **BREAKER OPERATION FUNCTION** is set to *Alarm* or *Control*.

- The breaker does not respond to a trip command within the programmed breaker operation delay time.
- The breaker does not respond to a close command within the programmed time.

When a breaker operation failure is declared, the selected output relays will operate, but the 2 CLOSE relay and 760 autoreclosure will be inhibited. If the 760 already has a reclosure scheme in progress, it will be sent to lockout.

■ **BREAKER OPERATION** ■ **[ENTER] for more**	The **BREAKER OPERATION** setpoints path is: **\ SETPOINTS \ S6 MONITORING \ EQUIPMENT \ BREAKER OPERATION**
BREAKER OPERATION **FUNCTION: Disabled**	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
BREAKER OPERATION **RELAYS (3-7): -----**	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
BREAKER OPERATION **DELAY: 0.10 s**	*Range: 0.03 to 1.00 in steps of 0.01 s* Enter the maximum time within which the breaker must respond to any open or close command. A Breaker Operation failure condition will result if the breaker does not respond within this programmed time. This time is a characteristic of the breaker being used.

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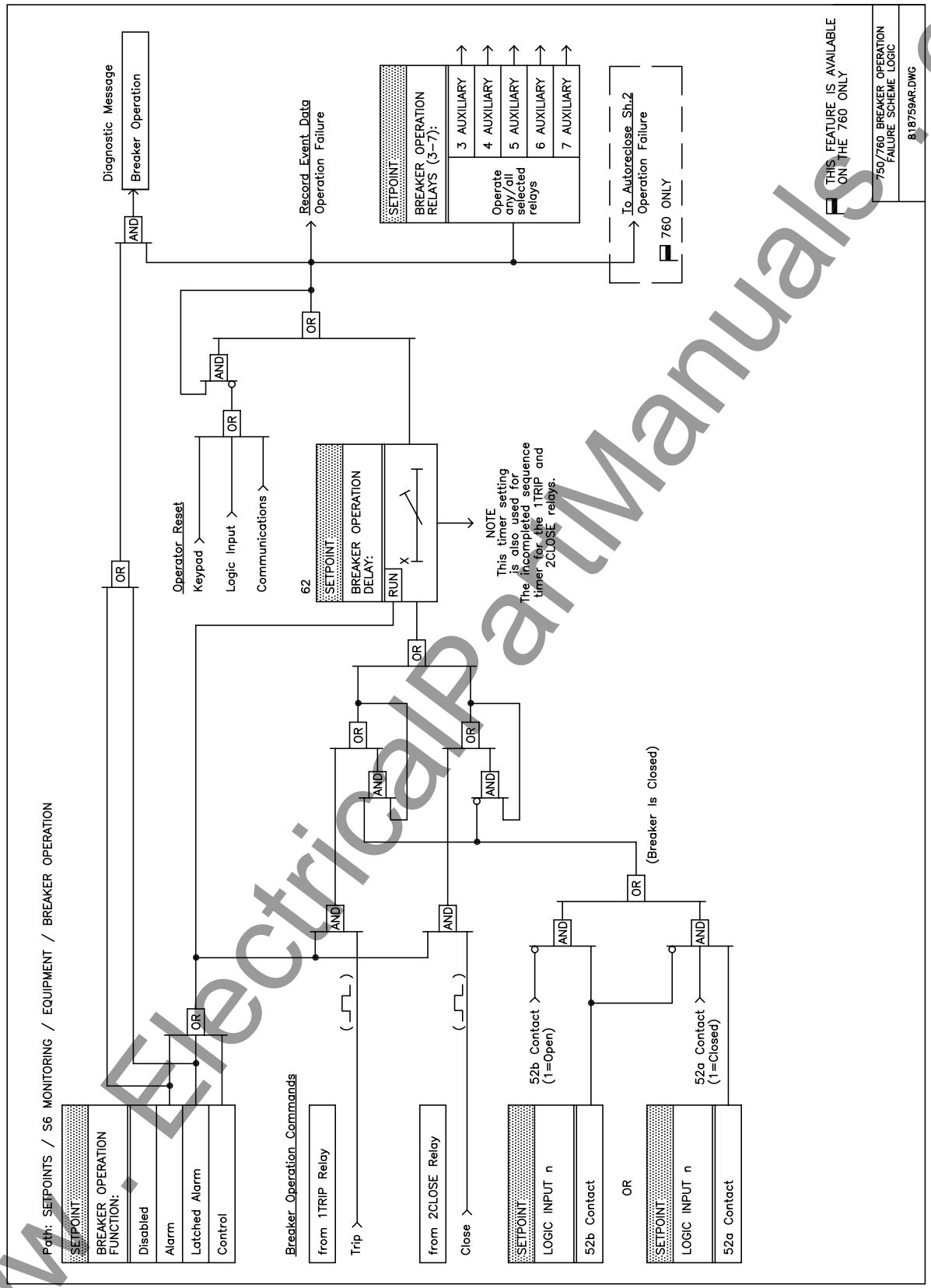


Figure 13–18: BREAKER OPERATION LOGIC DIAGRAM

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COIL MONITOR 1 and **2** are programmed in this subgroup. They are two identical elements that may be used to monitor trip or close coils. The operation of this feature is described in Section 3.2.11: TRIP / CLOSE COIL SUPERVISION on page 3–13.

■ COIL MONITOR 1 ■ [ENTER] for more	The Coil Monitor 1 setpoints path is: **\ SETPOINTS \ S6 MONITORING \ EQUIPMENT \ COIL MONITOR 1**
COIL MONITOR 1 NAME: Trip Coil Monitor	*Range: Any Combination of 18 Alphanumeric Characters* An 18 character field that will be displayed as part of the diagnostic messages and event recorder when events associated with this element occur.
COIL MONITOR 1 FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
COIL MONITOR 1 RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
BREAKER STATE BYPASS: Disabled	*Range: Enabled, Disabled* Detection of a failed circuit regardless of the breaker state (i.e. detection of a failed trip circuit when the breaker is open) requires **BREAKER STATE BYPASS** to be *Enabled*. Generally, this selection will require a wiring modification of the breaker, as detailed in Chapter 3: INSTALLATION.
COIL MONITOR 1 DELAY: 5 s	*Range: 5 to 100 in steps of 1 s* Select the delay required.
COIL MONITOR 1 TYPE: Trip	*Range: Trip, Close* Select the type of coil being monitored.

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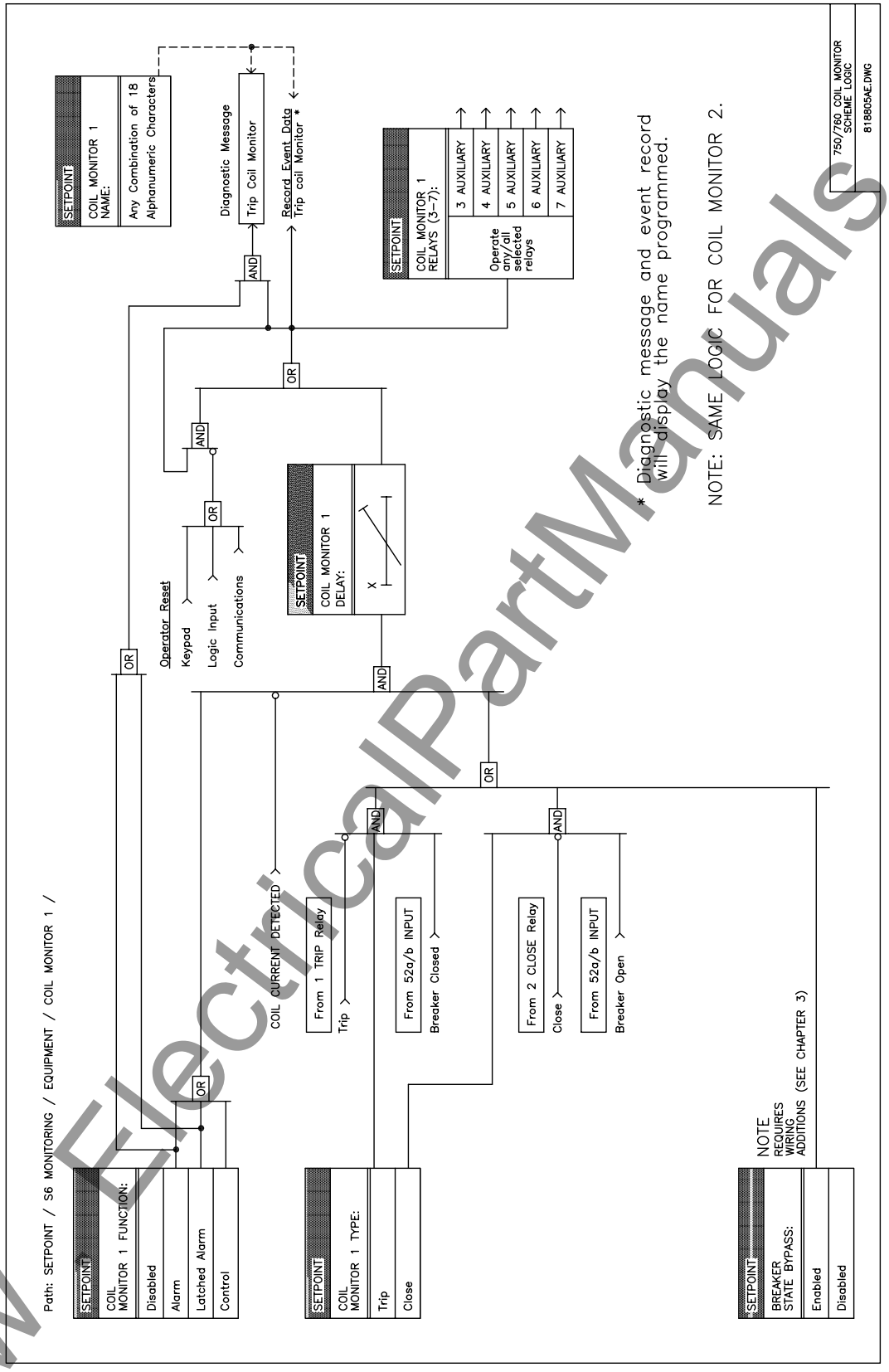


Figure 13–19: COIL MONITOR SCHEME LOGIC DIAGRAM

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The 750/760 detects a VT fuse failure when there are significant levels of negative sequence voltage without correspondingly significant levels of negative sequence current measured at the output CTs. Also, if there is not a significant amount of positive sequence voltage when there is positive sequence current then it could indicate that all the VT fuses have been pulled or the VTs have been racked out. The setpoints are as follows.

■ VT FAILURE ■ [ENTER] for more	The VT Failure setpoints path is: **\ SETPOINTS \ S6 MONITORING \ EQUIPMENT \ VT FAILURE**
VT FAILURE FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
VT FAILURE RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
VT FAILURE DELAY: 10 s	*Range: 0 to 60000 in steps of 1 s* Select the delay required.

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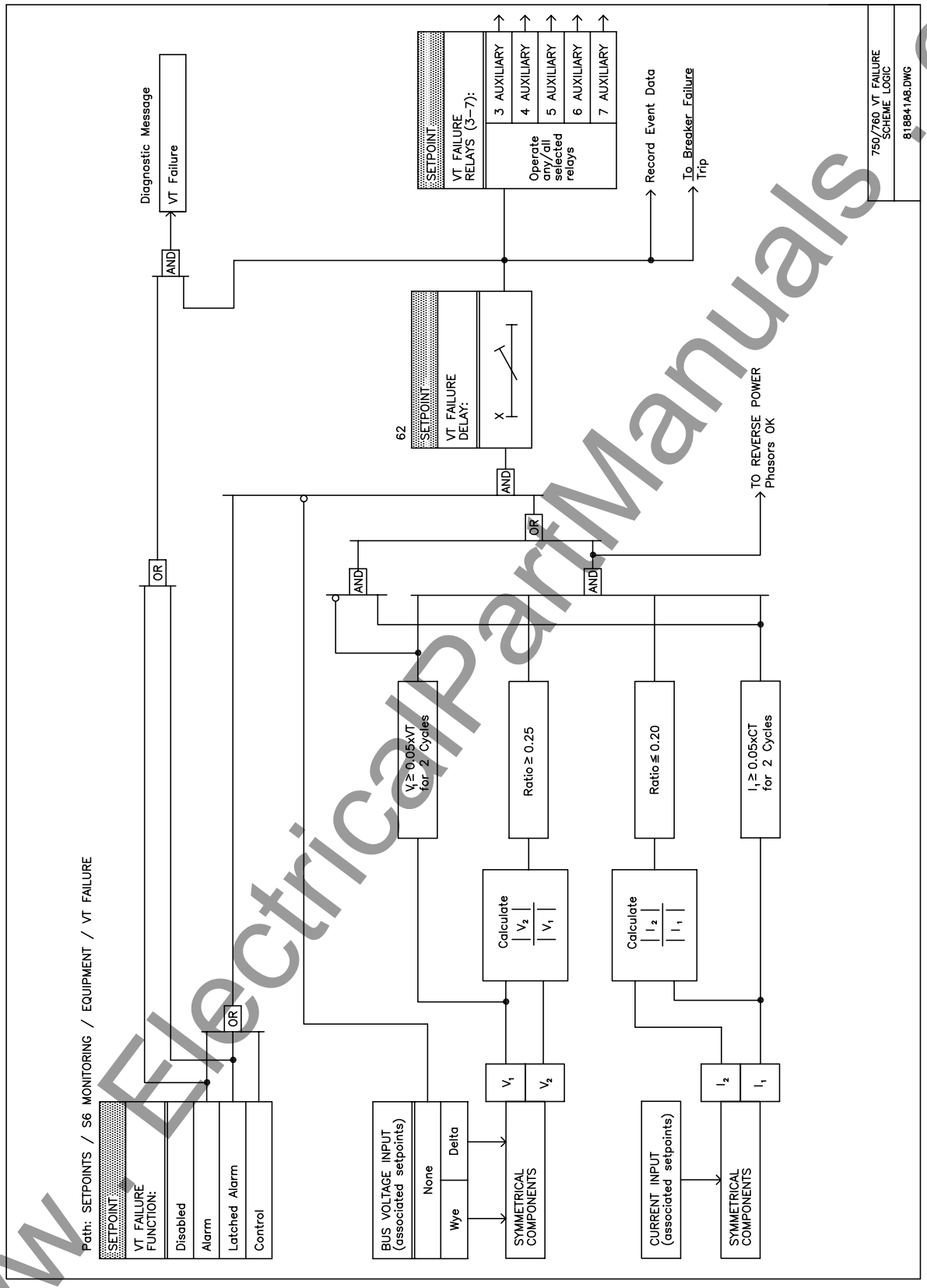


Figure 13–20: VT FAILURE LOGIC DIAGRAM

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13.9.1 DESCRIPTION

The 750/760 provides the ability to operate selected auxiliary relays after an adjustable interval for the quantities shown below. Pulses occur at the end of each programmed interval. Upon power up of the relay the Pulse Output function, if enabled, will continue from where it was at loss of control power. For example, if control power is removed when the positive watthours actual value is 16.0 MWh, when control power is re-applied a pulse will occur at 26 MWh if the interval is set to 10.0 MWh.

Note that the Output relay(s) used for this element must be set to *Self-Resetting* under **S4 OUTPUT RELAYS**. The pulses will consist of a one second on time and a one second off time. This feature should be programmed such that no more than one pulse per two seconds will be required or the pulsing will lag behind the interval activation.

13.9.2 SETPOINTS

The setpoints for this element are as follows.

■ PULSE OUTPUT ■ [ENTER] for more	The Energy Pulse Output setpoints path is: **\ SETPOINTS \ S6 MONITORING \ PULSE OUTPUT**
PULSE OUTPUT FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
POS WATTHOURS PULSE RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
POS WATTHOURS PULSE INTERVAL: 10.0 MWh	*Range: 0.0 to 6553.5 MWh in steps of 0.1 MWh*[1] Select the interval after which the selected relay(s) will be pulsed.
NEG WATTHOURS PULSE RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NEG WATTHOURS PULSE INTERVAL: 10.0 MWh	*Range: 0.0 to 6553.5 MWh in steps of 0.1 MWh*[1] Select the interval after which the selected relay(s) will be pulsed.
POS VARHOURS PULSE RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
POS VARHOURS PULSE INTRVL: 10.0 Mvarh	*Range: 0.0 to 6553.5 Mvarh in steps of 0.1 Mvarh*[1] Select the interval after which the selected relay(s) will be pulsed.
NEG VARHOURS PULSE RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
NEG VARHOURS PULSE INTRVL: 10.0 Mvarh	*Range: 0.0 to 6553.5 Mvarh in steps of 0.1 Mvarh*[1] Select the interval after which the selected relay(s) will be pulsed.

[1] Energy quantities auto-range to show units appropriate to the power system size.

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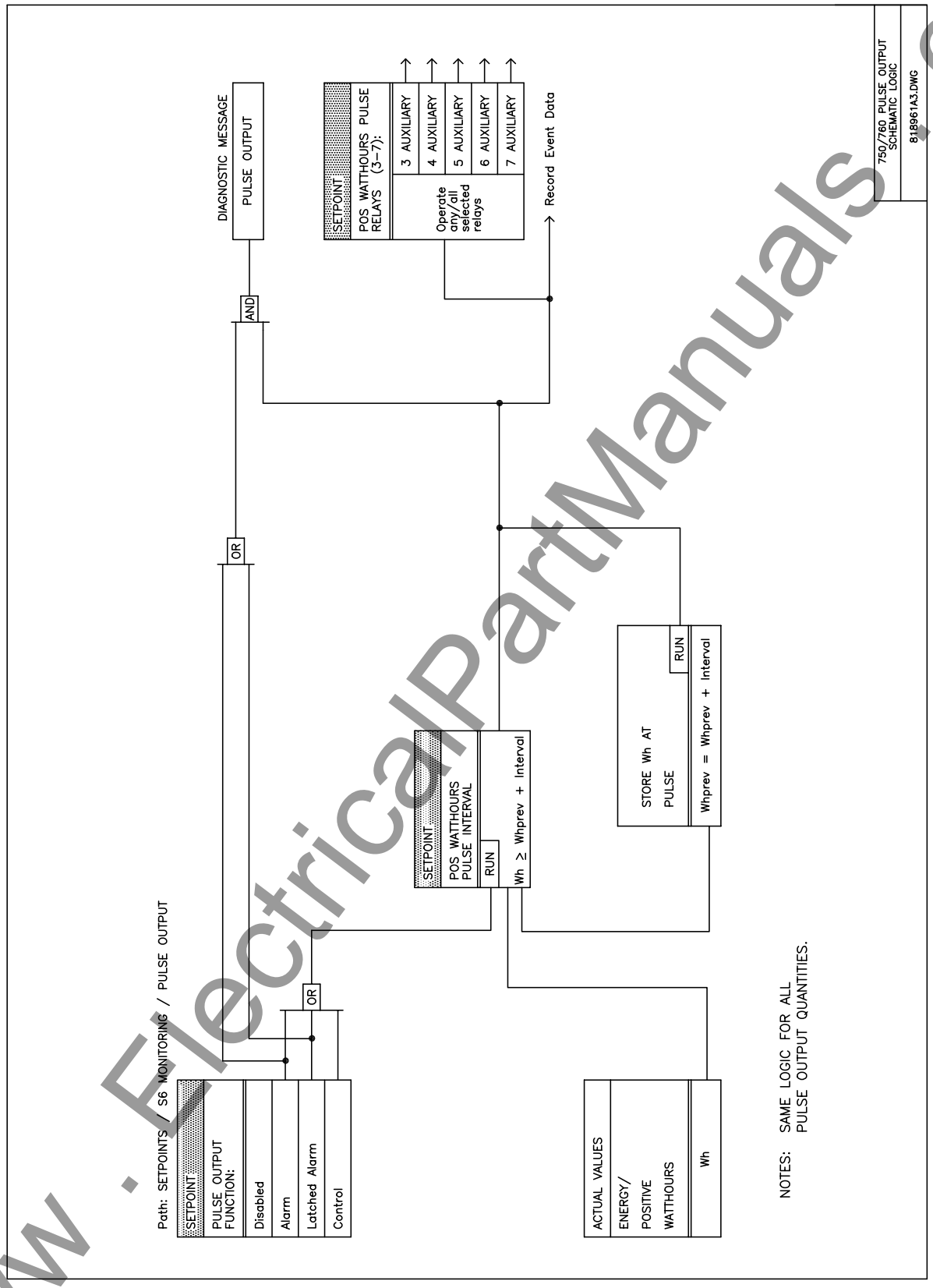


Figure 13–21: PULSE OUTPUT SCHEME LOGIC DIAGRAM

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14.1.1 DESCRIPTION

All setpoints contained under page **S5 PROTECTION** are reproduced in four groups, identified as Groups 1, 2, 3 and 4. These multiple setpoints provide the capability of both automatic and manual changes to protection settings for different operating situations. Automatic (adaptive) protection setpoint adjustment is available to change settings when the power system configuration is altered. By monitoring the state of a bus tie breaker on the bus connected to the associated feeder breaker, you may use different settings depending on whether the tie breaker is open or closed. Automatic group selection can be initiated by use of a logic input. The manual adjustment capability is available for those users who use different settings for different seasons of the year. Manual group selection can be initiated from the keypad or via communications.

In order to allow the display and editing of one group while another group is used for protection, two operating states have been assigned to setpoint groups. The 'Active' group is used for protection, and is indicated by the appropriate faceplate LED indicator being turned on continuously. The 'Edit' group is displayed and may be used to alter protection settings. It is indicated by the appropriate faceplate LED indicator being flashed. If a single group is selected to be both the Active and Edit group, the appropriate indicator is on continuously.

The setpoint group to be edited can only be selected by setpoint. Group 1 is the default for the active group and will be used unless another group is requested to become active. The group to become active can be selected by setpoint or by logic input. If there is a conflict in the selection of the active group, between a setpoint and logic input or between two logic inputs, the higher numbered group will be made active. For example, if the logic inputs for group 2, 3, and 4 are all asserted the relay would use group 4. If the logic input for group 4 then becomes de-asserted, the relay will use group 3. Any change from the default group 1 will be stored in the event recorder.

In some application conditions, the user may require that the relay will not change from the present active group. This prevention of a setpoint group change can be applied when any of the overcurrent (phase, neutral, ground, sensitive ground, or negative sequence), overvoltage, bus or line undervoltage, or underfrequency elements are picked-up.



NOTE

Pickup of a protection element is possible when selected to any function except ‘Disabled’, so elements that are not used to perform tripping can also inhibit setpoint changes. A setting change can also be prevented if the breaker is open, so that a fault detected before a reclosure will not cause a group change while the breaker is open.



CAUTION

Each setpoint group includes the selection of output relays 3-7 AUXILIARY that can be operated by the protection features. As these relays are hard-wired to external equipment, the selection should only be changed from that in Setpoint Group 1 with considerable care.

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■ SETPOINT GROUPS ■ [ENTER] for more	The Setpoints Groups setpoints path is: **\ SETPOINTS \ S7 CONTROL\ SETPOINT GROUPS**
ACTIVE SETPOINT GROUP: Group 1	*Range: Group 1, Group 2, Group 3, Group 4* Select the group to be used for protection.
EDIT SETPOINT GROUP: Active Group	*Range: Group 1, Group 2, Group 3, Group 4, Active Group* Select the group to be accessed and displayed. If *Active Group* is selected, the edit group will automatically be selected to the same as the active group.
OPEN BREAKER INHIBIT: Disabled	*Range: Disabled, Enabled* If *Enabled*, an open breaker will prevent changing the active group.
OVERCURRENT PICKUP INHIBIT: Disabled	*Range: Disabled, Enabled* If *Enabled*, an open breaker will prevent changing the active group.
OVERVOLTAGE PICKUP INHIBIT: Disabled	*Range: Disabled, Enabled* If *Enabled*, an overvoltage pickup element will prevent changing the active group.
UNDERVOLTAGE PICKUP INHIBIT: Disabled	*Range: Disabled, Enabled* If *Enabled*, an undervoltage element pickup will prevent changing the active group.
UNDERFREQ PICKUP INHIBIT: Disabled	*Range: Disabled, Enabled* If *Enabled*, an underfrequency element pickup will prevent changing the active group.

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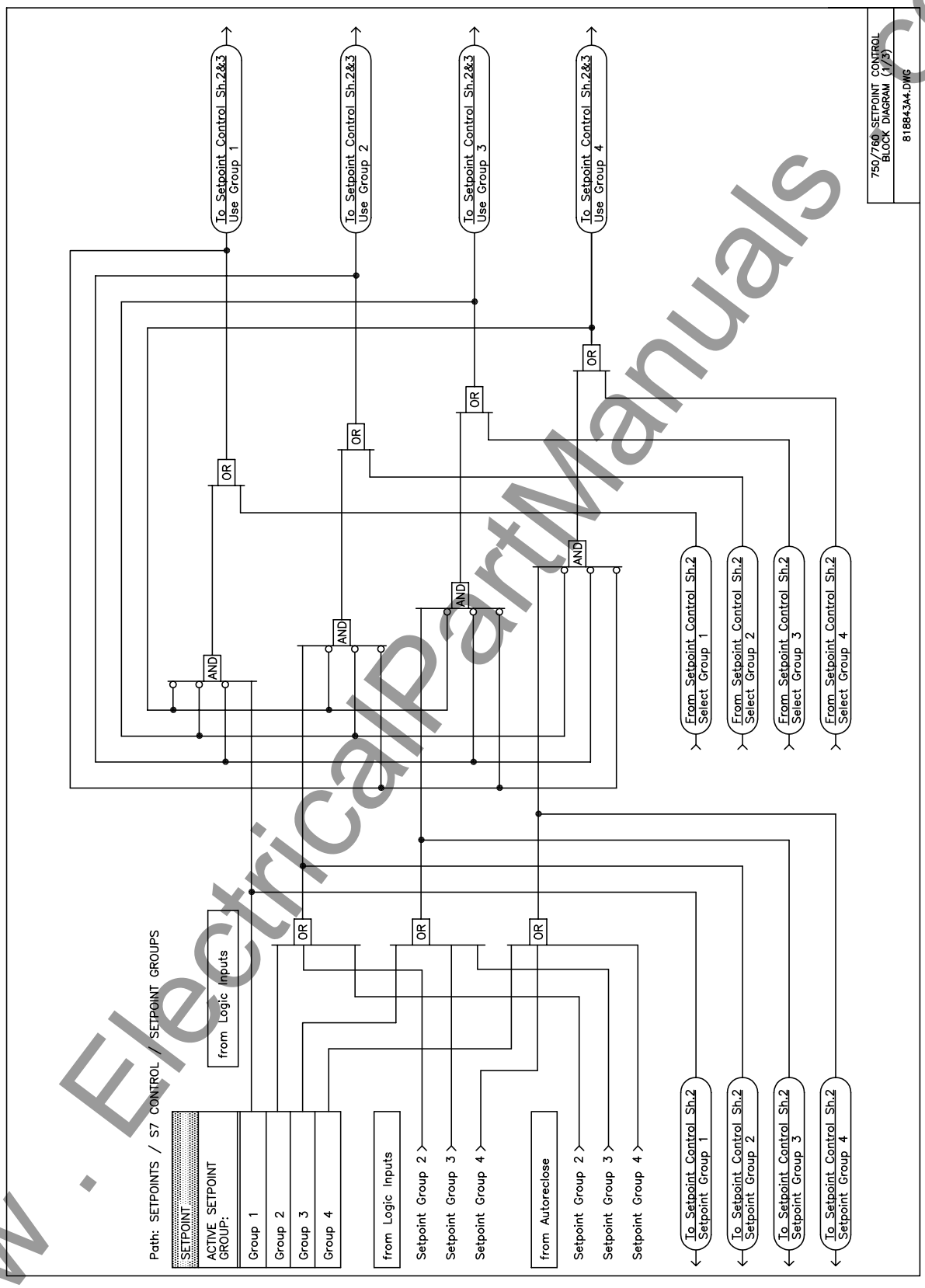


Figure 14–1: SETPOINT CONTROL (1 OF 3)

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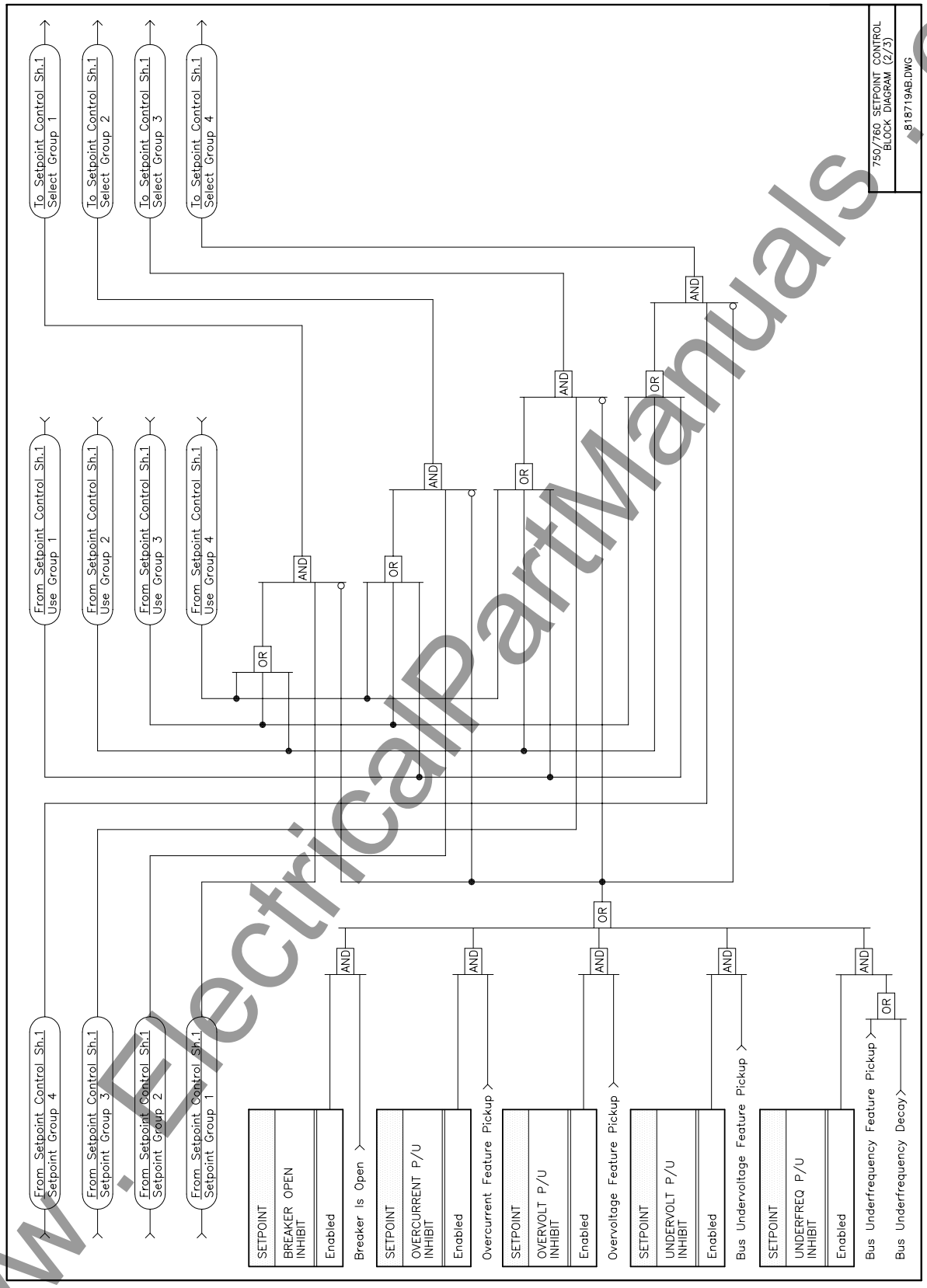


Figure 14–2: SETPOINT CONTROL (2 OF 3)

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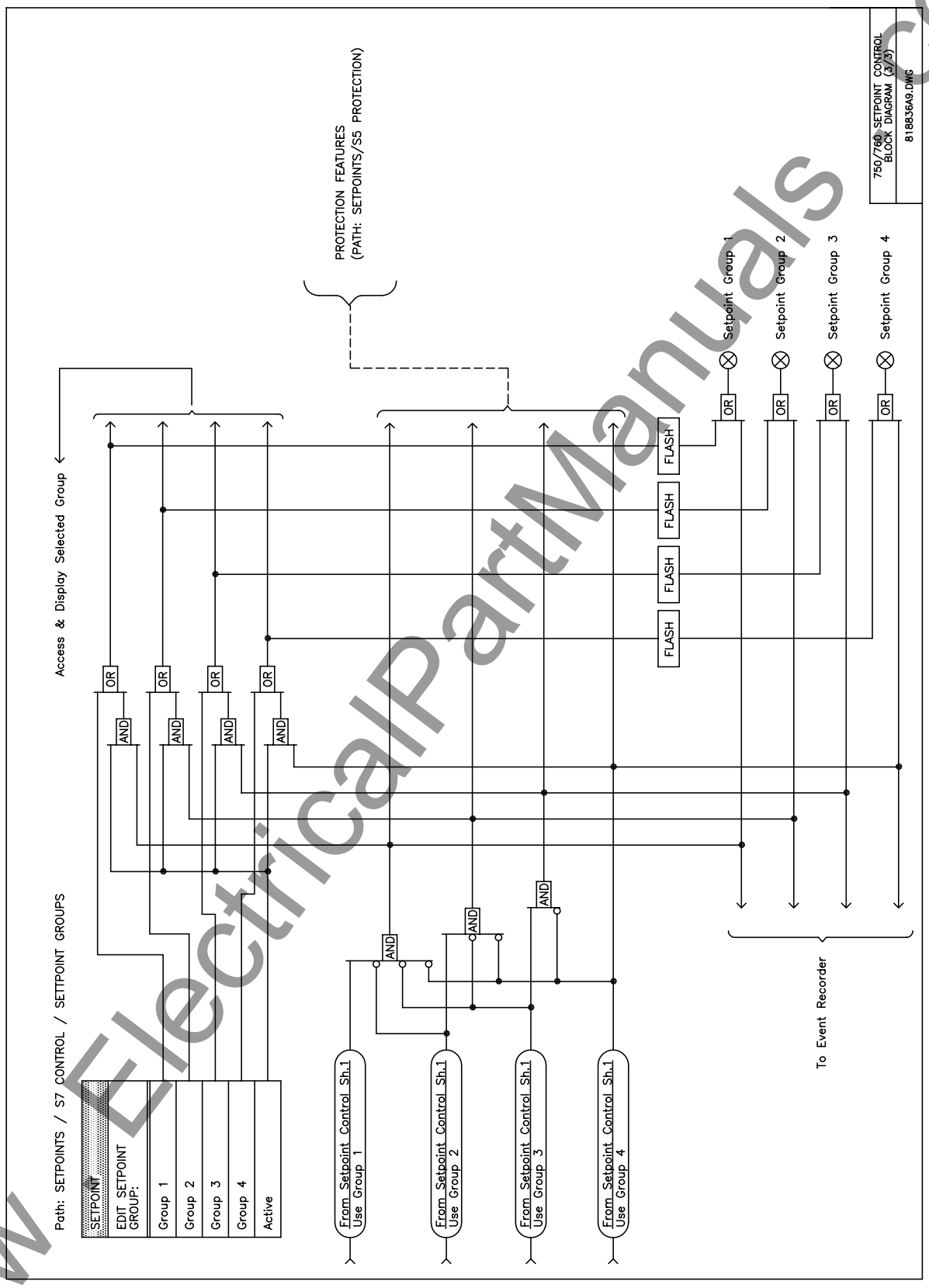


Figure 14–3: SETPOINT CONTROL (3 OF 3)

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14.2.1 DESCRIPTION

If a breaker can be a paralleling point between two generation sources, it is common practice to automatically perform a check to ensure the sources are within allowable voltage limits before permitting closing of the breaker. Synchrocheck provides this feature by checking that the bus and line input voltages are within the programmed differentials of voltage magnitude, phase angle position, and frequency. If this feature is enabled, the check will be performed before either manual close or automatic reclose signals can operate the 2 CLOSE output relay. The synchrocheck programming can allow for permitted closing if either or both of the sources are de-energized. The measured line input voltage magnitude and frequency are also made available as Actual Values under **A2 METERING \ SYNCHRO VOLTAGE**. The frequency is only displayed if the voltage at the relay terminals is at least 10.0 volts. The differential values of angle, magnitude, and frequency are also made available for display.

WARNING

With a Delta connected Bus VT, Phase to Neutral voltages cannot be determined. Thus Synchrocheck cannot be used with a Delta connected Bus VT and a Wye connected Line VT.

14.2.2 SETPOINTS

■ SYNCHROCHECK ■ [ENTER] for more	The Synchrocheck setpoints path is: **\ SETPOINTS \ S7 CONTROL \ SYCHROCHECK**
SYNCHROCHECK FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
SYNCHROCHECK RELAYS (3-7):	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
DEAD SOURCE PERMISSIVE: Off	*Range: Off, DB&DL, LL&DB, DL&LB, DL|DB, DLXDB* Selects the combination of dead and live sources that bypass synchrocheck and permit a breaker closure. The voltage levels that determine whether a source is dead or live are configurable in the next four setpoints. *Off*: Dead source permissive is disabled. *DB&DL*: Dead Bus AND Dead Line. *LL&DB*: Live Line AND Dead Bus. *DL&LB*: Dead Line AND Live Bus. *DL|DB*: Dead Line OR Dead Bus. *DLXDB*: Dead Line XOR Dead Bus (one source is Dead and one is Live).
DEAD BUS MAXIMUM VOLTAGE: 0.20 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the voltage magnitude as a fraction of the bus VT input nominal voltage. Below this setting the single bus voltage input used for synchrocheck will be considered 'Dead', or de-energized.
DEAD LINE MAXIMUM VOLTAGE: 0.20 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the voltage magnitude as a fraction of the line VT input nominal voltage. Below this setting the line voltage input used for synchrocheck is established as 'Dead', or de-energized.

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LIVE BUS MINIMUM VOLTAGE: 0.80 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the voltage magnitude as a fraction of the bus VT input nominal voltage. Above this setting the single bus voltage input used for synchrocheck is established as *Live*, or energized.
LIVE LINE MINIMUM VOLTAGE: 0.80 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the voltage magnitude as a fraction of the line VT input nominal voltage. Above this setting the line voltage input is established as *Live*, or energized.
MAXIMUM VOLTAGE DIFFERENCE: 2.00 kV	*Range: 0.01 to 100.00 in steps of 0.01 kV* Enter the voltage difference in kV, of the primary systems. A voltage magnitude differential on the two input voltages below this value is within the permissible limit for synchronism.
MAXIMUM ANGLE DIFFERENCE: 24°	*Range: 0 to 100 in steps of 1°* Enter the angular difference in degrees. An angular differential between the two input voltage phasors below this value is within the permissible limit for synchronism.
MAXIMUM FREQUENCY DIFFERENCE: 2.00 Hz	*Range: 0.0 to 5.00 in steps of 0.01 Hz* Enter the frequency difference in Hz. A frequency differential between the two input voltage systems below this value is within the permissible limit for synchronism.

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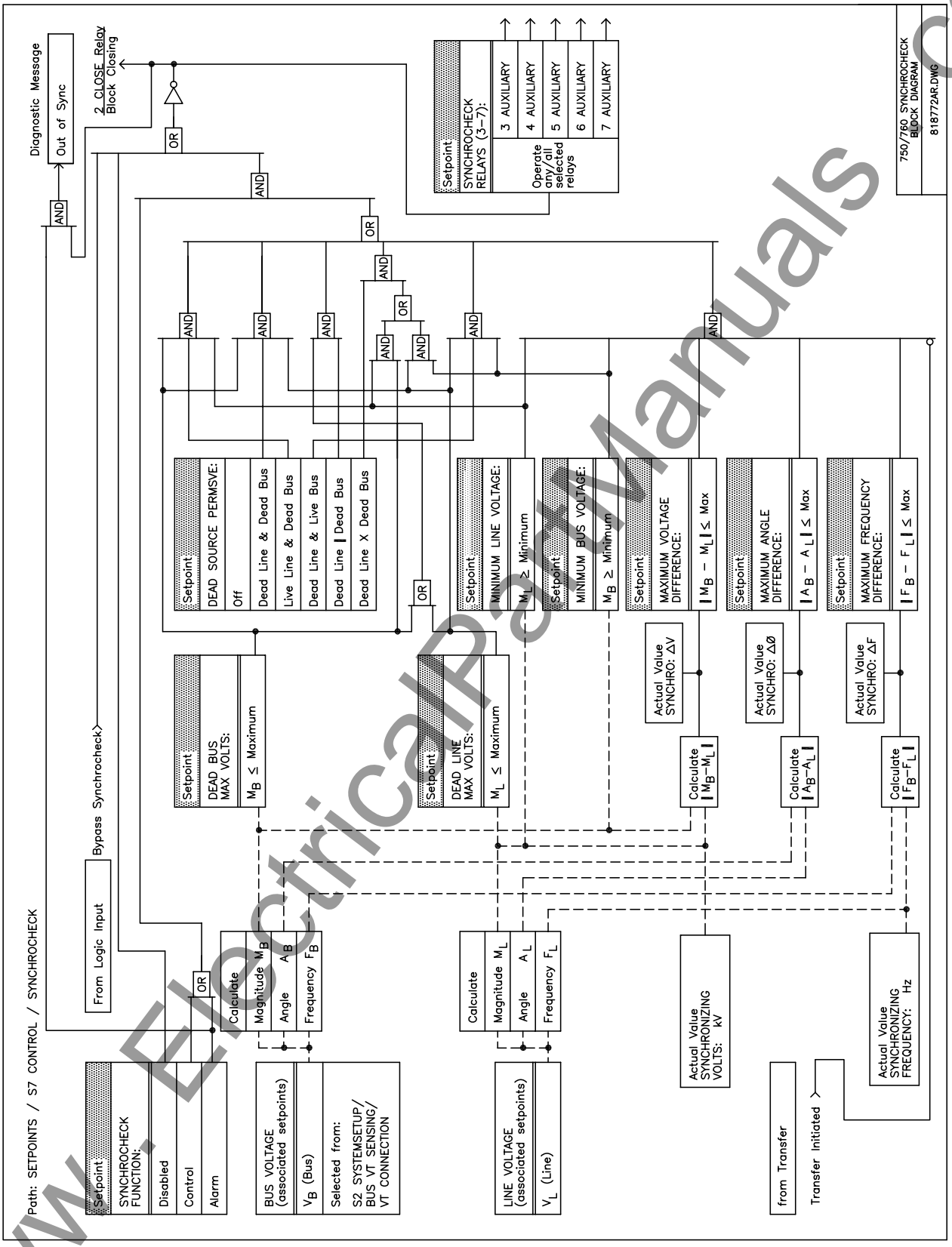


Figure 14–4: SYNCHROCHECK LOGIC DIAGRAM

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14.3.1 DESCRIPTION & SETPOINTS

The 750/760 can be programmed to block instantaneous overcurrent elements and raise the pickup level of time overcurrent elements when a manual breaker close is performed. This prevents optimally set overcurrent elements from erroneously operating on startup due to inrush currents.

■ MANUAL CLOSE ■ [ENTER] for more	The Manual Close Blocking setpoints path is: **\ SETPOINTS \ S7 CONTROL \ MANUAL CLOSE**
MANUAL CLOSE FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
MANUAL CLOSE RELAYS (3-7):	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
MANUAL CLOSE BLOCK TIME: 5 s	*Range: 1 to 1000 in steps of 1 s* Enter the period of time following a manual close for which overcurrent elements will be blocked or will have their pickup levels raised.
PHASE INST OC 1 BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block Phase Instantaneous O/C 1 element while manual close blocking is in effect.
NEUTRAL INST OC 1 BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block Neutral Instantaneous O/C 1 element while manual close blocking is in effect.
GROUND INST OC 1 BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block Ground Instantaneous O/C element while manual close blocking is in effect.
SENSTV GND INST OC BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block Sensitive Ground Instantaneous O/C while manual close blocking is in effect.
NEG SEQ INST OC BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block Negative Sequence Instantaneous O/C while manual close blocking in effect.
PHASE TIME OC 1 RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Enter the amount to raise pickup level for the Phase Time O/C 1 element while manual close blocking is in effect.
NEUTRAL TIME OC 1 RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Neutral Time O/C 1 element while manual close blocking is in effect.
GROUND TIME OC RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Ground Time O/C element while manual close blocking is in effect.
SENSTV GND TIME OC RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Sensitive Ground Time O/C element while manual close blocking is in effect.
NEG SEQ TIME OC RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Negative Sequence Time O/C element while manual close blocking is in effect.
SELECT SETPOINT GROUP: Active Group	*Range: Group 1, Group 2, Group 3, Group 4, Active Group* Select the setpoint group to be used while manual close blocking is in effect. If *Active Group* is selected, then the active setpoint group is not affected.

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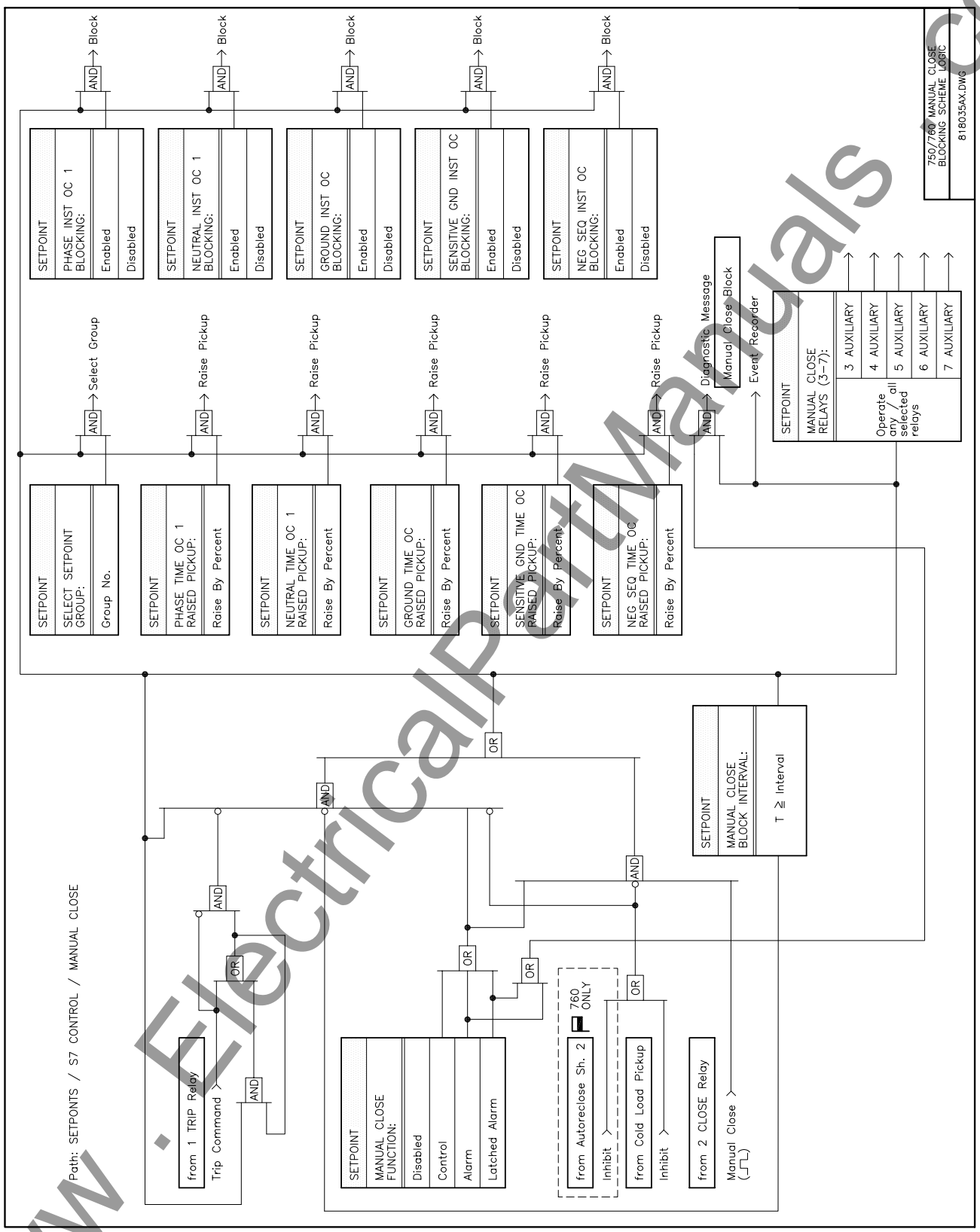


Figure 14–5: MANUAL CLOSE BLOCKING LOGIC DIAGRAM

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14.4.1 DESCRIPTION

The 750/760 can be programmed to block instantaneous overcurrent elements and to raise the pickup level of time overcurrent elements when a cold load condition is detected. Under normal operating conditions, the actual load on a feeder is less than the maximum connected load, since not all consumers require maximum load at the same time. When such a feeder is closed after a prolonged outage, the feeder inrush and motor accelerating current may be above some protection settings. Without historical data on a particular feeder, some utilities assume an initial cold load current of about 500% of normal load, decaying to 300% after one second, 200% after 2 seconds, and 150% after 4 seconds. See the figure below.

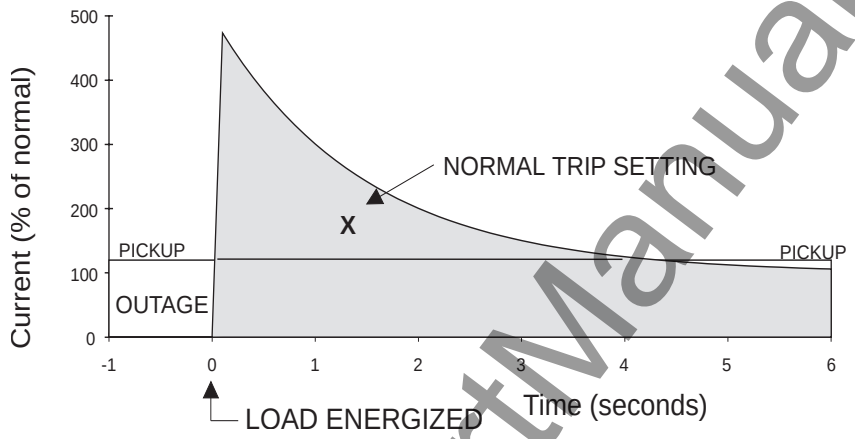


Figure 14–6: COLD LOAD PICKUP

A cold load condition is initiated and overcurrent settings are altered when all phase currents drop below 5% of the nominal current for an amount of time greater than the **OUTAGE TIME BEFORE COLD LOAD**. The cold load condition can also be immediately initiated by asserting the logic input function 'Cold Load Pickup'. Overcurrent settings are returned to normal after any phase current is restored to greater than 10% of nominal and then a timer of duration equal to **COLD LOAD PICKUP BLOCK TIME** expires.

14.4.2 SETPOINTS

■ COLD LOAD PICKUP ■ [ENTER] for more	The Cold Load Pickup Blocking setpoints path is: **\ SETPOINTS \ S7 CONTROL \ COLD LOAD PICKUP**
COLD LOAD PICKUP FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
COLD LOAD PICKUP RELAYS (3-7):	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
OUTAGE TIME BEFORE COLD LOAD: 100 min	*Range: 1 to 1000 in steps of 1 min.* Enter the minimum outage time required for a load to be considered cold.
COLD LOAD PICKUP BLOCK TIME: 5 s	*Range: 1 to 1000 s in steps of 1 s.* Enter the period of time following restoration of source to a feeder whose load has become cold for which overcurrent elements will be blocked or will have their pickup levels raised.

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PHASE INST OC 1 BLOCKING: Disabled	*Range: Disabled, Enabled* Enter *Enabled* to block the Phase Instantaneous Overcurrent 1 element while cold load pickup blocking is in effect.
NEUTRAL INST OC 1 BLOCKING: Disabled	*Range: Disabled, Enabled* Enter *Enabled* to block the Neutral Instantaneous Overcurrent element while cold load pickup blocking is in effect.
GROUND INST OC 1 BLOCKING: Disabled	*Range: Disabled, Enabled* Enter *Enabled* to block the Ground Instantaneous Overcurrent element while cold load pickup blocking is in effect.
SENSTV GND INST OC BLOCKING: Disabled	*Range: Disabled, Enabled* Enter *Enabled* to block the Sensitive Ground Instantaneous Overcurrent element while cold load pickup blocking is in effect.
NEG SEQ INST OC BLOCKING: Disabled	*Range: Disabled, Enabled* Enter *Enabled* to block the Negative Sequence Instantaneous Overcurrent element while cold load pickup blocking is in effect.
PHASE TIME OC 1 RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Phase Time Overcurrent 1 element while cold load pickup blocking is in effect.
NEUTRAL TIME OC 1 RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Neutral Time Overcurrent 1 element while cold load pickup blocking is in effect.
GROUND TIME OC RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Ground Time Overcurrent element while cold load pickup blocking is in effect.
SENSTV GND TIME OC RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Sensitive Ground Time Overcurrent element while cold load pickup blocking is in effect.
NEG SEQ TIME OC RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Negative Sequence Time Overcurrent element while cold load pickup blocking is in effect.
SELECT SETPOINT GROUP: Active Group	*Range: Group 1, Group 2, Group 3, Group 4, Active Group* Select the setpoint group that will be used while cold load pickup blocking is in effect. If *Active Group* is selected then the active setpoint group is not affected.

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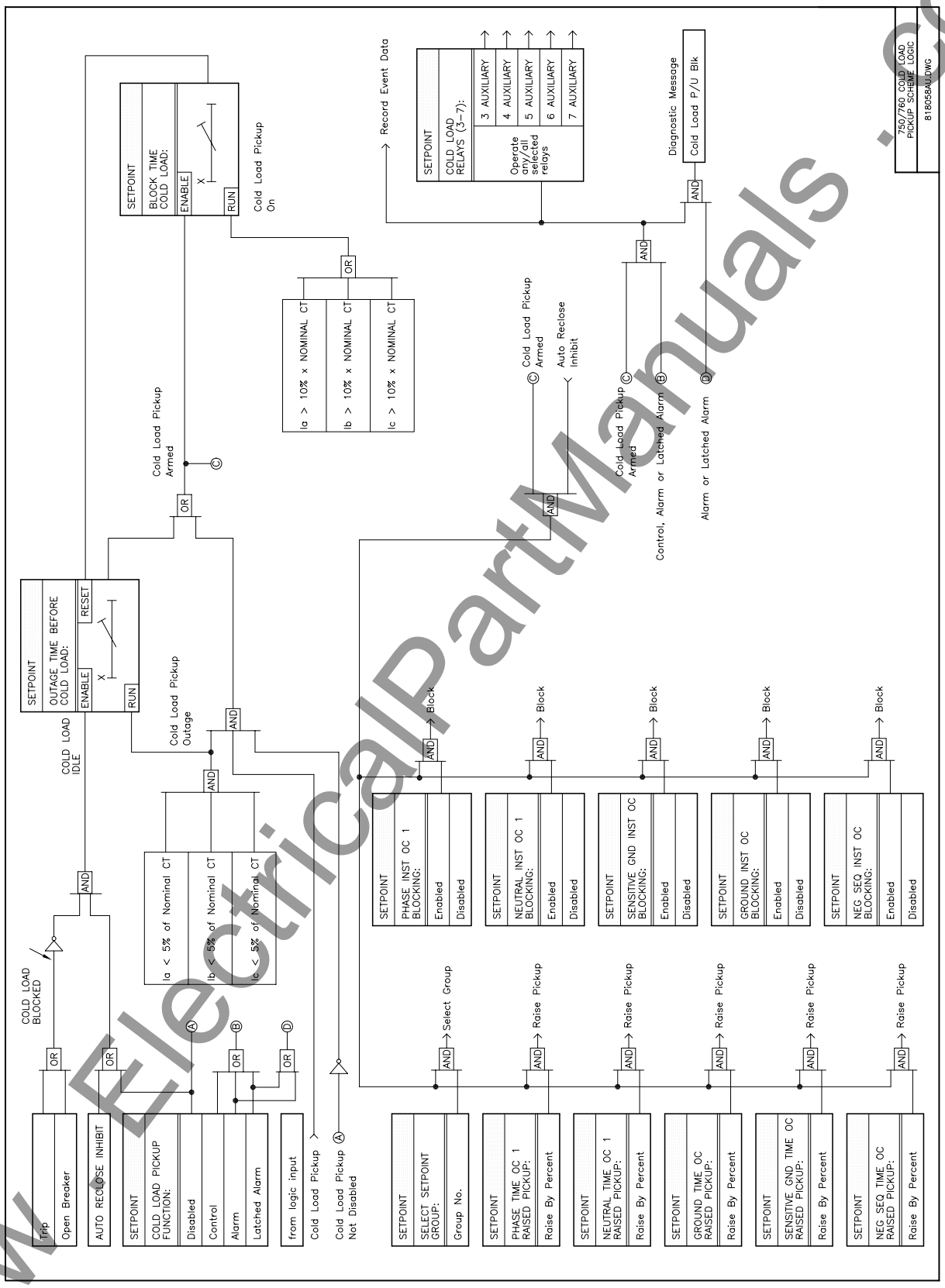


Figure 14–7: COLD LOAD PICKUP LOGIC DIAGRAM

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14.5.1 DESCRIPTION

This scheme is initiated by a trip of either the bus undervoltage 1 or 2 elements or the line undervoltage 3 or 4 elements. After the feeder breaker has been tripped, it will display message 'UVolt Restore Init' and operate any programmed output relays. Once initiated it will monitor the bus voltage level, and send a close command to the 2 CLOSE relay when the voltage on the programmed number of phases has risen above the programmed level for a selected time interval. The scheme is equipped with an incomplete sequence timer, so it will not remain initiated for an indeterminate time, but will automatically reset if the voltage does not recover during the programmed interval. Initiation of the scheme can be canceled by a reset command. Cancellation of a previous initiation is only effective if the voltage is above the restoration threshold. A 'Block Restoration' logic input is available to prevent both initiation and operation. It is recommended that if automatic undervoltage restoration is to be used, that the cold load pickup feature is also enabled, to prevent the breaker from tripping shortly after it is automatically closed.

14.5.2 SETPOINTS

■ UNDERVOLT RESTORE ■ [ENTER] for more	The Undervoltage Restoration setpoints path is: **\ SETPOINTS \ S7 CONTROL \ UNDERVOLT RESTORE**
UNDERVOLT RESTORE FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
UNDERVOLT RESTORE RELAYS (3-7):	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
UNDERVOLT RESTORE SOURCE: Bus	*Range: Bus, Line* Select the voltage source for undervoltage restoration.
PHASES REQUIRED FOR OPERATION: All Three	*Range: Any One, Any Two, All Three* Select the type of operation required. This display is only available if the **UNDERVOLT RESTORE SOURCE** setpoint is set to *Bus*.
UNDERVOLT RESTORE MIN VOLTS: 0.90 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the minimum value of voltage required to permit undervoltage restoration to close the breaker.
UNDERVOLT RESTORE DELAY: 10 s	*Range: 0 to 10000 in steps of 1 s* Select the interval for which the voltage must remain above the minimum level to permit undervoltage restoration to close the breaker.
INCOMPLETE SEQUENCE TIME: 100 min	*Range: 1 to 10000 in steps of 1 min* Select the interval during which the scheme will remain in operation after having been initiated, after which the operation will be canceled.

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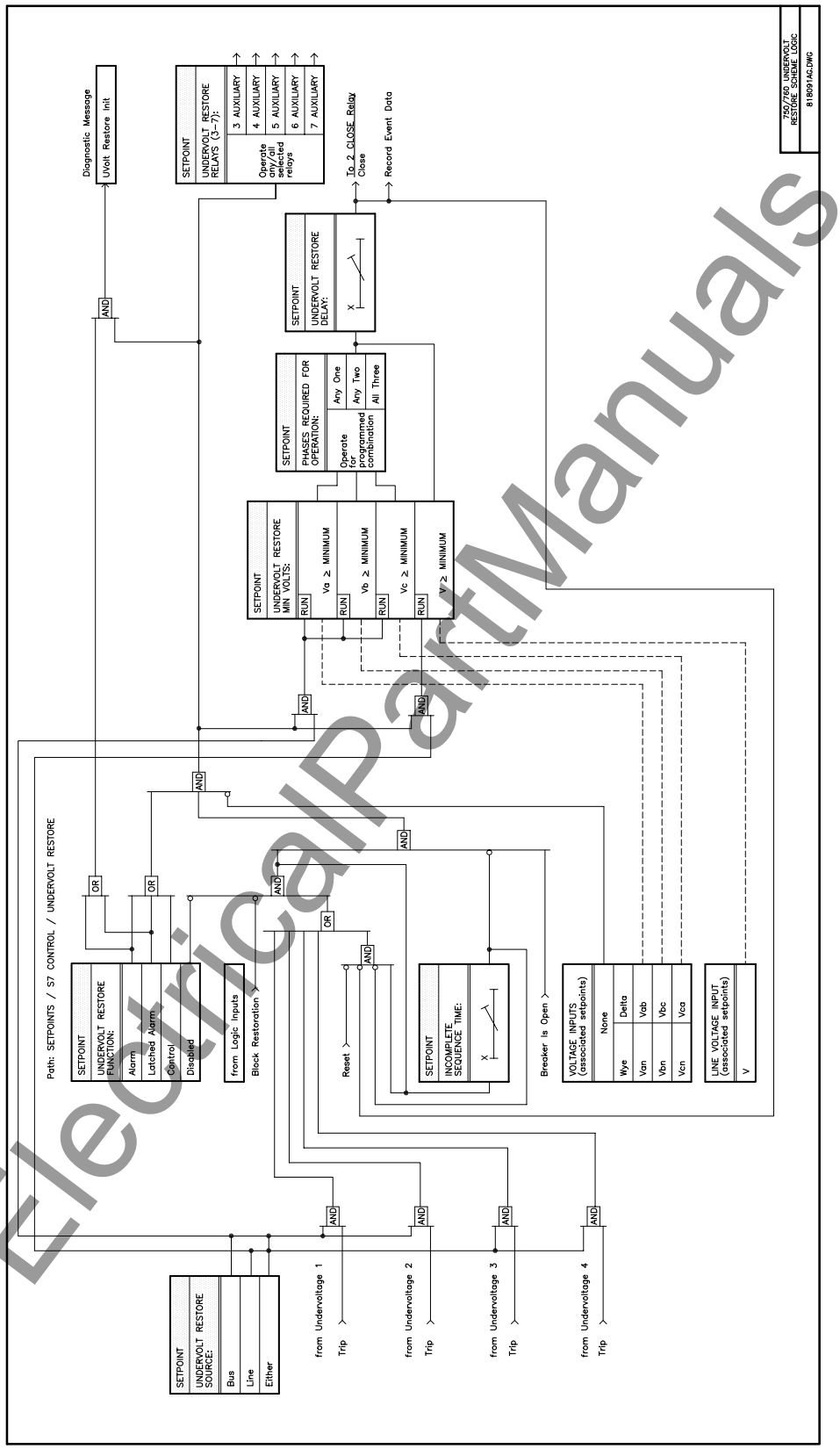


Figure 14–8: UNDERVOLTAGE RESTORATION LOGIC DIAGRAM

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14.6.1 DESCRIPTION

This scheme is initiated by a trip of either the bus underfrequency 1 or 2 elements. After the feeder breaker has been tripped, it will display message 'UFreq Restore Init' and operate any programmed output relays. Once initiated it will monitor the bus voltage level and frequency, and send a close command to the 2 CLOSE relay when the voltage on the phase A input has risen above the programmed minimum level and frequency for a selected time interval. The scheme is equipped with an incomplete sequence timer, so it will not remain initiated for an indeterminate time, but will automatically reset if the voltage does not recover during the programmed interval. Initiation of the scheme can be canceled by a reset command. Cancellation of a previous initiation is only effective if the voltage and frequency are above the restoration thresholds. A 'Block Restoration' logic input is available to prevent both initiation and operation. It is recommended that if automatic underfrequency restoration is to be used, that the cold load pickup feature is also enabled, to prevent the breaker from tripping shortly after it is automatically closed.

14.6.2 SETPOINTS

■ UNDERFREQ RESTORE ■ [ENTER] for more	The Underfrequency Restoration setpoints path is: **\ SETPOINTS \ S7 CONTROL \ UNDERFREQ RESTORE**
UNDERFREQ RESTORE FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Select the required function.
UNDERFREQ RESTORE RELAYS (3-7):	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the output relays required.
UNDERFREQ RESTORE MIN VOLTS: 0.90 x VT	*Range: 0.00 to 1.25 in steps of 0.01 x VT* Enter the minimum value of voltage required to permit underfrequency restoration to close the breaker.
UNDERFREQ RESTORE MIN FREQ: 59.90 Hz	Range: 20.00 to 65.00 in steps of 0.01 Hz Enter the minimum value of phase A bus frequency required to permit underfrequency restoration to close the breaker.
UNDERFREQ RESTORE DELAY: 10 s	*Range: 0 to 10000 in steps of 1 s* Select the interval for which the voltage must remain above the minimum level to permit underfrequency restoration to close the breaker.
INCOMPLETE SEQUENCE TIME: 100 min	*Range: 1 to 10000 in steps of 1 min* Select the interval during which the scheme will remain in operation after having been initiated, after which the operation will be canceled.

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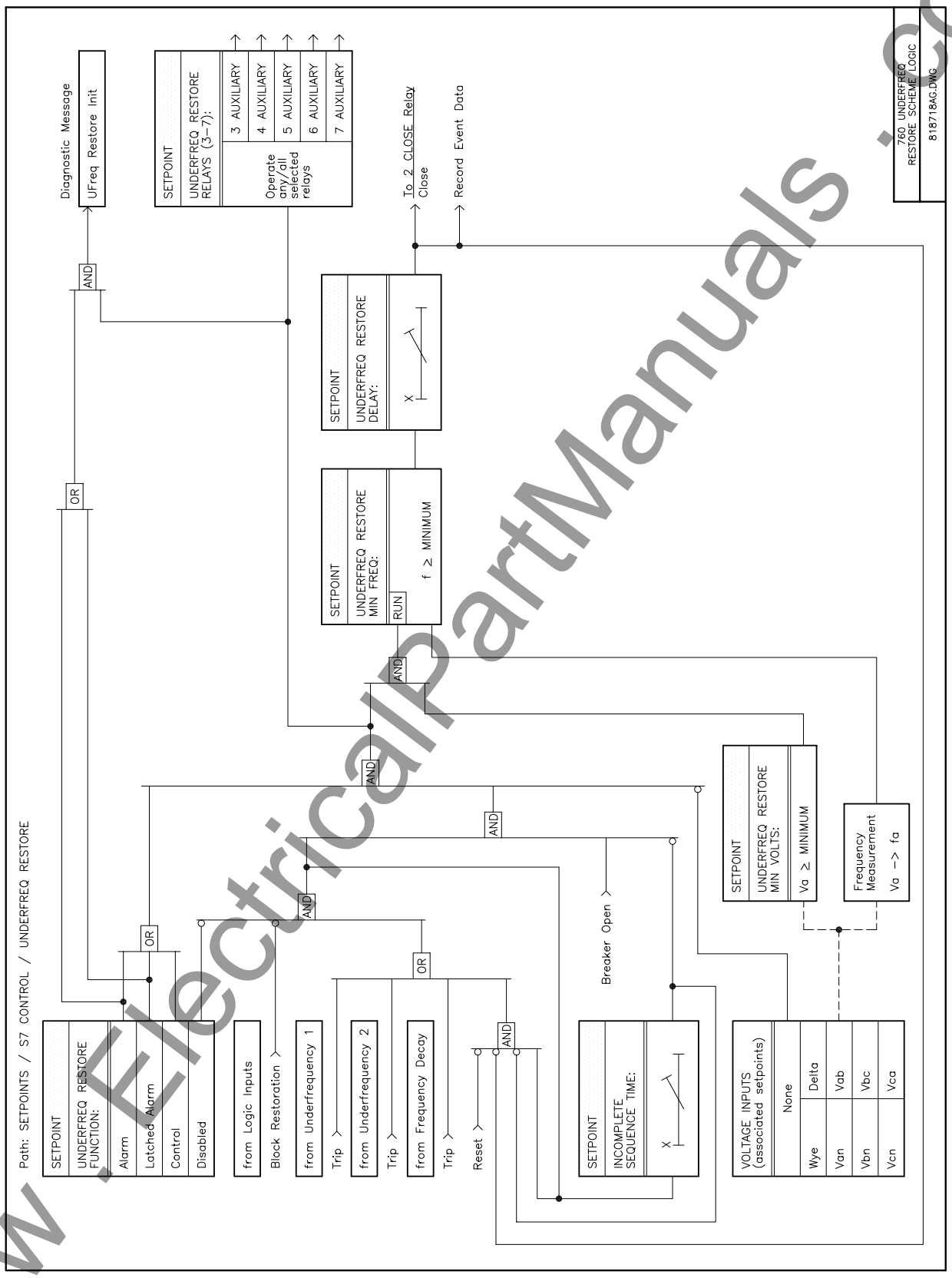


Figure 14–9: UNDERFREQUENCY RESTORATION LOGIC DIAGRAM

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14.7.1 DESCRIPTION

The Transfer scheme is intended for application to a set of three circuit breakers, two of which, (Incomers 1 and 2) connect sources of electrical energy to two busses which can be paralleled through the Bus Tie breaker. Normal configuration of the system is with both incoming breakers closed and the bus tie breaker open. Figure 14–2: SETPOINT CONTROL (2 OF 3) on page 14–4 shows this arrangement. The equipment designations on this drawing will be used in the discussion.

The transfer scheme is used to minimize the effect of outages on one of the incoming supplies by opening the incoming breaker connected to that supply, and then re-energizing the dead bus by closing the bus tie breaker to transfer the dead bus to the live source. To protect against damage to motors connected to the dead bus, the bus tie breaker is not allowed to close, after a transfer has been initiated, until the decaying (sometimes called residual) voltage on the bus has been reduced to a safe level.

After the lost source has been reestablished, the scheme provides three methods to restore the system to normal configuration, two manual and one automatic. If the sources cannot be synchronized, the bus tie breaker must be manually opened before the open incomer can be manually closed. In this procedure the incomer will only be allowed to close if the incoming source (line VT) voltage is above a live threshold and the load (bus VT) voltage is below a dead threshold value. If the sources are synchronized with synchrocheck supervision, it is possible to manually close the open incomer to parallel all three breakers. The scheme will then automatically open a breaker that had been previously selected to trip if all three breakers become closed. In this instance, the bus tie breaker is 'Selected To Trip' and will open. The automatic method of returning the system to normal configuration uses the undervoltage tripped portion of the restoration scheme.

In addition to the relay required for each of the three circuit breakers, it is required to connect one contact from a three-position switch to each relay. This switch (device 43/10) is used to select the breaker that will trip after all breakers become closed. It is also recommended that a two-position switch (device 43/83) with three contacts be connected to each relay as an 'Auto-Off' transfer scheme selector.

Because a relay is required on the bus tie breaker, it allows bus-splitting operation. This is accomplished by setting the time overcurrent elements in the relay on the bus tie breaker to trip faster than the incomers, opening the bus tie before an incomer when operating from only one source.

The scheme can be used in conjunction with both non-drawout and drawout switchgear. Drawout switchgear designs can make use of an auxiliary switch that confirms that the monitored breaker is in the 'Connected' position, and is therefore ready for operation. Fixed breaker installations can use contacts on the associated isolating disconnect switches (if available) for this purpose. The scheme design can be applied to:

1. Substations with no signaling from upstream equipment.
2. Substations with an upstream circuit breaker equipped with a trip signal (94).
3. Substations with a source transformer and transformer fault detection signal (86T).
4. Both 1 and 2 above.

The only differences in implementing the transfer scheme among the configurations presented above is by connecting additional logic signals to the relay when available and by placing a jumper on one logic input if the breaker is non-drawout and has no disconnect auxiliary switches.

Besides the setpoints and logic incorporated into the transfer scheme, the relays make use of some or all of the logic inputs, phase instantaneous (50P-1 or 2), neutral overcurrent (50N-1 or 2), both line undervoltage elements (27-3 and 27-4), and the synchrocheck (25) features of the relays.

The following discussion is based on configuration (4) above, using drawout breakers. Schematic diagrams of the DC connections required by an example scheme with this configuration are presented on Figure 14–11: TRANSFER SCHEME INCOMER NO. 1 DC SCHEMATIC, Figure 14–12: TRANSFER SCHEME INCOMER NO. 2 DC SCHEMATIC, and Figure 14–13: TRANSFER SCHEME BUS TIE BREAKER DC SCHEMATIC on

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pages 14–24 to 14–26. Logic for each relay of the scheme is presented in the logic diagrams on pages 14–27 to 14–29. Connections that are not required for configurations other than (4) are indicated as 'optional' on the schematic diagrams.

NOTE

All connections for AC voltage and current are outlined in the Installation chapter. The scheme design requires that the AC voltage connections for 'Line' and 'Bus' sources on the incomer relays be in accordance with Figure 14–10: TRANSFER SCHEME ONE LINE DIAGRAM on page 14–23 regardless of configuration. The connection of AC voltage to the relay on the bus tie does not affect operation of the scheme, **but** the connection to the line voltage input terminals *must be* a phase-phase voltage.

For the following discussion it is assumed that source 1 is the failed side. Identical logic with all 1s and 2s interchanged applies to relay 2 for a loss of source 2.

A transfer (trip of Incomer 1 followed by closing of the Bus Tie) from relay 1 can be initiated by:

- Operation of transformer 1 lockout relay (86T1).
- Operation of the source 1 breaker auxiliary trip device (94-1).
- Time out of relay 1 line voltage inverse time undervoltage element (27-4) caused by a low voltage on source 1.

A transfer initiation is blocked if:

- Any of the three breakers is not in the connected state.
- Incoming breaker 2 (which is to become the new source) is presently open.
- An overcurrent condition on bus 1 is detected by 50P-1 or 2 or 50N-1 or 2, to prevent a faulted bus from being transferred to a healthy source.
- The line voltage definite time undervoltage element (27-3) on source 2 is operated, indicating low voltage on the other source.

Once a condition has caused relay 1 to initiate a transfer, including the close signal to relay 3 on the Bus Tie breaker, the command is maintained until relay 1 determines that breaker 1 has opened. When relay 3 receives the close command from relay 1, it is captured and retained until either the Bus Tie breaker closes or the Block Transfer logic input is received. Relay 3 is inhibited from initiating a close command to breaker 3 by its synchrocheck element. Synchrocheck is used to provide the bus decayed (residual) voltage permission-to-close, which is only provided when the bus 1 voltage decays to the preset level.

The three breakers are under prevent-parallel checking whenever the transfer scheme is operational. If a third breaker is closed when the other two breakers are already closed, the scheme will automatically trip the breaker selected by switch 43/10, 'Selected To Trip'.

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14.7.2 SETPOINTS

■ TRANSFER ■ [ENTER] for more	The Transfer setpoints path is: **\ SETPOINTS \ S7 CONTROL \ TRANSFER**
TRANSFER FUNCTION: Disabled	*Range: Disabled, Incomer 1, Incomer 2, Bus Tie* If the transfer scheme is not required select *Disabled* for this setpoint. If not disabled, this setpoint is used to assign to the relay the function of the associated circuit breaker. This selection programs the relay to use the logic required by each of the three breakers. Select *Incomer 1* or *Incomer 2* for this setpoint if the relay is associated with the breaker to be used as Incomer 1 or 2 respectively. Select *Bus Tie* if the relay is associated with the bus tie breaker.
TRANSFER DELAY THIS SOURCE: 1.0 s	*Range: 0.0 to 10.0 in steps of 0.1 s* This delay time establishes an interval from the reset of an operated instantaneous overcurrent element on this source, during which the line instantaneous undervoltage element (27-3) is allowed to block a transfer. Select the desired delay.
TRANSFER DELAY OTHER SOURCE: 3.0 s	*Range: 0.0 to 10.0 in steps of 0.1 s* This delay time prevents transfers that could otherwise be caused by a non-simultaneous return of source voltages after a loss of both sources. It establishes an interval from the return of the first source to the return of the second source during which a transfer cannot be initiated. Select the desired delay.
BLOCK TRIP ON DOUBLE LOSS: Disabled	*Range: Disabled, Enabled* This setpoint selects the required scheme operation in the event of a simultaneous loss of both source 1 and source 2. If it is desired to have both of the Incomers trip on timed undervoltage when this occurs, select *Disabled*. If it is desired to prevent the Incomers from tripping on timed undervoltage when this occurs, select *Enabled*. With either selection a transfer-initiated close of the bus tie breaker is not allowed.

14.7.3 SETTINGS/FUNCTIONS OF ASSOCIATED ELEMENTS

Output Relays 4-7 Auxiliary (All breakers)

These output relays are used to implement the transfer scheme, and must therefore not be operated by any other feature of the relay. These relays must be programmed to have a non-operated state of 'De-energized' with the output type as 'Self-reset'. These are the default settings.

Instantaneous Phase-1 or 2 (50P1 or 2) and Instantaneous Neutral-1 or 2 (50N-1 or 2) (Incomers 1 and 2 only)

These fault detectors can be used as an input to transfer scheme logic in this application, and therefore the function setpoint of elements that are used must be set to *Control*. These elements block a transfer while a fault, which can cause a severe voltage dip, is present on the load side of the breaker. This fault should be cleared by time overcurrent protection on the incomer or an upstream breaker. If 50P is set properly, during this event it will allow the 27-4 element to time out before the inverse time phase overcurrent operates, but still prevent transfer initiation. The 50P element should be set above the maximum current caused by either the bus motor contribution to an upstream fault, or the maximum current during low voltage conditions. The 50N element should be set to detect arcing ground faults, but allow permitted unbalances.

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Line Voltage Undervoltage (27-3) (Incomers 1 and 2 only)

This element is used as an input to transfer scheme logic in this application, and therefore the function setpoint must be set to *Control*. An Undervoltage 3 operation is used to signal relay 2 to block transfer initiation from that relay, because source 1 is experiencing low voltage. Also, 27-3 is enabled by instantaneous overcurrent to block transfer initiation. This ensures that if a fault on the load side of bus 1 causes a dip below the undervoltage pickup setting, transfer will not be initiated until the voltage has risen above the voltage setting for the interval established by the **TRANSFER DELAY THIS SOURCE** setpoint. The pickup setting of 27-3 should be below the minimum expected normal (low) voltage, usually around 0.9 Pick Up voltage. A Definite Time curve with the delay set to zero provides instantaneous operation. The minimum operating voltage must be set to zero.

Line Voltage Undervoltage (27-4) (Incomers 1 and 2 only)

This element is used as an input to transfer scheme logic in this application, and therefore the function setpoint should be set to *Control*. An Undervoltage 4 operation is used to initiate a transfer on loss-of-source. Typical settings have a pickup about 0.7 to 0.8 of Pick Up voltage, a curve setting selected as 'Inverse Time', and a delay setting to provide operation in 0.7 to 1.4 seconds at 0 volts. The minimum operating voltage must be set to zero.

Synchrocheck (25) (Incomers 1 and 2 only)

The synchrocheck function can be selected as either *Control* or *Alarm*. It is imperative that setpoint **DEAD SOURCE PERMISSIVE** be set to *LL&DB* (Live Line and Dead Bus) to allow initial closing of the incoming breakers. The user establishes all other setpoints for this element.

Synchrocheck (25) (Bus Tie only)

This element is used to provide synchronism check supervision when paralleling the busses. The Dead Source Permissive portion of this feature is also used to measure the residual voltage on the bus that has lost source. To ensure that transfers are supervised by the decayed voltage magnitude only, the 'in-synchronism' elements are blocked while a transfer is in progress. The synchrocheck function can be selected as either *Control* or *Alarm*. It is imperative that setpoint **DEAD SOURCE PERMISSIVE** be set to either *DL|DB* (Dead Line or Dead Bus) or *DLXDB* (Dead Line or Dead Bus, but not both) to allow for transfers to either incomer.

The **DEAD BUS MAXIMUM VOLTAGE** and **DEAD LINE MAXIMUM VOLTAGE** setpoints establish the level of decayed voltage above which transfers are inhibited. A normal setting for this element is about 0.25 Pick Up of nominal voltage. Because the 750/760 measures a single phase-phase voltage, these values should be multiplied by $1 / \sqrt{3}$ to cover the case of a phase-ground fault on a measured phase reducing that phase voltage but leaving the other two phases at a higher voltage. If experience shows this setting causes a delay of transfer presenting problems, it is occasionally raised to a maximum of 0.40 Pick Up. The user establishes all other setpoints for this element.

14.7.4 LOGIC INPUTS FOR INCOMER #1, #2, & BUS TIE RELAYS

The programming of the required logic inputs is as follows. Note that the input number matches the wiring shown on the DC schematics. It is not necessary that the specific inputs are programmed as shown, but field connections must match the logic functions.

NOTE

If logic inputs identified as optional on the schematics and the following table are not required, they can be programmed to perform other functions. The Message Mode may be programmed to *Disabled* or *Self Reset*.

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Table 14–1: LOGIC INPUTS FOR INCOMER #1, #2, AND BUS TIE RELAYS

INPUT	INCOMER #1	INCOMER #2	BUS TIE
1	Name: ***Local Mode*** Asserted Logic: **Contact Open** **Contact Close** **Open | Von** **Open | Voff** **Closed | Von** **Closed | Voff**	Name: ***Local Mode*** Asserted Logic: **Contact Open** **Contact Close** **Open | Von** **Open | Voff** **Closed | Von** **Closed | Voff**	Name: ***Local Mode*** Asserted Logic: **Contact Open** **Contact Close** **Open | Von** **Open | Voff** **Closed | Von** **Closed | Voff**
2	Name: ***Remote Close*** Asserted Logic: **Contact Open** **Contact Close** **Open | Von** **Open | Voff** **Closed | Von** **Closed | Voff**	Name: ***Remote Close*** Asserted Logic: **Contact Open** **Contact Close** **Open | Von** **Open | Voff** **Closed | Von** **Closed | Voff**	Name: ***Remote Close*** Asserted Logic: **Contact Open** **Contact Close** **Open | Von** **Open | Voff** **Closed | Von** **Closed | Voff**
3	Name: ***Remote Open*** Asserted Logic: **Contact Open** **Contact Close** **Open | Von** **Open | Voff** **Closed | Von** **Closed | Voff**	Name: ***Remote Open*** Asserted Logic: **Contact Open** **Contact Close** **Open | Von** **Open | Voff** **Closed | Von** **Closed | Voff**	Name: ***Remote Open*** Asserted Logic: **Contact Open** **Contact Close** **Open | Von** **Open | Voff** **Closed | Von** **Closed | Voff**
4	Name: ***52a*** or ***52b Contact*** Asserted Logic: **Contact Close**	Name: ***52a*** or ***52b Contact*** Asserted Logic: **Contact Close**	Name: ***52a*** or ***52b Contact*** Asserted Logic: **Contact Close**
5	Name: ***Breaker Connected*** Asserted Logic: **Contact Close**	Name: ***Breaker Connected*** Asserted Logic: **Contact Close**	Name: ***Breaker Connected*** Asserted Logic: **Contact Close**
6	Name: ***Selected To Trip*** Asserted Logic: **Contact Open** **Contact Close**	Name: ***Selected To Trip*** Asserted Logic: **Contact Open** **Contact Close**	Name: ***Selected To Trip*** Asserted Logic: **Contact Open** **Contact Close**
7	Name: ***Undervoltage On Other Source*** Asserted Logic: **Contact Close**	Name: ***Undervoltage On Other Source*** Asserted Logic: **Contact Close**	Name: ***Close From Incomer 1*** Asserted Logic: **Contact Close**
8	Name: ***Incomer 2 Breaker Closed*** Asserted Logic: **Contact Close**	Name: ***Incomer 1 Breaker Closed*** Asserted Logic: **Contact Close**	Name: ***Incomer 1 Breaker Closed*** Asserted Logic: **Contact Close**
9	Name: ***Tie Breaker Connected*** Asserted Logic: **Contact Close**	Name: ***Tie Breaker Connected*** Asserted Logic: **Contact Close**	Name: ***Close From Incomer 2*** Asserted Logic: **Contact Close**
10	Name: ***Tie Breaker Closed*** Asserted Logic: **Contact Close**	Name: ***Tie Breaker Closed*** Asserted Logic: **Contact Close**	Name: ***Incomer 2 Breaker Closed*** Asserted Logic: **Contact Close**
11 †	Name: ***Block Transfer*** Asserted Logic: **Contact Open** **Contact Close**	Name: ***Block Transfer*** Asserted Logic: **Contact Open** **Contact Close**	Name: ***Block Transfer*** Asserted Logic: **Contact Open** **Contact Close**
12 †	Name: ***Transformer Lockout*** Asserted Logic: **Contact Open** **Contact Close**	Name: ***Transformer Lockout*** Asserted Logic: **Contact Open** **Contact Close**	
13 †	Name: ***Source Trip*** Asserted Logic: **Contact Open** **Contact Close**	Name: ***Source Trip*** Asserted Logic: **Contact Open** **Contact Close**	

† Inputs 11, 12, and 13 are optional

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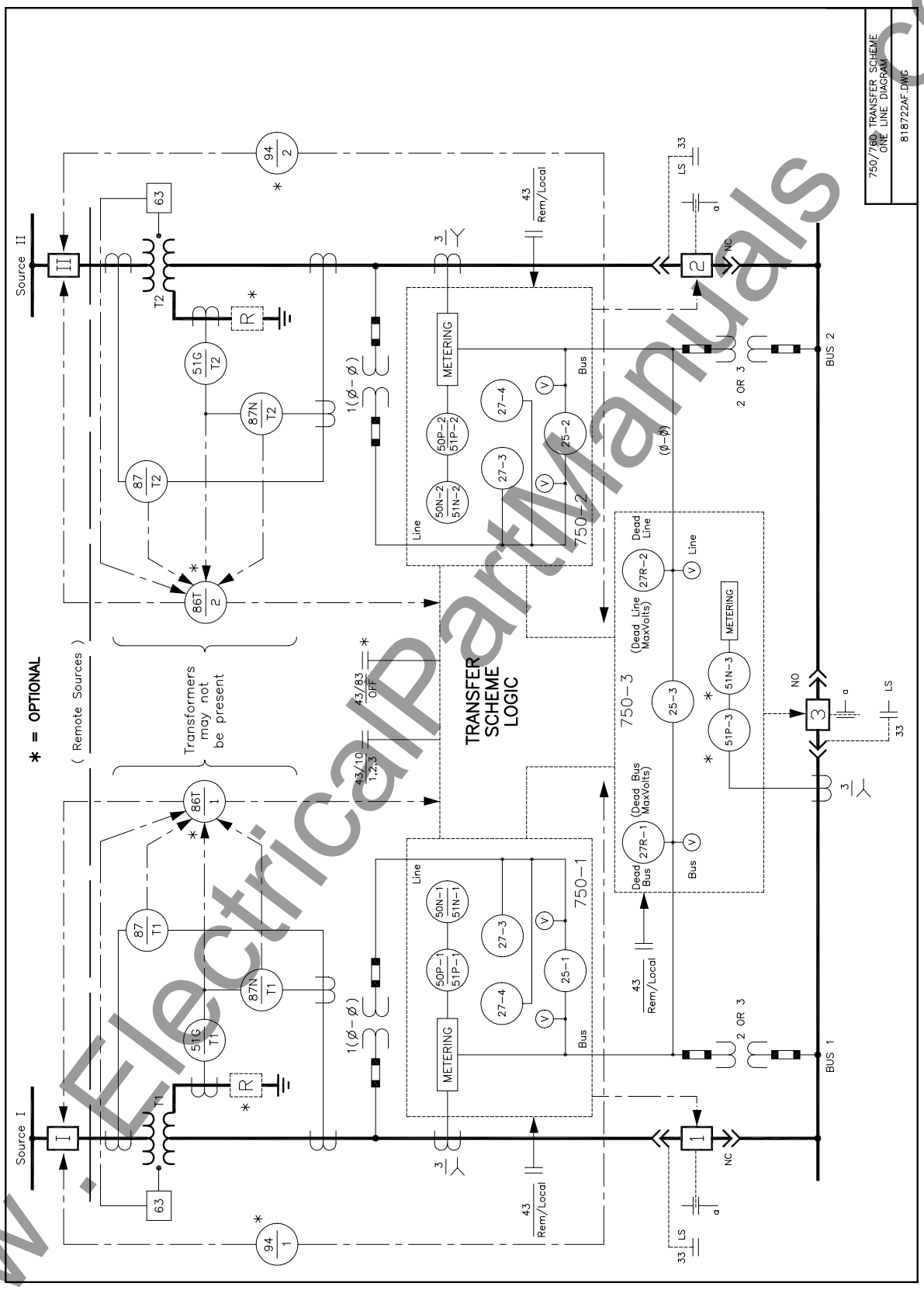


Figure 14–10: TRANSFER SCHEME ONE LINE DIAGRAM

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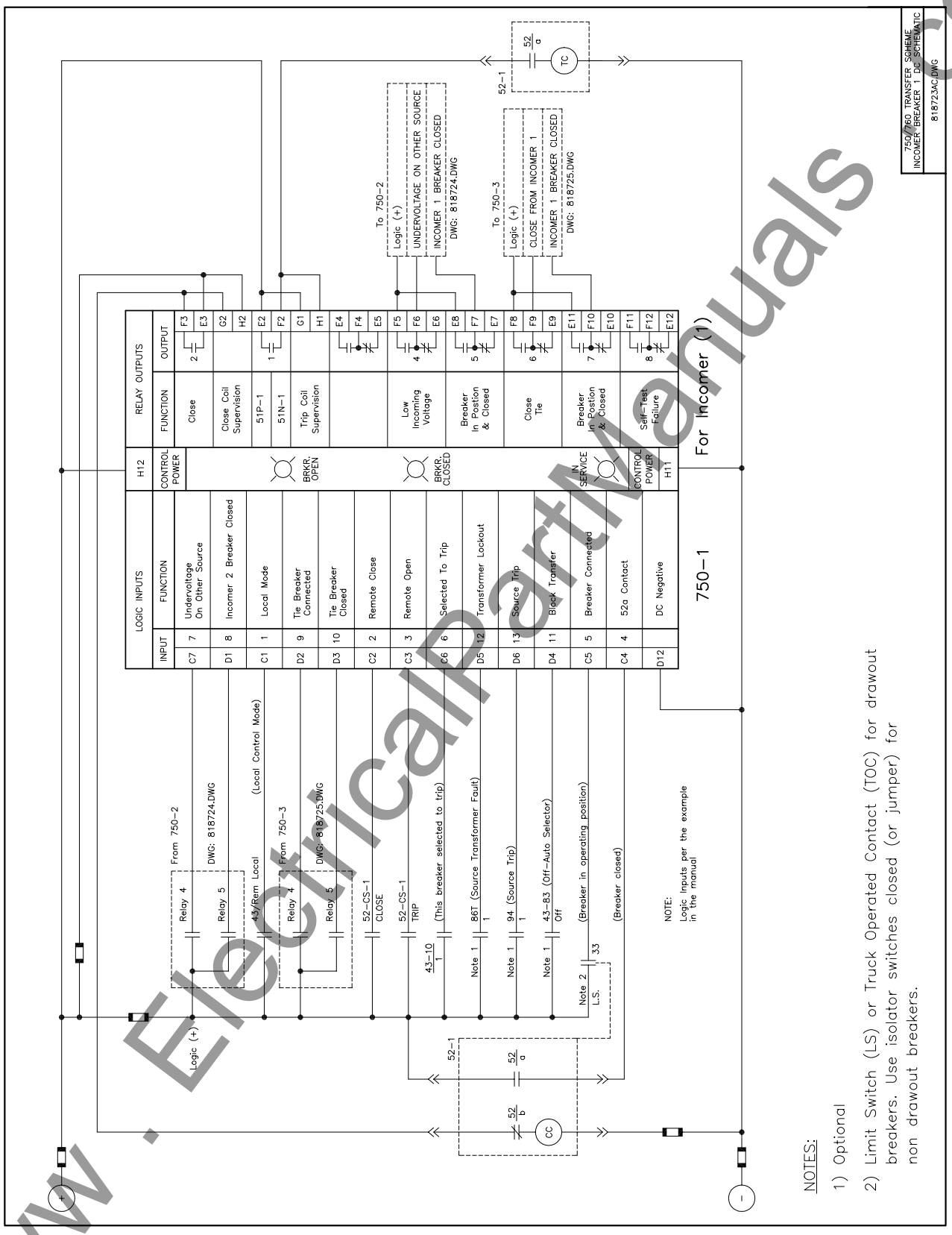


Figure 14–11: TRANSFER SCHEME INCOMER NO. 1 DC SCHEMATIC

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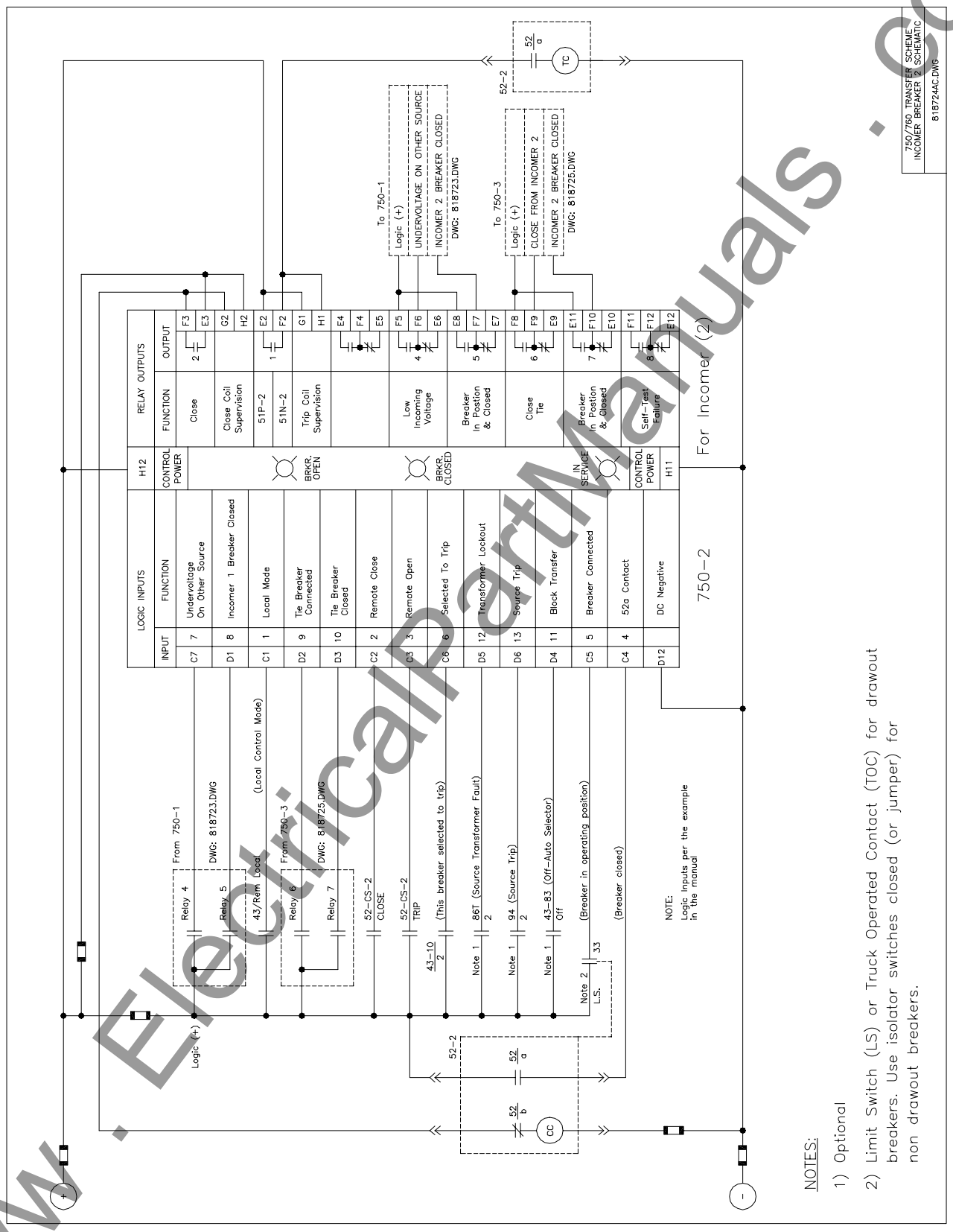


Figure 14–12: TRANSFER SCHEME INCOMER NO. 2 DC SCHEMATIC

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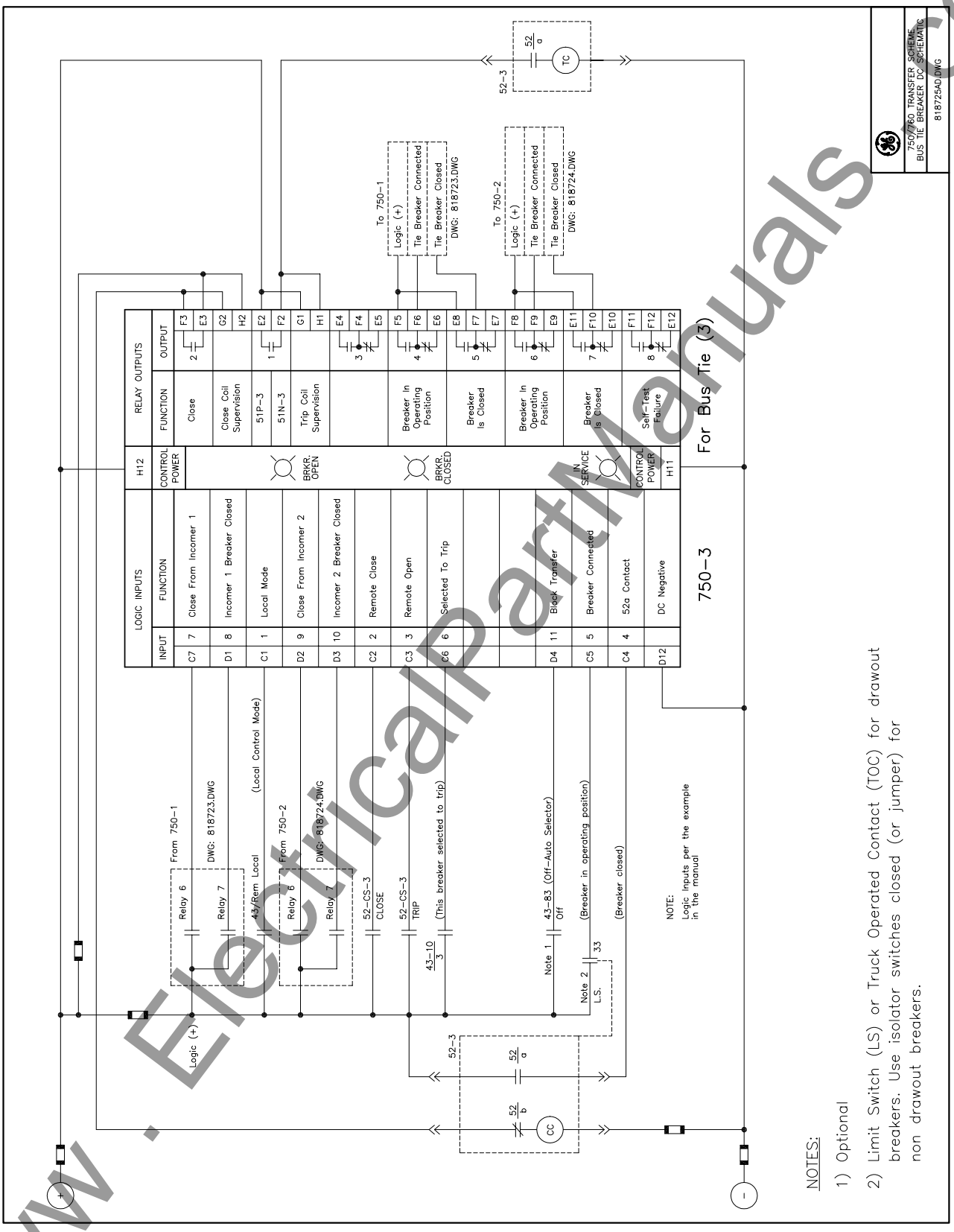


Figure 14–13: TRANSFER SCHEME BUS TIE BREAKER DC SCHEMATIC

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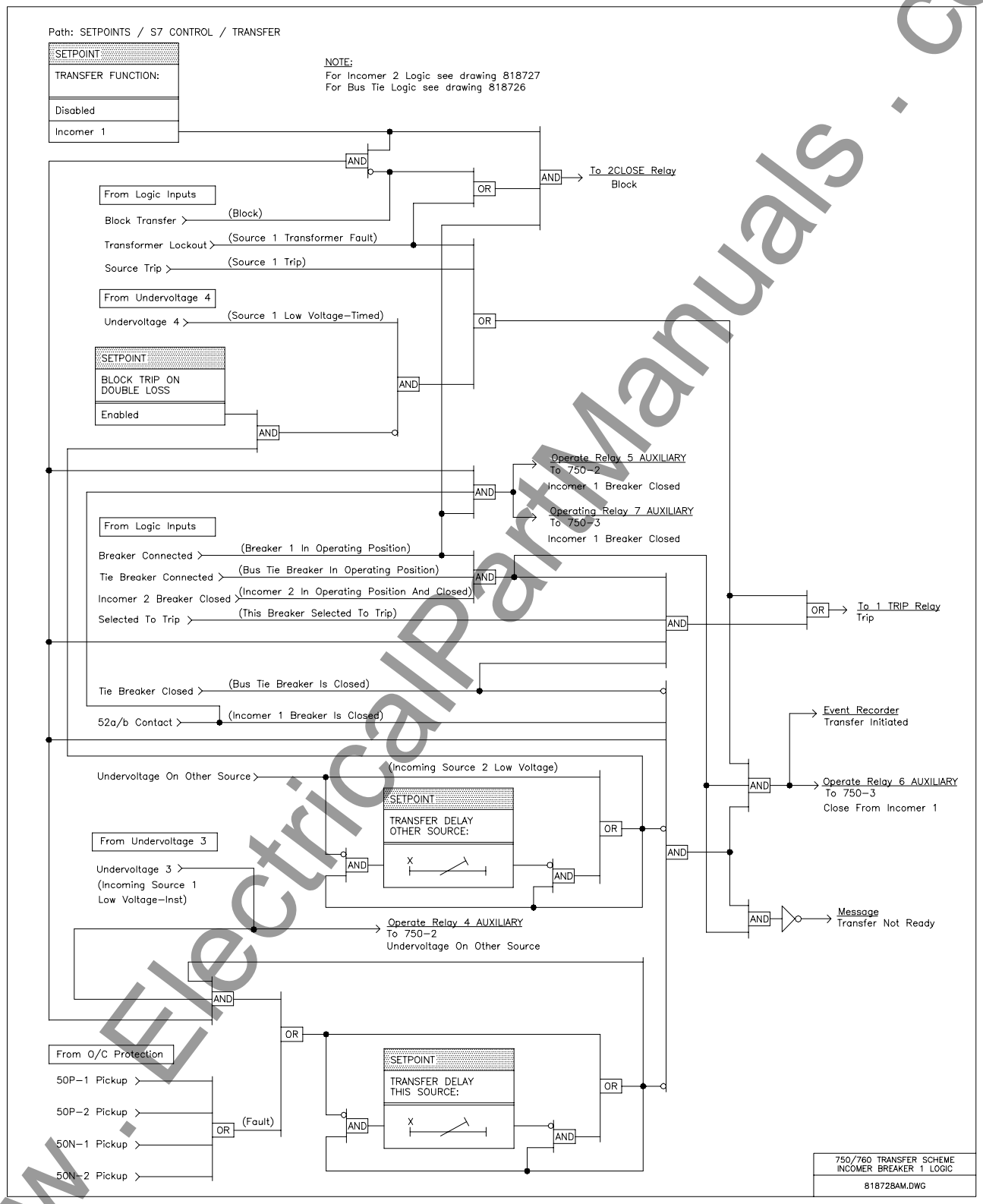


Figure 14–14: TRANSFER SCHEME INCOMER NO. 1 LOGIC DIAGRAM

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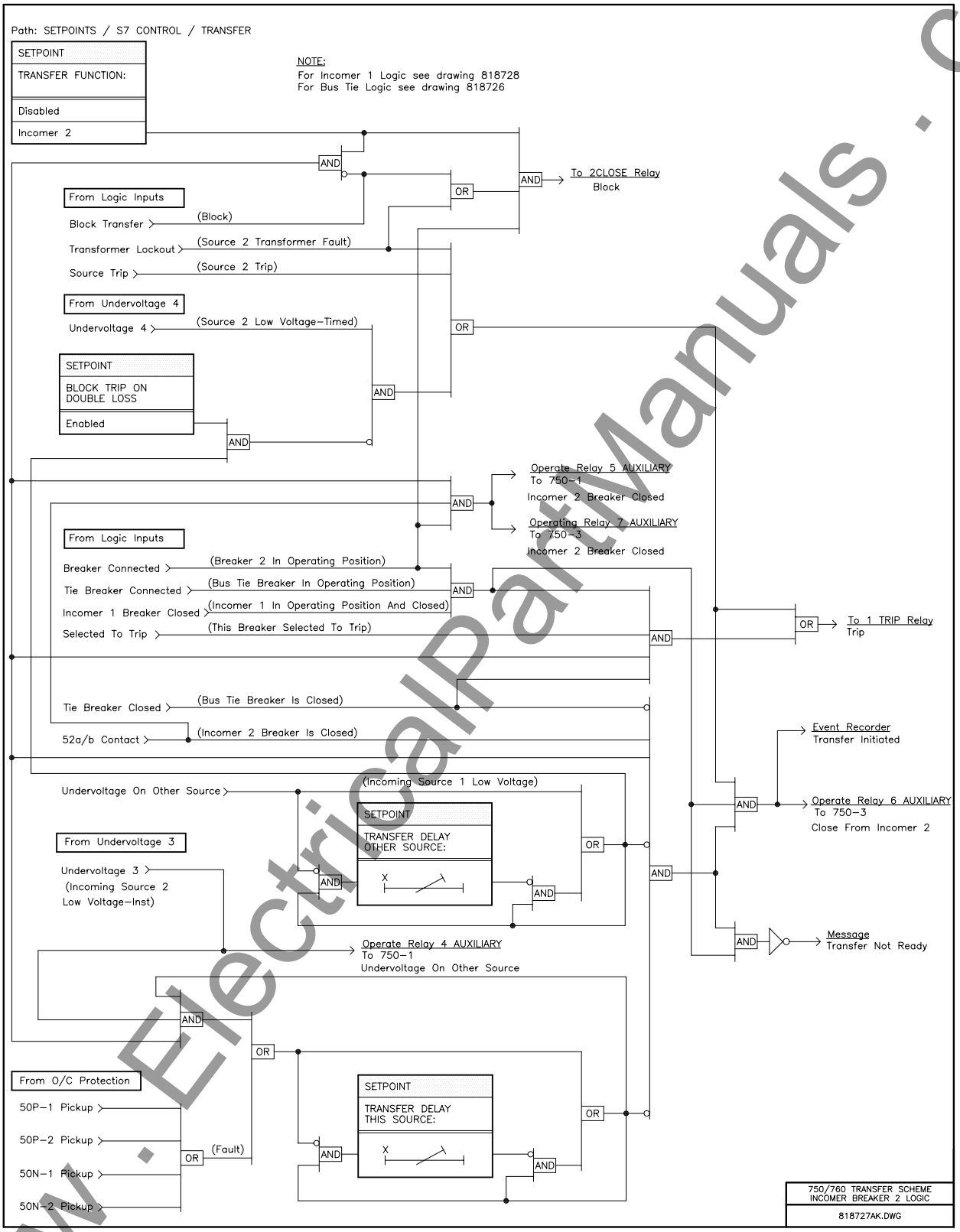


Figure 14–15: TRANSFER SCHEME INCOMER NO. 2 LOGIC DIAGRAM

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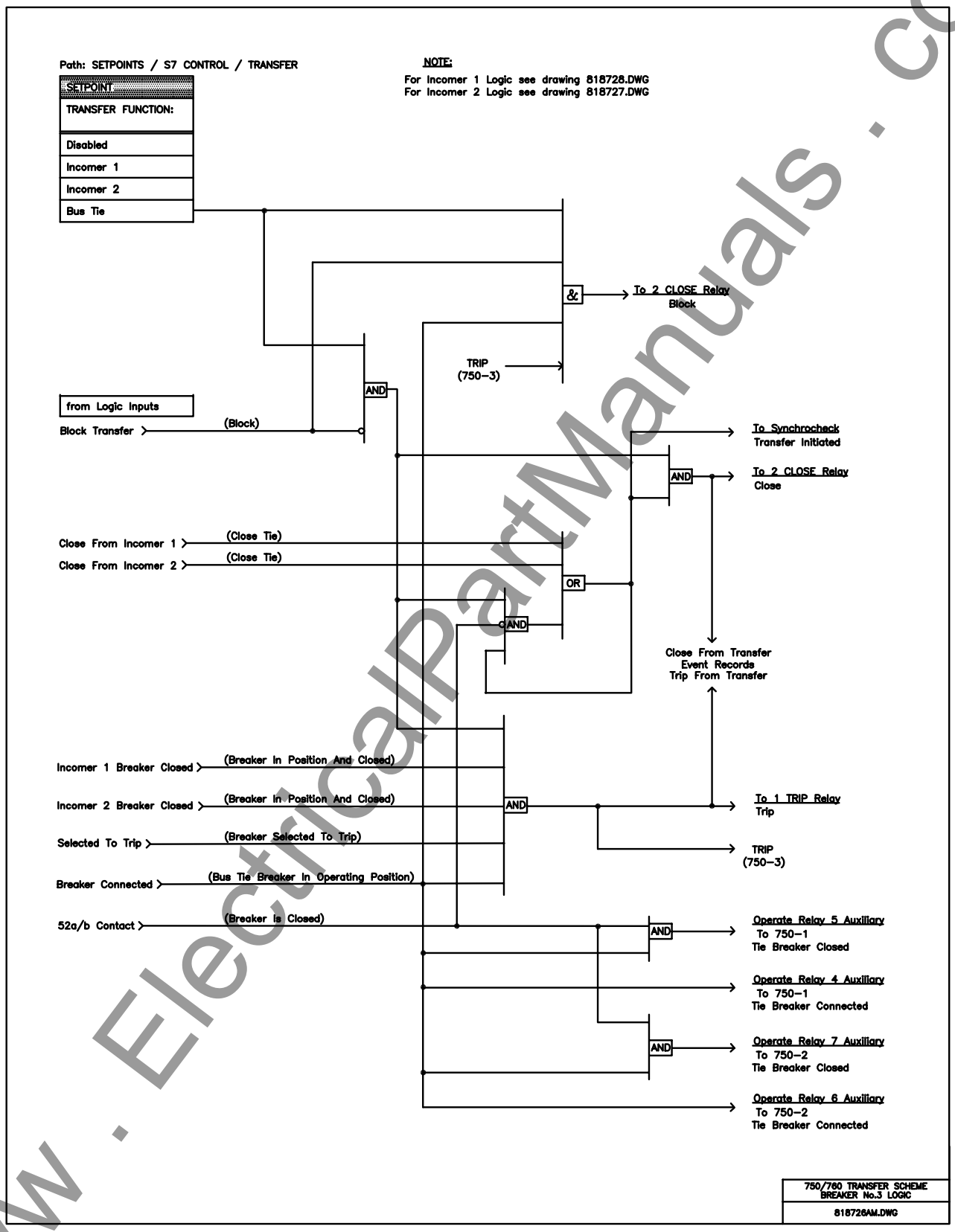


Figure 14–16: TRANSFER SCHEME BUS TIE BREAKER LOGIC DIAGRAM

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14.8.1 DESCRIPTION

The 760 has a very flexible autoreclose scheme that allows for the many different control strategies typical of utility applications. Up to four reclosure 'shots' are possible with separately programmable 'dead times' for each shot. Reclosure can be initiated from any 760 overcurrent element or from external sources. Between each shot, overcurrent protection settings can be adjusted in order to co-ordinate with downstream devices. To prevent breaker wear, a 'current supervision' feature can reduce the number of shots when the fault current is high. A 'zone co-ordination' feature can maintain protection coordination with downstream reclosers. Logic inputs are available for blocking and disabling the scheme.

Front panel LEDs indicate the present state of the autoreclose scheme. Note that display message group **A1 STATUS \ AUTORECLOSE** can also be accessed to determine the present state of the autoreclose scheme.

RECLOSURE ENABLED: The scheme is enabled and may reclose if a trip occurs.

RECLOSURE DISABLED: The scheme is not enabled and will not reclose until the scheme is enabled.

RECLOSURE IN PROGRESS: An autoreclosure has been initiated but the breaker has not yet been closed.

RECLOSURE LOCKOUT: The scheme has gone to 'lockout' and must be reset before further recloses are permitted.

The reclosure scheme is considered enabled when all of the following conditions are true:

1. The **AUTORECLOSURE FUNCTION** setpoint is set to *Enabled*.
2. Either a 52a or 52b contact is installed and has been programmed to a logic input function.
3. Neither the 'Block Reclosure' nor 'Cancel Reclosure' logic input functions are asserted.
4. The scheme is not in the lockout state.
5. The **AR BLOCK TIME UPON MANUAL CLOSE** timer is not active.

Following is a simplified description of how the autoreclose scheme works. See the application example section and logic diagrams at the end of this section for further details.

A fault occurs resulting in an overcurrent element tripping the circuit breaker and initiating a reclosure. Once the breaker is detected open a 'dead timer' is started. Once this timer exceeds the value programmed for the reclosure 1 setpoint **DEADTIME BEFORE RECLOSURE**, the shot counter is incremented and a breaker closure is initiated using the '2 Close' output contact. At the same time, overcurrent element characteristics are modified according to the reclosure 1 setpoints.

If the fault is permanent, subsequent overcurrent element(s) will trip and initiate reclosure. The scheme will eventually go to lockout when the **MAXIMUM NUMBER OF RECLOSURE SHOTS** has been met and another trip occurs. If a breaker failure condition is detected at any time during operation, the scheme will again go straight to lockout. When in lockout, the 760 disables the reclose scheme and returns all protection settings to their initial values. To re-enable the autoreclose scheme the relay must be reset via the front panel reset key, the 'Reset' logic input function, communications, or by a manual close operation. The latter resets the scheme only after the **AR BLOCK TIME UPON MANUAL CLOSE** timer expires, and no overcurrent elements are picked up.

If the fault is transient in nature then no overcurrent element(s) will trip after the breaker has closed. The scheme will automatically reset when the reset timer, started upon the first reclosure initiation, exceeds the setpoint **AUTORECLOSE RESET TIME**. This autoreclosure reset returns the shot counter to zero and all protection settings to their initial values.

An **anti-pumping** feature is built into the reset mechanism. Otherwise, breaker 'pumping' could occur when the fault level is between the initial overcurrent pickup level and the adjusted overcurrent pickup level for a reclosure shot. It prevents a permanent fault from continuously repeating the trip breaker, initiate reclose, close breaker, automatic reset of autoreclose scheme, trip breaker sequence. If this condition is detected the anti-pumping feature returns protection settings to their initial values without resetting the shot counter. The relay will then continue to trip and reclose until lockout is reached.

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14.8.2 SCHEME SETUP

The setpoints shown in this section setup the general characteristics of the scheme. The **AUTORECLOSE FUNCTION** and **MAXIMUM NUMBER OF RECLOSURE SHOTS** setpoints are critical and must be set appropriately.

NOTE: For an overcurrent element to initiate a reclosure it must be set to the 'Trip & AR' function.

■ SCHEME SETUP ■ [ENTER] for more	The Autoreclose Scheme Setup setpoints path is: **\ SETPOINTS \ S7 CONTROL \ AUTORECLOSE \ SCHEME SETUP**
AUTORECLOSE FUNCTION: Disabled	*Range: Enabled, Disabled* Enter *Enabled* to enable the autoreclose scheme.
MAXIMUM NUMBER OF RECLOSURE SHOTS: 1	*Range: 1 to 4 in steps of 1* Specify the number of reclosures that should be attempted before reclosure lockout occurs. The dead time and overcurrent characteristics for each reclosure shot are entered in the subsequent message groups RECLOSURE 1-4.
AUTORECLOSE RESET TIME: 60 s	*Range: 1 to 1000 in steps of 1 s* The reset timer is used to set the total time interval for a single fault event, from the first trip until either lockout or successful reclosure. Generally, this setpoint is set to the same delay that would be used for the 'reclaim time' in a traditional scheme with fixed protection settings. This time must be set to a value greater than the sum of all programmed dead times plus the maximum time to trip on each reclose shot. **NOTE: Set this timer to a delay longer than the incomplete sequence timer.**
AR BLOCK TIME UPON MANUAL CLOSE: 10 s	*Range: 0 to 200 in steps of 1 s* The autoreclose scheme can be disabled for a programmable time delay after the associated circuit breaker is manually closed. This prevents manual reclosing onto a fault. This delay must be longer than the slowest expected trip from any protection not blocked after manual closing. If no overcurrent trips occur after a manual close and this timer expires, the autoreclose scheme is automatically reset. The lockout state will be cleared and the shot counter will be set to zero. Note that manual circuit breaker closures can be initiated by either the front panel breaker CLOSE key when in local mode, or by the REMOTE CLOSE logic input and computer communications when in remote mode.

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AR EXTERNAL CLOSE LOGIC: Disabled	*Range: Enabled, Disabled* For applications where the breaker may be closed directly, without using the 760 to provide the closing signal to the breaker, enabling this setpoint will use breaker state to determine if a manual close has occurred. The 760 uses the detection of a manual close to disable the autoreclose scheme to prevent reclosing onto a fault. Also, if the Autoreclose scheme is in the lockout state, a successful manual close would result in the autoreclose scheme being automatically reset after the **AR BLOCK TIME UPON MANUAL CLOSE** time has expired. When *Enabled*, this setpoint uses the detection of the breaker going from the open state to the closed state to determine if a manual close has occurred. The breaker state is determined by the 52a/b contact feedback to the 760. When *Disabled*, only close commands sent via the 760 will be considered as a manual close for the autoreclose scheme logic.
INCOMPLETE SEQUENCE TIME: 30 s	*Range: 1 to 1000 in steps of 1 s* This timer is used to set the maximum time interval allowed for a single reclose shot. It is started whenever a reclosure is initiated and is active when the scheme is in the 'Reclosure In Progress' state. If all conditions allowing a breaker closure are not satisfied when this timer expires, the reclosure initiation is abandoned. Any combinations of the following conditions block the breaker from closing. Breaker status logic inputs (52a or 52b contact) fail to report the breaker has opened. The 'Block 2 Close Relay' logic input function is asserted. The synchrocheck feature is blocking breaker closes. **NOTE: This timer must be set to a delay less than the autoreclose reset timer.**
RECLOSURE ENABLED RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the relays required to operate while the front panel RECLOSURE ENABLED indicator is on.
RECLOSER IN PROGRESS RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the relays required to operate while the front panel RECLOSURE IN PROGRESS indicator is on. This indicator is on when the autoreclose scheme has been initiated, but has not yet sent a close command. This output could be used to block the operation of a transformer tap changer during a reclosure sequence.
RECLOSURE LOCKOUT RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the relays required to operate while the front panel RECLOSURE LOCKOUT indicator is on. This indicator is on when the autoreclose scheme has progressed to a lockout condition, such that no further breaker closures will be initiated until the 760 has been reset.

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14.8.3 AUTORECLOSE RATE SUPERVISION

The autoreclose rate supervision feature monitors the number of recloses per hour.

Once the number of recloses within one hour exceeds the **MAX AUTORECLOSE RATE** setpoint, the autoreclose scheme is sent to lockout.

■ RATE SUPERVISION ■ [ENTER] for more	The Autoreclose Rate Supervision setpoints path is: **\ SETPOINTS \ S7 CONTROL \ AUTORECLOSE \ RATE SUPERVISION**
RATE SUPERVISION FUNCTION: Disabled	*Range: Disabled, Alarm, Latched Alarm, Control* Enables or disables the autoreclose rate supervision scheme.
RATE SUPERVISION RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the relays required to operate when the Autoreclose Rate Supervision element operates.
MAX AUTORECLOSE RATE: 25 /hr	*Range: 1 to 50 in steps of 1 /hr* Selects the maximum number of reclosures that can occur in one hour before the Autoreclose scheme will go to lockout.

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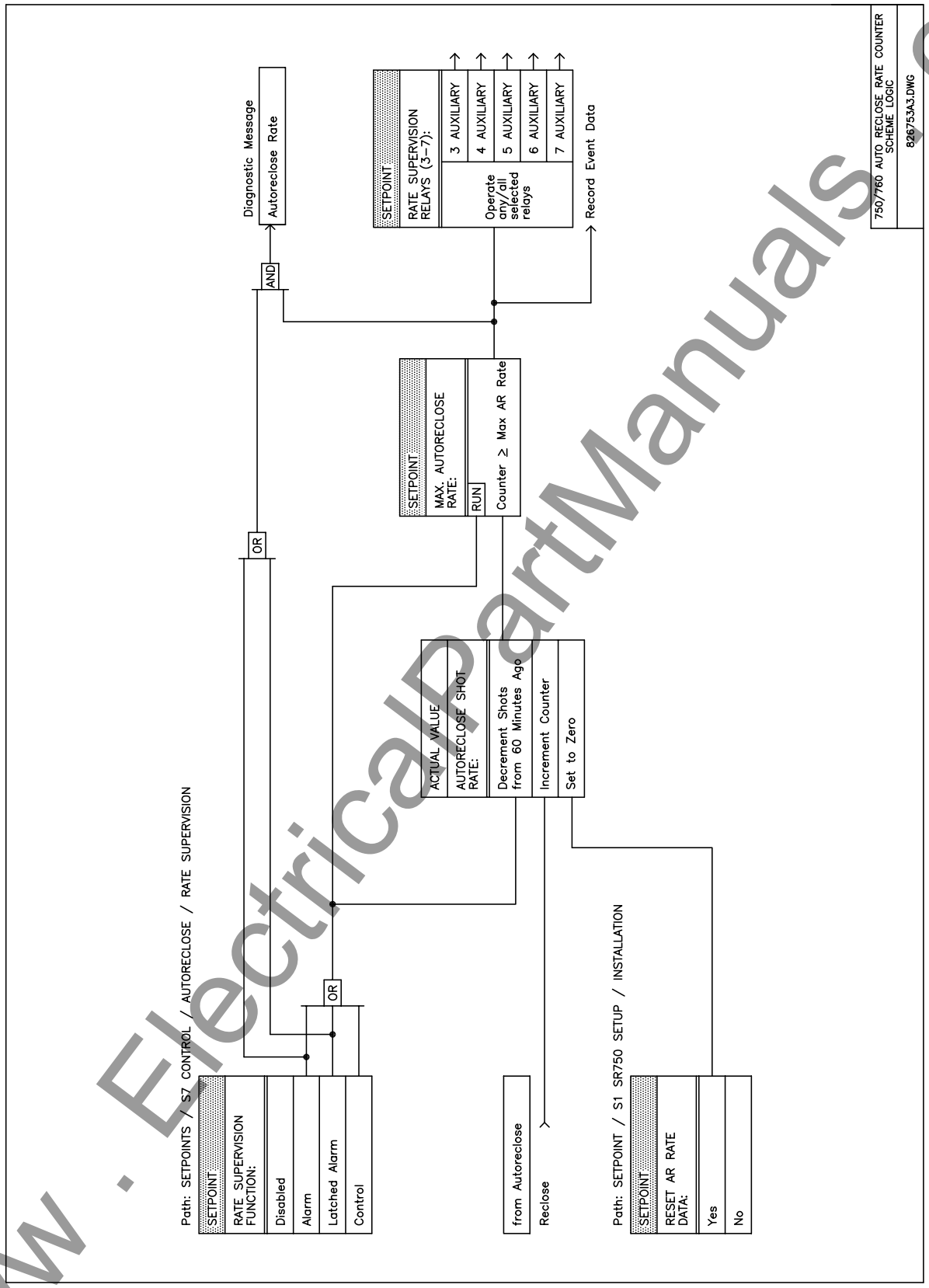


Figure 14–17: AUTORECLOSE RATE SUPERVISION LOGIC DIAGRAM

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14.8.4 AUTORECLOSE CURRENT SUPERVISION

The current supervision feature is used to limit breaker wear. When fault current exceeds user-programmed levels, it reduces the number of reclose shots permitted.

Once a reclose sequence is initiated, the maximum current measured on any phase is compared to the setpoint current levels. The relay then determines the maximum number of shots allowed or whether the scheme goes immediately to lockout. The lowest number of permitted shots, whether set by the **MAXIMUM NUMBER OF RECLOSE SHOTS** setpoint or the current supervision feature, always takes precedence unless current supervision takes the scheme to lockout. Lockout has the highest priority. Once the current supervision feature has reduced the total number of shots, a subsequent shot can still reduce the limit further.

■ CURRENT SUPERVSION ■ [ENTER] for more	The Autoreclose Current Supervision setpoints path is: **\ SETPOINTS \ S7 CONTROL \ AUTORECLOSE \ CURRENT SUPERVSION**
CURRENT SUPERVISION FUNCTION: Disabled	*Range: Enabled, Disabled* Enables or disables the autoreclose current supervision scheme.
3 SHOTS FOR CURRENT ABOVE: 17.00 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Selects the fault current level above which the number of autoreclose shots will be reduced to three.
2 SHOTS FOR CURRENT ABOVE: 18.00 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Selects the fault current level above which the number of autoreclose shots will be reduced to two.
1 SHOT FOR CURRENT ABOVE: 19.00 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Selects the fault current level above which the number of autoreclose shots will be reduced to one.
CURRENT SUPERVISION TO LOCKOUT: Disabled	*Range: Enabled, Disabled* If the autoreclose scheme is to be taken directly to lockout without reclosing, set this setpoint to Enabled.
LOCKOUT FOR CURRENT ABOVE: 20.00 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Selects the fault current level above which the autoreclose scheme will go to lockout.

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14.8.5 AUTORECLOSE ZONE COORDINATION

The 760 autoreclose scheme can be programmed to maintain coordination of overcurrent elements with a downstream recloser. If a downstream recloser is programmed to use different protection settings for different reclose shots, it may be necessary to change the protection settings on the 760 each time the recloser operates. To ensure that protection coordination is maintained, each 760 reclosure shot must be coordinated with each downstream recloser shot. In addition, the 760 reclose shot counter must always match the recloser shot counter. When a fault occurs downstream of the recloser and the 760 feeder breaker does not trip and reclose, the 760 reclosure shot counter must still be incremented.

Once enabled, this scheme assumes an external reclose operation has occurred when the feeder phase or neutral current exhibits a step increase in magnitude, due to fault current, followed by a step decrease in magnitude, due to a recloser opening. After the first detection of an external reclose, the shot counter is incremented by one, protection settings are changed, and the autoreclose scheme reset timer is initiated.

If the fault is permanent and the recloser continues to trip and reclose, the coordination feature will continue to increment the shot counter. If this continues to the maximum number of shots programmed in the 760, the autoreclose scheme will go to lockout.

If the fault is transient, then the autoreclose scheme and shot counter will eventually be reset by the normal reset mechanism.

NOTE

For correct operation of the coordination scheme, the 760 instantaneous protection elements must be set to have time delays longer than the maximum fault clearing time of the downstream recloser. In addition, the autoreclose reset timer must be set longer than the maximum time for the recloser to reach lockout.

■ ZONE COORDINATION ■ [ENTER] for more	The Autoreclose Zone Coordination setpoints path is: **\ SETPOINTS \ S7 CONTROL \ AUTORECLOSE \ ZONE COORDINATION**
ZONE COORDINATION FUNCTION: Disabled	*Range: Enabled, Disabled* Enables or disables the autoreclose zone coordination scheme.
PHASE CURRENT INCREASE: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* This setting selects the minimum phase current step increase that signifies a downstream fault. This current may be quite low for an end fault on a long feeder with a weak source.
NEUTRAL CURRENT INCREASE: 1.00 x CT	*Range: 0.05 to 20.00 in steps of 0.01 x CT* This setting selects the minimum neutral current step increase that signifies a downstream fault. This current may be quite low for an end fault on a long feeder with a weak source.
MAX FAULT CLEARING TIME: 10 s	*Range: 1 to 1000 in steps of 1 s* This setting is intended to reset the memory of an increasing current caused by an increase in feeder load since the new load current will not drop to operate the decreasing current detector. This delay must be set longer than the maximum fault clearing time on the recloser.

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14.8.6 RECLOSURE SHOTS 1 TO 4

The following setpoints are programmed independently and are repeated for each of the Reclosure Shots 1-4. These setpoints determine the dead time for a given shot and the overcurrent characteristics during that shot. Selections for shots, that are greater than the maximum number of shots programmed in the scheme setup, will not be used by the scheme.

■ RECLOSURE 1 ■ [ENTER] for more	The Reclosure 1 setpoints path is: **\ SETPOINTS \ S7 CONTROL \ AUTORECLOSE \ RECLOSURE 1**
DEADTIME BEFORE RECLOSURE: 0.50 s	*Range: 0.00 to 300.00 in steps of 0.01 s* Once the reclosure sequence has been initiated, selects the amount of time to wait before closing the breaker.
PHASE INST OC 1 BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block the Phase Instantaneous O/C 1 element while the reclose shot is in effect.
NEUTRAL INST OC 1 BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block the Neutral Instantaneous O/C 1 element while the reclose shot is in effect.
GROUND INST OC BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block the Ground Instantaneous O/C element while the reclose shot is in effect.
SENSTV GND INST OC BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block the Sensitive Ground Instantaneous O/C element while the reclose shot is in effect.
NEG SEQ INST OC BLOCKING: Disabled	*Range: Disabled, Enabled* Enable to block Negative Sequence Instantaneous O/C while the reclose shot is in effect.
PHASE TIME OC 1 RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Phase Time O/C 1 element while the reclose shot is in effect.
NEUTRAL TIME OC 1 RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Neutral Time O/C 1 element while the reclose shot is in effect.
GROUND TIME OC RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Ground Time O/C element while the reclose shot is in effect.
SENSTV GND TIME OC RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Sensitive Ground Time O/C element while the reclose shot is in effect.
NEG SEQ TIME OC RAISED PICKUP: 0%	*Range: 0 to 100 in steps of 1%* Selects the amount to raise the pickup level for the Negative Sequence Time O/C element while the reclose shot is in effect.
SELECT SETPOINT GROUP: Active	*Range: Group 1, Group 2, Group 3, Group 4, Active Group* Select the setpoint group that will be used while the reclose shot is in effect. If *Active Group* is selected then the active setpoint group is not affected. This setpoint provides enormous flexibility in the autoreclose scheme.

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14.8.7 APPLICATION EXAMPLE

Utility statistics indicate that a large percentage of feeder faults (about 80%) are of a transient nature. Typically, once the feeder is tripped an autorecloser automatically recloses the feeder breaker after a short time delay. If the fault was transient, the entire feeder is returned to normal service and customers experience a very short disturbance. If the fault is permanent and on the load side of another protection point, the reclosure scheme delays another trip of the breaker until this other device clears the fault so that service is disrupted only for loads beyond this other protection point.

A common phase protection scheme uses instantaneous elements in conjunction with automatic reclosing. The design goal is to select settings that will detect faults out to the most distant (in impedance terms) point of the feeder and provide fast operation. Typically 'loset' overcurrent elements are programmed to be blocked after the first reclosure. This gives downstream devices, such as fuses, time to interrupt a permanent fault, especially on a feeder tap. Loset elements would then be re-enabled after the scheme is reset. 'Hiset' elements may also be blocked on a subsequent shot with a faster time overcurrent curve selected to allow the fault to burn off. In this case a permanent fault would then cause a time overcurrent trip.

A typical autoreclose scheme as implemented in the 760 would respond to faults as follows:

1. With the breaker closed and protection enabled, a transient fault produces a current above the pickup of both Instantaneous OC 1(loset) and Time OC 1 elements.
2. The Time OC element begins to time, and the Instantaneous OC element operates, signaling the breaker to trip and initiate a reclosure.
3. The breaker trips and signals the autoreclose scheme that it is now open. The Instantaneous OC 1 and Time OC 1 elements automatically reset because the breaker is open.
4. If all requirements of the autoreclose scheme are fulfilled, autoreclose signals the breaker to close and advances the shot counter. Shot 1 settings block the Instantaneous OC element from further operation.
5. The breaker closes resulting in an inrush current of the feeder loads.
6. If the fault was transient, the current reduces to the load level before a trip occurs. The autoreclose scheme eventually resets and the cycle begins again at step 1.
7. If the fault is permanent, a current above the pickup of both the Instantaneous OC 1 and the Time OC 1 elements is produced. However, the Instantaneous OC 1 element is blocked from operating.
8. While the Time OC 1 element is timing, any protection devices between this relay and the fault location are provided an opportunity to isolate the fault.
9. If no protection downstream from the relay clears the fault, the Time OC 1 element will time-out, signaling the breaker to trip and initiate the autoreclose scheme again.
10. If the shot counter has not reached its maximum allowed value then the cycle begins at step 6 using protection settings for the current shot.
11. If the shot counter has reached its maximum then the scheme goes to lockout.

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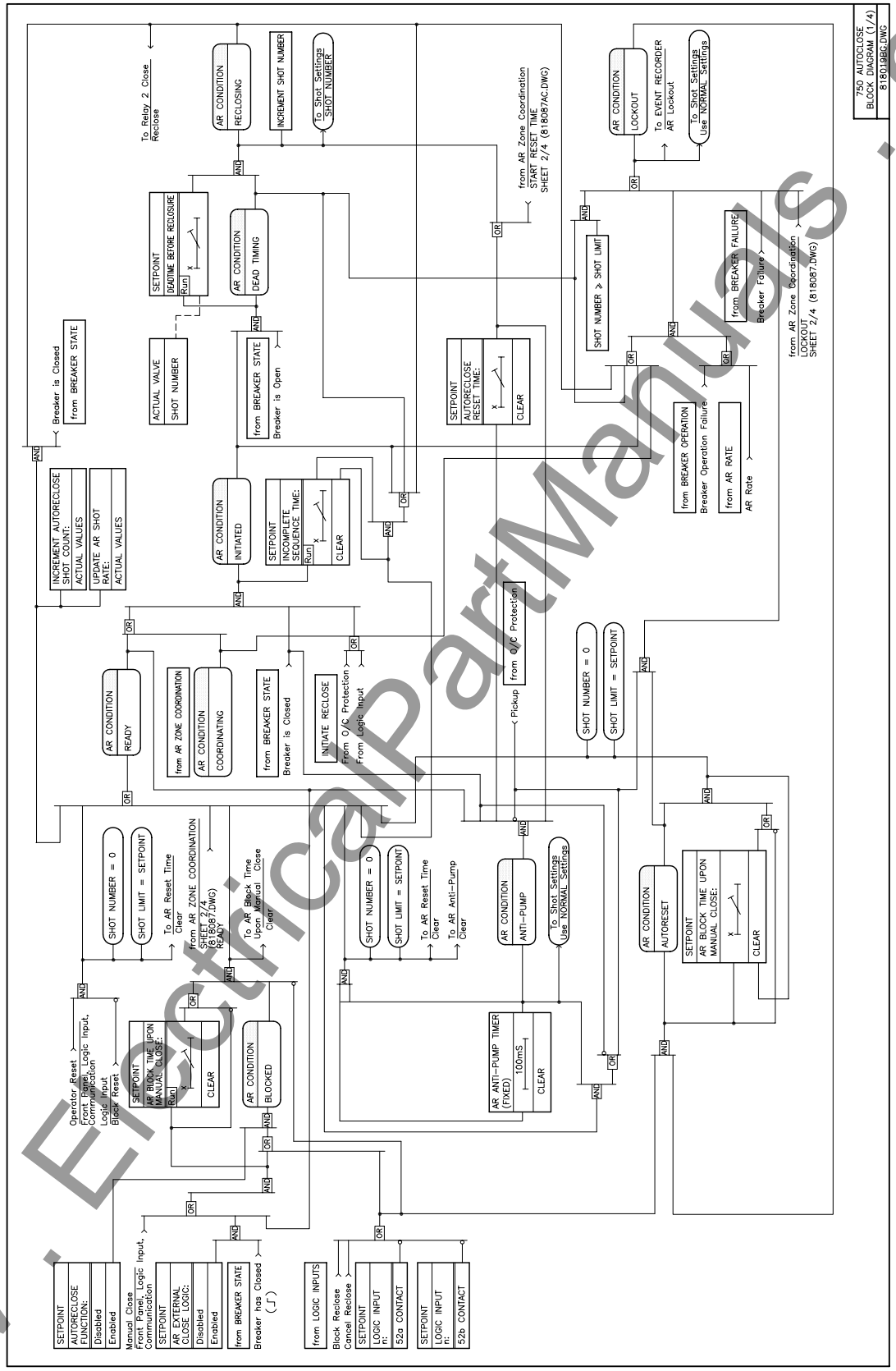


Figure 14–18: AUTORECLOSE LOGIC DIAGRAM (1 OF 4)

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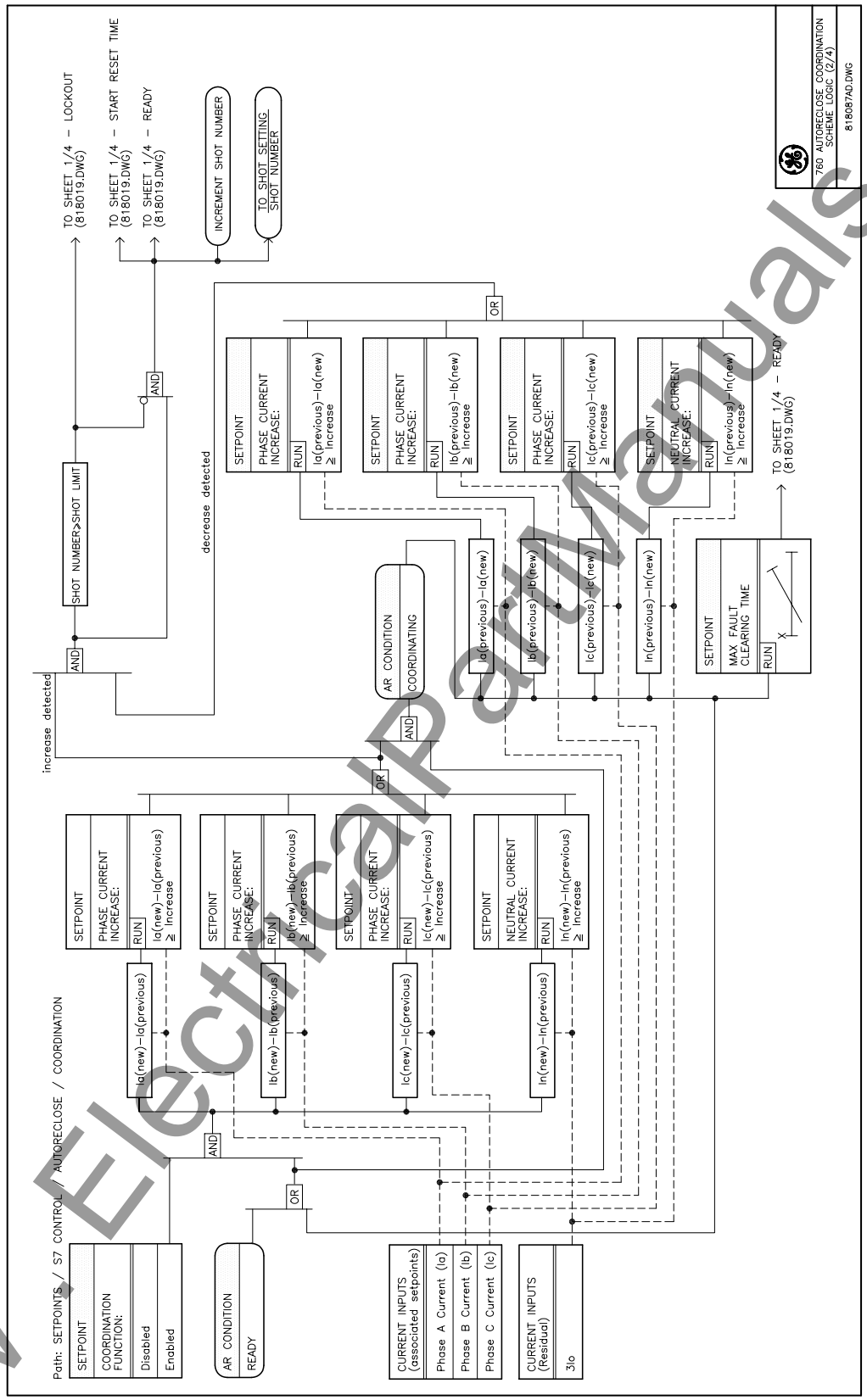


Figure 14–19: AUTORECLOSE LOGIC DIAGRAM (2 OF 4)

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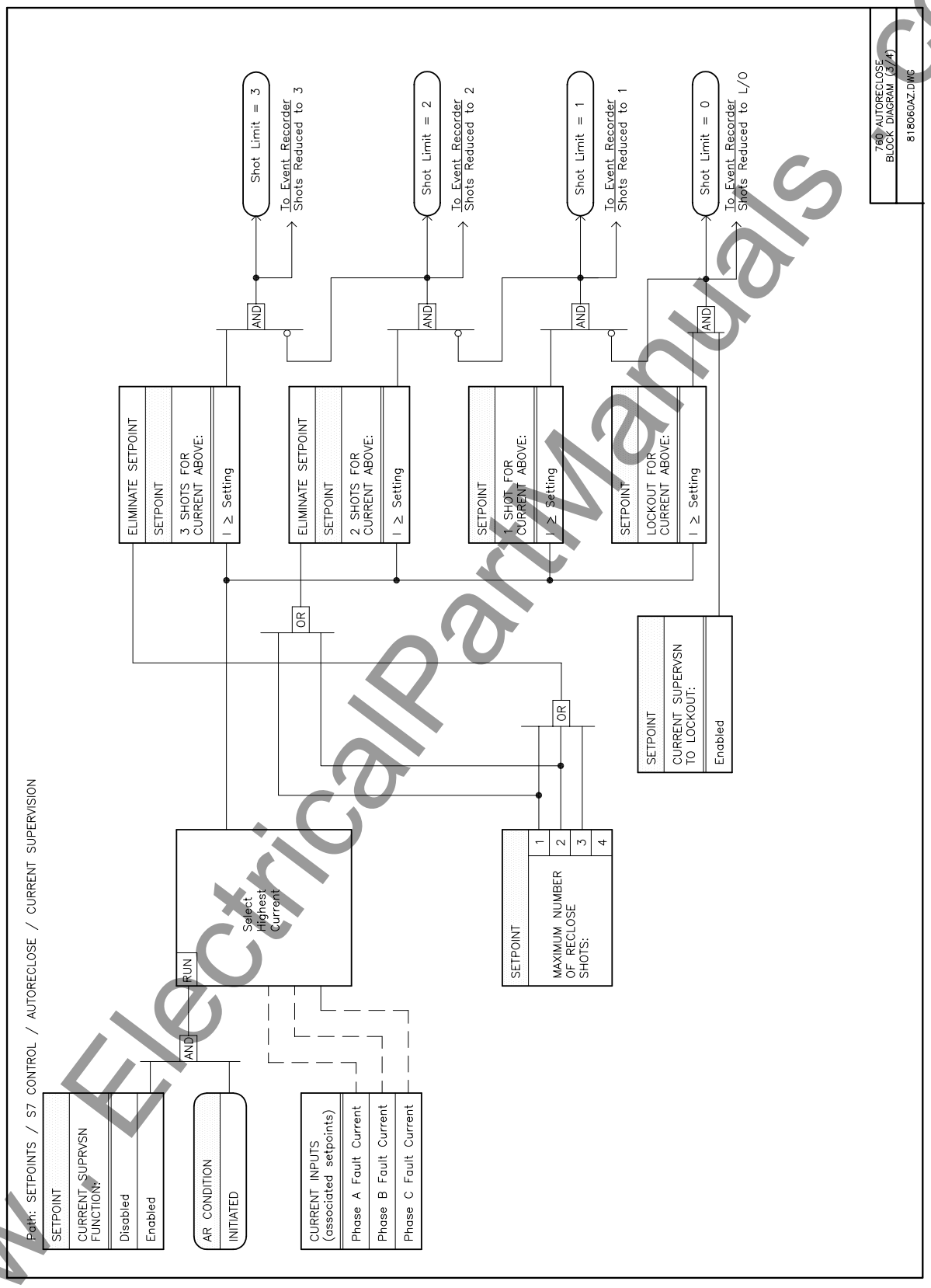


Figure 14–20: AUTORECLOSE LOGIC DIAGRAM (3 OF 4)

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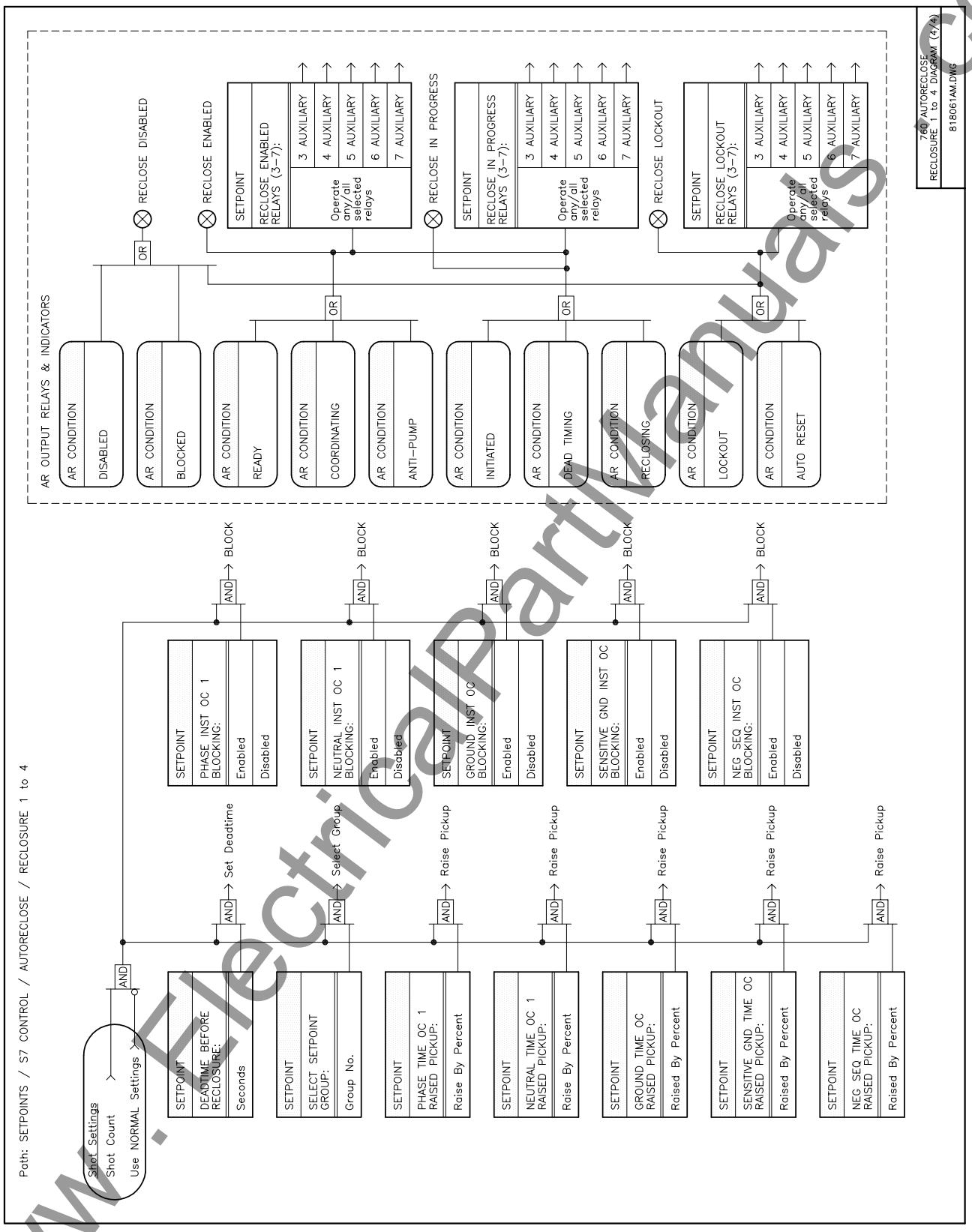


Figure 14–21: AUTORECLOSE LOGIC DIAGRAM (4 OF 4)

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15.1.1 DESCRIPTION

For testing purposes, the relay provides the ability to override the normal function of the solid state and output contacts. This is done by forcing each to energize or de-energize.

15.1.2 SETPOINTS

■ OUTPUT RELAYS ■ [ENTER] for more	The **OUTPUT RELAYS** setpoints path is: **\ SETPOINTS \ S8 TESTING \ OUTPUT RELAYS**
FORCE OUTPUT RELAYS FUNCTION: Disabled	*Range: Enabled, Disabled* Select *Enabled* to override the normal operation of the solid state and output contacts, with the state programmed in the messages that follow. Note that this setpoint will always be defaulted to the *Disabled* state at power up.
FORCE 1 TRIP RELAY: De-energized	*Range: Energized, De-energized* Select *De-energized* to force the 1 TRIP relay to the de-energized state while the setpoint **FORCE OUTPUT RELAYS FUNCTION** is set to *Enabled*. Select *Energized* to force the 1 TRIP relay to the energized state while the setpoint **FORCE OUTPUT RELAYS FUNCTION** is set to *Enabled*.
FORCE 2 CLOSE RELAY: De-energized	*Range: Energized, De-energized* Force the 2 CLOSE relay state as per the 1 TRIP relay.
FORCE 3 AUXILIARY RELAY: De-energized	*Range: Energized, De-energized* Force the 3 AUXILIARY relay state as per the 1 TRIP relay.
FORCE 4 AUXILIARY RELAY: De-energized	*Range: Energized, De-energized* Force the 4 AUXILIARY relay state as per the 1 TRIP relay.
FORCE 5 AUXILIARY RELAY: De-energized	*Range: Energized, De-energized* Force the 5 AUXILIARY relay state as per the 1 TRIP relay.
FORCE 6 AUXILIARY RELAY: De-energized	*Range: Energized, De-energized* Force the 6 AUXILIARY relay state as per the 1 TRIP relay.
FORCE 7 AUXILIARY RELAY: De-energized	*Range: Energized, De-energized* Force the 7 AUXILIARY relay state as per the 1 TRIP relay.
FORCE 8 SELF-TEST RELAY: De-energized	*Range: Energized, De-energized* Force the 8 SELF-TEST WARNING relay state as per the 1 TRIP relay.
FORCE SOLID STATE OUTPUT: De-energized	*Range: Energized, De-energized* Force the solid state output as per the 1 TRIP relay.

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15.2.1 DESCRIPTION

The relay provides the ability to operate any or all of the output relays 3-7 AUXILIARY, upon the pickup of any protection element. The pickup test feature is especially useful for automated testing. Through a 750/760 output contact, test equipment can monitor a pickup threshold.

15.2.2 SETPOINTS

■ PICKUP TEST ■ [ENTER] for more	The **PICKUP TEST** setpoints path is: **\ SETPOINTS \ S8 TESTING \ PICKUP TEST**
PICKUP TEST FUNCTION: Disabled	*Range: Enabled, Disabled* Select *Enabled* if the pickup of any sensing element, shown in Figure 15–1: PICKUP TEST LOGIC DIAGRAM on page 15–3, is required to be directed to an output relay. Note that this setpoint will always be defaulted to *Disabled* at power up.
PICKUP TEST RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Select the required relays to signal an output when any of the protection elements, or any of the permitted monitoring elements, senses a parameter above its pickup threshold.

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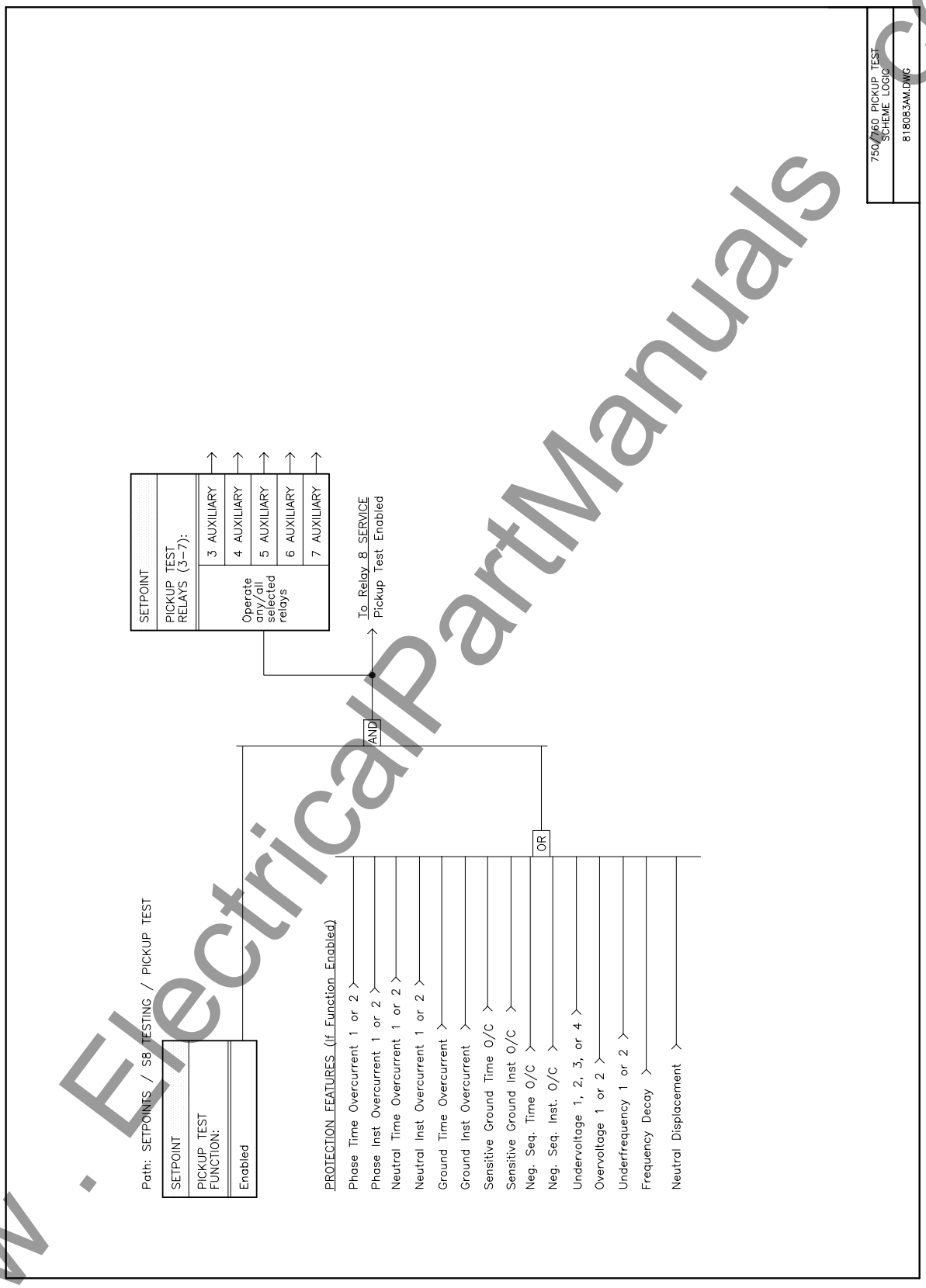


Figure 15–1: PICKUP TEST LOGIC DIAGRAM

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15.3.1 DESCRIPTION

The relay provides the ability to override the normal function of analog outputs, forcing each to any level from 0 to 100% of the output range.

15.3.2 SETPOINTS

■ ANALOG OUTPUTS ■ [ENTER] for more	The **ANALOG OUTPUTS** setpoints path is: **\ SETPOINTS \ S8 TESTING \ ANALOG OUTPUTS**
FORCE ANALOG OUTPUTS FUNCTION: Disabled	*Range: Enabled, Disabled* Select *Enabled* to override the normal operation of the analog outputs to the level programmed in the messages that follow. Note that this setpoint will always be defaulted to the *Disabled* state at power up.
FORCE ANALOG OUT 1: 0 %	*Range: 0 to 100 in steps of 1%* Enter the percentage of the DC mA output range to be signaled by the analog output #1 (2–8) when the setpoint **FORCE ANALOG OUTPUTS FUNCTION** is set to *Enabled*. For example, if the relay has been ordered with 4-20 mA analog outputs, setting this value to *100%* will output 20 mA, *0%* will output 4 mA, and *50%* will output 12 mA. This setting is repeated for **FORCE ANALOG OUT 1** through **FORCE ANALOG OUT 8**.

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15.4.1 DESCRIPTION

CAUTION

WHEN IN SIMULATION MODE, THE NORMAL PROTECTION AND CONTROL FEATURES ARE NOT OPERATIONAL. THIS IS INDICATED BY THE '8 SELF-TEST WARNING' RELAY BEING DE-ENERGIZED. IF SIMULATION MODE IS USED FOR FIELD TESTING ON EQUIPMENT, THE OPERATOR MUST PROVIDE OTHER MEANS OF PROTECTION AND CONTROL.

A simulation feature is provided for testing the functionality of the relay in response to program conditions, without the need of external AC voltage and current inputs. First time users will find this to be a valuable training tool. System parameters such as currents and voltages, phase angles, and system frequency are entered as setpoints. When placed in simulation mode, the relay suspends reading actual AC inputs, generates samples to represent the programmed phasors, and loads these samples into the memory to be processed by the relay. Both normal and fault conditions can be simulated to exercise a variety of relay features. There are three sets of input parameters used during simulation, each providing a particular state of the system, as shown below:

Prefault State: This state simulates the normal operating condition of a feeder carrying load current, by replacing the normal input parameters with programmed prefault values. Voltages are automatically set to the nominal value programmed in the **BUS VT NOMINAL SECONDARY VOLTAGE** setpoint. The neutral current is set to zero. Phase currents are balanced and set to the value programmed in the **PREFAULT PHASE A/B/C CURRENT** setpoint. The phase angle of each phase current relative to its corresponding phase neutral voltage is set to the value programmed in the **PREFAULT POWER FACTOR ANGLE** setpoint. The frequency of voltages and currents are automatically set to the values programmed in the **NOMINAL FREQUENCY** setpoint.

Fault State: This state simulates the faulted operating condition of a feeder by replacing the normal prefault feeder input parameters with programmed fault values. The magnitude and angle of each bus voltage and current, polarizing current, system frequency and analog input are set to the values programmed under the **FAULT VALUES** setpoints. The neutral current is calculated from the vector sum of the phase currents, and $3V_0$ from the vector sum of the phase voltages.

Postfault State: This state is intended to simulate a feeder that has tripped. Current is automatically set to 0 amps. Bus voltages are automatically balanced and set to phase A-N at 0°, B-N at 120° and C-N at 240°. The bus voltage magnitude and frequency are set to the entered values. The synchronizing voltage is set to the entered values of magnitude, angle (with respect to phase A-N bus voltage) and frequency.

There are two methods of running simulations. If the feeder circuit breaker is connected to the relay and can be opened and closed, a full operating sequence can be performed. If a breaker is not available, as is often the case, the relay can be made to simulate a breaker and allow the 760 to exercise its autoreclose feature. The operation of each method is described below.

1. If simulation of the feeder breaker is required set the **CIRCUIT BREAKER SIMULATION** setpoint to *Enabled*. After the required simulation setpoints have been entered, the relay is placed in the Prefault State by setting the **SIMULATION STATE** setpoint to *Prefault*. The relay replaces the normal AC inputs with those programmed on the **PREFAULT VALUES** setpoint page. Logic inputs, except for the 52a and 52b contacts, are monitored normally throughout the simulation. The relay's simulation of a circuit breaker is indicated by the status of the Breaker Open and Breaker Closed front panel indicators.

   The relay remains in the Prefault State until a command is received to enter the Fault State, either by (a) setting the **SIMULATION STATE** setpoint to the *Fault State*, or (b) a contact closure on a logic input whose function setpoint is set to *Simulate Fault*. The logic input makes the measurement of feature operating times possible when output relays are allowed to operate.

   In the *Fault State*, relay features respond to the programmed fault values, generating a trip, alarms, event records, triggers of trace memory and data logger, and front panel indications as necessary. Output relays only operate if permitted by the **ALLOW OPERATION OF RELAYS (3-7)** setpoint. The relay remains in the *Fault State* until it has detected a trip condition. Note that the 1 TRIP relay is not allowed to operate. At this time the simulated breaker is opened (as indicated by front panel indicators) and the relay is placed in *Postfault State*.

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The relay remains in the *Postfault State* until either a close command is sent to the relay, or the 760 autoreclose scheme has all requirements met and is ready to close. At this time the relay returns to the *Prefault State*. Note that the 2 CLOSE relay is not allowed to operate. Setting the **SIMULATION STATE** setpoint to *Disabled* also terminates simulation.

2. If simulation of the feeder breaker is not required set the **CIRCUIT BREAKER SIMULATION** setpoint to *Disabled*. After the required simulation setpoints have been entered, the relay is placed in simulation mode by setting the **SIMULATION STATE** setpoint to *Prefault*. The relay replaces the normal AC inputs with those programmed on the **PREFAULT VALUES** setpoint page. All logic inputs are monitored normally throughout the simulation including any set to monitor the 52a/52b contacts by which the front panel Breaker Open and Breaker Closed indicators are set.

   Operation is similar to that described in (1) above except that the 1 TRIP relay will operate if a trip condition is declared and the 2 CLOSE relay will operate in response to any form of close request. As well, the Simulation State is controlled by the monitored state of the breaker.

15.4.2 SETUP

■ SETUP ■ [ENTER] for more	The **SIMULATION SETUP** setpoints path is: **\ SETPOINTS \ S8 TESTING \ SIMULATION \ SETUP**
SIMULATION STATE: Disabled	*Range: Disabled, Prefault, Fault, Postfault* This setpoint must be programmed to *Disabled* if actual system inputs are to be monitored. If programmed to any other setting, the relay is in simulation mode and actual system parameters are not monitored. The system parameters simulated by the relay will be those in the section below that corresponds to the programmed value of this setpoint. For example, if programmed to *Fault*, then the system parameters will be set to those defined by the setpoints in Section 15.4.4 FAULT VALUES on page 15–7. Note: The simulation state may change due to a change in the operational state of the relay. For example, if set to *Fault* and a trip opens the breaker (either simulated or actual), the simulation state and this setpoint will automatically change to *Postfault*.
CIRCUIT BREAKER SIMULATION: Enabled	*Range: Enabled, Disabled* An operator can use the simulation feature to provide a complete functional test of the relay's protection features, except for the measurement of external input values. As this feature may be used for on-site testing, provision is made to block the operation of the output relays so the operation of other equipment is prevented. Enter *Enabled* to block the 1 TRIP and 2 CLOSE relays from operating, and ignore the 52a/52b auxiliary contacts, even if installed. In this mode, the circuit breaker will be simulated. Enter *Disabled* to allow the 1 TRIP and 2 CLOSE relays to open and close an actual circuit breaker connected to the relay. In this mode, the 52a/52b auxiliary contacts, if installed, will be read for feedback from the breaker.
ALLOW OPERATION OF RELAYS (3-7): -----	*Range: Any Combination of the 3-7 AUXILIARY Relays* Relays 1 TRIP and 2 CLOSE are allowed to operate by entering *Disabled* for **CIRCUIT BREAKER SIMULATION**. Relays 3-7 AUXILIARY can also be allowed to operate if selected by this setpoint. The 8 SELF-TEST WARNING relay is always allowed to operate. Note that the default setting blocks the operation of all output relays. For timing tests, a selected output relay can be set to be operational, to provide a signal to stop a timer.

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15.4.3 PREFAULT VALUES

For proper operation of the simulation, values entered here should be below the minimum trip setting of any protection feature. The relay will use these values when in the Prefault State. For delta or wye systems, the relay automatically sets the voltages to the setpoint value of VT nominal secondary voltage, with balanced voltage phase positions.

■ PREFAULT VALUES ■ [ENTER] for more	The **PREFAULT VALUES** setpoints path is: **\ SETPOINTS \ S8 TESTING \ SIMULATION \ PREFAULT VALUES**
PHASE A/B/C CURRENT LEVEL: 0.50 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Enter the RMS current for all phases in per unit of the nominal CT value.
POWER FACTOR ANGLE: 0° Lag	*Range: 0 to 359 in steps of 1°* Enter the angle by which the current in each phase will lag the corresponding phase-neutral voltage, in degrees.

15.4.4 FAULT VALUES

The Fault Simulation State allows adjustment of all current and voltage phasors so that a wide variety of system disturbances can be simulated. The frequency and the analog input values can also be adjusted to give complete flexibility. Fault bus voltage values are always entered as wye values, even if the relay is set to delta. The relay will calculate the equivalent line voltages. Voltage magnitudes are entered in per unit values relative to the nominal system voltage that is defined by the setpoints **NOMINAL VT SECONDARY VOLTAGE** and **VT RATIO**. Phase current magnitudes are entered in per unit values relative to the nominal system current that is defined by the setpoint **PHASE CT PRIMARY**. All phasor angles are referenced to the prefault A-N bus voltage at 0°.

■ FAULT VALUES ■ [ENTER] for more	*The Fault Values setpoints path is:* **\ SETPOINTS \ S8 TESTING \ SIMULATION \ FAULT VALUES**
PHASE A-N VOLTAGE LEVEL: 1.00 x VT	*Range: 0.00 to 2.00 in steps of 0.01 x VT* Enter the A-N RMS voltage.
PHASE A-N VOLTAGE POSITION: 0° Lag	*Range: 0 to 359 in steps of 1 °* Enter the A-N voltage angle.
PHASE B-N VOLTAGE LEVEL: 1.00 x VT	*Range: 0.00 to 2.00 in steps of 0.01 x VT* Enter the B-N RMS voltage.
PHASE B-N VOLTAGE POSITION: 120° Lag	*Range: 0 to 359 in steps of 1 °* Enter the B-N voltage angle.
PHASE C-N VOLTAGE LEVEL: 1.00 x VT	*Range: 0.00 to 2.00 in steps of 0.01 x VT* Enter the C-N RMS voltage.
PHASE C-N VOLTAGE POSITION: 240° Lag	*Range: 0 to 359 in steps of 1 °* Enter the C-N voltage angle.

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PHASE A CURRENT LEVEL: 0.00 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Enter the phase A RMS current.
PHASE A CURRENT POSITION: 60° Lag	*Range: 0 to 359 in steps of 1 °* Enter the phase A current angle.
PHASE B CURRENT LEVEL: 0.00 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Enter the phase B RMS current.
PHASE B CURRENT POSITION: 180° Lag	*Range: 0 to 359 in steps of 1 °* Enter the phase B current angle.
PHASE C CURRENT LEVEL: 0.00 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Enter the phase C RMS current.
PHASE C CURRENT POSITION: 300° Lag	*Range: 0 to 359 in steps of 1 °* Enter the phase C current angle.
GROUND CURRENT LEVEL: 0.00 x CT	*Range: 0.00 to 20.00 in steps of 0.01 x CT* Enter the ground RMS current in per unit of the **GROUND CT PRIMARY** setpoint.
GROUND CURRENT POSITION: 0° Lag	*Range: 0 to 359 in steps of 1 °* Enter the ground current angle.
SENSTV GND CURRENT LEVEL: 0.00 x CT	*Range: 0.005 to 1.000 in steps of 0.001 x CT* Enter the sensitive ground RMS current in per unit of the **SENSITIVE GROUND CT PRIMARY** setpoint.
SENSTV GND CURRENT POSITION: 0° Lag	*Range: 0 to 359 in steps of 1 °* Enter the sensitive ground current angle.
SYSTEM FREQUENCY 60.00 Hz	*Range: 20.00 to 65.00 in steps of 0.01 Hz* Enter the frequency that is to be simulated in the fault state, in Hz.
ANALOG INPUT CURRENT: 0.00 mA	Range: 0.00 to 20.00 in steps of 0.01 mA Enter the analog input current in the fault state, in mA.

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15.4.5 POSTFAULT VALUES

The Postfault State allows adjustment of the bus and line voltages in order to simulate an open breaker condition and allow testing of the synchrocheck feature. All phasor angles are referenced to the prefault A-N bus voltage at 0°.

■ POSTFAULT VALUES ■ [ENTER] for more	The **POSTFAULT VALUES** setpoints path is: **\ SETPOINTS \ S8 TESTING \ SIMULATION \ POSTFAULT VALUES**
BUS VOLTAGE LEVEL: 1.00 x VT	*Range: 0.00 to 2.00 in steps of 0.01 x VT* Enter the bus RMS voltage, in per unit of the nominal bus VT value. The relay automatically sets the bus voltages to be balanced with A-N voltage at 0°.
BUS VOLTAGE FREQUENCY: 60.00 Hz	*Range: 20.00 to 65.00 in steps of 0.01 Hz* Enter the bus frequency.
SYNC VOLTAGE LEVEL: 1.00 x VT	*Range: 0.00 to 2.00 in steps of 0.01 x VT* Enter the line RMS voltage, in per unit of the nominal line VT value.
SYNC VOLTAGE POSITION: 0° Lag	*Range: 0 to 359 in steps of 1 °* Enter the line voltage angle.
SYNC VOLTAGE FREQUENCY: 60.00 Hz	*Range: 20.00 to 65.00 in steps of 0.01 Hz* Enter the line frequency.

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15.5.1 DESCRIPTION

These messages are intended for factory use only, to perform testing and diagnostics. Entering the factory service passcode in the first message allows access to the command messages.

15.5.2 SETPOINTS

■ FACTORY SERVICE ■ [ENTER] for more	The **FACTORY SERVICE** setpoints path is: **\ SETPOINTS \ S8 TESTING \ FACTORY SERVICE**
ENTER FACTORY PASSCODE: ■	(Restricted Access For Factory Personnel Only)

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16.1.1 750/760 COMMUNICATIONS FEATURES

The GE Power Management 750/760 Feeder Management relays communicate with other computerized equipment such as programmable logic controllers, personal computers, or plant master computers using either the AEG Modicon Modbus protocol or the Harris Distributed Network Protocol (DNP), Version 3.0. Following are some general notes:

- The 750/760 relays always act as slave devices meaning that they never initiate communications; they only listen and respond to requests issued by a master computer.
- For MODBUS, a subset of the Remote Terminal Unit (RTU) format of the protocol is supported which allows extensive monitoring, programming and control functions using read and write register commands
- For DNP, the functionality is restricted to monitoring of essential relay data and control of important relay functions. A complete description of the services available via DNP may be found in Section 16.5: DNP 3.0 DEVICE PROFILE on page 16–84.

DNP is a complex protocol. As such, it is not within the scope of this manual to provide a description of the protocol's operation in anything approaching the detail required to understand how to use it to communicate with the relay. It is strongly recommended that interested users contact the *DNP Users Group* at the following address to obtain further information:

Gary Moore, Secretary
DNP Users Group
4526 Manilla Rd. S.E.
Calgary, AB Canada T2G 4B6
Tel: (403) 243-3335
Fax: (403) 243-1815

Members of the *DNP Users Group* are eligible to receive complete descriptions of all aspects of the protocol. The Users Group also operates a Website (www.dnp.org) on which technical information and support is available. They may also be contacted via e-mail at dnp@home.com.

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16.2.1 DESCRIPTION

Both the MODBUS and DNP protocols are hardware-independent so that the physical layer can be any of a variety of standard hardware configurations including RS232, RS422, RS485, fiber optics, etc. The 750/760 includes a front panel RS232 port and two rear terminal RS485 ports, one of which can also be configured as RS422. Data flow is half duplex in all configurations. See Chapter 3: INSTALLATION for details on wiring.

Each data byte is transmitted in an asynchronous format consisting of 1 start bit, 8 data bits, 1 stop bit, and possibly 1 parity bit. This produces a 10 or 11 bit data frame. This is important for transmission through modems at high bit rates (11 bit data frames are not supported by many modems at baud rates greater than 300).

The baud rate and parity are independently programmable for each communications port. Baud rates of 300, 1200, 2400, 4800, 9600, and 19200 are available. Even, odd, and no parity are available. See Section 8.2: COMMUNICATIONS on page 8–2 for further details.

The master device in any system must know the address of the slave device with which it is to communicate. The 750/760 will not act on a request from a master if the address in the request does not match the relay's slave address (unless the address is the broadcast address – see below).

A single setpoint selects the slave address used for all ports with the exception that for the front panel port the relay will accept any address when the MODBUS protocol is used. The slave address is otherwise the same regardless of the protocol in use, but note that the broadcast address is 0 for MODBUS and 65535 for DNP. The relay recognizes and processes a master request (under conditions that are protocol-specific) if the broadcast address is used but never returns a response.

DNP may be used on, at most, one of the communications ports. Any port(s) not selected to use DNP will communicate using MODBUS. Setpoint **S1 RELAY SETUP / COMMUNICATIONS / DNP PORT** is used to select which port will communicate using DNP.

The maximum time for a 750/760 relay to return a response to any (non-broadcast) master request will never exceed 1 second.

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16.3.1 DESCRIPTION

The remainder of the text in this chapter is dedicated to discussion of details of the MODBUS protocol. As noted above, specifics of DNP are best obtained directly from the *DNP Users Group*. Along with the Device Profile Document, the DNP specification provides sufficient information for a user to develop an interface should DNP wish to be used for communications with the relay.

16.3.2 DATA LINK LAYER

Communications takes place in packets which are groups of asynchronously framed byte data. The master transmits a packet to the slave and the slave responds with a packet. The end of a packet is marked by 'dead-time' on the communications line. The following describes general format of both transmit and receive packets. For exact details on packet formatting refer to subsequent sections describing each function code.

MODBUS Packet Format:

SLAVE ADDRESS	1 byte
FUNCTION CODE	1 byte
DATA	N bytes
CRC	2 bytes
DEAD TIME	3.5 bytes transmission time

SLAVE ADDRESS

This is the address of the slave device intended to receive the packet sent by the master and perform the desired action. Each slave device on a communication bus must have a unique address to prevent bus contention. All the relay ports have the same address which is programmable from 1 to 254; see Section 8.2: COMMUNICATIONS on page 8–2. Only the addressed slave will respond to a packet that starts with its address. Note that the front port is an exception to this rule; it will act on a message containing any slave address.

A master transmit packet with a slave address of 0 indicates a broadcast command. All slaves on the communication link will take action based on the packet, but none will respond to the master. Broadcast mode is only recognized when associated with FUNCTION CODES 05h, 06h, and 10h. For any other function code, a packet with broadcast mode slave address 0 will be ignored. See Section 16.3.11: CLOCK SYNCHRONIZATION OF MULTIPLE RELAYS on page 16–12 for an example of broadcast mode.

FUNCTION CODE

This is one of the supported functions codes of the 750/760 which tells the slave what action to perform. See Section 16.3.4: SUPPORTED FUNCTION CODES on page 16–5 for complete details. An exception response from the slave is indicated by setting the high order bit of the function code in the response packet. See Section 16.3.10: EXCEPTION RESPONSES on page 16–11 for further details.

DATA

This will be a variable number of bytes depending on the function code. This may include actual values, setpoints, or addresses sent by the master to the slave or by the slave to the master.

CRC

This is a two byte error checking code. The RTU version of Modbus includes a 16 bit cyclic redundancy check (CRC-16) with every packet which is an industry standard method used for error detection. If a GE Power Management Modbus slave device receives a packet in which an error is indicated by the CRC, the slave device will not act upon or respond to the packet thus preventing any erroneous operations. See Section 16.3.3: CRC-16 ALGORITHM for a description of how to calculate the CRC.

DEAD TIME

A packet is terminated when no data is received for a period of 3.5 byte transmission times (about 15 ms at 2400 baud, 2 ms at 19200 baud). Consequently, the transmitting device must not allow gaps between bytes longer than this interval. Once the dead time has expired without a new byte transmission, all slaves start listening for a new packet from the master except for the addressed slave.

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16.3.3 CRC-16 ALGORITHM

The CRC-16 algorithm essentially treats the entire data stream (data bits only; start, stop and parity ignored) as one continuous binary number. This number is first shifted left 16 bits and then divided by a characteristic polynomial (1100000000000101B). The 16 bit remainder of the division is appended to the end of the packet, MSByte first. The resulting packet including CRC, when divided by the same polynomial at the receiver will give a zero remainder if no transmission errors have occurred. This algorithm requires the characteristic polynomial to be reverse bit ordered. The most significant bit of the characteristic polynomial is dropped, since it does not affect the value of the remainder.

Note: A C programming language implementation of the CRC algorithm will be provided upon request.

Symbols:

-->	data transfer
A	16 bit working register
A_{low}	low order byte of A
A_{high}	high order byte of A
CRC	16 bit CRC-16 result
i,j	loop counters
(+)	logical EXCLUSIVE-OR operator
N	total number of data bytes
D_i	i-th data byte (i = 0 to N-1)
G	16 bit characteristic polynomial = 1010000000000001 (binary) with MSbit dropped and bit order reversed
shr (x)	right shift operator (the LSbit of x is shifted into a carry flag, a '0' is shifted into the MSbit of x, all other bits are shifted right one location)

Algorithm:

1. FFFF (hex) --> A
2. 0 --> i
3. 0 --> j
4. D_i (+) A_{low} --> A_{low}
5. j + 1 --> j
6. shr (A)
7. Is there a carry? No: go to step 8.
   Yes: G (+) A --> A and continue.
8. Is j = 8? No: go to 5.
   Yes: continue.
9. i + 1 --> i
10. Is i = N? No: go to 3.
    Yes: continue.
11. A --> CRC

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16.3.4 SUPPORTED FUNCTION CODES

Modbus officially defines function codes from 1 to 127 though only a small subset is generally needed. The 750/760 relays support some of these functions, as summarized in the following table. Subsequent sections describe each function code in detail.

Table 16–1: GE POWER MANAGEMENT 750/760 MODBUS FUNCTION CODES

FUNCTION CODE		MODBUS DEFINTION	GE POWER MANAGEMENT DEFINITION
HEX	DEC		
01	1	Read Coil Status	Read Binary Status
02	2	Read Input Status	Read Binary Status
03	3	Read Holding Registers	Read Actual Values or Setpoints
04	4	Read Input Registers	Read Actual Values or Setpoints
05	5	Force Single Coil	Execute Operation
06	6	Preset Single Register	Store Single Setpoint
10	16	Preset Multiple Registers	Store Multiple Setpoints

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16.3.5 FUNCTION CODE 01H/02H: READ BINARY STATUS

These function codes allow the master to read one or more consecutive binary status bits from an 750/760. The status bits are packed into bytes with the first addressed bit occupying the least significant bit position of the first returned byte. Enough bytes are returned to contain all requested status bits. The last byte is zero-padded as required. The maximum number of status bits that can be read in a single request is 1920 (although this greatly exceeds the number of status bits defined in the 750/760).

The addresses of the bits that can be read using these functions are the same as the point indices defined for the DNP Binary Input objects (e.g., address zero references the “Relay In Service” status). Refer to Section 16.5: DNP 3.0 DEVICE PROFILE on page 16–84 for the definition of all binary status data. Note that function codes 01H and 02H are identical in their operation.

The following table shows the format of the master and slave packets. The example shows a master device requesting 10 status bit values starting at address 13h from slave device 11; the slave device responds with the bit values 1, 0, 1, 1, 0, 0, 1, 0, 0 and 1 from binary status addresses 13h through 1Ch inclusive. Note that two bytes are required to contain the response data. The first byte contains the first eight data bits stored in the least significant to the most significant bit position. The second byte contains the last two data bits stored in the least two significant bit positions. Note that the rest of the second byte is zero-filled.

Table 16–2: MASTER/SLAVE PACKET FORMAT FOR FUNCTION CODE 01H/02H

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	01	FUNCTION CODE	01
DATA STARTING ADDRESS - hi	00	BYTE COUNT	02
DATA STARTING ADDRESS - lo	13	DATA BYTE #1 - hi	4D
NUMBER OF DATA BITS - hi	00	DATA BYTE #2 - lo	02
NUMBER OF DATA BITS - lo	0A	CRC - lo	CC
CRC - lo	4F	CRC - hi	AE
CRC - hi	58		

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16.3.6 FUNCTION CODE 03H/04H: READ ACTUAL VALUES/SETPOINTS

This function code allows the master to read one or more consecutive data registers (actual values or setpoints) from an 750/760. Data registers are always 16 bit (two byte) values transmitted high order byte first. The maximum number of registers that can be read in a single packet is 120. See the section MEMORY MAP for exact details on the data registers.

Since some PLC implementations of Modbus only support one of function codes 03h and 04h, the 750/760 interpretation allows either function code to be used for reading one or more consecutive data registers. The data starting address will determine the type of data being read. Function codes 03h and 04h are therefore identical.

The following table shows the format of the master and slave packets. The example shows a master device requesting 3 register values starting at address 200h from slave device 11; the slave device responds with the values 555, 0, and 100 from registers 200h, 201h, and 202h respectively.

Table 16–3: MASTER/SLAVE PACKET FORMAT FOR FUNCTION CODE 03H/04H

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	**EXAMPLE (HEX)**	**PACKET FORMAT**	**EXAMPLE (HEX)**
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	03	FUNCTION CODE	03
DATA STARTING ADDRESS - hi	02	BYTE COUNT	06
DATA STARTING ADDRESS - lo	00	DATA #1 - hi	02
NUMBER OF REGISTERS - hi	00	DATA #1 - lo	2B
NUMBER OF REGISTERS - lo	03	DATA #2 - hi	00
CRC - lo	06	DATA #2 - lo	00
CRC - hi	E3	DATA #3 - hi	00
		DATA #3 - lo	64
		CRC - lo	C8
		CRC - hi	BA

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16.3.7 FUNCTION CODE 05H - EXECUTE OPERATION

This function code allows the master to perform various operations in the 750/760. Available operations are shown in Table 16–5: SUMMARY OF OPERATION CODES FOR FUNCTION 05H on page 16–9.

The following table shows the format of the master and slave packets. The example shows a master device requesting the slave device 11 to perform a reset. The hi and lo CODE VALUE bytes always have the values 'FF' and '00' respectively and are a remnant of the original Modbus definition of this function code.

Table 16–4: MASTER/SLAVE PACKET FORMAT FOR FUNCTION CODE 05H

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	05	FUNCTION CODE	05
OPERATION CODE - hi	00	OPERATION CODE - hi	00
OPERATION CODE - lo	01	OPERATION CODE - lo	01
CODE VALUE - hi	FF	CODE VALUE - hi	FF
CODE VALUE - lo	00	CODE VALUE - lo	00
CRC - lo	DF	CRC - lo	DF
CRC - hi	6A	CRC - hi	6A

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Table 16–5: SUMMARY OF OPERATION CODES FOR FUNCTION 05H

OPERATION CODE (HEX)	DEFINITION	DESCRIPTION
0000	NO OPERATION	Does not do anything.
0001	RESET	Performs the same function as the front panel *RESET* key.
0002	OPEN BREAKER	Performs the same function as the front panel *OPEN* key. The 760 must be in REMOTE mode for this operation to be effective.
0003	CLOSE BREAKER	Performs the same function as the front panel *CLOSE* key. The 760 must be in REMOTE mode for this operation to be effective.
0004	SET TIME	Sets the internal clock time. See 16.3.11 CLOCK SYNCHRONIZATION OF MULTIPLE RELAYS on page 16–12.
0005	SET DATE	Sets the internal clock date. See 16.3.11 CLOCK SYNCHRONIZATION OF MULTIPLE RELAYS on page 16–12.
0006	TRIGGER TRACE MEMORY	Performs the same function as the logic input function *TRIGGER TRACE MEMORY*.
0007	CLEAR ENERGY USE DATA	Performs the same function as front panel *CLEAR ENERGY USE DATA* command.
0008	CLEAR MAX DEMAND DATA	Performs the same function as the front panel *CLEAR MAX DEMAND DATA* command.
0009	CLEAR EVENT RECORDER DATA	Performs the same function as the front panel *CLEAR EVENT RECORDER DATA* command.
000A	RESET TRIP COUNTER DATA	Performs the same function as the front panel *RESET TRIP COUNTER DATA* command.
000B	RESET ARCING CURRENT DATA	Performs the same function as the front panel *RESET ARCING CURRENT DATA* command.
000C	DISPLAY OVERRIDE PACKET	Displays the 40 character (20 register) *Override_Packet* (memory map addresses 10B1 to 10C4 hex) for the time specified in *Override_Time* (memory map address 10B0 hex).
000D	TRIGGER DATA LOGGER	Performs the same function as the logic input function *TRIGGER DATA LOGGER*.
000E	RESET TRACE MEMORY	Resets the Trace Memory oscillography data by clearing the number of captured events to zero.
000F	RESET DATA LOGGER	Resets the Data Logger by clearing the number of captured events to zero.
0010	RESET AR COUNT DATA	Resets the Autoreclose Count by clearing the AUTORECLOSE SHOT COUNT to zero.
0011	RESET AR RATE DATA	Resets the Autoreclose Shot Rate by clearing the AUTORECLOSE SHOT RATE to zero.

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16.3.8 FUNCTION CODE 06H - STORE SINGLE SETPOINT

This function code allows the master to modify the contents of a single setpoint register in a 750/760. Setpoint registers are always 16 bit (two byte) values transmitted high order byte first. See Table 16–15: MODBUS MEMORY MAP on page 16–18. The following table shows the format of the master and slave packets. It shows a master device storing the value 200 at memory map address 1100h to slave device 11.

Table 16–6: MASTER/SLAVE PACKET FORMAT FOR FUNCTION CODE 06H

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	06	FUNCTION CODE	06
DATA STARTING ADDRESS - hi	11	DATA STARTING ADDRESS - hi	11
DATA STARTING ADDRESS - lo	00	DATA STARTING ADDRESS - lo	00
DATA - hi	00	DATA - hi	00
DATA - lo	C8	DATA - lo	C8
CRC - lo	8F	CRC - lo	8F
CRC - hi	F0	CRC - hi	F0

16.3.9 FUNCTION CODE 10H - STORE MULTIPLE SETPOINTS

This function code allows the master to modify the contents of a one or more consecutive setpoint registers in a 750/760. Setpoint registers are 16 bit (two byte) values transmitted high order byte first. The maximum number of setpoint registers that can be stored in a single packet is 60. The table below shows the format of the master and slave packets. It shows a master device storing the value 200 at memory map address 1100h, and the value 1 at memory map address 1101h to slave device 11.

Table 16–7: MASTER/SLAVE PACKET FORMAT FOR FUNCTION CODE 10H

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	10	FUNCTION CODE	10
DATA STARTING ADDRESS - hi	11	DATA STARTING ADDRESS - hi	11
DATA STARTING ADDRESS - lo	00	DATA STARTING ADDRESS - lo	00
NUMBER OF SETPOINTS - hi	00	NUMBER OF SETPOINTS - hi	00
NUMBER OF SETPOINTS - lo	02	NUMBER OF SETPOINTS - lo	02
BYTE COUNT	04	CRC - lo	46
DATA #1 - high order byte	00	CRC - hi	64
DATA #1 - low order byte	C8		
DATA #2 - high order byte	00		
DATA #2 - low order byte	01		
CRC - low order byte	27		
CRC - high order byte	01		

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16.3.10 EXCEPTION RESPONSES

Programming or operation errors happen because of illegal data in a packet, hardware or software problems in the slave device, etc. These errors result in an exception response from the slave. The GE Power Management 750/760 implements the error codes listed in Table 16–9: EXCEPTION RESPONSE ERROR CODES on page 16–11. The slave detecting one of these errors sends a response packet to the master with the high order bit of the function code set to 1.

The following table shows the format of the master and slave packets. The example shows a master device sending the unsupported function code 39h to slave device 11.

Table 16–8: MASTER/SLAVE PACKET FORMAT FOR UNSUPPORTED FUNCTION CODE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	39	FUNCTION CODE	B9
CRC - low order byte	CD	ERROR CODE	01
CRC - high order byte	F2	CRC - low order byte	93
		CRC - high order byte	95

Table 16–9: EXCEPTION RESPONSE ERROR CODES

ERROR CODE	MODBUS DEFINITION	GE POWER MANAGEMENT IMPLEMENTATION
01	ILLEGAL FUNCTION	The function code of the master query packet is not a function code supported by the slave.
02	ILLEGAL DATA ADDRESS	The address referenced in the data field of the master query packet is not an address supported by the slave.
03	ILLEGAL DATA VALUE	The value referenced in the data field of the master query packet is not allowable in the addressed slave location.
04	FAILURE IN ASSOCIATED DEVICE	The addressed slave has internal failure which prevents it from performing the action as requested.
05 †	ACKNOWLEDGE	The addressed slave device has accepted and is processing a long duration command. Poll for status.
06 †	BUSY, REJECTED PACKET	The packet was received without error, but the slave device is engaged in processing a long duration command. Retransmit later, when the slave device may be free.
07 †	NAK - NEGATIVE ACKNOWLEDGE	The packet was received without error, but the request could not be performed, because this version of the 750/760 does not have the requested operation available.

† Some implementations of Modbus may not support these exception responses.

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16.3.11 CLOCK SYNCHRONIZATION OF MULTIPLE RELAYS

The time and date of multiple relays on the same communication link can be synchronized so that time stamping of events on different relays can be correlated. The following procedure describes how to synchronize the clocks of multiple relays. Since the clock is accurate to 1 minute per month, performing this procedure every 10 minutes will result in synchronization accuracy of ±10 ms.

1. Store values for the date and time setpoints Set Date and Set Time at locations 1006h and 1008h in the Memory Map respectively into each slave device.
2. Broadcast (via slave address 0) the SET DATE operation code via function code 05h to all connected slaves to synchronize the dates.
3. Broadcast (via slave address 0) the SET TIME operation code via function code 05h to all connected slaves to synchronize the times. If synchronizing to an external clock source then this command should be sent when the time is equal to the value stored in SET TIME.

The following table shows the format of the master and slave packets for a master device storing the date of June 10, 1994 and time of 2:15:30 PM to slave device 11 as required by step one of the procedure.

Table 16–10: MASTER/SLAVE PACKET FORMAT FOR CLOCK SYNCHRONIZATION

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	11	SLAVE ADDRESS	11
FUNCTION CODE	10	FUNCTION CODE	10
DATA STARTING ADDRESS - hi	10	DATA STARTING ADDRESS - hi	10
DATA STARTING ADDRESS - lo	06	DATA STARTING ADDRESS - lo	06
NUMBER OF SETPOINTS - hi	00	NUMBER OF SETPOINTS - hi	00
NUMBER OF SETPOINTS - lo	04	NUMBER OF SETPOINTS - lo	08
BYTE COUNT	08	CRC - lo	27
DATA #1 - hi (Month = 6)	06	CRC - hi	9B
DATA #1 - lo (Day = 10)	0A		
DATA #2 - hi (Year=1994=07CAh)	07		
DATA #2 - lo (Year=1994=07CAh)	CA		
DATA #3 - hi (Hour=2pm=14)	0E		
DATA #3 - lo (Minute=15)	0F		
DATA #4 - hi (Sec=30000ms=7530h)	75		
DATA #4 - lo (Sec=30000ms=7530h)	30		
CRC - lo	37		
CRC - hi	0C		

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The following table shows the format of the master and slave packets for a master device sending the STORE TIME operation code to all slave devices on the communications link as required by step three of the procedure.

Table 16–11: MASTER/SLAVE PACKET FORMAT FOR STORE TIME OPERATION CODE

MASTER TRANSMISSION		SLAVE RESPONSE	
PACKET FORMAT	EXAMPLE (HEX)	PACKET FORMAT	EXAMPLE (HEX)
SLAVE ADDRESS	00	No response from slave.	
FUNCTION CODE	05		
OPERATION CODE - hi	00		
OPERATION CODE - lo	04		
CODE VALUE - hi	FF		
CODE VALUE - lo	00		
CRC - lo	CC		
CRC - hi	2A		

16.3.12 READING THE EVENT RECORDER

All Event Recorder data can be read from Modbus registers found in the address range 2000h - 20FFh.

The 'Number of Events Since Last Clear' register at address 2001h is incremented by one every time a new event occurs. The register is cleared to zero when the Event Recorder is cleared. When a new event occurs, it is assigned an 'event number' which is equal to the incremented value of this register; the newest event will have an event number equal to the Number of Events. This register can be used to determine if any new events have occurred by periodically reading the register to see if the value has changed. If the Number of Events has increased then there are new events available.

Only the data for a single event can be read from the Modbus memory map in a single data packet. The 'Event Number Selector' register at address 2000h selects the event number for which data can be read from the memory map. For example, to read the data for event number 123, the value 123 must first be written to this register. All the data for event number 123 can now be read from the 'Event Record Data' registers at addresses 2010h to 201Dh. Only the last 128 events are actually stored in the relay's memory. Attempting to retrieve data for elder events that are not stored will result in a Modbus exception response when writing to the 'Event Number Selector'.

The following example illustrates how information can be retrieved from the Event Recorder:

A SCADA system polls the Number of Events register once every minute. It now reads a value of 27 from the register when previously the value was 24 which means that three new events have occurred. The SCADA system writes a value of 25 to the Event Number Selector register. It then reads the data for event number 25 from the Event Record Data registers and stores the data to permanent memory for retrieval by an operator. The system now writes the value 26 to the selector and then reads the data for event number 26. Finally, the value 27 is written to the selector followed by reading the data for this event. All the data for the new events has now been retrieved by the SCADA system so it resumes polling the Number of Events register.

The data for an event should be straightforward to interpret from the information given in the Memory Map except for the 'Cause of Event' register. Data format F24 describes the event cause register which contains several 'fields' of information. The 'Event Type' field determines how to interpret the remainder of the register. Interpreting the event cause register is most easily described with several examples.

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Table 16–12: EVENT CAUSE INTERPRETATION

EVENT CAUSE REGISTER VALUE	EVENT CAUSE INTERPRETATION
1003h	Breaker Opened
3501h	A-C Phase Time Overcurrent 1 Trip
8501h	A-C Phase Time Overcurrent 1 Dropout
4212h	B Overvoltage 1 Alarm
6514h	User Input A Asserted via Contact Input
7009h	Clock Not Set

16.3.13 READING TRACE MEMORY

All Trace Memory waveform data can be read from Modbus registers found in the address range 2100h to 215Fh. In order to understand the following description, familiarity with the settings for Trace Memory is required; refer to Section 8.6: TRACE MEMORY on page 8–6.

The 'Number of Trace Memory Triggers Since Last Clear' register is incremented by one every time a new Trace Memory is triggered. This register is cleared to zero when Trace Memory is cleared. When a new trigger occurs, the associated waveform data is assigned a 'Trace Memory Number' which is equal to the incremented value of this register; the newest data will have a number equal to the Number of Trace Memory Triggers. This register can be used to determine if any new data has been captured by periodically reading it to see if the value has changed; if the Number of Trace Memory Triggers has increased then there is new data available.

The Trace Memory **BUFFER ORGANIZATION** setpoint determines the number of samples that are captured per channel for each separate trigger. This setpoint also determines how many data triggers are stored in memory. For example if the setting is *4x1024* then there are 1024 samples per channel per trigger and the last three data triggers can be read from memory. Note that only 64 samples of one data channel for a single waveform can be read from the Modbus memory map in a single data packet. The 'Trace Memory Selectors' registers determine which waveform data can be read from the memory map.

The 'Trace Memory Number Selector' determines which Trace Memory can be read. For example, to read the data for Trace Memory number 3, the value 3 must first be written to this register. Data for Trace Memory number 3 can now be read from the 'Trace Memory Information' registers at addresses 2111h to 2119h. These registers include a trigger cause (see Section 16.3.12: READING THE EVENT RECORDER on page 16–13 for a description of the data format), a trigger time and date stamp, and the sampling frequency. There is also the 'Start Index' and 'Trigger Index' which determine how to 'unravel' the data samples; see the description of the circular data structure below.

The 'Trace Memory Channel Selector' determines which data channel samples can be read from the 'Trace Memory Samples' registers at addresses 2120h to 215Fh; refer to format F26 for a complete listing of the available data channels. For example, to read Vc voltage samples a value of 6 is written to this register. Note that this register also determines the data format of the samples.

The 'Trace Memory Sample Selector' (TMSS) determines which block of 64 samples can be read from the 'Trace Memory Samples' registers. The total number of samples stored for one channel is variable and depends on the 'Buffer Organization' setpoint. The 'Number of Trace Memory Samples Stored' register indicates the number of samples that have already been accumulated for the selected Trace Memory Number; this register may have a value less than the total number of samples that can be stored if a trigger just occurred and there are an appreciable number of post-trigger samples to capture.

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The samples are stored in a circular buffer; the figure below shows how a waveform might be stored for one channel. The 'Trace Memory Start Index' determines where the waveform begins in the buffer. Likewise, the 'Trace memory Trigger Index' determines where the trigger point is. In this example the Start Index is 96 and the Trigger Index is 224; note that the indices are always a multiple of sixteen.

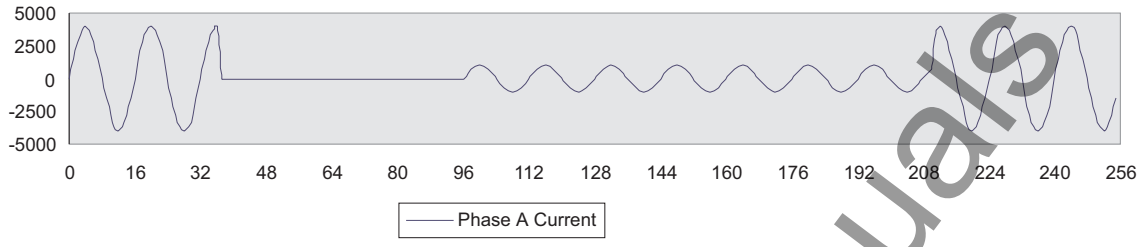


Figure 16–1: TRACE MEMORY CIRCULAR BUFFER

The following example illustrates how information can be retrieved from Trace Memory:

1. A SCADA system polls the Number of Trace Memory Triggers register once every minute. It now reads a value of 4 from the register where previously the value was 3 which means that a new data has been captured. The SCADA system proceeds with the following steps to read all the waveform data. After these steps it resumes polling the Number of Trace Memory Triggers register.
2. Read Trace Memory Buffer Organization setpoint
3. Write a value of 4 to the Trace Memory Number Selector
4. Read all the Trace Memory Information registers and store to SCADA memory
5. Set variables TMCS and TMSS to 0
6. Write TMCS to Trace Memory Channel Selector
7. Write TMSS to Trace Memory Sample Selector
8. Read 64 samples from Trace Memory Samples and store to SCADA memory
9. Increment TMSS by 64
10. If TMSS < Total Number of Samples then goto 5
11. Increment CS by 1
12. If TMCS < total number of channels available then goto 4
13. Done

All the Trace Memory data for the most recent trigger is now stored to SCADA memory. The SCADA software could now 'unravel' the circular buffers using the Start Index and Trigger Index registers that were read in step 3 and store them permanently to file or perhaps generate a graphical picture.

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16.3.14 READING THE DATA LOGGER

All Data Logger information can be read from Modbus registers found in the address range 2200h to 22ffh. In order to understand the following description, familiarity with the settings for the Data Logger is required; refer to Section 8.7: DATA LOGGER on page 8–7. Reading the Data Logger is very similar to reading Trace Memory and the description for the latter should be used with note of the exceptions described below.

The data channels in the Data Logger are programmable and are determined by the **CHANNEL 1-8 SOURCE** setpoints. These setpoints determine the format of data samples for a given channel.

In *Continuous* mode the 'Number of Data Log Triggers Since Last Clear' is always equal to one.

In *Continuous* mode the Data Logger only maintains one buffer of 4096 samples for each channel. Since the buffer is being continuously updated the 'Data Log Start Index' will change once the buffer is full and new data is added (overwriting old data and thus moving the location of the starting index). At slow sampling rates this is less important but when sampling is performed at a high rate it is very likely that the start index will move between subsequent reads of the memory map.

In *Continuous* mode the "Data Log Trigger Index" will always index the last sample added to the buffer. Thus, it too, will also be quickly and continuously changing if the sampling rate is high.

In *Continuous* mode the "Data Log Trigger Cause" will be set to zero and the time and date are when the last sample data was written to the buffer.

16.3.15 ACCESSING DATA VIA THE USER MAP

The 750/760 has a powerful feature, called the User Map, which allows a computer to read up to 120 non-consecutive data registers (setpoints or actual values) by using one Modbus packet. It is often necessary for a master computer to continuously poll various values in each of the connected slave relays. If these values are scattered throughout the memory map, reading them would require numerous transmissions and would burden the communication link. The User Map can be programmed to join any memory map address to one in the block of consecutive User Map locations, so that they can be accessed by reading these consecutive locations.

The User Map feature consists of *User Map Addresses #1 to #120* at locations 0180h to 01F7h in the Memory Map. These are the setpoints which store the memory map addresses of the values that are to be accessed. The data registers are read from the *User Map Values #1 to #120* at locations 0100h to 0177h in the Memory Map. Reading the register at the location of *User Map Value #1* returns the value at the address stored in *User Map Address #1*, *User Map Value #2* the value at *User Map Address #2*, and so on. Storing registers is not allowed using the User Map.

The following table shows the register addresses to store in the User Map Addresses #1 to #6 so that several different data registers can be read in one continuous block from User Map Value #1 to #6. Reading the User Map Values is done via function code 03h or 04h.

NOTE

The User Memory Map is only intended to be used to READ data in a proficient manner for the master computer. The communication system should not be configured in a manner that generates WRITES to these locations continuously, as these settings are stored in the EEPROM that has a maximum of 100000 program/erase cycles.

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Table 16–13: REGISTER ADDRESSES FOR USER MAP

DATA REGISTER DESCRIPTION	VALUES TO STORE IN USER MAP ADDRESSES	LOCATIONS IN USER MAP VALUES TO READ DATA
General Status	Store 0200h @ 0180h	0100h
Active Condition	Store 0210h @ 0181h	0101h
Phase A RMS Current	Store 0300h @ 0182h	0102h
Phase B RMS Current	Store 0301h @ 0183h	0103h
Phase C RMS Current	Store 0302h @ 0184h	0104h
Phase CT Primary	Store 1100h @ 0185h	0105h

16.3.16 MEMORY MAP ORGANIZATION

The 750/760 Memory Map describes all the data registers that can be accessed via serial communications. The Memory Map address range is grouped into several categories as outlined in the following table. All memory map locations are two byte (16 bit) values. The remaining pages of this chapter list all locations of the Memory Map. Addresses for all locations are shown in hexadecimal. Consult the range, step, units, and the data format (listed after the memory map) to interpret register values.

NOTE

Many Modbus communications drivers add 40001d to the actual adresss of the register addresses. For example, if address 0h was to be read, then 40001d would be the address required by the Modbus communications driver; similarly, if address 320h (800d) was to be read, then 40801d would be the address required by the Modbus communications driver.

Table 16–14: MEMORY MAP ORGANIZATION

MEMORY MAP SECTION	ADDRESS RANGE (HEX)	DESCRIPTION
Product ID	0000 to 007F	Identification and revision information.
Commands	0080 to 00FF	Substitute command locations. Read and write access.
User Map	0100 to 01FF	User Map Values and Addresses. See 16.3.15: ACCESSING DATA VIA THE USER MAP on page 16–16 for details.
Actual Values	0200 to 0FFF	Actual values data. Read Only.
Setpoints	1000 to 1FFF	Setpoints data. Read and Write.
Event Recorder, Trace Memory, Data Log	2000 to 2FFF	See Sections 16.3.12: READING THE EVENT RECORDER, 16.3.13: READING TRACE MEMORY, and 16.3.14: READING THE DATA LOGGER on pages 16–13 to 16–16.
Reserved	3000 to 3FFF	Reserved for future use.
Factory Service Data	4000 to FFFF	Reserved.

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Table 16–15: MODBUS MEMORY MAP (Sheet 1 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
A5	**PRODUCT ID**				**READ ONLY**
0000	GE Power Management Product Device Code	---	---	F1	---
0001	Hardware Revision	1 to 26	---	F13	---
0002	Software Revision	---	---	F14	---
0003	Version Number	000 to 999	---	F1	---
0004	Bootware Revision	---	---	F14	---
0005	Installed Options	---	---	F15	---
0006	Serial Number (4 words)	---	---	F33	---
000A	Date Of Manufacture (2 words)	---	---	F23	---
	COMMANDS				**READ/WRITE**
0080	Command Operation Code	---	---	F19	0
0081[1]	Simulate Front Panel Key Press	---	---	F55	---
0088	Communications Port Passcode (4 words)	---	---	F33	---
S8	**VIRTUAL INPUTS**				**READ/WRITE**
0090	Reserved				
0091	Virtual Input 1	---	---	F66	Not Asserted
0092	Virtual Input 2	---	---	F66	Not Asserted
:	:				
00A4	Virtual Input 20	---	---	F66	Not Asserted
	SET TIME / DATE				**READ/WRITE**
00F0[1]	Set Time (2 words)	---	---	F22	---
00F2[1]	Set Date (2 words)	---	---	F23	---
	USER MAP VALUES				**READ ONLY**
0100	User Map Value #1	---	---	---	---
0101	User Map Value #2	---	---	---	---
:	:				
0177	User Map Value #120	---	---	---	---
	USER MAP ADDRESSES				**READ/WRITE**
0180	User Map Address #1	0000 to FFFF	hex	F1	0
0181	User Map Address #2	0000 to FFFF	hex	F1	0
:	:				
01F7	User Map Address #120	0000 to FFFF	hex	F1	0

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 2 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
A1	**SYSTEM STATUS**				**READ ONLY**
0200	General Status	---	---	F21	---
0201	760 Operation Status	---	---	F44	---
0202	Communications Port Setpoint Access Status	---	---	F30	---
0203	Reserved				
0204	Contact Input Status	---	---	F46	---
0205	Coil Monitor Status	---	---	F47	---
0206	Output Relay Status	---	---	F40	---
0207	Date (2 words)	---	---	F23	---
0209	Time (2 words)	---	---	F22	---
020B	Active Setpoint Group	---	---	F79	---
020C	Edit Setpoint Group	---	---	F79	---
	ACTIVE CONDITION QUEUE				**READ ONLY**
0210	Active Condition #1	---	---	F24	---
0211	Active Condition #2	---	---	F24	---
:	:				
022F	Active Condition #32	---	---	F24	---
	LATCHED CONTACT INPUT STATE				**READ ONLY**
0230	Contact Input Status (Closed Contacts are Latched Until Read via Communications)	---	---	F46	---
	LATCHED OUTPUT RELAY STATE				**READ ONLY**
0231[8]	Output Relay Status (Asserted Outputs are Latched Until Read via Communications)	---	---	F40	---
A1	**LOGIC INPUT STATES**				**READ ONLY**
0240	Reserved	---	---	---	---
0241	Logic Input 1 State	---	---	F69	---
0242	Logic Input 2 State	---	---	F69	---
:	:				
0254	Logic Input 20 State	---	---	F69	---
A1	**AUTORECLOSE STATUS - 760 ONLY**				**READ ONLY**
0260	Autoreclose Shot Number	---	---	F1	---
0261	Autoreclose Shots Remaining	---	---	F1	---
0262	Manual Close Blocking	---	---	F30	---
0263	Reserved	---	---	---	---
0264[8]	Recloses per hour	---	---	F1	---
A1	**AUTORECLOSE STATUS - 760 ONLY**				**READ ONLY**
0270[8]	Reclosure Count	---	---	F1	---

[1] [2] [3] [4] [5] [6] [7] [8] [9] For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 3 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
0271[8]	Reclosure Count Last Reset Date (2 words)	---	---	F23	---
A1	**LAST TRIP DATA**				**READ ONLY**
02E0	Date of Last Trip (2 words)	---	---	F23	---
02E2	Time of Last Trip (2 words)	---	---	F22	---
02E4	Cause of Last Trip	---	---	F24	---
02E5	Last Trip Phase A Current	0 to 65535	A	F1	---
02E6	Last Trip Phase B Current	0 to 65535	A	F1	---
02E7	Last Trip Phase C Current	0 to 65535	A	F1	---
02E8	Last Trip Ground Current	0 to 65535	A	F1	---
02E9	Last Trip A-N (A-B) Voltage	0.00 to 600.00	kV	F3	---
02EA	Last Trip B-N (B-C) Voltage	0.00 to 600.00	kV	F3	---
02EB	Last Trip C-N (C-A) Voltage	0.00 to 600.00	kV	F3	---
02EC	Last Trip System Frequency	0.00 to 90.00	Hz	F3	---
02ED	Last Trip Analog Input	0 to 65535	Units	F1	---
02EE	Last Trip Neutral Current	0 to 65535	A	F1	---
02EF[3]	Last Trip Sensitive Ground Current	0.00 to 655.35	A	F3	---
02F0[5]	Last Trip Neutral Voltage	0.00 to 655.35	kV	F3	---
A2	**CURRENT AND VOLTAGE**				**READ ONLY**
02FE[5]	Neutral Voltage	0.00 to 655.35	kV	F3	---
02FF[3]	Sensitive Ground Current	0.00 to 655.35	A	F3	---
0300	Phase A RMS Current	0 to 65535	A	F1	---
0301	Phase B RMS Current	0 to 65535	A	F1	---
0302	Phase C RMS Current	0 to 65535	A	F1	---
0303	Percent of Load-to-Trip	0 to 2000	%	F1	---
0304	Ground Current	0 to 65535	A	F1	---
0305	A-N RMS Voltage	0.00 to 600.00	kV	F3	---
0306	B-N RMS Voltage	0.00 to 600.00	kV	F3	---
0307	C-N RMS Voltage	0.00 to 600.00	kV	F3	---
0308	A-B RMS Voltage	0.00 to 600.00	kV	F3	---
0309	B-C RMS Voltage	0.00 to 600.00	kV	F3	---
030A	C-A RMS Voltage	0.00 to 600.00	kV	F3	---
030B[3]	Reserved for Polarizing Current	---	---	---	---
030C	Average Current	0 to 65535	A	F1	---
030D	Average Line Voltage	0.00 to 600.00	kV	F3	---
030E	Average Phase Voltage	0.00 to 600.00	kV	F3	---
030F	Neutral Current	0 to 65535	A	F1	---

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 4 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
A2	**3ϕ POWER, FREQUENCY**				**READ ONLY**
0310[2]	3ϕ Real Power	-30000 to 30000	kW	F86	---
0311[2]	3ϕ Reactive Power	-30000 to 30000	kvar	F86	---
0312[2]	3ϕ Apparent Power	0 to 30000	kVA	F86	---
0313	3ϕ Power Factor	-0.99 to +1.00	---	F6	---
0314	System Frequency	0.00 to 90.00	Hz	F3	---
0315[1]	System Frequency Decay Rate	-10.00 to 10.00	Hz/s	F6	---
0316[1]	Auto Ranging Power / Energy Multiplier	1 to 100	---	F1	---
A2	**SYNCHRONIZING VOLTAGE**				**READ ONLY**
0318	Synchronizing RMS Voltage	0.00 to 600.00	kV	F3	---
0319	Synchronizing RMS Voltage Frequency	0.00 to 90.00	Hz	F3	---
031A	Synchronizing Voltage Difference	0.00 to 600.00	kV	F3	---
031B	Synchronizing Phase Difference	0 to 359	°	F1	---
031C	Synchronizing Frequency Difference	0.00 to 90.00	Hz	F3	---
031D	Synchronizing Voltage Angle	0 to 359	° Lag	F1	---
A2	**ENERGY USE**				**READ ONLY**
0320[2]	Positive Watthours (2 words)	0 to 4e9	kWh	F86	---
0322	Positive Watthour Cost (2 words)	0 to 4e9	$	F7	---
0324[2]	Negative Watthours (2 words)	0 to 4e9	kWh	F86	---
0326	Negative Watthour Cost (2 words)	0 to 4e9	$	F7	---
0328[2]	Positive Varhours (2 words)	0 to 4e9	kvarh	F86	---
032A[2]	Negative Varhours (2 words)	0 to 4e9	kvarh	F86	---
032C	Energy Use Data Last Reset (2 words)	---	---	F23	---
A2	**LAST DEMAND**				**READ ONLY**
0330	Last Phase A Current Demand	0 to 65535	A	F1	---
0331	Last Phase B Current Demand	0 to 65535	A	F1	---
0332	Last Phase C Current Demand	0 to 65535	A	F1	---
0333[2]	Last Real Power Demand	-30000 to 30000	kW	F86	---
0334[2]	Last Reactive Power Demand	-30000 to 30000	kvar	F86	---
0335[2]	Last Apparent Power Demand	0 to 30000	kVA	F86	---
A2	**MAXIMUM DEMAND**				**READ ONLY**
0340	Maximum Phase A Current Demand	0 to 65535	A	F1	---
0341	Maximum Phase A Current Date (2 words)	---	---	F23	---
0343	Maximum Phase A Current Time (2 words)	---	---	F22	---
0345	Maximum Phase B Current Demand	0 to 65535	A	F1	---

[1] [2] [3] [4] [5] [6] [7] [8] [9] For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 5 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
0346	Maximum Phase B Current Date (2 words)	---	---	F23	---
0348	Maximum Phase B Current Time (2 words)	---	---	F22	---
034A	Maximum Phase C Current Demand	0 to 65535	A	F1	---
034B	Maximum Phase C Current Date (2 words)	---	---	F23	---
034D	Maximum Phase C Current Time (2 words)	---	---	F22	---
034F[2]	Maximum Real Power Demand	-30000 to 30000	kW	F86	---
0350	Maximum Real Power Date (2 words)	---	---	F23	---
0352	Maximum Real Power Time (2 words)	---	---	F22	---
0354[2]	Maximum Reactive Power Demand	-30000 to 30000	kvar	F86	---
0355	Maximum Reactive Power Date (2 words)	---	---	F23	---
0357	Maximum Reactive Power Time (2 words)	---	---	F22	---
0359[2]	Maximum Apparent Power Demand	0 to 30000	kVA	F86	---
035A	Maximum Apparent Power Date (2 words)	---	---	F23	---
035C	Maximum Apparent Power Time (2 words)	---	---	F22	---
035E	Demand Data Last Reset (2 words)	---	---	F23	---
A2	**1ϕ POWER**				**READ ONLY**
0360[1]	ϕA Real Power	-30000 to 30000	kW	F86	---
0361[1]	ϕA Reactive Power	-30000 to 30000	kvar	F86	---
0362[1]	ϕA Apparent Power	0 to 30000	kVA	F86	---
0363[1]	ϕA Power Factor	-0.99 to +1.00	---	F6	---
0364[1]	ϕB Real Power	-30000 to 30000	kW	F86	---
0365[1]	ϕB Reactive Power	-30000 to 30000	kvar	F86	---
0366[1]	ϕB Apparent Power	0 to 30000	kVA	F86	---
0367[1]	ϕB Power Factor	-0.99 to +1.00	---	F6	---
0368[1]	ϕC Real Power	-30000 to 30000	kW	F86	---
0369[1]	ϕC Reactive Power	-30000 to 30000	kvar	F86	---
036A[1]	ϕC Apparent Power	0 to 30000	kVA	F86	---
036B[1]	ϕC Power Factor	-0.99 to +1.00	---	F6	---
A2	**ANALOG INPUT**				**READ ONLY**
0370	Analog Input	0 to 65535	Units	F1	---
0371	Analog Input Fast Rate of Change	---	Units / min.	F5	---
0372	Analog Input Slow Rate of Change	---	Units / hr.	F5	---
A3	**TRIP COUNTERS**				**READ ONLY**
0380	Breaker Trips	0 to 65535	---	F1	---
0381	Ground Overcurrent Trips	0 to 65535	---	F1	---

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 6 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
0382	Neutral Overcurrent Trips	0 to 65535	---	F1	---
0383	One Phase Overcurrent Trips	0 to 65535	---	F1	---
0384	Two Phase Overcurrent Trips	0 to 65535	---	F1	---
0385	Three Phase Overcurrent Trips	0 to 65535	---	F1	---
0386	Trip Counters Last Reset Date (2 words)	---	---	F23	---
0388	Negative Sequence Overcurrent Trips	0 to 65535	---	F1	---
0389[3]	Sensitive Ground Overcurrent Trips	0 to 65535	---	F1	---
A3	**TOTAL ARCING CURRENT**				**READ ONLY**
03A0	Total Arcing Current Phase A	0 to 65535	kA^2cyc	F1	---
03A1	Total Arcing Current Phase B	0 to 65535	kA^2cyc	F1	---
03A2	Total Arcing Current Phase C	0 to 65535	kA^2cyc	F1	---
03A3	Total Arcing Current Last Reset (2 words)	---	---	F23	---
A1	**FAULT LOCATION 1**				**READ ONLY**
03B0	Date of Fault (2 words)	---	---	F23	---
03B2	Time of Fault (2 words)	---	---	F22	---
03B4	Type of Fault	---	---	F76	---
03B5	Distance to Fault	-327.68 to 327.67	km, mi	F52	---
03B6	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---
A1	**FAULT LOCATION 2**				**READ ONLY**
03B8	Date of Fault (2 words)	---	---	F23	---
03BA	Time of Fault (2 words)	---	---	F22	---
03BC	Type of Fault	---	---	F76	---
03BD	Distance to Fault	-327.68 to 327.67	km	F52	---
03BE	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---
A1	**FAULT LOCATION 3**				**READ ONLY**
03C0	Date of Fault (2 words)	---	---	F23	---
03C2	Time of Fault (2 words)	---	---	F22	---
03C4	Type of Fault	---	---	F76	---
03C5	Distance to Fault	-327.68 to 327.67	km	F52	---
03C6	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---
A1	**FAULT LOCATION 4**				**READ ONLY**
03C8	Date of Fault (2 words)	---	---	F23	---
03CA	Time of Fault (2 words)	---	---	F22	---
03CC	Type of Fault	---	---	F76	---
03CD	Distance to Fault	-327.68 to 327.67	km	F52	---
03CE	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 7 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
A1	**FAULT LOCATION 5**				**READ ONLY**
03D0	Date of Fault (2 words)	---	---	F23	---
03D2	Time of Fault (2 words)	---	---	F22	---
03D4	Type of Fault	---	---	F76	---
03D5	Distance to Fault	-327.68 to 327.67	km	F52	---
03D6	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---
A1	**FAULT LOCATION 6**				**READ ONLY**
03D8	Date of Fault (2 words)	---	---	F23	---
03DA	Time of Fault (2 words)	---	---	F22	---
03DC	Type of Fault	---	---	F76	---
03DD	Distance to Fault	-327.68 to 327.67	km	F52	---
03DE	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---
A1	**FAULT LOCATION 7**				**READ ONLY**
03E0	Date of Fault (2 words)	---	---	F23	---
03E2	Time of Fault (2 words)	---	---	F22	---
03E4	Type of Fault	---	---	F76	---
03E5	Distance to Fault	-327.68 to 327.67	km	F52	---
03E6	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---
A1	**FAULT LOCATION 8**				**READ ONLY**
03E8	Date of Fault (2 words)	---	---	F23	---
03EA	Time of Fault (2 words)	---	---	F22	---
03EC	Type of Fault	---	---	F76	---
03ED	Distance to Fault	-327.68 to 327.67	km	F52	---
03EE	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---
A1	**FAULT LOCATION 9**				**READ ONLY**
03F0	Date of Fault (2 words)	---	---	F23	---
03F2	Time of Fault (2 words)	---	---	F22	---
03F4	Type of Fault	---	---	F76	---
03F5	Distance to Fault	-327.68 to 327.67	km	F52	---
03F6	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---
A1	**FAULT LOCATION 10**				**READ ONLY**
03F8	Date of Fault (2 words)	---	---	F23	---
03FA	Time of Fault (2 words)	---	---	F22	---
03FC	Type of Fault	---	---	F76	---
03FD	Distance to Fault	-327.68 to 327.67	km	F52	---
03FE	Line Z1 to Fault (magnitude)	0.00 to 655.35	Ω	F53	---

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 8 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
A2	**CURRENT PHASE ANGLES**				**READ ONLY**
0400	Phase A Current Angle	0 to 359	° Lag	F1	---
0401	Phase B Current Angle	0 to 359	° Lag	F1	---
0402	Phase C Current Angle	0 to 359	° Lag	F1	---
0403	Neutral Current Angle	0 to 359	° Lag	F1	---
0404	Ground Current Angle	0 to 359	° Lag	F1	---
0405[3]	Reserved Polarizing Current Angle	---	---	---	---
0406[3]	Sensitive Ground Current Angle	0 to 359	° Lag	F1	---
A2	**VOLTAGE PHASE ANGLES**				**READ ONLY**
0410	A-N Voltage Angle	0 to 359	° Lag	F1	---
0411	B-N Voltage Angle	0 to 359	° Lag	F1	---
0412	C-N Voltage Angle	0 to 359	° Lag	F1	---
0413	A-B Voltage Angle	0 to 359	° Lag	F1	---
0414	B-C Voltage Angle	0 to 359	° Lag	F1	---
0415	C-A Voltage Angle	0 to 359	° Lag	F1	---
0416[5]	Neutral Voltage Angle	0 to 359	° Lag	F1	---
A2	**SYMMETRICAL COMPONENTS**				**READ ONLY**
0420	Positive Sequence Current Magnitude	0 to 65535	A	F1	---
0421	Positive Sequence Current Angle	0 to 359	° Lag	F1	---
0422	Negative Sequence Current Magnitude	0 to 65535	A	F1	---
0423	Negative Sequence Current Angle	0 to 359	° Lag	F1	---
0424	Zero Sequence Current Magnitude	0 to 65535	A	F1	---
0425	Zero Sequence Current Angle	0 to 359	° Lag	F1	---
0426	Positive Sequence Voltage Magnitude	0.00 to 600.00	kV	F3	---
0427	Positive Sequence Voltage Angle	0 to 359	° Lag	F1	---
0428	Negative Sequence Voltage Magnitude	0.00 to 600.00	kV	F3	---
0429	Negative Sequence Voltage Angle	0 to 359	° Lag	F1	---
042A	Zero Sequence Voltage Magnitude	0.00 to 600.00	kV	F3	---
042B	Zero Sequence Voltage Angle	0 to 359	° Lag	F1	---
	PROTECTION FUNCTION STATES				**READ ONLY**
0600	Reserved				
0601[2]	Phase Time Overcurrent 1	---	---	F49	---
0602[2]	Phase Instantaneous Overcurrent 1	---	---	F49	---
0603[2]	Phase Instantaneous Overcurrent 2	---	---	F49	---
0604[2]	Ground Time Overcurrent	---	---	F49	---
0605[2]	Ground Instantaneous Overcurrent	---	---	F49	---

[1] [2] [3] [4] [5] [6] [7] [8] [9] For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 9 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
0606[2]	Neutral Time Overcurrent 1	---	---	F49	---
0607[2]	Neutral Time Overcurrent 2	---	---	F49	---
0608[2]	Neutral Instantaneous Overcurrent 1	---	---	F49	---
0609[2]	Neutral Instantaneous Overcurrent 2	---	---	F49	---
060A[2]	Phase Directional is Reverse	---	---	F49	---
060B[2]	Neutral Directional is Reverse	---	---	F49	---
060C	Manual Close Blocking	---	---	F49	---
060D	Cold Load Pickup Blocking	---	---	F49	---
060E	Bus Undervoltage 1	---	---	F49	---
060F	Bus Undervoltage 2	---	---	F49	---
0610	Line Undervoltage 3	---	---	F49	---
0611	Line Undervoltage 4	---	---	F49	
0612	Overvoltage 1	---	---	F49	---
0613	Overvoltage 2	---	---	F49	---
0614	Underfrequency 1	---	---	F49	---
0615	Underfrequency 2	---	---	F49	---
0616	Phase Current Level	---	---	F49	---
0617	Neutral Current Level	---	---	F49	---
0618	Power Factor 1	---	---	F49	---
0619	Power Factor 2	---	---	F49	---
061A	Synchrocheck Block (Not In Sync)	---	---	F49	---
061B	Current Demand	---	---	F49	---
061C	Real Power Demand	---	---	F49	---
061D	Reactive Power Demand	---	---	F49	---
061E	Apparent Power Demand	---	---	F49	---
061F	Analog Input Threshold 1	---	---	F49	---
0620	Analog Input Threshold 2	---	---	F49	---
0621	Analog Input Rate of Change 1	---	---	F49	---
0622	Analog Input Rate of Change 2	---	---	F49	---
0623	Overfrequency	---	---	F49	---
0624	Trip Counter	---	---	F49	---
0625	Arcing Current	---	---	F49	---
0626	VT Failure	---	---	F49	---
0627	Breaker Failure	---	---	F49	---
0628	Breaker Operation Failure	---	---	F49	---
0629	Trip Coil Monitor	---	---	F49	---

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 10 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
062A	Close Coil Monitor	---	---	F49	---
062B	User Input A	---	---	F49	---
062C	User Input B	---	---	F49	---
062D	User Input C	---	---	F49	---
062E	User Input D	---	---	F49	---
062F	User Input E	---	---	F49	---
0630	User Input F	---	---	F49	---
0631	User Input G	---	---	F49	---
0632	User Input H	---	---	F49	---
0633	Negative Sequence Instantaneous O/C	---	---	F49	---
0634	Negative Sequence Time O/C	---	---	F49	---
0635	Negative Sequence Overvoltage	---	---	F49	---
0636	Undervoltage Restoration	---	---	F49	---
0637	Underfrequency Restoration	---	---	F49	---
0638[1]	Phase Time Overcurrent 2	---	---	F49	---
0639[1]	Frequency Decay	---	---	F49	---
063A[3]	Negative Sequence Directional is Reverse	---	---	F49	---
063B[3]	Sensitive Ground Instantaneous O/C	---	---	F49	---
063C[3]	Sensitive Ground Time O/C	---	---	F49	---
063D[3]	Sensitive Ground Directional is Reverse	---	---	F49	---
063E[5]	Reserved for MOD 008	---	---	F49	---
063F[5]	Neutral Displacement	---	---	F49	---
0640[5]	Pulse Output Positive Watthours	---	---	F49	---
0641[5]	Pulse Output Negative Watthours	---	---	F49	---
0642[5]	Pulse Output Positive Varhours	---	---	F49	---
0643[5]	Pulse Output Negative Varhours	---	---	F49	---
0644[6]	Ground Directional is Reverse	---	---	F49	---
0645[7]	Reserved for MOD 010	---	---	F49	---
0646[8]	User Input I	---	---	F49	---
0647[8]	User Input J	---	---	F49	---
0648[8]	User Input K	---	---	F49	---
0649[8]	User Input L	---	---	F49	---
064A[8]	User Input M	---	---	F49	---
064B[8]	User Input N	---	---	F49	---

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 11 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
064C[8]	User Input O	---	---	F49	---
064D[8]	User Input P	---	---	F49	---
064E[8]	User Input Q	---	---	F49	---
064F[8]	User Input R	---	---	F49	---
0650[8]	User Input S	---	---	F49	---
0651[8]	User Input T	---	---	F49	---
0652[8]	Autoreclose Rate Supervision	---	---	F49	---
0653[8]	Restricted Earth Fault	---	---	F49	---
S1	**750/760 SETUP**				**READ/WRITE**
1000	Reserved				
1001	Flash Message Time	0.5 to 10.0	s	F2	4.0 s
1002	Default Message Timeout	10 to 900	s	F1	300 s
1003	Default Message Intensity (25, 50, 75, or100)	25 to 100	%	F1	25%
1004[1]	Display Filter Constant	0 to 255	---	F1	0
1005	Reserved				
1006	Set Date (2 words)	---	---	F23	01/01/1993
1008	Set Time (2 words)	---	---	F22	00:00:00.000
100A	760 Operation	---	---	F29	Not Ready
100B[2]	IRIG-B Signal Type	---	---	F43	None
100C	Encrypted Passcode (4 words)	---	---	F33	"AIKFBAIK"
S1	**EVENT RECORDER SETUP**				**READ/WRITE**
1010	Event Recorder Function	---	---	F30	Enabled
1011	Recording of Trip Events	---	---	F30	Enabled
1012	Recording of Alarm Events	---	---	F30	Enabled
1013	Recording of Control Events	---	---	F30	Disabled
1014	Recording of Logic Input Events	---	---	F30	Enabled
1015	Recording of Pickup Events	---	---	F30	Enabled
1016	Recording of Dropout Events	---	---	F30	Enabled
1017[8]	Recording of Set Time/Date Events	---	---	F30	Enabled
S1	**TRACE MEMORY SETUP**				**READ/WRITE**
1018	Buffer Organization	---	---	F81	16 x 256
1019	Trigger Position	0 to 100	%	F1	25%
101A	Trigger Source	---	---	F82	Pickup & Trip
S1	**DEFAULT MESSAGES**				**READ/WRITE**
1020	Number Of Messages Selected (read only)	0 to 20	---	F1	3

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 12 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1021	Default Message #1	---	---	F32	---
1022	Default Message #2	---	---	F32	---
1023	Default Message #3	---	---	F32	---
:	:				
103E	Default Message #30	---	---	F32	---
S1	**USER TEXT MESSAGES**				**READ/WRITE**
1040	User Text Message 1 (20 words)	---	---	F33	"Text 1"
1054	User Text Message 2 (20 words)	---	---	F33	"Text 2"
1068	User Text Message 3 (20 words)	---	---	F33	"Text 3"
107C	User Text Message 4 (20 words)	---	---	F33	"Text 4"
1090	User Text Message 5 (20 words)	---	---	F33	"Text 5"
S1	**OVERRIDE MESSAGE**				**READ/WRITE**
10B0	Override Message Display Time	0 to 9000	s	F1	0 s
10B1	Override Message (20 words)	---	---	F33	"This is a test"
S1	**COMMUNICATIONS**				**READ/WRITE**
10D0	Slave Address	1 to 254	---	F1	254
10D1	COM1 Baud Rate	---	---	F31	9600
10D2	COM1 Parity	---	---	F27	None
10D3	COM1 Communication Hardware	---	---	F17	RS485
10D4	Front Panel RS232 Baud Rate	---	---	F31	9600
10D5	Front Panel RS232 Parity	---	---	F27	None
10D6	Reserved				
10D7	Reserved				
10D8	COM2 Baud Rate	---	---	F31	9600
10D9	COM2 Parity	---	---	F27	None
10DA	DNP Port	---	---	F62	None
10DB	DNP Point Mapping	---	---	F30	Disabled
S1	**DATA LOGGER**				**READ/WRITE**
10E0	Sample Rate	---	---	F74	1 cycle
10E1	Continuous Mode	---	---	F30	Disabled
10E2	Buffer Organization	---	---	F81	16 x 256
10E3	Trigger Position	0 to 100	%	F1	25%
10E4	Trigger Source	---	---	F82	Pickup & Trip
10E5	Channel 1 Source	---	---	F77	I_a
10E6	Channel 2 Source	---	---	F77	I_b
10E7	Channel 3 Source	---	---	F77	I_c
10E8	Channel 4 Source	---	---	F77	I_g

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 13 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
10E9	Channel 5 Source	---	---	F77	V_{an}
10EA	Channel 6 Source	---	---	F77	V_{bn}
10EB	Channel 7 Source	---	---	F77	V_{cn}
10EC	Channel 8 Source	---	---	F77	Frequency
S1[8]	**DNP COMMUNICATIONS**				**READ/WRITE**
10F0[8]	Transmission Delay	0 to 65000	ms	F1	0 ms
10F1[8]	Data Link Confirmation Mode	---	---	F89	Never
10F2[8]	Data Link Confirmation Timeout	1 to 65000	ms	F1	1000 ms
10F3[8]	Data Link Confirmation Retries	0 to 100	---	F1	3
10F4[8]	Select/Operate Arm Timer Duration	1 to 65000	ms	F1	10000 ms
10F5[8]	Write Time Interval	0 to 65000	ms	F1	0 ms
10F6[8]	Inhibit Cold Restart	---	---	F30	Disabled
10F7[9]	3 Key Reset of Max Demand Values	---	---	F30	Disabled
S2	**SYSTEM SETUP**				**READ/WRITE**
1100	Phase CT Primary	1 to 50000	A	F1	1000 A
1101	Reserved				
1102	Ground CT Primary	1 to 50000	A	F1	50 A
1103	Bus VT Connection Type	---	---	F28	Wye
1104	Bus Nominal VT Secondary Voltage	50.0 to 240.0	V	F2	120.0 V
1105	Bus VT Ratio	1.0 to 5000.0	xxx: 1	F2	120.0:1
1106	Nominal Frequency	25 to 60	Hz	F1	60 Hz
1107	Cost of energy	1.0 to 25.0	¢/kWh	F2	5.0 ¢/kWh
1108[3]	Reserved for Polarizing CT Primary	---	---	---	---
1109	Line VT Connection	---	---	F18	V_{bn}
110A	Line Nominal VT Secondary Voltage	50.0 to 240.0	V	F2	120.0 V
110B	Line VT Ratio	1.0 to 5000.0	xxx: 1	F1	120.0:1
110C[1]	Phase Sequence	---	---	F83	ABC
110D[3]	Sensitive Ground CT Primary	1 to 50000	A	F1	1000 A
S3	**LOGIC INPUT ASSERTED LOGIC**				**READ/WRITE**
1140[2]	Logic Input 1 Asserted Logic	---	---	F63	Contact Close
1141[2]	Logic Input 2 Asserted Logic	---	---	F63	Contact Close
1142[2]	Logic Input 3 Asserted Logic	---	---	F63	Contact Close
:	:	:	:	:	:
114D[2]	Logic Input 14 Asserted Logic	---	---	F63	Contact close

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 14 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
114E[1]	Logic Input 15 Asserted Logic	---	---	F64	Disabled
114F[1]	Logic Input 16 Asserted Logic	---	---	F64	Disabled
:	:	:	:	:	:
1153[1]	Logic Input 20 Asserted Logic	---	---	F64	Disabled
S3	**BREAKER FUNCTIONS**				**READ/WRITE**
1160	52a Contact	---	---	F65	Disabled
1161	52b Contact	---	---	F65	Disabled
1162	Breaker Connected	---	---	F65	Disabled
S3	**CONTROL FUNCTIONS**				**READ/WRITE**
1170	Local Mode	---	---	F65	Disabled
1171	Remote Reset	---	---	F65	Disabled
1172	Remote Open	---	---	F65	Disabled
1173	Remote Close	---	---	F65	Disabled
1174	Cold Load Pickup	---	---	F65	Disabled
1175	Setpoint Group 2	---	---	F65	Disabled
1176	Setpoint Group 3	---	---	F65	Disabled
1177	Setpoint Group 4	---	---	F65	Disabled
S3	**USER INPUT A**				**READ/WRITE**
1180	User Input A Name (9 registers)	---	---	F33	User Input A
1189	User Input A Source	---	---	F65	Disabled
118A	User Input A Function	---	---	F37	Disabled
118B	User Input A Relays	---	---	F57	None
118C	User Input A Delay	0.00 to 600.00	s	F3	0.00 s
S3	**USER INPUT B**				**READ/WRITE**
1190	User Input B Name (9 registers)	---	---	F33	User Input B
1199	User Input B Source	---	---	F65	Disabled
119A	User Input B Function	---	---	F37	Disabled
119B	User Input B Relays	---	---	F57	None
119C	User Input B Delay	0.00 to 600.00	s	F3	0.00 s
S3	**USER INPUT C**				**READ/WRITE**
11A0	User Input C Name (9 registers)	---	---	F33	User Input C
11A9	User Input C Source	---	---	F65	Disabled
11AA	User Input C Function	---	---	F37	Disabled
11AB	User Input C Relays	---	---	F57	None
11AC	User Input C Delay	0.00 to 600.00	s	F3	0.00 s
S3	**USER INPUT D**				**READ/WRITE**
11B0	User Input D Name (9 registers)	---	---	F33	User Input D

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 15 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
11B9	User Input D Source	---	---	F65	Disabled
11BA	User Input D Function	---	---	F37	Disabled
11BB	User Input D Relays	---	---	F57	None
11BC	User Input D Delay	0.00 to 600.00	s	F3	0.00 s
S3	**USER INPUT E**				**READ/WRITE**
11C0	User Input E Name (9 registers)	---	---	F33	User Input E
11C9	User Input E Source	---	---	F65	Disabled
11CA	User Input E Function	---	---	F37	Disabled
11CB	User Input E Relays	---	---	F57	None
11CC	User Input E Delay	0.00 to 600.00	s	F3	0.00 s
S3	**USER INPUT F**				**READ/WRITE**
11D0	User Input F Name (9 registers)	---	---	F33	User Input F
11D9	User Input F Source	---	---	F65	Disabled
11DA	User Input F Function	---	---	F37	Disabled
11DB	User Input F Relays	---	---	F57	None
11DC	User Input F Delay	0.00 to 600.00	s	F3	0.00 s
S3	**USER INPUT G**				**READ/WRITE**
11E0	User Input G Name (9 registers)	---	---	F33	User Input G
11E9	User Input G Source	---	---	F65	Disabled
11EA	User Input G Function	---	---	F37	Disabled
11EB	User Input G Relays	---	---	F57	None
11EC	User Input G Delay	0.00 to 600.00	s	F3	0.00 s
S3	**USER INPUT H**				**READ/WRITE**
11F0	User Input H Name (9 registers)	---	---	F33	User Input H
11F9	User Input H Source	---	---	F65	Disabled
11FA	User Input H Function	---	---	F37	Disabled
11FB	User Input H Relays	---	---	F57	None
11FC	User Input H Delay	0.00 to 600.00	s	F3	0.00 s
S3	**BLOCKING FUNCTIONS**				**READ/WRITE**
1240	Block 1 TRIP Relay	---	---	F65	Disabled
1241	Block 2 CLOSE Relay	---	---	F65	Disabled
1242	Block Reset	---	---	F65	Disabled
1243	Block Undervoltage 1	---	---	F65	Disabled
1244	Block Undervoltage 2	---	---	F65	Disabled
1245	Block Undervoltage 3	---	---	F65	Disabled
1246	Block Undervoltage 4	---	---	F65	Disabled
1247	Block Underfrequency 1	---	---	F65	Disabled

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 16 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1248	Block Underfrequency 2	---	---	F65	Disabled
1249	Bypass Synchrocheck	---	---	F65	Disabled
124A[2]	Block Breaker Statistics	---	---	F65	Disabled
124B	Block Negative Sequence Voltage	---	---	F65	Disabled
124C	Block Restoration	---	---	F65	Disabled
124D	Block Frequency Decay	---	---	F65	Disabled
124E[5]	Reserved for MOD 008	---	---	F65	Disabled
124F[5]	Block Neutral Displacement	---	---	F65	Disabled
S3	**OVERCURRENT BLOCKING FUNCTIONS**				**READ/WRITE**
1260	Block All Overcurrent	---	---	F65	Disabled
1261	Block All Phase Overcurrent	---	---	F65	Disabled
1262	Block All Ground Overcurrent	---	---	F65	Disabled
1263	Block All Neutral Overcurrent	---	---	F65	Disabled
1264[2]	Block Phase Time Overcurrent 1	---	---	F65	Disabled
1265[2]	Block Phase Instantaneous Overcurrent 1	---	---	F65	Disabled
1266[2]	Block Phase Instantaneous Overcurrent 2	---	---	F65	Disabled
1267[2]	Block Ground Time Overcurrent	---	---	F65	Disabled
1268[2]	Block Ground Instantaneous Overcurrent	---	---	F65	Disabled
1269[2]	Block Neutral Time Overcurrent 1	---	---	F65	Disabled
126A[2]	Block Neutral Time Overcurrent 2	---	---	F65	Disabled
126B[2]	Block Neutral Instantaneous Overcurrent 1	---	---	F65	Disabled
126C[2]	Block Neutral Instantaneous Overcurrent 2	---	---	F65	Disabled
126D	Block Negative Sequence Time Overcurrent	---	---	F65	Disabled
126E	Block Negative Sequence Instantaneous Overcurrent	---	---	F65	Disabled
126F	Block Phase Time Overcurrent 2	---	---	F65	Disabled
1270[3]	Block All Sensitive Ground Overcurrent	---	---	F65	Disabled
1271[3]	Block Sensitive Ground Instantaneous O/C	---	---	F65	Disabled
1272[3]	Block Sensitive Ground Time O/C	---	---	F65	Disabled
S3	**TRANSFER FUNCTIONS**				**READ/WRITE**
1280	Selected To Trip	---	---	F65	Disabled
1281	Undervoltage on Other Source	---	---	F65	Disabled
1282	Incomer 1 Breaker Closed	---	---	F65	Disabled
1283	Incomer 2 Breaker Closed	---	---	F65	Disabled
1284	Tie Breaker Connected	---	---	F65	Disabled
1285	Tie Breaker Closed	---	---	F65	Disabled

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 17 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1286	Block Transfer	---	---	F65	Disabled
1287	Transformer Lockout	---	---	F65	Disabled
1288	Source Trip	---	---	F65	Disabled
1289	Close From Incomer 1	---	---	F65	Disabled
128A	Close From Incomer 2	---	---	F65	Disabled
S3	**AUTORECLOSE FUNCTIONS (760 ONLY)**				**READ/WRITE**
1290	Initiate Reclosure	---	---	F65	Disabled
1291	Cancel Reclosure	---	---	F65	Disabled
1292	Block Reclosure	---	---	F65	Disabled
S3	**MISCELLANEOUS FUNCTIONS**				**READ/WRITE**
12A0	Trigger Trace Memory	---	---	F65	Disabled
12A1	Simulate Fault	---	---	F65	Disabled
12A2	Trigger Data Logger	---	---	F65	Disabled
12A3[8]	Start Demand Interval	---	---	F65	Disabled
S4	**RELAY 1 TRIP**				**READ/WRITE**
1300[8]	Relay 1 TRIP Seal In Time	0.00 to 9.99	s	F3	0.04s
S4	**RELAY 2 CLOSE**				**READ/WRITE**
1310[8]	Relay 2 CLOSE Seal In Time	0.00 to 9.99	s	F3	0.04 s
S4	**RELAY 3 AUXILIARY**				**READ/WRITE**
1320	Relay 3 AUXILIARY Name (8 words)	---	---	F33	"AUXILIARY"
1328	Relay 3 AUXILIARY Non-operated State	---	---	F34	De-energized
1329	Relay 3 AUXILIARY Output Type	---	---	F35	Self-resetting
132A	Relay 3 AUXILIARY Pulse Dwell Time	0.1 to 6000.0	s	F2	0.1 s
S4	**RELAY 4 AUXILIARY**				**READ/WRITE**
1330	Relay 4 AUXILIARY Name (8 words)	---	---	F33	"AUXILIARY"
1338	Relay 4 AUXILIARY Non-operated State	---	---	F34	De-energized
1339	Relay 4 AUXILIARY Output Type	---	---	F35	Self-resetting
133A	Relay 4 AUXILIARY Pulse Dwell Time	0.1 to 6000.0	s	F2	0.1 s
S4	**RELAY 5 AUXILIARY**				**READ/WRITE**
1340	Relay 5 AUXILIARY Name (8 words)	---	---	F33	"AUXILIARY"
1348	Relay 5 AUXILIARY Non-operated State	---	---	F34	De-energized
1349	Relay 5 AUXILIARY Output Type	---	---	F35	Self-resetting
134A	Relay 5 AUXILIARY Pulse Dwell Time	0.1 to 6000.0	s	F2	0.1 s
S4	**RELAY 6 AUXILIARY**				**READ/WRITE**
1350	Relay 6 AUXILIARY Name (8 words)	---	---	F33	"AUXILIARY"
1358	Relay 6 AUXILIARY Non-operated State	---	---	F34	De-energized
1359	Relay 6 AUXILIARY Output Type	---	---	F35	Self-resetting

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 18 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
135A	Relay 6 AUXILIARY Pulse Dwell Time	0.1 to 6000.0	s	F2	0.1 s
S4	**RELAY 7 AUXILIARY**				**READ/WRITE**
1360	Relay 7 AUXILIARY Name (8 words)	---	---	F33	"AUXILIARY"
1368	Relay 7 AUXILIARY Non-operated State	---	---	F34	De-energized
1369	Relay 7 AUXILIARY Output Type	---	---	F35	Self-resetting
136A	Relay 7 AUXILIARY Pulse Dwell Time	0.1 to 6000.0	s	F2	0.1 s
S3[8]	**USER INPUT I**				**READ/WRITE**
1370[8]	User Input I Name (9 registers)	---	---	F33	User Input I
1379[8]	User Input I Source	---	---	F65	Disabled
137A[8]	User Input I Function	---	---	F37	Disabled
137B[8]	User Input I Relays	---	---	F57	None
137C[8]	User Input I Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT J**				**READ/WRITE**
1380[8]	User Input J Name (9 registers)	---	---	F33	User Input J
1389[8]	User Input J Source	---	---	F65	Disabled
138A[8]	User Input J Function	---	---	F37	Disabled
138B[8]	User Input J Relays	---	---	F57	None
138C[8]	User Input J Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT K**				**READ/WRITE**
1390[8]	User Input K Name (9 registers)	---	---	F33	User Input K
1399[8]	User Input K Source	---	---	F65	Disabled
139A[8]	User Input K Function	---	---	F37	Disabled
139B[8]	User Input K Relays	---	---	F57	None
139C[8]	User Input K Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT L**				**READ/WRITE**
13A0[8]	User Input L Name (9 registers)	---	---	F33	User Input L
13A9[8]	User Input L Source	---	---	F65	Disabled
13AA[8]	User Input L Function	---	---	F37	Disabled
13AB[8]	User Input L Relays	---	---	F57	None
13AC[8]	User Input L Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT M**				**READ/WRITE**
13B0[8]	User Input M Name (9 registers)	---	---	F33	User Input M
13B9[8]	User Input M Source	---	---	F65	Disabled

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 19 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
13BA[8]	User Input M Function	---	---	F37	Disabled
13BB[8]	User Input M Relays	---	---	F57	None
13BC[8]	User Input M Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT N**				**READ/WRITE**
13C0[8]	User Input N Name (9 registers)	---	---	F33	User Input N
13C9[8]	User Input N Source	---	---	F65	Disabled
13CA[8]	User Input N Function	---	---	F37	Disabled
13CB[8]	User Input N Relays	---	---	F57	None
13CC[8]	User Input N Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT O**				**READ/WRITE**
13D0[8]	User Input O Name (9 registers)	---	---	F33	User Input O
13D9[8]	User Input O Source	---	---	F65	Disabled
13DA[8]	User Input O Function	---	---	F37	Disabled
13DB[8]	User Input O Relays	---	---	F57	None
13DC[8]	User Input O Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT P**				**READ/WRITE**
13E0[8]	User Input P Name (9 registers)	---	---	F33	User Input P
13E9[8]	User Input P Source	---	---	F65	Disabled
13EA[8]	User Input P Function	---	---	F37	Disabled
13EB[8]	User Input P Relays	---	---	F57	None
13EC[8]	User Input P Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT Q**				**READ/WRITE**
13F0[8]	User Input Q Name (9 registers)	---	---	F33	User Input Q
13F9[8]	User Input Q Source	---	---	F65	Disabled
13FA[8]	User Input Q Function	---	---	F37	Disabled
13FB[8]	User Input Q Relays	---	---	F57	None
13FC[8]	User Input Q Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT R**				**READ/WRITE**
1400[8]	User Input R Name (9 registers)	---	---	F33	User Input R
1409[8]	User Input R Source	---	---	F65	Disabled
140A[8]	User Input R Function	---	---	F37	Disabled
140B[8]	User Input R Relays	---	---	F57	None

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 20 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
140C[8]	User Input R Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT S**				**READ/WRITE**
1410[8]	User Input S Name (9 registers)	---	---	F33	User Input S
1419[8]	User Input S Source	---	---	F65	Disabled
141A[8]	User Input S Function	---	---	F37	Disabled
141B[8]	User Input S Relays	---	---	F57	None
141C[8]	User Input S Delay	0.00 to 600.00	s	F3	0.00 s
S3[8]	**USER INPUT T**				**READ/WRITE**
1420[8]	User Input T Name (9 registers)	---	---	F33	User Input T
1429[8]	User Input T Source	---	---	F65	Disabled
142A[8]	User Input T Function	---	---	F37	Disabled
142B[8]	User Input T Relays	---	---	F57	None
142C[8]	User Input T Delay	0.00 to 600.00	s	F3	0.00 s
S2	**FLEXCURVE A TRIP TIMES**				**READ/WRITE**
1430	FlexCurve A Trip Time at 1.03 x PU	0 to 65535	ms	F1	0 ms
1431	FlexCurve A Trip Time at 1.05 x PU	0 to 65535	ms	F1	0 ms
1432	FlexCurve A Trip Time at 1.10 x PU	0 to 65535	ms	F1	0 ms
1433	FlexCurve A Trip Time at 1.20 x PU	0 to 65535	ms	F1	0 ms
1434	FlexCurve A Trip Time at 1.30 x PU	0 to 65535	ms	F1	0 ms
1435	FlexCurve A Trip Time at 1.40 x PU	0 to 65535	ms	F1	0 ms
1436	FlexCurve A Trip Time at 1.50 x PU	0 to 65535	ms	F1	0 ms
1437	FlexCurve A Trip Time at 1.60 x PU	0 to 65535	ms	F1	0 ms
1438	FlexCurve A Trip Time at 1.70 x PU	0 to 65535	ms	F1	0 ms
1439	FlexCurve A Trip Time at 1.80 x PU	0 to 65535	ms	F1	0 ms
143A	FlexCurve A Trip Time at 1.90 x PU	0 to 65535	ms	F1	0 ms
143B	FlexCurve A Trip Time at 2.00 x PU	0 to 65535	ms	F1	0 ms
143C	FlexCurve A Trip Time at 2.10 x PU	0 to 65535	ms	F1	0 ms
143D	FlexCurve A Trip Time at 2.20 x PU	0 to 65535	ms	F1	0 ms
143E	FlexCurve A Trip Time at 2.30 x PU	0 to 65535	ms	F1	0 ms
143F	FlexCurve A Trip Time at 2.40 x PU	0 to 65535	ms	F1	0 ms
1440	FlexCurve A Trip Time at 2.50 x PU	0 to 65535	ms	F1	0 ms
1441	FlexCurve A Trip Time at 2.60 x PU	0 to 65535	ms	F1	0 ms
1442	FlexCurve A Trip Time at 2.70 x PU	0 to 65535	ms	F1	0 ms
1443	FlexCurve A Trip Time at 2.80 x PU	0 to 65535	ms	F1	0 ms
1444	FlexCurve A Trip Time at 2.90 x PU	0 to 65535	ms	F1	0 ms

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 21 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1445	FlexCurve A Trip Time at 3.00 x PU	0 to 65535	ms	F1	0 ms
1446	FlexCurve A Trip Time at 3.10 x PU	0 to 65535	ms	F1	0 ms
1447	FlexCurve A Trip Time at 3.20 x PU	0 to 65535	ms	F1	0 ms
1448	FlexCurve A Trip Time at 3.30 x PU	0 to 65535	ms	F1	0 ms
1449	FlexCurve A Trip Time at 3.40 x PU	0 to 65535	ms	F1	0 ms
144A	FlexCurve A Trip Time at 3.50 x PU	0 to 65535	ms	F1	0 ms
144B	FlexCurve A Trip Time at 3.60 x PU	0 to 65535	ms	F1	0 ms
144C	FlexCurve A Trip Time at 3.70 x PU	0 to 65535	ms	F1	0 ms
144D	FlexCurve A Trip Time at 3.80 x PU	0 to 65535	ms	F1	0 ms
144E	FlexCurve A Trip Time at 3.90 x PU	0 to 65535	ms	F1	0 ms
144F	FlexCurve A Trip Time at 4.00 x PU	0 to 65535	ms	F1	0 ms
1450	FlexCurve A Trip Time at 4.10 x PU	0 to 65535	ms	F1	0 ms
1451	FlexCurve A Trip Time at 4.20 x PU	0 to 65535	ms	F1	0 ms
1452	FlexCurve A Trip Time at 4.30 x PU	0 to 65535	ms	F1	0 ms
1453	FlexCurve A Trip Time at 4.40 x PU	0 to 65535	ms	F1	0 ms
1454	FlexCurve A Trip Time at 4.50 x PU	0 to 65535	ms	F1	0 ms
1455	FlexCurve A Trip Time at 4.60 x PU	0 to 65535	ms	F1	0 ms
1456	FlexCurve A Trip Time at 4.70 x PU	0 to 65535	ms	F1	0 ms
1457	FlexCurve A Trip Time at 4.80 x PU	0 to 65535	ms	F1	0 ms
1458	FlexCurve A Trip Time at 4.90 x PU	0 to 65535	ms	F1	0 ms
1459	FlexCurve A Trip Time at 5.00 x PU	0 to 65535	ms	F1	0 ms
145A	FlexCurve A Trip Time at 5.10 x PU	0 to 65535	ms	F1	0 ms
145B	FlexCurve A Trip Time at 5.20 x PU	0 to 65535	ms	F1	0 ms
145C	FlexCurve A Trip Time at 5.30 x PU	0 to 65535	ms	F1	0 ms
145D	FlexCurve A Trip Time at 5.40 x PU	0 to 65535	ms	F1	0 ms
145E	FlexCurve A Trip Time at 5.50 x PU	0 to 65535	ms	F1	0 ms
145F	FlexCurve A Trip Time at 5.60 x PU	0 to 65535	ms	F1	0 ms
1460	FlexCurve A Trip Time at 5.70 x PU	0 to 65535	ms	F1	0 ms
1461	FlexCurve A Trip Time at 5.80 x PU	0 to 65535	ms	F1	0 ms
1462	FlexCurve A Trip Time at 5.90 x PU	0 to 65535	ms	F1	0 ms
1463	FlexCurve A Trip Time at 6.00 x PU	0 to 65535	ms	F1	0 ms
1464	FlexCurve A Trip Time at 6.50 x PU	0 to 65535	ms	F1	0 ms
1465	FlexCurve A Trip Time at 7.00 x PU	0 to 65535	ms	F1	0 ms
1466	FlexCurve A Trip Time at 7.50 x PU	0 to 65535	ms	F1	0 ms
1467	FlexCurve A Trip Time at 8.00 x PU	0 to 65535	ms	F1	0 ms
1468	FlexCurve A Trip Time at 8.50 x PU	0 to 65535	ms	F1	0 ms
1469	FlexCurve A Trip Time at 9.00 x PU	0 to 65535	ms	F1	0 ms

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 22 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
146A	FlexCurve A Trip Time at 9.50 x PU	0 to 65535	ms	F1	0 ms
146B	FlexCurve A Trip Time at 10.0 x PU	0 to 65535	ms	F1	0 ms
146C	FlexCurve A Trip Time at 10.5 x PU	0 to 65535	ms	F1	0 ms
146D	FlexCurve A Trip Time at 11.0 x PU	0 to 65535	ms	F1	0 ms
146E	FlexCurve A Trip Time at 11.5 x PU	0 to 65535	ms	F1	0 ms
146F	FlexCurve A Trip Time at 12.0 x PU	0 to 65535	ms	F1	0 ms
1470	FlexCurve A Trip Time at 12.5 x PU	0 to 65535	ms	F1	0 ms
1471	FlexCurve A Trip Time at 13.0 x PU	0 to 65535	ms	F1	0 ms
1472	FlexCurve A Trip Time at 13.5 x PU	0 to 65535	ms	F1	0 ms
1473	FlexCurve A Trip Time at 14.0 x PU	0 to 65535	ms	F1	0 ms
1474	FlexCurve A Trip Time at 14.5 x PU	0 to 65535	ms	F1	0 ms
1475	FlexCurve A Trip Time at 15.0 x PU	0 to 65535	ms	F1	0 ms
1476	FlexCurve A Trip Time at 15.5 x PU	0 to 65535	ms	F1	0 ms
1477	FlexCurve A Trip Time at 16.0 x PU	0 to 65535	ms	F1	0 ms
1478	FlexCurve A Trip Time at 16.5 x PU	0 to 65535	ms	F1	0 ms
1479	FlexCurve A Trip Time at 17.0 x PU	0 to 65535	ms	F1	0 ms
147A	FlexCurve A Trip Time at 17.5 x PU	0 to 65535	ms	F1	0 ms
147B	FlexCurve A Trip Time at 18.0 x PU	0 to 65535	ms	F1	0 ms
147C	FlexCurve A Trip Time at 18.5 x PU	0 to 65535	ms	F1	0 ms
147D	FlexCurve A Trip Time at 19.0 x PU	0 to 65535	ms	F1	0 ms
147E	FlexCurve A Trip Time at 19.5 x PU	0 to 65535	ms	F1	0 ms
147F	FlexCurve A Trip Time at 20.0 x PU	0 to 65535	ms	F1	0 ms
S2	**FLEXCURVE B**				**READ/WRITE**
1480	FlexCurve B (80 words - see FlexCurve A)	0 to 65535	ms	F1	0 ms
S5	**PHASE TIME OVERCURRENT 1**				**READ/WRITE**
1500	Phase Time Overcurrent 1 Function	---	---	F37	Trip
1501	Phase Time Overcurrent 1 Relays	---	---	F57	None
1502[2]	Phase Time Overcurrent 1 Curve	---	---	F36	Ext Inverse
1503	Phase Time Overcurrent 1 Voltage Restraint	---	---	F30	Disabled
1504[1]	Phase Time Overcurrent 1 Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1505[1]	Phase Time Overcurrent 1 Multiplier	0.00 to 100.00	---	F3	1.00
1506[1]	Phase Time Overcurrent 1 Reset Time	---	---	F68	Instantaneous
1507[1]	Phase Time Overcurrent 1 Direction	---	---	F84	Disabled
S5	**PHASE INSTANTANEOUS OVERCURRENT 1**				**READ/WRITE**
1508[2]	Phase Instantaneous Overcurrent 1 Function	---	---	F37	Disabled
1509[2]	Phase Instantaneous Overcurrent 1 Relays	---	---	F57	None

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 23 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
150A[2]	Phase Instantaneous Overcurrent 1 Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
150B[2]	Phase Instantaneous Overcurrent 1 Delay	0.00 to 600.00	s	F3	0.00 s
150C	Phases Required for Operation	---	---	F41	Any One
150D[1]	Phase Instantaneous Overcurrent 1 Direction	---	---	F84	Disabled
S5	**PHASE INSTANTANEOUS OVERCURRENT 2**				**READ/WRITE**
1510[2]	Phase Instantaneous Overcurrent 2 Function	---	---	F37	Disabled
1511[2]	Phase Instantaneous Overcurrent 2 Relays	---	---	F57	None
1512[2]	Phase Instantaneous Overcurrent 2 Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1513[2]	Phase Instantaneous Overcurrent 2 Delay	0.00 to 600.00	s	F3	0.00 s
1514	Phases Required for Operation	---	---	F41	Any One
1515[1]	Phase Instantaneous Overcurrent 2 Direction	---	---	F84	Disabled
S5	**PHASE DIRECTIONAL**				**READ/WRITE**
1520	Phase Directional Function	---	---	F38	Disabled
1521	Phase Directional Maximum Torque Angle	0 to 359	° Lead	F1	30° Lead
1522[1]	Minimum Polarizing Voltage	0.00 to 1.25	x VT	F3	0.05 x VT
1523	Phase Directional Relays	---	---	F57	None
1524[4]	Block OC When Voltage Memory Expires	---	---	F30	Disabled
S5	**PHASE TIME OVERCURRENT 2**				**READ/WRITE**
1530[1]	Phase Time Overcurrent 2 Function	---	---	F37	Disabled
1531[1]	Phase Time Overcurrent 2 Relays	---	---	F57	None
1532[1]	Phase Time Overcurrent 2 Curve	---	---	F36	Ext. Inverse
1533[1]	Phase Time Overcurrent 2 Voltage Restraint	---	---	F30	Disabled
1534[1]	Phase Time Overcurrent 2 Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1535[1]	Phase Time Overcurrent 2 Multiplier	0.00 to 100.00	---	F3	1.00
1536[1]	Phase Time Overcurrent 2 Reset Time	---	---	F68	Instantaneous
1537[1]	Phase Time Overcurrent 2 Direction	---	---	F84	Disabled
S5	**GROUND TIME OVERCURRENT**				**READ/WRITE**
1600	Ground Time Overcurrent Function	---	---	F37	Disabled
1601	Ground Time Overcurrent Relays	---	---	F57	None
1602	Ground Time Overcurrent Curve	---	---	F36	Ext. Inverse
1603[1]	Ground Time Overcurrent Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1604[1]	Ground Time Overcurrent Multiplier	0.00 to 100.00	---	F3	1.00
1605[1]	Ground Time Overcurrent Reset Time	---	---	F68	Instantaneous
1606[6]	Ground Time Overcurrent Direction	---	---	F84	Disabled

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 24 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
S5	**GROUND INSTANTANEOUS OVERCURRENT**				**READ/WRITE**
1608[2]	Ground Instantaneous Overcurrent Function	---	---	F37	Disabled
1609[2]	Ground Instantaneous Overcurrent Relays	---	---	F57	None
160A[2]	Ground Instantaneous Overcurrent Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
160B[2]	Ground Instantaneous Overcurrent Delay	0.00 to 600.00	s	F3	0.00 s
160C[6]	Ground Instantaneous Overcurrent Direction	---	---	F84	Disabled
S5	**GROUND DIRECTIONAL**				**READ/WRITE**
160E[6]	Ground Directional Function	---	---	F38	Disabled
160F[6]	Ground Directional Maximum Torque Angle	0 to 359	° Lead	F1	315°
1610[6]	Ground Directional Minimum Polarizing Voltage	0.00 to 1.25	x VT	F3	0.05 x VT
1611[6]	Ground Directional Polarizing	---	---	F50	Voltage
1612[6]	Ground Directional Relays	---	---	F57	None
S5	**NEUTRAL TIME OVERCURRENT 1**				**READ/WRITE**
1630	Neutral Time Overcurrent 1 Function	---	---	F37	Disabled
1631	Neutral Time Overcurrent 1 Relays	---	---	F57	None
1632	Neutral Time Overcurrent 1 Curve	---	---	F36	Ext. Inverse
1633[1]	Neutral Time Overcurrent 1 Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1634[1]	Neutral Time Overcurrent 1 Multiplier	0.00 to 100.00	---	F3	1.00
1635[1]	Neutral Time Overcurrent 1 Reset Time	---	---	F68	Instantaneous
1636[1]	Neutral Time Overcurrent 1 Direction	---	---	F84	Disabled
S5	**NEUTRAL INSTANANEOUS OVERCURRENT 1**				**READ/WRITE**
1640[2]	Neutral Instantaneous Overcurrent 1 Function	---	---	F37	Disabled
1641[2]	Neutral Instantaneous Overcurrent 1 Relays	---	---	F57	None
1642[2]	Neutral Instantaneous Overcurrent 1 Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1643[2]	Neutral Instantaneous Overcurrent 1 Delay	0.00 to 600.00	s	F3	0.00 s
1644[1]	Neutral Instantaneous Overcurrent 1 Direction	---	---	F84	Disabled
S5	**NEUTRAL INSTANTANEOUS OVERCURRENT 2**				**READ/WRITE**
1650[2]	Neutral Instantaneous Overcurrent 2 Function	---	---	F37	Disabled
1651[2]	Neutral Instantaneous Overcurrent 2 Relays	---	---	F57	None
1652[2]	Neutral Instantaneous Overcurrent 2 Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1653[2]	Neutral Instantaneous Overcurrent 2 Delay	0.00 to 600.00	s	F3	0.00 s
1654[1]	Neutral Instantaneous Overcurrent 2 Direction	---	---	F84	Disabled

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 25 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
S5	**NEUTRAL TIME OVERCURRENT 2**				**READ/WRITE**
1660[1]	Neutral Time Overcurrent 2 Function	---	---	F37	Disabled
1661[1]	Neutral Time Overcurrent 2 Relays	---	---	F57	None
1662[1]	Neutral Time Overcurrent 2 Curve	---	---	F36	Ext. Inverse
1663[1]	Neutral Time Overcurrent 2 Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1664[1]	Neutral Time Overcurrent 2 Multiplier	0.00 to 100.00	---	F3	1.00
1665[1]	Neutral Time Overcurrent 2 Reset Time	---	---	F68	Instantaneous
1666[1]	Neutral Time Overcurrent 2 Direction	---	---	F84	Disabled
S5	**NEUTRAL DIRECTIONAL**				**READ/WRITE**
1670[1]	Neutral Directional Function	---	---	F38	Disabled
1671[1]	Neutral Directional Maximum Torque Angle	0 to 359	°	F1	315°
1672[1]	Minimum Polarizing Voltage	0.00 to 1.25	x VT	F3	0.05 x VT
1674[1]	Neutral Directional Polarizing	---	---	F50	Voltage
1675[1]	Neutral Directional Relays	---	---	F57	None
S5	**NEGATIVE SEQUENCE TIME OVERCURRENT**				**READ/WRITE**
1700	Negative Sequence Time Overcurrent Function	---	---	F37	Disabled
1701	Negative Sequence Time Overcurrent Relays	---	---	F57	None
1702[1]	Negative Sequence Time Overcurrent Curve	---	---	F36	Ext. Inverse
1703[1]	Negative Sequence Time Overcurrent Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1704[1]	Negative Sequence Time Overcurrent Multiplier	0.00 to 100.00	---	F3	1.00
1705[1]	Negative Sequence Time Overcurrent Reset Time	---	---	F68	Instantaneous
1706[1]	Negative Sequence Time Overcurrent Direction	---	---	F84	Disabled
S5	**NEGATIVE SEQUENCE INST OVERCURRENT**				**READ/WRITE**
1710	Negative Sequence Inst Overcurrent Function	---	---	F37	Disabled
1711	Negative Sequence Instantaneous Overcurrent Relays	---	---	F57	None
1712	Negative Sequence Instantaneous Overcurrent Pickup	0.05 to 20.00	x CT	F3	1.00 x CT
1713	Negative Sequence Instantaneous Overcurrent Delay	0.00 to 600.00	s	F3	0.00 s
1714[1]	Negative Sequence Inst Overcurrent Direction	---	---	F84	Disabled
S5	**NEGATIVE SEQUENCE VOLTAGE**				**READ/WRITE**
1720	Negative Sequence Voltage Function	---	---	F39	Disabled
1721	Negative Sequence Voltage Relays	---	---	F57	None
1722[2]	Negative Sequence Voltage Pickup	0.00 to 1.25	x VT	F3	0.10
1723	Negative Sequence Voltage Delay	0.0 to 6000.0	s	F2	2.0 s

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 26 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
S5	**NEGATIVE SEQUENCE DIRECTIONAL**				**READ/WRITE**
1730[1]	Negative Sequence Directional Function	---	---	F38	Disabled
1731[1]	Neg Seq Directional Maximum Torque Angle (MTA)	0 to 359	°	F1	315°
1732[1]	Minimum Polarizing Voltage	0.00 to 1.25	x VT	F3	0.05 x VT
1733[1]	Negative Sequence Directional Relays	---	---	F57	None
S5	**SENSITIVE GROUND INSTANTANEOUS OC**				**READ/WRITE**
1740[3]	Sensitive Ground Instantaneous Overcurrent Function	---	---	F37	Disabled
1741[3]	Sensitive Ground Instantaneous Overcurrent Relays	---	---	F57	None
1742[3]	Sensitive Ground Instantaneous Overcurrent Pickup	0.005 to 1.000	x CT	F70	0.100 x CT
1743[3]	Sensitive Ground Instantaneous Overcurrent Delay	0.00 to 600.00	s	F3	0.00 s
1744[3]	Sensitive Ground Instantaneous Overcurrent Direction	---	---	F84	Disabled
S5	**SENSITIVE GROUND TIME OC**				**READ/WRITE**
1750[3]	Sensitive Ground Time Overcurrent Function	---	---	F37	Disabled
1751[3]	Sensitive Ground Time Overcurrent Relays	---	---	F57	None
1752[3]	Sensitive Ground Time Overcurrent Curve	---	---	F36	Ext. Inverse
1753[3]	Sensitive Ground Time Overcurrent Pickup	0.005 to 1.000	x CT	F70	0.100 x CT
1754[3]	Sensitive Ground Time Overcurrent Multiplier	0.00 to 100.00	---	F3	1.00
1755[3]	Sensitive Ground Time Overcurrent Reset Time	---	---	F68	Instantaneous
1756[3]	Sensitive Ground Time Overcurrent Direction	---	---	F84	Disabled
S5	**SENSITIVE GROUND DIRECTIONAL**				**READ/WRITE**
1760[3]	Sensitive Ground Directional Function	---	---	F38	Disabled
1761[3]	Sensitive Ground Directional Maximum Torque Angle	0 to 359	°	F1	315°
1762[3]	Minimum Polarizing Voltage	0.00 to 1.25	x VT	F3	0.05 x VT
1763[3]	Sensitive Ground Directional Polarizing	---	---	F50	Voltage
1764[3]	Sensitive Ground Directional Relays	---	---	F57	None
S5[7]	**RESERVED FOR MOD 010**				**READ/WRITE**
1767[7]	Reserved for MOD 010				
1768[7]	Reserved for MOD 010				
1769[7]	Reserved for MOD 010				
176A[7]	Reserved for MOD 010				
176B[7]	Reserved for MOD 010				
S5	**RESTRICTED EARTH FAULT (REF)**				**READ/WRITE**
1770[8]	Restricted Earth Fault Function	---	---	F39	Disabled

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 27 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1771[8]	Restricted Earth Fault Relays	---	---	F57	None
1772[8]	Restricted Earth Fault Pickup	0.005 to 1.000	x CT	F70	0.100 x CT
1773[8]	Restricted Earth Fault Delay	0.00 to 600.00	s	F3	0.00 s
S5	**BUS UNDERVOLTAGE 1**				**READ/WRITE**
1780	Bus Undervoltage 1 Function	---	---	F39	Disabled
1781	Bus Undervoltage 1 Relays	---	---	F57	None
1782[2]	Bus Undervoltage 1 Pickup	0.00 to 1.25	x VT	F3	0.75 x VT
1783	Bus Undervoltage 1 Delay	0.0 to 6000.0	s	F2	2.0 s
1784	Bus Undervoltage 1 Phases Required for Operation	---	---	F41	All Three
1785[2]	Bus Undervoltage 1 Minimum Operating Voltage	0.00 to 1.25	x VT	F3	0.30 x V
1786	Bus Undervoltage 1 Curve	---	---	F45	Definite Time
S5	**BUS UNDERVOLTAGE 2**				**READ/WRITE**
1788	Bus Undervoltage 2 Function	---	---	F39	Disabled
1789	Bus Undervoltage 2 Relays	---	---	F57	None
178A[2]	Bus Undervoltage 2 Pickup	0.00 to 1.25	x VT	F3	0.75 x VT
178B	Bus Undervoltage 2 Delay	0.0 to 6000.0	s	F2	2.0 s
178C	Bus Undervoltage 2 Phases Required for Operation	---	---	F41	All Three
178D[2]	Bus Undervoltage 2 Minimum Operating Voltage	0.00 to 1.25	x VT	F3	0.30 x V
178E	Bus Undervoltage 2 Curve	---	---	F45	Definite Time
S5	**OVERVOLTAGE 1**				**READ/WRITE**
1790	Overvoltage 1 Function	---	---	F39	Disabled
1791	Overvoltage 1 Relays	---	---	F57	None
1792[2]	Overvoltage 1 Pickup	0.00 to 1.25	x VT	F3	1.25 x VT
1793	Overvoltage 1 Delay	0.0 to 6000.0	s	F2	2.0 s
1794	Overvoltage 1 Phases Required for Operation	---	---	F41	All Three
S5	**OVERVOLTAGE 2**				**READ/WRITE**
1798	Overvoltage 2 Function	---	---	F39	Disabled
1799	Overvoltage 2 Relays	---	---	F57	None
179A[2]	Overvoltage 2 Pickup	0.00 to 1.25	x VT	F3	1.25 x VT
179B	Overvoltage 2 Delay	0.0 to 6000.0	s	F2	2.0 s
179C	Overvoltage 2 Phases Required for Operation	---	---	F41	All Three
S5	**UNDERFREQUENCY 1**				**READ/WRITE**
17A0	Underfrequency 1 Function	---	---	F39	Disabled
17A1	Underfrequency 1 Relays	---	---	F57	None
17A2	Underfrequency 1 Pickup	20.00 to 65.00	Hz	F3	59.00 Hz
17A3	Underfrequency 1 Delay	0.00 to 600.00	s	F3	2.00 s

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 28 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
17A4[2]	Underfrequency 1 Minimum Operating Voltage	0.00 to 1.25	x VT	F3	0.70 x VT
17A5[1]	Underfrequency 1 Minimum Operating Current	0.00 to 20.00	x CT	F3	0.20 x CT
S5	**UNDERFREQUENCY 2**				**READ/WRITE**
17A8	Underfrequency 2 Function	---	---	F39	Disabled
17A9	Underfrequency 2 Relays	---	---	F57	None
17AA	Underfrequency 2 Pickup	20.00 to 65.00	Hz	F3	58.00 Hz
17AB	Underfrequency 2 Delay	0.00 to 600.00	s	F3	3.00 s
17AC[2]	Underfrequency 2 Minimum Operating Voltage	0.00 to 1.25	x VT	F3	0.70 x VT
17AD[1]	Underfrequency 2 Minimum Operating Current	0.00 to 20.00	x CT	F3	0.20 x CT
S5	**LINE UNDERVOLTAGE 3**				**READ/WRITE**
17B0	Line Undervoltage 3 Function	---	---	F39	Disabled
17B1	Line Undervoltage 3 Relays	---	---	F57	None
17B2[2]	Line Undervoltage 3 Pickup	0.00 to 1.25	x VT	F3	0.75 x VT
17B3	Line Undervoltage 3 Delay	0.0 to 6000.0	s	F2	2.0 s
17B4[2]	Line Undervoltage 3 Minimum Operating Voltage	0.00 to 1.25	x VT	F3	0.30 x V
17B5	Line Undervoltage 3 Curve	---	---	F45	Definite Time
S5	**LINE UNDERVOLTAGE 4**				**READ/WRITE**
17B8	Line Undervoltage 4 Function	---	---	F39	Disabled
17B9	Line Undervoltage 4 Relays	---	---	F57	None
17BA[2]	Line Undervoltage 4 Pickup	0.00 to 1.25	x VT	F3	0.75 x VT
17BB	Line Undervoltage 4 Delay	0.0 to 6000.0	s	F2	2.0 s
17BC[2]	Line Undervoltage 4 Minimum Operating Voltage	0.00 to 1.25	x VT	F3	0.30 x V
17BD	Line Undervoltage 4 Curve	---	---	F45	Definite Time
S5	**FREQUENCY DECAY**				**READ/WRITE**
17C0[1]	Frequency Decay Function	---	---	F39	Disabled
17C1[1]	Frequency Decay Relays	---	---	F57	None
17C2[1]	Frequency Decay Rate	0.1 to 5.0	Hz/s	F2	1.0 Hz/s
17C3[1]	Frequency Decay Pickup	20.00 to 65.00	Hz	F3	59.50 Hz
17C4[1]	Frequency Decay Delay	0.00 to 600.00	s	F3	2.00 s
17C5[1]	Frequency Decay Minimum Operating Voltage	0.00 to 1.25	x VT	F3	0.70 x VT
17C6[1]	Frequency Decay Minimum Operating Current	0.00 to 20.00	x CT	F3	0.00 x CT
S5[5]	**RESERVED FOR MOD 008**				**READ/WRITE**
17C8	Reserved for MOD 008	---	---	F39	Disabled
17C9	Reserved for MOD 008	---	---	F57	None
17CA	Reserved for MOD 008	0.015 to 0.600	x RATED	F70	0.050 x RATED

[1] [2] [3] [4] [5] [6] [7] [8] [9] For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 29 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
17CB	Reserved for MOD 008	0.0 to 6000.0	s	F2	10.0 s
S5[5]	**NEUTRAL DISPLACEMENT**				**READ/WRITE**
17CE	Neutral Displacement Function	---	---	F39	Disabled
17CF	Neutral Displacement Relays	---	---	F57	None
17D0	Neutral Displacement Pickup	0.00 to 1.25	x VT	F3	1.00 x VT
17D1	Neutral Displacement Multiplier	0.00 to 100.00	---	F3	1.00
17D2	Neutral Displacement Curve	---	---	F36	Ext. Inverse
17D3	Neutral Displacement Reset Time	---	---	F68	Instantaneous
S6	**PHASE CURRENT LEVEL**				**READ/WRITE**
1800	Phase Current Level Function	---	---	F38	Disabled
1801	Phase Current Level Relays	---	---	F57	None
1802	Phase Current Level Pickup	0.05 to 20.00	x CT	F3	1.10 x CT
1803	Phase Current Level Delay	0 to 60,000	s	F1	2 s
S6	**NEUTRAL CURRENT LEVEL**				**READ/WRITE**
1808	Neutral Current Level Function	---	---	F38	Disabled
1809	Neutral Current Level Relays	---	---	F57	None
180A	Neutral Current Level Pickup	0.05 to 20.00	x CT	F3	1.10 x CT
180B	Neutral Current Level Delay	0 to 60,000	s	F1	2 s
S6	**POWER FACTOR 1**				**READ/WRITE**
1810	Power Factor 1 Function	---	---	F38	Disabled
1811	Power Factor 1 Relays	---	---	F57	None
1812	Power Factor 1 Pickup (+ Lag, - Lead)	-0.99 to +1.00	---	F6	0.80 Lag
1813	Power Factor 1 Dropout (+ Lag, - Lead)	-0.99 to +1.00	---	F6	1
1814	Power Factor 1 Delay	0 to 60,000	s	F1	50 s
S6	**POWER FACTOR 2**				**READ/WRITE**
1818	Power Factor 2 Function	---	---	F38	Disabled
1819	Power Factor 2 Relays	---	---	F57	None
181A	Power Factor 2 Pickup (+ Lag, - Lead)	-0.99 to +1.00	---	F6	0.80 Lag
181B	Power Factor 2 Dropout (+ Lag, - Lead)	-0.99 to +1.00	---	F6	1
181C	Power Factor 2 Delay	0 to 60,000	s	F1	50 s
S6	**FAULT LOCATOR**				**READ/WRITE**
1830	Length of Feeder	0.1 to 99.9	km, mi	F2	0.1
1831	Units of Length	---	---	F75	km
1832	Zpos (Resistive) of Feeder	0.01 to 99.99	Ω	F3	0.01 Ω
1833	Zpos (Inductive) of Feeder	0.01 to 99.99	Ω	F3	0.01 Ω
1834	Zzero (Resistive) of Feeder	0.01 to 99.99	Ω	F3	0.01 Ω
1835	Zzero (Inductive) of Feeder	0.01 to 99.99	Ω	F3	0.01 Ω

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 30 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1836[1]	Fault Type Output to Relays 4 to 7	---	---	F30	Disabled
1837[9]	Fault Location After Trip	----	----	F30	Disabled
S6	**CURRENT DEMAND**				**READ/WRITE**
1840	Current Demand Function	---	---	F38	Disabled
1841	Current Demand Measurement Type	---	---	F58	Thermal Exp.
1842	Current Demand Thermal 90% Response	---	---	F16	15 min.
1843	Current Demand Time Interval	---	---	F16	20 min.
1844	Current Demand Relays	---	---	F57	None
1845	Current Demand Pickup	10 to 10000	A	F1	1000 A
S6	**REAL POWER DEMAND**				**READ/WRITE**
1848	Real Power Demand Function	---	---	F38	Disabled
1849	Real Power Demand Measurement Type	---	---	F58	Block Interval
184A	Real Power Demand Thermal 90% Response	---	---	F16	15 min.
184B	Real Power Demand Time Interval	---	---	F16	20 min.
184C	Real Power Demand Relays	---	---	F57	None
184D[2]	Real Power Demand Pickup	1 to 30000	kW	F86	100 kW
S6	**REACTIVE POWER DEMAND**				**READ/WRITE**
1850	Reactive Power Demand Function	---	---	F38	Disabled
1851	Reactive Power Demand Measurement Type	---	---	F58	Block Interval
1852	Reactive Power Demand Thermal 90% Response	---	---	F16	15 min.
1853	Reactive Power Demand Time Interval	---	---	F16	20 min.
1854	Reactive Power Demand Relays	---	---	F57	None
1855[2]	Reactive Power Demand Pickup	1 to 30000	kvar	F86	100 kvar
S6	**APPARENT POWER DEMAND**				**READ/WRITE**
1858	Apparent Power Demand Function	---	---	F38	Disabled
1859	Apparent Power Demand Measurement Type	---	---	F58	Block Interval
185A	App. Power Demand Thermal 90% Response	---	---	F16	15 min.
185B	Apparent Power Demand Time Interval	---	---	F16	20 min.
185C	Apparent Power Demand Relays	---	---	F57	None
185D[2]	Apparent Power Demand Pickup	1 to 30000	kVA	F86	100 kVA
S6[5]	**PULSE OUTPUT**				**READ/WRITE**
1860	Pulse Output Function	---	---	F38	Disabled
1861	Positive Watthours Pulse Output Relays	---	---	F57	None
1862	Positive Watthours Pulse Interval	0 to 65535	kWh	F86	100 kWh
1863	Negative Watthours Pulse Output Relays	---	---	F57	None
1864	Negative Watthours Pulse Interval	0 to 65535	kWh	F86	100 kWh

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 31 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1865	Positive Varhours Pulse Output Relays	---	---	F57	None
1866	Positive Varhours Pulse Interval	0 to 65535	kvarh	F86	100 kvarh
1867	Negative Varhours Pulse Output Relays	---	---	F57	None
1868	Negative Varhours Pulse Interval	0 to 65535	kvarh	F86	100 kvarh
S6	**ANALOG INPUT SETUP**				**READ/WRITE**
1880	Analog Input Name (10 words)	---	---	F33	"ANALOG INPUT"
188A	Analog Input Units (3 words)	---	---	F33	"µA"
188D	Analog Input Range	---	---	F42	0-20 mA
188E	Analog Input Minimum Value	0 to 65535	Units	F1	0
188F	Analog Input Maximum Value	0 to 65535	Units	F1	20000
S6	**ANALOG INPUT THRESHOLD 1**				**READ/WRITE**
18A0[9]	Analog Threshold 1 Function	---	---	F38	Disabled
18A1	Analog Threshold 1 Relays	---	---	F57	None
18A2	Analog Threshold 1 Pickup	0 to 65535	Units	F1	100
18A3	Analog Threshold 1 Delay	0 to 60,000	s	F1	100 s
18A4[1]	Analog Threshold 1 Pickup Type	---	---	F85	Over
S6	**ANALOG INPUT THRESHOLD 2**				**READ/WRITE**
18A8	Analog Threshold 2 Function	---	---	F38	Disabled
18A9	Analog Threshold 2 Relays	---	---	F57	None
18AA	Analog Threshold 2 Pickup	0 to 65535	Units	F1	100
18AB	Analog Threshold 2 Delay	0 to 60,000	s	F1	100 s
18AC[1]	Analog Threshold 2 Pickup Type	---	---	F85	Over
S6	**ANALOG INPUT RATE 1**				**READ/WRITE**
18B0	Analog In Rate 1 Function	---	---	F38	Disabled
18B1	Analog In Rate 1 Relays	---	---	F57	None
18B2	Analog In Rate 1 Pickup	-1000.0 to 1000.0	Units / hr.	F5	10.0 µA/hr.
18B3	Analog In Rate 1 Delay	0 to 60,000	s	F1	0 s
S6	**ANALOG INPUT RATE 2**				**READ/WRITE**
18B8	Analog In Rate 2 Function	---	---	F38	Disabled
18B9	Analog In Rate 2 Relays	---	---	F57	None
18BA	Analog In Rate 2 Pickup	-1000.0 to 1000.0	Units / hr.	F5	10.0 µA/hr.
18BB	Analog In Rate 2 Delay	0 to 60,000	s	F1	0 s
S6	**ANALOG OUTPUT 1**				**READ/WRITE**
18C0	Analog Output 1 Parameter	---	---	F77	Disabled
18C1	Analog Output 1 Minimum	---	---	F78	0
18C2	Analog Output 1 Maximum	---	---	F78	0

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 32 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
S6	**ANALOG OUTPUT 2**				**READ/WRITE**
18C4	Analog Output 2 Parameter	---	---	F77	Disabled
18C5	Analog Output 2 Minimum	---	---	F78	0
18C6	Analog Output 2 Maximum	---	---	F78	0
S6	**ANALOG OUTPUT 3**				**READ/WRITE**
18C8	Analog Output 3 Parameter	---	---	F77	Disabled
18C9	Analog Output 3 Minimum	---	---	F78	0
18CA	Analog Output 3 Maximum	---	---	F78	0
S6	**ANALOG OUTPUT 4**				**READ/WRITE**
18CC	Analog Output 4 Parameter	---	---	F77	Disabled
18CD	Analog Output 4 Minimum	---	---	F78	0
18CE	Analog Output 4 Maximum	---	---	F78	0
S6	**ANALOG OUTPUT 5**				**READ/WRITE**
18D0	Analog Output 5 Parameter	---	---	F77	Disabled
18D1	Analog Output 5 Minimum	---	---	F78	0
18D2	Analog Output 5 Maximum	---	---	F78	0
S6	**ANALOG OUTPUT 6**				**READ/WRITE**
18D4	Analog Output 6 Parameter	---	---	F77	Disabled
18D5	Analog Output 6 Minimum	---	---	F78	0
18D6	Analog Output 6 Maximum	---	---	F78	0
S6	**ANALOG OUTPUT 7**				**READ/WRITE**
18D8	Analog Output 7 Parameter	---	---	F77	Disabled
18D9	Analog Output 7 Minimum	---	---	F78	0
18DA	Analog Output 7 Maximum	---	---	F78	0
S6	**ANALOG OUTPUT 8**				**READ/WRITE**
18DC	Analog Output 8 Parameter	---	---	F77	Disabled
18DD	Analog Output 8 Minimum	---	---	F78	0
18DE	Analog Output 8 Maximum	---	---	F78	0
S6	**OVERFREQUENCY**				**READ/WRITE**
18E0	Overfrequency Function	---	---	F38	Disabled
18E1	Overfrequency Relays	---	---	F57	None
18E2	Overfrequency Pickup	20.00 to 65.00	Hz	F3	60.50 Hz
18E3	Overfrequency Delay	0.0 to 6000.0	s	F2	5.0 s
S6	**TRIP COUNTER**				**READ/WRITE**
1900	Trip Counter Function	---	---	F38	Disabled
1901	Trip Counter Relays	---	---	F57	None
1902	Trip Counter Limit	1 to 10000	---	F1	10000 Trips

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 33 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
S6	**TOTAL ARCING CURRENT**				**READ/WRITE**
1908	Total Arcing Current Function	---	---	F38	Disabled
1909	Total Arcing Current Relays	---	---	F57	None
190A	Total Arcing Current Start Delay	0 to 100	ms	F1	32 ms
190B	Total Arcing Current Limit	1 to 50000	kA^2-cyc	F1	1000 kA^2cyc
S6	**VT FAILURE**				**READ/WRITE**
1918	VT Failure Function	---	---	F38	Disabled
1919	VT Failure Relays	---	---	F57	None
191A	VT Failure Delay	0 to 60,000	s	F1	10 s
S8	**SIMULATION SETUP**				**READ/WRITE**
1920	Simulation Status	---	---	F48	Disabled
1921	Circuit Breaker Simulation	---	---	F30	Enabled
1922	Allow Operation of Relays	---	---	F57	None
S8	**SIMULATION PRE-FAULT VALUES**				**READ/WRITE**
1930	Prefault Phase A/B/C Current Level	0.00 to 20.00	x CT	F3	0.50 x CT
1931	Prefault Power Factor Angle	0 to 359	° Lag	F1	0° Lag
S8	**SIMULATION FAULT VALUES**				**READ/WRITE**
1940	Fault Phase A-N Voltage Level	0.00 to 2.00	x VT	F3	1.00 x VT
1941	Fault Phase A-N Voltage Position	0 to 359	° Lag	F1	0° Lag
1942	Fault Phase B-N Voltage Level	0.00 to 2.00	x T	F3	1.00 x VT
1943	Fault Phase B-N Voltage Position	0 to 359	° Lag	F1	120° Lag
1944	Fault Phase C-N Voltage Level	0.00 to 2.00	x T	F3	1.00 x VT
1945	Fault Phase C-N Voltage Position	0 to 359	° Lag	F1	240° Lag
1946	Fault Phase A Current Level	0.00 to 20.00	x CT	F3	1.00 x CT
1947	Fault Phase A Current Position	0 to 359	° Lag	F1	60° Lag
1948	Fault Phase B Current Level	0.00 to 20.00	x CT	F3	1.00 x CT
1949	Fault Phase B Current Position	0 to 359	° Lag	F1	180° Lag
194A	Fault Phase C Current Level	0.00 to 20.00	x CT	F3	1.00 x CT
194B	Fault Phase C Current Position	0 to 359	° Lag	F1	300° Lag
194C	Fault System Frequency	20.00 to 65.00	Hz	F3	60.00 Hz
194D	Fault Analog Input Current	0.00 to 20.00	mA	F3	0.00 mA
194E[3]	Reserved for Fault Polarizing Current Level	0.00 to 20.00	x CT	F70	1.00 x CT
194F[3]	Reserved for Fault Polarizing Current Position	0 to 359	° Lag	F1	0°
1950	Fault Ground Current Level	0.00 to 20.00	x CT	F3	0.00 x CT
1951	Fault Ground Current Position	0 to 359	° Lag	F1	0°
1952[3]	Fault Sensitive Ground Current Level	0.005 to 1.000	x CT	F70	0.100 x CT

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 34 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1953[3]	Fault Sensitive Ground Current Position	0 to 359	° Lag	F1	0°
S8	**SIMULATION POST-FAULT VALUES**				**READ/WRITE**
1960	Postfault Bus Voltage Level	0.00 to 2.00	x VT	F3	1.00 x VT
1961	Postfault Bus Voltage Frequency	20.00 to 65.00	Hz	F3	60.00 Hz
1962	Postfault Synchronous Voltage Level	0.00 to 2.00	x VT	F3	1.00 x VT
1963	Postfault Synchronous Voltage Position	0 to 359	° Lag	F1	0°
1964	Postfault Synchronous Voltage Frequency	20.00 to 65.00	Hz	F3	60.00 Hz
S5	**BREAKER FAILURE**				**READ/WRITE**
1980	Breaker Failure Function	---	---	F38	Disabled
1981	Breaker Failure Relays	---	---	F57	None
1982	Breaker Failure Delay 1	0.03 to 1.00	s	F3	0.10 s
1983	Breaker Failure Current	0.05 to 20.00	x CT	F3	1.00 x CT
1984	Breaker Failure Delay 2	0.00 to 1.00	s	F3	0.00 s
S6	**BREAKER OPERATION**				**READ/WRITE**
1988	Breaker Operation Function	---	---	F38	Disabled
1989	Breaker Operation Relays	---	---	F57	None
198A	Breaker Operation Delay	0.03 to 1.00	s	F3	0.10 s
S6	**COIL MONITOR 1**				**READ/WRITE**
1990	Coil Monitor 1 Function	---	---	F38	Disabled
1991	Coil Monitor 1 Relays	---	---	F57	None
1992	Breaker State Bypass	---	---	F30	Disabled
1993[8]	Coil Monitor 1 Delay	5 to 100	s	F1	5 s
1994[8]	Coil Monitor 1 Type	---	---	F90	Trip
S6	**COIL MONITOR 2**				**READ/WRITE**
1998	Coil Monitor 2 Function	---	---	F38	Disabled
1999	Coil Monitor 2 Relays	---	---	F57	None
199A	Breaker State Bypass	---	---	F30	Disabled
199B[8]	Coil Monitor 2 Delay	5 to 100	s	F1	5 s
199C[8]	Coil Monitor 2 Type	---	---	F90	Close
S6[8]	**COIL MONITOR NAMES**				**READ/WRITE**
19A0[8]	Coil Monitor 1 Name (9 registers)	---	---	F33	Trip Coil Monitor
19A9[8]	Coil Monitor 2 Name (9 registers)	---	---	F33	Close Coil Monitor
S6[8]	**ANALOG INPUT THRESHOLD NAMES**				**READ/WRITE**
19B2[8]	Analog Input Threshold 1 Name (9 registers)	---	---	F33	Analog Threshld 1
19BB[8]	Analog Input Threshold 2 Name (9 registers)	---	---	F33	Analog Threshld 2

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 35 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
S8	**FORCE OUTPUT RELAYS**				**READ/WRITE**
1A00	Force Output Relays Function	---	---	F30	Disabled
1A01	Force 1 TRIP Relay	---	---	F34	De-energized
1A02	Force 2 CLOSE Relay	---	---	F34	De-energized
1A03	Force 3 ALARM Relay	---	---	F34	De-energized
1A04	Force 4 AUXILIARY Relay	---	---	F34	De-energized
1A05	Force 5 AUXILIARY Relay	---	---	F34	De-energized
1A06	Force 6 AUXILIARY Relay	---	---	F34	De-energized
1A07	Force 7 AUXILIARY Relay	---	---	F34	De-energized
1A08	Force 8 SELF-TEST WARNING Relay	---	---	F34	De-energized
1A09	Force Solid State Output	---	---	F34	De-energized
S8	**FORCE ANALOG OUTPUTS**				**READ/WRITE**
1A10	Force Analog Outputs Function	---	---	F30	Disabled
1A11	Force Analog Output 1	0 to 100	%	F1	0%
1A12	Force Analog Output 2	0 to 100	%	F1	0%
1A13	Force Analog Output 3	0 to 100	%	F1	0%
1A14	Force Analog Output 4	0 to 100	%	F1	0%
1A15	Force Analog Output 5	0 to 100	%	F1	0%
1A16	Force Analog Output 6	0 to 100	%	F1	0%
1A17	Force Analog Output 7	0 to 100	%	F1	0%
1A18	Force Analog Output 8	0 to 100	%	F1	0%
S8	**PICKUP TEST**				**READ/WRITE**
1A20	Pickup Test Function	---	---	F30	Disabled
1A21	Pickup Test Relays	---	---	F57	None
S7	**SETPOINT GROUP**				**READ/WRITE**
1B00	Active Setpoint Group	---	---	F79	Group 1
1B01	Edit Setpoint Group	---	---	F80	Active Group
1B02	Breaker Open Inhibit	---	---	F30	Disabled
1B03	Overcurrent Pickup Inhibit	---	---	F30	Disabled
1B04	Overvoltage Pickup Inhibit	---	---	F30	Disabled
1B05	Undervoltage Pickup Inhibit	---	---	F30	Disabled
1B06	Underfrequency Pickup Inhibit	---	---	F30	Disabled
S7	**SYNCHROCHECK**				**READ/WRITE**
1B10	Synchrocheck Function	---	---	F38	Disabled
1B11	Dead Source Permissive	---	---	F20	OFF
1B12[2]	Dead Bus Maximum Voltage	0.00 to 1.25	x VT	F3	0.20 x VT
1B13[2]	Dead Line Maximum Voltage	0.00 to 1.25	x VT	F3	0.20 x VT

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 36 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1B14[2]	Live Bus Minimum Voltage	0.00 to 1.25	x VT	F3	0.80 x VT
1B15[2]	Live Line Minimum Voltage	0.00 to 1.25	x VT	F3	0.80 x VT
1B16[2]	Maximum Voltage Difference	0.01 to 100.00	kV	F3	2.00 kV
1B17	Maximum Angle Difference	0 to 100	°	F1	24°
1B18	Maximum Frequency Difference	0 to 5.00	Hz	F3	2.00 Hz
1B19	Synchrocheck Relays	---	---	F57	None
S7	**MANUAL CLOSE FEATURE BLOCKING**				**READ/WRITE**
1B20	Manual Close Feature Blocking Function	---	---	F38	Disabled
1B21	Manual Close Relays	---	---	F57	None
1B22[2]	Manual Close Block Time	1 to 1000	s	F1	5 s
1B23[1]	Select Setpoint Group	---	---	F80	Active Group
1B24[2]	Overcurrent Blocking Flags	---	---	F59	None blocked
1B25[2]	Phase Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1B26[2]	Neutral Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1B27[2]	Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1B28[2]	Negative Sequence Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1B29[3]	Sensitive Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
S7	**COLD LOAD FEATURE BLOCKING**				**READ/WRITE**
1B40	Cold Load Pickup Feature Blocking Function	---	---	F38	Disabled
1B41	Cold Load Pickup Relays	---	---	F57	None
1B42	Outage Time Before Cold Load	1 to 1000	min.	F1	100 min.
1B43[2]	Cold Load Pickup Block Time	1 to 1000	s	F1	5 s
1B44[1]	Select Setpoint Group	---	---	F80	Active Group
1B45[2]	Overcurrent Blocking Flags	---	---	F59	None blocked
1B46[2]	Phase Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1B47[2]	Neutral Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1B48[2]	Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1B49[2]	Negative Sequence Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1B4A[3]	Sensitive Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
S7	**UNDERVOLTAGE RESTORATION**				**READ/WRITE**
1B60	Undervoltage Restoration Function	---	---	F38	Disabled
1B61	Undervoltage Restoration Relays	---	---	F57	None
1B62	Undervoltage Restoration Phases Required for Operation	---	---	F41	All Three
1B63[2]	Undervoltage Restoration Minimum Voltage	0.00 to 1.25	x VT	F3	0.90 x V

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 37 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1B64	Undervoltage Restoration Delay	0 to 10000	s	F1	10 s
1B65	Undervoltage Restoration Incomplete Sequence Time	1 to 10,000	min.	F1	100 min.
1B66[3]	Undervoltage Restoration Source	---	---	F87	Bus
S7	**UNDERFREQUENCY RESTORATION**				**READ/WRITE**
1B70	Underfrequency Restoration Function	---	---	F38	Disabled
1B71	Underfrequency Restoration Relays	---	---	F57	None
1B72[2]	Underfrequency Restoration Minimum Voltage	0.00 to 1.25	x VT	F3	0.90 x V
1B73[8]	Underfrequency Restoration Minimum Frequency	20.00 to 65.00	Hz	F3	59.90 Hz
1B74	Underfrequency Restoration Delay	0 to 10000	s	F1	10 s
1B75	Underfrequency Restoration Incomplete Sequence Time	1 to 10,000	min.	F1	100 min.
S7	**TRANSFER**				**READ/WRITE**
1B80	Transfer Function	---	---	F56	Disabled
1B81	Transfer Delay This Source	0.0 to 10.0	s	F2	1.0 s
1B82	Transfer Delay Other Source	0.0 to 10.0	s	F2	3.0 s
1B83	Block Trip On Double Loss	---	---	F30	Disabled
S7	**AUTORECLOSE SETUP - 760 ONLY**				**READ/WRITE**
1BA0	Autoreclose Function	---	---	F30	Disabled
1BA1	Number of Reclosure Shots	1 to 4	1	F1	1
1BA2	Autoreclose Reset Time	1 to 1000	s	F1	60 s
1BA3	Autoreclose Block Time Upon Manual Close	0 to 200	s	F1	10 s
1BA4	Incomplete Sequence Time	1 to 1000	s	F1	30 s
1BA5	Reclosure Enabled Relays	---	---	F57	None
1BA6	Reclose In Progress Relays	---	---	F57	None
1BA7	Reclosure Lockout Relays	---	---	F57	None
1BA8[8]	Autoreclose External Close Logic	---	---	F30	Disabled
S7	**AUTORECLOSE RATE SUPERVISION - 760 ONLY**				**READ/WRITE**
1BAA[8]	Rate Supervision Function	---	---	F38	Disabled
1BAB[8]	Max Autoreclose Rate	1 to 50	/hr.	F1	25
1BAC[8]	Rate Supervision Relays	---	---	F57	None
S7	**CURRENT SUPERVISION - 760 ONLY**				**READ/WRITE**
1BB0	Current Supervision Function	---	---	F30	Disabled
1BB1[2]	3 Shots For Current Above	0.00 to 20.00	x CT	F3	17.00 x CT
1BB2[2]	2 Shots For Current Above	0.00 to 20.00	x CT	F3	18.00 x CT
1BB3[2]	1 Shot For Current Above	0.00 to 20.00	x CT	F3	19.00 x CT
1BB4	Current Supervision To Lockout	---	---	F30	Disabled

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 38 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
1BB5[2]	Lockout For Current Above	0.00 to 20.00	x CT	F3	20.00 x CT
S7	**ZONE COORDINATION - 760 ONLY**				**READ/WRITE**
1BB8[1]	Zone Coordination Function	---	---	F30	Disabled
1BB9[1]	Phase Current Increase	0.05 to 20.00	x CT	F3	1.00 x CT
1BBA[1]	Neutral Current Increase	0.05 to 20.00	x CT	F3	1.00 x CT
1BBB[1]	Maximum fault Clearing Time	1 to 1000	s	F1	10 s
S7	**RECLOSURE SHOT 1 - 760 ONLY**				**READ/WRITE**
1BC0[2]	Deadtime Before Reclosure 1	0.00 to 300.00	s	F3	0.50 s
1BC1[1]	Select Setpoint Group	---	---	F80	Active Group
1BC2[2]	Overcurrent Blocking Flags	---	---	F59	None blocked
1BC3[1]	Phase Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1BC4[1]	Neutral Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1BC5[1]	Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1BC6[1]	Negative Sequence Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1BC7[3]	Sensitive Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
S7	**RECLOSURE SHOT 2 - 760 ONLY**				**READ/WRITE**
1BD0[2]	Deadtime Before Reclosure 2	0.00 to 300.00	s	F3	3.00 s
1BD1[1]	Select Setpoint Group	---	---	F80	Active Group
1BD2[2]	Overcurrent Blocking Flags	---	---	F59	None blocked
1BD3[1]	Phase Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1BD4[1]	Neutral Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1BD5[1]	Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1BD6[1]	Negative Sequence Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1BD7[3]	Sensitive Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
S7	**RECLOSURE SHOT 3 - 760 ONLY**				**READ/WRITE**
1BE0[2]	Deadtime Before Reclosure 3	0.00 to 300.00	s	F3	4.00 s
1BE1[1]	Select Setpoint Group	---	---	F80	Active Group
1BE2[2]	Overcurrent Blocking Flags	---	---	F59	None blocked
1BE3[1]	Phase Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1BE4[1]	Neutral Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1BE5[1]	Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1BE6[1]	Negative Sequence Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1BE7[3]	Sensitive Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 39 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
S7	**RECLOSURE SHOT 4 - 760 ONLY**				**READ/WRITE**
1BF0[2]	Deadtime Before Reclosure 4	0.00 to 300.00	s	F3	5.00 s
1BF1[1]	Select Setpoint Group	---	---	F80	Active Group
1BF2[2]	Overcurrent Blocking Flags	---	---	F59	None blocked
1BF3[1]	Phase Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1BF4[1]	Neutral Time Overcurrent 1 Raised Pickup	0 to 100	%	F1	0%
1BF5[1]	Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1BF6[1]	Negative Sequence Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
1BF7[3]	Sensitive Ground Time Overcurrent Raised Pickup	0 to 100	%	F1	0%
S3	**LOGIC INPUTS NAMES**				**READ/WRITE**
1C00[1]	Logic Input 1 Name (9 words = 18 characters)	---	---	F33	Logic Input 1
1C09[1]	Logic Input 2 Name (9 words = 18 characters)	---	---	F33	Logic Input 2
:	:	:	:	:	:
1CAB[1]	Logic Input 20 Name (9 words = 18 characters)	---	---	F33	Logic Input 20
A4	**EVENT RECORD SELECTOR**				**READ/WRITE**
2000	Event Number Selector	0 to 65535	---	F1	0
A4	**EVENT RECORDOR INFORMATION**				**READ ONLY**
2001	Number of Events Since Clear	0 to 65535	---	F1	0
2002	Event Recorder Last Cleared (2 words)	---	---	F23	---
A4	**EVENT RECORD DATA**				**READ ONLY**
2010	Record #N Date of Event (2 words)	---	---	F23	---
2012	Record #N Time of Event (2 words)	---	---	F22	---
2014	Record #N Cause of Event	---	---	F24	---
2015	Record #N Phase A Current Magnitude	0 to 65535	A	F1	---
2016	Record #N Phase B Current Magnitude	0 to 65535	A	F1	---
2017	Record #N Phase C Current Magnitude	0 to 65535	A	F1	---
2018	Record #N Ground Current Magnitude	0 to 65535	A	F1	---
2019	Record #N A-N (A-B) Voltage Magnitude	0.00 to 600.00	kV	F3	---
201A	Record #N B-N (B-C) Voltage Magnitude	0.00 to 600.00	kV	F3	---
201B	Record #N C-N (C-A) Voltage Magnitude	0.00 to 600.00	kV	F3	---
201C	Record #N System Frequency	0.00 to 90.00	Hz	F3	---
201D	Record #N Analog Input	0 to 65535	Units	F1	---
201E[1]	Record #N Phase A Current Angle	0 to 359	° Lag	F1	---
201F[1]	Record #N Phase B Current Angle	0 to 359	° Lag	F1	---
2020[1]	Record #N Phase C Current Angle	0 to 359	° Lag	F1	---

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 40 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
2021[1]	Record #N Ground Current Angle	0 to 359	° Lag	F1	---
2022[1]	Record #N A-N (A-B) Voltage Angle	0 to 359	° Lag	F1	---
2023[1]	Record #N B-N (C-B) Voltage Angle	0 to 359	° Lag	F1	---
2024[1]	Record #N C-N Voltage Angle	0 to 359	° Lag	F1	---
2025[1]	Record #N Synchronizing RMS Voltage Magnitude	0.00 to 600.00	kV	F3	---
2026[1]	Record #N Synchronizing Voltage Angle	0 to 359	° Lag	F1	---
2027[1]	Record #N Synchronizing RMS Voltage Frequency	0.00 to 90.00	Hz	F3	---
2028[3]	Record #N Sensitive Ground Current Magnitude	0.00 to 655.35	A	F3	---
2029[3]	Record #N Sensitive Ground Current Angle	0 to 359	° Lag	F1	---
	TRACE MEMORY SELECTORS				**READ/WRITE**
2100	Trace Memory Number Selector	0 to 65535	---	F1	0
2101	Trace Memory Channel Selector	---	---	F26	I_a
2102	Trace Memory Sample Selector (TMSS)	0 to 4095	---	F1	0
	TRACE MEMORY INFORMATION				**READ ONLY**
2110	Number of Trace Memory Triggers Since Clear	0 to 65535	---	F1	---
2111	Number of Trace Memory Samples Stored	0 to 4096	---	F1	---
2112	Trace Memory Start Index	0 to 4095	---	F1	---
2113	Trace Memory Trigger Index	0 to 4095	---	F1	---
2114	Trace Memory Trigger Cause	---	---	F24	---
2115	Trace Memory Trigger Date	---	---	F23	---
2117	Trace Memory Trigger Time	---	---	F22	---
2119	Trace Memory Sampling Frequency	16.00 to 65.00	Hz	F3	---
	TRACE MEMORY SAMPLES				**READ ONLY**
2120	Trace Memory Sample TMSS+0	---	---	F25	---
2121	Trace Memory Sample TMSS+1	---	---	F25	---
:	:	:	:	:	:
215F	Trace Memory Sample TMSS+63	---	---	F25	---
	DATA LOG SELECTORS				**READ/WRITE**
2200	Data Log Number Selector	0 to 65535	---	F1	0
2201	Data Log Channel Selector	0 to 7	---	F1	0
2202	Data Log Sample Selector (DLSS)	0 to 4095	---	F1	0
	DATA LOG INFORMATION				**READ ONLY**
2210	Number of Data Log Triggers Since Clear	0 to 65535	---	F1	---
2211	Number of Data Log Samples Stored	0 to 4096	---	F1	---
2212	Data Log Start Index	0 to 4095	---	F1	---
2213	Data Log Trigger Index	0 to 4095	---	F1	---

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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Table 16–15: MODBUS MEMORY MAP (Sheet 41 of 41)

ADDR	DESCRIPTION	RANGE	UNITS	TYPE	FACTORY DEFAULT
2214	Data Log Trigger Cause	---	---	F24	---
2215	Data Log Trigger Date	---	---	F23	---
2217	Data Log Trigger Time	---	---	F22	---
	DATA LOG SAMPLES				**READ ONLY**
2220	Data Log Sample DLSS+0	---	---	F78	---
2221	Data Log Sample DLSS+1	---	---	F78	---
:	:	:	:	:	:
225F	Data Log Sample DLSS+63	---	---	F78	---

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–59.

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16.4.2 NOTES FOR MEMORY MAP

The footnotes used in the memory map are explained below:

[1] These registers are new for version 2.10

[2] These registers have been changed from version 2.00 to 2.10

[3] These registers are new or have changed for version 3.00

[4] These registers are new or have changed for version 3.10

[5] These registers are new or have changed for version 3.20

[6] These registers are new for version 3.30

[7] These registers are new or have changed for version 3.40 MOD 010

[8] These registers are new or have changed for version 3.60

[9] These registers are new or have changed for version 3.70

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 1 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
F1		**UNSIGNED VALUE**
		Example: 1234 stored as 1234
F2		**UNSIGNED VALUE, 1 DECIMAL PLACE**
		Example: 123.4 stored as 1234
F3		**UNSIGNED VALUE, 2 DECIMAL PLACES**
		Example: 12.34 stored as 1234
F4		2's COMPLEMENT SIGNED VALUE
		Example: -1234 stored as -1234
F5		**2's COMPLEMENT SIGNED VALUE, 1 DECIMAL PLACE**
		Example: -123.4 stored as -1234
F6		**2's COMPLEMENT SIGNED VALUE, 2 DECIMAL PLACES**
		Example: -12.34 stored as -1234
F7		**UNSIGNED LONG VALUE (32 bits)**
		High order word of long value stored in 1st 16 bits
		Low order word of long value stored in 2nd 16 bits
		Example: 123456 stored as 123456
F8		**UNSIGNED LONG VALUE, 1 DECIMAL PLACE (32 bits)**
		High order word of long value stored in 1st 16 bits
		Low order word of long value stored in 2nd 16 bits
		Example: 12345.6 stored as 123456
F9		**UNSIGNED LONG VALUE, 2 DECIMAL PLACES (32 bits)**
		High order word of long value stored in 1st 16 bits
		Low order word of long value stored in 2nd 16 bits
		Example: 1234.56 stored as 123456
F10		**2's COMPLEMENT SIGNED LONG VALUE (32 bits)**
		High order word of long value stored in 1st 16 bits
		Low order word of long value stored in 2nd 16 bits
		Example: -123456 stored as -123456
F11		**2's COMPLEMENT SIGNED LONG VALUE, 1 DECIMAL PLACE (32 bits)**
		High order word of long value stored in 1st 16 bits
		Low order word of long value stored in 2nd 16 bits
		Example: -12345.6 stored as -123456
F12		**2's COMPLEMENT SIGNED LONG VALUE, 2 DECIMAL PLACES (32 bits)**
		High order word of long value stored in 1st 16 bits
		Low order word of long value stored in 2nd 16 bits

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 2 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
		Example: -1234.56 stored as -123456
F13		**HARDWARE REVISION**
	1	A
	2	B
		:
	26	Z
F14		**SOFTWARE REVISION**
	0F00h	Major Revision Number (0 to 9 in steps of 1)
	00F0h	Minor Revision Number (0 to 9 in steps of 1)
	000Fh	Ultra Minor Revision Number (0 to 9 in steps of 1)
		Example: Revision 2.83 stored as 0283 hex
F15		**INSTALLED OPTIONS**
	0001h	Phase Current Inputs (0 = 1 A, 1 = 5 A)
	0002h	Ground Current Input (0 = 1 A, 1 = 5 A)
	0004h[3]	Sensitive Ground Current Input (0 = 1 A, 1 = 5 A)
	0030h	Power Supply (0 = LO, 1 = MID, 2 = HI)
	0080h	Breaker Closed LED (0 = Red, 1 = Green)
	0F00h	Analog Outputs (0 = A1, 1 = A5, 2 = A20, 3 = A10)
	8000h	750/760 Product Selector (0=750, 1=760)
F16		**DEMAND INTERVAL/RESPONSE**
	0	5 min.
	1	10 min.
	2	15 min.
	3	20 min.
	4	30 min.
	5	60 min.
F17		**COMMUNICATION HARDWARE**
	0	RS485
	1	RS422
F18		**LINE VT CONNECTION**
	0	V_{an}
	1	V_{bn}
	2	V_{cn}
	3	V_{ab}
	4	V_{cb}
F19		**COMMAND OPERATION CODE**
	0	NO OPERATION

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 3 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION	
	1	RESET	
	2	OPEN BREAKER	
	3	CLOSE BREAKER	
	4	SET TIME	
	5	SET DATE	
	6	TRIGGER TRACE MEMORY	
	7	CLEAR ENERGY USE DATA	
	8	CLEAR MAX DEMAND DATA	
	9	CLEAR EVENT RECORDER DATA	
	10	RESET TRIP COUNTER DATA	
	11	RESET ARCING CURRENT DATA	
	12	DISPLAY OVERRIDE MESSAGE	
	13	TRIGGER DATA LOGGER	
	14	RESET TRACE MEMORY	
	15	RESET DATA LOGGER	
	16 [7]	RESET AUTORECLOSE SHOT COUNT DATA **760 ONLY!**	
	17 [7]	RESET AUTORECLOSE SHOT RATE DATA **760 ONLY!**	
F20		**DEAD SOURCE PERMISSIVE**	
	0	Off	
	1	DB **&** DL	
	2	LL **&** DB	
	3	DL **&** LB	
	4	DB **|** DL	
	5	DB **X** DB	
F21		**GENERAL STATUS**	
	0001h	760 Relay In Service	(0 = Not In Service, 1 = In Service)
	0002h	Trip	(0 = No Active Trip Conditions, 1 = Active Trip Condition)
	0004h	Alarm	(0 = No Active Alarm Conditions, 1 = Active Alarm Conditions)
	0008h	Pickup	(0 = No Protection Picked Up, 1 = Protection Picked Up)
	0010h	Setpoint Group 1	(0 = Disabled, 1 = Enabled)
	0020h	Setpoint Group 2	(0 = Disabled, 1 = Enabled)
	0040h	Setpoint Group 3	(0 = Disabled, 1 = Enabled)
	0080h	Setpoint Group 4	(0 = Disabled, 1 = Enabled)
	0100h	Breaker Open	(0 = Breaker Is Closed, 1 = Breaker Is Open)
	0200h	Breaker Closed	(0 = Breaker Is Open, 1 = Breaker Is Closed)
	0400h	Reclosure Enabled	(0 = Disabled, 1 = Enabled) **760 ONLY!**
	0800h	Reclosure Disabled	(0 = Enabled, 1 = Disabled) **760 ONLY!**

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 4 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	1000h	Reclosure In Progress (0 = Not In Progress, 1 = In Progress) **760 ONLY!**
	2000h	Reclosure Lockout (0 = Not In Lockout, 1 = In Lockout) **760 ONLY!**
	4000h	Local Mode (0 = Enabled, 1 = Disabled)
	8000h	Message (0 = No Diagnostic Message, 1 = There are Diagnostic Messages)
F22		**TIME (32 bits)**
		Hours / Minutes (HH:MM:xx.xxx) 1st 16 bits
	FF00h	Hours (0= 12am, 1=1am,..., 12=12pm,..., 23=11pm)
	00FFh	Minutes (0 to 59 in steps of 1)
		Seconds (xx:xx:SS.SSS) (2nd 16 bits)
	FFFFh	(0 = 00.000 s, 1=00.001 s, 59999=59.999 s)
		NOTE: If the time has never been set then all 32 bits will be 1.
F23		**DATE (32 bits)**
		Month / Day (MM/DD/xxxx) (2nd 16 bits)
	FF00h	Month (1 = January, 2 = February,..., 12 = December)
	00FFh	Day (1 to 31 in steps of 1)
		Year (xx/xx/YYYY) (2nd 16 bits)
	FFFFh	1990 to 2089 in steps of 1
		NOTE: If the date has never been set then all 32 bits will be 1.
F24		**EVENT TYPE**
	F000h	EVENT TYPE:
	1	General
	2	Pickup
	3	Trip
	4 [8]	Alarm
	5	Control
	6	Logic Input
	7	Self-Test Warning
	8	Dropout
		THE FORMAT FOR THE REMAINDER OF THE REGISTER DEPENDS UPON THE EVENT TYPE.
		GENERAL EVENT TYPE:
	00FFh	EVENT CAUSE:
	1	Control Power Off
	2	Control Power On
	3	Breaker Opened
	4	Breaker Closed
	5	Breaker Not Connected

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 5 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	6	Reset
	7	Open Breaker
	8	Close Breaker
	9	Set Time
	10	Set Date
	11	Trigger Trace Memory
	12	Clear Energy Use
	13	Clear Max Demand
	14	Clear Event Recorder
	15	Reset Trip Counter
	16	Reset Arcing Current
	17	Display Override Message
	18	Trigger Data Logger
	20	Transfer Initiated
	21	Transfer Not Ready
	22	Close From Transfer
	23	Trip From Transfer
	30	Reclosure 1 **760 ONLY!**
	31	Reclosure 2 **760 ONLY!**
	32	Reclosure 3 **760 ONLY!**
	33	Reclosure 4 **760 ONLY!**
	34	Reclosure Lockout **760 ONLY!**
	35	Shots Reduced to 3 **760 ONLY!**
	36	Shots Reduced to 2 **760 ONLY!**
	37	Shots Reduced to 1 **760 ONLY!**
	38	Shots Reduced to L/O **760 ONLY!**
	39	Autoreclose Reset **760 ONLY!**
	40	Setpoint Group 1 Active
	41	Setpoint Group 2 Active
	42	Setpoint Group 3 Active
	43	Setpoint Group 4 Active
	44 [7]	Reset AR Count **760 ONLY!**
	45 [7]	Reset AR Shot Rate **760 ONLY!**
		PICKUP / TRIP / ALARM LATCHED ALARM / CONTROL / DROPOUT EVENT TYPES:
		PHASES:
	0100h	Phase A (0 = No Fault, 1 = Fault)

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 6 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	0200h	Phase B (0 = No Fault, 1 = Fault)
	0400h	Phase C (0 = No Fault, 1 = Fault)
	00FFh	CAUSE OF EVENT
	1 [2]	Phase Time Overcurrent 1
	2 [2]	Phase Instantaneous Overcurrent 1
	3 [2]	Phase Instantaneous Overcurrent 2
	4 [2]	Ground Time Overcurrent
	5 [2]	Ground Instantaneous Overcurrent
	6 [2]	Neutral Time Overcurrent 1
	7 [2]	Neutral Time Overcurrent 2
	8 [2]	Neutral Instantaneous Overcurrent 1
	9 [2]	Neutral Instantaneous Overcurrent 2
	10 [2]	Phase Directional is Reverse
	11 [2]	Neutral Directional is Reverse
	12 [2]	Manual Close Feature Blocking
	13	Cold Load Pickup Feature Blocking
	14	Bus Undervoltage 1
	15	Bus Undervoltage 2
	16	Line Undervoltage 3
	17	Line Undervoltage 4
	18	Overvoltage 1
	19	Overvoltage 2
	20	Underfrequency 1
	21	Underfrequency 2
	22	Phase Current Level
	23 [1]	Neutral Current Level
	24	Power Factor 1
	25	Power Factor 2
	26	Out Of Synchronization
	27	Current Demand
	28	Real Power Demand
	29	Reactive Power Demand
	30	Apparent Power Demand
	31	Analog Input Threshold 1
	32	Analog Input Threshold 2
	33	Analog Input Rate of Change 1
	34	Analog Input Rate of Change 2

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 7 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	35	Overfrequency
	36	Trip Counter
	37	Arcing Current
	38	VT Failure
	39	Breaker Failure
	40	Breaker Operation
	41	Trip Coil Monitor
	42	Close Coil Monitor
	43	User Input A
	44	User Input B
	45	User Input C
	46	User Input D
	47	User Input E
	48	User Input F
	49	User Input G
	50	User Input H
	51	Negative Sequence Instantaneous Overcurrent
	52	Negative Sequence Time Overcurrent
	53	Negative Sequence Overvoltage
	54	Undervoltage Restoration
	55	Underfrequency Restoration
	56	Phase Time Overcurrent 2
	57 [1]	Frequency Decay
	58 [1]	Negative Sequence is Reverse
	59 [3]	Sensitive Ground Instantaneous Overcurrent
	60 [3]	Sensitive Ground Time Overcurrent
	61 [3]	Sensitive Ground Direction is Reverse
	62 [4]	Reserved for MOD 008
	63 [4]	Neutral Displacement
	64 [4]	Positive Watthours Pulse Output
	65 [4]	Negative Watthours Pulse Output
	66 [4]	Positive Varhours Pulse Output
	67 [4]	Negative Varhours Pulse Output
	68 [5]	Ground Directional is Reverse
	69 [6]	Reserved for MOD 010
	70 [7]	User Input I
	71 [7]	User Input J

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 8 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	72 [7]	User Input K
	73 [7]	User Input L
	74 [7]	User Input M
	75 [7]	User Input N
	76 [7]	User Input O
	77 [7]	User Input P
	78 [7]	User Input Q
	79 [7]	User Input R
	80 [7]	User Input S
	81 [7]	User Input T
	82 [7]	Autoreclose Rate **760 ONLY!**
	83 [7]	Restricted Earth Fault
		LOGIC INPUT EVENT TYPE:
	0100h	Contact State (0 = Open, 1 = Closed)
	0200h	Virtual State (0 = Off, 1 = On)
	0400h	Logic Input State (0 = Not Asserted, 1 = Asserted)
	00FFh	INPUT FUNCTION
	1	52a Contact
	2	52b Contact
	3	Breaker Connected
	10	Local Mode
	11	Remote Reset
	12	Remote Open
	13	Remote Close
	14	Cold Load Pickup
	15	Setpoint Group 2
	16	Setpoint Group 3
	17	Setpoint Group 4
	20	User Input A
	21	User Input B
	22	User Input C
	23	User Input D
	24	User Input E
	25	User Input F
	26	User Input G
	27	User Input H

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 9 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	30	Block 1 TRIP
	31	Block 2 CLOSE
	32	Block Reset
	33	Block Undervolt 1
	34	Block Undervolt 2
	35	Block Undervolt 3
	36	Block Undervolt 4
	37	Block Underfreq 1
	38	Block Underfreq 2
	39	Bypass Synchrocheck
	40	Block Trip Count
	41	Block Negative Sequence Overvoltage
	42	Block Restoration
	43 [1]	Block Freq Decay
	50	Block All OC
	51	Block Phase OC
	52	Block Ground OC
	53	Block Neutral OC
	54 [2]	Block Phase Time OC 1
	55 [2]	Block Phase Instantaneous OC 1
	56 [2]	Block Phase Instantaneous OC 2
	57 [2]	Block Ground Time OC
	58 [2]	Block Ground Instantaneous OC
	59 [2]	Block Neutral Time OC 2
	60 [2]	Block Neutral Time OC 1
	61 [2]	Block Neutral Instantaneous OC 1
	62 [2]	Block Neutral Instantaneous OC 2
	63	Block Negative Sequence Instantaneous Overcurrent
	64	Block Negative Sequence Time Overcurrent
	65 [1]	Block Phase Time OC 2
	70	Selected To Trip
	71	UV On Other Source
	72	Incomer 1 Closed
	73	Incomer 2 Closed
	74	BusTie Connected
	75	Bus Tie Closed
	76	Block Transfer

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 10 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	77	Xmfr Lockout
	78	Source Trip
	79	Cls From Incomer 1
	80	Cls From Incomer 2
	90	Initiate Reclosure
	91	Cancel Reclosure
	92	Block Reclosure
	100	Trigger Trace Memory
	101	Simulate Fault
	102	Trigger Data Log
	103 [3]	Block All Sensitive Ground Overcurrent
	104 [3]	Block Sensitive Ground Instantaneous O/C
	105 [3]	Block Sensitive Ground Time O/C
	106 [4]	Reserved for MOD 008
	107 [4]	Block Neutral Displacement
	108 [7]	User Input I
	109 [7]	User Input J
	110 [7]	User Input K
	111 [7]	User Input L
	112 [7]	User Input M
	113 [7]	User Input N
	114 [7]	User Input O
	115 [7]	User Input P
	116 [7]	User Input Q
	117 [7]	User Input R
	118 [7]	User Input S
	119 [7]	User Input T
	120 [7]	Start Demand Interval
		SELF-TEST WARNING EVENT TYPE:
	00FFh	EVENT CAUSE:
	1	Relay Not Ready
	2	Analog Output +32V
	3	FLASH Corrupt
	4	EEPROM Corrupt
	5	Dry Contact +32V
	6	A/D Virtual Ground

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 11 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	7	Internal RS485
	8	Internal Temperature
	9	Clock Not Set
	10	Prototype Software
	11	Not Calibrated
	12	Force Relays
	13	Force Analog Out
	14	Simulation Mode
	15	Pickup Test
	16	Factory Service Mode
	17	IRIG-B Failure
	18 [7]	Not Used
	19 [7]	Not Used
	20 [7]	RTC Crystal
F25		**2's COMPLEMENT SIGNED VALUE**
		To convert phase currents to Amps, multiply by 'Phase CT Primary' and divide by 1000. To convert ground current to Amps, multiply by 'Ground CT Primary' and divide by 1000. To convert sensitive ground current to Amps, multiply by 'Sensitive Ground CT Primary' and divide by 10000.
		To convert to voltages to Volts, multiply by 'VT Ratio', multiply by 'VT Secondary Voltage' and divide by 1000.
F26		**TRACE MEMORY CHANNEL SELECTOR**
		The contents of the Trace Memory Samples depends on the value contained in the Trace Memory Channel Selector as follows:
		DATA CHANNEL TYPE
	0	Phase A Current F25
	1	Phase B Current F25
	2	Phase C Current F25
	3	Ground Current F25
	4	A-N (A-B) Voltage F25
	5	B-N Voltage F25
	6	C-N (C-B) Voltage F25
	7	Line Voltage F25
	8	Output Relay States F40
	9	Logic Input States F46
	10 [3]	Sensitive Ground Current F25
F27		**COMMUNICATIONS PARITY**
	0	None
	1	Odd

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 12 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	2	Even
F28		**VT CONNECTION TYPE**
	0	None
	1	Wye
	2	Delta
F29		**760 OPERATION**
	0	Not Ready
	1	Ready
F30		**ENABLED/DISABLED**
	0	0 = Disabled
	1	1 = Enabled
F31		**BAUD RATE**
	0	300 Baud
	1	1200 Baud
	2	2400 Baud
	3	4800 Baud
	4	9600 Baud
	5	19200 Baud
F32		**DEFAULT MESSAGE**
		Internally Defined
F33		**ASCII TEXT CHARACTERS**
	00FFh	Second ASCII Character
	FF00h	First ASCII Character
F34		**RELAY NON-OPERATED STATE**
	0	De-energized
	1	Energized
F35		**RELAY OUTPUT TYPE**
	0	Self-Resetting
	1	Latched
	2	Pulsed
F36		**OVERCURRENT CURVE SHAPE**
	0	Extremely Inverse
	1	Very Inverse
	2	Normally Inverse
	3	Moderately Inverse
	4	Definite Time
	5	IEC Curve A

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 13 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION	
	6	IEC Curve B	
	7	IEC Curve C	
	8	FlexCurve A	
	9	FlexCurve B	
	10	IAC Extreme Inverse	
	11	IAC Very Inverse	
	12	IAC Inverse	
	13	IAC Short Inverse	
	14	IEC Short Inverse	
F37		**TRIP/ALARM/CONTROL FUNCTION**	
	0	Disabled	
	1	Trip	
	2	Trip & Autoreclose **760 ONLY!**	
	3	Alarm	
	4	Control	
	5 [8]	Latched Alarm	
F38		**ALARM/CONTROL FUNCTION**	
	0	Disabled	
	3	Alarm	
	4	Control	
	5 [8]	Latched Alarm	
	6 [9]	Blk Thrsh 1 (Analog Input Threshold 2 ONLY)	
F39		**TRIP/ALARM/CONTROL FUNCTION**	
	0	Disabled	
	1	Trip	
	3	Alarm	
	4	Control	
	5 [8]	Latched Alarm	
F40		**OUTPUT RELAY STATUS**	
	0001h	Relay 1 TRIP	(0 = Not Operated, 1 = Operated)
	0002h	Relay 2 CLOSE	(0 = Not Operated, 1 = Operated)
	0004h	Relay 3 ALARM	(0 = Not Operated, 1 = Operated)
	0008h	Relay 4 AUXILIARY	(0 = Not Operated, 1 = Operated)
	0010h	Relay 5 AUXILIARY	(0 = Not Operated, 1 = Operated)
	0020h	Relay 6 AUXILIARY	(0 = Not Operated, 1 = Operated)
	0040h	Relay 7 AUXILIARY	(0 = Not Operated, 1 = Operated)
	0080h	Relay 8 SERVICE	(0 = Not Operated, 1 = Operated)

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 14 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION	
F41		**CURRENT/VOLTAGE PHASES**	
	1	Any One	
	2	Any Two	
	3	All Three	
F42[2]		**ANALOG INPUT RANGE**	
	0	0-1 mA	
	1	0-5 mA	
	2	4-20 mA	
	3	0-20 mA	
	4[1]	0-10 mA	
F43[2]		**IRIG-B SIGNAL TYPE**	
	0	None	
	1	DC Shift	
	2	Amplitude Modulated	
F44		**OUT OF SERVICE STATES**	
	0001h	Major Internal Failure	(0=Disabled, 1=Enabled)
	0002h	Minor Internal Failure	(0=Disabled, 1=Enabled)
	0004h	Testing Mode	(0=Disabled, 1=Enabled)
	0020h	Code Programming Mode	(0=Disabled, 1=Enabled)
F45		**UNDERVOLTAGE CURVE TYPE**	
	0	Definite Time	
	1	Inverse Time	
F46		**CONTACT INPUT STATUS**	
	0001h	Contact Input 1 State	(0=Open, 1=Closed)
	0002h	Contact Input 2 State	(0=Open, 1=Closed)
	0004h	Contact Input 3 State	(0=Open, 1=Closed)
	0008h	Contact Input 4 State	(0=Open, 1=Closed)
	0010h	Contact Input 5 State	(0=Open, 1=Closed)
	0020h	Contact Input 6 State	(0=Open, 1=Closed)
	0040h	Contact Input 7 State	(0=Open, 1=Closed)
	0080h	Contact Input 8 State	(0=Open, 1=Closed)
	0100h	Contact Input 9 State	(0=Open, 1=Closed)
	0200h	Contact Input 10 State	(0=Open, 1=Closed)
	0400h	Contact Input 11 State	(0=Open, 1=Closed)
	0800h	Contact Input 12 State	(0=Open, 1=Closed)
	1000h	Contact Input 13 State	(0=Open, 1=Closed)
	2000h	Contact Input 14 State	(0=Open, 1=Closed)

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 15 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION	
	4000h	Setpoint Access State	(0=Restricted, 1=Allowed)
F47		**TRIP/CLOSE COIL STATUS**	
	0001h	Coil Monitor 1 Circuit Status	(0=Open, 1=Closed)
	0002h	Coil Monitor 2 Circuit Status	(0=Open, 1=Closed)
F48		**SIMULATION STATUS**	
	0	Disabled	
	1	Prefault State	
	2	Fault State	
	3	Postfault State	
F49		**PROTECTION FUNCTION STATE**	
	1000h	Pickup	(0=Not picked up, 1=Picked up)
	2000h	Operate	(0=Not operating, 1=Operating)
	4000h	Latched	(0=Not latched, 1=Latched)
	8000h	Latched Alarm	(0=Not latched, 1=Latched)
	0100h	Phase A	(0=Phase A is not picked up/operating, 1= Phase A is picked up/operating)
	0200h	Phase B	(0=Phase B is not picked up/operating, 1= Phase B is picked up/operating)
	0400h	Phase C	(0=Phase C is not picked up/operating, 1= Phase C is picked up/operating)
F50		**POLARIZATION**	
	0	Voltage	
	1	Current	
	2	Dual	
F51		**A100 SELF TEST ERRORS**	
	0001h	+32V Analog Output Voltage Monitor	(0 = OK, 1 = Failed)
	0002h	+32V Switch Input Voltage Monitor	(0 = OK, 1 = Failed)
	0004h	Real Time Clock	(0 = OK, 1 = Unable to Start)
	0008h	Not Used	
	0010h	EEPROM Failure	(0 = OK, 1 = Failed)
	0020h	Internal Temperature (-40 to 70 °C)	(0 = OK, 1= Out of Range)
	0040h	A/D Converter Virtual Ground	(0 = OK, 1 = Out of Spec)
	0080h	Not Calibrated	(0 = OK, 1 = Not Calibrated)
	0100h [7]	Not Used	
	8000h	Prototype Unit	(0 = OK, 1 = Installed)
F52		**2's COMPLEMENT SIGNED VALUE, 2 DECIMAL PLACES - DISTANCE TO FAULT**	
		Example: -12.34 stored as -1234	
		NOTE: A value of 327.67 indicates that the distance could not be calculated	
F53		**UNSIGNED VALUE, 2 DECIMAL PLACES - LINE Z1 TO FAULT**	
		Example: 12.34 stored as 1234	

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 16 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION	
		NOTE: A value of 655.35 indicates that the impedance could not be calculated	
F54		**FORCE LED STATE**	
	0001h	LED #1 (Top)	(0 = Off, 1 = On)
	0002h	LED #2	(0 = Off, 1 = On)
	0004h	LED #3	(0 = Off, 1 = On)
	0008h	LED #4	(0 = Off, 1 = On)
	0010h	LED #5	(0 = Off, 1 = On)
	0020h	LED #6	(0 = Off, 1 = On)
	0040h	LED #7	(0 = Off, 1 = On)
	0080h	LED #8 (Bottom)	(0 = Off, 1 = On)
F55		**FRONT PANEL KEY**	
	0	'0'	
	1	'1'	
	2	'2'	
	3	'3'	
	4	'4'	
	5	'5'	
	6	'6'	
	7	'7'	
	8	'8'	
	9	'9'	
	10	'.'	
	13	'Value Up'	
	14	'Value Down'	
	15	'Message Up'	
	16	'Message Down'	
	17	'Next'	
	18	'Enter'	
	19	'Escape'	
	20	'Setpoints'	
	21	'Actual'	
	22	'Reset'	
	23	'Open'	
	24	'Close'	
	25	'Help'	
	31	No Key	

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 17 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION	
F56		**TRANSFER FUNCTION**	
	0	Disabled	
	1	Incomer 1	
	2	Incomer 2	
	3	Bus Tie	
F57		**OUTPUT RELAYS (3-7)**	
	0004h	Relay 3 ALARM	(0 = Do Not Operate, 1 = Operate)
	0008h	Relay 4 AUXILIARY	(0 = Do Not Operate, 1 = Operate)
	0010h	Relay 5 AUXILIARY	(0 = Do Not Operate, 1 = Operate)
	0020h	Relay 6 AUXILIARY	(0 = Do Not Operate, 1 = Operate)
	0040h	Relay 7 AUXILIARY	(0 = Do Not Operate, 1 = Operate)
F58		**DEMAND MEASUREMENT TYPE**	
	0	Thermal Exponential	
	1	Block Interval	
	2	Rolling Demand	
F59 [2]		**OVERCURRENT BLOCKING FLAGS**	
	0001h [2]	Phase Instantaneous Overcurrent 1	(0 = Do Not Block, 1= Block)
	0002h [2]	Neutral Instantaneous Overcurrent 1	(0 = Do Not Block, 1= Block)
	0004h [2]	Ground Instantaneous Overcurrent	(0 = Do Not Block, 1= Block)
	0008h [2]	Negative Sequence Instantaneous Overcurrent	(0 = Do Not Block, 1= Block)
	0010h [3]	Sensitive Ground Instantaneous Overcurrent	(0 = Do Not Block, 1= Block)
F61		**C400 SELF TEST ERRORS**	
	0001h	A100 Communications	(0 = OK, 1 = Failing)
	8000h	Prototype Unit	(0 = OK, 1 = Installed)
F62		**PORT USED FOR DNP**	
	0	None	
	1	COM1	
	2	COM2	
	3	Front	
F63 [2]		**INPUTS 1-14 ASSERTED LOGIC**	
	0 [1]	Disabled	
	1 [1]	Contact Close	
	2 [1]	Contact Open	
	3 [1]	Virtual On	
	4 [1]	Virtual Off	
	5 [1]	Closed & V_{on}	
	6 [1]	Closed & V_{off}	

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 18 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	7 [1]	Open **&** V_{on}
	8 [1]	Open **&** V_{off}
	9 [1]	Closed **|** V_{on}
	10 [1]	Closed **|** V_{off}
	11 [1]	Open **|** V_{on}
	12 [1]	Open **|** V_{off}
	13 [1]	Closed **X** V_{on}
	14 [1]	Closed **X** V_{off}
	15 [1]	Open **X** V_{on}
	16 [1]	Open **X** V_{off}
F64 [2]		**INPUTS 15-20 ASSERTED LOGIC**
	0 [1]	Disabled
	1 [1]	Virtual On
	2 [1]	Virtual Off
F65		**LOGIC INPUT FUNCTION**
	0	Disabled
	1	Input 1
	2	Input 2
	3	Input 3
	:	:
	20	Input 20
F66		**LOGIC INPUT STATE**
	0	Off
	1	On
F68		**RESET TIME MODEL**
	0	Instantaneous
	1	Linear
F69		**LOGIC INPUT STATE**
	0100h	Contact State (0 = Open, 1 = Closed)
	0200h	Virtual State (0 = Off, 1 = On)
	0400h	Logic Input State (0 = Not Asserted, 1 = Asserted)
F70		**UNSIGNED VALUE, 3 DECIMAL PLACES**
		Example: 1.234 stored as 1234
F71		**FACTORY SERVICE COMMANDS**
	0	Clear Any Pending Commands
	1	Load Factory Default Setpoints
	2	Load Factory Default Calibration Data

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 19 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	3	Clear Diagnostic Data
F72		**FORCE HARDWARE**
	0001h	LED's (0=Normal, 1=Use LED force codes)
	0002h [8]	Reserved
	0004h	A100 Output Relay Watchdog (0=Normal, 1=Stop Updating)
	0008h	C400 Watchdog (0=Normal, 1=Stop Updating)
	0010h	485 Communication Port (0=Normal, 1=Echo)
	0020h	E485 Communication Port (0=Normal, 1=Echo)
	0040h	A100 Watchdog (0=Normal, 1=Stop Updating)
F73		**DYNAMIC OVERCURRENT PRIORITY**
	0	No Priority Adjustment
	1	Voltage Restraint
	2	Manual Close
	3	Cold Load
	4	Autoreclose
F74		**DATA LOGGER SAMPLE RATE**
	0	1 cycle
	1	1 second
	2	1 minute
	3	5 minutes
	4	10 minutes
	5	15 minutes
	6	20 minutes
	7	30 minutes
	8	60 minutes
F75		**UNITS OF LENGTH**
	0	km
	1	Miles
F76		**TYPE OF FAULT**
	0001h	øA (0=Not involved, 1= Involved)
	0002h	øB (0=Not involved, 1= Involved)
	0004h	øC (0=Not involved, 1= Involved)
	0008h	Ground (0=Not involved, 1= Involved)
		Example: øB to øC to Ground = 000Eh
F77 [2]		**ANALOG OUTPUT PARAMETER TYPE**
	0	Disabled
	1	Phase A Current

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 20 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	2	Phase B Current
	3	Phase C Current
	4	Average Phase Current
	5	% of Load to Trip
	6	Neutral Current
	7	Phase A-N Voltage
	8	Phase B-N Voltage
	9	Phase C-N Voltage
	10	Average Phase Voltage
	11	Line A-B Voltage
	12	Line B-C Voltage
	13	Line C-A Voltage
	14	Average Line Voltage
	15	Frequency
	16	3ϕ Real Power (MW)
	17	3ϕ Reactive Power (Mvar)
	18	3ϕ Apparent Power (MVA)
	19	3ϕ Power Factor
	20	Last Phase A Current Demand
	21	Last Phase B Current Demand
	22	Last Phase C Current Demand
	23	Last Real Power Demand
	24	Last Reactive Power Demand
	25	Last Apparent Power Demand
	26	Analog Input
	27	Last Fault Location
	28	Positive Watthours
	29	Negative Watthours
	30	Positive Varhours
	31	Negative Varhours
	32	Ground Current
	33 [1]	ϕA Real Power (MW)
	34 [1]	ϕA Reactive Power (Mvar)
	35 [1]	ϕA Apparent Power (MVA)
	36 [1]	ϕA Power Factor
	37 [1]	ϕB Real Power (MW)
	38 [1]	ϕB Reactive Power (Mvar)

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 21 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	39 [1]	ϕB Apparent Power (MVA)
	40 [1]	ϕB Power Factor
	41 [1]	ϕC Real Power (MW)
	42 [1]	ϕC Reactive Power (Mvar)
	43 [1]	ϕC Apparent Power (MVA)
	44 [1]	ϕC Power Factor
	45 [1]	Synchro Voltage
	46 [1]	Synchro Frequency
	47 [1]	Synchro Voltage Angle
	48 [1]	Sychro Voltage Difference
	49 [1]	Sychro Angle Difference
	50 [1]	Sychro Frequency Difference
	51 [1]	Frequency Decay Rate
	52 [3]	Polarizing Current
	53 [1]	Phase A Current Angle
	54 [1]	Phase B Current Angle
	55 [1]	Phase C Current Angle
	56 [1]	Neutral Current Angle
	57 [1]	Ground Current Angle
	58 [3]	Polarizing Current Angle
	59 [1]	A-N Voltage Angle
	60 [1]	B-N Voltage Angle
	61 [1]	C-N Voltage Angle
	62 [1]	A-B Voltage Angle
	63 [1]	B-C Voltage Angle
	64 [1]	C-A Voltage Angle
	65 [1]	Positive Sequence Current Magnitude
	66 [1]	Positive Sequence Current Angle
	67 [1]	Negative Sequence Current Magnitude
	68 [1]	Negative Sequence Current Angle
	69 [1]	Zero Sequence Current Magnitude
	70 [1]	Zero Sequence Current Angle
	71 [1]	Positive Sequence Voltage Magnitude
	72 [1]	Positive Sequence Voltage Angle
	73 [1]	Negative Sequence Voltage Magnitude
	74 [1]	Negative Sequence Voltage Angle
	75 [1]	Zero Sequence Voltage Magnitude

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 22 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
	76 [1]	Zero Sequence Voltage Angle
	77 [3]	Sensitive Ground Current
	78 [3]	Sensitive Ground Current Angle
	79 [4]	Neutral Voltage
	80 [4]	Neutral Voltage Angle
F78 [2]		**ANALOG OUTPUT MINIMUM / MAXIMUM**
		The Range, Step Value, and Units for the Analog Output Minimum and Maximum depends upon the parameter type programmed for the output. The following table shows the format for a given parameter type:

PARAMETER	RANGE	STEP	UNITS
All currents	0 to 65535	1	Amps
All voltages	0.00 to 655.35	0.01	kV
% Load to Trip	0 to 2000	1	%
Frequency	20.00 to 65.00	0.01	Hz
All Power / Energy	see F86		
Power Factor	-0.99 to +1.00	0.01	---
Analog Input	0 to 65535	1	units
Fault Location	-1000.0 to +1000.0	0.1	km / miles
Frequency Delay	-10.00 to +10.00	0.01	Hz/s
All Angles	0 to 359	1	° Lag

F79		**SETPOINT GROUP**
	0	Group 1
	1	Group 2
	2	Group 3
	3	Group 4
F80		**EDIT SETPOINT GROUP**
	0	Group 1
	1	Group 2
	2	Group 3
	3	Group 4
	4	Active Group
F81		**TRACE MEMORY / DATA LOGGER BUFFER ORGANIZATION**
	0	2 x 2048
	1	4 x 1024
	2	8 x 512
	3	16 x 256

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 23 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
F82		**TRACE MEMORY / DATA LOGGER TRIGGER**
	0x0001	Trigger on pickup
	0x0002	Trigger on dropout
	0x0004	Trigger on trip
	0x0008	Trigger on alarm
	0x0010	Trigger on control
F83 [1]		**PHASE SEQUENCE**
	0	ABC
	1	ACB
F84 [1]		**OVERCURRENT DIRECTION**
	0	Disabled
	1	Forward
	2	Reverse
F85 [1]		**PICKUP TYPE**
	0	Over
	1	Under
F86 [1]		**AUTO-RANGING POWER / ENERGY**
		All power quantities auto-range to display units relative to the nominal power of the system as defined below. Multiply the power quantity in question by the multiplier in register 0316h to yield the correct reading. The SI prefix for all power and energy quantities before scaling by the multiplier is 'k'. All power quantities are signed, single word registers (F4). All energy quantities are unsigned, double word registers (F7). The multiplier is determined from the nominal power which is defined as the product of three setpoints: P_N = Phase CT Primary x Bus VT Secondary Voltage x Bus VT Ratio **NOMINAL POWER P_N** / **MULTIPLIER** $P_N < 1$ MVA / 1 1 MVA $\le P_N <$ 10 MVA / 10 10 MVA $\le P_N$ / 100 Example: If the 3ϕ Real Power register (0310) has a value of '123' and the Multiplier register (0316) has a value of '10' then the value to display is 1230 kW.
F87 [3]		**UNDERVOLTAGE RESTORATION SOURCE**
	0	Bus
	1	Line
F88 [6]		**RESERVED FOR MOD 010**
	0	
	1	

1 2 3 4 5 6 7 8 9 For explanation of Table footnotes, see page 16–83.

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Table 16–16: MODBUS MEMORY MAP DATA FORMATS (Sheet 24 of 24)

TYPE	VALUE / BIT MASK	DESCRIPTION
F89 [7]		**DNP DATA LINK CONFIRMATION MODE**
	0	Never
	1	Sometimes
	2	Always
F90 [7]		**COIL MONITOR TYPE**
	0	Trip
	1	Close

[1] [2] [3] [4] [5] [6] [7] [8] [9] For explanation of Table footnotes, see page 16–83.

16.4.4 NOTES FOR MEMORY MAP DATA FORMATS

The footnotes used in the memory map data formats are explained below:

[1] These formats/values are new for version 2.10

[2] These formats/values have been changed in some way from version 2.00 to 2.10

[3] These formats are new or have changed for version 3.00

[4] These formats are new or have changed for version 3.20

[5] These formats/values are new for version 3.30

[6] These formats/values are new for version 3.31 MOD 010

[7] These formats/values are new or have changed for version 3.60

[8] These formats/values are new or have changed for version 3.70

[9] These formats/values are new or have changed for version 4.00

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DNP 3.0
DEVICE PROFILE DOCUMENT

Vendor Name: General Electric Power Management

Device Name: 750/760 Feeder Management Relay

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):

Binary Input (Object 1, Variations 1 and 2)
Binary Output (Object 10, Variation 2)
Analog Input (Object 30, Variations 1, 2, 3 and 4)
Analog Input Change (Object 32, Variations 1, 2, 3 and 4)
Warm Restart (Function code 14)

Maximum Data Link Frame Size (octets): Transmitted: 292 Received: 292	Maximum Application Fragment Size (octets): Transmitted: 2048 Received: 2048
Maximum Data Link Re-tries: ☐ None ☐ Fixed ☒ Configurable (Note 1)	Maximum Application Layer Re-tries: ☒ None ☐ Configurable

Requires Data Link Layer Confirmation:
- ☐ Never
- ☐ Always
- ☐ Sometimes
- ☒ Configurable (Note 1)

Requires Application Layer Confirmation:
- ☐ Never
- ☐ Always
- ☒ When reporting Event Data
- ☐ When sending multi-fragment responses
- ☐ Sometimes
- ☐ Configurable

Timeouts while waiting for:

Data Link Confirm	☐ None	☐ Fixed	☐ Variable	☒ Configurable (Note 1)
Complete Appl. Fragment	☒ None	☐ Fixed	☐ Variable	☐ Configurable
Application Confirm	☒ None	☐ Fixed	☐ Variable	☐ Configurable
Complete Appl. Response	☒ None	☐ Fixed	☐ Variable	☐ Configurable

Others: (None)

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DNP 3.0
DEVICE PROFILE DOCUMENT (Continued)

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
Trip/Close	☐ Never	☐ Always	☒ Sometimes	☐ Configurable

(For an explanation of the above, refer to the discussion accompanying the point list for the Binary Output/ Control Relay Output Block objects)

Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable

Reports Binary Input Change Events when no specific variations requested:

- ☐ Never
- ☒ Only time-tagged
- ☐ Only non-time-tagged
- ☐ Configurable to send both, one or the other

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

Sends Unsolicited Responses:

- ☒ Never
- ☐ Configurable
- ☐ Only certain objects
- ☐ Sometimes
- ☐ ENABLE/DISABLE UNSOLICITED Function codes supported

Sends Static Data in Unsolicited Responses:

- ☒ Never
- ☐ When Device Restarts
- ☐ When Status Flags Change

Default Counter Object/Variation:

- ☒ No Counters Reported
- ☐ Configurable
- ☐ Default Object
  Default Variation
- ☐ Point-by-point list attached

Counters Roll Over at:

- ☒ No Counters Reported
- ☐ Configurable
- ☐ 16 Bits
- ☐ 32 Bits
- ☐ Other Value
- ☐ Point-by-point list attached

Sends Multi-Fragment Responses: ☐ Yes ☒ No

1. The data link layer confirmation mode, confirmation timeout and number of retries are all configurable. Refer to the setpoints defined under **S1 RELAY SETUP / COMMUNICATIONS / DNP** for more details. Additional setpoints related to DNP are discussed in Section 8.3: DNP COMMUNICATIONS on page 8–3.

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The table below gives a list of all objects recognized and returned by the relay. Additional information is provided on the following pages including a list of the default variations returned for each object and lists of defined point numbers for each object.

IMPLEMENTATION TABLE

OBJECT			REQUEST		RESPONSE	
Obj	Var	Description	Func. Codes	Qual Codes (Hex)	Func. Codes	Qual Codes (Hex)
1	0	Binary Input - All Variations	1	06		
1	1	Binary Input	1	00, 01, 06	129	00, 01
1	2	Binary Input With Status	1	00, 01, 06	129	00, 01
2	0	Binary Input Change - All Variations	1	06, 07, 08		
2	1	Binary Input Change Without Time	1	06, 07, 08	129	17, 28
2	2	Binary Input Change With Time	1	06, 07, 08	129	17, 28
10	0	Binary Output - All Variations	1	06		
10	2	Binary Output Status	1	00, 01, 06	129	00, 01
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	17, 28
30	0	Analog Input - All Variations	1	06		
30	1	32-Bit Analog Input With Flag	1	00, 01, 06	129	00, 01
30	2	16-Bit Analog Input With Flag	1	00, 01, 06	129	00, 01
30	3	32-Bit Analog Input Without Flag	1	00, 01, 06	129	00, 01
30	4	16-Bit Analog Input Without Flag	1	00, 01, 06	129	00, 01
32	0	Analog Input Change - All Variations	1	06, 07, 08		
32	1	32-Bit Analog Input Change Without Time	1	06, 07, 08	129	17, 28
32	2	16-Bit Analog Input Change Without Time	1	06, 07, 08	129	17, 28
32	3	32-Bit Analog Input Change With Time	1	06, 07, 08	129	17, 28
32	4	16-Bit Analog Input Change With Time	1	06, 07, 08	129	17, 28
50	1	Time and Date	1, 2	07 (Note 1)	129	07
60	1	Class 0 Data (Note 2)	1	06	129	
60	2	Class 1 Data (Note 3)	1	06, 07, 08	129	
60	3	Class 2 Data (Note 3)	1	06, 07, 08	129	
60	4	Class 3 Data (Note 3)	1	06, 07, 08	129	
80	1	Internal Indications	2	00 (Note 4)	129	
		No object	13			
		No object	14			
		No object	23			

Table Notes:

1. For this object, the quantity specified in the request must be exactly 1 as there is only one instance of this object defined in the relay.
2. All static input data known to the relay is returned in response to a request for Class 0. This includes all objects of type 1 (Binary Input), type 10 (Binary Output) and type 30 (Analog Input).
3. The point tables for Binary Input and Analog Input objects contain a field which defines to which event class the corresponding static data has been assigned to.
4. For this object, the qualifier code must specify an index of 7 only.

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The following table specifies the default variation for all objects returned by the relay. These are the variations that will be returned for the object in a response when no specific variation is specified in a request.

DEFAULT VARIATIONS		
Object	**Description**	**Default Variation**
1	Binary Input - Single Bit	1
2	Binary Input Change With Time	2
10	Binary Output Status	2
30	16-Bit Analog Input Without Flag	4
32	16-Bit Analog Input Change Without Time	2

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POINT LIST FOR: BINARY INPUT (OBJECT 01)
BINARY INPUT CHANGE (OBJECT 02)

Index	Description	Event Class Assigned To	Notes
0	Relay In Service	Class 1	
1	Trip Condition(s) Active	Class 1	
2	Alarm Condition(s) Active	Class 1	
3	Protection Picked Up	Class 1	
4	Setpoint Group 1 Active	Class 1	
5	Setpoint Group 2 Active	Class 1	
6	Setpoint Group 3 Active	Class 1	
7	Setpoint Group 4 Active	Class 1	
8	Breaker Is Open	Class 1	
9	Breaker Is Closed	Class 1	
10	Reclosure Enabled	Class 1	Note 1
11	Reclosure Disabled	Class 1	Note 1
12	Reclosure In Progress	Class 1	Note 1
13	Reclosure Locked Out	Class 1	Note 1
14	Local Mode Active	Class 1	
15	Diagnostic Message(s) Active	Class 1	
16	Major Internal Failure	Class 1	
17	Minor Internal Failure	Class 1	
18	Testing Mode Active	Class 1	
19	Contact Input 1 Closed	Class 1	
20	Contact Input 2 Closed	Class 1	
21	Contact Input 3 Closed	Class 1	
22	Contact Input 4 Closed	Class 1	
23	Contact Input 5 Closed	Class 1	
24	Contact Input 6 Closed	Class 1	
25	Contact Input 7 Closed	Class 1	
26	Contact Input 8 Closed	Class 1	
27	Contact Input 9 Closed	Class 1	
28	Contact Input 10 Closed	Class 1	
29	Contact Input 11 Closed	Class 1	
30	Contact Input 12 Closed	Class 1	
31	Contact Input 13 Closed	Class 1	
32	Contact Input 14 Closed	Class 1	
33	Setpoint Access Jumper Present	Class 1	
34	Coil Monitor 1 Circuit Closed	Class 1	
35	Coil Monitor 2 Circuit Closed	Class 1	

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POINT LIST FOR: BINARY INPUT (OBJECT 01) BINARY INPUT CHANGE (OBJECT 02) (Continued)

Index	Description	Event Class Assigned To	Notes
36	Relay 1 TRIP Operated	Class 1	
37	Relay 2 CLOSE Operated	Class 1	
38	Relay 3 AUXILIARY Operated	Class 1	
39	Relay 4 AUXILIARY Operated	Class 1	
40	Relay 5 AUXILIARY Operated	Class 1	
41	Relay 6 AUXILIARY Operated	Class 1	
42	Relay 7 AUXILIARY Operated	Class 1	
43	Relay 8 SERVICE Operated	Class 1	

Notes:

1. The function associated with this point is only defined for the 760. A value of zero will always be returned from an 750.
2. An event object will be generated as a result of any change in any point.

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POINT LIST FOR: BINARY OUTPUT (OBJECT 10) CONTROL RELAY OUTPUT BLOCK (OBJECT 12)

Index	Description
0	Reset
1	Open Breaker
2	Close Breaker
3	Virtual Input 1
4	Virtual Input 2
5	Virtual Input 3
6	Virtual Input 4
7	Virtual Input 5
8	Virtual Input 6
9	Virtual Input 7
10	Virtual Input 8
11	Virtual Input 9
12	Virtual Input 10
13	Virtual Input 11
14	Virtual Input 12
15	Virtual Input 13
16	Virtual Input 14
17	Virtual Input 15
18	Virtual Input 16
19	Virtual Input 17
20	Virtual Input 18
21	Virtual Input 19
22	Virtual Input 20
23	Breaker Control

The following restrictions should be observed when using object 12 to control the points listed in the above table.

1. The Count field is checked first. If it is zero, the command will be accepted but no action will be taken. If this field is non-zero, the command will be executed exactly once regardless of its value.
2. The Control Code field of object 12 is then inspected:
   - The Queue, and Clear sub-fields are ignored.
   - If the Code sub-field is NUL, then the command will be accepted without any action being taken.
   - A Code sub-field of “Pulse On” (1) is valid only for points 0 through 2. This is used to activate the function (e.g., Reset) associated with the point.
   - A Code sub-field of “Pulse On” (1) in combination with a value in the Trip/Close sub-field form a “Trip” or “Close” value. A “Trip” value consists of a “Pulse On” (1) in the Code sub-field and a 2 in the Trip/Close sub-field. This results in a value of 81 (hex) in the Control Code field. A “Close” value consists of a “Pulse On” (1) in the Code sub-field and a 1 in the Trip/Close sub-field. This results in a value of 41 (hex) in the Control Code field.

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- A Code sub-field of “Latch On” (3) or “Latch Off” (4) is valid for all virtual input points (i.e., points 3 through 22). This is used to set the associated Virtual Input on (“Latch On”) or off (“Latch Off”). As well, a “Close” value in the Control Code field will cause the virtual input to be turned on while a “Trip” value in this field will cause the virtual input to be turned off.
- The “Breaker Control” point (23) will only accept a “Trip” or “Close” value. A value of “Trip” will activate the “Breaker Open” function. Similarly, a value of “Close” will activate the “Breaker Close” function.
- All operations not defined above are invalid and will be rejected.

3. The On Time and Off Time fields are ignored. A ”Pulse On” Code takes effect immediately when received, therefore timing is irrelevant.
4. The Status field in the response will reflect the success or failure of the control attempt thus:
   - A Status of “Request Accepted” (0) will be returned if the command was accepted.
   - A Status of “Request not Accepted due to Formatting Errors” (3) will be returned if the Control Code field was incorrectly formatted or an invalid Code was present in the command.
   - A Status of “Control Operation not Supported for this Point” (4) will be returned if an attempt was made to operate the “Open Breaker” (1), “Close Breaker” (2) or “Breaker Control” (23) points and the relay is in local mode (this status is indicated by Object 1, Point 14).

Setting or clearing a Virtual Input will always succeed, however an operate of the Reset, Open Breaker, Close Breaker or Breaker Control points may fail (even if the command is accepted) due to other inputs or conditions (e.g., blocks) existing at the time. To verify the success or failure of an operate of these points it is necessary that the associated Binary Input(s) be examined after the control attempt is performed.

When using object 10 to read the status of a Binary Output, a read of points 0 through 2 and 23 will always return zero. For other points, the current state of the corresponding Virtual Input will be returned.

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In the following table, the entry in the “Format” column indicates that the format of the associated data point can be determined by looking up the entry in the Memory Map Data Formats table. For example, an “F1” format is described in that table as a (16-bit) unsigned value without any decimal places. Therefore, the value read should be interpreted in this manner.

POINT LIST FOR: ANALOG INPUT (OBJECT 30)
ANALOG INPUT CHANGE (OBJECT 32)

(Note 5) Index when Point Mapping Is:		Format	Description	Event Class Assigned To	Notes
Disabled	Enabled				
n/a	0	-	User Map Value 1		
n/a	1	-	User Map Value 2		
.	.	-	.		
.	.	-	.		
.	.	-	.		
n/a	118	-	User Map Value 119		
n/a	119	-	User Map Value 120		
0	120	F49	Phase Time Overcurrent 1	Class 1	
1	121	F49	Phase Instantaneous Overcurrent 1	Class 1	
2	122	F49	Phase Instantaneous Overcurrent 2	Class 1	
3	123	F49	Ground Time Overcurrent	Class 1	
4	124	F49	Ground Instantaneous Overcurrent	Class 1	
5	125	F49	Neutral Time Overcurrent 1	Class 1	
6	126	F49	Neutral Time Overcurrent 2	Class 1	
7	127	F49	Neutral Instantaneous Overcurrent 1	Class 1	
8	128	F49	Neutral Instantaneous Overcurrent 2	Class 1	
9	129	F49	Phase Directional Is Reverse	Class 1	
10	130	F49	Neutral Directional Is Reverse	Class 1	
11	131	F49	Manual Close Blocking	Class 1	
12	132	F49	Cold Load Pickup Blocking	Class 1	
13	133	F49	Bus Undervoltage 1	Class 1	
14	134	F49	Bus Undervoltage 2	Class 1	
15	135	F49	Line Undervoltage 3	Class 1	
16	136	F49	Line Undervoltage 4	Class 1	
17	137	F49	Overvoltage 1	Class 1	
18	138	F49	Overvoltage 2	Class 1	
19	139	F49	Underfrequency 1	Class 1	
20	140	F49	Underfrequency 2	Class 1	
21	141	F49	Phase Current Level	Class 1	
22	142	F49	Neutral Current Level	Class 1	
23	143	F49	Power Factor 1	Class 1	
24	144	F49	Power Factor 2	Class 1	

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POINT LIST FOR: ANALOG INPUT (OBJECT 30) ANALOG INPUT CHANGE (OBJECT 32) (Continued)

(Note 5) Index when Point Mapping Is:		Format	Description	Event Class Assigned To	Notes
Disabled	Enabled				
25	145	F49	Synchrocheck Block (Not In Sync)	Class 1	
26	146	F49	Current Demand	Class 1	
27	147	F49	Real Power Demand	Class 1	
28	148	F49	Reactive Power Demand	Class 1	
29	149	F49	Apparent Power Demand	Class 1	
30	150	F49	Analog Input Threshold 1	Class 1	
31	151	F49	Analog Input Threshold 2	Class 1	
32	152	F49	Analog Input Rate of Change 1	Class 1	
33	153	F49	Analog Input Rate of Change 2	Class 1	
34	154	F49	Overfrequency	Class 1	
35	155	F49	Trip Counter	Class 1	
36	156	F49	Arcing Current	Class 1	
37	157	F49	VT Failure	Class 1	
38	158	F49	Breaker Failure	Class 1	
39	159	F49	Breaker Operation Failure	Class 1	
40	160	F49	Trip Coil Monitor	Class 1	
41	161	F49	Close Coil Monitor	Class 1	
42	162	F49	User Input A	Class 1	
43	163	F49	User Input B	Class 1	
44	164	F49	User Input C	Class 1	
45	165	F49	User Input D	Class 1	
46	166	F49	User Input E	Class 1	
47	167	F49	User Input F	Class 1	
48	168	F49	User Input G	Class 1	
49	169	F49	User Input H	Class 1	
50	170	F49	Negative Sequence Instantaneous Overcurrent	Class 1	
51	171	F49	Negative Sequence Time Overcurrent	Class 1	
52	172	F49	Negative Sequence Overvoltage	Class 1	
53	173	F49	Undervoltage Restoration	Class 1	
54	174	F49	Underfrequency Restoration	Class 1	
55	175	F49	Phase Time Overcurrent 2	Class 1	
56	176	F49	Frequency Decay	Class 1	
57	177	F49	Negative Sequence Directional Is Reverse	Class 1	
58	178	F49	Sensitive Ground Instantaneous Overcurrent	Class 1	
59	179	F49	Sensitive Ground Time Overcurrent	Class 1	

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POINT LIST FOR: ANALOG INPUT (OBJECT 30) ANALOG INPUT CHANGE (OBJECT 32) (Continued)

(Note 5) Index when Point Mapping Is:		Format	Description	Event Class Assigned To	Notes
Disabled	Enabled				
60	180	F49	Sensitive Ground Directional Is Reverse	Class 1	
61	181	F1	Phase A RMS Current	Class 2	Note 3
62	182	F1	Phase B RMS Current	Class 2	Note 3
63	183	F1	Phase C RMS Current	Class 2	Note 3
64	184	F1	Percent Of Load-To-Trip	Class 2	Note 3
65	185	F1	Ground Current	Class 2	Note 3
66	186	F3	Phase A-Neutral RMS Voltage	Class 2	Note 3
67	187	F3	Phase B-Neutral RMS Voltage	Class 2	Note 3
68	188	F3	Phase C-Neutral RMS Voltage	Class 2	Note 3
69	189	F3	Phase A-Phase B RMS Voltage	Class 2	Note 3
70	190	F3	Phase B-Phase C RMS Voltage	Class 2	Note 3
71	191	F3	Phase C-Phase A RMS Voltage	Class 2	Note 3
72	192	F3	Sensitive Ground Current	Class 2	Note 3
73	193	F1	Average Current	Class 2	Note 3
74	194	F3	Average Line Voltage	Class 2	Note 3
75	195	F3	Average Phase Voltage	Class 2	Note 3
76	196	F1	Neutral Current	Class 2	Note 3
77	197	F86	3ϕ Real Power	Class 2	Note 3
78	198	F86	3ϕ Reactive Power	Class 2	Note 3
79	199	F86	3ϕ Apparent Power	Class 2	Note 3
80	200	F6	3ϕ Power Factor	Class 2	Note 3
81	201	F3	System Frequency	Class 2	Note 4
82	202	F1	Analog Input	Class 2	Note 3
83	203	F23	Date Of Last Trip (Upper 16 Bits - See Note 1)	Class 1	Note 1
84	204	F23	Date Of Last Trip (Lower 16 Bits - See Note 1)	Class 1	Note 1
85	205	F22	Time Of Last Trip (Upper 16 Bits - See Note 1)	Class 1	Note 1
86	206	F22	Time Of Last Trip (Lower 16 Bits - See Note 1)	Class 1	Note 1
87	207	F24	Cause Of Last Trip	Class 1	
88	208	F1	Last Trip Phase A RMS Current	Class 1	
89	209	F1	Last Trip Phase B RMS Current	Class 1	
90	210	F1	Last Trip Phase C RMS Current	Class 1	
91	211	F1	Last Trip Ground Current	Class 1	
92	212	F3	Last Trip Sensitive Ground Current	Class 1	
93	213	F3	Last Trip A-N (A-B) RMS Voltage	Class 1	
94	214	F3	Last Trip B-N (B-C) RMS Voltage	Class 1	

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POINT LIST FOR: ANALOG INPUT (OBJECT 30) ANALOG INPUT CHANGE (OBJECT 32) (Continued)

(Note 5) Index when Point Mapping Is:		Format	Description	Event Class Assigned To	Notes
Disabled	Enabled				
95	215	F3	Last Trip C-N (C-A) RMS Voltage	Class 1	
96	216	F3	Last Trip System Frequency	Class 1	
97	217	F1	Last Trip Analog Input	Class 1	
98	218	F1	Last Trip Neutral Current	Class 1	
99	219	F23	Date Of Fault 1 (Upper 16 Bits - See Note 1)	Class 3	Note 1
100	220	F23	Date Of Fault 1 (Lower 16 Bits - See Note 1)	Class 3	Note 1
101	221	F22	Time Of Fault 1 (Upper 16 Bits - See Note 1)	Class 3	Note 1
102	222	F22	Time Of Fault 1 (Lower 16 Bits - See Note 1)	Class 3	Note 1
103	223	F76	Type Of Fault 1	Class 3	
104	224	F52	Distance To Fault 1	Class 3	
105	225	F53	Line Z1 To Fault 1 (Magnitude)	Class 3	
106	226	F23	Date Of Fault 2 (Upper 16 Bits - See Note 1)		Note 1
107	227	F23	Date Of Fault 2 (Lower 16 Bits - See Note 1)		Note 1
108	228	F22	Time Of Fault 2 (Upper 16 Bits - See Note 1)		Note 1
109	229	F22	Time Of Fault 2 (Lower 16 Bits - See Note 1)		Note 1
110	230	F76	Type Of Fault 2		
111	231	F52	Distance To Fault 2		
112	232	F53	Line Z1 To Fault 2 (Magnitude)		
113	233	F23	Date Of Fault 3 (Upper 16 Bits - See Note 1)		Note 1
114	234	F23	Date Of Fault 3 (Lower 16 Bits - See Note 1)		Note 1
115	235	F22	Time Of Fault 3 (Upper 16 Bits - See Note 1)		Note 1
116	236	F22	Time Of Fault 3 (Lower 16 Bits - See Note 1)		Note 1
117	237	F76	Type Of Fault 3		
118	238	F52	Distance To Fault 3		
119	239	F53	Line Z1 To Fault 3 (Magnitude)		
120	240	F23	Date Of Fault 4 (Upper 16 Bits - See Note 1)		Note 1
121	241	F23	Date Of Fault 4 (Lower 16 Bits - See Note 1)		Note 1
122	242	F22	Time Of Fault 4 (Upper 16 Bits - See Note 1)		Note 1
123	243	F22	Time Of Fault 4 (Lower 16 Bits - See Note 1)		Note 1
124	244	F76	Type Of Fault 4		
125	245	F52	Distance To Fault 4		
126	246	F53	Line Z1 To Fault 4 (Magnitude)		
127	247	F23	Date Of Fault 5 (Upper 16 Bits - See Note 1)		Note 1
128	248	F23	Date Of Fault 5 (Lower 16 Bits - See Note 1)		Note 1
129	249	F22	Time Of Fault 5 (Upper 16 Bits - See Note 1)		Note 1

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POINT LIST FOR: ANALOG INPUT (OBJECT 30) ANALOG INPUT CHANGE (OBJECT 32) (Continued)

(Note 5) Index when Point Mapping Is:		Format	Description	Event Class Assigned To	Notes
Disabled	Enabled				
130	250	F22	Time Of Fault 5 (Lower 16 Bits - See Note 1)		Note 1
131	251	F76	Type Of Fault 5		
132	252	F52	Distance To Fault 5		
133	253	F53	Line Z1 To Fault 5 (Magnitude)		
134	254	F23	Date Of Fault 6 (Upper 16 Bits - See Note 1)		Note 1
135	255	F23	Date Of Fault 6 (Lower 16 Bits - See Note 1)		Note 1
136	256	F22	Time Of Fault 6 (Upper 16 Bits - See Note 1)		Note 1
137	257	F22	Time Of Fault 6 (Lower 16 Bits - See Note 1)		Note 1
138	258	F76	Type Of Fault 6		
139	259	F52	Distance To Fault 6		
140	260	F53	Line Z1 To Fault 6 (Magnitude)		
141	261	F23	Date Of Fault 7 (Upper 16 Bits - See Note 1)		Note 1
142	262	F23	Date Of Fault 7 (Lower 16 Bits - See Note 1)		Note 1
143	263	F22	Time Of Fault 7 (Upper 16 Bits - See Note 1)		Note 1
144	264	F22	Time Of Fault 7 (Lower 16 Bits - See Note 1)		Note 1
145	265	F76	Type Of Fault 7		
146	266	F52	Distance To Fault 7		
147	267	F53	Line Z1 To Fault 7 (Magnitude)		
148	268	F23	Date Of Fault 8 (Upper 16 Bits - See Note 1)		Note 1
149	269	F23	Date Of Fault 8 (Lower 16 Bits - See Note 1)		Note 1
150	270	F22	Time Of Fault 8 (Upper 16 Bits - See Note 1)		Note 1
151	271	F22	Time Of Fault 8 (Lower 16 Bits - See Note 1)		Note 1
152	272	F76	Type Of Fault 8		
153	273	F52	Distance To Fault 8		
154	274	F53	Line Z1 To Fault 8 (Magnitude)		
155	275	F23	Date Of Fault 9 (Upper 16 Bits - See Note 1)		Note 1
156	276	F23	Date Of Fault 9 (Lower 16 Bits - See Note 1)		Note 1
157	277	F22	Time Of Fault 9 (Upper 16 Bits - See Note 1)		Note 1
158	278	F22	Time Of Fault 9 (Lower 16 Bits - See Note 1)		Note 1
159	279	F76	Type Of Fault 9		
160	280	F52	Distance To Fault 9		
161	281	F53	Line Z1 To Fault 9 (Magnitude)		
162	282	F23	Date Of Fault 10 (Upper 16 Bits - See Note 1)		Note 1
163	283	F23	Date Of Fault 10 (Lower 16 Bits - See Note 1)		Note 1
164	284	F22	Time Of Fault 10 (Upper 16 Bits - See Note 1)		Note 1

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POINT LIST FOR: ANALOG INPUT (OBJECT 30) ANALOG INPUT CHANGE (OBJECT 32) (Continued)

(Note 5) Index when Point Mapping Is:		Format	Description	Event Class Assigned To	Notes
Disabled	Enabled				
165	285	F22	Time Of Fault 10 (Lower 16 Bits - See Note 1)		Note 1
166	286	F76	Type Of Fault 10		
167	287	F52	Distance To Fault 10		
168	288	F53	Line Z1 To Fault 10 (Magnitude)		
169	289	F49	Reserved for MOD 008	Class 1	
170	290	F49	Neutral Displacement	Class 1	
171	291	F49	Ground Directional is Reverse	Class 1	
172	292	F49	Reserved For MOD 010	Class 1	
173	293	F49	User Input I	Class 1	
174	294	F49	User Input J	Class 1	
175	295	F49	User Input K	Class 1	
176	296	F49	User Input L	Class 1	
177	297	F49	User Input M	Class 1	
178	298	F49	User Input N	Class 1	
179	299	F49	User Input O	Class 1	
180	300	F49	User Input P	Class 1	
181	301	F49	User Input Q	Class 1	
182	302	F49	User Input R	Class 1	
183	303	F49	User Input S	Class 1	
184	304	F49	User Input T	Class 1	
185	305	F49	Autoreclose Rate Supervision	Class 1	
186	306	F49	Restricted Earth Fault	Class 1	
187	307	F1	Auto Ranging Power / Energy Multiplier	Class 2	
188	308	F3	Neutral Voltage	Class 2	Note 3
189	309	F3	Last Trip Neutral Voltage	Class 1	

NOTES:

1. To support existing SCADA hardware that is not capable of 32-bit data reads, the upper and lower 16-bit portions of all time and date values have been assigned to separate points. To read a date or time, it is necessary to read both the upper and lower 16-bit portions, concatenate these two values to form a 32-bit value and interpret the result in the format associated with the point (i.e., F22 for time, F23 for date).
2. Points which have an assigned event class will generate an event object as a result of any change in the point's value unless otherwise noted.
3. An event object will be generated if the point's value changes by a minimum of 2% of its previous value.
4. An event object will be generated if the system frequency changes by 0.04Hz or more.
5. There are two defined maps for Analog Output points. The map that is used is specified by the setting of the "DNP Point Mapping" setpoint at Modbus address 10DB (hex). This setpoint may be set to a value of "Disabled" or "Enabled". When "Disabled", only the preassigned Analog Output points are available beginning at point index 0.

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When “Enabled”, the User Map Values are assigned to points 0 through 119 with the preassigned Analog Outputs following beginning with point index 120. The value read from points 0 through 119 will depend upon the value programmed into the corresponding User Map Address setpoint (note that programming of these setpoints can only be accomplished via Modbus). Refer to Section 16.3.15: ACCESSING DATA VIA THE USER MAP on page 16–16 for more information.

Please note that changes in User Map Values never generate event objects.

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17.1.1 DESCRIPTION

The following procedures can be used to verify the proper operation of the 750 and/or 760 Feeder Management Relay®. Although not a total functional verification, the tests in this chapter check the major operating points. Before commissioning the relay, users should read Chapter 3: INSTALLATION which provides important information about wiring, mounting, and safety concerns. One should also become familiar with the relay as described in Chapters 2: GETTING STARTED and 7: SETPOINTS.

17.1.2 REQUIREMENTS

The test procedures outlined in this section are for field verification that the relay is operational and programmed as required for the application.

It is not necessary to field test every characteristic of every relay feature. The various features are implemented in software, which is thoroughly tested at the factory. Our recommendation is to field test all of the input, display, and output hardware, and features which are to be operational in the specific application.

The setpoints which must be addressed for the measurement of every parameter and the operation of every feature are shown on the logic diagrams. All settings must be set to the application requirement by the user before beginning the tests. **To facilitate testing it is recommended that all functions be initially set to Disabled. Every feature which will be used in the application should be set to the required function for the test, then returned to Disabled at completion. Each feature can then be testing without complications caused by operations of other features. At the completion of all tests each feature is then set as required.**

The procedures for testing of common operations will not be repeated in every test. The common features, and the test procedure location are as follows:

Thermal Exponential Demand Characteristic	Measurement of Current Demand
Block Interval Demand Characteristic	Measurement of Current Demand
Rolling Interval Demand Characteristic	Measurement of Current Demand
Feature Function as 'Trip'	Phase Time Overcurrent 1
Feature Function as 'Alarm'	Phase Time Overcurrent 1
Feature Function as 'Control'	Phase Time Overcurrent 1
Fixed Delay Timing	Phase Time Overcurrent 1
Front Panel RESET Key Resetting	Phase Time Overcurrent 1
Logic Input Resetting	Phase Time Overcurrent 1
Feature Blocking from Logic Inputs	Phase Time Overcurrent 1
Element Operation of Output Relays	Phase Time Overcurrent 1
Number Of Faulted Phases	Phase Instantaneous Overcurrent 1
Feature Function as 'Trip + AR'	Autoreclose (760 Only)

We also recommend that the procedures outlined in Section 17.10: PLACING THE RELAY IN SERVICE on page 17–74 be performed for all installations to verify proper operation and function of the equipment.

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17.2.1 SAFETY PRECAUTIONS

CAUTION **HAZARD may result if the product is not used for its intended purposes**

CAUTION **DANGEROUSLY HIGH VOLTAGES ARE PRESENT ON THE REAR TERMINALS OF THE RELAY, CAPABLE OF CAUSING DEATH OR SERIOUS INJURY. USE EXTREME CAUTION AND FOLLOW ALL SAFETY RULES WHEN HANDLING, TESTING, OR ADJUSTING THE EQUIPMENT.**

CAUTION **DO NOT OPEN THE SECONDARY CIRCUIT OF A LIVE CT, SINCE THE HIGH VOLTAGE PRODUCED IS CAPABLE OF CAUSING DEATH OR SERIOUS INJURY, OR DAMAGE TO THE CT INSULATION.**

CAUTION **THE RELAY USES COMPONENTS WHICH ARE SENSITIVE TO ELECTROSTATIC DISCHARGES. WHEN HANDLING THE UNIT, CARE SHOULD BE TAKEN TO AVOID CONTACT WITH TERMINALS AT THE REAR OF THE RELAY.**

CAUTION **ENSURE THAT THE CONTROL POWER APPLIED TO THE RELAY, AND THE AC CURRENT AND VOLTAGE INPUTS, MATCH THE RATINGS SPECIFIED ON THE RELAY NAMEPLATE. DO NOT APPLY CURRENT TO THE CT INPUTS IN EXCESS OF THE TIME × CURRENT SPECIFIED LIMITS.**

CAUTION **ENSURE THAT THE LOGIC INPUT WET CONTACTS ARE CONNECTED TO VOLTAGES BELOW THE MAXIMUM VOLTAGE SPECIFICATION OF 300 VDC.**

17.2.2 CONVENTIONS

The following conventions are used for the remainder of this chapter:

- It is assumed the relay VT and CT inputs are wired in accordance with Figure 3–9: TYPICAL WIRING DIAGRAM on page 3–7. With these connections, and assumed where ever phase angles are noted, a unity power factor current in the primary circuit flows into the relay current marked terminal, with no phase shift with respect to the corresponding phase-neutral voltage.
- Phase rotation of the relay test set is ABC.
- A current which lags a voltage has a positive phase angle.
- Phase A to neutral voltage is indicated by V_{an} (arrowhead on the “a“).
- Phase A to B voltage is indicated by V_{ab} (arrowhead on the “a“).
- The sign convention for power parameters is as shown in Section 6.3.6: POWER on page 6–11.
- The actual value display at the beginning of some sections is the display for the measured parameter. All actual values are mentioned with their “path” as a means of specifying where to find the particular message. For instance, the analog input, which in the message structure is located under actual values page **A2 METERING** as the first message under subheading **ANALOG INPUT**, would be written as: **A2 METERING \ ANALOG INPUT \ ANALOG INPUT.**

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17.2.3 TEST EQUIPMENT REQUIRED

Excluding the tests which check the data acquisition of AC system currents and voltages, tests may be performed using the powerful simulation feature of the relay, without the need of external AC voltage and current inputs. System parameters, such as current and voltage phasor information, are entered as setpoints. When placed in simulation mode, the relay suspends reading actual AC inputs, and uses the programmed phasors to generate sample values which are placed in the Trace Memory. All metering calculations and logic associated with protection, monitoring, and control, are performed normally, using phasors calculated from the samples placed in the memory instead of phasors generated from the input parameter data acquisition system. The advantage of using simulation is that all metering calculations can be proven without the inaccuracies associated with current and voltage sources.

Assuming that the simulation feature is not used, the following equipment is necessary to perform any test included in this chapter:

General Purpose:

- 3ϕ variable AC current and voltage source (V, A, ϕ, Hz)
- 3ϕ power multimeter (V, A, ϕ, Hz, W, var, VA, Wh, varh, PF)
- variable DC mA source
- accurate timing device
- multimeters

Specific Purpose:

- Synchrocheck requires two single phase variable voltage sources with adjustable frequency and phase.
- Underfrequency requires a dynamic relay test set with at least two preset modes.
- Distance-to-fault: requires a dynamic relay test set with at least three preset modes.
- Analog Input Rate-of-Change requires a DC current generator with the capacity to generate current ramps adjustable for duration's from 1 minute to 2 hours, from 0-20 mA.

Optional:

- PC running the 750/760 PC program.

17.2.4 INSTALLATION CHECKS

1. Check that the relay phase current inputs, specified on the nameplate, are correct for the connected current transformers.
2. Check that the relay ground current input, specified on the nameplate, is correct for the connected current transformer (if applicable).
3. Check that the relay auxiliary voltage, specified on the nameplate, is correct for the supplied voltage.
4. Check that the installed relay agrees with the drawings, particularly the Analog Output range.
5. Check that the external wiring is correct.
6. Check that all grounding terminals of the relay are properly connected to the ground bus.

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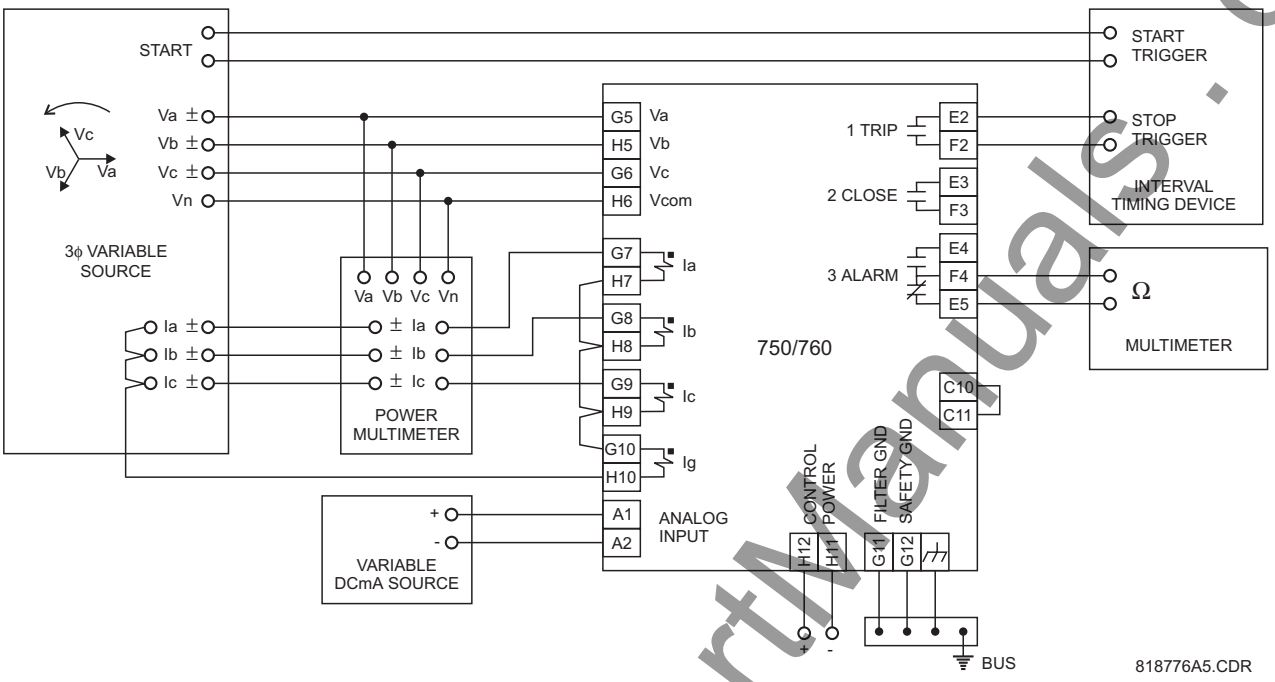


Figure 17–1: RELAY TEST WIRING – WYE CONNECTION

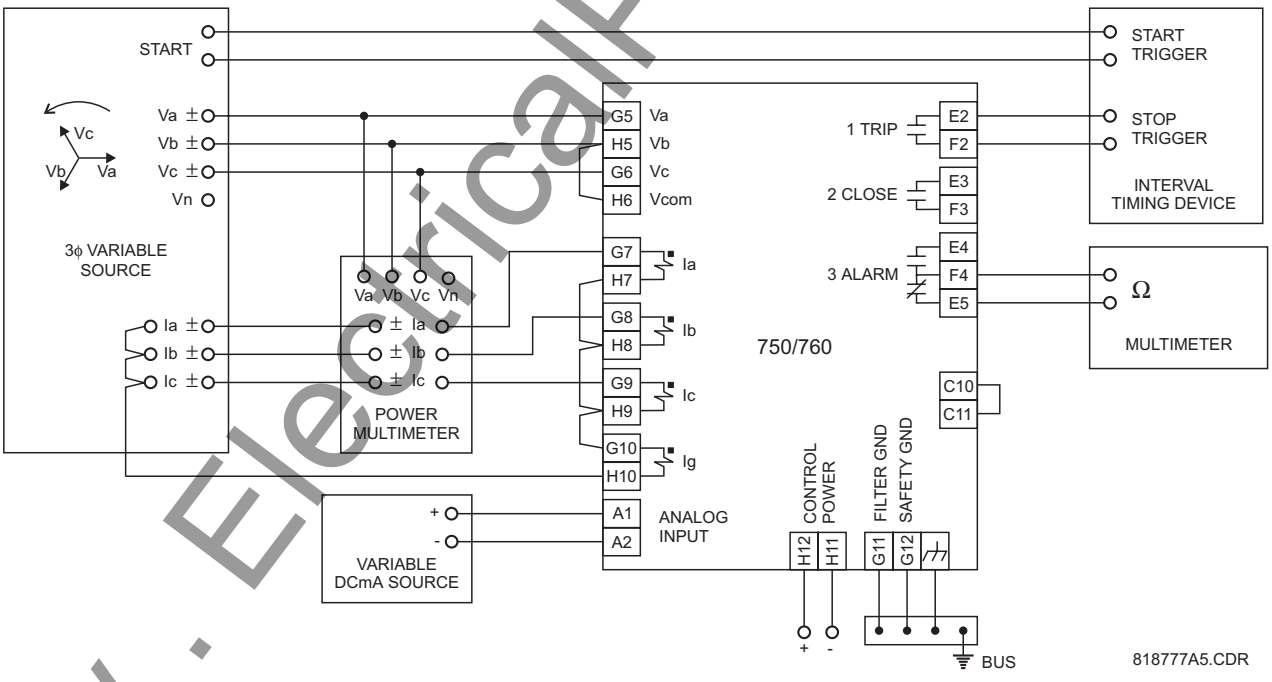


Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION

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Actual Values Display:

For these first tests, setpoints **INPUT 1 (2-14) ASSERTED LOGIC** should be programmed as *Closed* / V_{on}.

Under subheading **A1 STATUS \ VIRTUAL INPUTS \ LOGIC INPUT 1 (2-14)**

1. Turn on this input and check that the display shows this state.
2. Turn off this input and check that the display shows this state.

Under subheading **A1 STATUS \ HARDWARE INPUTS \ CONTACT 1 (2-14) STATE**

1. Close the contact connected to this input and check that the display shows this state.
2. Open the contact connected to this input and check that the display shows this state.

a) PROCEDURE

1. Set all inputs 1 through 14, both contact and virtual, to the de-asserted state.
2. Enter (example) settings under subheading **S3 LOGIC INPUTS \ USER INPUT A **

USER INPUT A NAME:	*User Input A*
USER INPUT A SOURCE:	*Input 1*
USER INPUT A FUNCTION:	*Alarm*
USER INPUT A RELAYS (3-7):	*3----*
USER INPUT A DELAY:	*0.00 s*

b) USER INPUT A FUNCTION SETPOINT SET TO ALARM

For INPUT ASSERTED LOGIC setpoints set to *Contact Close*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint **USER INPUT A SOURCE** to the closed state. Note that the corresponding virtual input will have no affect.
5. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
6. Set the monitored contact for the logic input programmed in setpoint **USER INPUT A SOURCE** to the open state. Again note that the corresponding virtual input will have no affect.
7. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Contact Close* input.

For INPUT ASSERTED LOGIC setpoints set to *Contact Open*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the open state. Note that the corresponding virtual input will have no affect.
5. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.

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6. Set the monitored contact for the logic input programmed in setpoint **USER INPUT A SOURCE** to the closed state. Again note that the corresponding virtual input will have no affect.
7. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Contact Open* input.

For INPUT ASSERTED LOGIC setpoints set to *Virtual On*

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored virtual input for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the on state. Note that the corresponding contact input will have no affect.
5. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
6. Set the virtual input for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the off state. Again note that the corresponding contact input will have no affect.
7. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Virtual On* input.

For INPUT ASSERTED LOGIC setpoints set to *Virtual Off*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored virtual input for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the off state. Note that the corresponding contact input will have no affect.
5. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
6. Set the virtual input for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the on state. Again note that the corresponding contact input will have no affect.
7. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Virtual Off* input.

For INPUT ASSERTED LOGIC setpoints set to *Closed & V_{on}*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the open state and the virtual input to the off state. Check that no diagnostic message is on the display with the 3 auxiliary LED and relay deactivated.
5. Set the monitored contact to the closed state with the virtual input remaining in the off state. Check that no diagnostic message is on the display with the 3 auxiliary LED and relay deactivated.
6. Leave the monitored contact in the closed state and put the virtual input in the on state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.

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7. Set the monitored contact to the open state and the virtual input to the off state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Closed & V_{on}* input.

For INPUT ASSERTED LOGIC setpoints set to *Closed & V_{off}*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the open state and the virtual input to the on state. Check that no diagnostic message is on the display with the 3 auxiliary LED and relay deactivated.
5. Set the monitored contact to the closed state with the virtual input remaining in the on state. Check that no diagnostic message is on the display with the 3 auxiliary LED and relay deactivated.
6. Leave the monitored contact in the closed state and put the virtual input in the off state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
7. Set the monitored contact to the open state and the virtual input to the on state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Closed & Voff* input.

For INPUT ASSERTED LOGIC setpoints set to *Open & V_{on}*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the closed state and the virtual input to the off state. Check that no diagnostic message is on the display with the 3 auxiliary LED and relay deactivated.
5. Set the monitored contact to the open state with the virtual input remaining in the off state. Check that no diagnostic message is on the display with the 3 auxiliary LED and relay deactivated.
6. Leave the monitored contact in the open state and put the virtual input in the on state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
7. Set the monitored contact to the closed state and the virtual input to the off state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Open & V_{on}* input.

For INPUT ASSERTED LOGIC setpoints set to *Open & V_{off}*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the closed state and the virtual input to the on state. Check that no diagnostic message is on the display with the 3 auxiliary LED and relay deactivated.
5. Set the monitored contact to the open state with the virtual input remaining in the on state. Check that no diagnostic message is on the display with the 3 auxiliary LED and relay deactivated.
6. Leave the monitored contact in the open state and put the virtual input in the off state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.

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7. Set the monitored contact to the closed state and the virtual input to the on state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Open & V_{off}* input.

For INPUT ASSERTED LOGIC setpoints set to *Closed* / V_{on}:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the closed state and the virtual input to the off state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
5. Leave the monitored contact in the closed state and put the virtual input in the on state. Check that the diagnostic message, the 3 auxiliary LED and relay remain activated.
6. Set the monitored contact to the open state and leave the virtual input in the on state. Check that the diagnostic message, the 3 auxiliary LED and relay remain activated.
7. Leave the monitored contact in the open state and put the virtual input in the off state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Closed* / V_{on} input.

For INPUT ASSERTED LOGIC setpoints set to *Closed* / V_{off}:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the closed state and the virtual input to the on state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
5. Leave the monitored contact in the closed state and put the virtual input in the off state. Check that the diagnostic message, the 3 auxiliary LED and relay remain activated.
6. Set the monitored contact to the open state and leave the virtual input in the off state. Check that the diagnostic message, the 3 auxiliary LED and relay remain activated.
7. Leave the monitored contact in the open state and put the virtual input in the on state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Closed* / V_{off} input.

For INPUT ASSERTED LOGIC setpoints set to *Open* / V_{on}:

3. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the open state and the virtual input to the off state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
4. Leave the monitored contact in the open state and put the virtual input in the on state. Check that the diagnostic message, the 3 auxiliary LED and relay remain activated.
5. Set the monitored contact to the closed state and leave the virtual input in the on state. Check that the diagnostic message, the 3 auxiliary LED and relay remain activated.
6. Leave the monitored contact in the closed state and put the virtual input in the off state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
7. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Open* / V_{on} input.

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For INPUT ASSERTED LOGIC setpoints set to *Open / V_{off}*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the open state and the virtual input to the on state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
5. Leave the monitored contact in the open state and put the virtual input in the off state. Check that the diagnostic message, the 3 auxiliary LED and relay remain activated.
6. Set the monitored contact to the closed state and leave the virtual input in the off state. Check that the diagnostic message, the 3 auxiliary LED and relay remain activated.
7. Leave the monitored contact in the closed state and put the virtual input in the on state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Open/ V_{off}* input.

For INPUT ASSERTED LOGIC setpoints set to *Closed X V_{on}*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the closed state and the virtual input to the off state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
5. Leave the monitored contact in the closed state and put the virtual input in the on state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
6. Set the monitored contact to the open state and leave the virtual input in the on state. Check that the diagnostic message appears on the display with the 3 auxiliary LED and relay activated.
7. Leave the monitored contact in the open state and put the virtual input in the off state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Closed X V_{on}* input.

For INPUT ASSERTED LOGIC setpoints set to *Closed X V_{off}*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the closed state and the virtual input to the on state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
5. Leave the monitored contact in the closed state and put the virtual input in the off state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
6. Set the monitored contact to the open state and leave the virtual input in the off state. Check that the diagnostic message appears on the display with the 3 auxiliary LED and relay activated.
7. Leave the monitored contact in the open state and put the virtual input in the on state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Closed X V_{off}* input.

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For INPUT ASSERTED LOGIC setpoints set to *Open X V_{on}*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the open state and the virtual input to the off state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
5. Leave the monitored contact in the open state and put the virtual input in the on state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
6. Set the monitored contact to the closed state and leave the virtual input in the on state. Check that the diagnostic message appears on the display with the 3 auxiliary LED and relay activated.
7. Leave the monitored contact in the closed state and put the virtual input in the off state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Open X V_{on}* input.

For INPUT ASSERTED LOGIC setpoints set to *Open X V_{off}*:

3. Check that there is no logic input diagnostic message on the display.
4. Set the monitored contact for the logic input programmed in setpoint message **USER INPUT A SOURCE** to the open state and the virtual input to the on state. Check that the diagnostic message, either *User Input A* or the name programmed in setpoint **USER INPUT A NAME**, appears on the display with the 3 auxiliary LED and relay activated. Check in the Event Recorder that the selected function has been invoked.
5. Leave the monitored contact in the open state and put the virtual input in the off state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
6. Set the monitored contact to the closed state and leave the virtual input in the off state. Check that the diagnostic message appears on the display with the 3 auxiliary LED and relay activated.
7. Leave the monitored contact in the closed state and put the virtual input in the on state. Check that the diagnostic message is removed from the display with the 3 auxiliary LED and relay deactivated.
8. Repeat steps 3 through 7 for all functions programmed to be asserted by a *Open X V_{off}* input.

c) USER INPUT A FUNCTION SETPOINT SET TO CONTROL

The procedure to test this element is identical to that outlined for **USER INPUT A FUNCTION** setpoint set to *Alarm*, with the following exceptions: there will not be any diagnostic message or Alarm LED.

d) USER INPUT A FUNCTION SETPOINT SET TO TRIP

The procedure to test this element is identical to that outlined for **USER INPUT A FUNCTION** setpoint set to *Alarm*, with the following exceptions: The 1 TRIP relay and LED will activate along with the 3 auxiliary relay and LED. At the end of each test, a reset must be performed in order to clear the trip diagnostic message and TRIP status LED.

17.4.2 VIRTUAL INPUTS 15-20

Follow the Virtual On and Virtual Off Input Asserted Logic procedures outlined for **LOGIC/VIRTUAL INPUTS 1-14**.

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17.5.1 INDICATORS

Front panel OUTPUT STATUS indicators.

17.5.2 PROCEDURE

1. Enter settings under subheading **S8 TESTING \ OUTPUT RELAYS **

FORCE OUTPUT RELAYS FUNCTION:	*Enabled*
FORCE 1 TRIP RELAY:	*De-energized*
FORCE 2 CLOSE RELAY:	*De-energized*
FORCE 3 AUXILIARY RELAY:	*De-energized*
FORCE 4 AUXILIARY RELAY:	*De-energized*
FORCE 5 AUXILIARY RELAY:	*De-energized*
FORCE 6 AUXILIARY RELAY:	*De-energized*
FORCE 7 AUXILIARY RELAY:	*De-energized*
FORCE 8 SELF-TEST RELAY:	*De-energized*
FORCE SOLID STATE OUTPUT:	*De-energized*

2. Using a multimeter, check that all output relays are de-energized (i.e. N.O. contacts are open, N.C. contacts are closed).
3. Change setting to: **S8 TESTING \ OUTPUT RELAYS \ FORCE 1 TRIP RELAY**: *Energized*
4. Check that the 1 TRIP output is energized (i.e. N.O. contacts are closed), and the 1 TRIP indicator on the faceplate is illuminated.
5. Change setting to: **S8 TESTING \ OUTPUT RELAYS \ FORCE 1 TRIP RELAY**: *De-Energized*
6. Repeat steps 3 through 5 for output relays 2 through 8 inclusive.
7. Observing polarity, connect a DC source of a minimum of 5 volt, in series with a limiting resistor that will permit a minimum current of 100 mA, in series with the Solid State output. Observing polarity, connect a DC voltmeter across the limiting resistor. Check there is no voltage displayed on the voltmeter.
8. Change setting to: **S8 TESTING \ OUTPUT RELAYS \ FORCE SOLID STATE OUTPUT**: *Energized*
9. Check that a voltage has appeared on the voltmeter. Turn off the source and disconnect the test wiring.
10. Change setting to: **S8 TESTING \ OUTPUT RELAYS \ FORCE SOLID STATE OUTPUT**: *De-Energized*
11. Change setting to: **S8 TESTING \ OUTPUT RELAYS \ FORCE OUTPUT RELAYS FUNCTION**: *Disabled*

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17.6.1 MEASUREMENT OF INPUT CURRENT

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy: 1 A CTs: ± 0.01 A for 0.01 to 1.99 A
± 0.2 A for 2.00 to 20.00 A
5 A CTs: ± 0.05 A for 0.05 to 9.99 A
±1.0 A for 10.00 to 100.00 A

a) PHASE AND NEUTRAL CURRENT INPUTS

Actual Values Displays:

Under subheading **A2 METERING \ CURRENT **

A: B: C: (Magnitude)
AVERAGE CURRENT (Magnitude)
PHASE A CURRENT (Phasor)
PHASE B CURRENT (Phasor)
PHASE C CURRENT (Phasor)
NEUTRAL CURRENT (Phasor)
POS SEQ CURRENT (Phasor)
NEG SEQ CURRENT (Phasor)
ZERO SEQ CURRENT (Phasor)

Procedure:

1. Inject 1-phase current of various values into the relay phase current input one phase at a time, and observe the magnitude. Note that the average, positive sequence, negative sequence and zero sequence magnitudes are 1/3 of the phase current magnitude for this test. The neutral current will match the phase current magnitude.
2. Inject 3-phase current of various values and angles into the relay phase current input and note the measured current phasors and symmetrical components.

b) GROUND AND SENSITIVE GROUND CURRENT INPUT

Actual Values Displays:

Under subheading **A2 METERING \ CURRENT **

GROUND CURRENT (Phasor)
SENSTV GND CURRENT (Phasor)

Procedure:

1. Inject current of various values into the relay ground input, terminals G10-H10, and note the current.
2. Inject current of various values into the relay sensitive ground input, terminals G3-H3, and note the current.

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Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

a) BUS VOLTAGE

Expected Accuracy:

Phase-neutral voltages ± 0.68 V for 50 to 130 V
± 2.18 V for other voltages within specified limits

Phase-phase voltages ± 0.68 V for 50 to 130 V (V_{ab} and V_{cb})
± 1.36 V for 50 to 130 V (calculated V_{ac})
± 2.18 V for all other voltages within the specified limits (V_{ab} and V_{cb})
± 4.36 V for all other voltages within the specified limits (calculated V_{ac})

Actual Values Displays:

Under subheading **A2 METERING \ VOLTAGE **

AB: BC: CA: (Magnitude)
AVERAGE LINE VOLTAGE (Magnitude)
AN: BN: CN: (Magnitude) *(not available when connected Delta)*
AVERAGE PHASE VOLTAGE: (Magnitude) *(not available when connected Delta)*
LINE A-B VOLTAGE (Phasor)
LINE B-C VOLTAGE (Phasor)
LINE C-A VOLTAGE (Phasor)
PHASE A-N VOLTAGE (Phasor) *(not available when connected Delta)*
PHASE B-N VOLTAGE (Phasor) *(not available when connected Delta)*
PHASE C-N VOLTAGE (Phasor) *(not available when connected Delta)*
POS SEQ VOLTAGE (Phasor)
NEG SEQ VOLTAGE (Phasor)
ZERO SEQ VOLTAGE (Phasor)
NEUTRAL (3VO) VOLTAGE (Phasor)

Procedure:

1. Inject 1-phase voltage of various values into the relay bus voltage input one phase at a time, and observe the magnitude. Note that for Wye VTs the positive sequence, negative sequence and zero sequence magnitudes are 1/3 of the phase voltage magnitude for this test. For Delta VTs the zero sequence voltage will be displayed as 0. The positive sequence and negative sequence magnitudes will be √3 of the line voltage magnitude.
2. Inject 3-phase voltage of various values and angles into the relay bus voltage input and note the measured voltage phasors & symmetrical components. For Delta VTs the zero sequence voltage will be shown as 0.

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b) BUS VOLTAGE FREQUENCY

Expected Accuracy:

Frequency: ± 0.02 Hz of injected value within the range 16.00 to 90.00 Hz
Undervoltage Inhibit: 10 V secondary

Actual Values Displays:

Under subheading **A2 METERING \ FREQUENCY **

SYSTEM FREQUENCY

Procedure:

1. Inject a voltage of nominal value at nominal frequency into phase A. Check that the frequency is measured and displayed.
2. Check the undervoltage inhibit level by slowly reducing the voltage until the frequency is no longer measured, and "0.00 Hz" is displayed.
3. Return the voltage to nominal. Adjust the frequency above and below nominal, and note the frequency measured by the relay.

Actual Values Displays:

Under subheading **A2 METERING \ FREQUENCY **

FREQUENCY DECAY RATE

Procedure:

Vary the frequency of the phase A voltage and verify the measured **FREQUENCY DECAY RATE**.

c) SYNCHRO VOLTAGE AND SYNCHRO FREQUENCY

Expected Accuracy: Voltage: ± 0.68 V for 50 to 130 V
Frequency: ± 0.02 Hz of injected value within the range 16.00 to 90.00 Hz

Actual Values Displays:

Under subheading **A2 METERING \ SYNCHRO VOLTAGE **

SYNCHRO VOLTAGE (Phasor)
SYNCHRO FREQUENCY
SYNCHRO DELTA ΔF: ΔV: ΔF:

Procedure:

Inject voltage of various magnitudes and frequencies into the line voltage input and verify the displays.

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17.6.3 MEASUREMENT OF REAL POWER & WATTHOURS

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy:

Real Power:	± 1% of full scale	currents 5% to 199% of nominal	voltages 50 to 130 V
Watthours:	± 2% of full scale	currents 5% to 199% of nominal	voltages 50 to 130 V

Actual Values Displays:

Under subheading **A2 METERING \ POWER **

3Φ REAL POWER
ΦA REAL POWER *(not available when connected Delta)*
ΦB REAL POWER *(not available when connected Delta)*
ΦC REAL POWER *(not available when connected Delta)*

Under subheading **A2 METERING \ ENERGY**

POSITIVE WATTHOURS
NEGATIVE WATTHOURS

Procedure:

1. To reduce the time required for watthour measurements, set the input VT and CT ratios to high values. Inject 3-phase voltage and current of various values and angles into the relay. Note that real power is measured and displayed.
2. Maintain voltage and current at various settings for a time sufficient to achieve a minimum of 20 MWh for each test interval. Check that watthours is measured and displayed. Note that watthours for load in the positive direction and in the negative direction are stored in separate registers. The test procedure should be performed for loads in each direction.

17.6.4 MEASUREMENT OF REACTIVE POWER & VARHOURS

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy:

Reactive Power:	± 1% of full scale	currents 5% to 199% of nominal	voltages 50 to 130 V
Varhours:	± 2% of full scale	currents 5% to 199% of nominal	voltages 50 to 130 V

Actual Values Displays:

Under subheading **A2 METERING \ POWER **

3Φ REACTIVE POWER
ΦA REACTIVE POWER *(not available when connected Delta)*
ΦB REACTIVE POWER *(not available when connected Delta)*
ΦC REACTIVE POWER *(not available when connected Delta)*

Under subheading **A2 METERING \ ENERGY **

POSITIVE VARHOURS
NEGATIVE VARHOURS

Procedure:

Follow the procedure outlined in the previous section above.

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17.6.5 MEASUREMENT OF APPARENT POWER

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy: ± 1% of full scale currents 5% to 199% of nominal voltages 50 to 130 V

Actual Values Displays:

Under subheading **A2 METERING \ POWER **

3Φ APPARENT POWER
ΦA APPARENT POWER *(not available when connected Delta)*
ΦB APPARENT POWER *(not available when connected Delta)*
ΦC APPARENT POWER *(not available when connected Delta)*

Procedure:

Follow the procedure outlined in Section 17.6.3: MEASUREMENT OF REAL POWER & WATTHOURS on page 17–15.

17.6.6 MEASUREMENT OF POWER FACTOR

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy: ± 0.02 of injected value currents 5% to 199% of nominal voltages 50 to 130 V

Actual Values Displays:

Under subheading **A2 METERING \ POWER **

3Φ POWER FACTOR
ΦA POWER FACTOR *(not available when connected Delta)*
ΦB POWER FACTOR *(not available when connected Delta)*
ΦC POWER FACTOR *(not available when connected Delta)*

Procedure:

Inject phase voltage and phase current of various values and angles into the relay. Check that power factor is measured and displayed correctly for each phase. Note the 3-phase power factor = total 3ϕ real power / total 3ϕ apparent power.

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Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy: ± 2.0% of full scale

To reset the "Last Demand" reading to 0 between tests, cycle the relay power source off/on.

Block Interval and Rolling demand measurement types must be tested in synchronization with the internal clock. Both of these measurements start with the first interval of the day at 12:00:00.000 midnight. To synchronize, preset the injection levels, then turn the current off. Select the relay display (not the 750/760PC program) to **A1 STATUS \ CLOCK \ CURRENT TIME**. Apply the test current when the clock is at the beginning of an interval measurement period, as determined by the **TIME INTERVAL** setpoint for the element.

Actual Values Displays:

Under subheading **A2 METERING \ DEMAND \ PHASE A CURRENT **

LAST PHASE A CURRENT DEMAND
MAX PHASE A CURRENT DEMAND (DATE, TIME)

Under subheading **A2 METERING \ DEMAND \ PHASE B CURRENT **

LAST PHASE B CURRENT DEMAND
MAX PHASE B CURRENT DEMAND (DATE, TIME)

Under subheading **A2 METERING \ DEMAND \ PHASE C CURRENT **

LAST PHASE C CURRENT DEMAND
MAX PHASE C CURRENT DEMAND (DATE, TIME)

Procedure:

Thermal Exponential Demand: (Example for a response time setting of 5 minutes.)

1. Clear demand data registers by entering *Yes* at **S1 RELAY SETUP \ CLEAR DATA \ CLEAR MAX DEMAND DATA?**
2. Inject a fixed value of current into phase A. Record the measured current demand at 1, 2, 3, 4, 5 and 10 min. after the application of current. The demand, in percent of injected current, should be as follows:

Time (min.)	1	2	3	4	6	10
Demand (% of Input)	36.9	60.1	74.8	84.1	90.0	99.0

3. For other response time settings, multiply the row 1 times above by [selected response time ÷ 5].
4. Check that the maximum current demand, including date & time of occurrence, is recorded and displayed.
5. Repeat steps 2 to 4 for phases B and C.

Block Interval Demand: (Example for a time interval setting of 5 minutes.)

Repeat steps 2 to 5 from Thermal Exponential Demand. Record the measured current demand at 1, 2, 3, 4, 5 and 6 min. after the application of current. The demand, in percent of injected current, should be as follows:

Time (min.)	1	2	3	4	5	6
Demand (% of Input)	0.0	0.0	0.0	0.0	100.0	100.0

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Rolling Demand: (Example for a time interval setting of 5 minutes.)

Repeat steps 2 to 5 from Thermal Exponential Demand. Record the measured current demand at 1, 2, 3, 4, 5 and 6 min. after the application of current. The demand, in percent of injected current, should be as follows:

Time (min.)	1	2	3	4	5	6
Demand (% of Input)	20.0	40.0	60.0	80.0	100.0	100.0

17.6.8 MEASUREMENT OF REAL POWER DEMAND

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy: ± 2.0% of full scale

Actual Values Displays:

Under subheading **A2 METERING \ DEMAND \ REAL POWER **

LAST REAL POWER DEMAND
MAX REAL POWER DEMAND (DATE, TIME)

Procedure:

Follow the procedure in Section 17.6.7: MEASUREMENT OF CURRENT DEMAND on page 17–17, except that the injected and monitored parameter is watts.

17.6.9 MEASUREMENT OF REACTIVE POWER DEMAND

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy: ± 2.0% of full scale

Actual Values Displays:

Under subheading **A2 METERING \ DEMAND \ REACTIVE POWER **

LAST REACTIVE POWER DEMAND
MAX REACTIVE POWER DEMAND (DATE, TIME)

Procedure:

Follow the procedure in Section 17.6.7: MEASUREMENT OF CURRENT DEMAND on page 17–17, except that the injected and monitored parameter is vars.

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17.6.10 MEASUREMENT OF APPARENT POWER DEMAND

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy: ± 2.0% of full scale

Actual Values Displays:

Under subheading **A2 METERING \ DEMAND \ APPARENT POWER **

LAST APPARENT POWER DEMAND
MAX APPARENT POWER DEMAND (DATE, TIME)

Procedure:

Follow the procedure in Section 17.6.7: MEASUREMENT OF CURRENT DEMAND on page 17–17, except that the injected and monitored parameter is VA.

17.6.11 CALCULATION OF PERCENT OF LOAD-TO-TRIP

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy: equivalent to that of phase current inputs

Actual Values Displays:

Under subheading **A2 METERING \ CURRENT **

% OF LOAD-TO-TRIP

Note:

Percent of load-to-trip is calculated from the phase with the highest current reading. It is the ratio of this current to the lowest pickup setting among the phase time and instantaneous overcurrent protection features. If all of these features are disabled, the value displayed will be 0.

Procedure:

Inject current of various values into phase A. Check that percent load-to-trip is calculated as the correct percentage of the most sensitive operational phase O/C element and displayed. Repeat for phases B and C.

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17.6.12 MEASUREMENT OF ANALOG INPUT

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Expected Accuracy: ± 1.0% of full scale

Actual Values Displays:

Under subheading **A2 METERING \ ANALOG INPUT **

ANALOG INPUT

Procedure:

Inject steady values of DC current (in mA) of various values into relay terminals A1(+) and A2(-). Check that the analog input is correctly measured and displayed.

Actual Values Displays:

Under subheading **A2 METERING \ ANALOG INPUT **

ANALOG INPUT /MIN.

Procedure:

Inject a fixed rate of ramping DC current (in mA) of various values into relay terminals A1(+) and A2(-) for at least 2 minutes. At the end of this time check that the analog input is correctly measured and displayed.

Actual Values Displays:

Under subheading **A2 METERING \ ANALOG INPUT **

ANALOG INPUT /HOUR

Procedure:

Inject a fixed rate of ramping DC current (in mA) of various values into relay terminals A1(+) and A2(-) for at least 2 hours. At the end of this time check that the analog input is correctly measured and displayed.

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17.7.1 DESCRIPTION

The Active setpoint group is indicated by a continuously illuminated LED, and the Edit group by an intermittently illuminated LED on the relay faceplate. When changing settings for testing be careful to check the correct group is adjusted and selected as the active group.

17.7.2 SETPOINT GROUPS

Verify that settings in a particular setpoint group are being used by the protection elements when the particular group is selected to be active. There are three alternative strategies that can be used to provide this verification:

1. Test any one protection element that has different settings in different groups
2. Test a random selection of protection elements in different groups
3. Test all protection elements that are not disabled in every group

Once one of the above strategies is selected, the following procedures are used to test protection elements.

17.7.3 PHASE TIME OVERCURRENT 1

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Notes:

The following tests, other than Linear Reset Timing, are based on using the “Instantaneous” reset time characteristic. If the “Linear” reset time characteristic is required, either ensure that there is sufficient time between test current injections, or cycle relay power off/on to discharge the energy measurement accumulator to 0.

a) PROCEDURE TO CHECK

Pickup with One Phase For Operation:

1. Inject current at a level below the pickup level into phase A.
2. Slowly increase the current until the PICKUP indicator comes on. Note the pickup value.
3. Slowly reduce the current until the PICKUP indicator goes out. Note the dropout level, which should be 2% of CT less than pickup when pickup ≤ CT or 97 to 98% of pickup when pickup > CT.
4. Repeat steps 1 through 3 for phases B and C.

Indications and Operations caused by a Trip Function, with front panel RESET Key Resetting:

1. Inject current to cause a pickup and wait until the element times to Trip.
2. Check that the TRIP and MESSAGE indicators are flashing, the Last Trip message is displayed, and output relay 1 TRIP and any others programmed to operate (as well as their associated LED indicators) operate.
3. Slowly reduce the current until the PICKUP indicator goes out. Check that the TRIP and MESSAGE indicators are flashing, and that output relay 1 TRIP and any others programmed to operate (as well as their associated LED indicators) reset.
4. Press the front panel RESET key. Check that the TRIP and MESSAGE indicators go off, and the Last Trip message is no longer displayed. Turn current off.

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Indications and Operations caused by a Trip Function, with Logic Input Resetting:

1. Ensure that the reset logic input control function has been assigned to a logic input.
2. Perform steps 1 through 3 above.
3. Assert a logic input to provide a reset. Check that the TRIP and MESSAGE indicators are now off, and the Last Trip message is no longer displayed. Turn current off.

Indications and Operations caused by an Alarm Function:

1. Inject current to cause a pickup and wait until the element times to Alarm. Check that the ALARM and MESSAGE indicators are flashing, the Active Alarm message is displayed, and any output relays programmed to operate (as well as their associated LED indicators) operate.
2. Slowly reduce the current until the PICKUP indicator goes out. Check that the ALARM and MESSAGE indicators go off, and that any output relays programmed to operate (as well as their associated LED indicators) reset, and the Active Alarm message is no longer displayed. Turn current off.

Indications and Operations caused by a Control Function:

1. Inject current to cause a pickup and wait until the element times-out. Check that any output relays programmed to operate (as well as their associated LED indicators) operate.
2. Slowly reduce the current until the PICKUP indicator goes out. Check that any output relays programmed to operate (as well as their associated LED indicators) reset. Turn current off.

Indications and Operations caused by a Latched Alarm Function, with front panel RESET Key Resetting:

1. Inject current to cause a pickup and wait until the element times to Alarm.
2. Check that the ALARM and MESSAGE indicators are flashing, the Active Alarm message is displayed, and any output relays programmed to operate (as well as their associated LED indicators) operate.
3. Slowly reduce the current until the PICKUP indicator goes out. Check that the ALARM and MESSAGE indicators are flashing, and that any output relays programmed to operate (as well as their associated LED indicators) reset.
4. Press the front panel RESET key. Check that the ALARM and MESSAGE indicators go off, and the Active Alarm message is no longer displayed. Turn current off.

Blocking From Logic Inputs:

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Block Phase Time 1". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic inputs "Block Phase O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

Timing:

1. Connect the Stop Trigger.
2. Preset the injection current level to 2.0 x pickup. Turn the current off, and reset the timer.
3. Inject the preset current into phase A and note the measured delay time. Check this time against the time established by the settings. Reset the timer.
4. Preset the injection current level to 4.0 x pickup. Turn the current off, and reset the timer.

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5. Inject the preset current into phase B and note the measured delay time. Check this time against the time established by the settings. Reset the timer.
6. Preset the injection current level to 7.0 x pickup. Turn the current off, and reset the timer.
7. Inject the preset current into phase C and note the measured delay time. Check this time against the time established by the settings.
8. Turn current off and disconnect the Stop Trigger.

Linear Reset Timing:

To confirm that the time O/C element is using linear reset timing, if so programmed, inject a current above the pickup level for approximately half the time required to Trip. Turn the current off, reset the interval timer, and then re-apply immediately. The time-to-trip should be much less than the trip-time established by the settings.

Voltage Restrained Phase Time Overcurrent:

1. Apply 3-phase nominal voltage to the relay.
2. Inject current below the pickup level into phase A. Slowly increase the current until the PICKUP indicator is on. Note the pickup value is the pickup current of the Curve in use. Slowly reduce the current until the PICKUP indicator goes off. Note the dropout level, which should be 2% of CT less than pickup when pickup ≤ CT or 97 to 98% of pickup when pickup > CT. Reduce the current to zero.
3. Repeat step 2 for current injected into phases B and C.
4. Set all input voltages to 0. Slowly increase phase A current until the PICKUP indicator comes on. Check that this current is 9-11% of the measured full voltage pickup current. Increase input voltage V_{ab} until the PICKUP indicator goes out. This should be at 9-11% of the nominal phase-phase voltage. This test establishes the lower knee of the operating characteristic.
5. Increase voltage V_{ab} to 60% of the nominal phase-phase voltage. (The PICKUP indicator is off.) Increase phase A current until the PICKUP indicator comes on. This should be at 59-61% of the full voltage measured pickup current.
6. Increase voltage V_{ab} to 130% of nominal. (The PICKUP indicator is off.) Increase phase A current to 90% of normal pickup, and hold this value. Slowly decrease V_{ab} until the PICKUP indicator just comes on. This should be at 89-91% of nominal V_{ab}. This establishes the upper knee of the characteristic, and shows the pickup is not altered above 90% voltage. Reduce current and voltages to 0.
7. Repeat steps 4 through 6 for current injected in phase B and controlling voltage V_{cb}.
8. Repeat steps 4 through 6 for current injected in phase C and controlling voltage V_{ca}.

Trip Timing with Voltage Restraint:

The timing characteristics under voltage restraint can be checked by setting the input voltage to a given level, establishing a new pickup current, and then following the procedure outlined earlier under Trip Timing.

17.7.4 PHASE TIME OVERCURRENT 2

The procedure to test this element is identical to that for Phase Time O/C 1, with the following exception.

Blocking From Logic Inputs:

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Block Phase Time 2". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic inputs "Block Phase O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

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17.7.5 PHASE INSTANTANEOUS OVERCURRENT 1

The procedure to test this element is identical to Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exceptions. Pickup, Indication and Operation are subject to the test 'phases required for operation' and not subject to the tests 'linear reset timing' and 'voltage restrained phase time overcurrent'.

Pickup with Two Phases For Operation:

1. Inject current into phase B at 150% of pickup.
2. Inject current at a level below the pickup level into phase A.
3. Slowly increase the phase A current until the PICKUP indicator comes on. Note the pickup value.
4. Slowly reduce the phase A current until the PICKUP indicator goes out. Note the dropout level, which should be 2% of CT less than pickup when pickup ≤ CT or 97 to 98% of pickup when pickup > CT.
5. Repeat steps 1 through 4 for each other pair of phases; B and C, and C and A.

Pickup with Three Phases For Operation:

1. Inject current into phase B and C at 150% of pickup.
2. Inject current at a level below the pickup level into phase A.
3. Slowly increase the phase A current until the PICKUP indicator comes on. Note the pickup value.
4. Slowly reduce the phase A current until the PICKUP indicator goes out. Note the dropout level, which should be 2% of CT less than pickup when pickup ≤ CT or 97 to 98% of pickup when pickup > CT.
5. Repeat steps 1 through 4 for current at 150% in phases C and A and adjusted in B.
6. Repeat steps 1 through 4 for current at 150% in phases B and A and adjusted in C.

Blocking From Logic Inputs:

1. Inject current into the required number of phases to cause a pickup.
2. Assert a logic input to provide a "Block Phase Inst 1". The PICKUP indicator should immediately go out.
3. Repeat 1 and 2 for logic inputs "Block Phase O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

Timing:

1. Connect the Stop Trigger to the interval timer.
2. Preset the current source to a minimum of 110% of pickup current. Turn the current off, and reset the timer.
3. Inject the preset current into the required number of phases and note the delay time. Reset the timer.
4. Repeat step 3 four more times and obtain an average of the time intervals.
5. Reset the relay and disconnect the “Stop Trigger.”

17.7.6 PHASE INSTANTANEOUS OVERCURRENT 2

The procedure to test this element is identical to that outlined in Section 17.7.5: PHASE INSTANTANEOUS OVERCURRENT 1 on page 17–24, with the following exception.

Blocking From Logic Inputs:

1. Inject current into the required number of phases to cause a pickup.
2. Assert a logic input to provide a "Block Phase Inst 2". The PICKUP indicator should immediately go out.
3. Repeat 1 and 2 for logic inputs "Block Phase O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

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Figure 17–3: PHASE DIRECTIONAL – PHASE A FORWARD OPERATING REGIONS is a plot of the operating characteristic of the phase directional feature for various settings of MTA for phase A. Other characteristics for specific MTA settings can be deduced from this diagram. Note that the diagram is plotted for the phase current referred to both the system phase-neutral voltage and the polarizing voltage used for phase A (the polarizing voltages for phase B and C are V_{ca} and V_{ab} respectively).

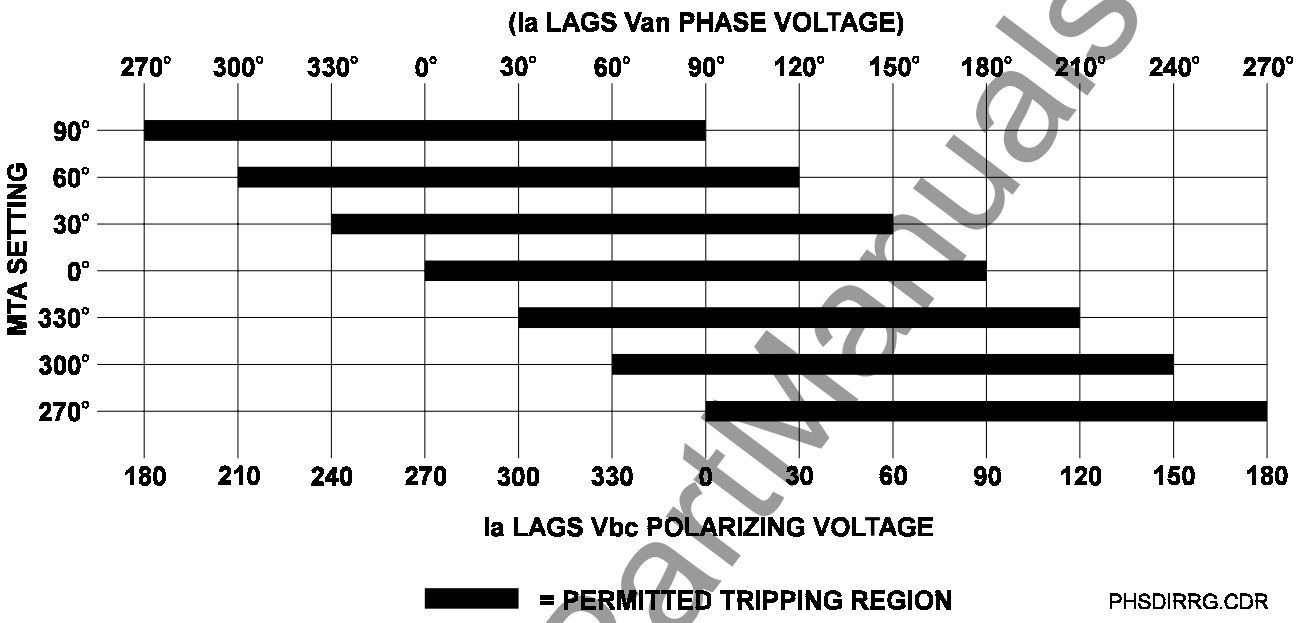


Figure 17–3: PHASE DIRECTIONAL – PHASE A FORWARD OPERATING REGIONS

NOTE

The following descriptions present angles with reference to the *polarizing* voltage and assume an MTA setting of 180°. For an MTA setting other than 180° alter the noted angles to those established by the programmed MTA.

a) FORWARD TRIPPING AND WYE CONNECTED VTs

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION on page 17–4.

Characteristics:

1. Set $V_{an} = V_{bn} = V_{cn} >$ **MINIMUM POLARIZING VOLTAGE** setpoint at 0°, 120°, and 240° respectively. Inject phase A current of 0.2 x CT at an angle which is in phase with the polarizing voltage. This angle is outside the tripping region, so tripping should be blocked. If the function is set to *Control*, check that any output relays programmed for this condition are operated. If the function is set to *Alarm*, check that the ALARM and MESSAGE indicators are flashing, the correct Phase Directional Reverse alarm message is displayed, and any output relays programmed for this condition are operated.
2. Slowly increase the angle of the phase A current in the lagging direction. The directional element should detect current flow in the tripping direction when the phase A current is lagging the polarizing voltage by more than 90° ± 2°. The alarm and output relays should reset.
3. Continue to increase the lagging angle until the alarm is again raised. The phase A current should be lagging the polarizing voltage by an angle of 270° ± 2°.
4. Continue to increase the angle until the phase A current is once again in phase with the polarizing voltage. The alarm should remain.
5. Repeat the above steps 1 through 4 for current angle adjusted in each of phase B and C.

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b) FORWARD TRIPPING AND DELTA CONNECTED VTs

Test Connections per Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Characteristics:

1. Set $V_{ab} = V_{bc} = V_{ca}$ > **MINIMUM POLARIZING VOLTAGE** setpoint at 0°, 120°, and 240° respectively. Inject phase A current of 0.2 x CT at an angle which is in phase with the polarizing voltage. This angle is outside the tripping region, so tripping should be blocked. If the function is set to *Control*, check that any output relays programmed for this condition are operated. If the function is set to *Alarm*, check that the ALARM and MESSAGE indicators are flashing, the correct Phase Directional Reverse alarm message is displayed, and any output relays programmed for this condition are operated.
2. Slowly increase the angle of the phase A current in the lagging direction. The directional element should detect current flow in the tripping direction when the phase A current is lagging the polarizing voltage by more than 90° ± 2°. The alarm and output relays should reset.
3. Continue to increase the lagging angle until the alarm is again raised. The phase A current should be lagging the polarizing voltage by an angle of 270° ± 2°.
4. Continue to increase the angle until the phase A current is once again in phase with the polarizing voltage. The alarm should remain.
5. Repeat the above steps 1 through 4 for current angle adjusted in each of phase B and C.

17.7.8 NEUTRAL TIME OVERCURRENT 1

The procedure to test this element is identical to that outlined in Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exceptions.

Current is injected into any one phase, and the element is not subject to the test “phases required for operation” and “voltage restrained time overcurrent”.

Blocking From Logic Inputs

1. Inject current to cause a pickup.
2. Assert logic input to provide a "Block Neutral Time 1". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic inputs "Block Neutral O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

17.7.9 NEUTRAL TIME OVERCURRENT 2

The procedure to test this element is identical to that outlined in Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exception.

Current is injected into any one phase, and the element is not subject to the test "phases required for operation” and “voltage restrained time overcurrent”.

Blocking From Logic Inputs:

1. Inject current to cause a pickup.
2. Assert logic input to provide a "Block Neutral Time 2". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic inputs "Block Neutral O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

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17.7.10 NEUTRAL INSTANTANEOUS OVERCURRENT 1

The procedure to test this element is identical to that outlined in Section 17.7.5: PHASE INSTANTANEOUS OVERCURRENT 1 on page 17–24, with the following exceptions.

Current is injected into any one phase, and the element is not subject to the test "phases required for operation", and not subject to the tests "linear reset timing" and "voltage restrained time overcurrent".

Blocking From Logic Inputs

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Block Neutral Inst 1". The PICKUP indicator should immediately go out.
3. Repeat 1 and 2 for logic inputs "Block Neutral O/C", "Block All O/C" and "Block 1 TRIP Relay" as required.

17.7.11 NEUTRAL INSTANTANEOUS OVERCURRENT 2

The procedure to test this element is identical to that outlined in Section 17.7.5: PHASE INSTANTANEOUS OVERCURRENT 1 on page 17–24, with the following exceptions. Current is injected into any one phase, and the element is not subject to the test "phases required for operation", and not subject to the tests "linear reset timing" and "voltage restrained time overcurrent".

Blocking From Logic Inputs

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Block Neutral Inst 2". The PICKUP indicator should immediately go out.
3. Repeat 1 and 2 for logic inputs "Block Neutral O/C", "Block All O/C" and "Block 1 TRIP Relay" as required.

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If dual polarizing is required, check the operation of the voltage and current polarized elements individually as outlined below, then check the overall dual polarized response as outlined at the end of this section.

a) FORWARD TRIPPING WITH VOLTAGE POLARIZATION

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION on page 17–4.

Figure 17–4: NEUTRAL DIRECTIONAL – VOLTAGE POLARIZED FOWARD OPERATING REGIONS below is a plot of the operating characteristic of the voltage polarized neutral directional feature for various settings of MTA. Other characteristics for specific MTA settings can be deduced from this diagram. Note that the diagram is plotted for the residual current referred to the system faulted-phase phase-to-neutral voltage.

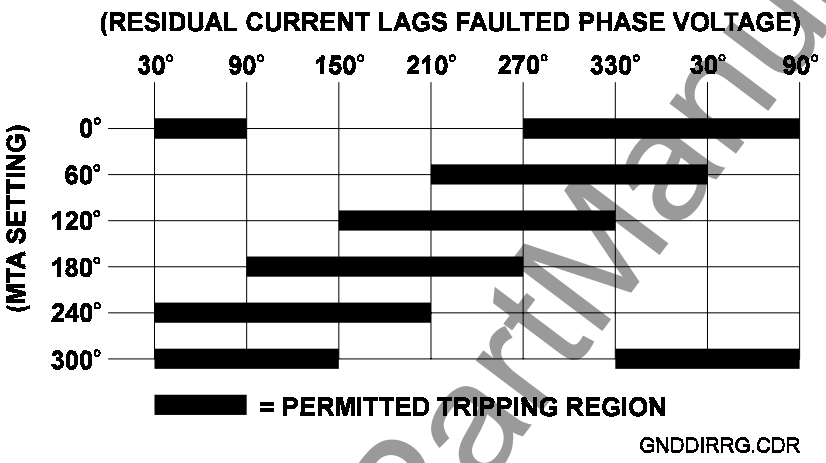


Figure 17–4: NEUTRAL DIRECTIONAL – VOLTAGE POLARIZED FOWARD OPERATING REGIONS

NOTE

The following descriptions present angles with reference to the *faulted phase voltage* and assume an MTA setting of 180°. For an MTA setting other than 180° alter the noted angles to those established by the programmed MTA.

Characteristics

1. Set $V_{an} = V_{bn} = V_{cn}$ = nominal voltage at 0°, 120°, and 240° respectively. Set a current of 0.2 of nominal to lag V_{an} by 180° (this is in the tripping direction) and inject into phase A. Note that $-V_o$ is less than the MINIMUM POLARIZING VOLTAGE.
2. Reduce V_{an} until $-V_o$ is greater than the MINIMUM POLARIZING VOLTAGE.
3. Slowly increase the angle of the phase A current in the lagging direction. At an angle lagging V_{an} by 270 ± 2°, any output relays programmed for this condition should operate if the function is set to "Control". If the function is set to *Alarm*, check that the ALARM and MESSAGE indicators are flashing, the Neutral Directional Reverse alarm message is displayed, and any output relays programmed for this condition are operated.
4. Continue to increase the lagging angle through 0°, until the block message disappears at an angle lagging V_{an} by 90 ± 2°. Turn the current off.
5. If desired, repeat the above steps 1 through 4 for phases B and C using I_b with faulted phase voltage V_{bn} and I_c with faulted phase voltage V_{cn}.

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b) FORWARD TRIPPING W/ CURRENT POLARIZATION

Test Connections per Figure 17–5: NEUTRAL DIRECTIONAL TEST CONNECTION WITH POLARIZING CURRENT.

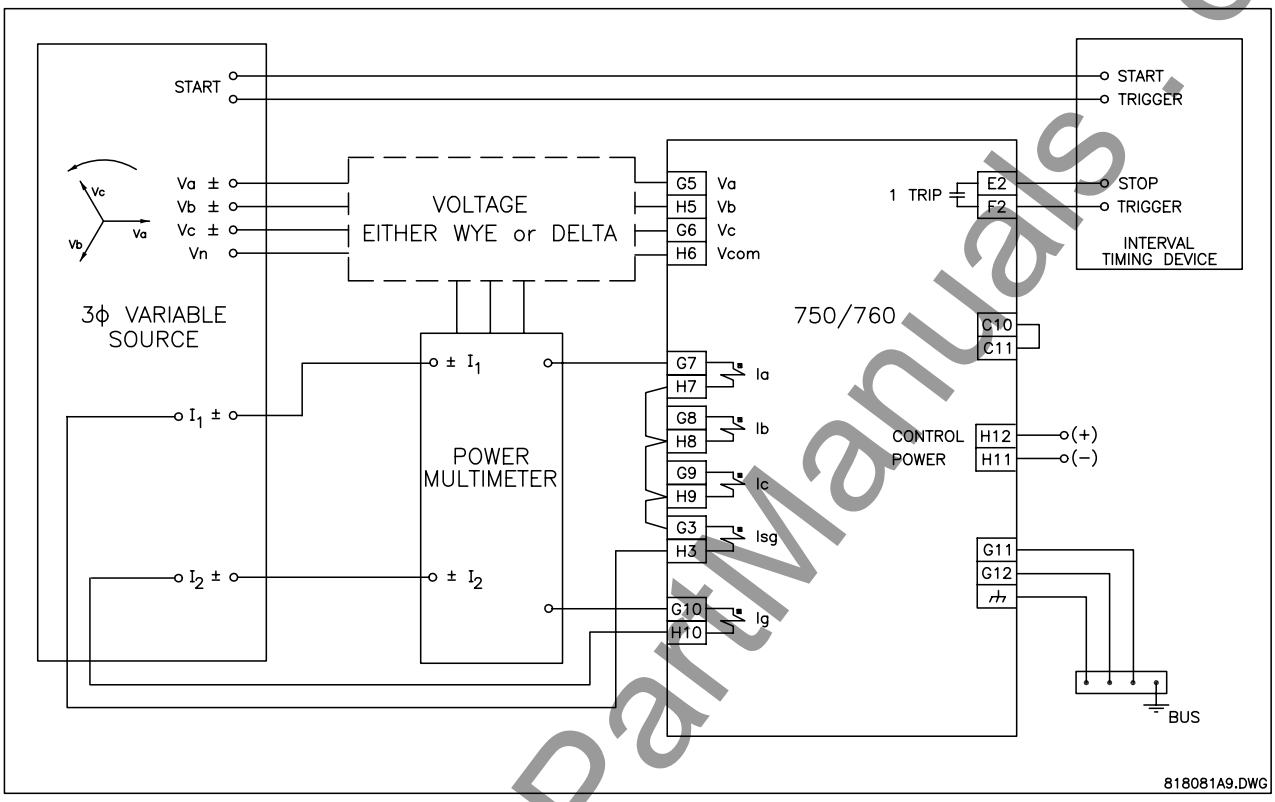


Figure 17–5: NEUTRAL DIRECTIONAL TEST CONNECTION WITH POLARIZING CURRENT

NOTE

The following description presents angles with reference to the *polarizing current*.

Characteristics

1. Set a current of 0.2 of nominal and inject into the ground current input (terminals G10,H10).
2. Set a $3I_0$ current to 0.2 of nominal and in-phase with the ground current (this is the trip direction) and inject into the relay via the phase current inputs.
3. Increase the lagging angle of $3I_0$. At an angle lagging the ground current by 90 ± 2°, any output relays programmed for this condition should operate if the function is set to *Control*. If the function is set to *Alarm*, check that the ALARM and MESSAGE indicators are flashing, the Neutral Directional Reverse alarm message is displayed, and any output relays programmed for this condition are operated.
4. Continue to increase the lagging angle until the block message disappears at an angle lagging the ground current by 270 ± 2°. Turn the current off.

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c) FORWARD TRIPPING WITH DUAL POLARIZATION

Test Connections per Figure 17–5: NEUTRAL DIRECTIONAL TEST CONNECTION WITH POLARIZING CURRENT.

As operations of each neutral directional sensing element have been checked under voltage and current polarization, it is only necessary to check that both directional elements are operational, and that either element can block tripping for reverse faults.

1. Set V_{an} to 60%, and V_{bn} = V_{cn} to 100% nominal voltage at phase angles of 0°, 120°, and 240°, respectively.
2. Inject a current of 0.2 x nominal into the phase current input of the relay ($3I_0$) at an angle outside the tripping region of the set MTA, as compared to faulted phase voltage V_{an}. The Neutral Directional Reverse alarm should appear.
3. Inject a current of 0.2 x nominal, lagging the $3I_0$ current by 180°, into the ground current input. The block alarm should remain.
4. Increase the angle of the ground current lagging $3I_0$ current through a complete 360° rotation back to the original angle of lagging by 180°. The block alarm should remain throughout the rotation as the voltage polarized element is still blocking.
5. Maintaining the ground current angle lagging $3I_0$ by 180° increase the angle of $3I_0$ lagging the V_{an} voltage through a complete 360° rotation back to the original angle. The block alarm should remain throughout the rotation as the current polarized element is still blocking.
6. Increase the angle of the ground current lagging $3I_0$ current until the currents are in-phase. The block alarm should remain.
7. Maintaining the ground current angle in-phase with $3I_0$ increase the angle of $3I_0$ lagging the V_{an} voltage until into the permitted region. The block alarm should disappear when the angle reaches the tripping region.

17.7.13 GROUND TIME OVERCURRENT

The procedure to test this element is identical to that outlined for Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exceptions.

Current is injected into the ground input terminals, and the element is not subject to the "phases required for operation" and “voltage restrained time overcurrent” tests.

Blocking From Logic Inputs

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Block Ground Time". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic inputs "Block Ground O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

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17.7.14 GROUND INSTANTANEOUS OVERCURRENT

The procedure to test this element is identical to that outlined for Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exceptions.

Current is injected into the ground input terminals, and the element is not subject to the test "phases required for operation" and not subject to the tests “linear reset timing” and “voltage restrained time overcurrent”.

Blocking From Logic Inputs:

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Block Ground Inst". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic inputs "Block Ground O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

17.7.15 GROUND DIRECTIONAL OVERCURRENT

The procedure to test this element is identical to that outlined for Section 17.7.12: NEUTRAL DIRECTIONAL OVERCURRENT on page 17–28, except the operating current is the ground current. Also, Ground Directional may only be voltage polarized.

17.7.16 SENSITIVE GROUND TIME OVERCURRENT

The procedure to test this element is identical to that outlined for Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exceptions.

Current is injected into the sensitive ground input terminals, and the element is not subject to the "phases required for operation" and “voltage restrained time overcurrent” tests.

Blocking From Logic Inputs

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Blk Sens Gnd Time". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic inputs "Block Sens Gnd O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

17.7.17 SENSITIVE GROUND INSTANTANEOUS OVERCURRENT

The procedure to test this element is identical to that outlined for Section 17.7.5: PHASE INSTANTANEOUS OVERCURRENT 1 on page 17–24, with the following exceptions.

Current is injected into the sensitive ground input terminals, and the element is not subject to the test "phases required for operation" and not subject to the tests “linear reset timing” and “voltage restrained time overcurrent”.

Blocking From Logic Inputs:

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Blk Sens Gnd Inst". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic inputs "Block Sens Gnd O/C", "Block All O/C" and “Block 1 TRIP Relay” as required.

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17.7.18 SENSITIVE GROUND DIRECTIONAL OVERCURRENT

The procedure to test this element is identical to that outlined for Section 17.7.12: NEUTRAL DIRECTIONAL OVERCURRENT on page 17–28, except the operating current is the sensitive ground current.

17.7.19 NEGATIVE SEQUENCE TIME OVERCURRENT

The procedure to test this element is identical to that outlined for Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exceptions.

Current is injected into any one phase of the phase input terminals and the negative sequence current magnitude is 1/3 of the injected current. The element is not subject to the "phases required for operation" or “voltage restrained time overcurrent” tests.

Blocking From Logic Inputs

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Block Neg Seq Time". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic input "Block All O/C" and “Block 1 TRIP Relay” as required.

17.7.20 NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT

The procedure to test this element is identical to that outlined for Section 17.7.5: PHASE INSTANTANEOUS OVERCURRENT 1 on page 17–24, with the following exceptions.

Current is injected into any one phase of the phase input terminals and the negative sequence current magnitude is 1/3 of the injected current. The element is not subject to the "phases required for operation" test and not subject to the tests “linear reset timing” and “voltage restrained time overcurrent”.

Blocking From Logic Inputs

1. Inject current to cause a pickup.
2. Assert a logic input to provide a "Block Neg Seq Inst". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic input "Block All O/C" and “Block 1 TRIP Relay” as required.

17.7.21 NEGATIVE SEQUENCE DIRECTIONAL OVERCURRENT

The procedure to test this element is identical to that outlined for Section 17.7.7: PHASE DIRECTIONAL OVERCURRENT on page 17–25, except the injected current must be a negative sequence current.

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Procedure To Check:

a) FOR WYE VTs

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION on page 17–4.

A negative sequence voltage can be created by injecting a single phase voltage, or a set of three single-phase voltages with a known negative sequence component. For single phase injection the negative sequence voltage magnitude is the injected voltage divided by 3.

Pickup:

1. Inject a negative sequence voltage = 0 into the bus voltage input of the relay. The PICKUP indicator should be off.
2. Slowly raise the voltage until the PICKUP indicator comes on. This is the pickup level.
3. Lower the voltage until the PICKUP indicator goes out. This is the reset voltage, which should be 2% of VT less than the pickup level.

b) FOR DELTA VTs

Test Connections per Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

A negative sequence voltage can be created by injecting a single phase-phase voltage, or a set of two phase-phase voltages with a known negative sequence component. For a single phase-phase injection the negative sequence voltage magnitude is the injected voltage divided by √3.

Pickup

1. Inject a negative sequence voltage = 0 into the bus voltage input of the relay. The PICKUP indicator should be off.
2. Slowly raise the voltage until the PICKUP indicator comes on. This is the pickup level.
3. Lower the voltage until the PICKUP indicator goes out. This is the reset voltage, which should be 2% of VT less than the pickup level.

Indications and Operations are as outlined under Phase Time Overcurrent 1.

Blocking From Logic Inputs:

1. Inject voltage to cause a pickup.
2. Assert a logic input to provide a "Block Neg Seq Voltage". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic input “Block 1 TRIP Relay” as required.

Timing:

1. Connect the “Stop Trigger."
2. Set the voltage source to the required test voltage, then turn off the voltage.
3. Reset the timer. Turn the voltage on and measure the operating time. Repeat steps 2 and 3 four more times and obtain an average of the time intervals.
4. Reset the relay and disconnect the “Stop Trigger.”

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a) FOR WYE VTs

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION on page 17–4.

Pickup with One Phase For Operation:

1. Inject V_{an} = V_{bn} = V_{cn} = nominal voltage into the bus voltage input of the relay. The PICKUP indicator should be off.
2. Slowly lower V_{an} until the PICKUP indicator comes on. This is the pickup voltage.
3. Continue to lower V_{an} until the PICKUP indicator goes out. This is the programmed Minimum Operating Voltage level minus 2% of VT.
4. Raise V_{an} until the PICKUP indicator comes on, and continue to increase until the indicator goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.
5. Repeat steps 1 through 4 except adjust V_{bn} and V_{cn} in turn.

Pickup with Two Phases For Operation:

1. Inject V_{cn} = nominal voltage and V_{an} = V_{bn} = a voltage between the Minimum Operating Voltage and the pickup voltage into the bus voltage input of the relay. The PICKUP indicator should be on.
2. Slowly raise V_{an} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.
3. Reduce V_{an} until the PICKUP indicator comes on. This is the pickup voltage of V_{an}.
4. Continue to lower V_{an} until the PICKUP indicator goes out. This is the programmed Minimum Operating Voltage of V_{an} minus 2% of VT.
5. Slowly raise V_{an} until the PICKUP indicator comes on, then reduce V_{bn} until the PICKUP indicator goes out. This is the programmed Minimum Operating Voltage of V_{bn} minus 2% VT.
6. Slowly raise V_{bn} until the PICKUP indicator first comes on and then goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.
7. Lower V_{bn} until the PICKUP indicator comes on. This is the pickup voltage of V_{bn}.
8. Repeat steps 1 through 7, substituting V_{cn} for V_{an}, V_{an} for V_{bn} and V_{bn} for V_{cn}.
9. Repeat steps 1 through 7, substituting V_{bn} for V_{an}, V_{cn} for V_{bn} and V_{an} for V_{cn}.

Pickup with Three Phases For Operation:

1. Inject V_{an} = V_{bn} = V_{cn} = a voltage between the Minimum Operating Voltage and the pickup voltage into the bus voltage input of the relay. The PICKUP indicator should be on.
2. Slowly raise V_{an} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.
3. Reduce V_{an} until the PICKUP indicator comes on. This is the pickup voltage of V_{an}.
4. Slowly raise V_{bn} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.
5. Reduce V_{bn} until the PICKUP indicator comes on. This is the pickup voltage of V_{bn}
6. Slowly raise V_{cn} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.
7. Reduce V_{cn} until the PICKUP indicator comes on. This is the pickup voltage of V_{cn}.

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8. Lower V_{an} until the PICKUP indicator goes out. This is the programmed Minimum Operating Voltage of V_{an} minus 2% of VT.
9. Slowly raise V_{an} until the PICKUP indicator comes on. This is the Minimum Operating Voltage level.
10. Reduce V_{bn} until the PICKUP indicator goes out. This is the programmed Minimum Operating Voltage of V_{bn} minus 2% of VT.
11. Slowly raise V_{bn} until the PICKUP indicator comes on. This is the Minimum Operating Voltage level.
12. Reduce V_{cn} until the PICKUP indicator goes out. This is the programmed Minimum Operating Voltage of V_{cn} minus 2% of VT.
13. Slowly raise V_{cn} until the PICKUP indicator comes on. This is the Minimum Operating Voltage level.

b) FOR DELTA VTs

Test Connections per Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Pickup with One Phase For Operation:

1. Inject V_{ab} = V_{cb} = nominal voltage into the bus voltage input of the relay. The PICKUP indicator should be off.
2. Slowly lower V_{ab} until the PICKUP indicator comes on. This is the pickup voltage.
3. Continue to lower V_{ab} until the PICKUP indicator goes out. This is the Minimum Operating Voltage minus 2% of VT.
4. Raise V_{ab} until the PICKUP indicator comes on, and continue to increase until the indicator goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.
5. Repeat steps 1 through 4 except adjust V_{bc}.

Pickup with Two or Three Phases For Operation:

1. Inject V_{ab} = nominal voltage and V_{cb} = a voltage between the Minimum Operating Voltage and the pickup voltage into the bus voltage input of the relay. The PICKUP indicator should be on.
2. Slowly raise V_{cb} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.
3. Reduce V_{cb} until the PICKUP indicator comes on. This is the pickup voltage of V_{cb}.
4. Continue to lower V_{cb} until the PICKUP indicator goes out. This is the programmed Minimum Operating Voltage of V_{cb} minus 2% of VT.
5. Slowly raise V_{cb} until the PICKUP indicator comes on. This is the Minimum Operating Voltage level.
6. Reduce V_{ab} until the PICKUP indicator goes out. This is the programmed Minimum Operating Voltage of V_{ab} minus 2% of VT.
7. Slowly raise V_{ab} until the PICKUP indicator first comes on and then goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.
8. Lower V_{ab} until the PICKUP indicator comes on. This is the pickup voltage of V_{ab}.

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c) FOR WYE and DELTA VTs

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Indications and Operations are as outlined under Phase Time Overcurrent 1.

Blocking From Logic Inputs:

1. Inject voltage into the required number of phases to cause a pickup.
2. Assert a logic input to provide a "Block Undervolt 1 (2)". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic input “Block 1 TRIP Relay” as required.

Timing:

1. Connect the “Stop Trigger."
2. Set the voltage source to nominal voltage.
3. Reset the timer. Turn the voltage off in the required number of phases, and measure the operating time.
4. Repeat steps 2 and 3 four more times and obtain an average of the time intervals.
5. Reset the relay and disconnect the “Stop Trigger.”

17.7.24 LINE UNDERVOLT 3 (4)

Pickup

1. Inject nominal voltage into the line voltage input of the relay. The PICKUP indicator should be off.
2. Slowly lower the voltage until the PICKUP indicator comes on. This is the pickup voltage.
3. Continue to lower the voltage until the PICKUP indicator goes out. This is the programmed Minimum Operating Voltage minus 2% of VT.
4. Raise the voltage until the PICKUP indicator comes on, and continue to increase until the indicator goes out. This is the reset voltage, which should be the pickup value plus 2% of VT.

Indications and Operations are as outlined under Phase Time Overcurrent 1.

Blocking From Logic Inputs:

1. Inject voltage to cause a pickup.
2. Assert a logic input to provide a "Block Undervolt 3 (4)". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic input “Block 1 TRIP Relay” as required.

Timing:

1. Connect the “Stop Trigger."
2. Set the voltage source to nominal voltage.
3. Reset the timer. Turn on the voltage, and measure the operating time.
4. Repeat steps 2 and 3 four more times and obtain an average of the time intervals.
5. Reset the relay and disconnect the “Stop Trigger.”

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a) FOR WYE VTs

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION on page 17–4.

Pickup with One Phase For Operation:

1. Inject $V_{an} = V_{bn} = V_{cn} = 0$ into the bus voltage input of the relay. The PICKUP indicator should be off.
2. Slowly raise V_{an} until the PICKUP indicator comes on. This is the pickup voltage.
3. Lower V_{an} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value minus 2% of VT.
4. Repeat steps 1 through 3 except adjust V_{bn} and V_{cn} in turn.

Pickup with Two Phases For Operation:

1. Inject $V_{an} = V_{bn}$ = nominal voltage and V_{cn} = a voltage above the pickup into the bus voltage input of the relay. The PICKUP indicator should be off.
2. Slowly raise V_{an} until the PICKUP indicator goes on. This is the pickup voltage of V_{an}.
3. Reduce V_{an} until the PICKUP indicator goes off. This is the reset voltage of V_{an} which should be the pickup value minus 2% of VT.
4. Raise V_{an} until the PICKUP indicator comes on.
5. Repeat steps 1 through 4, substituting V_{cn} for V_{an}, V_{an} for V_{bn} and V_{bn} for V_{cn}.
6. Repeat steps 1 through 4, substituting V_{bn} for V_{an}, V_{cn} for V_{bn} and V_{an} for V_{cn}.

Pickup with Three Phases For Operation:

1. Inject $V_{an} = V_{bn} = V_{cn}$ = a voltage above the pickup voltage into the bus voltage input of the relay. The PICKUP indicator should be on.
2. Slowly lower V_{an} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value minus 2% of VT.
3. Raise V_{an} until the PICKUP indicator comes on. This is the pickup voltage of V_{an}.
4. Slowly lower V_{bn} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value minus 2% of VT.
5. Raise V_{bn} until the PICKUP indicator comes on. This is the pickup voltage of V_{bn}.
6. Slowly lower V_{cn} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value minus 2% of VT.
7. Raise V_{cn} until the PICKUP indicator comes on. This is the pickup voltage of V_{cn}.

b) FOR DELTA VTs

Test Connections per Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Pickup with One Phase For Operation:

1. Inject $V_{ab} = V_{cb} = 0$ into the bus voltage input of the relay. The PICKUP indicator should be off.
2. Slowly raise V_{ab} until the PICKUP indicator comes on. This is the pickup voltage.
3. Lower V_{ab} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value minus 2% of VT.
4. Repeat steps 1 through 3 except adjust V_{bc}.

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Pickup with Two or Three Phases For Operation:

1. Inject $V_{ab} = V_{cb} >$ pickup into the bus voltage input. The PICKUP indicator should be on.
2. Lower V_{ab} until the PICKUP indicator goes out. This is the reset voltage, which should be the pickup value minus 2% of VT.
3. Slowly raise V_{ab} until the PICKUP indicator comes on. This is the pickup voltage.
4. Repeat steps 1 through 3 except adjust V_{bc}.

c) FOR WYE and DELTA VTs

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4. Indications and Operations are as outlined under Phase Time Overcurrent 1.

Blocking From Logic Inputs:

1. Inject voltage to cause a pickup.
2. Assert a logic input to provide a "Block 1 TRIP Relay".

Timing:

1. Connect the “Stop Trigger."
2. Set the voltage source to the required test voltage, then turn off voltage.
3. Reset the timer. Turn the voltage on in the required number of phases, and measure the operating time. Repeat steps 2 and 3 four more times and obtain an average of the time intervals.
4. Reset the relay and disconnect the “Stop Trigger.”

17.7.26 NEUTRAL DISPLACEMENT (WYE VTs ONLY)

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION on page 17–4.

Pickup Level:

1. Apply a three phase balanced nominal voltage to the relay.
2. Reduce *one* phase voltage slowly until the Neutral Displacement element operates. Note this voltage.
3. Calculate the $3V_o$ (neutral voltage i.e. residual voltage) being supplied to the relay using the formula:
   $3V_o = V_a + V_b + V_c$.
4. Repeat steps 1 through 3 except adjust V_{bn} and V_{cn} in turn.

Blocking From Logic Inputs:

1. Cause a pickup of the Neutral Displacement element.
2. Assert a logic input to provide a "Blk Ntr Displacement". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic input “Block 1 TRIP Relay” as required.

Timing:

1. Connect the Stop Trigger.
2. Preset the neutral (residual) voltage to be 150% of the pickup setting.
3. Inject the preset neutral (residual) voltage into the relay and note the delay time. Reset the timer.
4. Repeat step 3 four more times and obtain an average of the time intervals. Disconnect the stop trigger when finished.

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Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Procedure To Check:

Minimum Operating Voltage Supervision:

1. Set the injection source well below the pickup frequency. Inject V_a = 0 V into the bus voltage input of the relay with $I_a = I_b = I_c$ above the Minimum Operating Current level. The PICKUP indicator should be off.
2. Slowly increase the voltage in phase A until the PICKUP indicator comes on. Check that the pickup voltage is the selected Minimum Operating Voltage.
3. Slowly reduce the voltage. Note the voltage at which the PICKUP indicator goes out. Check that this drop-out voltage is the pickup voltage minus 2 x VT nominal. Turn the injection voltage off.

Minimum Operating Current Supervision:

1. Set the injection source well below the pickup frequency. Inject V_a = 0 V into the bus voltage input and $I_a = I_b = I_c$ = 0 A into the phase current inputs of the relay. The PICKUP indicator should be off.
2. Slowly increase the voltage in phase A above the selected Minimum Operating Voltage. The PICKUP indicator should remain off.
3. Slowly increase the phase A current until the PICKUP indicator turns on. This is the Minimum Operating Current level. Now reduce the current until the PICKUP indicator turns off. Note the dropout level, which should be 2% of CT less than the Minimum Operating Current level when the level is ≤ CT. When the Minimum Operating Current level is > CT, the dropout level should be 97 to 98% of the Minimum Operating Current level.
4. Slowly increase the phase B current until the PICKUP indicator turns on. This is the Minimum Operating Current level. Now reduce the current until the PICKUP indicator turns off. Note the dropout level, which should be 2% of CT less than the Minimum Operating Current level when the level is ≤ CT. When the Minimum Operating Current level is > CT, the dropout level should be 97 to 98% of the Minimum Operating Current level.
5. Slowly increase the phase C current until the PICKUP indicator turns on. This is the Minimum Operating Current level. Now reduce the current until the PICKUP indicator turns off. Note the dropout level, which should be 2% of CT less than the Minimum Operating Current level when the level is ≤ CT. When the Minimum Operating Current level is > CT, the dropout level should be 97 to 98% of the Minimum Operating Current level.

NOTE

For all procedures following, the injected voltage and currents are always above the minimum operating levels.

Pickup:

1. Inject voltage at a frequency above the pickup level into phase V_a. Slowly decrease the frequency until the PICKUP indicator comes on. Note the pickup value.
2. Slowly increase the frequency until the PICKUP indicator goes out. Note the dropout level, which should be the pickup plus 0.03 Hz.

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Indications and Operations are as outlined under Phase Time Overcurrent 1.

Blocking From Logic Inputs:

1. Inject voltage and current above minimum at a frequency to cause a pickup.
2. Assert a logic input to provide a "Block Underfreq 1 (2)". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic input “Block 1 TRIP Relay” as required.

Timing:

1. Connect the “Stop Trigger.”
2. Set the voltage source prefault mode to nominal voltage, current and frequency.
3. Set the voltage source fault mode to nominal voltage and current, but with a frequency below pickup.
4. Set the source to prefault mode, reset the timer, and apply to the relay.
5. Jump the source to fault mode and measure the operating time.
6. Repeat steps 4 and 5 four more times and obtain an average of the time intervals.
7. Reset the relay and disconnect the “Stop Trigger.”

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Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Procedure To Check:

Minimum Operating Voltage Supervision:

1. Inject voltage into the V_a bus voltage input at a level well below the Minimum Operating Voltage level. Also inject $I_a = I_b = I_c$ at a level well above the Minimum Operating Current level. Starting with the V_a frequency at a level well below the Frequency Decay Pickup, drop the frequency of V_a at a speed greater than the **FREQUENCY DECAY RATE** setting. The pickup indicator should remain off.
2. Inject voltage into the V_a bus voltage input at a level well above the Minimum Operating Voltage level. Also inject $I_a = I_b = I_c$ at a level well above the Minimum Operating Current level. Starting with the V_a frequency at a level well below the Frequency Decay Pickup, drop the frequency of V_a at a speed greater than the **FREQUENCY DECAY RATE** setting. The pickup indicator should come on while the V_a frequency is dropping.

Minimum Operating Current Supervision:

1. Inject voltage into the V_a bus voltage input at a level well above the Minimum Operating Voltage level. Also inject $I_a = I_b = I_c$ at a level well below the Minimum Operating Current level. Starting with the V_a frequency at a level well below the Frequency Decay Pickup, drop the frequency of V_a at a speed greater than the **FREQUENCY DECAY RATE** setting. The pickup indicator should remain off.
2. With the V_a voltage at a level well above the Minimum Operating Voltage level, increase I_a to a level well above the Minimum Operating Current level. Currents I_b and I_c should be well below the Minimum Operating Current level. Starting with the V_a frequency at a level well below the Frequency Decay Pickup, drop the frequency of V_a at a speed greater than the **FREQUENCY DECAY RATE** setting. The pickup indicator should come on while the V_a frequency is dropping.
3. With the V_a voltage at a level well above the Minimum Operating Voltage level, increase I_b to a level well above the Minimum Operating Current level. Currents I_a and I_c should be well below the Minimum Operating Current level. Starting with the V_a frequency at a level well below the Frequency Decay Pickup, drop the frequency of V_a at a speed greater than the **FREQUENCY DECAY RATE** setting. The pickup indicator should come on while the V_a frequency is dropping.
4. With the V_a voltage at a level well above the Minimum Operating Voltage level, increase I_c to a level well above the Minimum Operating Current level. Currents I_a and I_b should be well below the Minimum Operating Current level. Starting with the V_a frequency at a level well below the Frequency Decay Pickup, drop the frequency of V_a at a speed greater than the **FREQUENCY DECAY RATE** setting. The pickup indicator should come on while the V_a frequency is dropping.

NOTE

For all procedures following, the injected voltage and currents are always above the minimum operating levels.

Pickup:

1. Starting with the V_a frequency at a level well above the Frequency Decay Pickup, drop the frequency of V_a at a speed greater than the Frequency Decay Rate setting, to a level still well above the Frequency Decay Pickup. The pickup indicator should remain off.
2. Continue dropping the V_a frequency at a speed greater than the Frequency Decay Rate. When the frequency drops below the Frequency Decay Pickup the PICKUP indicator will come on.

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Rate:

1. With the V_a frequency at a level well below the Frequency Decay Pickup, drop the frequency of V_a at a speed less than the **FREQUENCY DECAY RATE** setting. The pickup indicator should remain off.
2. With the V_a frequency at a level well below the Frequency Decay Pickup, drop the frequency of V_a at a speed greater than the **FREQUENCY DECAY RATE** setting. The pickup indicator will come on.

Indications and Operations are as outlined under Phase Time Overcurrent 1.

Blocking From Logic Inputs:

1. Decrease the V_a frequency at a rate to cause a pickup.
2. Assert a logic input to provide a "Block Frequency Decay". The PICKUP indicator should immediately go out.
3. Repeat steps 1 and 2 for logic input “Block 1 TRIP Relay” as required.

Timing:

1. Connect the Stop Trigger.
2. Preset the ramp-rate to a minimum of 110% of the pickup and reset the timer.
3. Inject the preset voltage into the V_a bus voltage input and note the measured delay time. Reset the timer.
4. Repeat step 3 four more times and obtain an average of the time intervals.
5. Disconnect the Stop Trigger.

17.7.29 BREAKER FAILURE

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

1. Ensure the wiring to the circuit breaker trip and close circuits is complete.
2. Energize the breaker trip and close circuits and close the breaker.
3. Carefully disconnect a wire to open the trip circuit.
4. Set a test current level 3% above the Breaker Failure Current setpoint and inject current into a phase current input. (All O/C protection features are Disabled.)
5. Assert a Trip logic input, which cannot be performed by the breaker. After a delay the element should generate an output. (The delay time can be checked in the Event Recorder.) Turn the current off and Reset the relay.
6. Reduce the current magnitude to 3% below the Breaker Failure Current setpoint and inject current into a phase current input. Assert a Trip logic input, which cannot be performed by the breaker. The element should not generate an output.

Indications and Operations are as outlined under Phase Time Overcurrent 1. This element has no Trip function.

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17.8.1 PHASE CURRENT LEVEL

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

1. Set the Delay time to 0.
2. Inject current at a level below the pickup level into phase A.
3. Slowly increase the current until pickup is reached and the element generates an output.
4. Slowly reduce the current until the element resets, which should be 2% of CT less than pickup when pickup ≤ CT or 97 to 98% of pickup when pickup > CT.
5. Repeat steps 2 to 4 for phase B and C current.
6. Set the Delay timer to the required setting.

Indications and Operations caused by the various Functions are as outlined under Phase Time O/C, with the following exception.

There is no Trip function for this element.

Timing:

1. Set the test source to a current at least 110% of pickup. Turn off and reset the timer.
2. Inject current into the relay and measure the time to operate.
3. Repeat step 2 four more times and obtain an average of the time intervals
4. Disconnect the Stop Trigger.

17.8.2 NEUTRAL CURRENT LEVEL

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

The testing for this element is the same as for the Phase Current Level element, except current is the residual current injected into the phase current inputs.

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Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

NOTE

Because of the broad range of variables that can be encountered in actual systems a representative configuration with a set of impedances and instrument transformers have been chosen to demonstrate these tests. The model used to calculate the voltage and current phasors for the tests is a radial, 10 km long, three phase, four wire system of 13.8 kV nominal and 600 amp feeder capacity. At the relay location there are wye-connected VTs rated 14400/120 V and CTs rated 600/5 A. A prefault load of about 8.5 MVA exists on the feeder. The relay is a 5 Amp unit.

Model Impedances (Ω)	Zpos = Zneg	Zzero
Source	0.028 + j0.662	0.028 + j0.662
Feeder	1.250 + j5.450	5.280 + j15.79

The source voltage (ahead of the source impedance) is 14.0 kV∠1.6°. Any overcurrent feature, all of which can cause a fault location calculation by tripping, set to a pickup current below the programmed test current, can be used for the tests.

Procedure:

1. Program the test set with the following *prefault* voltages and currents.

   V_{an} = 67.8∠0°; V_{bn} = 67.8∠240°; V_{cn} = 67.8∠120°; I_a = 2.9∠330°; I_b = 2.9∠210°; I_c = 2.9∠90°

2. Program the test set with the following fault voltages and currents.

   V_{an} = 59.0∠0°; V_{bn} = 67.4∠241°; V_{cn} = 67.4∠121°; I_a = 13.0∠286°; I_b = 2.9∠210°; I_c = 2.9∠90°

   This fault is from phase A to ground, placed 5.0 km from the relay.

3. Inject the prefault voltages and currents, then apply the fault. The relay should trip and determine the type of fault (A-G), the distance to the fault (5.0 km) and the reactance to the fault (2.73 Ω).

4. Program the test set with the following fault voltages and currents.

   V_{an} = 67.4∠2°; V_{bn} = 60.3∠242°; V_{cn} = 67.4∠122°; I_a = 2.9∠330°; I_b = 12.0∠166°; I_c = 2.9∠90°

   This fault is phase B to ground, placed 6.0 km from the relay.

5. Inject the prefault voltages and currents, then apply the fault. The relay should trip and determine the type of fault (B-G), the distance to the fault (6.0 km) and the reactance to the fault (3.27 Ω).

6. Program the test set with the following fault voltages and currents.

   V_{an} = 67.4∠2°; V_{bn} = 67.4∠242°; V_{cn} = 61.3∠120°; I_a = 2.9∠330°; I_b = 2.9∠210°; I_c = 9.9∠47°

   This fault is phase C to ground, placed 7.0 km from the relay.

7. Inject the prefault voltages and currents, then apply the fault. The relay should trip and determine the type of fault (C-G), the distance to the fault (7.0 km) and the reactance to the fault (3.82 Ω).

8. Program the test set with the following fault voltages and currents.

   V_{an} = 60.4∠4°; V_{bn} = 67.4∠242°; V_{cn} = 61.7∠117°; I_a = 11.4∠253°; I_b = 2.9∠210°; I_c = 11.4∠73°

   This fault is phase A to C, placed 8.0 km from the relay.

9. Inject the prefault voltages and currents, then apply the fault parameters. The relay should trip and determine the type of fault (A-C), the distance to the fault (8.0 km) and the reactance to the fault (4.36 Ω).

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10. Program the test with the following fault voltages and currents.

    V_{an} = 62.2∠358°; V_{bn} = 61.0∠244°; V_{cn} = 67.4∠122°; I_a = 10.3∠313°; I_b = 10.3∠133°; I_c = 2.9∠90°

    This fault is phase A to B, placed 9.0 km from the relay.

11. Inject the prefault voltages and currents, then apply the fault. The relay should trip and determine the type of fault (A-B), the distance to the fault (9.0 km) and the reactance to the fault (4.91 Ω).

12. Program the test with the following fault voltages and currents.

    V_{an} = 60.3∠0°; V_{bn} = 60.3∠240°; V_{cn} = 60.3∠120°; I_a = 10.8∠283°; I_b = 10.8∠163°; I_c = 10.8∠43°

    This fault is phase A to B to C, placed 10.0 km from the relay.

13. Inject the prefault voltages and currents, then apply the fault. The relay should trip and determine the type of fault (A-B-C), the distance to the fault (10.0 km) and the reactance to the fault (5.45 Ω).

17.8.4 CURRENT DEMAND

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

1. Clear demand data registers before starting this test.
2. Inject a fixed value of current. Monitor the actual value of the measured demand, and note the level at which the feature generates an output. Turn the current off.

Indications and Operations caused by the various Functions are as outlined under Phase Time O/C, with the following exception:

There is no Trip function for this element.

17.8.5 REAL POWER DEMAND

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

1. Clear demand data registers before starting this test.
2. Inject a fixed value of watts. Monitor the actual value of the measured demand, and note the level at which the feature generates an output. Turn the current off.

Indications and Operations caused by the various Functions are as outlined under Phase Time O/C, with the following exception:

There is no Trip function for this element.

17.8.6 REACTIVE POWER DEMAND

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

1. Clear demand data registers before starting this test.
2. Inject a fixed value of vars. Monitor the actual value of the measured demand, and note the level at which the feature generates an output. Turn the current off.

Indications and Operations caused by the various Functions are as outlined under Phase Time O/C, with the following exception.

There is no Trip function for this element.

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17.8.7 APPARENT POWER DEMAND

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

1. Clear demand data registers before starting this test.
2. Inject a fixed value of VA. Monitor the actual value of the measured demand, and note the level at which the feature generates an output. Turn the current off.

Indications and Operations caused by the various Functions are as outlined under Phase Time O/C, with the following exception:

There is no Trip function for this element.

17.8.8 ANALOG THRESHOLD 1 (2)

1. Inject DC mA current at a level below the pickup level into the analog input.
2. Slowly increase the current until the element generates an output. Slowly reduce the current until the element reset.

Timing:

1. Connect the Stop Trigger.
2. Preset the DC mA current source to a minimum of 110% of the pickup current. Turn the current off, and reset the timer.
3. Inject the preset current into the analog input and note the measured delay time. Reset the timer.
4. Repeat step 3 four more times and obtain an average of the time intervals.
5. Disconnect the Stop Trigger.

17.8.9 ANALOG IN RATE 1 (2)

1. Connect the output of a dc ramping-current generator to the analog input.
2. Remove the power supply from the relay to ensure the analog input memory is set to zero, then apply power to the relay.
3. Set the ramp-rate below the rate-of-change pickup and inject into the analog input. Wait for 90 seconds (fast rate) or 90 minutes (slow rate) to ensure the relay has properly measured the input ramping-rate. The relay should not pickup. Cycle the relay power supply Off then On.
4. Adjust the ramp-rate to a higher rate and again apply and; if the relay doesn't pickup cycle the relay power supply Off then On. Repeat this procedure until the element generates an output.

Indications and Operations caused by the various Functions are as outlined under Phase Time O/C, with the following exception:

There is no Trip function for this element.

Timing:

1. Connect the Stop Trigger.
2. Preset the ramp-rate to a minimum of 110% of the pickup. Turn the current off, and reset the timer.
3. Inject the preset current into the analog input and note the measured delay time. Reset the timer.
4. Repeat step 3 four more times and obtain an average of the time intervals.
5. Disconnect the Stop Trigger.

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17.8.10 OVERFREQUENCY

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

1. Inject voltage at a frequency below the pickup level into phase A.
2. Slowly increase the frequency until the element generates an output.
3. Slowly reduce the frequency until the element resets.

Indications and Operations caused by the various Functions are as outlined under Phase Time O/C, with the following exception.

There is no Trip function for this element.

Timing:

1. Connect the Stop Trigger.
2. Preset the voltage source frequency to a minimum of 110% of pickup. Turn voltage off and reset the timer.
3. Inject the preset voltage into phase A and note the measured delay time. Reset the timer.
4. Repeat step 3 four more times and obtain an average of the time intervals.
5. Disconnect the “Stop Trigger.”

17.8.11 POWER FACTOR 1(2)

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Minimum Operating Voltage/Current Supervision:

1. Inject fixed values of voltage and current at about nominal values, at unity power factor. Slowly increase the angle of lagging current, waiting for a time longer than the delay setting before each adjustment, until the element generates an output.

Indications and Operations caused by the various Functions are as outlined under Phase Time O/C, with the following exception.

There is no Trip function for this element.

2. Slowly reduce voltage V_a magnitude until the power factor feature resets. Note the dropout voltage, which should be at about 30% of the selected nominal voltage. Return V_a to nominal.
3. Repeat step 2 for V_b.
4. Repeat step 2 for V_c.
5. Slowly reduce I_a and I_b magnitude to 0. The power factor feature should remain operated.
6. Slowly reduce I_c magnitude to 0. The power factor feature should reset.
7. Return I_a to nominal. The power factor feature should operate again. Return I_b and I_c to nominal.
8. Decrease the angle of lagging (balanced) current until the feature drops-out and resets the output relays.

Timing:

1. Connect the Stop Trigger.
2. Preset the 3-phase voltage and current inputs to a power factor more lagging than the pickup level. Turn voltages and currents off, and reset the timer.

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3. Inject the preset voltage and current and note the measured delay time. Reset the timer.
4. Repeat step 3 four more times and obtain an average of the time intervals.
5. Disconnect the “Stop Trigger.”

17.8.12 VT FAILURE

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

1. Set $V_{an} = V_{bn} = V_{cn}$ = nominal voltage at 0°, 120°, and 240° respectively, and inject into the relay. With these balanced voltages 120° apart, the positive sequence voltage (V_1) is greater than 0.05 x VT.
2. Set $I_a = I_b = I_c$ = 1 x CT at 0°, 120°, and 240° respectively, and inject into the relay. With these balanced currents 120° apart, the positive sequence current (I_1) is greater than 0.05 x CT.
3. Remove the balanced voltages so the positive sequence voltage (V_1) is less than 0.05 x VT. If this function is set to “Control”, any output relays programmed for this condition should operate. If the function is set to “Alarm”, check that the ALARM and MESSAGE indicators are flashing, the VT Failure alarm message is displayed, and any output relays programmed for this condition are operated.
4. Apply the balanced voltages and the VT Failure condition should reset.
5. Now reduce V_{an} until the VT Failure condition returns. Verify the ratio of the negative sequence voltage (V_2) to the positive sequence voltage (V_1) is 0.25 at this point. Return V_{an} to nominal and the VT Failure condition should reset. Repeat this step for V_{bn} and V_{cn}.
6. With $V_{an} = V_{bn} = V_{cn}$ returned to nominal voltage at 0°, 120°, and 240° respectively, reduce V_{an} until the VT Failure condition returns. Now reduce I_a until the VT Failure condition resets. Verify the ratio of the negative sequence current (I_2) to the positive sequence current (I_1) > 0.20 at this point. Return I_a to nominal and the VT Failure condition should reset. Repeat this step for I_b and I_c.

17.8.13 TRIP COIL MONITOR

1. Ensure the wiring to the circuit breaker trip and close circuits is complete.
2. Energize the breaker trip and close circuits and close the breaker.
3. Carefully disconnect a wire to open the trip circuit. After 5 seconds the element should generate an output.
4. Restore the open circuit and the element should reset.
5. If the Open Breaker permissive is Enabled, and the trip circuit wiring has been arranged to permit this operation, open the breaker.
6. Repeat steps 3 and 4.

Indications and Operations caused by the various Functions are as outlined under Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exceptions.

There is no Trip function for this element.

17.8.14 CLOSE COIL MONITOR

1. Ensure the wiring to the circuit breaker trip and close circuits is complete.
2. Energize the breaker trip and close circuits and open the breaker.
3. Carefully disconnect a wire to open the close circuit. After 5 seconds the element should generate an output.
4. Restore the open circuit and the element should reset.

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5. If the Closed Breaker permissive is Enabled, and the close circuit wiring has been arranged to permit this operation, close the breaker.
6. Repeat steps 3 and 4.

Indications and Operations caused by the various Functions are as outlined under Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exceptions.

There is no Trip function for this element.

17.8.15 BREAKER OPERATION FAILURE

1. Ensure the wiring to the circuit breaker trip and close circuits is complete.
2. Energize the breaker trip and close circuits and open the breaker.
3. Carefully disconnect a wire to open the close circuit. Apply a momentary Close command to the relay. After a delay the element should generate an output (the delay time can be checked in the Event Recorder).
4. Restore the open circuit and Reset the relay.
5. Close the breaker.
6. Carefully disconnect a wire to open the trip circuit. Apply a momentary Trip command to the relay. After a delay the element should generate an output (the delay time can be checked in the Event Recorder)
7. Restore the open circuit and Reset the relay.
8. Open and close the breaker a number of times to confirm the delay time provides sufficient margin to allow for normal operation of the breaker.

Indications and Operations caused by the various Functions are as outlined under Section 17.7.3: PHASE TIME OVERCURRENT 1 on page 17–21, with the following exceptions.

There is no Trip function for this element.

17.8.16 ARCING CURRENT

This test requires equipment which is seldom readily available in the field. It is suggested that as this feature does not require extreme levels of reliability and security it is not necessary to be field-tested. (A procedure is available upon request for those users wishing to perform this test.

We suggest the following procedure to confirm this element is operational.

1. Check the value displayed under **A3 \ MAINTENANCE \ ARCING CURRENT \ TOTAL ARCING CURRENT** for each phase. Set the **TOTAL ARCING CURRENT LIMIT** to a level just above this value. Now perform a number of O/C element tests, with current maintained after the Trip command, until this element generates an output.
2. Be sure to reset the Total Arcing Current memory and setpoint at the end of this test.

Indications and Operations caused by the various Functions are as outlined under Phase Time O/C, with the following exceptions.

There is no Trip function for this element.

17.8.17 ANALOG OUTPUT CHANNELS

1. Connect a milliammeter to channel output terminals as required.
2. Follow the test procedures previously outlined for the channel parameter observing the output on the milliammeter.

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17.8.18 IRIG-B

1. Disconnect the IRIG-B input to the relay from the signal source.
2. Under **S1 RELAY SETUP \ CLOCK** manually set the relay date and time to incorrect values.
3. Under **A1 STATUS \ CLOCK** check that the relay has accepted the programmed date and time.
4. Set the IRIG-B Time Sync setpoint to the required signal type - the relay should display self-test warning IRIG-B Failure.
5. Connect the IRIG-B input from the signal source to the relay and check the signal is available at the relay terminals.
6. Self-test warning IRIG-B Failure should be removed from the display.
7. Under **A1 STATUS \ CLOCK** check that the relay clock now displays the correct date and time.

17.8.19 PULSE OUTPUT

1. Inject quantity to be used to provide a pulse output.
2. Observe that the pulses occur at the proper intervals by using the Actual Value measurement provided by the relay. A counter or oscilloscope may also be used to confirm pulse timing.

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NOTE

The relay is defaulted to setpoint group 1, and will be using this group for setpoints unless specifically changed to another group. This procedure assumes the relay is using group 1 initially, as indicated by the LED on the faceplate.

Make connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

1. Change setpoint **SETPOINTS \ S7 CONTROL \ SETPOINT GROUPS \ ACTIVE SETPOINT GROUP** to Group 2 with the **EDIT SETPOINT GROUP** set to Active Group. The LED on the faceplate should now indicate the relay is using setpoint group 2.
2. Change at least one protection element setpoint from the setting in group 1.
3. Repeat steps 2 and 3 for active setpoint group selections of Group 3 and Group 4, while monitoring that the LED indicators show the correct group.
4. Check that the operation of the protection feature programmed is controlled by the setting in group 4.
5. Change setpoint **SETPOINTS \ S7 CONTROL \ SETPOINT GROUPS \ ACTIVE SETPOINT GROUP** to Group 3. The LED on the faceplate should now indicate the relay is using setpoint group 3.
6. Check that the operation of the protection feature programmed is controlled by the setting in group 3.
7. Change setpoint **SETPOINTS \ S7 CONTROL \ SETPOINT GROUPS \ ACTIVE SETPOINT GROUP** to Group 2. The LED on the faceplate should now indicate the relay is using setpoint group 2.
8. Check that the operation of the protection feature programmed is controlled by the setting in group 2.
9. Change setpoint **SETPOINTS \ S7 CONTROL \ SETPOINT GROUPS \ ACTIVE SETPOINT GROUP** to Group 1. The LED on the faceplate should now indicate the relay is using setpoint group 1.
10. Check that the operation of the protection feature programmed is controlled by the setting in group 1.
11. Assert logic input Setpoint Group 2, and check that the LED indicator shows Setpoint Group 2.
12. Assert logic input Setpoint Group 3, and check that the LED indicator shows Setpoint Group 3.
13. Assert logic input Setpoint Group 4, and check that the LED indicator shows Setpoint Group 4.
14. De-assert logic input Setpoint Group 4, and check that the LED indicator shows Setpoint Group 3.
15. De-assert logic input Setpoint Group 3, and check that the LED indicator shows Setpoint Group 2.
16. De-assert logic input Setpoint Group 2, and check that the LED indicator shows Setpoint Group 1.
17. Check that the changing of setpoint groups is placed in the event recorder.

If setpoint BREAKER OPEN INHIBIT is to be Enabled

1. Assert a breaker state logic input so that the relay determines the breaker is closed.
2. Assert logic input Setpoint Group 2. The faceplate LED should indicate the relay is using setpoint group 2.
3. De-assert the breaker state logic input so that the relay determines the breaker is open.
4. De-assert logic input Setpoint Group 2. The LED on the faceplate should indicate the relay is still using setpoint group 2.
5. Assert the breaker state logic input so that the relay determines the breaker is closed.
6. The LED on the faceplate should indicate the relay is now using setpoint group 1.

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If setpoint OVERCURRENT P/U INHIBIT is to be Enabled

1. Assert logic input Setpoint Group 2. The faceplate LED should indicate the relay is using setpoint group 2.
2. Inject current above the pickup setting of an overcurrent element that is not Disabled.
3. De-assert logic input Setpoint Group 2. The LED on the faceplate should indicate the relay is still using setpoint group 2.
4. Reduce the injected current until the overcurrent element resets.
5. The LED on the faceplate should indicate the relay is now using setpoint group 1. Turn current off.

If setpoint OVERVOLT P/U INHIBIT is to be Enabled

1. Assert logic input Setpoint Group 2. The faceplate LED should indicate the relay is using setpoint group 2.
2. Inject voltage above the pickup setting of an overvoltage element that is not Disabled.
3. De-assert logic input Setpoint Group 2. The LED on the faceplate should indicate the relay is still using setpoint group 2.
4. Reduce the injected voltage until the overvoltage element resets.
5. The LED on the faceplate should indicate the relay is now using setpoint group 1. Turn voltage off.

If setpoint UNDERVOLT P/U INHIBIT is to be Enabled

1. Inject voltage above the pickup setting of an undervoltage element that is not Disabled.
2. Assert logic input Setpoint Group 2. The faceplate LED should indicate the relay is using setpoint group 2.
3. Reduce voltage below the pickup setting of an undervoltage element that is not Disabled.
4. De-assert logic input Setpoint Group 2. The LED on the faceplate should indicate the relay is still using setpoint group 2.
5. Increase the injected voltage until the undervoltage element resets.
6. The LED on the faceplate should indicate the relay is now using setpoint group 1. Turn voltage off.

If setpoint UNDERFREQ P/U INHIBIT is to be Enabled

1. Inject voltage with frequency above the pickup setting of an underfrequency element that is not Disabled.
2. Assert logic input Setpoint Group 2. The faceplate LED should indicate the relay is using setpoint group 2.
3. Reduce frequency below the pickup setting of an underfrequency element that is not Disabled.
4. De-assert logic input Setpoint Group 2. The LED on the faceplate should indicate the relay is still using setpoint group 2.
5. Increase the injected frequency until the underfrequency element resets.
6. The LED on the faceplate should indicate the relay is now using setpoint group 1. Turn voltage off.

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1. Make test connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4 and also connect a variable voltage source to the line voltage input.
2. Initially set the function setpoint to Control, the Dead Source Permissive setpoint to Off and the Maximum Voltage Difference setpoint to 100 kV.
3. As there are no input voltages, any selected output relays should now be operated along with the Out Of Sync control message.
4. Change the function setting to Alarm. The alarm message and LED should be displayed, and any selected output relays should remain operated.
5. Inject a balanced three-phase voltage at nominal voltage and frequency into the bus voltage input.
6. Turn off the voltage and make parallel connections (observing polarity) from the bus voltage input that corresponds with the selection made under subheading **S2 SYSTEM SETUP \ LINE VT SENSING \ VT CONNECTION** to the line voltage input. Turn the voltage on and check that these voltages show difference measurements of 0 under **A2 METERING \ VOLTAGE \ SYNCHRO DELTA**. (The ΔV will not be 0 unless the bus and line VTs have identical ratings. If the difference is not shown as 0, calculate the two equivalent primary voltage values for the injected voltage; they should be the same.) This checks that the relay has selected the correct bus voltage input for the synchrocheck measurements. Turn the voltage off and remove the parallel connections.
7. Inject a single-phase voltage at nominal voltage and frequency into the bus voltage input that corresponds with the selection made under subheading **S2 SYSTEM SETUP \ LINE VT SENSING \ VT CONNECTION**.
8. Inject voltage and frequency into the line voltage input and adjust this voltage until ΔV, $\Delta\Phi$ and ΔF as shown under subheading **A2 METERING \ VOLTAGE \ SYNCHRO DELTA** are all 0. Reduce the line voltage magnitude to 0.
9. The “Out of Sync” alarm will be displayed as the line voltage is below the minimum voltage requirement. Slowly raise this voltage until the “Out of Sync” alarm is no longer displayed. This magnitude should be the setpoint value.
10. Raise the line voltage input to the nominal value, and lower the bus voltage magnitude to 0. The “Out of Sync” alarm will be displayed as the bus voltage is below the minimum voltage requirement. Slowly raise this voltage until the “Out of Sync” alarm is no longer displayed. This magnitude should be the setpoint value.
11. Enter the required setting of Maximum Voltage Difference. The “Out of Sync” alarm will be displayed as the voltage difference is above the maximum difference requirement.
12. While monitoring ΔV on the display, slowly raise the bus voltage until the “Out of Sync” alarm is no longer displayed. Check that the voltage difference is the selected value.
13. Set the bus voltage magnitude to nominal, and the line voltage to a level above the minimum required voltage.
14. The “Out of Sync” alarm will be displayed as the voltage difference is above the maximum difference requirement.
15. While monitoring ΔV on the display, slowly raise the line voltage until the “Out of Sync” alarm is no longer displayed. Check that the voltage difference is the selected value.
16. Set both line and bus voltage magnitude and frequency to nominal. Adjust the line voltage phase position to lag the bus voltage by 180°.
17. The “Out of Sync” alarm will be displayed as the angle difference is above the maximum difference requirement.

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18. While monitoring $\Delta\phi$ on the display, slowly increase the line voltage lagging phase position until the "Out of Sync" alarm is no longer displayed. Check that the angle difference is the selected value. Return the line voltage angle to 0°.
19. Set the line voltage frequency to a value lower than allowed by the maximum frequency difference.
20. While monitoring ΔF on the display, slowly increase the line voltage frequency until the "Out of Sync" alarm is no longer displayed. Check that the frequency difference is the selected value.
21. Set the line voltage to a frequency higher than permitted by the maximum frequency difference.
22. The "Out of Sync" alarm will be displayed as the frequency difference is above the maximum difference requirement. While monitoring ΔF on the display, slowly decrease the line voltage frequency until the "Out of Sync" alarm is no longer displayed. Check that the frequency difference is the selected value. Turn voltages off.

If the Dead Source Permissive feature is to be used, set the Maximum Voltage Difference, Maximum Angle Difference, and Maximum Frequency Difference setpoints to the minimum values; and the Dead Source Permissive, Dead Bus Maximum Voltage, Dead Line Maximum Voltage, Live Bus Minimum Voltage, and Live Line Minimum Voltage setpoints to the required settings.

For a DEAD SOURCE PERMISSIVE setpoint of *DB & DL*, perform the following steps:

1. Set the bus voltage to a magnitude above the dead-bus level, and nominal frequency and inject into the relay.
2. Set the line voltage to a magnitude above the dead-line level, 180° out-of-phase with the bus voltage, at the same frequency, and inject into the relay. This ensures synchronism cannot be achieved. The "Out of Sync" alarm will be displayed as both the bus and line voltages are above their dead-setting limits.
3. Turn the bus voltage off. The "Out of Sync" alarm will be displayed as line voltage is above the dead limit.
4. Slowly reduce the line voltage, until the "Out of Sync" alarm is no longer displayed. This should be at the dead line max volt limit. Return the voltages to the level prior to the reduction.
5. The "Out of Sync" alarm will be displayed as both the bus and line voltages are above their dead-setting limits.
6. Turn the line voltage off. The "Out of Sync" alarm will be displayed.
7. Slowly reduce the bus voltage, until the "Out of Sync" alarm is no longer displayed. This should be at the dead bus max volt limit. Turn the voltages off.

For a DEAD SOURCE PERMISSIVE setpoint of *LL & DB*, perform the following steps:

1. Set the line voltage to nominal magnitude and frequency and inject into the relay. Set the bus voltage to a magnitude above the dead-bus level, 180° out-of-phase with the line voltage, at the same frequency, and inject into the relay. This ensures synchronism cannot be achieved.
2. The "Out of Sync" alarm will be displayed as the bus voltage is above its dead-setting limit.
3. Slowly reduce the bus voltage magnitude until the "Out of Sync" alarm is no longer displayed. This should be at the dead bus max volt limit. Turn both voltages off. The "Out of Sync" alarm will be displayed as the line voltage is below its minimum voltage setting limit.
4. Slowly increase the line voltage magnitude until the "Out of Sync" alarm is no longer be displayed. This should be at the minimum live line voltage limit. Turn both voltages off.

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For a DEAD SOURCE PERMISSIVE setpoint of *DL & LB*, perform the following steps:

1. Set the bus voltage to nominal magnitude and frequency and inject into the relay. Set the line voltage to a magnitude above the dead-line level, 180° out-of-phase with the bus voltage, at the same frequency, and inject into the relay. This ensures synchronism cannot be achieved.
2. The "Out of Sync" alarm will be displayed as the line voltage is above its dead-setting limit.
3. Slowly reduce the line voltage magnitude until the "Out of Sync" alarm is no longer displayed. This should be at the dead line max volt limit. Turn both voltages off.
4. The "Out of Sync" alarm will be displayed as the bus voltage is below its minimum voltage setting limit.
5. Slowly increase the bus voltage magnitude until the "Out of Sync" alarm is no longer displayed. This should be at the minimum live bus voltage limit. Turn both voltages off.

For a DEAD SOURCE PERMISSIVE setpoint of *DL | DB*, perform the following steps:

1. Set the bus voltage to nominal magnitude and frequency and inject into the relay. Set the line voltage to nominal magnitude, 180° out-of-phase with the bus voltage, at the same frequency, and inject into the relay. This ensures synchronism cannot be achieved.
2. The "Out of Sync" alarm will be displayed as both voltages are above the dead-setting limits.
3. Slowly reduce the line voltage magnitude until the "Out of Sync" alarm is no longer displayed. This should be at the dead line max volt limit. Increase the line voltage to nominal magnitude.
4. Slowly reduce the bus voltage magnitude until the "Out of Sync" alarm is no longer displayed. This should be at the dead bus max volt limit. Turn both voltages off.

For a DEAD SOURCE PERMISSIVE setpoint of *DL X DB*, perform the following steps:

1. Set the bus voltage to a magnitude above the max dead-bus limit and below the min live-bus limit at nominal frequency and inject into the relay. Set the line voltage to a magnitude above the min live-line limit, 180° out-of-phase with the bus voltage, at the same frequency, and inject into the relay. This ensures synchronism cannot be achieved. The "Out of Sync" alarm will be displayed.
2. Slowly decrease the bus voltage magnitude until the "Out of Sync" alarm is no longer displayed. This should be just below the max dead-bus volt limit.
3. Slowly decrease the line voltage magnitude until the "Out of Sync" alarm is again displayed. This should be just below the min live-line volt limit.
4. Decrease the line voltage magnitude to below the max dead-line limit. The "Out of Sync" alarm should remain displayed.
5. Increase the bus voltage magnitude to above the min live-bus limit at which point the "Out of Sync" alarm is no longer displayed.
6. Slowly increase the line voltage magnitude. At just above the max dead-line limit the "Out of Sync" alarm should be displayed. Turn both voltages off.

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Make connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Function and Timer Control:

Assert the 52a (or 52b) Contact logic input to simulate an open breaker.

1. If in Local mode, press the front panel CLOSE key momentarily to generate a close command, if in Remote mode assert a momentary Remote Close logic input to cause the relay to go into manual close blocking, and generate an output from this feature. Check that any selected output relays have operated. If the function is selected as Alarm, the alarm message should be displayed with the ALARM LED turned on.
2. After a time interval equal to the Manual Close Block Time, the above indications should reset. This interval can be checked in the Event Recorder.

a) CONTROL OF O/C PROTECTION FEATURES

Phase Inst OC 1 Blocking

1. Set a test current, in the number of phases required to generate an output, to a level above the pickup of this element then turn the current off.
2. Apply a Close command, as described above, and immediately inject the test current to the relay. The element will not pickup as it is blocked by manual close blocking. Wait until the element operates, as shown by the PICKUP indicator coming on, at the end of the programmed Manual Close Block Time.
3. Turn the current off. The time interval can be checked in the Event Recorder.

Neutral Inst OC 1 Blocking

1. Follow the procedure described for Phase Inst OC 1 Blocking, injecting current as appropriate.
2. Ground Inst OC Blocking
3. Follow the procedure described for Phase Inst OC 1 Blocking, injecting current as appropriate.

Ground Inst OC Blocking

Follow the procedure described for Phase Inst OC 1 Blocking, injecting current as appropriate.

Sensitive Ground Inst OC Blocking

Follow the procedure described for Phase Inst OC 1 Blocking, injecting current as appropriate.

Neg Seq Inst OC Blocking

Follow the procedure described for Phase Inst OC 1 Blocking, injecting current as appropriate.

Phase Time OC 1 Raised Pickup

1. Ensure all other O/C features are Disabled.
2. Manual Close Blocking will raise the pickup setting of the Curve normally used by this feature the programmed percentage. Set a test current to a level between the normal pickup setting and the raised setting, then turn the current off.
3. Apply a Close command, as described above, and immediately inject the test current into the relay. Phase time O/C will not pickup as the pickup current is raised. Increase the injection current until the PICKUP

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indicator comes on, before the manual close feature times-out and returns the pickup to normal. Check that the raised pickup level is correct. Turn current off, and wait until the alarm is removed from the display.

4. Set a test current to a level between the normal pickup setting and the raised setting, then turn the current off.
5. Apply a Close command, as described above, and immediately inject the test current into the relay. Phase time O/C will not pickup as the pickup current is raised.
6. At the end of the programmed **MANUAL CLOSE BLOCK TIME** the PICKUP indicator should come on, as the pickup setting has returned to normal. When this happens, reduce the injection current until the PICKUP indicator goes out. The **MANUAL CLOSE BLOCK TIME** can be checked in the Event Recorder.

Neutral Time OC 1 Raised Pickup

Follow the procedure outlined for Phase Time O/C 1 Raised Pickup, injecting current as appropriate.

Ground Time OC Raised Pickup

Follow the procedure outlined for Phase Time O/C 1 Raised Pickup, injecting current as appropriate.

Sensitive Ground Time OC Raised Pickup

Follow the procedure outlined for Phase Time O/C 1 Raised Pickup, injecting current as appropriate.

Neg Seq Time OC Raised Pickup

Follow the procedure outlined for Phase Time O/C 1 Raised Pickup, injecting current as appropriate.

Select Setpoint Group

Apply a manual close and verify that the selected setpoint group becomes active when the breaker closes. Verify that settings return to the previous setpoint group after the **MANUAL CLOSE BLOCK TIME** expires.

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Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Procedure To Check:

Function and Timer Control:

1. Enable the Cold Load Pickup setpoint to cause the relay to go into cold load pickup operation after the setpoint Outage Time Before Cold Load expires. Check that any selected output relays have operated. If the function is selected as Alarm, the alarm message and LED should also be turned on.
2. Inject a current in any phase below 10% of nominal, and slowly increase. The relay should go into cold load operation when the current is above 10% of nominal. The alarm message and LED should reset and any output relays programmed to operate should dropout after a time interval equal to the cold load pickup block time. This interval can be checked in the Event Recorder.
3. Reduce this current to 3% of nominal and simultaneously start a timer. This feature should generate an output at the end of the **OUTAGE TIME BEFORE COLD LOAD** setting.

a) CONTROL OF O/C PROTECTION FEATURES

Phase Inst OC 1 Blocking

1. Set a test current, in the number of phases required to generate an output, to a level above the pickup of this element then turn the current off.
2. Assert a Cold Load Pickup logic input, and immediately apply the test current to the relay. The element will not pickup as it is blocked by cold load pickup blocking. Wait until the element operates, as shown by the PICKUP indicator coming on at the end of the programmed Cold Load Pickup Block Time.
3. Turn the current off. The time interval can be checked in the Event Recorder.

Neutral Inst OC 1 Blocking

Follow the procedure described for Phase Inst OC 1 Blocking, injecting current as appropriate.

Ground Inst OC Blocking

Follow the procedure described for Phase Inst OC 1 Blocking, injecting current as appropriate.

Sensitive Ground Inst OC Blocking

Follow the procedure described for Phase Inst OC 1 Blocking, injecting current as appropriate.

Neg Seq Inst OC Blocking

Follow the procedure described for Phase Inst OC 1 Blocking, injecting current as appropriate.

Phase Time OC 1 Raised Pickup

1. Ensure all other O/C features are Disabled.
2. Cold Load Pickup Blocking will raise the pickup setting of the Curve normally used by the programmed percentage. Set a test current to a level between the normal pickup setting and the raised setting, (at least 5% of nominal current) then turn the current off.
3. Assert a Cold Load Pickup logic input and immediately inject the test current into the relay. Phase Time O/C 1 will not pickup as the pickup current is raised. Increase the injection current until the PICKUP indicator

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comes on, before the cold load pickup blocking feature times-out and returns the pickup to normal. Check that the raised pickup level is correct. Turn current off, and wait until the alarm is removed from the display.

4. Set a test current to a level between the normal pickup setting and the raised setting, then turn the current off.
5. Assert a Cold Load Pickup logic input and immediately inject the test current into the relay. Phase time O/C 1 will not pickup as the pickup current is raised.
6. At the end of the programmed Cold Load Pickup Block Time the PICKUP indicator should come on, as the pickup setting has returned to normal. When this happens, reduce the injection current until the PICKUP indicator goes out. The Cold Load Pickup Block Time interval can be checked in the Event Recorder.

Neutral Time OC 1 Raised Pickup

Follow the procedure outlined for Phase Time O/C 1 Raised Pickup, injecting current as appropriate.

Ground Time OC Raised Pickup

Follow the procedure outlined for Phase Time O/C 1 Raised Pickup, injecting current as appropriate.

Sensitive Ground Time OC Raised Pickup

Follow the procedure outlined for Phase Time O/C 1 Raised Pickup, injecting current as appropriate.

Neg Seq Time OC Raised Pickup

Follow the procedure outlined for Phase Time O/C 1 Raised Pickup, injecting current as appropriate.

Select Setpoint Group

Apply a Cold Load Pickup logic input and verify that the selected setpoint group becomes active. Verify that settings return to the previous setpoint group after the Cold Load Pickup Block Time interval expires.

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Procedure To Check Logic and Timers

1. Make connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.
2. Note that Undervoltage 1 must be programmed, with the function as Trip, and Undervoltage 2 must be Disabled.
3. Assert or De-assert a logic input to simulate a closed breaker.
4. Inject a balanced three-phase voltage at nominal voltage and frequency into the bus voltage input.
5. Initially set the undervoltage restoration function setpoint to Alarm, and other setpoints as required.
6. Turn the voltage off. After the programmed delay Undervoltage 1 should cause a trip, which should not initiate undervoltage restoration as the breaker is closed. Diagnostic message "Uvolt Restore Init" should not be displayed.
7. Assert or De-assert a logic input to simulate an open breaker, which should initiate undervoltage restoration. The diagnostic alarm message and LED should be displayed, and any output relays programmed to operate for this condition should operate.
8. Change the Undervoltage Restoration function setpoint to Control, and the diagnostic message should change to control and the ALARM LED should turn off. Return this setpoint to Alarm.
9. Assert logic input Block Restoration. The diagnostic alarm message and LED should be removed from the display, and any output relays that operated should reset.
10. De-assert the logic input. The alarm message and LED should again be displayed and output relays operated. After the delay programmed in Incomplete Sequence Time the alarm message and LED should be removed from the display and output relays reset.
11. Return the reduced voltage to nominal, resetting both the undervoltage trip condition and undervoltage restoration.
12. Reduce voltage until Undervoltage 1 trips, then immediately return the voltage to nominal. The diagnostic alarm message and LED should be displayed, and output relays operated.
13. Provide a Reset to the relay, and the alarm message and LED should be removed from the display and output relays reset. Remove the Reset.
14. Arrange the interval timer to start on appearance of voltage and stop when the 2 CLOSE relay operates.
15. Turn the voltage off to cause an Undervoltage 1 trip, then reset the timer.
16. Turn the voltage on. The 2 CLOSE relay should operate after the delay programmed in setpoint **UNDERVOLT RESTORE DELAY**.
17. If Undervoltage 2 initiation is to be checked change the **UNDERVOLTAGE RESTORATION** function setpoint to *Disabled*, **UNDERVOLTAGE 1 FUNCTION** to *Disabled*, **UNDERVOLTAGE 2 FUNCTION** to *Trip* and repeat steps 3 through 7.

a) FOR WYE VTs

Test Connections per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION on page 17–4.

Procedure To Check Minimum Voltage with One Phase For Operation

1. Assert or De-assert a logic input to simulate an open breaker.
2. Set Undervolt Restore Delay to 0.

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3. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
4. Reduce the injected voltages to cause an undervoltage trip, then set V_{bn} and V_{cn} to 0
5. Slowly raise V_{an} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{an}.
6. Repeat steps 3 through 5 except adjust V_{bn} and V_{cn} in turn.

Procedure To Check Minimum Voltage with Two Phases For Operation:

1. Assert or De-assert a logic input to simulate an open breaker.
2. Set Undervolt Restore Delay to 0.
3. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
4. Reduce the injected voltages to cause an undervoltage trip, then set V_{bn} to 0 and V_{cn} to nominal.
5. Slowly raise V_{an} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{an} with V_{cn}.
6. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
7. Reduce the injected voltages to cause an undervoltage trip, then set V_{cn} to 0 and V_{bn} to nominal.
8. Slowly raise V_{an} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{an} with V_{bn}.
9. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
10. Reduce the injected voltages to cause an undervoltage trip, then set V_{cn} to 0 and V_{an} to nominal.
11. Slowly raise V_{bn} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{bn} with V_{an}.
12. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
13. Reduce the injected voltages to cause an undervoltage trip, then set V_{an} to 0 and V_{cn} to nominal.
14. Slowly raise V_{bn} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{bn} with V_{cn}.
15. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
16. Reduce the injected voltages to cause an undervoltage trip, then set V_{an} to 0 and V_{bn} to nominal.
17. Slowly raise V_{cn} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{cn} with V_{bn}.
18. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
19. Reduce the injected voltages to cause an undervoltage trip, then set V_{bn} to 0 and V_{an} to nominal.
20. Slowly raise V_{cn} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{cn} with V_{an}.

Procedure To Check Minimum Voltage with Three Phases For Operation:

1. Assert or De-assert a logic input to simulate an open breaker.
2. Set Undervolt Restore Delay to 0.
3. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
4. Reduce the injected voltages to cause an undervoltage trip, then set V_{an} and V_{cn} to nominal.

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5. Slowly raise V_{an} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{an}.
6. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
7. Reduce the injected voltages to cause an undervoltage trip, then set V_{an} and V_{cn} to nominal.
8. Slowly raise V_{bn} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{bn}.
9. Inject $V_{an} = V_{bn} = V_{cn}$ = nominal voltage into the bus voltage input of the relay.
10. Reduce the injected voltages to cause an undervoltage trip, then set V_{an} and V_{bn} to nominal.
11. Slowly raise V_{cn} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{cn}.

b) FOR DELTA VTs

Test Connections per Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.

Procedure To Check Minimum Voltage with One Phase For Operation

1. Assert or De-assert a logic input to simulate an open breaker.
2. Set Undervolt Restore Delay to 0.
3. Inject $V_{ab} = V_{cb}$ = nominal voltage into the bus voltage input of the relay.
4. Reduce the injected voltages to cause an undervoltage trip, then set V_{cb} to 0
5. Slowly raise V_{ab} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{ab}.
6. Repeat steps 3 through 5 except adjust V_{cb}.

Pickup with Two or Three Phases For Operation:

1. Assert or De-assert a logic input to simulate an open breaker.
2. Set Undervolt Restore Delay to 0.
3. Inject $V_{ab} = V_{cb}$ = nominal voltage into the bus voltage input of the relay.
4. Reduce the injected voltages to cause an undervoltage trip, then set V_{cb} to nominal
5. Slowly raise V_{ab} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{ab}.
6. Inject $V_{ab} = V_{cb}$ = nominal voltage into the bus voltage input of the relay.
7. Reduce the injected voltages to cause an undervoltage trip, then set V_{ab} to nominal
8. Slowly raise V_{cb} until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERVOLT RESTORE MIN VOLTS** for V_{cb}.

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a) PROCEDURE FOR LOGIC AND TIMERS

1. Make connections for this test per Figure 17–1: RELAY TEST WIRING – WYE CONNECTION or Figure 17–2: RELAY TEST WIRING – DELTA CONNECTION on page 17–4.
2. Note that **UNDERFREQUENCY 1** must be programmed, with the function as *Trip*, **MINIMUM VOLTAGE** as 0, and **UNDERFREQUENCY 2** must be *Disabled*.
3. Assert or De-assert a logic input to simulate a closed breaker.
4. Inject a voltage at nominal voltage and frequency into the bus voltage phase A input.
5. Initially set **UNDERFREQUENCY RESTORATION** setpoint to *Alarm*, and other setpoints as required.
6. Reduce the frequency to below the underfrequency pickup level. After the programmed delay **UNDERFREQUENCY 1** should cause a trip, which should not initiate underfrequency restoration as the breaker is closed. Diagnostic message "Ufreq Restore Init" should not be displayed.
7. Assert or De-assert a logic input to simulate an open breaker, which should initiate underfrequency restoration. The diagnostic alarm message and LED should be displayed, and any output relays programmed to operate for this condition should operate.
8. Change the Underfrequency Restoration function setpoint to Control, and the diagnostic message should change to control and the ALARM LED should turn off. Return this setpoint to Alarm.
9. Assert logic input Block Restoration. The diagnostic alarm message and LED should be removed from the display, and any output relays that operated should reset.
10. De-assert the logic input. The alarm message and LED should again be displayed and output relays operated. After the delay programmed in **INCOMPLETE SEQUENCE TIME**, the alarm message and LED should be removed from the display and output relays reset.
11. Return the reduced frequency to nominal, resetting both the underfrequency trip condition and underfrequency restoration.
12. Reduce frequency until Underfrequency 1 trips, then immediately return the frequency to nominal. The diagnostic alarm message and LED should be displayed, and output relays operated.
13. Provide a Reset to the relay, and the alarm message and LED should be removed from the display and output relays reset. Remove the Reset.
14. Arrange the interval timer to start on appearance of voltage and stop when the 2 CLOSE relay operates.
15. Turn the voltage, of a frequency to cause an Underfrequency 1 trip, off. Reset the timer.
16. Turn the voltage on. The 2 CLOSE relay should operate after the delay programmed in setpoint **UNDERFREQ RESTORE DELAY**.
17. If Underfrequency 2 initiation is to be checked, change **UNDERFREQUENCY RESTORATION** to *Disabled*, **UNDERFREQUENCY 1** to *Disabled*, **UNDERFREQUENCY 2** to *Trip* and repeat steps 3 through 7.

b) PROCEDURE TO CHECK MINIMUM VOLTAGE

1. Assert or De-assert a logic input to simulate an open breaker.
2. Set **UNDERFREQ RESTORE DELAY** to *0*.
3. Inject a voltage below the **UNDERFREQ RESTORE MIN VOLTS** level into the bus voltage input of the relay.
4. Reduce the injected frequency to cause an underfrequency trip, then increase the frequency to nominal.
5. Slowly raise V_a until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERFREQ RESTORE MIN VOLTS**.

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c) PROCEDURE TO CHECK MINIMUM FREQUENCY

1. Assert or De-assert a logic input to simulate an open breaker.
2. Set **UNDERFREQ RESTORE DELAY** to *0*.
3. Inject nominal voltage into the bus voltage input of the relay.
4. Reduce the injected frequency to cause an underfrequency trip.
5. Slowly increase the frequency until the 2 CLOSE relay operates. This is the operating level of setpoint **UNDERFREQ RESTORE MIN FREQ**.

17.9.7 TRANSFER SCHEME

a) COMMON LOGIC

1. Ensure that the **PHASE INST O/C 1**, **NEUTRAL INST O/C 1**, **LINE UNDERVOLTAGE 3**, **LINE UNDERVOLTAGE 4**, **SYNCHROCHECK** and **LOGIC INPUT** features in the relays programmed as Incomer 1 and Incomer 2 have been tested and are *Enabled*.
2. Ensure that the **SYNCHROCHECK** and **LOGIC INPUT** features in the relay programmed as Bus Tie has been tested and is *Enabled*.
3. Ensure all circuit breakers are disconnected from their normal positions in the primary circuit, are open and operating properly, and the close and trip circuits have been tested and are energized.
4. De-assert logic inputs 1, 2, 3, 4, 5, 6, 11, 12 and 13 at both Incomer relays. De-assert logic inputs 1, 2, 3, 4, 5, 6 and 11 at the Bus Tie relay.
5. At this time both of the Incomer relays should have output relays 1 TRIP and 4 operated, output relays 5 through 7 reset, and be displaying the message Transfer Not Ready. At the Bus Tie breaker relay output relays 4 through 7 should be reset (de-energized).
6. Parallel the Line to Bus voltage inputs of the Incomer 1 relay to the Bus voltage input of the Bus Tie relay and connect this circuit to a voltage source (Source 1 for these tests.) Do not energize the source.
7. Parallel the Line to Bus voltage inputs of the Incomer 2 relay to the Line voltage input of the Bus Tie relay and connect this circuit to a voltage source (Source 2 for these tests.) Do not energize the source.
8. Assert logic input 5 (Breaker Connected) at the Bus Tie relay - output relays 4 and 6 on the Bus Tie relay should operate.
9. Assert logic input 5 (Breaker Connected) at the Incomer 1 relay - nothing should happen.
10. Assert logic input 2 (Remote Close) at the Incomer 1 relay - nothing should happen. Energize Source 1 at nominal voltage - the Incomer 1 breaker should close, output relay 4 should reset and relays 5 and 7 on the Incomer 1 relay should operate.
11. Assert logic input 5 (Breaker Connected) at the Incomer 2 relay - nothing should happen.
12. Assert logic input 2 (Remote Close) at the Incomer 2 relay - nothing should happen. Energize Source 2 at nominal voltage - the Incomer 2 breaker should close, output relay 4 should reset and relays 5 and 7 on the Incomer 2 relay should operate.
13. De-assert logic input 5 (Breaker Connected) at the Bus Tie relay - output relays 4 and 6 on the Bus Tie relay should reset, and at both Incomer relays the message Transfer Not Ready should be displayed.
14. Assert logic input 5 (Breaker Connected) at the Bus Tie relay - output relays 4 and 6 on the Bus Tie relay should operate, and at both Incomer relays the message Transfer Not Ready should be removed from the display.
15. De-assert logic input 5 (Breaker Connected) at the Incomer 1 relay - at the Incomer 1 relay output relays 5 and 7 should reset; at both Incomer relays the message Transfer Not Ready should be displayed.

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16. Assert logic input 5 (Breaker Connected) at the Incomer 1 relay - at the Incomer 1 relay output relays 5 and 7 should operate; at both Incomer relays the message Transfer Not Ready should be removed from the display.
17. Momentarily assert logic input 3 (Remote Open) at the Incomer 1 relay - the Incomer 1 breaker should trip and output relays 5 and 7 should reset; at both Incomer relays the message Transfer Not Ready should be displayed.
18. Momentarily assert logic input 2 (Remote Close) at the Incomer 1 relay - the Incomer 1 breaker should close and output relays 5 and 7 should operate; at both Incomer relays the message Transfer Not Ready should be removed.
19. De-assert logic input 5 (Breaker Connected) at the Incomer 2 relay - at the Incomer 2 relay output relays 5 and 7 should reset; at both Incomer relays the message Transfer Not Ready should be displayed.
20. Assert logic input 5 (Breaker Connected) at the Incomer 2 relay - at the Incomer 2 relay output relays 5 and 7 should operate; at both Incomer relays the message Transfer Not Ready should be removed from the display.
21. Momentarily assert logic input 3 (Remote Open) at the Incomer 2 relay - the Incomer 2 breaker should trip and output relays 5 and 7 should reset; at both Incomer relays the message Transfer Not Ready should be displayed.
22. Momentarily assert logic input 2 (Remote Close) at the Incomer 2 relay - the Incomer 2 breaker should close and output relays 5 and 7 should operate; at both Incomer relays the message Transfer Not Ready should be removed from the display.
23. Momentarily assert logic input 2 (Remote Close) at the Bus Tie relay - the Bus Tie breaker should close and output relays 5 and 7 should operate; at both Incomer relays the Transfer Not Ready message should be displayed.
24. Momentarily assert logic input 3 (Remote Open) at the Bus Tie relay - the Bus Tie breaker should trip and output relays 5 and 7 should reset; at both Incomer relays the Transfer Not Ready message should be removed from the display.
25. Assert logic input 11 (Block Transfer) at the Incomer 1 relay - output relays 5 and 7 should reset; at both Incomer relays the Transfer Not Ready message should be displayed.
26. De-assert logic input 11 (Block Transfer) at the Incomer 1 relay - output relays 5 and 7 should operate; at both Incomer relays the Transfer Not Ready message should be removed from the display.
27. Assert logic input 11 (Block Transfer) at the Incomer 2 relay - output relays 5 and 7 should reset; at both Incomer relays the Transfer Not Ready message should be displayed.
28. De-assert logic input 11 (Block Transfer) at the Incomer 2 relay - output relays 5 and 7 should operate; at both Incomer relays the Transfer Not Ready message should be removed from the display.
29. Check the Event Recorders in the Incomer 1 and 2 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

b) LOW VOLTAGE LOGIC

1. Slowly reduce test voltage Source 1 supplying Incomer relay 1. At the pickup voltage of the Line Undervoltage 3 feature output relay 4 should operate. At this time the Incomer 2 relay should display the Transfer Not Ready message.
2. Slowly increase test voltage Source 1. At the reset voltage of the Line Undervoltage 3 feature output relay 4 should reset. At the Incomer 2 relay after the time delay of setpoint Transfer Delay Other Source the message Transfer Not Ready should be removed from the display.

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3. Slowly reduce test voltage Source 2 supplying Incomer relay 2. At the pickup voltage of the Line Undervoltage 3 feature output relay 4 should operate. At this time the Incomer 1 relay should display the Transfer Not Ready message.
4. Slowly increase test voltage Source 2. At the reset voltage of the Line Undervoltage 3 feature output relay 4 should reset. At the Incomer 1 relay after the time delay of setpoint Transfer Delay Other Source the message Transfer Not Ready should be removed from the display. Turn voltages off - Incomer breakers 1 and 2 should trip when Undervoltage-4 times-out.
5. Check the Event Recorders in both Incomers and the Bus Tie relay for the correct messages and sequences, then clear the recorders.

c) TRANSFER INITIATED BY LOCKOUT 86-1

1. Energize both test sources at nominal voltage, close Incomer breakers 1 and 2, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
2. At the Incomer 1 relay assert Logic Input No. 12 (Transformer Lockout.) The Incomer 1 relay should trip the Incomer 1 breaker and operate output relay 6 to send a Close From Incomer 1 signal to the Bus Tie relay. Output relay 6 at the Incomer 1 relay should reset when the Incomer 1 breaker trips, removing the signal to the Bus Tie relay. The Bus Tie breaker should not close as the voltage on its Bus and Line inputs is too high.
3. Slowly reduce the test Source 1 voltage. The Bus Tie breaker should close when the voltage is below the Dead Bus Max Volts setpoint of its Synchrocheck feature. Increase the voltage to nominal.
4. At the Incomer 1 relay de-assert Logic Input No. 12 (Transformer Lockout.)
5. Momentarily assert logic input 3 (Remote Open) at the Bus Tie relay. The Bus Tie breaker should open.
6. Momentarily assert logic input 2 (Remote Close) at the Incomer 1 relay. The Incomer 1 breaker should close.
7. Check the Event Recorders in the Incomer 1 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

d) TRANSFER INITIATED BY LOCKOUT 86-2

1. Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
2. At the Incomer 2 relay assert Logic Input No. 12 (Transformer Lockout.) The Incomer 2 relay should trip the Incomer 2 breaker and operate output relay 6 to send a Close From Incomer 2 signal to the Bus Tie relay. Output relay 6 at the Incomer 2 relay should reset when the Incomer 2 breaker trips, removing the signal to the Bus Tie relay. The Bus Tie breaker should not close as the voltage on its Bus and Line inputs is too high.
3. Slowly reduce the test Source 2 voltage. The Bus Tie breaker should close when the voltage is below the Dead Line Max Volts setpoint of its Synchrocheck feature. Increase the voltage to nominal.
4. At the Incomer 2 relay de-assert Logic Input No. 12 (Transformer Lockout.)
5. Momentarily assert logic input 3 (Remote Open) at the Bus Tie relay. The Bus Tie breaker should open.
6. Momentarily assert logic input 2 (Remote Close) at the Incomer 2 relay. The Incomer 2 breaker should close. Check the Event Recorders in the Incomer 2 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

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e) TRANSFER INITIATED BY SOURCE TRIP NO. 1

1. Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
2. At the Incomer 1 relay assert Logic Input No. 13 (Source Trip.) The Incomer 1 relay should trip the Incomer 1 breaker and operate output relay 6 to send a Close From Incomer 1 signal to the Bus Tie relay. Output relay 6 at the Incomer 1 relay should reset when the Incomer 1 breaker trips, removing the signal to the Bus Tie relay. The Bus Tie breaker should not close as the voltage on its Bus and Line inputs is too high.
3. Slowly reduce the test Source 1 voltage. The Bus Tie breaker should close when the voltage is below the Dead Bus Max Volts setpoint of its Synchrocheck feature. Increase the voltage to nominal.
4. At the Incomer 1 relay de-assert Logic Input No. 13 (Source Trip.)
5. Momentarily assert logic input 3 (Remote Open) at the Bus Tie relay. The Bus Tie breaker should open.
6. Momentarily assert logic input 2 (Remote Close) at the Incomer 1 relay. The Incomer 1 breaker should close.
7. Check the Event Recorders in the Incomer 1 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

f) TRANSFER INITIATED BY SOURCE TRIP NO. 2

1. Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
2. At the Incomer 2 relay assert Logic Input No. 13 (Source Trip.) The Incomer 2 relay should trip the Incomer 2 breaker and operate output relay 6 to send a Close From Incomer 2 signal to the Bus Tie relay. Output relay 6 at the Incomer 2 relay should reset when the Incomer 2 breaker trips, removing the signal to the Bus Tie relay. The Bus Tie breaker should not close as the voltage on its Bus and Line inputs is too high.
3. Slowly reduce the test Source 2 voltage. The Bus Tie breaker should close when the voltage is below the Dead Line Max Volts setpoint of its Synchrocheck feature. Increase the voltage to nominal.
4. At the Incomer 2 relay de-assert Logic Input No. 13 (Source Trip.)
5. Momentarily assert logic input 3 (Remote Open) at the Bus Tie relay. The Bus Tie breaker should open.
6. Momentarily assert logic input 2 (Remote Close) at the Incomer 2 relay. The Incomer 2 breaker should close.
7. Check the Event Recorders in the Incomer 2 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

g) TRANSFER INITIATED BY UNDERVOLTAGE ON SOURCE 1

1. Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
2. Turn test Source 1 off. The Undervoltage 3 feature of the Incomer 1 relay should operate immediately and operate output relay 4; at the Incomer 2 relay output relay 3 will operate and the Transfer Not Ready message will be displayed. When the Undervoltage 4 feature times-out the Incomer 1 relay should trip breaker 1 and operate output relay 6 to send a Close From Incomer 1 signal to the Bus Tie relay. Output relay 6 should reset when breaker 1 trips, removing the signal to the Bus Tie relay. Upon receiving the signal from the Incomer 1 relay the Bus Tie relay should close the Bus Tie Breaker.
3. Check the Event Recorders in the Incomer 1 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

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h) MANUAL RESTORATION OF INCOMER 1

1. Turn test Source 1 on and adjust Source 1 to be out-of-synchronism with Source 2.
2. At the Bus Tie relay assert Logic Input No. 06 (Selected To Trip.)
3. At the Incomer 1 relay assert Logic Input No. 02 (Remote Close.) The Incomer 1 breaker should not close as it cannot pass synchrocheck. Adjust Source 1 until in-synchronism with Source 2. At this time the Incomer 1 breaker should close and the Bus Tie breaker should trip. Turn off both voltages.
4. At the Bus Tie relay de-assert Logic Input No. 06 (Selected To Trip.) Check the Event Recorders in the Incomer 1 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

i) TRANSFER INITIATED BY UNDERVOLTAGE ON SOURCE 2

1. Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
2. Turn test Source 2 off. The Undervoltage 3 feature of Incomer 2 relay should operate immediately and operate output relay 4; at the Incomer 1 relay output relay 3 will operate and the Transfer Not Ready message will be displayed. When the Undervoltage 4 feature times-out the Incomer 2 relay should trip Incomer breaker 2 and operate output relay 6 to send a Close From Incomer 2 signal to the Bus Tie relay. Output relay 6 should reset when breaker 2 trips, removing the signal to the Bus Tie relay. Upon receiving the signal from the Incomer 2 relay the Bus Tie relay should close the Bus Tie Breaker.
3. Check the Event Recorders in the Incomer 2 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

j) MANUAL RESTORATION OF INCOMER 2

1. Turn test Source 2 on and adjust Source 2 to be out-of-synchronism with Source 1.
2. At the Bus Tie relay assert Logic Input No. 06 (Selected To Trip.
3. At the Incomer 2 relay assert Logic Input No. 02 (Remote Close.) The Incomer 2 breaker 2 should not close as it cannot pass synchrocheck. Adjust Source 2 until in-synchronism with Source 1. At this time the Incomer 2 breaker should close and the Bus Tie breaker should trip. Turn off both voltages.
4. At the Bus Tie relay de-assert Logic Input No. 06 (Selected To Trip.)
5. Check the Event Recorders in the Incomer 2 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

k) SIMULTANEOUS LOSS OF BOTH SOURCES

1. Energize the line voltage input of both incomer relays from a single source at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both relays.
2. Turn the test source off. The Undervoltage 3 element of both incomer relays should operate immediately and operate output relay 4; at both incomers the Transfer Not Ready message will be displayed.

If setpoint **BLOCK TRIP ON DOUBLE LOSS** *is set to Disabled:*

3. When the Undervoltage 4 element times-out the incomer relays should trip the incomer breakers. The bus tie breaker should not close.
4. Check the Event Recorders in both incomer relays for the correct messages and sequences, then clear the recorders.

If setpoint **BLOCK TRIP ON DOUBLE LOSS** *is set to Enabled:*

3. When the Undervoltage 4 element times-out the incomer relays should not trip the incomer breakers. The bus tie breaker should not close.
4. Check the Event Recorders in both incomer relays for the correct messages and sequences, then clear the recorders.

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l) AFTER-PARALLEL TRIPPING OF SELECTED INCOMER

1. Energize both test sources at nominal voltage, still in-synchronism, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
2. At the Incomer 1 relay assert Logic Input No. 06 (Selected To Trip.)
3. At the Bus Tie relay assert Logic Input No. 02 (Remote Close.) The Bus Tie breaker should close as the voltages are in-synchronism. After this the Incomer 1 breaker should trip.
4. At the Incomer 1 relay de-assert Logic Input No. 06 (Selected To Trip.)
5. At the Incomer 2 relay assert Logic Input No. 06 (Selected To Trip.)
6. At the Incomer 1 relay assert Logic Input No. 02 (Remote Close.) The Incomer 1 breaker should close as the voltages are in-synchronism. After this the Incomer 2 breaker should trip. Turn the voltages off.
7. Check the Event Recorders in the Incomer 1 and 2 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

m) TRANSFER BLOCKED BY OVERCURRENT ON INCOMER 1

1. Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
2. Disable the Neutral Inst O/C 1 feature. Inject a current into the phase current input of the Incomer 1 relay. Slowly increase this current until the Phase Inst O/C 1 element operates. At the Incomer 1 relay and the Transfer Not Ready message should be displayed.
3. Slowly decrease the injected current until the Phase Inst O/C 1 element resets. At the Incomer 1 relay after the delay time of setpoint **TRANSFER DELAY THIS SOURCE** and the Transfer Not Ready message should be removed from the display.
4. Enable the Neutral Inst O/C 1 feature and Disable the Phase Inst O/C 1 feature. Inject a current into the phase current input of the Incomer 1 relay. Slowly increase this current until the Neutral Inst O/C 1 element operates. At the Incomer 1 relay the Transfer Not Ready message should be displayed.
5. Slowly decrease the injected current until the Neutral Inst O/C 1 element resets. At the Incomer 1 relay after the delay time of setpoint **TRANSFER DELAY THIS SOURCE** and the Transfer Not Ready message should be removed from the display.

n) TRANSFER BLOCKED BY OVERCURRENT ON INCOMER 2

1. Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
2. Disable the Neutral Inst O/C 1 feature. Inject a current into the phase current input of the Incomer 2 relay. Slowly increase this current until the Phase Inst O/C 1 element operates. At the Incomer 2 relay the Transfer Not Ready message should be displayed.
3. Slowly decrease the injected current until the Phase Inst O/C 1 element resets. At the Incomer 2 relay after the delay time of setpoint Transfer Delay This Source and the Transfer Not Ready message should be removed from the display.
4. Enable the Neutral Inst O/C 1 feature and Disable the Phase Inst O/C 1 feature. Inject a current into the phase current input of the Incomer 2 relay. Slowly increase this current until the Neutral Inst O/C 1 element operates. At the Incomer 2 relay the Transfer Not Ready message should be displayed.
5. Slowly decrease the injected current until the Neutral Inst O/C 1 element resets. At the Incomer 2 relay after the delay time of setpoint Transfer Delay This Source and the Transfer Not Ready message should be removed from the display.

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Test connections per the figure below:

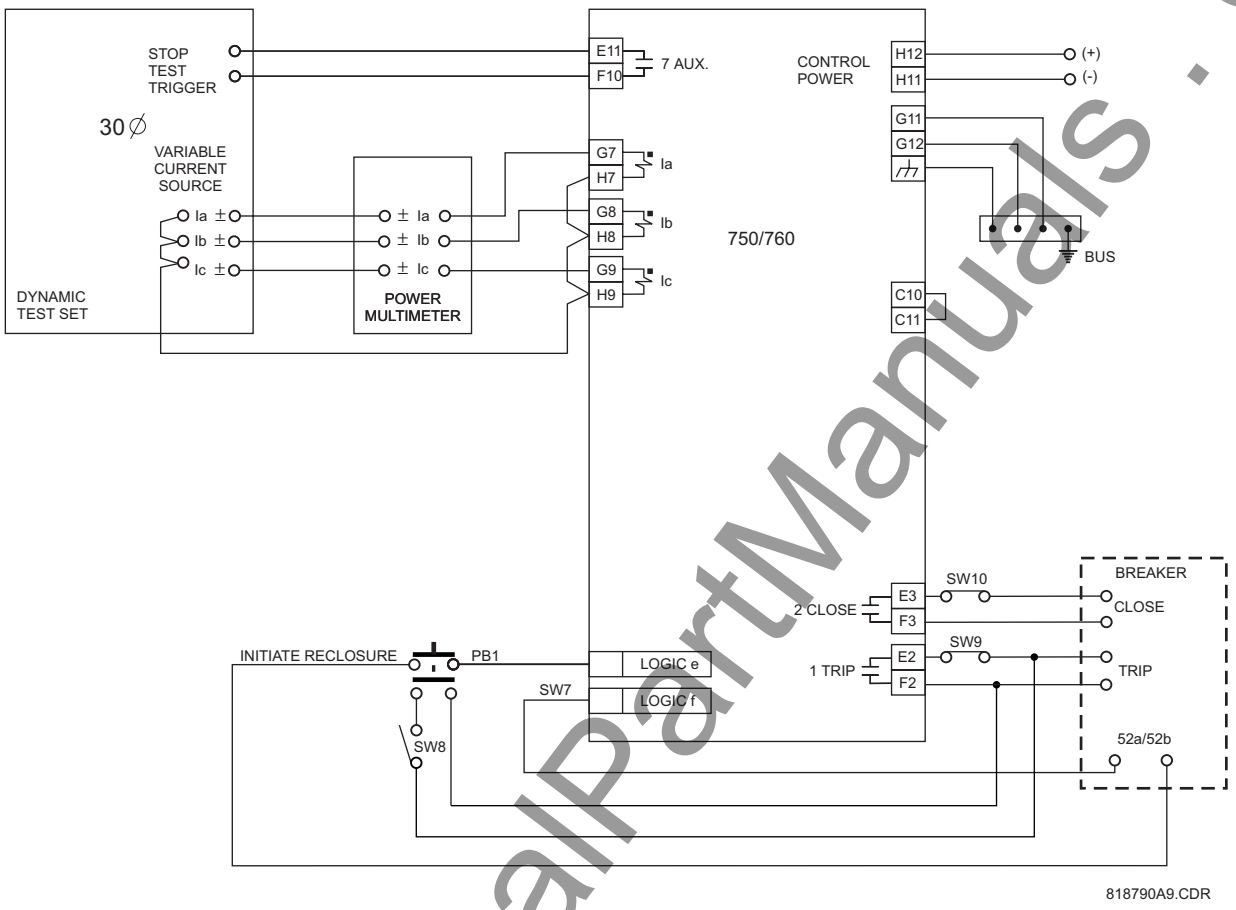


Figure 17–6: AUTORECLOSE TEST CONNECTION

NOTE

For these tests output relay 7 Auxiliary is programmed to operate when the relay trips, to stop the timer. If this is inconvenient, use any other output auxiliary relay.

Overall Operation:

1. Check that the relay is in the local control mode, and the LOCAL indicator is on. Open and close the breaker by pressing the relay BREAKER OPEN and BREAKER CLOSE pushbuttons. Check that the BREAKER OPEN and BREAKER CLOSED indicators are correctly displaying the state of the breaker. Leave the breaker open.
2. Check that indicator RECLOSURE ENABLED is lit and that RECLOSURE DISABLED is off.
3. Close the breaker by pressing the BREAKER CLOSE pushbutton. The RECLOSURE ENABLED indicator should go out, and the RECLOSURE DISABLED indicator should come on during the 'AR block time upon manual close'. Immediately after this interval, check that indicator RECLOSURE ENABLED is on, and the RECLOSURE IN PROGRESS and RECLOSURE DISABLED indicators are off. Any output relays programmed to operate for Reclose Enabled should now be operated.
4. Check the interval of the 'AR block time upon manual close' by observing the RECLOSURE ENABLED LED.

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NOTE

For all further testing, ensure that a reclose is not initiated until after the programmed 'AR block time upon manual close' has elapsed, after a manual close.

5. Assert a Block Reclosure logic input. The RECLOSURE ENABLED indicator should go out and the RECLOSURE DISABLED indicator come on. De-assert the Block Reclosure logic input. The RECLOSURE ENABLED indicator should come on and the RECLOSURE DISABLED indicator should go out.
6. Assert a Cancel Reclosure logic input. The RECLOSURE ENABLED indicator should go out and the RECLOSURE DISABLED indicator come on. De-assert the Cancel Reclosure logic input. The RECLOSURE ENABLED indicator should come on and the RECLOSURE DISABLED indicator should go out.
7. Display **A1 STATUS \ AUTORECLOSE \ AUTORECLOSE SHOT IN EFFECT** – the value displayed should be *0*.
8. Momentarily assert the Initiate Reclosure logic input. The RECLOSURE IN PROGRESS indicator should come on immediately, and any output relays programmed to operate for Reclose In Progress should now be operated. After the delay programmed for Incompleted Sequence Time the RECLOSURE IN PROGRESS indicator will go out, as the breaker has not tripped, and the incomplete sequence timer has canceled the reclose in progress. Any output relays operated above should now be reset. Check the interval of the incomplete sequence timer by observing the RECLOSURE IN PROGRESS LED.
9. Momentarily assert the Initiate Reclosure logic input causing a reclose in progress indication. Immediately assert the Block Reclosure logic input and the scheme should become disabled, canceling the reclose in progress. Assert the Initiate Reclosure logic input and check that the scheme does not become in progress. De-assert the Block Reclosure logic input and the scheme should become in progress.
10. Assert a Cancel Reclosure logic input and the scheme should become disabled, canceling the reclose in progress. De-assert the Cancel Reclosure logic input and the scheme should become enabled.
11. Assert the Initiate Reclosure logic input then immediately after assert the Remote Open logic input, initiating a reclose and tripping the breaker. (The RECLOSURE IN PROGRESS indicator is now on.) Check that **AUTORECLOSE SHOT IN EFFECT** is 0. Before the programmed dead-time interval for Reclosure 1 has elapsed, press the BREAKER CLOSE pushbutton. The breaker should not close, as reclose is in progress. The breaker should reclose at the end of the dead-time interval, incrementing the shot counter to 1. Before the scheme resets check that the reading under **A1 STATUS \ AUTORECLOSE \ AUTORECLOSE SHOTS REMAINING** is the number of shots programmed less one. This reading should change to the number of shots programmed when the scheme is automatically reset at the end of the reset interval. The event recorder should have recorded logic input Initiate Reclosure, Remote Open, the Reclose, and Reclosure Reset. Check the interval of the autoreclose reset timer in the event recorder.
12. Assert the Initiate Reclosure logic input then immediately after assert the Remote Open logic input, initiating a reclose and tripping the breaker. Check that the breaker trips and later recloses, and the displayed number of shots remaining is reduced by one. Immediately assert the Initiate Reclosure and Remote Open logic inputs again, to initiate another trip and reclose and the displayed number of shots remaining is reduced by one again. Repeat this procedure until the programmed number of shots have been performed. Initiate Reclosure once more and the scheme should go to lockout; the RECLOSURE LOCKOUT and RECLOSE DISABLED indicators should now be on, and the RECLOSURE ENABLED indicator should be off. Any output relays programmed to operate for Lockout should now be operated.
13. The event recorder should have recorded each logic input for Initiate Reclosure, each Reclose, and Reclosure Lockout. Check the interval of deadtime for each shot in the event recorder.
14. Press the relay RESET pushbutton; Lockout should be canceled and the displayed number of shots should return to the programmed value. (The event recorder should record this reset.) Check that the RECLOSE LOCKOUT and RECLOSE DISABLED indicators are off, and the RECLOSURE ENABLED indicator is now on. Any output relays operated above should now be de-energized. Close the breaker.
15. Repeat step 12. Assert a Close command, either locally or remotely, and observe that lockout is reset at the end of the AR block time upon manual close, with indications as above.

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16. Set a current level above the pickup threshold of any time overcurrent element and turn the current off.
17. Repeat step 12. Assert a Close command, either locally or remotely, and turn the current on. Check that lockout is not reset at the end of the manual close blocking time interval, and the breaker eventually trips. Turn the current off.

If Breaker Operation Failure, and/or Breaker Failure features are Operational:

Open test switch SW9 to prevent a trip command from the relay from operating the breaker. Enable one of the O/C elements which is to be programmed for a function of Trip + AR. Inject a current above the pickup level of both the operational O/C feature and the Breaker Failure Current into the relay, until the feature sends a trip, which will also initiate reclosure. After the failure delay time a breaker failure condition will be determined, which should immediately set the reclose scheme to the Lockout state, turning the RECLOSURE LOCKOUT indicator on. Turn the injected current off and Reset the relay. Disable the O/C element and close both the breaker and SW9.

Current Supervision:

1. Note that the number of reclosure shots programmed controls the messages in this group. If 4 shots are programmed, all messages are available. If 3 shots are programmed, setpoint **3 SHOTS FOR CURRENT ABOVE** is not available on the relay. If 2 shots are programmed, setpoints **3 SHOTS FOR CURRENT ABOVE** and **2 SHOTS FOR CURRENT ABOVE** are not available on the relay. The following procedure assumes 4 shots are programmed.
2. Close the breaker and wait until reclosure is enabled.
3. Display **A1 STATUS \ AUTORECLOSE \ AUTORECLOSE SHOTS REMAINING** – the value displayed should be 4.
4. Open SW9 so the breaker cannot trip. Inject current and slowly ramp higher until an instantaneous feature sends a trip, which also initiates reclosure. The value displayed should be 4 (it has not yet decremented).
5. Continue to very slowly increase the current until the value displayed becomes 3. Continue to very slowly increase the current, until the value displayed sequentially becomes 2 and then 1, at the currents programmed. Very slowly increase the current, at the current programmed, until the relay goes to Lockout.

Zone Coordination:

1. Select the **MAXIMUM NUMBER OF RECLOSURE SHOTS** to be 4. Set the test set to a current level above the setting of the **PHASE CURRENT INCREASE** setpoint, and ensure that the neutral current is below the **NEUTRAL CURRENT INCREASE** setpoint by making this setting a large value. Turn on the current. Then, before the **MAX FAULT CLEARING TIME** has elapsed, turn off the current. The **SHOT NUMBER IN EFFECT** should have been incremented. Reset the relay. Turn on the current. Then, after the **MAX FAULT CLEARING TIME** has elapsed, turn off the current. The **SHOT NUMBER IN EFFECT** should not have been incremented. Reset the relay.
2. Set the current level below the setting of the **PHASE CURRENT INCREASE** setpoint. Turn the current on and then off. The **SHOT NUMBER IN EFFECT** should not change.
3. Set the current level above the setting of the **PHASE CURRENT INCREASE** setpoint, but below the Neutral Current Increase setpoint. Turn the current on and then off. The **SHOT NUMBER IN EFFECT** should increment. Repeatedly turning the current on and then off should continue to increment the Shot in Effect to the **MAXIMUM NUMBER OF RECLOSURE SHOTS**, and the Autoreclose scheme will go into lockout.
4. Set the current level such that the neutral current is below the **NEUTRAL CURRENT INCREASE** setpoint and the phase current is below the **PHASE CURRENT INCREASE** setpoint. Turn the current on and then off. The **SHOT NUMBER IN EFFECT** should not change.
5. Set the current level such that the neutral current is above the **NEUTRAL CURRENT INCREASE** setpoint and the phase current is below the **PHASE CURRENT INCREASE** setpoint. Turn the current on and then off. The **SHOT IN EFFECT** should increment as in step 3.

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Instantaneous O/C Blocking:

1. Select the **MAX NUMBER OF RECLOSURE SHOTS** to be 4. With Phase Inst OC 1 function selected as *Trip + AR*, set the test set to a current level above the pickup of this element, and inject into a phase input. The relay should trip and reclose 4 times. Turn off the current, reset the relay and close the breaker.
2. Enable Phase Inst OC 1 Blocking for Reclosure Shot 1. Turn on the current. The relay should trip and reclose once. The Shot in Effect display should show 1. The PICKUP indicator should be off. Once the Autoreclose Reset Time has expired, the relay will then pickup, trip and reclose until lockout as the fault current is still present. Turn off the current, reset the relay and close the breaker.
3. Disable Phase Inst OC 1 Blocking for Reclosure Shot 1, and Enable for Reclosure Shot 2. Turn on the current. Reclosure Shot 2 should not operate, and the PICKUP indicator will be off. Turn off the current and reset the relay.
4. Repeat procedure 3 using Phase Inst OC 1 Blocking for each of the 4 Reclosure Shot settings.
5. Repeat steps 1-4 for each Instantaneous OC Blocking setpoint, disabling each Instantaneous OC element before moving on to the next.

Raised Pickup of Time O/C Elements:

1. Keep the Maximum Number of Reclosure Shots at 4. With the Phase Time OC 1 function selected as Trip + AR, set the test set to a current level above the pickup of this element. Turn off the current, reset the relay and close the breaker.
2. In Reclosure Shot 1 settings, select the Phase Time OC 1 Raised Pickup such that it brings the pickup level just below the actual current that is being injected. Turn on the current. The relay should trip and reclose 4 times.
3. In Reclosure Shot 1 settings, select the Phase Time OC 1 Raised Pickup such that it brings the pickup level just above the actual current that is being injected. Turn on the current. The relay should trip and reclose once. The Shot in Effect display should show 1. The PICKUP indicator should be off. Once the Autoreclose Reset Time has expired, the relay will then pickup, trip and reclose until lockout as the fault current is still present. Turn off the current, reset the relay and close the breaker.
4. Return Phase Time OC 1 Raised Pickup to 0 for Reclosure Shot 1, and set it to a level that is above the actual current for Reclosure Shot 2. Turn on the current. Reclosure Shot 2 should not operate, and the PICKUP indicator will be off. Turn off the current and reset the relay.
5. Repeat procedure 4 using Phase Time OC 1 Blocking for each of the 4 Reclosure Shot settings.
6. Repeat steps 1-5 for each Time OC Raised Pickup setpoint, disabling each Time OC element before moving on to the next.

Select Setpoint Group:

1. Keep the Maximum Number of Reclosure Shots at 4. In Setpoint Group 1, Enable **PHASE TIME OC 1** to *Trip + AR*. In Setpoint Group 2, Enable **PHASE TIME OC 2** to *Trip + AR*. In Setpoint Group 3, Enable **PHASE INST OC 1** to *Trip + AR*. In Setpoint Group 4, Enable **PHASE INST OC 2** to *Trip + AR*. Select the same pickup level for each element.
2. For Reclosure Shot 1 settings, set the **SELECT SETPOINT GROUP** setpoint to *Group 2*. Similarly, set it to *Group 3* for **RECLOSURE SHOT 2**, *Group 4* for **RECLOSURE SHOT 3**, and *Group 1* for **RECLOSURE SHOT 4**.
3. Set the test set to a current level above the pickup of these elements. With the current source off, Reset the relay, and clear the event recorder.
4. Turn on the current. The relay should Trip + AR 4 times caused by the following elements, in order, Phase Time OC 1, Phase Time OC 2, Phase Inst OC 1, Phase Inst OC 2, Phase Time OC 1. The event recorder will show this sequence of events. Turn off the current, and reset the relay.

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17.10.1 DESCRIPTION

NOTE

The procedure outlined in this section is explicitly confined to the operation of the relay, and does not include the operation of any equipment external to the relay.

1. Cycle through the relay setpoints and set each setpoint in each group to the required value.
2. Upload all the relay setpoints for all groups to a computer file or printer for a final inspection to confirm that all setpoints are correct.
3. Set the relay clock (date and time) if IRIG-B is not used or unavailable.
4. Clear all historical values stored in the relay by entering *Yes* at the following messages.

   Under subheading **S1 RELAY SETUP \ CLEAR DATA **

   CLEAR ENERGY USE DATA?
   CLEAR MAX DEMAND DATA?
   CLEAR EVENT RECORDER DATA?

   Under subheading **S1 RELAY SETUP \ INSTALLATION**

   RESET TRIP COUNTER DATA?
   RESET ARCING CURRENT DATA?
5. Turn off all test voltages, and the power supply to the relay. Remove all test wiring connections, and restore to normal any panel wiring disturbed for testing.
6. Perform a complete visual inspection to confirm that the relay is ready to be placed in service. Energize the relay power supply circuit and check that the RELAY IN SERVICE indicator is on, and that the 8 SELF-TEST WARNING indicator is off, establishing that the relay is operating normally.
7. For complete on-load checking of the relay, it is required to supply load current to the relay in a known direction of power flow, with a known approximate value of power factor. The load current should be high enough to be certain that the main CTs are connected correctly. The power system should be arranged to fulfill these conditions before the feeder to which the relay is connected is energized. Advise operators of the possibility of a trip on initial energization.

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1. If possible, before closing the feeder breaker to supply load, energize the VT circuit to which the relay is connected. Check that all relay measurements are as expected.

   Under subheading **A2 METERING \ VOLTAGE **

   AB: BC: CA: *(Magnitude)*
   AVERAGE LINE VOLTAGE: *(Magnitude)*
   AN: BN: CN: *(Magnitude)* **(not available when connected Delta)**
   AVERAGE PHASE VOLTAGE: kV *(Magnitude)* **(not available when connected Delta)**
   LINE A-B VOLTAGE *(Phasor)*
   LINE B-C VOLTAGE *(Phasor)*
   LINE C-A VOLTAGE *(Phasor)*
   PHASE A-N VOLTAGE *(Phasor)* **(not available when connected Delta)**
   PHASE B-N VOLTAGE *(Phasor)* **(not available when connected Delta)**
   PHASE C-N VOLTAGE *(Phasor)* **(not available when connected Delta)**
   POS SEQ VOLTAGE *(Phasor)*
   NEG SEQ VOLTAGE *(Phasor)*
   ZERO SEQ VOLTAGE *(Phasor)*

2. To have an immediate indication upon closing of the load level and whether some overcurrent protection is operating, before closing the feeder breaker display the actual value **A2 METERING \ CURRENT \ % OF LOAD-TO-TRIP.**

3. After the feeder circuit breaker is closed and the feeder is carrying load current, check that all relay measurements are as expected.

   Under subheading **A2 METERING \ CURRENT **

   A: B: C: *(Magnitude)*
   AVERAGE CURRENT *(Magnitude)*
   PHASE A CURRENT *(Phasor)*
   PHASE B CURRENT *(Phasor)*
   PHASE C CURRENT *(Phasor)*
   NEUTRAL CURRENT *(Phasor)*
   GROUND CURRENT *(Phasor)*
   SENSTV GND CURRENT *(Phasor)*
   POS SEQ CURRENT *(Phasor)*
   NEG SEQ CURRENT *(Phasor)*
   ZERO SEQ CURRENT *(Phasor)*

Under subheading **A2 METERING \ POWER SYSTEM \ POWER **

REAL POWER
REACTIVE POWER
APPARENT POWER
POWER FACTOR

Under subheading **A2 METERING \ FREQUENCY \ SYSTEM FREQUENCY**

It is very important to confirm that the input CTs are connected properly to provide correct directional control and metering calculations. A first check of this connection is to note that the values of Watts and Vars as calculated by the relay have the correct sign. This is done by comparing the relay measurements, which are signed by the conventions shown in Figure 6–3: POWER QUANTITY RELATIONSHIPS on page 6–12, to the known feeder load characteristics.

4. After some time has passed, dependent on feeder load and demand time interval settings, check the following measured values:

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Under subheading **A2 METERING \ POWER SYSTEM \ ENERGY USE **

POSITIVE WATTHOURS
POSITIVE WATTHOUR COST
NEGATIVE WATTHOURS
NEGATIVE WATTHOUR COST
POSITIVE VARHOURS
NEGATIVE VARHOURS

Under subheading **A2 METERING \ DEMAND \ PHASE A CURRENT **

LAST PHASE A CURRENT DEMAND
MAX PHASE A CURRENT DEMAND

Under subheading **A2 METERING \ DEMAND \ PHASE B CURRENT **

LAST PHASE B CURRENT DEMAND
MAX PHASE B CURRENT DEMAND

Under subheading **A2 METERING \ DEMAND \ PHASE C CURRENT **

LAST PHASE C CURRENT DEMAND
MAX PHASE C CURRENT DEMAND

Under subheading **A2 METERING \ DEMAND \ REAL POWER **

LAST REAL POWER DEMAND
MAX REAL POWER DEMAND

Under subheading **A2 METERING \ DEMAND \ REACTIVE POWER **

LAST REACTIVE POWER DEMAND
MAX REACTIVE POWER DEMAND

Under subheading **A2 METERING \ DEMAND \ APPARENT POWER **

LAST APPARENT POWER DEMAND
MAX APPARENT POWER DEMAND

17.10.3 DIELECTRIC STRENGTH TESTING OF THE RELAY

A fully assembled production version of the relay is tested in its metal case. The dielectric strength of all the input/output terminals are tested with respect to its grounded chassis and terminal G12 (safety ground). The test voltage of the tester, from the initial value of 0 V AC, is raised to 2 kV AC in such a manner (slowly) that no appreciable transients occur. The voltage is maintained for 1 minute and is then reduced smoothly to zero as rapidly as possible. According to IEC255-5, the Hi-Pot test is repeated with a voltage not less than 500 V AC.

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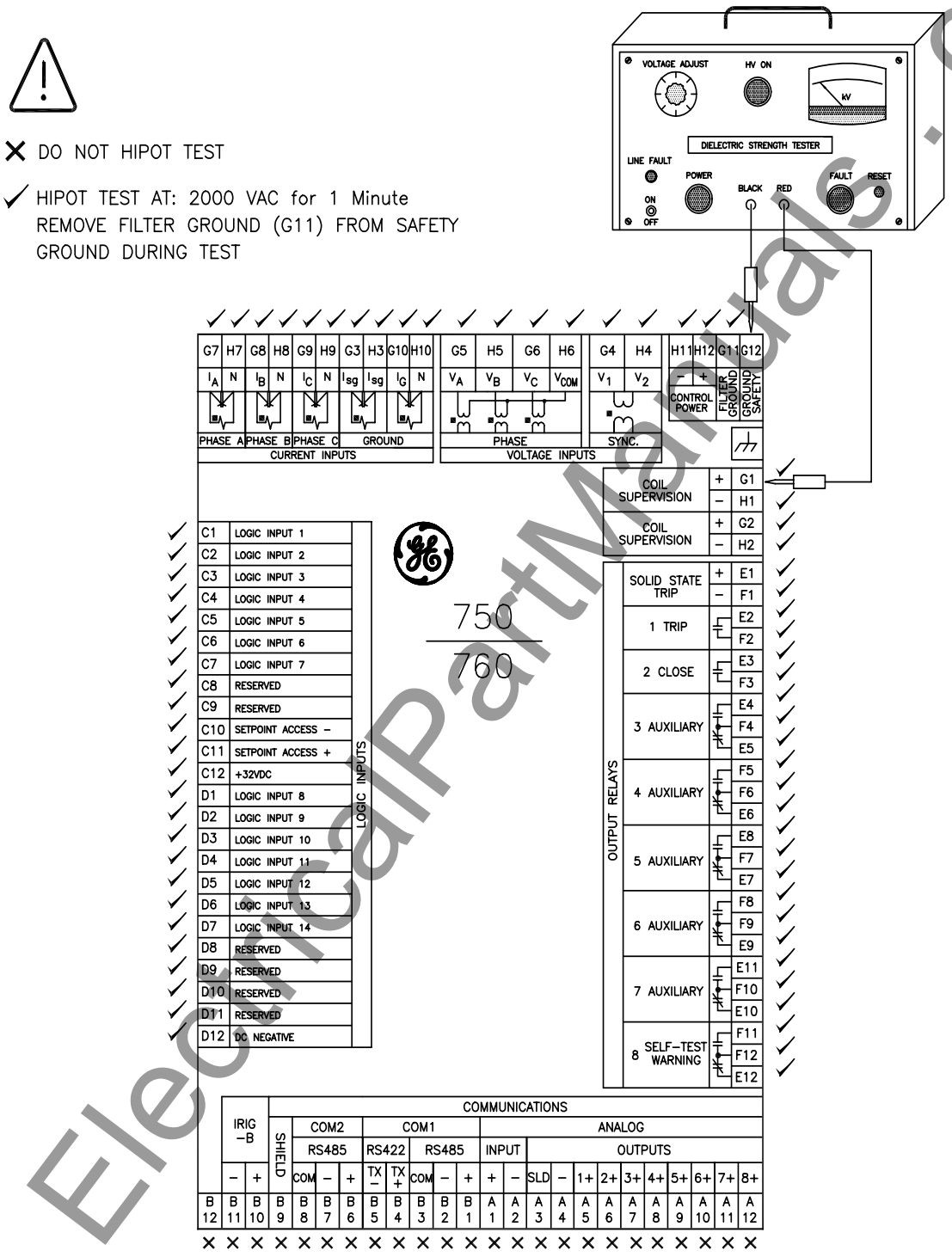


Figure 17–7: DIELECTRIC STRENGTH TEST WIRING DIAGRAM

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EU DECLARATION OF CONFORMITY

Applicable Council Directives: 73/23/EEC The Low Voltage Directive
89/336/EEC The EMC Directive

Standard(s) to Which Conformity is Declared:

IEC 947-1	Low Voltage Switchgear and Controlgear
IEC1010-1:1990+ A 1:1992+ A 2:1995	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use
CISPR 11 / EN 55011:1997	Class A – Industrial, Scientific, and Medical Equipment
EN 50082-2:1997	Electromagnetic Compatibility Requirements, Part 2: Industrial Environment
IEC100-4-3 / EN 61000-4-3	Immunity to Radiated RF
EN 61000-4-6	Immunity to Conducted RF

Manufacturer's Name: General Electric Power Management.

Manufacturer's Address: 215 Anderson Ave.
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Manufacturer's Representative in the EU: Christina Bataller Mauleon
GE Power Management
Avenida Pinoa 10
48710 Zamudio, Spain
Tel.: 34-94-4858835 Fax: 34-94-4858838

Type of Equipment: Feeder Management Relay

Model Number: 750/760

First Year of Manufacture: 1994

I the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards

Full Name: John Saunders

Position: Manufacturing Manager

Signature:



Place: GE Power Management

Date: 08/24/1998

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GE POWER MANAGEMENT RELAY WARRANTY

General Electric Power Management Inc. (GE Power Management) warrants each relay it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, GE Power Management will undertake to repair or replace the relay providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any relay which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a GE Power Management authorized factory outlet.

GE Power Management is not liable for special, indirect or consequential damages or for loss of profit or for expenses sustained as a result of a relay malfunction, incorrect application or adjustment.

For complete text of Warranty (including limitations and disclaimers), refer to GE Power Management Standard Conditions of Sale.

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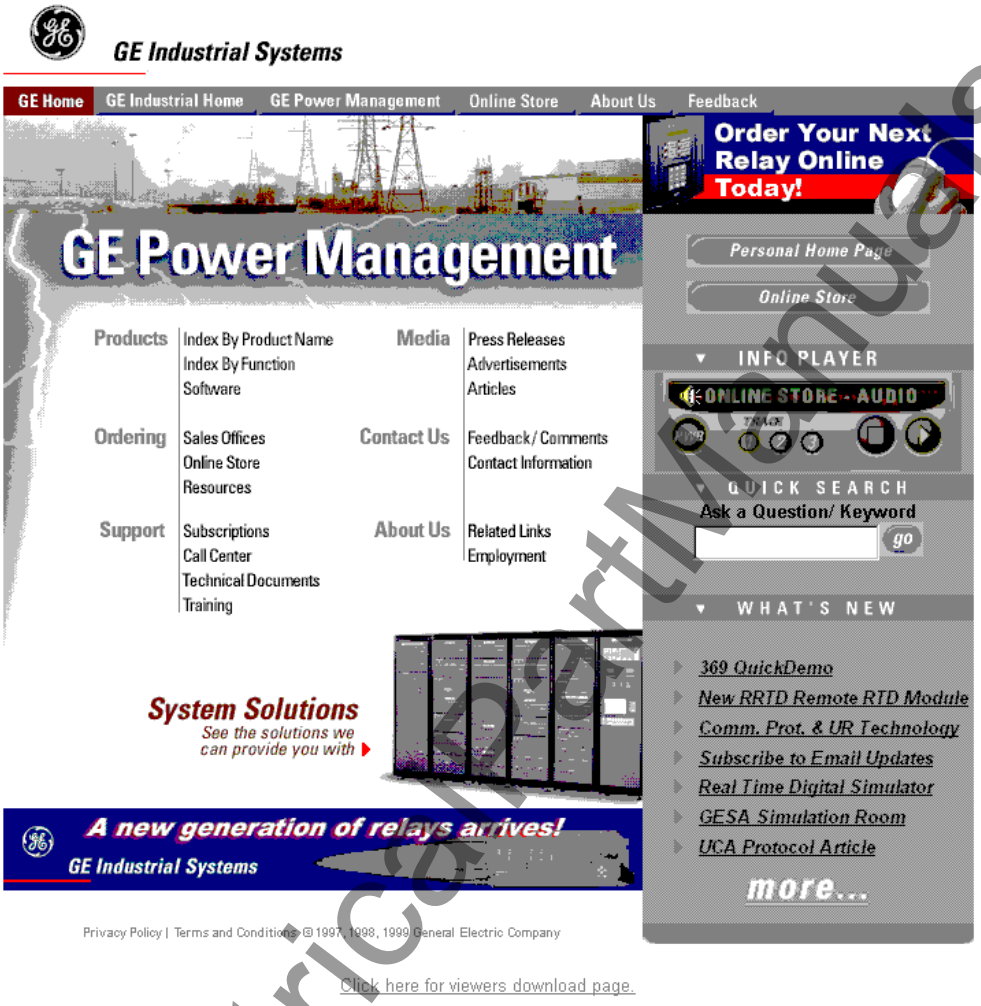
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