

# 750/760 Feeder Management Relay Instruction Manual



Software Revision: 7.4x

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## GE Grid Solutions

650 Markland Street

Markham, Ontario

Canada L6C 0M1

Tel: +1 905 927 7070 Fax: +1 905 927 5098

Internet: <http://www.gegridsolutions.com>



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GE Multilin 750/760 Feeder Management Relay instruction manual for revision 7.4x

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Part number: 1601-0120-AN (October 2016)

# Safety words and definitions

The following symbols used in this document indicate the following conditions:



Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.



Indicates practices not related to personal injury.



Indicates general information and practices, including operational information and practices, that are not related to personal injury.



When this symbol appears on the unit, refer to documentation for full ratings and or potential hazard.

## General Safety Precautions

### **DANGER**

Ensure that all connections to the product are correct so as to avoid accidental risk of shock and/or fire, for example such as can arise from high voltage connected to low voltage terminals.

### **CAUTION**

Follow the requirements of this manual, including adequate wiring size and type, terminal torque settings, voltage, current magnitudes applied, and adequate isolation/clearance in external wiring from high to low voltage circuits.

Use the device only for its intended purpose and application.

Ensure that all ground paths are uncompromised for safety purposes during device operation and service.

Ensure that the control power applied to the device, the AC current, and voltage input match the ratings specified on the relay nameplate. Do not apply current or voltage in excess of the specified limits.

Only qualified personnel are to operate the device. Such personnel must be thoroughly familiar with all safety cautions and warnings in this manual and with applicable country, regional, utility, and plant safety regulations.

Hazardous voltages can exist in the power supply and at the device connection to current transformers, voltage transformers, control, and test circuit terminals. Make sure all sources of such voltages are isolated prior to attempting work on the device.

Hazardous voltages can exist when opening the secondary circuits of live current transformers. Make sure that current transformer secondary circuits are shorted out before making or removing any connection to the current transformer (CT) input terminals of the device.

For tests with secondary test equipment, ensure that no other sources of voltages or currents are connected to such equipment and that trip and close commands to the circuit breakers or other switching apparatus are isolated, unless this is required by the test procedure and is specified by appropriate utility/plant procedure.

When the device is used to control primary equipment, such as circuit breakers, isolators, and other switching apparatus, all control circuits from the device to the primary equipment must be isolated while personnel are working on or around this primary equipment to prevent any inadvertent command from this device.

Use an external disconnect to isolate the mains voltage supply.



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# 750/760 Feeder Management Relay

## Chapter 1: Getting Started

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### 1.1 Important Procedures

#### 1.1.1 Cautions and Warnings

Please read this chapter to guide you through the initial setup of your new relay.

#### **WARNING**

Before attempting to install or use the relay, it is imperative that all **WARNINGS** and **CAUTIONS** in this manual are reviewed to help prevent personal injury, equipment damage, and/or downtime.

#### **CAUTION**



When this symbol appears on the unit, refer to documentation for full ratings and or potential hazard.

#### 1.1.2 Inspection Checklist

- ▷ Open the relay packaging and inspect the unit for physical damage.
- ▷ View the rear nameplate and verify that the correct model has been ordered.
- ▷ Ensure that the following items are included:
  - Instruction Manual (on CD)
  - GE EnerVista CD (includes software and relay documentation)
  - Mounting screws.

For product information, instruction manual updates, and the latest software updates, please visit the GE Multilin website at <http://www.gegridsolutions.com>.



If there is any noticeable physical damage, or any of the contents listed are missing, please contact GE Multilin immediately.

NOTE

### 1.1.3 Manual Organization

To speed things up, this introductory chapter provides a step-by-step tutorial for a simple feeder application. Important wiring considerations and precautions discussed in *Electrical Installation* on page 3–10 should be observed for reliable operation. Detailed information regarding accuracy, output relay contact ratings, and so forth are detailed in *Specifications* on page 2–11. 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 and encouraged.

Setpoints and actual values are indicated as follows in the manual:

**A2 METERING ▷ ▽ DEMAND ▷ PHASE A CURRENT ▷ LAST PHASE A CURRENT DEMAND**

This 'path representation' illustrates the location of an specific actual value or setpoint with regards to its previous menus and sub-menus. In the example above, the **LAST PHASE A CURRENT DEMAND** actual value is shown to be a item in the Phase A Current sub-menu, which itself is an item in the Demand menu, which is an item of actual values page A2 Metering).

Sub-menu levels are entered by pressing the MESSAGE ► key. When inside a sub-menu, the ◀ MESSAGE key returns to the previous sub-menu. The MESSAGE ▼ and MESSAGE ▲ keys are used to scroll through the settings in a sub-menu. The display indicates which keys can be used at any given point. A summary of the menu structure for setpoints and actual values can be found on pages 5–1 and 6–1, respectively.



## 1.2 Using the Relay

### 1.2.1 Menu Navigation

The relay has three types of display messages: actual values, setpoints, and target messages.

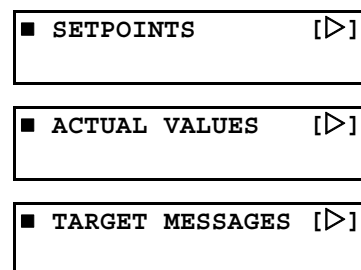
**Setpoints** are programmable settings entered by the user. These types of messages are located within a menu structure that groups the information into categories. Navigating the menu structure is described below. A summary of the menu structure for setpoints and actual values can be found in *Setpoints Main Menu* on page 5–1 and *Actual Values Main Menu* on page 6–1, respectively.

**Actual values** include the following information:

1. The status of logic inputs (both virtual and hardware), last trip information, fault location, and relay date and time.
2. Metering values measured by the relay, such as current, voltage, frequency, power, energy, demand, and analog inputs.
3. Maintenance data. This is useful statistical information that may be used for preventive maintenance. It includes trip counters and accumulated arcing current.
4. Event recorder downloading tool.
5. Product information including model number, firmware version, additional product information, and calibration dates.
6. Oscillography and data logger downloading tool.
7. A list of active conditions.

Alarms, trip conditions, diagnostics, and system flash messages are grouped under **Target messages**.

- ▷ Press the **MENU** key to access the header of each the three main menus (for setpoints, actual values, and target messages), displayed as follows:



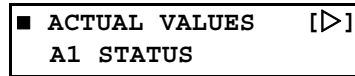
- ▷ Press the **MENU** key to display the header for the setpoints menu, then press the **MESSAGE ►** key to display the header of the first setpoints page. The setpoint pages are numbered, have an 'S' prefix for easy identification, and have a name which provides a general idea of the settings available in that page.

- ▷ Press the MESSAGE ▼ and MESSAGE ▲ keys to scroll through all the available setpoint page headers.



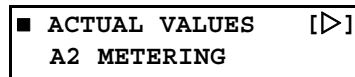
Press the MESSAGE ► key to enter the corresponding page. Press the MESSAGE ▼ and MESSAGE ▲ keys to scroll through the page headers until the required message is reached. The end of a page is indicated by the message **END OF PAGE Sn**, where *n* represents the number of the setpoints page.

- ▷ Press the **MENU** key to display the header for the actual values menu, then press the MESSAGE ► 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. Pressing the MESSAGE ▼ and MESSAGE ▲ keys will scroll through all the available actual values page headers.

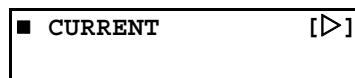


Press the MESSAGE ► key to enter the corresponding page. Press the MESSAGE ▼ and MESSAGE ▲ keys to scroll through the page headers until the required message is reached. The end of a page is indicated by the message **END OF PAGE An**, where *n* represents the number of the actual values page.

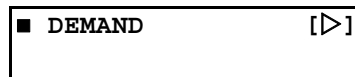
- ▷ Select the actual values menu and press the MESSAGE ► key to enter the first page. Press the MESSAGE ▼ or MESSAGE ▲ keys until the **A2 METERING** page appears.



- ▷ Press the MESSAGE ► key to display the first sub-page heading for Page 2 of actual values.



- ▷ Press the MESSAGE ▼ and MESSAGE ▲ keys to scroll the display up and down through the sub-page headers. Pressing the ◀ MESSAGE key at any sub-page heading will return the display to the heading of the corresponding setpoint or actual value page, and pressing it again will return the display to the actual values main menu header.
- ▷ Press the MESSAGE ▼ key until the **DEMAND** sub-page heading appears. At this point, press the MESSAGE ► key to display the messages in this sub-page.



If instead you press the MESSAGE ▲ key, the display will return to the previous sub-page heading; in this case,

■ ENERGY	[▷]
----------	-----

When the symbols ■ and [▷] appear on the top line, it indicates that additional sub-pages are available and can be accessed by pressing the MESSAGE ► key. Pressing MESSAGE ► while at the Demand sub-page heading displays the following:

■ PHASE A CURRENT	[▷]
----------------------	-----

- ▷ Press the ◀ MESSAGE key to return to the Demand sub-page heading.
- ▷ Press the MESSAGE ► 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.

LAST PHASE A CURRENT	
DEMAND:	0 A

The menu path to this value is shown as **A2 METERING ▷ ▽ DEMAND ▷ PHASE A CURRENT ▷ LAST PHASE A CURRENT DEMAND**. Setpoints and actual values messages are referred to in this manner throughout the manual.

To summarize the above example, the **A2 METERING ▷ ▽ DEMAND ▷ PHASE A CURRENT ▷ LAST PHASE A CURRENT DEMAND** path representation describes the following key-press sequence: press the MENU key until the actual values menu header is displayed, then press the MESSAGE ► and MESSAGE ▼ keys until the **A2 METERING** message is displayed, then press the MESSAGE ► and MESSAGE ▼ keys to display the **DEMAND** message, then press the MESSAGE ► key to reach the **PHASE A CURRENT** message, followed by MESSAGE ► one last time to display the **LAST PHASE A CURRENT DEMAND** actual value.

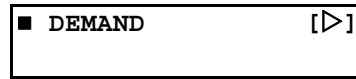
- ▷ Press the MESSAGE ▼ key to display the next actual value message.
- ▷ Press the MESSAGE ▼ or MESSAGE ▲ keys to scroll the display through all the actual value displays in this second sub-page.

MAX PHASE A CURRENT	
DEMAND:	0 A

- ▷ Press the ◀ MESSAGE key to reverse the process described above and return the display to the previous level.

■ PHASE A CURRENT	[▷]
----------------------	-----

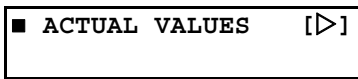
- ▷ Press the ◀ MESSAGE key twice to return to the **A2 METERING ▷▽** **DEMAND** sub-page header.



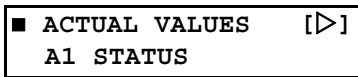
### 1.2.2 Panel Keying Example

The following figure gives a specific example of how the keypad is used to navigate through the menu structure. Specific locations are referred to throughout this manual by using a 'path representation'. The example shown in the figure gives the key presses required to read the total arcing current in phase B denoted by the path **A3 MAINTENANCE ▷▽** **ARCING CURRENT ▷▽** **TOTAL ARCING CURRENT ∅B**.

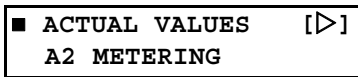
- ▷ Press the menu key until the relay displays the actual values page.



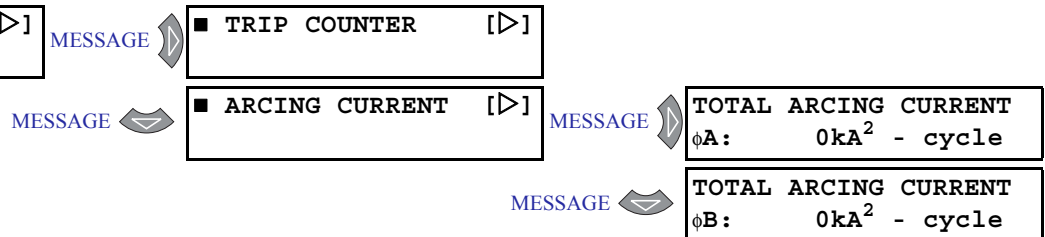
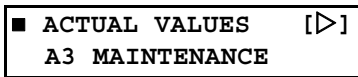
Press the MESSAGE  key



Press the MESSAGE  key



Press the MESSAGE  key



## 1.3 Changing Setpoints

### 1.3.1 Introduction

There are several classes of setpoints, each distinguished by the way their values are displayed and edited.

The relay's menu is arranged in a tree structure. Each setting in the menu is referred to as a setpoint, and each setpoint in the menu may be accessed as described in the previous section.

The settings are arranged in pages with each page containing related settings; for example, all the Phase Time Overcurrent 1 settings are contained within the same page. As previously explained, the top menu page of each setting group describes the settings contained within that page. Pressing the MESSAGE keys allows the user to move between these top menus. A complete editable setpoint chart is available as an Excel spreadsheet from the GE Multilin website at <http://www.gegridsolutions.com>.

All of the 750/760 settings fall into one of following categories: device settings, system settings, logic input settings, output relay settings, monitoring settings, control settings, and testing settings.



NOTE

**IMPORTANT NOTE: Settings are stored and used by the relay immediately after they are entered. As such, caution must be exercised when entering settings while the relay is in service. Modifying or storing protection settings is not recommended when the relay is in service, since any incompatibility or lack of coordination with other previously saved settings may cause unwanted operations.**

Now that we have become more familiar with maneuvering through messages, we can learn how to edit the values used by all setpoint classes.

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.

The jumper does not restrict setpoint access via serial communications. 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 eight (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 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 can disable setpoint access once all modifications are complete. For the communications ports, writing an invalid passcode into the register previously used to enable setpoint access disables access. In addition, setpoint access is automatically disabled on an interface if no activity is detected for thirty minutes.

The EnerVista 750/760 Setup software incorporates a facility for programming the relay's passcode as well as enabling and disabling setpoint access. For example, when an attempt is made to modify a setpoint but access is restricted, the software 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 the programmer's responsibility to incorporate appropriate security for the application.

### 1.3.2 The HELP Key

Pressing the HELP key displays 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.

### 1.3.3 Numerical Setpoints

Each numerical setpoint has its own minimum, maximum, and step value. These parameters define the acceptable setpoint value range. Two methods of editing and storing a numerical setpoint value are available.

The first method uses the 750/760 numeric keypad in the same way as any electronic calculator. A number is entered one digit at a time with the 0 to 9 and decimal keys. The left-most digit is entered first and the right-most digit is entered last. Pressing ESCAPE before the ENTER key returns the original value to the display.

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

For example:

- ▷ Select the **S2 SYSTEM SETUP ▷ ▽ BUS VT SENSING ▷ NOMINAL VT SECONDARY VOLTAGE** setpoint message.

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

- ▷ Press the 6, 3, decimal, and 9 keys.  
The display message will change as shown.

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

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.

**NEW SETPOINT  
STORED**

### 1.3.4 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** keys.

For example:

- ▷ Move to the **S2 SYSTEM SETUP ▷ ▾ BUS VT SENSING ▷ VT CONNECTION TYPE** setpoint message.

**VT CONNECTION TYPE:**  
Wye

- ▷ Press the **VALUE ▲** key until the “Delta” value is displayed as shown (in this manual, setpoint values are always shown in double quotation marks).

**VT CONNECTION TYPE:**  
Delta

- ▷ Press the **ENTER** key to store this change into memory. As before, confirmation of this action will momentarily flash on the display.

**NEW SETPOINT  
STORED**

The example shown in the following figures illustrates the key presses required to enter system parameters such as the phase CT primary rating, ground CT primary rating, bus VT connection type, secondary voltage, and VT ratio.

The following values will be entered:

Phase CT primary rating: 650 A  
 Ground CT primary rating: 100 A  
 Bus VT connection type: Delta  
 Secondary voltage: 115 V  
 VT Ratio:  $14400 / 115 = 125.2$

To set the phase CT primary rating, modify the **S2 SYSTEM SETUP ▷ CURRENT SENSING ▷ PHASE CT PRIMARY** setpoint as shown below.

- ▷ Press the MENU key until the relay displays the setpoints menu header.

■ SETPOINTS [▷]

Press MESSAGE ▶

■ SETPOINTS [▷]  
S1 RELAY SETUP

Press MESSAGE ▼

■ SETPOINTS [▷]  
S2 SYSTEM SETUP

Press MESSAGE ▶

■ CURRENT [▷]  
SENSING

Press MESSAGE ▶

PHASE CT PRIMARY:  
1000 A

PHASE CT PRIMARY:  
650 A

Press the VALUE keys until 650 A is displayed, or enter the value directly via the numeric keypad.

Press the ENTER key to store the setpoint.

NEW SETPOINT  
STORED

To set the ground CT primary rating, modify the **S2 SYSTEM SETUP** ▷ **CURRENT SENSING** ▷ **GROUND CT PRIMARY** setpoint as shown below.

- ▷ Press the MENU key until the relay displays the setpoints menu header.

■ SETPOINTS [▷]

▷ Press MESSAGE ▶

■ SETPOINTS [▷]  
S1 RELAY SETUP

▷ Press MESSAGE ▼

■ SETPOINTS [▷]  
S2 SYSTEM SETUP

Press MESSAGE ▶

■ CURRENT [▷]  
SENSING

Press MESSAGE ▶

PHASE CT PRIMARY:  
1000 A

Press MESSAGE ▼

GND CT PRIMARY:  
50 A

Press the VALUE keys until 100 A is displayed, or enter the value directly via the numeric keypad.

Press the ENTER key to store the setpoint.

GND CT PRIMARY:  
100 A

NEW SETPOINT  
STORED

To set the ground bus VT connection type, modify the **S2 SYSTEM SETUP** ▷ **BUS VT SENSING** ▷ **VT CONNECTION TYPE** setpoint as shown below.



- ▷ Press the **MENU** key until the relay displays the setpoints menu header.

Press MENU

```
■ SETPOINTS [▷]
```

Press MESSAGE ▶

```
■ SETPOINTS [▷]
S1 RELAY SETUP
```

Press MESSAGE ▼

```
■ SETPOINTS [▷]
S2 SYSTEM SETUP
```

Press MESSAGE ▶

```
■ CURRENT [▷]
SENSING
```

Press MESSAGE ▼

```
■ BUS VT SENSING [▷]
```

Press MESSAGE ▶

```
VT CONNECTION TYPE:
Wye
```

Press the VALUE keys until the value of "Delta" appears on the display.

```
VT CONNECTION TYPE:
Delta
```

Press the ENTER key to store the setpoint.

```
NEW SETPOINT
STORED
```

To set the secondary voltage, modify the **S2 SYSTEM SETUP** ▶ **BUS VT SENSING** ▶ **NOMINAL VT SECONDARY VOLTAGE** setpoint as shown below.

- ▷ Press the **MENU** key until the relay displays the setpoints menu header.

Press MENU

```
■ SETPOINTS [▷]
```

Press MESSAGE ▶

```
■ SETPOINTS [▷]
S1 RELAY SETUP
```

Press MESSAGE ▼

```
■ SETPOINTS [▷]
S2 SYSTEM SETUP
```

Press MESSAGE ▶

```
■ CURRENT [▷]
SENSING
```

Press MESSAGE ▼

```
■ BUS VT SENSING [▷]
```

Press MESSAGE ▶

```
VT CONNECTION TYPE:
Wye
```

Press MESSAGE ▼

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

Press the VALUE keys until 115.0 V is displayed, or enter the value directly via the numeric keypad.

```
NOMINAL VT SECONDARY
VOLTAGE: 115.0 V
```

Press the ENTER key to store the setpoint.

```
NEW SETPOINT
STORED
```

To set the VT ratio, modify the **S2 SYSTEM SETUP** ▶ **BUS VT SENSING** ▶ **VT RATIO** setpoint as shown below.

▷Press the **MENU** key until the relay displays the setpoints menu header.

Press MENU

■ **SETPOINTS** [▷]

Press MESSAGE ▶

■ **SETPOINTS** [▷]  
S1 RELAY SETUP

Press MESSAGE ▼

■ **SETPOINTS** [▷]  
S2 SYSTEM SETUP

Press MESSAGE ▶

■ **CURRENT SENSING** [▷]

Press MESSAGE ▼

■ **BUS VT SENSING** [▷]

Press MESSAGE ▶

**VT CONNECTION TYPE:**  
Wye

Press MESSAGE ▼

**NOMINAL VT SECONDARY VOLTAGE:** 120.0 V

Press MESSAGE ▼

**VT RATIO:**  
120.0:1

Press the **VALUE** keys until 125.2:1 is displayed, or enter the value directly via the numeric keypad.

**VT RATIO:**  
125.2:1

Press the **ENTER** key to store the setpoint.

**NEW SETPOINT STORED**

If an entered setpoint value is out of range, the relay displays the following message:

**OUT-OF RANGE -  
VALUE NOT STORED**

To have access to information on maximum, minimum, step value, and information on technical support, press the **HELP** key. For the previous example, pressing the **HELP** key during setpoint entry displays the corresponding minimum, maximum and step values for the displayed setpoint, as well as contact information if further assistance is required.

For example, the help screens for the **PHASE CT PRIMARY** setpoint are shown below:

	<b>PHASE CT PRIMARY:</b> <b>1000 A</b>
Press HELP	<b>MIN: 1</b> <b>MAX: 5000</b>
Press HELP	<b>IN STEPS OF:</b> <b>1</b>
Press HELP	<b>PRESS [0] - [9] OR</b> <b>[VALUE ▲▼] TO EDIT</b>
Press HELP	<b>PRESS [ENTER] TO</b> <b>STORE NEW VALUE</b>
Press HELP	<b>FOR FURTHER HELP</b> <b>REFER TO MANUAL</b>
Press HELP	<b>INTERNET ADDRESS</b> <b>www.GEgrid solutions.com</b>
Press HELP	<b>TECH SUPPORT</b> <b>Tel: (905) 927-7070</b>
Press HELP	<b>TECH SUPPORT</b> <b>Fax: (905) 927-5098</b>

### 1.3.5 Output Relay Setpoints

Each output relay setpoint has the Auxiliary Output Relays 3 to 7 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.

- ▷ Select the **S5 PROTECTION** ▷ **PHASE CURRENT** ▷ **PHASE TIME OVERCURRENT 1** ▷ **PHASE TIME O/C 1 RELAYS (3-7)** setpoint message.

<b>PHASE TIME O/C 1</b> <b>RELAYS (3-7): -----</b>
-------------------------------------------------------

- ▷ If an application requires the Phase TOC protection element to operate the Auxiliary Output 3 relay, select this output relay by pressing the **3** key.

<b>PHASE TIME O/C 1</b> <b>RELAYS (3-7): 3-----</b>
--------------------------------------------------------

- ▷ Press the **ENTER** key to store this change into memory. As before, confirmation of this action will momentarily flash on the display.

<b>NEW SETPOINT</b> <b>STORED</b>
--------------------------------------

The output relay setpoint values are represented by a 1-row, 5-column matrix. For example, a value of **3---7** activates Auxiliary Relays 3 and 7, while a value of **34567** activates all five auxiliary relays.

### 1.3.6 Text Setpoints

Text setpoints accept user-defined character strings as values. 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**, and **ESCAPE** keys.

For example:

- ▷ Move to message **S3 LOGIC INPUTS** ▷ ▾ **USER INPUT A** ▷ **USER INPUT A NAME** setpoint message.  
The name of this user defined input will be changed in this example from the generic **User Input A** to something more descriptive.

```

USER INPUT A NAME:
User 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:
█ser Input A
```

- ▷ Press the **VALUE** keys 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 the text **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 MESSAGE ► key to remove the solid cursor and view the result. Once a character is entered by pressing the **ENTER** key, it is automatically saved in flash memory as a new setpoint.

```

USER INPUT A NAME:
Substation Monitor
```

---

## 1.4 Application Example

### 1.4.1 Description

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.

The following example is only one of many possible applications of the 750/760 relay. Important points to keep in mind before developing settings for any multifunction numerical relay like the 750/760 are as follows:

- Gather system data, including, but not limited to:
  - CT primary and secondary ratings for all CTs used to feed the relay
  - VT primary and secondary ratings for both the bus and line VTs
  - System frequency
  - System phase sequence
- Define the protection elements that will be enabled. Prepare a list of protection functions including the following information. By default, all the protection functions must be assumed Disabled:
  - pickup parameter
  - operating curve (if applicable)
  - time dial or multiplier
  - any additional intentional time delay
  - directionality (if applicable)
- Define how many output contacts will be energized in response to a given protection function. Note that the 750/760 relay can be programmed to *trip* and, at the same time, to energize one, a combination, or all five auxiliary relays during the process.
- Define if the output relays will be set as fail-safe type.
- Define if the 750/760 will be used to close the breaker. If that will be the case, gather information on the conditions that will be used to verify synchronism.
- Define if the relay will be used to monitor the status of the breaker. It is strongly recommended that the 750/760 always be programmed to monitor breaker status by means of a digital input connected to the one of the 750/760 logic inputs. Use an auxiliary contact from the breaker either a normally open contact, 52a, which is normally in open position when the breaker is open, or a normally closed contact, 52b, which is in closed position when the breaker is open. A combination of both can also be utilized, adding the capability for monitoring pole discrepancy, an indication of a potential mechanical problem within the main contact mechanism of the breaker.
- If the relay will be used to respond to logic inputs, prepare a list including:
  - logic input name
  - condition by which the logic input would be considered asserted
  - function that the logic input will initiate within the 750/760.
- If the relay will be used to perform Monitoring functions and act upon certain conditions, gather information such as:

- minimum and maximum values
- alarm and trip values
- time delays
- demand method to be used
- breaker timings
- It is important to familiarize yourself with the relay control functions before setting up the relay. Some control functions such as the Transfer scheme, which takes automatic control of the auxiliary outputs, or the autorecloser that uses the auxiliary outputs for specific pre-defined functions, can have an unwanted effects in the performance of other functions within 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.

Refer to the following figures for schematics related to this application example.

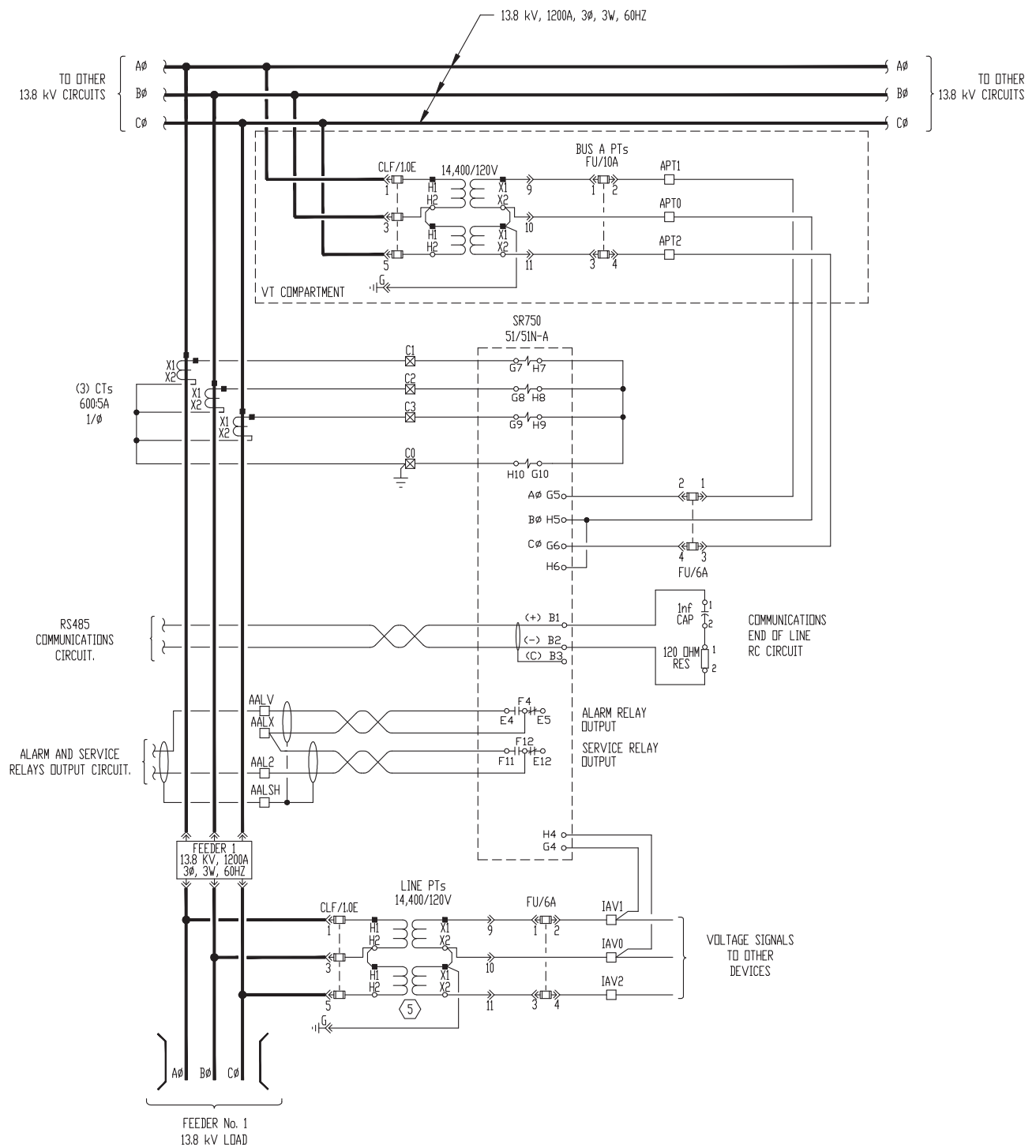


FIGURE 1-1: Typical Three-Line Diagram

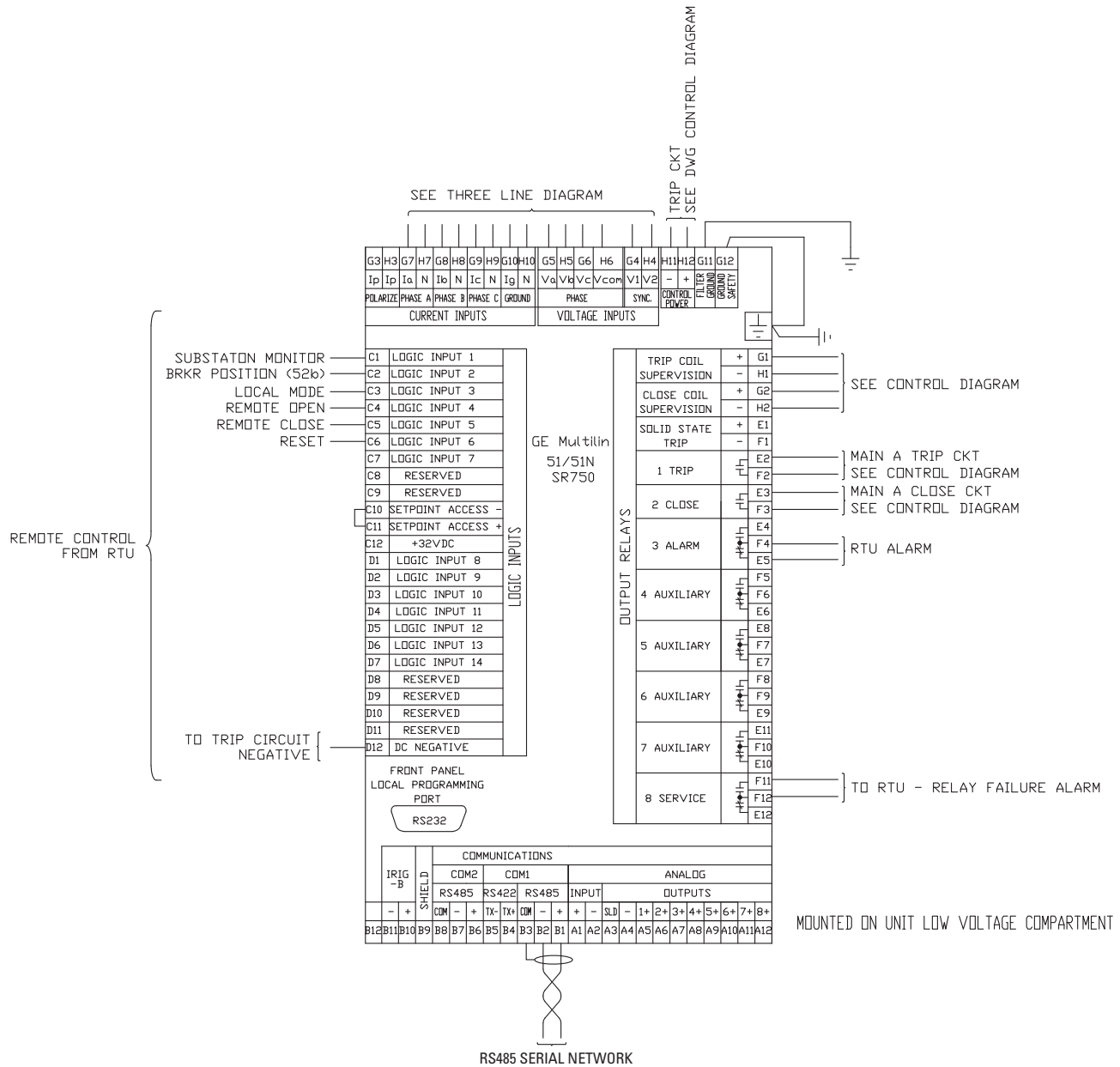


FIGURE 1-2: Typical Connection Diagram



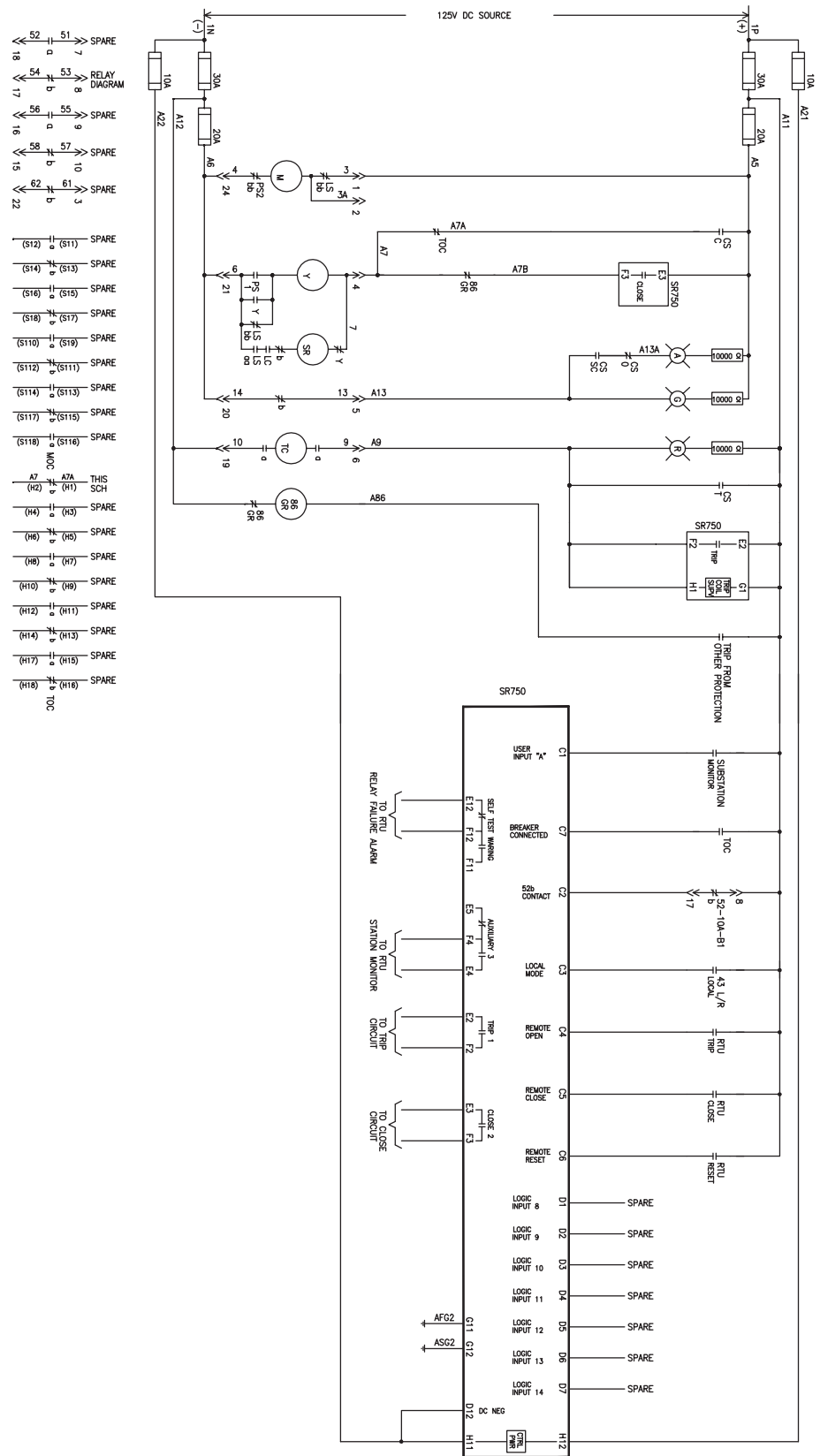


FIGURE 1-3: Typical Control Diagram

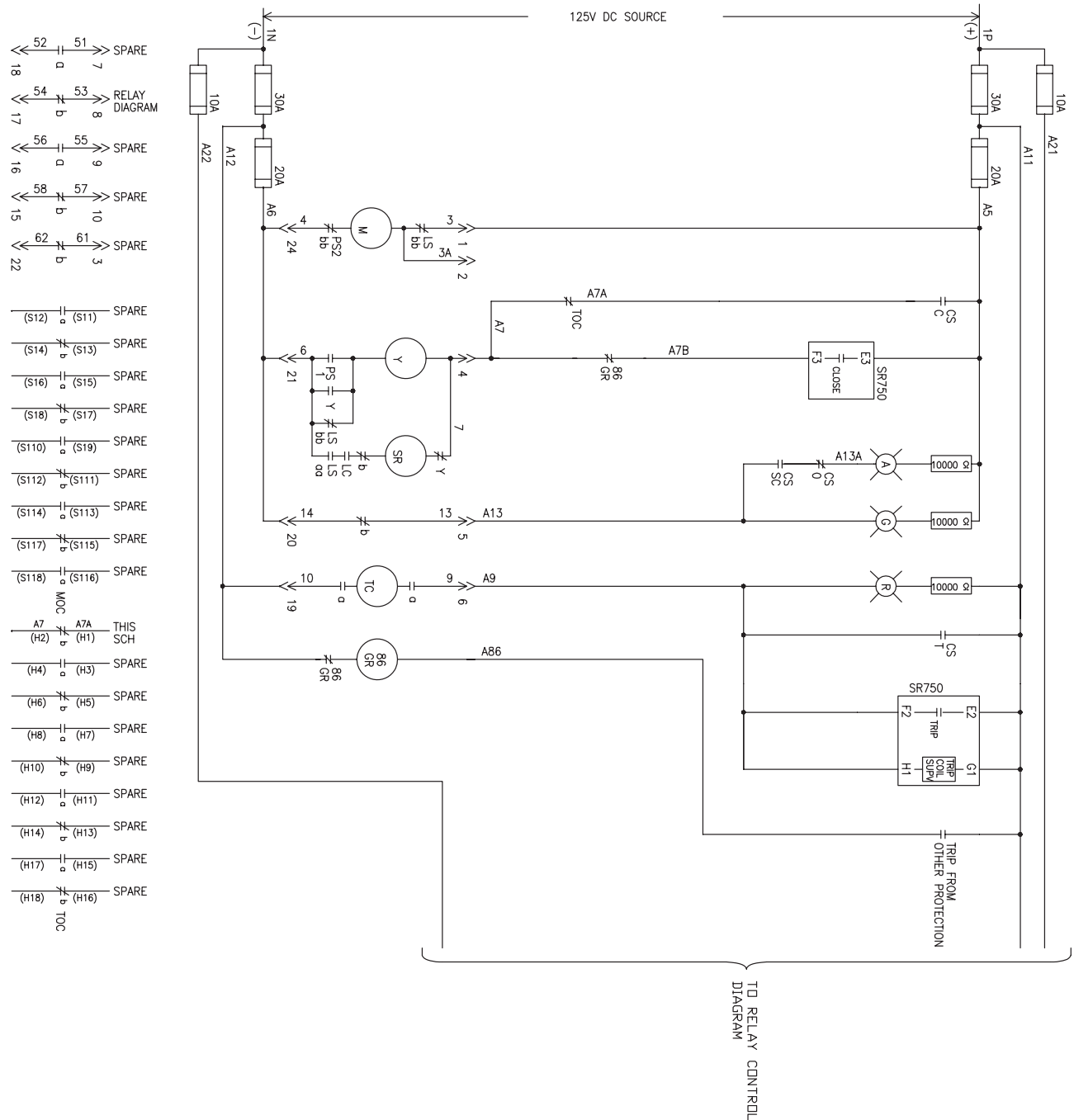


FIGURE 1-4: Typical Breaker Control Diagram

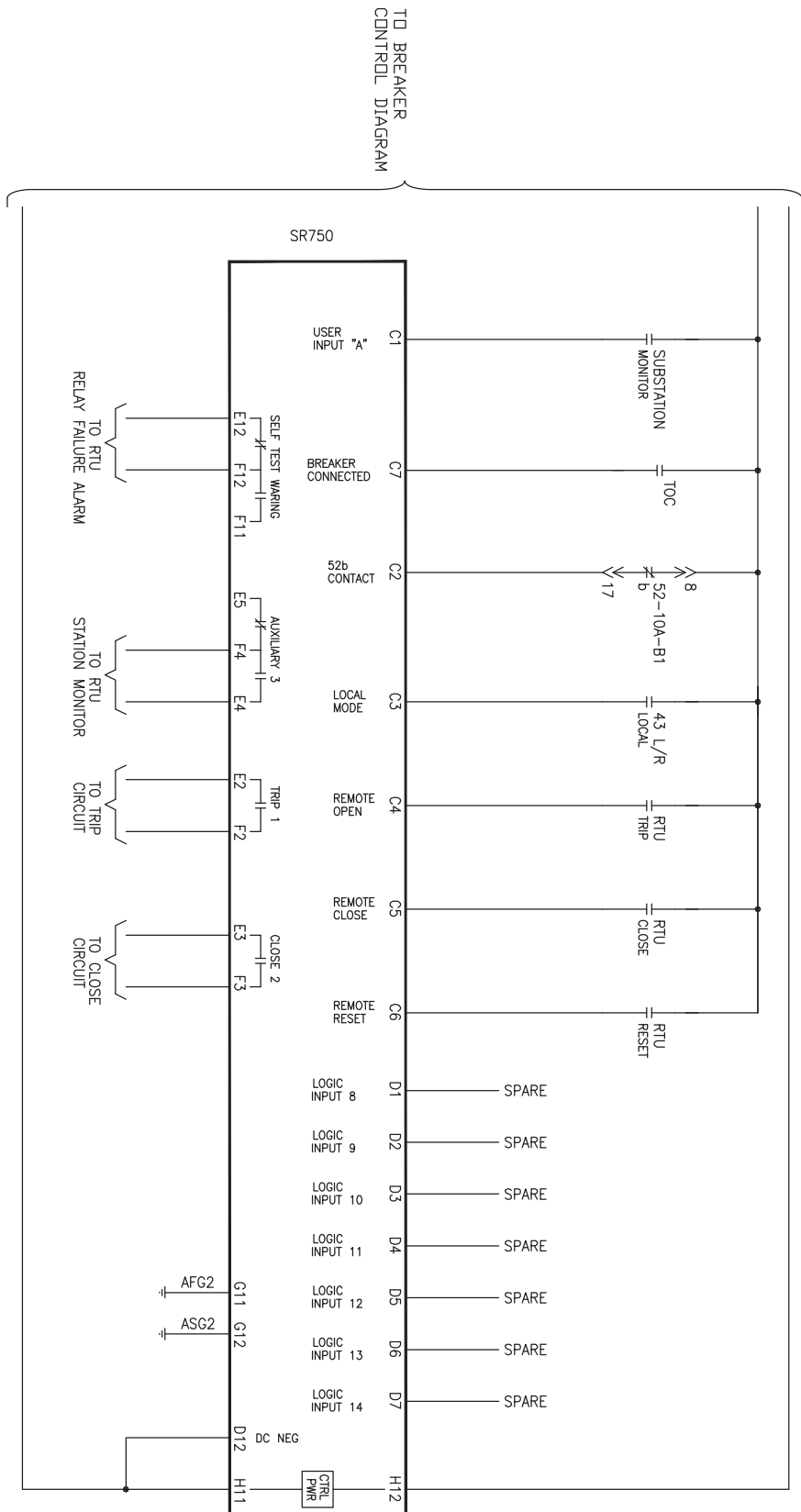


FIGURE 1-5: Typical Relay Control Diagram

- **Power System Data**
  1. System: 3 $\phi$ , 4 wire
  2. Frequency: 60 Hz
  3. Line-to-line voltage: 13.8 kV
  4. Maximum current: 600 A

The above data will be used to set the relay system parameters.

- **Control System Requirements**
  1. All protection elements used are to trip the breaker.
  2. Breaker position monitoring via 52b contact only.
  3. Only current metering is required.
  4. Contact Inputs: Remote open and close contacts from RTU.
  5. Remote/local selection from panel hand switch. Reset from RTU.
  6. Alarm after 100 second delay from substation monitor. This is normally used to signal the remote center when someone has gained access to the substation.
  7. Contact Outputs:
    - Trip and close to breaker control circuit (trip and close relays).
    - Relay failure alarm to RTU (self-test warning, no programming req'd).
    - Alarm contact to RTU (setup in User Function for "Substation Monitor")
    - No data communications to other equipment.

The above data will be used to set the output relays to achieve breaker control and to set digital inputs for breaker status, remote operations, remote status, and alarm indication. The example assumes that the communications between the station and the master control center will be done by the RTU. Alarms, status indication, and breaker commands will be hard-wired from the relay to the RTU. Please note that, similar information could be exchanged between the RTU and the relay via an RS485 or RS422 serial link using Modbus RTU protocol. Refer to GE Publication *GEK-106473: 750/760 Communications Guide* for additional information.

- **Instrument Transformer Data**
  1. Bus VTs: 2  $\times$  Delta connected, ratio = 14.4 kV:120 V
  2. Phase CTs: 3  $\times$  Wye connected, ratio = 600:5 A

The above data will be used to set the relay system parameters, such as CT and VT connections, VT secondary voltage, and CT and VT primary to secondary ratios.

- **Phase Protection Settings**
  1. Time Overcurrent 1 (51P1): Curve Shape = Moderately Inverse; Pickup = 840 A; Multiplier = 20.2
  2. Instantaneous Overcurrent 1 (50P1): Pickup = 840 A; Phases Required = Any Two; Delay = 0 s
  3. Instantaneous Overcurrent 2 (50P2): Pickup = 10100 A; Phases Required = Any Two; Delay = 0 s

- **Neutral Protection Settings**

1. Time Overcurrent 1 (function 51N1):
  - Curve shape = Moderately Inverse
  - Pickup = 120 A
  - Multiplier = 10
2. Instantaneous Overcurrent 1 (function 50N1):
  - Pickup = 120 A
  - Phases required = Any two
  - Delay = 0 seconds
3. Instantaneous Overcurrent 2 (function 50N2):
  - Pickup = 2000 A
  - Phases required = Any two
  - Delay = 0 seconds

The above data will be used to configure the relay protection. In this example, the relay will be used for Phase and Neutral Overcurrent protection only; that is, functions 51P1, 50P1, 50P2, 51N1, 50N1, and 50N2.

In this manual, Neutral Overcurrent is to the residual current, calculated from the currents measured at the phase CT inputs: terminals G7-H7 for phase A, G8-H8 for phase B and G9-H9 for phase C. Since it is a calculated value, it cannot be used to generate oscillography. Ground Overcurrent refers to the current measured at terminals G10-H10, or at terminals G3-H3 for Sensitive Ground Overcurrent, when the relay is fitted to measure sensitive ground current.

You should now be familiar with maneuvering through and editing setpoints. 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.

### 1.4.2 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 the Power System Data and Instrument Transformer Data headings in the previous subsection. From this information and the resulting calculations, program the page S2 setpoints as indicated.

For current transformers, make the following change in the **S2 SYSTEM SETUP ▷ CURRENT SENSING** setpoints page:

**PHASE CT PRIMARY:** "600 A"

Since the example does not contemplate a ground CT, the setpoints for **GND CT PRIMARY**, and **SENSTV GND CT** can be left unchanged. For additional information refer to *Current Sensing* on page 5-22.

For voltage transformers, make the following changes in the **S2 SYSTEM SETUP ▷ ▽ BUS VT SENSING** setpoints page:

**VT CONNECTION TYPE:** "Delta"

**NOMINAL VT SECONDARY VOLTAGE:** "115.0 V"

(for a 138 kV system,  $13.8 \text{ kV} / 120 = 115 \text{ V}$ )

**VT RATIO:** "120:1" ( $14.4 \text{ kV VT}_{\text{primary}} / 120 \text{ V VT}_{\text{secondary}}$ )

For the case where Bus VTs are connected in Wye, the system settings are:

**VT CONNECTION TYPE:** "Wye"

**NOMINAL VT SECONDARY VOLTAGE:** "66.4 V" (the phase-to-neutral voltage must be entered. For a 13.8 kV system, we have  $13.8 \text{ kV } \phi\text{-}\phi \div \sqrt{3} = 7.97 \text{ kV } \phi\text{-N}$ ; therefore,  $7.97 \text{ kV} / 120 = 66.4 \text{ V}$ )

**VT RATIO:** "120:1" ( $14.4 \text{ kV VT}_{\text{primary}} / 120 \text{ V VT}_{\text{secondary}}$ )

For additional information, refer to *Bus VT Sensing* on page 5–22.

The 750/760 was designed to display primary system values. Current and voltage measurements are performed at secondary levels, which the relay transforms to primary values using CT and VT ratios, as well as nominal secondary values.

Configuring the relay for current measurement is simple and it only requires setting the CT ratios. CT inputs can be 1 A or 5 A and must be specified when the relay is purchased. There is additional flexibility with regards to the VT inputs, as nominal values are not required before the relay is ordered; therefore, more settings are needed to prepare the relay for voltage measurements.

Make the following change in the **S2 SYSTEM SETUP** ▾ ▽ **POWER SYSTEM** setpoints page to reflect the power system:

**NOMINAL FREQ:** "60 Hz"

For additional information, refer to *Power System* on page 5–23.

### 1.4.3 S3 Logic Inputs Setpoints

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

To properly configure the relay to respond to digital inputs, they need to be defined as follows:

1. The digital inputs should be re-named. Changing the default names to meaningful names is strongly recommended so they can be easily identified in the LCD and in event reports.
2. The asserted logic must be identified. Refer to *S3 Logic Inputs* on page 5–26 for additional information.
3. The functionality of the logic inputs must be defined. Note that a logic input can be utilized for more than one application.

If step 3 is not done, the relay will not perform any function, even if the logic input is defined and the asserted logic is met. The last two steps use the following setpoints pages:

- **S3 LOGIC INPUTS** ▾ ▽ **BREAKER FUNCTIONS** for breaker status.
- **S3 LOGIC INPUTS** ▾ ▽ **CONTROL FUNCTIONS** for local/remote operations, cold load pick up, and setpoint group changes.
- **S3 LOGIC INPUTS** ▾ ▽ **USER INPUTS** to energize output relays adding time delay.

- **S3 LOGIC INPUTS ▷ ▾ BLOCK FUNCTION** to block protection functions other than overcurrent functions
- **S3 LOGIC INPUTS ▷ ▾ BLOCK OC FUNCTIONS** to block overcurrent functions.
- **S3 LOGIC INPUTS ▷ ▾ TRANSFER FUNCTIONS** to set inputs that will work with the automatic transfer scheme.
- **S3 LOGIC INPUTS ▷ ▾ RECLOSER FUNCTIONS** (760 relay only) to set inputs to work with the autorecloser functions.
- **S3 LOGIC INPUTS ▷ ▾ MISC FUNCTIONS** to trigger oscillography, fault simulation, and start demand intervals.

For breaker position monitoring, enter the following values in the **S3 LOGIC INPUTS ▷ LOGIC INPUTS SETUP** page:

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

Then, to define the functionality of the logic input, enter the following value in the **S3 LOGIC INPUTS ▷ ▾ BREAKER FUNCTIONS** setpoint page:

**52B CONTACT:** "Input 2"

For the Remote Open/Close and Reset RTU contacts, enter the following values in the **S3 LOGIC INPUTS ▷ LOGIC INPUTS SETUP** setpoints page to define the logic inputs. Using the MESSAGE ▼ key, find the appropriate logic name message and then define the logic input asserted logic to complete the logic input definition as follows:

**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"

Once the Logic Input definitions are completed, it is necessary to define their functionality by entering the following values in the **S3 LOGIC INPUTS ▷ ▾ CONTROL FUNCTIONS** setpoint page. Using the MESSAGE ▼ key, locate the appropriate logic function and select the corresponding logic input to perform the function.

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

If, for example, the same logic input would be needed to perform the functionality of Close and Reset, then the following should have been entered:

**RESET:** "Input 5"  
**REMOTE CLOSE:** "Input 5"

To setup an Alarm-after-Delay input, make the following changes to the **S3 LOGIC INPUTS ▷ ▾ USER INPUT A** setpoints page. Press the MESSAGE ▼ key after each setpoint is completed to move to the next message.

**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"

#### 1.4.4 S5 Protection Setpoints

The S5 Protection setpoints page contains setpoints for entering protection element characteristics. In our example, these characteristics are specified under the **S5 PROTECTION ▷ PHASE CURRENT** and **S5 PROTECTION ▷ NEUTRAL CURRENT** headings. From this data and the resulting calculations, program the page S5 setpoints as indicated. When setting the relay for the first time, other setpoints not listed in this example will be left disabled.

For the Phase Time Overcurrent 1 element, enter the following values in the **S5 PROTECTION ▷ PHASE CURRENT ▷ PHASE TIME OVERCURRENT 1** page. Press the MESSAGE ▼ key after each setpoint is completed to move to the next message.

**PHASE TIME OC 1 FUNCTION:** "Trip"

**PHASE TIME OC 1 PICKUP:** "1.40 x CT" (calculated as 840 A pickup / 600 A primary)

**PHASE TIME OC 1 CURVE:** "Mod Inverse"

**PHASE TIME OC 1 MULTIPLIER:** "20.20"

**PHASE TIME OC 1 RESET:** "Instantaneous"

For the Phase Instantaneous Overcurrent 1 element, enter the following values in the **S5 PROTECTION ▷ PHASE CURRENT ▷ PHASE INST OVERCURRENT 1** setpoints page. Press the MESSAGE ▼ key after each setpoint is completed to move to the next message.

**PHASE INST OC 1 FUNCTION:** "Trip"

**PHASE INST OC 1 PICKUP:** "1.40 x CT" (calculated as 840 A pickup / 600 A primary)

**PHASE INST OC 1 DELAY:** "0.00 s"

**PHASES REQUIRED FOR OPERATION:** "Any Two"

For the Phase Instantaneous Overcurrent 2 element, enter the following values in the **S5 PROTECTION ▷ PHASE CURRENT ▷ PHASE INST OVERCURRENT 2** setpoints page. Press the MESSAGE ▼ key after each setpoint is completed to move to the next message.

**PHASE INST OC 2 FUNCTION:** "Trip"

**PHASE INST OC 2 PICKUP:** "16.83 x CT" (from 10100 A pickup / 600 A primary)

**PHASE INST OC 2 DELAY:** "0.00 s"

**PHASES REQUIRED FOR OPERATION:** "Any Two"

For the Neutral Time Overcurrent 1 element, enter the following values in the **S5 PROTECTION ▷ NEUTRAL CURRENT ▷ NEUTRAL TIME OVERCURRENT 1** page. Press the MESSAGE ▼ key after each setpoint is completed to move to the next message.

**NEUTRAL TIME OC 1 FUNCTION:** "Trip"

**NEUTRAL TIME OC 1 PICKUP:** "0.20 x CT" (from 120 A pickup / 600 A primary)

**NEUTRAL TIME OC 1 CURVE:** "Mod Inverse"

**NEUTRAL TIME OC 1 MULTIPLIER:** "10.00"

**NEUTRAL TIME OC 1 RESET:** "Instantaneous"

For the Neutral Instantaneous Overcurrent 1 element, enter the following values in the **S5 PROTECTION ▷ NEUTRAL CURRENT ▷ NEUTRAL INST OVERCURRENT 1** setpoints page. Press the MESSAGE ▼ key after each setpoint is completed to move to the next message.



**NEUTRAL INST OC 1 FUNCTION:** "Trip"

**NEUTRAL INST OC 1 PICKUP:** "0.20 x CT" (from 120 A pickup / 600 A primary)

**NEUTRAL INST OC 1 DELAY:** "0.00 s"

For the Neutral Instantaneous Overcurrent 2 element, enter the following values in the **S5 PROTECTION** > **NEUTRAL CURRENT** > **NEUTRAL INST OVERCURRENT 2** setpoints page. Press the MESSAGE ▼ key after each setpoint is completed to move to the next message.

**NEUTRAL INST OC 2 FUNCTION:** "Trip"

**NEUTRAL INST OC 2 PICKUP:** "3.33 x CT" (from 2000 A pickup / 600 A primary)

**NEUTRAL INST OC 2 DELAY:** "0.00 s"

The Ground Overcurrent element is disabled by entering the following values in the **S5 PROTECTION** > **GROUND CURRENT** > **GROUND TIME OVERCURRENT** setpoints page:

**GROUND TIME O/C FUNCTION:** "Disabled"

**GROUND INST O/C FUNCTION:** "Disabled"

The Negative Sequence Overcurrent elements is disabled by entering the following values in the **S5 PROTECTION** > **NEGATIVE SEQUENCE** setpoints page:

**NEG SEQ TIME OVERCURRENT** > **NEG SEQ TIME OC FUNCTION:** "Disabled"

**NEG SEQ INST OVERCURRENT** > **NEG SEQ INST OC FUNCTION:** "Disabled"

## 1.4.5 Installation

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 when it leaves the factory. A minor self-test warning message informs the user that the 750/760 has not yet been programmed. If this warning is ignored, protection is active and will be using factory default setpoints. The Relay In Service LED Indicator will be on.

The following message indicates that the relay is in the Not Ready state:

<p><b>SELF-TEST WARNING</b> <b>Relay Not Ready</b></p>
------------------------------------------------------------

Move to the **S1 RELAY SETUP** > **INSTALLATION** > **750 OPERATION** setpoint message. To put the relay in the Ready state, press the VALUE ▲ key until the **READY** message is displayed and press ENTER. Enter "Yes" at the **ARE YOU SURE?** prompt. The Relay In Service LED Indicator will now turn on and the **SELF TEST WARNING: Relay Not Ready** diagnostic message will disappear.

---

## 1.5 Commissioning

Extensive commissioning tests are available in Chapter : Commissioning.

Commissioning tables for recording required settings are available in Microsoft Excel format from the GE Multilin website at <http://www.gegridsolutions.com>. The website also contains additional technical papers and FAQs relevant to the 750/760 Feeder Management Relay.



# 750/760 Feeder Management Relay

## Chapter 2: Introduction

---

### 2.1 Overview

#### 2.1.1 Description

The 750/760 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 provide a more intuitive interface, setpoints can be entered with a PC running the EnerVista 750/760 Setup software provided with the relay. Even with minimal computer knowledge, this menu-driven software provides easy access to all front panel functions. Actual values 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 and a single-line diagram of protection and control features is shown below. For a complete understanding of each feature operation, refer to Chapter 5: Setpoints. 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.

ANSI	PROTECTION / CONTROL	FEEDER			BUS		TRANSFORMER		LINE	
		Capacitor	Radial	Two-ended	Backup	Transfer	Backup	Backup		
27	Bus / Line Undervoltage	●	●	●	●	●			●	
47	Negative Sequence Voltage	●	●	●	●			●	●	
50	Phase/Neutral/Gnd/Neg Seq/Sens Gnd Inst O/C	●	●	●				●	●	
51	Phase/Neutral/Gnd/Neg Seq/Sens Gnd Time O/C	●	●	●	●	●		●	●	
59	Bus Overvoltage/Neutral Displacement	●	●	●	●			●	●	
67	Phase/Neutral/Neg Seq/Sens Gnd/Gnd Directional Control			●	●			●	●	
81	Bus Underfrequency/Rate of Change				●			●	●	
	Undervoltage Automatic Restoration	●	●	●	●			●		
	Underfrequency Automatic Restoration	●	●	●	●			●		
	Breaker Failure with Current Superv.	●	●	●	●	●		●	●	
	Bus Transfer					●				
	Programmable Logic Inputs	●	●	●	●	●		●	●	
	Multiple Setpoint Groups	●	●	●	●	●		●	●	

MONITORING / CONTROL		FEEDER			BUS		TRANSFORMER		LINE	
25	Synchrocheck			●		●			●	
50	Phase/Neutral Current Level	●	●	●	●	●		●	●	
55	Power Factor	●	●							
79	Autoreclose (760 only)		●	●					●	
81	Overfrequency								●	
	Breaker Open/Close	●	●	●	●	●		●	●	
	Manual Close Feature Blocking	●	●	●		●		●		
	Cold Load Pickup Feature Blocking		●	●	●			●		
	Breaker Operation Failure	●	●	●	●	●		●	●	
	Trip/Close Circuit Failure	●	●	●	●	●		●	●	
	Total Breaker Arcing Current	●	●	●	●	●		●	●	
	VT Failure	●	●	●					●	
	Demand (A, MW, Mvar, MVA)	●	●	●	●	●		●	●	
	Analog Input	●	●	●	●	●		●	●	
	Event Recording	●	●	●	●	●		●	●	
	Analog Output	●	●	●					●	
	Fault Locator		●	●					●	
	Trip Counter	●	●	●	●	●		●	●	

826712A1.CDR

FIGURE 2-1: Summary of Features

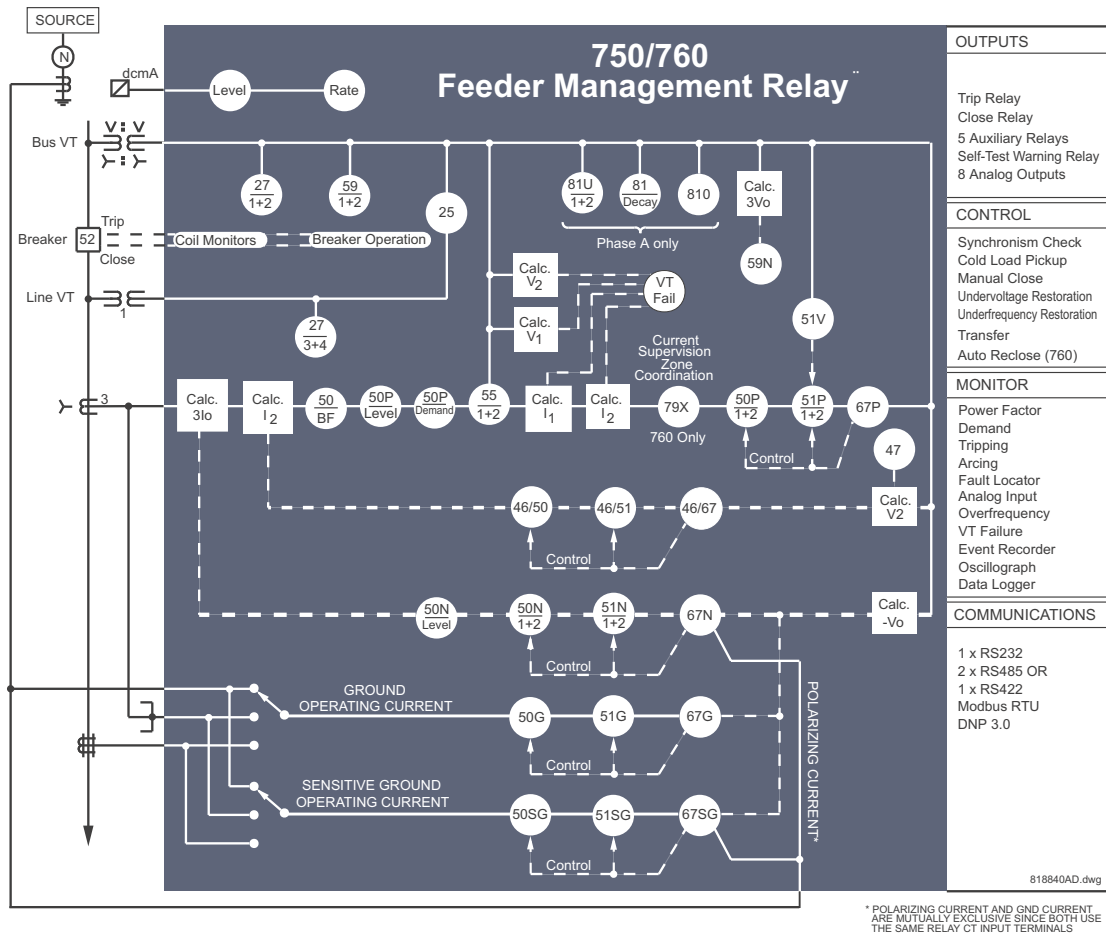


FIGURE 2-2: Functional Block Diagram

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## 2.2 Theory of Operation

### 2.2.1 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; a Grid Connect DSTni-LX Turbo 186 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. The remainder of this section describes the algorithms and operations that are critical to protection elements.

### 2.2.2 Current and Voltage Waveform Capture

Current and voltage transformers (CTs and VTs) are used to scale-down the incoming current and voltage signals from the source instrument transformers. The 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 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 EnerVista 750/760 Setup software for display and diagnostics.

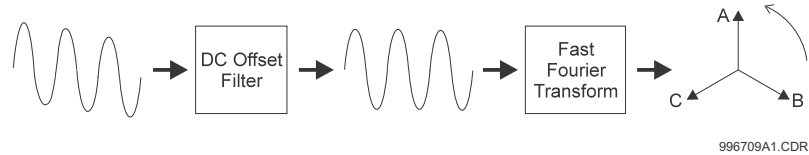
### 2.2.3 Frequency Tracking

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/second. 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.

### 2.2.4 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:



### 2.2.5 Processing of AC Current Inputs

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 discussion 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.

A novel filtering of the phase and ground currents is employed on the relay to assure fast and secure Phase and Ground Instantaneous over-current operation. With an integrated CT saturation detection mechanism, these protections can detect and produce stable operation even for fault currents heavily distorted by the saturation of the Current Transformers.

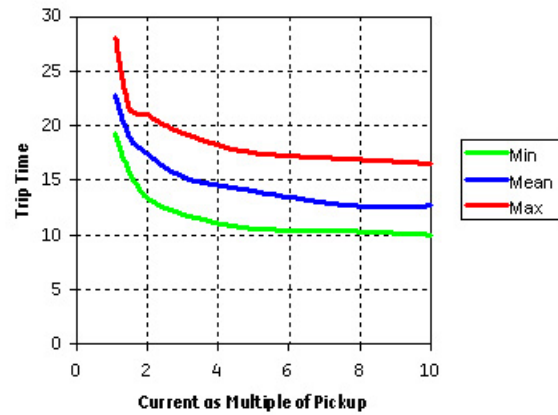
### 2.2.6 Protection Elements

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.

The phase input currents for the Phase over-current protections are estimated at rate of four times per cycle.

The figure below presents the IOC trip times – from fault inception till closure of a trip rated output – of the 750 relay. The response time depends on the ratio between the fault current and the applied setting and varies from 16ms for high multiples of pickup to 25ms for multiple of 1.2 times pickup.





### 2.2.7 Logic Inputs

Contact inputs are de-bounced 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.

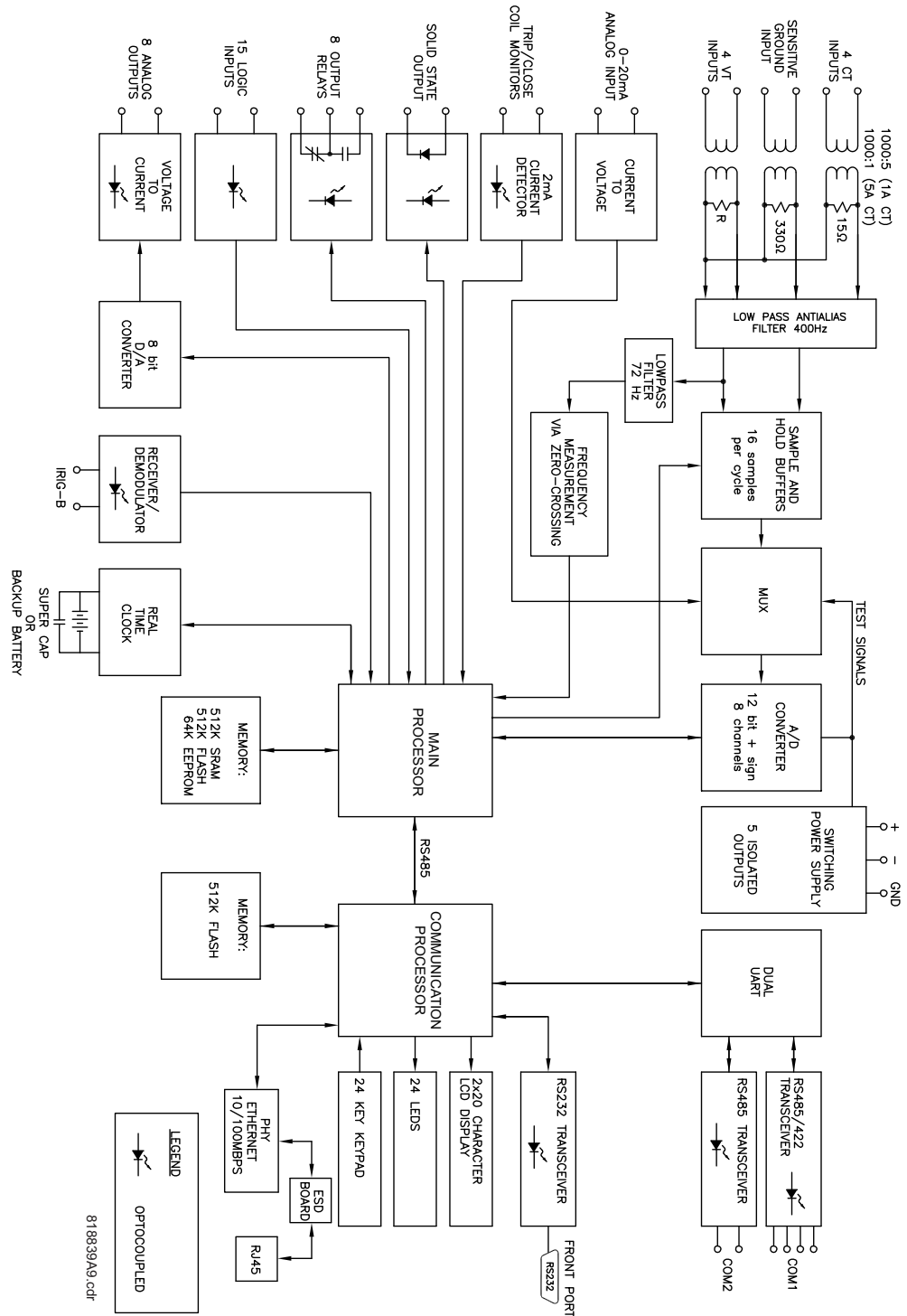


FIGURE 2-3: Hardware Block Diagram

## 2.3 Ordering

### 2.3.1 Order Codes

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.

	750	-	*	-	*	-	*	-	*	-	*	-	*	-	*	750 Feeder Management Relay
	760	-	*	-	*	-	*	-	*	-	*	-	*	-	*	760 Feeder Management Relay
<b>Base Unit</b>	750															750 relay
	760															760 relay with autoreclose
<b>Phase Current Inputs</b>	P1															1 A phase current inputs
	P5															5 A phase current inputs
<b>Zero-Sequence Current Inputs</b>	G1															1 A zero-sequence current inputs
	G5															5 A zero-sequence current inputs
<b>Sensitive Ground or Polarizing Current Input</b>	S1															1 A sensitive ground current input
	S5															5 A sensitive ground current input
	D1															1 A polarizing current input (MOD009)
	D5															5 A polarizing current input (MOD009)
<b>Control Power</b>	LO															20 to 60 V DC; 20 to 48 V AC at 48 to 62 Hz
	HI															88 to 300 V DC; 70 to 265 V AC at 48 to 62 Hz
<b>Analog Outputs</b>	A1															Eight (8) 0 to 1 mA analog outputs
	A5															Eight (8) 0 to 5 mA analog outputs
	A10															Eight (8) 0 to 10 mA analog outputs
	A20															Eight (8) 4 to 20 mA analog outputs
<b>Breaker Closed LED</b>	R															Red LED for Breaker Closed indicator
	G															Green LED for Breaker Closed indicator
<b>Display/Ethernet</b>	B															Discontinued: Basic display
	E															Enhanced display
	T															Enhanced display with Ethernet
<b>Environmental Protection</b>														H		Harsh (Chemical) Environment Conformal Coating

### 2.3.2 Example Order Codes

1. The 750-P1-G1-S1-LO-A10-R-B specifies a 750 Feeder Management Relay with 1 A phase, zero-sequence, and sensitive ground current inputs, low control power, eight 0 to 10 mA analog outputs, a red LED for the Breaker Closed indicator, and a basic display.
2. The 760-P5-G5-S5-HI-A20-G-T specifies a 760 Feeder Management Relay with autoreclose, 5 A phase, zero-sequence, and sensitive ground current inputs, high control power, eight 4 to 20 mA analog outputs, a green LED for the Breaker Closed indicator, and enhanced display with Ethernet (10Base-T).

### 2.3.3 Accessories

- **DEMO:** Metal carry case in which the 750/760 can be mounted
- **SR19-1 or SR19-2 PANEL:** Single or double cutout 19-inch panels
- **RS-232/485:** RS232 to RS485 converter box for harsh industrial environments
- **1 A and 5 A PHASE CTs:** 50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 600, 750, and 1000 CT ratios
- **SR 1 $\frac{3}{8}$ -inch COLLAR:** For shallow switchgear, the collar reduces the depth of the relay by 1 3/8 inches
- **SR 3-inch COLLAR:** For shallow switchgear, the collar reduces the depth of the relay by 3 inches.

## 2.4 Specifications

### 2.4.1 Applicability

#### APPLICABILITY

Systems:	3 or 4 wire, 600 kV maximum 5000 A maximum
Frequency:	25 to 60 Hz nominal (frequency tracking allows operation from 16 to 65 Hz)

### 2.4.2 Inputs

#### CONTROL POWER

Options:	LO/HI (specify with order)
LO range:	20 to 60 V DC 20 to 48 V AC at 48 to 62 Hz
HI range:	88 to 300 V DC 70 to 265 V AC at 48 to 62 Hz
Power:	25 VA nominal, 35 VA max.
Total loss of voltage ride through time (0% control power):	16 ms

#### PHASE CURRENT

Source CT:	1 to 50000 A primary, 1 or 5 A secondary
Relay input:	1 A or 5 A (specify with order)
Conversion range:	0.01 to 20 × CT (fundamental frequency only)
Accuracy:	at < 2 × CT: ±0.5% of 2 × CT at ≥ 2 × CT: ±1% of 20 × CT
Overload withstand:	1 second at 80 × rated current; continuous at 3 × rated current
Calculated neutral current errors:	3 × phase inputs

#### GROUND CURRENT

Source CT:	1 to 50000 A primary, 1 or 5 A secondary
Relay input:	1 A or 5 A (specify with order)
Conversion range:	0.01 to 20 × CT (fundamental frequency only)
Accuracy:	at < 2 × CT: ±0.5% of 2 × CT at ≥ 2 × CT: ±1% of 20 × CT
Overload withstand:	1 second at 80 × rated current; continuous at 3 × rated current

CT Input	Current	Burden (typical)	
		VA	OHMS
1 A Phase & Ground	1 A	0.025 VA	0.02
	5 A	0.60 VA	
	20 A	10 VA	
5 A Phase & Ground	5 A	0.40 VA	0.02
	25 A	10 VA	
	100 A	120 VA	

**SENSITIVE GROUND CURRENT**

Source CT:	1 to 50000 A primary, 1 or 5 A secondary
Relay input:	1 A or 5 A (specify with order)
Burden:	< 0.2 VA at 1 or 5 A
Conversion range: Low end:	$0.005 \times CT$
	Maximum: 500 A primary (fundamental frequency only)
Accuracy:	at $< 0.1 \times CT$ : $\pm 0.2\%$ of $1 \times CT$ at $\geq 0.1 \times CT$ : $\pm 1\%$ of $1 \times CT$
Overload withstand:	1 second at $80 \times$ rated current; continuous at $3 \times$ rated current

**BUS AND LINE VOLTAGE**

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 to 240 V phase-neutral
Burden:	< 0.025 VA at 120 V or > 576 KW
Maximum continuous:	273 V phase-neutral (full-scale) at fundamental frequency only
Accuracy (0 to 40°C):	$\pm 0.25\%$ of full scale (11 to 130 V); $\pm 0.8\%$ of full scale (130 to 273 V). For open delta, the calculated phase has errors 2 times those shown.

**LOGIC INPUTS**

Inputs:	14 contact and / or virtual inputs, 6 virtual only (functions assigned to logic inputs)
Dry contacts:	1000 $\Omega$ maximum ON resistance (32 V DC at 2 mA provided by relay)
Wet contacts:	30 to 300 V DC at 2.0 mA (external DC voltage only)

**ANALOG INPUT**

Current Input:	0 to 1 mA, 0 to 5 mA, 0 to 10 mA, 0 to 20 mA, or 4 to 20 mA (programmable)
Input impedance:	375 $\Omega \pm 10\%$
Conversion range:	0 to 21 mA
Accuracy:	$\pm 1\%$ of full scale

**TRIP & CLOSE COIL MONITORING**

Acceptable voltage range:	20 to 250 V DC
Trickle current:	2 to 5 mA

**IRIG-B**

Amplitude modulated:	2.5 to 6 Vpk-pk at 3:1 signal ratio
DC shift:	TTL
Input impedance:	20 k $\Omega \pm 10\%$
Error:	$\pm 1.0$ ms

**2.4.3 Measured Parameters**

NOTE

In the following specifications, accuracies are based on less than  $2 \times CT$  and 50 to 130 V inputs. The full-scale is defined as follows: Full Scale =  $2 \times CT$  at  $1 \times VT_{Full\ Scale} \times \sqrt{3}$ .

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**

Phasors: Phase A RMS current  
Phase B RMS current  
Phase C RMS current

% of load-to-trip accuracy:  $\pm 0.5\%$  of full-scale

### **VOLTAGE**

Phasors: Phase A-N (A-B) voltage  
Phase B-N (B-C) voltage  
Phase C-N (C-A) voltage

Accuracy:  $\pm 0.25\%$  of full scale

### **FREQUENCY**

Measured: A-N (A-B) bus and line voltage

Range: 16 to 65 Hz

Accuracy:  $\pm 0.02$  Hz

### **SYMMETRICAL COMPONENTS**

Current level accuracy:  $\pm 1.5\%$  of full scale

Voltage level accuracy:  $\pm 0.75\%$  of full scale

Current and voltage angle accuracy:  $\pm 2^\circ$

### **3 $\Phi$ POWER FACTOR**

Range: 0.00 Lag to 1.00 to 0.00 Lead

Accuracy:  $\pm 0.02$

### **3 $\Phi$ REAL POWER**

Range:  $-3000.0$  to  $3000.0$  MW

Accuracy:  $\pm 1\%$  of full scale

### **3 $\Phi$ REACTIVE POWER**

Range:  $-3000.0$  to  $3000.0$  Mvar

Accuracy:  $\pm 1\%$  of full scale

(see note above)

### **3 $\Phi$ APPARENT POWER**

Range:  $-3000.0$  to  $3000.0$  MVA

Accuracy:  $\pm 1\%$  of full scale (see note above)

### **WATT-HOURS**

Range:  $-2.1 \times 10^8$  to  $2.1 \times 10^8$  MWh

Accuracy:  $\pm 2\%$  of full scale (see note above) per hour

### **VAR-HOURS**

Range:  $-2.1 \times 10^8$  to  $2.1 \times 10^8$  Mvarh

Accuracy:  $\pm 2\%$  of full scale (see note above) per hour

### **DEMAND RANGE**

Phase A/B/C current: 0 to 65535 A

3 $\Phi$  real power:  $-3000.0$  to  $3000.0$  MW

3 $\Phi$  reactive power:  $-3000.0$  to  $3000.0$  Mvar

3 $\Phi$  apparent power:  $-3000.0$  to  $3000.0$  MVA

### **DEMAND MEASUREMENT**

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:  $\pm 2\%$  of full scale  
(see note above)

#### 2.4.4 Protection Elements

##### **PHASE / NEUTRAL / GROUND / NEGATIVE SEQUENCE TIME OVERCURRENT**

Pickup level: 0.05 to 20.00  $\times$  CT in steps of 0.01  
 Dropout level: 97 to 98% of pickup level, or pickup level minus 2% of nominal current (0.02  $\times$  CT), whichever is less  
 Curves: 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 to 100.00 in steps of 0.01  
 Reset type: Instantaneous/Linear  
 Level accuracy: per current input  
 ( $I_2$  is 3  $\times$  input error)  
 Timing accuracy:  $\pm 3\%$  of trip time or  $\pm 40$  ms (whichever is greater) at  $\geq 1.03 \times$  PU

##### **SENSITIVE GROUND TIME OVERCURRENT**

Pickup level: 0.005 to 1.000  $\times$  CT in steps of 0.001  
 Dropout level: 97 to 98% of pickup level, or pickup level minus 2% of nominal current (0.02  $\times$  CT), whichever is less  
 Curves: 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 to 100.00 in steps of 0.01  
 Reset type: Instantaneous/Linear  
 Level accuracy: per sensitive ground current input  
 Timing accuracy:  $\pm 3\%$  of trip time or  $\pm 40$  ms (whichever is greater) at  $\geq 1.03 \times$  PU

##### **VOLTAGE RESTRAINED PHASE TIME OVERCURRENT**

Pickup adjustment: Modifies pickup from 0.10 to 0.90  $\times$  VT nominal in a fixed line relationship

##### **PHASE / GROUND INSTANTANEOUS OVERCURRENT**

Pickup level: 0.05 to 20.00  $\times$  CT in steps of 0.01  
 Dropout level: 97 to 98% of pickup level, or pickup level minus 2% of nominal current (0.02  $\times$  CT), whichever is less  
 Time delay: 0 to 600.00 s in steps of 0.01  
 Level accuracy: per phase / neutral / ground current input ( $I_2$  is 3  $\times$  phase input error)  
 Operate time (Phase instantaneous, 0 ms time delay): 25 ms max. (output relay included), 1.5  $\times$  pickup @ 60 Hz, and 20 ms max. (solid state output included), 1.5  $\times$  pickup @ 60 Hz  
 Operate time (Ground instantaneous, 0 ms time delay): 50 ms max. (output relay included), 1.5  $\times$  pickup @ 60 Hz, and 45 ms max. (solid state output included), 1.5  $\times$  pickup @ 60 Hz  
 Timing accuracy:  $\pm 20$  ms or  $\pm 0.1\%$  of time delay setting (whichever is greater)  
 Phases: Any one, any two, or all three (programmable) phases must operate for output (not for  $I_2$ )

##### **NEUTRAL / NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT**

Pickup level: 0.05 to 20.00  $\times$  CT in steps of 0.01  
 Dropout level: 97 to 98% of pickup level, or pickup level minus 2% of nominal current (0.02  $\times$  CT), whichever is less  
 Time delay: 0 to 600.00 s in steps of 0.01



Level accuracy:	per phase / neutral / ground current input ( $I_2$ is $3 \times$ phase input error)
Operate time (0 ms time delay):	50 ms max. (output relay included), $1.5 \times$ pickup @ 60 Hz, and 45 ms max. (solid state output included), $1.5 \times$ pickup @ 60 Hz
Timing accuracy:	$\pm 20$ ms or $\pm 0.1\%$ of time delay setting (whichever is greater)
Phases:	Any one, any two, or all three (programmable) phases must operate for output (not for $I_2$ )

**SENSITIVE GROUND INSTANTANEOUS OVERCURRENT**

Pickup level:	0.005 to $1.000 \times CT$ in steps of 0.001
Dropout level:	97 to 98% of pickup level, or pickup level minus 2% of nominal current ( $0.02 \times CT$ ), whichever is less
Time delay:	0 to 600.00 s in steps of 0.01
Level accuracy:	per sensitive ground current input
Operate time (0 ms time delay):	50 ms max. (output relay included), $1.5 \times$ pickup @ 60 Hz, and 45 ms max. (solid state output included), $1.5 \times$ pickup @ 60 Hz
Timing accuracy:	$\pm 20$ ms or $\pm 0.1\%$ of time delay setting (whichever is greater)

**PHASE DIRECTIONAL**

Relay Connection:	$90^\circ$ (quadrature)
Polarizing Voltage:	Vbc (phase A); Vca (phase B); Vab (phase C)
MTA:	0 to $359^\circ$ in steps of 1
Angle Accuracy:	$\pm 2^\circ$
Operation Delay:	25 to 40 ms

**NEUTRAL DIRECTIONAL**

NOTE

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

Polarizing voltage:	$-V_o$
Polarizing current:	$I_g$
MTA:	0 to $359^\circ$ in steps of 1
Angle accuracy:	$\pm 2^\circ$
Operation delay:	25 to 40 ms

**GROUND / SENSITIVE GROUND DIRECTIONAL**

NOTE

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

Polarizing voltage:	$-V_o$
Polarizing current:	$I_g$
MTA:	0 to $359^\circ$ in steps of 1
Angle accuracy:	$\pm 2^\circ$
Operation delay:	25 to 40 ms

**BUS / LINE UNDERVOLTAGE**

Minimum voltage: >	programmable threshold from 0.00 to $1.25 \times VT$ in steps of 0.01
Pickup level:	0 to $1.25 \times VT$ in steps of 0.01
Dropout level:	102 to 103% of pickup
Curve:	Definite Time or Inverse Time
Time delay:	0 to 6000.0 s in steps of 0.1

Phases: Any one, any two, or all three (programmable) phases must operate for output (Bus Undervoltage only)

Level accuracy: per voltage input

Timing accuracy:  $\pm 100$  ms

**OVERVOLTAGE**

Pickup level: 0 to  $1.25 \times V_T$  in steps of 0.01

Dropout level: 97 to 98% of pickup level

Time delay: 0.0 to 6000.0 s in steps of 0.1 (Definite Time)

Phases: Any one, any two, or all three (programmable) phases must operate for output

Level accuracy: per voltage input

Timing accuracy:  $\pm 100$  ms

**NEGATIVE SEQUENCE VOLTAGE**

Pickup level: 0 to  $1.25 \times V_T$  in steps of 0.01

Dropout level: 97 to 98% of pickup level

Time delay: 0 to 6000.0 s in steps of 0.1 (Definite Time / Inverse Time)

Level accuracy:  $3 \times$  voltage input error

Timing accuracy:  $\pm 100$  ms

**UNDERFREQUENCY**

Minimum voltage: 0 to  $1.25 \times V_T$  in steps of 0.01 in Phase A

Pickup level: 20 to 65 Hz in steps of 0.01

Dropout level: Pickup + 0.03 Hz

Time delay: 0 to 600.00 s in steps of 0.01 (Definite Time)

Level accuracy:  $\pm 0.02$  Hz

Timing accuracy:  $\pm 100$  ms

**BREAKER FAILURE**

Pickup level: 0.05 to  $20.0 \times CT$  in steps of 0.01

Dropout level: 97 to 98% of pickup level

Time delay: 0.03 to 1.00 s in steps of 0.01

Timing accuracy:  $\pm 20$  ms error

Level accuracy: per CT input

**NEUTRAL DISPLACEMENT**

Pickup level: 0.00 to  $1.25 \times V_T$  in steps of 0.01

Dropout level: 97 to 98% of pickup level

Curves: 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 to 100.00 in steps of 0.01

Reset type: Instantaneous/Linear

Level accuracy:  $3 \times$  voltage input error

Timing accuracy:  $\pm 50$  ms

**REVERSE POWER (IF ENABLED)**

Pickup level: 0.015 to  $0.600 \times$  rated power

Dropout level: 94 to 95% of pickup

Reset time: less than 100 ms

Level accuracy: see  $3\Phi$  Real Power metering

Time delay: 0.0 to 6000.0 s in steps of 0.1

Timing accuracy:  $\pm 200$  ms (includes Reverse Power pickup time)

## 2.4.5 Monitoring Elements

### PHASE/NEUTRAL CURRENT

Pickup level:	0.05 to 20.00 × CT in steps of 0.01
Dropout level:	97 to 98% of pickup level
Time delay:	0 to 60000 s in steps of 1 (Definite Time)
Level accuracy:	per current input
Timing accuracy:	±100 ms

### POWER FACTOR

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 60000 s in steps of 1 (Definite Time)
Level accuracy:	±0.02
Timing accuracy:	±100 ms

### ANALOG INPUT THRESHOLD

Pickup level:	0 to 65535 units in steps of 1
Dropout level:	2 to 20% of Pickup (programmable, under/over)
Time delay:	0 to 60000 s in steps of 1
Level accuracy:	±1%
Timing accuracy:	±100 ms

### ANALOG INPUT RATE

Pickup level:	-1000 to 1000 units/hour in steps of 0.1
Dropout level:	97 to 98% of pickup level
Time delay:	0 to 60000.0 s in steps of 1
Level accuracy:	±1%
Timing accuracy:	±100 ms

### OVERFREQUENCY

Required voltage:	>30% of nominal, phase A
Pickup level:	20.01 to 65.00 Hz in steps of 0.01
Dropout level:	Pickup - 0.03 Hz
Time delay:	0.0 to 6000.0 s in steps of 0.1
Level accuracy:	±0.02 Hz
Timing accuracy:	±100 ms

### FAULT LOCATOR

Range:	-327 to 327 km (or miles) 0 to 65534 ohms
Memory:	stores 10 most recent faults

### DATA LOGGER

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 minutes
Trigger source:	pickup/trip/dropout, control/alarm event, logic input, manual command, or continuous
Trigger position:	0 to 100%
Storage:	2 to 16 events with 2048 to 256 samples of data respectively (4096 if continuous)

### TRIP COUNTERS

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

**DEMAND**

Demand accuracies are based on less than  $2 \times CT$  and 50 to 130 V inputs.

Measured values:	Phase A/B/C current (A), 3 $\Phi$ real power (MW), 3 $\Phi$ reactive power (Mvar), 3 $\Phi$ 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	
- Amps pickup level:	10 to 10000 in steps of 1
- MW pkp level:	0.1 to 3000.0 in steps of 0.1
- Mvar pkp level:	0.1 to 3000.0 in steps of 0.1
- MVA pkp level:	0.1 to 3000.0 in steps of 0.1
- Level accuracy:	$\pm 2\%$

**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 50000 kA <sup>2</sup> -cycles in steps of 1
Start delay:	0 to 100 ms in steps of 1

**TRIP / CLOSE COIL MONITORS**

Detect open trip and close circuits.

**PULSED OUTPUT**

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

**LAST TRIP DATA**

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

**WAVEFORM CAPTURE**

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:	2 to 16 events with 4096 to 512 samples of data respectively

**EVENT RECORDER**

Number of events:	512
Content:	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.

**2.4.6 Control Elements****SYNCHROCHECK**

Voltage difference:	0.01 to 100.00 kV in steps of 0.01
Phase difference:	0 to 100° in steps of 1
Frequency difference:	0.00 to 5.00 Hz in steps of 0.01

Operate time:	up to 140 ms for 60 Hz up to 160 ms for 50 Hz
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 (either dead line or dead bus)

### SETPOINT GROUPS

Number of groups:	4
Accessibility:	Can be changed from logic input or through communications
Included features:	TOC Curves, Phase TOC and IOC, Neutral TOC and IOC, Ground TOC and IOC, Negative Sequence OC and Voltage, Phase Directional, Ground Directional, Overvoltage, Undervoltage, Underfrequency, Breaker Failure

### UNDERVOLTAGE RESTORATION

Initiated by:	Trip from Undervoltage 1 to 4
Minimum voltage level:	0.00 to $1.25 \times VT$ in steps of 0.01
Time delay:	0 to 10000 s in steps of 1
Incomplete seq. time:	1 to 10000 min. in steps of 1
Phases:	Any one, any two, or all three (programmable) phases must operate for output
Level accuracy:	per voltage input
Timing accuracy:	$\pm 100$ ms

### UNDERFREQUENCY RESTORATION

Initiated by:	Trip from Underfrequency 1/2
Minimum voltage level:	0.00 to $1.25 \times VT$ in steps of 0.01
Minimum freq. level:	20.00 to 65.00 Hz in steps of 0.01
Time delay:	0 to 10000 s in steps of 1
Incomplete seq. time:	1 to 10000 min. in steps of 1
Level accuracy:	Per voltage and frequency input
Timing accuracy:	$\pm 100$ ms

### MANUAL CLOSE BLOCKING

Operated by:	manual close command.
Programmability:	Block IOC for a selected period. raise TOC pickup for a selected period.

### COLD LOAD PICKUP BLOCKING

Operated by:	logic input command or automatically
Programmability:	Block IOC for a selected period; raise TOC pickup for a selected period.

### TRANSFER SCHEME

Applicability:	Used for double-bus system with two normally-closed incoming and one normally-open bus tie circuit breaker.
Closing:	Automatic closing of the bus tie breaker after a loss of one source, with bus decayed voltage permissive.
Trip:	Trips a pre-selected breaker after the third breaker is manually closed (prevent parallel operation).

### AUTORECLOSE (760 ONLY)

Reclose attempts:	Up to four (4) before lockout.
Blocking:	Each reclose shot can block IOC and raise TOC Pickup.
Adjustability:	Current supervision can adjust the maximum number of shots to be attempted.

## 2.4.7 Outputs

### ANALOG OUTPUTS

Type:	Active
Outputs:	8 Channels; specify one of the following output ranges when ordering:
Ranges:	0 to 1 mA, 0 to 5 mA, 0 to 10 mA, 4 to 20 mA
Max. load:	12 k $\Omega$ for 0 to 1 mA output, 2.4 k $\Omega$ for 0 to 5 mA output, 1.2 k $\Omega$ for 0 to 10 mA output, 600 $\Omega$ for 4 to 20 mA output
Isolation:	Fully isolated
Accuracy:	$\pm 1\%$ of full scale
Response:	100% indication in less than 6 power system cycles (100 ms at 60 Hz)

### SOLID STATE TRIP

Make & carry:	15 A at 250 V DC for 500 ms
---------------	-----------------------------

## 2.4.8 Output Relays

Relay contacts must be considered unsafe to touch when the 750/760 is energized! If the output relay contacts are required for low voltage accessible applications, it is the customer's responsibility to ensure proper insulation levels.

### CONFIGURATION

Number:	8
Type:	Form A: Trip (1) and Close (2) Relays Form C: Auxiliary Relays 3 to 7 and Self-Test Warning Relay 8
Contacts:	silver alloy
Durability:	100 000 operations (at 1800 operations/hour) at rated load

### TRIP CONTACT (FORM A) RATINGS

Applicability:	Trip and Close Relays (relays 1 and 2)
Make and carry:	30 A (per ANSI/IEEE C37.90)
Carry:	10 A @ 250 VAC (continuous)
Break:	0.4 A @ 250 VDC (L/R = 40 ms)

### SERVICE CONTACT (FORM C) RATINGS

Applicability:	Auxiliary Relays (relays 3 to 7), and Self-Test Warning Relay (relay 8)
Make and Carry:	30 A (per ANSI/IEEE C37.90)
Carry:	5 A @ 250 VAC (continuous)
Break:	0.3 A @ 250 VDC (L/R = 40 ms) 3 A @ 240 VAC (P.F. = 0.4)

## 2.4.9 CPU

### COMMUNICATIONS

Baud rate:	300 to 19200 baud
Parity:	programmable
Protocol:	Modbus RTU or DNP 3.0
Ethernet:	10Base-T RJ45 connector Modbus TCP/IP Version 2.0 / IEEE 802.3 Maximum 4 sessions

**EEPROM**

100000 program/erase cycles max.

**CLOCK**

Resolution: 1 ms  
 Accuracy with IRIG-B:  $\pm 1$  ms  
 Accuracy without IRIG-B:  $\pm 5$  minutes/month  
 Supercap backup life: 45 days when control power is off

**2.4.10 Physical****TEMPERATURE**

Operating range:  $-40^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$   
 Ambient storage:  $-40^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$   
 Ambient shipping:  $-40^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$



NOTE

At temperatures below  $-20^{\circ}\text{C}$ , the LCD contrast may become impaired.

**ENVIRONMENTAL**

Ambient operating temperature:  $-40^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$   
 Ambient storage temperature:  $-40^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$   
 Humidity: up to 90% non-condensing  
 Pollution degree: 2  
 IP Rating: 40-X

**LONG-TERM STORAGE**

Environment: In addition to the above environmental considerations, the relay should be stored in an environment that is dry, corrosive-free, and not in direct sunlight.

Correct storage: Prevents premature component failures caused by environmental factors such as moisture or corrosive gases. Exposure to high humidity or corrosive environments will prematurely degrade the electronic components in any electronic device regardless of its use or manufacturer, unless specific precautions, such as those mentioned in the Environmental section above, are taken.



NOTE

It is recommended that all relays be powered up once per year, for one hour continuously, to avoid deterioration of electrolytic capacitors and subsequent relay failure.

**CASE**

Type: Fully drawout unit (automatic CT shorts)  
 Approvals: Meets CE drawout specifications  
 Seal: Seal provision  
 Door: Dust tight door  
 Mounting: Panel or 19" rack mount  
 Weight: 7.9 kg (case and relay)  
 9.4 kg (shipping weight)

2.4.11 Testing

**TYPE TESTING**

The table below lists the 750/760 type tests:

Standard	Test Name	Level
EIA 485	RS485 Communications Test	32 units at 4000 ft.
IEC 60068-2-30	Relative Humidity Cyclic	55°C at 95% RH
IEC 60068-2-38	Composite Temperature/Humidity	65/-10°C at 93% RH
IEC 60255-5	Dielectric Strength	2300 V AC
IEC 60255-5	Insulation Resistance	>100 MΩ / 500 V AC / 10 s
IEC 60255-21-1	Sinusoidal Vibration	2 g
IEC 60255-21-2	Shock and Bump	5 g / 10 g / 15 g
IEC 60255-21-3	Seismic	6 g
IEC 60255-22-1	Damped Oscillatory Burst, 1 MHz	2.5 kV / 1 kV
IEC 60255-22-2	Electrostatic Discharge: Air / Direct	15 kV / 8 kV
IEC 60255-22-3	Radiated RF Immunity	10 V/m
IEC 60255-22-4	Electrical Fast Transient / Burst Immunity	2 kV
IEC 60255-22-5	Surge Immunity	4 kV / 2 kV
IEC 60255-22-6	Conducted RF Immunity, 150 kHz to 80 MHz	10 V/m
IEC 60255-25	Radiated RF Emission	Group 1 Class A
IEC 60255-25	Conducted RF Emission	Group 1 Class A
IEC 60529	Ingress of Solid Objects and Water (IP)	IP40 (front), IP10 (back)
IEC 61000-4-8	Power Frequency Magnetic Field Immunity	100 A/m continuous 1000 A/m short duration
IEC 61000-4-9	Pulse Magnetic Field Immunity	1000 A/m
IEC 61000-4-11	Voltage Dip; Voltage Interruption	0%, 40%, 100%
IEEE C37.90.1	Oscillatory Transient SWC	±2.5 kV
IEEE C37.90.3	Electrostatic Discharge: Air and Direct	±15 kV / ±8 kV

**SIMULATION**

Programmable pre-fault, fault, and post-fault parameters simulation modes. Simulation of circuit breaker and selection of whether or not to operate outputs relays.

**PRODUCTION TESTS**

Thermal cycling: Operational test at ambient, reducing to -40°C and then increasing to 60°C  
 Dielectric strength: (order code 'LO') 550 VAC for 1 second  
 (order code 'HI') 2200 VAC for 1 second

**DO NOT CONNECT FILTER GROUND TO SAFETY GROUND DURING ANY PRODUCTION TESTS.**



## 2.4.12 Approvals

### APPROVALS

CE:	Conforms to EMC and LVD directive
EN:	EN60255-26 zone B EMC - CE for Europe
EN LVD (Low Voltage Directive):	EN60255-27 LVD - CE for Europe
ISO:	GE Multilin's Quality Management System is registered to ISO9001:2000
UL:	UL listed for the USA and Canada, E83849



**Specifications subject to change without notice.**

NOTE





# 750/760 Feeder Management Relay

## Chapter 3: Installation

### 3.1 Mechanical Installation

#### 3.1.1 Drawout Case

The 750/760 is packaged with 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.

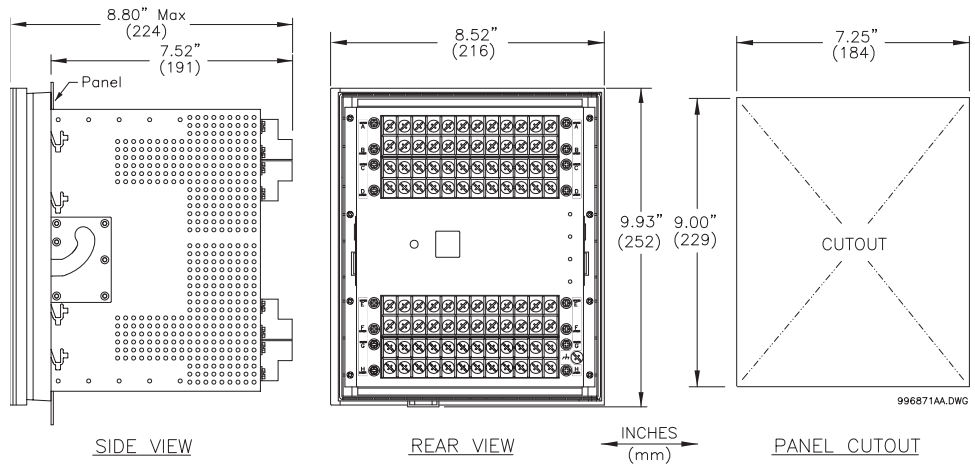


FIGURE 3-1: Case Dimensions

To prevent unauthorized removal of the drawout relay, a wire lead seal can be installed through the slot in the middle of the locking latch. With this seal in place, the relay cannot be removed. 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.

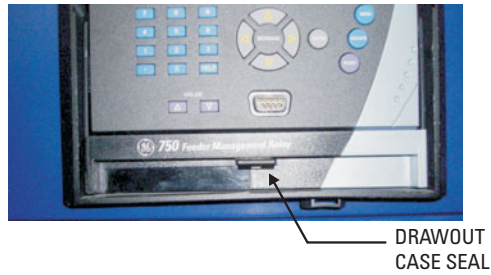


FIGURE 3-2: Drawout Case Seal

3.1.2 Installation

The 750/760 can be mounted alone or adjacent to another 469/489/745/750/760 unit on a standard 19-inch 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.

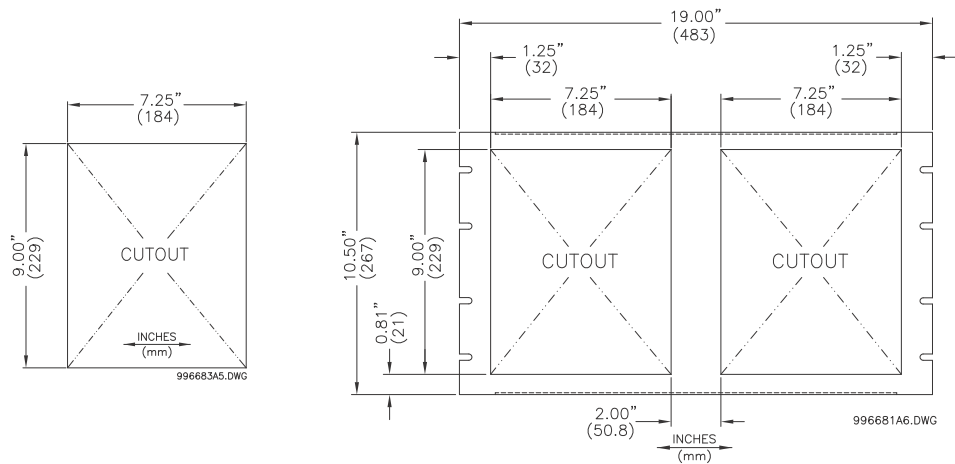


FIGURE 3-3: Single and Double Unit Panel Cutouts

Before mounting the relay 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 front bezel is flush with the panel, apply pressure to the bezel's front while bending the retaining tabs 90°. 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 unit is now ready for panel wiring.

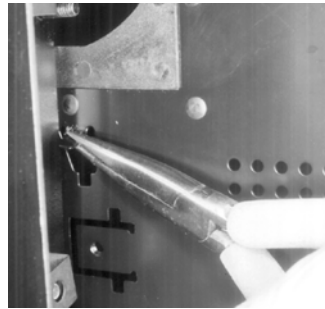


FIGURE 3-4: Mounting Tabs

### 3.1.3 Unit Withdrawal and Insertion



NOTE

**FOLLOW YOUR COMPANY'S PPE AND GUIDELINE BEFORE ATTEMPTING TO WORK ON LIVE VOLTAGE, AND SWITCHGEAR.**

**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.

If using an ethernet connection, refer to *Ethernet Connection* (section 3.1.4) before starting the following procedure.

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.



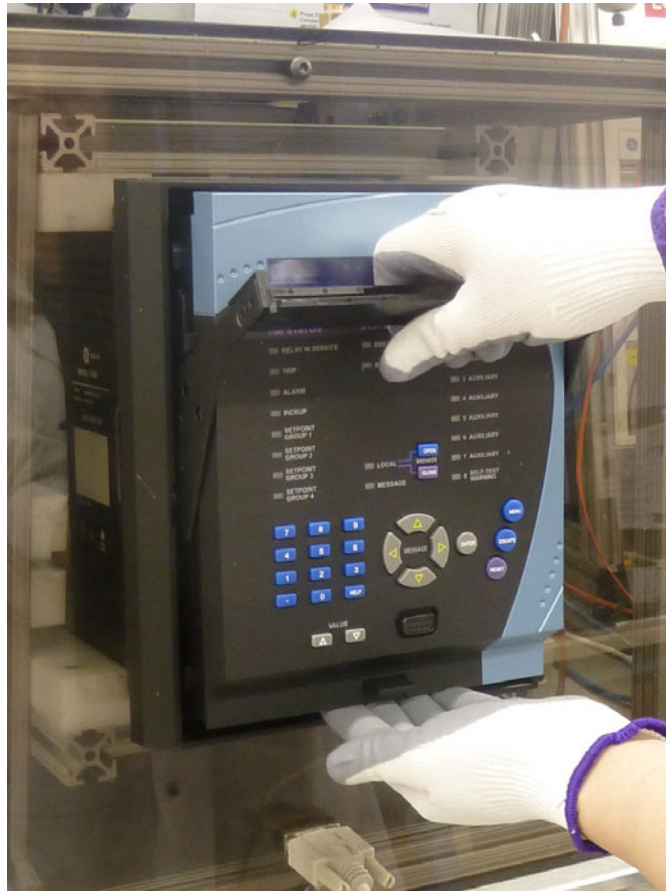
**FIGURE 1: Press the latch up and pull the handle**

3. With the latch raised, pull the center of the handle outward. Once disengaged, continue rotating the handle up to the stop position.
4. The handle should reach the “stop” position with minimum effort. If the handle is stuck or hard to rotate to its “stop” position, do NOT force it in order to withdraw the relay. Re-insert the relay into its draw-out case, and engage the relay into the switchgear by removing the wiring from the terminals. Contact GE Grid Solutions Technical Support team for any additional assistance.



**FIGURE 2: Rotating the handle to the “stop” position**

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



**FIGURE 3: 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.



No special ventilation requirements need to be observed during the installation of the unit. The unit does not require cleaning.



### 3.1.4 Ethernet Connection

If using the 750/760 with the Ethernet 10Base-T option, ensure that the network cable is disconnected from the rear RJ45 connector before removing the unit from the case. This prevents any damage to the connector.

The unit may also be removed from the case with the network cable connector still attached to the rear RJ45 connector, provided that there is at least 16" of network cable available when removing the unit from the case. This extra length allows the network cable to be disconnected from the RJ45 connector from the front of the switchgear panel. Once disconnected, the cable can be left hanging safely outside the case for re-inserting the unit back into the case.

The unit may then be re-inserted by first connecting the network cable to the units' rear RJ45 connector (see step 3 of *Unit Withdrawal and Insertion* on page 3-3).

#### **CAUTION**

Ensure that the network cable does not get caught inside the case while sliding in the unit. This may interfere with proper insertion to the case terminal blocks and damage the cable.

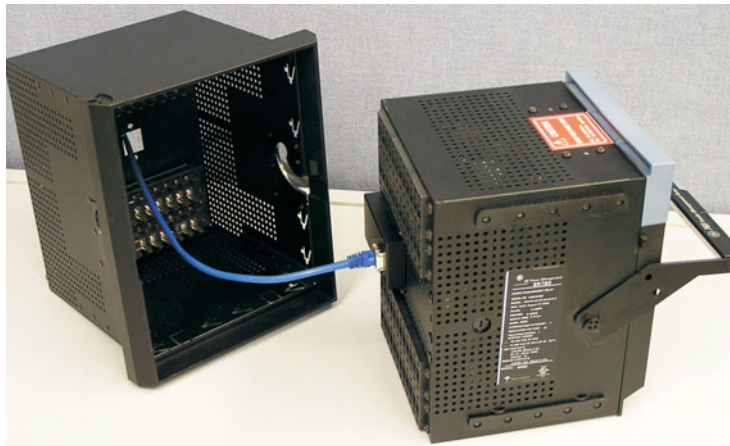


FIGURE 3-5: Ethernet Cable Connection

### 3.1.5 Rear Terminal Layout

A broad range of applications are available for the 750/760 relays. 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. The figure 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.

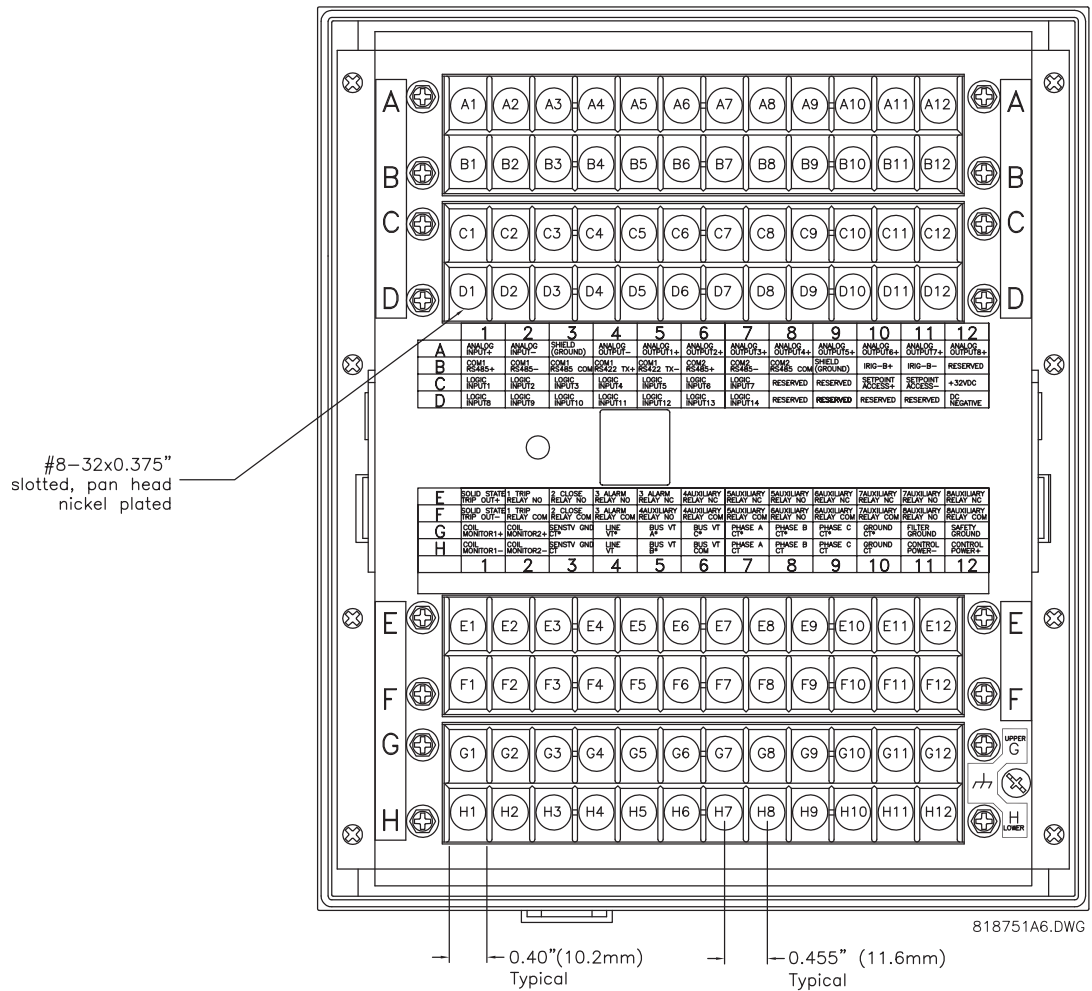


FIGURE 3-6: Rear Terminal Layout

The rear terminal assignments are indicated on the following table:

Table 3-7: Rear Terminal Assignments

TERMINAL	DESCRIPTION	TERMINAL	DESCRIPTION
<b>ANALOG INPUT / OUTPUTS</b>			
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

Table 3–7: Rear Terminal Assignments

TERMINAL	DESCRIPTION	TERMINAL	DESCRIPTION
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
<b>COMMUNICATION</b>		<b>OUTPUT RELAYS</b>	
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 WARNNG RELAY COM
<b>LOGIC INPUTS</b>		<b>CT and VT INPUTS / GROUND</b>	
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
<b>LOGIC INPUTS</b>		<b>CT and VT INPUTS / POWER</b>	
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 +

### 3.2 Electrical Installation

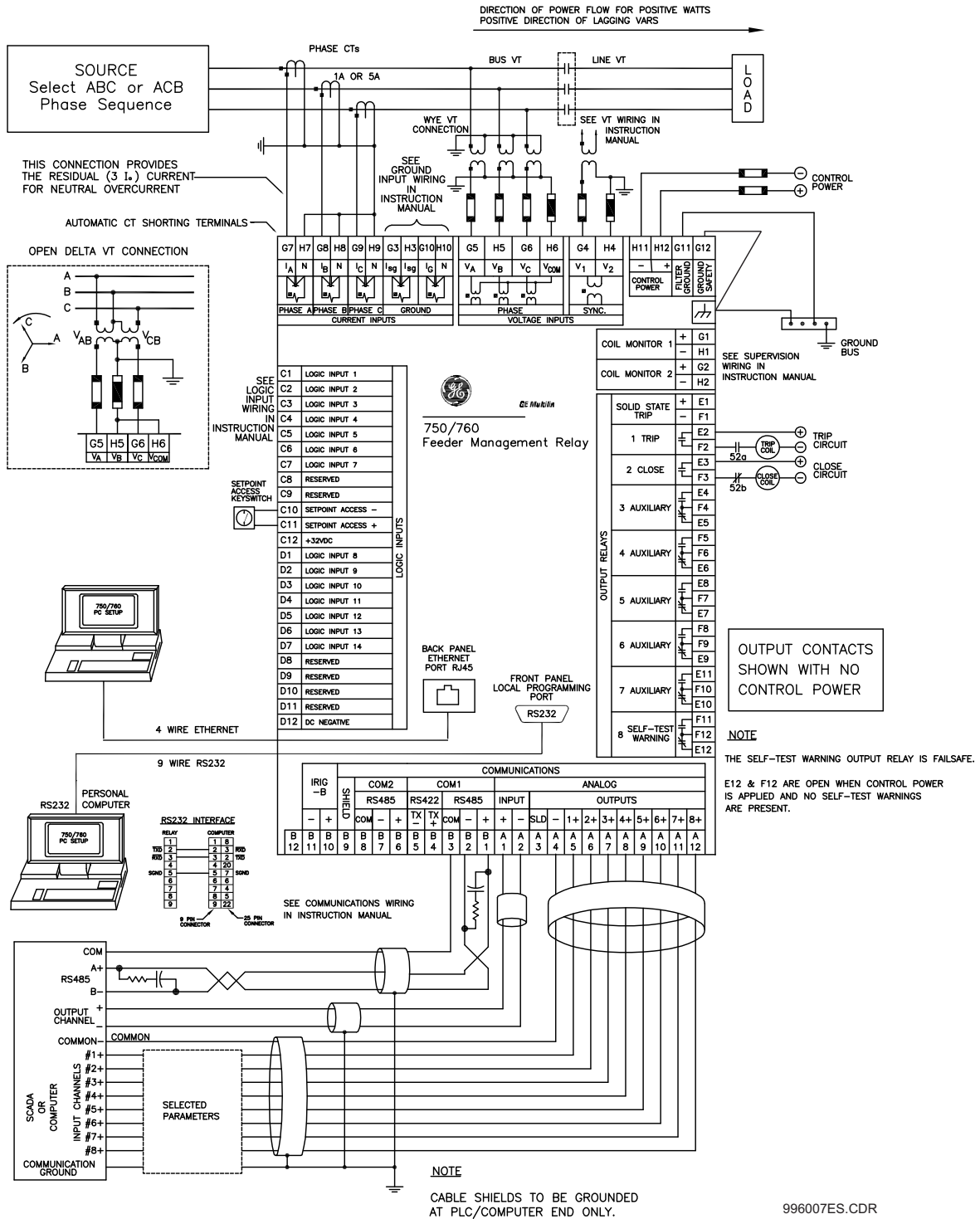


FIGURE 3-8: Typical Wiring Diagram

### 3.2.1 Phase Sequence and Transformer Polarity

For the correct operation of many relay features, the instrument transformer polarities shown above in the *Typical Wiring Diagram* on page 3–10 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.

### 3.2.2 Current Inputs

The 750/760 relays have five (5) 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.



**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.**



**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  $20 \times$  CT rating. This becomes apparent if the pickup level is set above the nominal CT rating.**

### 3.2.3 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 and H10) and three possible sensitive ground connections using the sensitive ground current input (Terminals G3 and H3).

The ground input (Terminals G10 and 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.

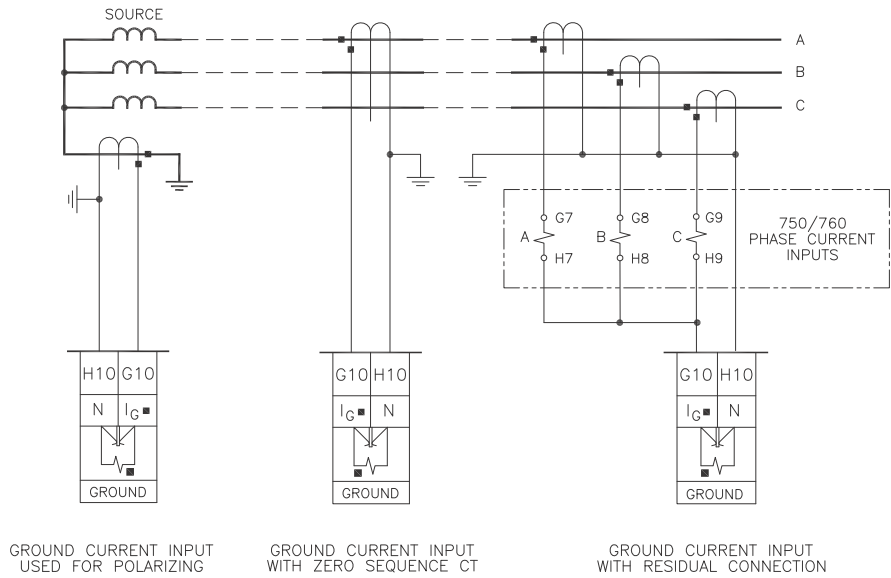
The sensitive ground current input is intended for use either with a CT in a source neutral of a high-impedance grounded system, or on ungrounded systems. On ungrounded systems it is connected residually with the phase current inputs. In this case, the **SENSTV GND CT PRIMARY** setpoint should be programmed 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.



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

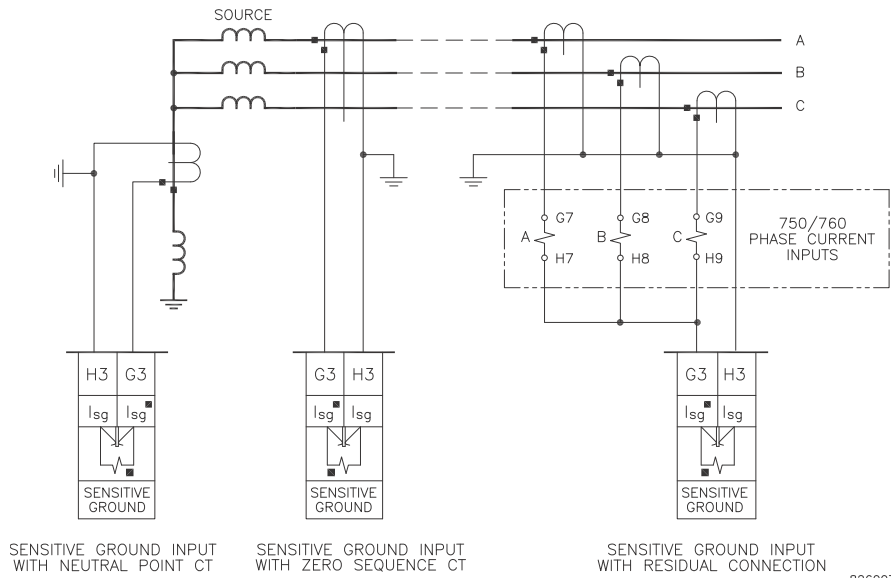


The Sensitive Ground input (G3 and H3 terminals) must only be used on systems where the maximum ground current does not exceed 500 A.



826003A3.DWG

FIGURE 3-9: Ground Inputs



826007A3.DWG

FIGURE 3-10: Sensitive Ground Inputs

### 3.2.4 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 and 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. For more details see page 5-72.

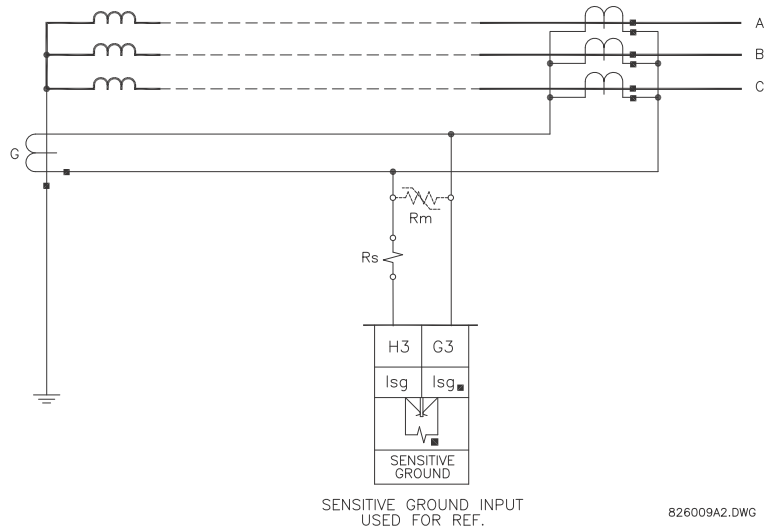


FIGURE 3-11: Restricted Earth Fault Inputs

**3.2.5 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.

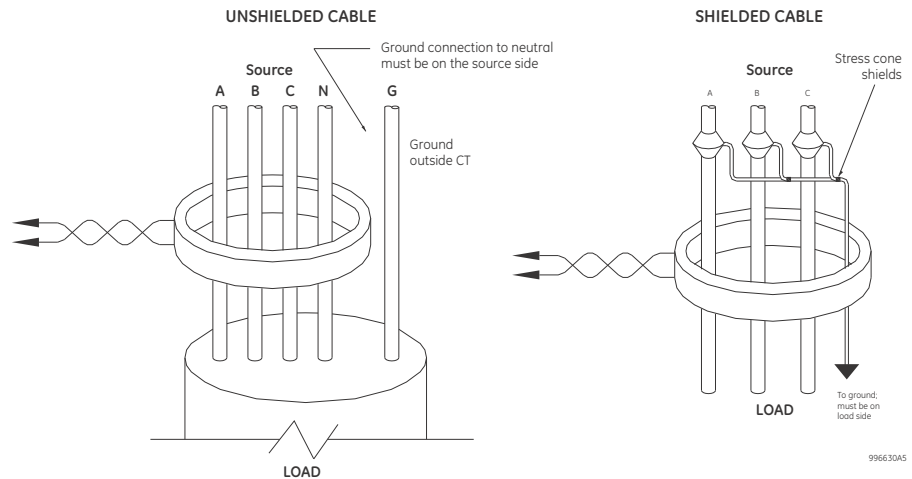


FIGURE 3-12: Zero Sequence (Core Balance) CT Installation

**3.2.6 Voltage Inputs**

The 750/760 relays 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.

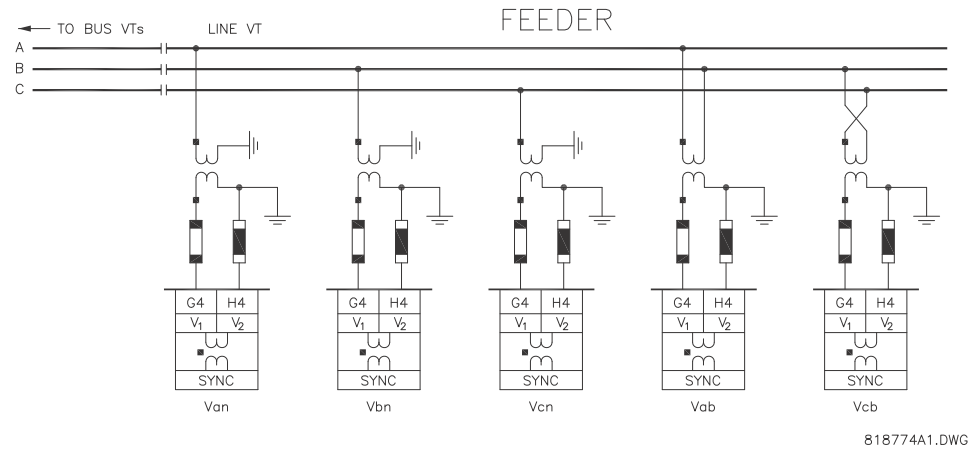


FIGURE 3-13: Line VT Connections



If Delta VTs are used, the 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.

### 3.2.7 Control Power



**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



**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.**



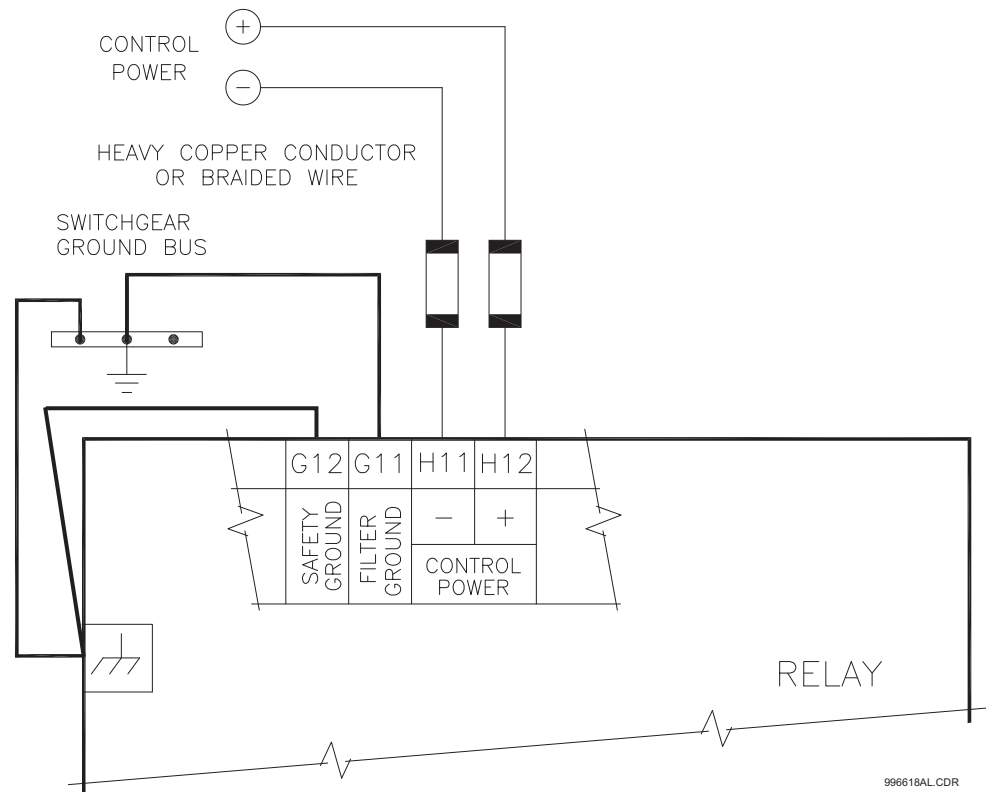


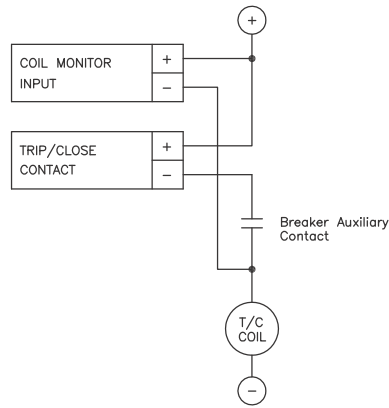
FIGURE 3-14: Control Power Connection

### 3.2.8 Trip/Close Coil Supervision

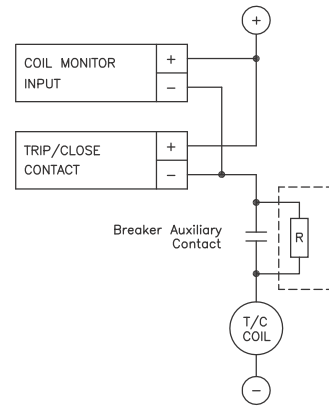
Supervision of a breaker trip coil requires the relay supervision circuit to be wired in parallel with the Trip contact. Likewise, supervision of the close coil requires the supervision circuit to be wired in parallel with the Close contact. Each connection places an impedance across the associated contact, 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 **BRKR STATE BYPASS** setpoint is “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.

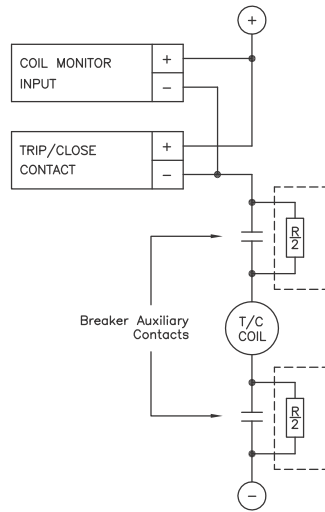
Circuit breakers equipped with standard control circuits have a 52a auxiliary contact which only allows tripping of the breaker when it is closed. In this breaker state, the 52a contact is closed and a trickle current will flow through the trip circuitry. When the breaker is open, the 52a auxiliary contact 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.



DRAWING A: CONNECTION WHERE ACCESS TO BREAKER COIL IS AVAILABLE ('BREAKER STATE BYPASS' SETPOINT SHOULD BE ENABLED FOR THIS TYPE OF CONNECTION.)\*



DRAWING B: ALTERNATE PATH WITH ONE BREAKER AUXILIARY CONTACT.



DRAWING C: ALTERNATE PATH WITH TWO BREAKER AUXILIARY CONTACTS

VALUE OF RESISTOR 'R'

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

RESISTOR CONNECTED	BREAKER STATE BYPASS SETPOINT*
YES	ENABLED
NO	DISABLED

\* SEE S6 MONITORING FOR ADDITIONAL SETPOINTS

FIGURE 3-15: Trip/Close Coil Supervision

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.

When the **BRKR STATE BYPASS** setpoint is "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 FIGURE 3-15: *Trip/Close Coil Supervision* on page 3-16. 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.

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.

### 3.2.9 Logic Inputs

External contacts can be connected to the relay's fourteen (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.

#### **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.**

A dry contact has one side connected to Terminal C12. This is the +32 V DC 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 be connected to the relay's DC negative rail at Terminal D12. The maximum external source voltage for this arrangement is 300 V DC.

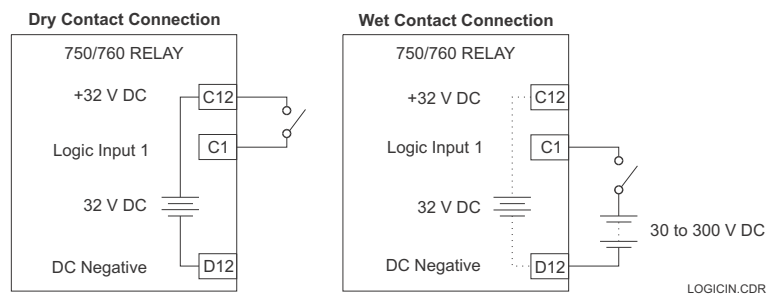


FIGURE 3-16: Dry and Wet Contact Connections



It is recommended to use shielded twisted pair wires grounded at one end only for analog input and analog output connections to the relay. Ensure the maximum burden limits are not exceeded as per relay specifications and avoid locating wire in close proximity to current carrying cables, contactors or other sources of high EMI.

### 3.2.10 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 V 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.

### 3.2.11 Analog Outputs



It is recommended to use shielded twisted pair wires grounded at one end only for analog input and analog output connections to the relay. Ensure the maximum burden limits are not exceeded as per relay specifications, and avoid locating wire in close proximity to current carrying cables, contactors or other sources of high EMI.

The 750/760 relays provide eight (8) analog output channels whose full scale range was specified at the time of ordering. Refer to *Outputs* on page 2–20 for the specifications and *Ordering* on page 2–9 for the complete listing.

Each analog output channel can be programmed to represent one of the parameters measured by the relay. For details, see *Analog Outputs* on page 5–110.

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 V 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

$$R_{LOAD} = \frac{V_{FULL\ SCALE}}{I_{MAX}} \quad (\text{EQ 3.1})$$

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

$$R_{LOAD} = \frac{V_{FULL\ SCALE}}{I_{MAX}} = \frac{5\ V}{0.001\ A} = 5\ k\Omega \quad (\text{EQ 3.2})$$

For a 0 to 5 mA channel this resistor would be 1 kW and for a 4 to 20 mA channel this resistor would be 250  $\Omega$ . The Analog Output connection diagram is shown below.

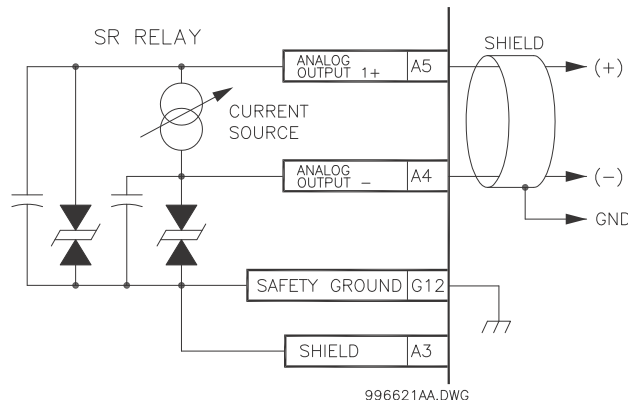


FIGURE 3–17: Analog Output Connection

### 3.2.12 Serial Communications

The 750/760 relays 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 GE Publication *GEK-106473: 750/760 Communications Guide*. 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.

The RS485 port is disabled when the Ethernet option is ordered.

To minimize errors from noise, the use of shielded twisted-pair wire is recommended. Correct polarity should also be observed. For instance, 750/760 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 opto-coupled data interface also acts to reduce noise coupling. To ensure maximum reliability, all equipment should have similar transient protection devices installed.

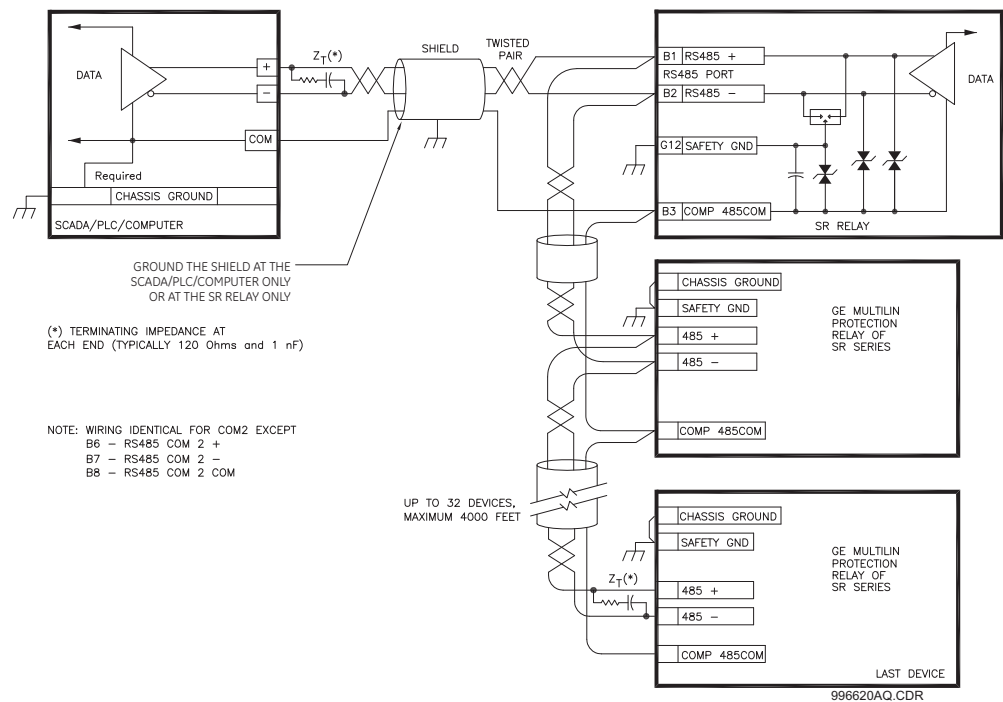


FIGURE 3-18: RS485 Wiring Diagram

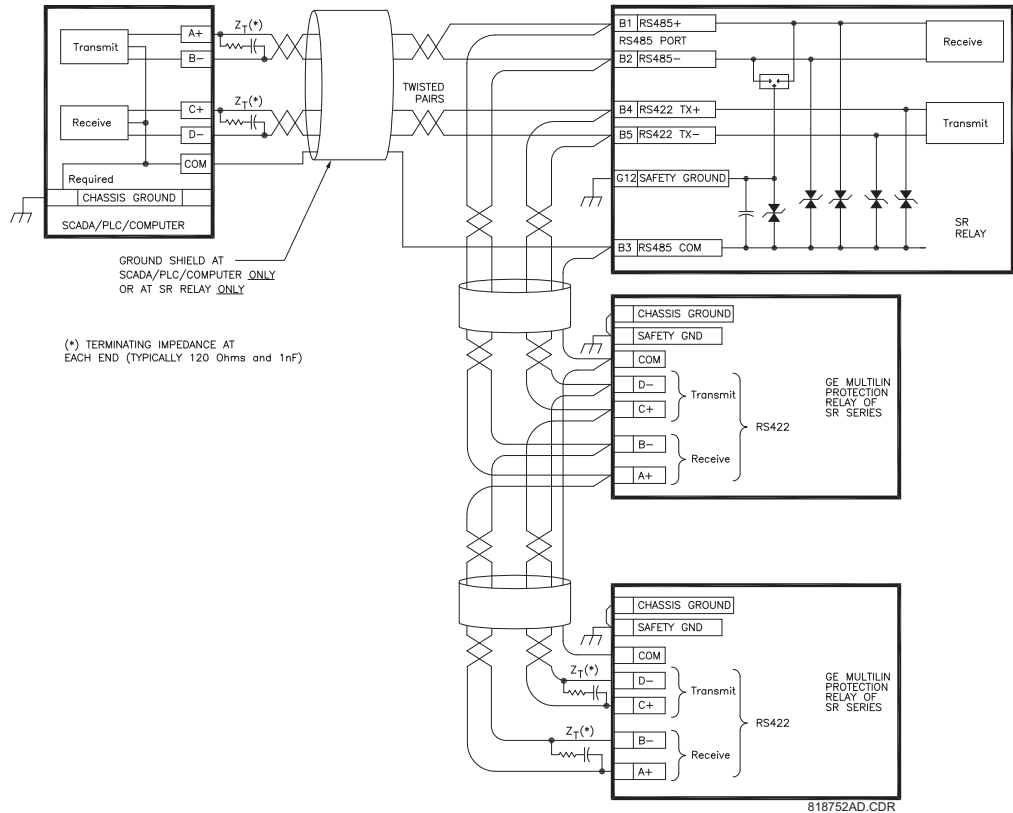


FIGURE 3-19: RS422 Wiring Diagram

### 3.2.13 RS232 Communications

The 9-pin RS232 serial port located on the front panel is used in conjunction with the EnerVista 750/760 Setup software 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, ensure the relay address is set to 1 and the baud rate is set to 9600.**

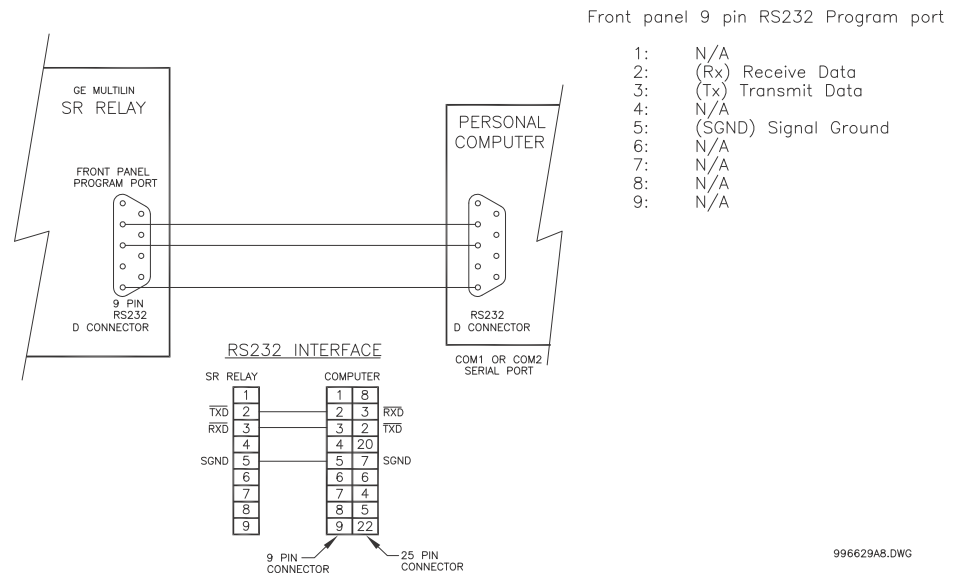


FIGURE 3-20: RS232 Connection

### 3.2.14 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.

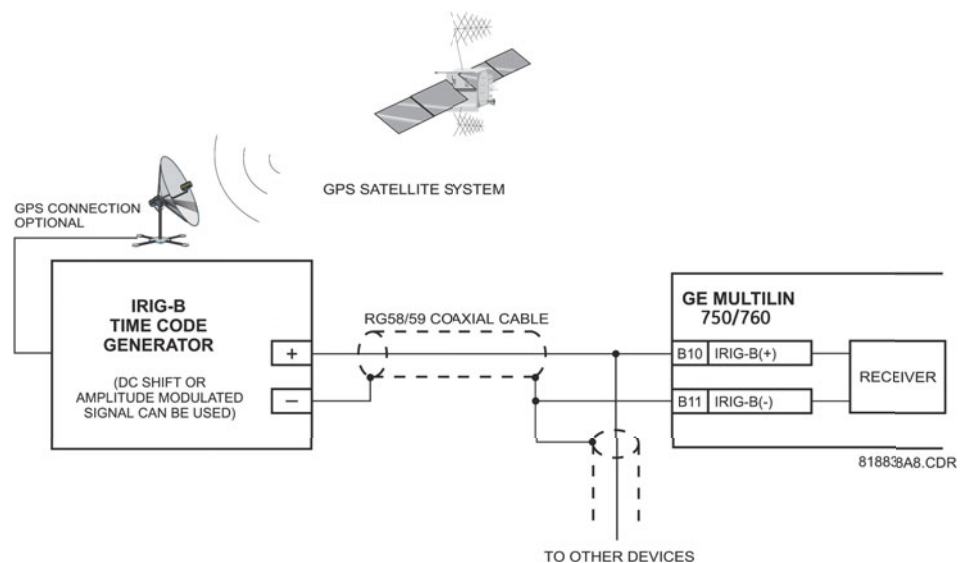


FIGURE 3-21: IRIG-B Connection







# 750/760 Feeder Management Relay

## Chapter 4: Interfaces

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### 4.1 Front Panel Interface

#### 4.1.1 Description

The front panel provides local operator interface with a liquid crystal 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 EnerVista 750/760 Setup software.

#### 4.1.2 Display

The 40-character liquid crystal display (LCD) allows visibility under varied lighting conditions. When the keypad and display are not being used, system information is displayed by scrolling through a maximum of 30 user-defined default messages. These default messages appear only after a user-defined period of inactivity. Pressing any key during default message scrolling returns the display to the last message shown before the default messages appeared. Any trip, alarm, or start block is displayed immediately, automatically overriding the default messages.

## 4.2 LED Indicators

### 4.2.1 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 and holding the HELP key for about one second 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

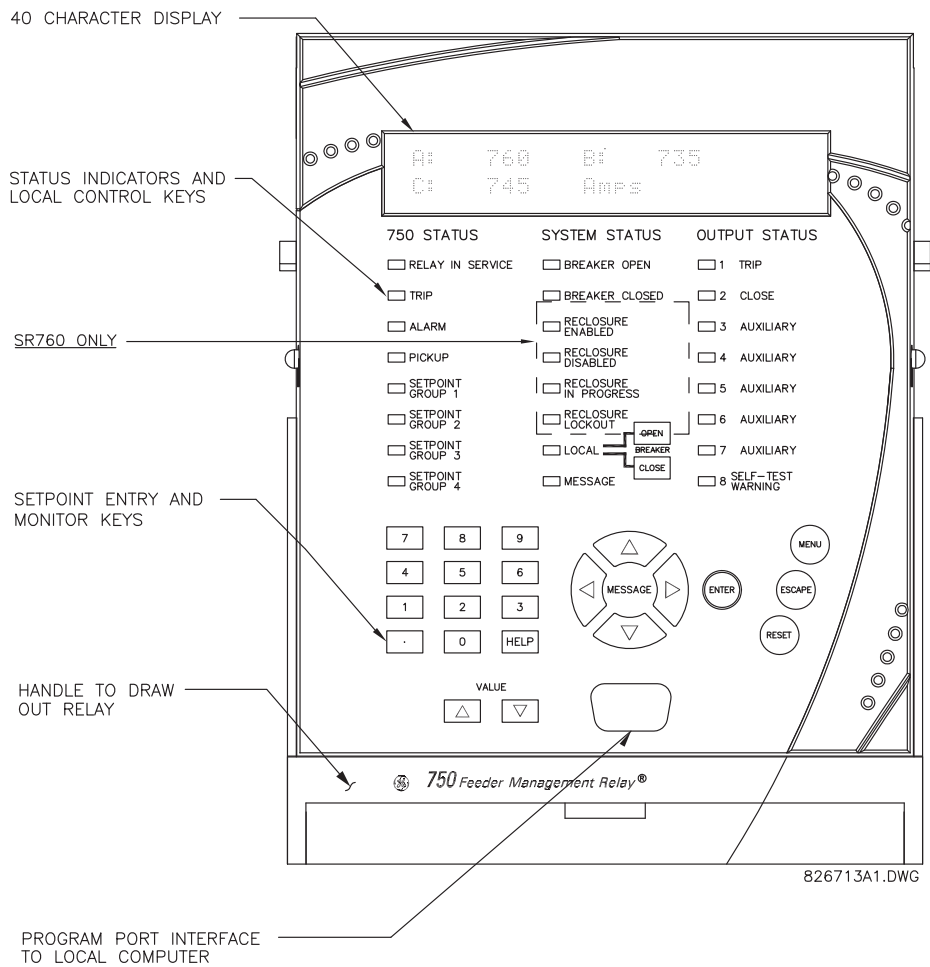


FIGURE 4-1: 750/760 Front Panel

### 4.2.2 750/760 Status LED 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 Self-Test Warning LED 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 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: This relay flashes while the relay is detecting an alarm condition. After the 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 to 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.

### 4.2.3 System Status LED Indicators

- **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 LED 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.

**The Open and Closed Status Indicator colors are interchangeable at the time of placing a 750/760 order.**



NOTE

- **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 LED 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 LED.
- **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.

Breaker operations performed by 750/760 outputs in response to logic inputs energized with contacts from a local control switch are considered as remote operations. When the 750/760 is in local mode, the local panel is the relay faceplate; everything else is considered remote, even the control switch that might be installed in the same switchgear compartment. It is important not to confuse this with the concept of Station Local/Remote Mode, in which case the same Control Switch is considered local.

- **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, MESSAGE ▼ 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 LED continues to flash if any diagnostic message is active. To return to the diagnostic messages from the normally displayed messages, press the MENU key until the following message is displayed:

■ TARGET  
 MESSAGES [▶]

Now, press the MESSAGE ▶ key followed by the message ▼ key to scroll through the messages. Note that diagnostic messages for alarms disappear with the condition while diagnostic messages for trips remain until cleared by a reset.

#### 4.2.4 Output Status LED Indicators

The 750/760 has eight (8) output relays: the 1 Trip, 2 Close, and 8 Self-Test Warning relays have fixed operation while the 3 to 7 Auxiliary relays 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 Trip LED turns on briefly while the Trip Relay is energized. After the

auxiliary breaker contacts indicate that the breaker has opened, the Trip Relay and indicator stop operating. **If both 52a and 52b auxiliary contacts are not installed, the Trip Relay and indicator will de-energize 100 ms after the trip condition clears, or after two seconds.**

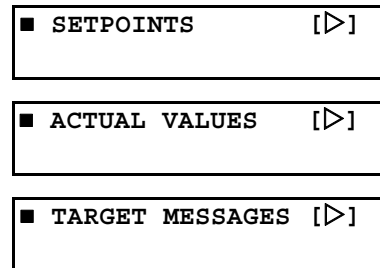
- **2 CLOSE:** A close sequence can be initiated by a 760 reclosure or a remote, serial, or front panel close command. When started, the Close LED turns on briefly while the Close Relay energizes. After the auxiliary breaker contacts indicate that the breaker has closed, the Close Relay and indicator stop operating. **If both 52a and 52b auxiliary contacts are not installed, the Close Relay and indicator operate for 200 ms.**
- **3 to 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 Auxiliary LEDs (3 to 7) will turn on while the corresponding relays are operating.
- **8 SELF-TEST WARNING:** During normal operation, this indicator is off with the fail-safe 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 Self-Test Warning Relay signals loss of protection by de-energizing, but the LED indicator remains off. Since there are no shorting contacts across the Self-Test Warning Relay, both the normally open and normally closed contacts are open when the unit is drawn out.

## 4.3 Relay Messages

### 4.3.1 Keypad Operation

The 750/760 display messages are organized into Main Menus, Pages, and Sub-pages. There are three main menus labeled Setpoints, Actual Values, and Target Messages.

Pressing the MENU key followed by the MESSAGE ▼ key scrolls through the three Main Menu headers, which appear in sequence as follows:



Pressing the MESSAGE ▶ key or the ENTER key from these Main Menu pages will display the corresponding menu Page. Use the MESSAGE ▲ and MESSAGE ▼ keys to scroll through the Page headers.

When the display shows **SETPOINTS**, pressing the MESSAGE ▶ key or the ENTER key will display the page headers of programmable parameters (referred to as setpoints in the manual). When the display shows **ACTUAL VALUES**, pressing the MESSAGE ▶ key or the ENTER key displays the page headers of measured parameters (referred to as actual values in the manual). When the display shows **TARGET MESSAGES**, pressing the MESSAGE ▶ key or the ENTER key displays the page headers of event messages or alarm conditions.

Each page is broken down further into logical sub-pages of messages. The MESSAGE ▲ and MESSAGE ▼ keys are used to navigate through the sub-pages. A summary of the setpoints and actual values pages can be found in the Chapters : Setpoints and : Actual Values, respectively.

The ENTER key is dual purpose. It is used to enter the sub-pages and to store altered setpoint values into memory to complete the change. The MESSAGE ▶ key can also be used to enter sub-pages but not to store altered setpoints.

The ESCAPE key is also dual purpose. It is used to exit the sub-pages and to cancel a setpoint change. The MESSAGE ◀ key can also be used to exit sub-pages and to cancel setpoint changes.

The 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 resets any latched conditions that are not presently active. This includes resetting latched output relays, latched Trip LEDs, 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 MESSAGE ▲ and MESSAGE ▼ keys scroll 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 LED is on there are messages to be viewed with the MENU key by selecting target messages as described earlier.

Pressing the OPEN key will attempt to open the breaker connected to the Trip Relay by closing the contact. Likewise, the CLOSE key will attempt to close the breaker connected to the 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.

### 4.3.2 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 LED flashes when there are diagnostic messages available; press the MENU key until the relay displays **TARGET MESSAGES**, then press the MESSAGE ► key, followed by the MESSAGE ▼ key, to scroll through the messages. The following shows the format of the various diagnostic messages.

<b>PICKUP: &lt;F&gt;</b> < Cause >	These messages show any elements that are presently picked up.
<b>TRIP: &lt;F&gt;</b> < Cause >	These messages indicate that an element has tripped. The message remains in the diagnostic queue until the relay is reset.
<b>ALARM: &lt;F&gt;</b> < 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.
<b>SELF-TEST WARNING:</b> < Cause >	These messages show any self-test warnings.

### 4.3.3 Self-Test Warnings

The relay performs self-diagnostics at initialization after power-up, and continually 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.

The relay performs a diagnostic while counting events, to check excessive wear on non-volatile memory (EEPROM). Maintenance alerts indicate excessive use.

"Event Rate High": This alert usually indicates that communication with a programmable logic controller or SCADA is continually recording events in the 750 event recorder. Programmable controller should be revised or 750 setpoints adjusted to reduce event recording.



**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 Self-Test Warning Relay, except these self-tests do not de-energize: Clock Not Set, Internal RS485, Internal Temp, and IRIG-B Failure.
- 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 LED.
- Inhibit operation of all output relays.

**Table 4–2: Self-Test Warnings**

<b>Error</b>	<b>Severity</b>	<b>Description</b>
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. Contact Multilin Technical Support.
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. Contact Multilin Technical Support.
Clock Not Set	Minor	Occurs if the clock has not been set. Refer to section 5.2.3 for how to set the clock.
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. Contact Multilin Technical Support.
EEPROM Corrupt	Major	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. Contact Multilin Technical Support.
EEPROM Usage High	Maintenance Alert	Occurs when the relay has recorded more than 51 million events, which are written on an EEPROM. Design limit of the Event recorder is limited by EEPROM write limit. Further writes on the EEPROM could fail. Contact Multilin Technical Support.
Event Rate High	Maintenance Alert	Occurs when the relay has counted 5 million events in less than a year. The date interval is checked at milestone events 5 million, 10 million, 15 million and so on. This warning indicates that the relay is recording events at a rate higher than under normal conditions. Check if the DCS of SCADA system is writing date and time to the device more frequently than once per hour. Reduce the date and time updates to twice a day, or "disable" the " <b>RECORD DATE/TIME EVENTS</b> " setting.
Factory Service	Major	This warning occurs when the relay is in factory service mode. Contact Multilin Technical Support.
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. Contact Multilin Technical Support.



Table 4–2: Self-Test Warnings

Error	Severity	Description
Force Analog Out	Minor	Occurs when the <b>FORCE A/O FUNCTION</b> setpoint is "Enabled".
Force Relays	Minor	Occurs when the <b>FORCE OUTPUT RELAYS FUNCTION</b> setpoint is "Enabled".
Internal RS485	Minor	Caused by a failure of the internal communication link between the main processor and the communication processor. Attempts to read actual values or write setpoints were unsuccessful. Contact Multilin Technical Support.
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	Caused when IRIG-B time synchronization has been enabled but the signal cannot be decoded. Ensure correct IRIG-B signal is available to the device.
Not Calibrated	Minor	This warning occurs when the relay has not been factory calibrated. Contact Multilin Technical Support.
Pickup Test	Minor	Occurs when the <b>PICKUP TEST FUNCTION</b> setpoint is "Enabled".
Prototype Software	Minor	Occurs when prototype software has been loaded into the relay. Contact Multilin Technical Support for the correct firmware update.
Relay Not Ready	Minor	This warning occurs when the <b>750/760 OPERATION</b> setpoint has not been set to "Ready".
Simulation Mode	Minor	This warning occurs when the simulation feature of the relay is active.
Self-Test 1	Major	This warning occurs when <ul style="list-style-type: none"> <li>750 receives DNP protocol command to cold restart.</li> <li>Enervista 750 Setup software sends Modbus command to 750 for firmware update, from version 7.31 or previous version, to version 7.40.</li> <li>Watchdog timer expiry.</li> </ul>
Self-Test 2	Major	This warning occurs when microprocessor self-monitoring detects task execution failure.
Test Mode 3	Major	This warning occurs when Enervista 750 Setup software sends Modbus command to 750 for firmware update from version 7.40 to a following version.

#### 4.3.4 Flash Messages

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 **SI RELAY SETUP** >> **FRONT PANEL** >> **FLASH MESSAGE TIME**. The factory default flash message time is 4 seconds.

<b>ADJUSTED VALUE HAS BEEN STORED</b>	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.
<b>COMMAND IS BEING EXECUTED</b>	This flash message is displayed in response to executing a command message. Entering "Yes" at a command will display the message <b>ARE YOU SURE?</b> . Entering "Yes" again will perform the requested command and display this flash message.
<b>DEFAULT MESSAGE HAS BEEN ADDED</b>	This flash message is displayed in response to pressing the decimal key, followed by the ENTER key twice, on any message in <b>SI RELAY SETUP ▾ ▽ DEFAULT MESSAGES</b> .
<b>DEFAULT MESSAGE HAS BEEN REMOVED</b>	This message is displayed in response to pressing the decimal key, followed by the ENTER key twice, on any selected default message in <b>SI RELAY SETUP ▾ ▽ DEFAULT MESSAGES</b> .
<b>ENTER PASSCODE IS INVALID</b>	This flash message is displayed in response to an incorrectly entered passcode when attempting to enable or disable setpoint access.
<b>ENTRY MISMATCH - CODE NOT STORED</b>	This message is displayed while changing the password with the <b>SI RELAY SETUP ▾ PASSCODE ▾ ▽ CHANGE PASSCODE</b> setpoint. If the passcode entered at the <b>PLEASE RE-ENTER A NEW PASSCODE</b> prompt is different from the one entered <b>PLEASE ENTER A NEW PASSCODE</b> prompt, the relay dumps the new passcode and display this message
<b>INVALID KEY: MUST BE IN LOCAL MODE</b>	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.
<b>NEW PASSCODE STORED</b>	This message is displayed in response to changing the programmed passcode from the <b>SI RELAY SETUP ▾ PASSCODE ▾ ▽ CHANGE PASSCODE</b> setpoint. The directions to change the passcode were followed correctly and the new passcode was stored as entered.
<b>NEW SETPOINT STORED</b>	This flash message is displayed in response to the ENTER key while on any setpoint message. The edited value was stored as entered.
<b>NO CONDITIONS ARE CURRENTLY ACTIVE</b>	This flash message is displayed in response to the MESSAGE ► key when the relay is displaying <b>TARGET MESSAGES</b> and the Message LED is off. There are no active conditions to display in the diagnostic message queue.
<b>OUT OF RANGE - VALUE NOT STORED</b>	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.

<b>PLEASE ENTER A NON-ZERO PASSCODE</b>	This flash message is displayed while changing the passcode with the <b>SI RELAY SETUP ▷ PASSCODE ▷▽ CHANGE PASSCODE</b> setpoint. An attempt was made to change the passcode to "0" when it was already "0".
<b>PRESS [ENTER] TO ADD AS DEFAULT</b>	This flash message is displayed for 5 seconds in response to pressing the decimal key, followed by the ENTER key while displaying any setpoint or actual value message except those in <b>SI RELAY SETUP ▷▽ DEFAULT MESSAGES</b> . Pressing the ENTER key again while this message is displayed adds the setpoint or actual value message to the default list.
<b>PRESS [ENTER] TO BEGIN TEXT EDIT</b>	This message is displayed in response to the VALUE keys while on a setpoint message with a text entry value. The ENTER key must be pressed to begin editing.
<b>PRESS [ENTER] TO REMOVE MESSAGE</b>	This flash message is displayed for 5 seconds in response to pressing the decimal key, followed by the ENTER key while displaying one of the selected default messages in the subgroup <b>SI RELAY SETUP ▷▽ DEFAULT MESSAGES</b> . Pressing the ENTER key again while this message is displayed removes the default message from the list.
<b>PRESSED KEY IS INVALID HERE</b>	This flash message is displayed in response to any pressed key that has no meaning in the current context.
<b>RESETTING LATCHED CONDITIONS</b>	This flash message is displayed in response to the RESET key. All active latched conditions (trips, alarms, or latched relays) for which the activating condition is no longer present will be cleared.
<b>SETPOINT ACCESS DENIED (PASSCODE)</b>	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.
<b>SETPOINT ACCESS DENIED (SWITCH)</b>	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.
<b>SETPOINT ACCESS IS NOW ALLOWED</b>	This flash message is displayed in response to correctly entering the programmed passcode at the <b>SI RELAY SETUP ▷ PASSCODE ▷▽ ALLOW ACCESS TO SETPOINTS</b> setpoint. The command to allow access to setpoints has been successfully executed and setpoints can be changed and entered.
<b>SETPOINT ACCESS IS NOW RESTRICTED</b>	This flash message is displayed in response to entering the correct programmed passcode at the <b>SI RELAY SETUP ▷ PASSCODE ▷▽ RESTRICT ACCESS TO SETPOINTS</b> setpoint. The command to restrict access to setpoints has been successfully executed and setpoints cannot be changed.

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## 4.4 EnerVista 750/760 Setup Software Interface

### 4.4.1 Overview

The EnerVista 750/760 Setup software provides a graphical user interface (GUI) as one of two human interfaces to a 750/760 device. The alternate human interface is implemented via the device's faceplate keypad and display (see the first section in this chapter).

The EnerVista 750/760 Setup software provides a single facility to configure, monitor, maintain, and trouble-shoot the operation of relay functions, connected over serial communication networks. It can be used while disconnected (i.e. off-line) or connected (i.e. on-line) to a 750/760 device. In off-line mode, settings files can be created for eventual downloading to the device. In on-line mode, you can communicate with the device in real-time.

This no-charge software, provided with every 750/760 relay, can be run from any computer supporting Microsoft Windows 95 or higher. This chapter provides a summary of the basic EnerVista 750/760 Setup software interface features. The EnerVista 750/760 Setup Help File provides details for getting started and using the software interface.

With the EnerVista 750/760 Setup running on your PC, it is possible to:

- Program and modify setpoints
- Load/save setpoint files from/to disk
- Read actual values and monitor status
- Perform waveform capture and log data
- Plot, print, and view trending graphs of selected actual values
- Download and playback waveforms
- Get help on any topic

### 4.4.2 Hardware

Communications from the EnerVista 750/760 Setup to the 750/760 can be accomplished three ways: RS232, RS485, and Ethernet communications. The following figures below illustrate typical connections for RS232, RS485, and Ethernet communications.



FIGURE 4-3: Communications using the Front RS232 Port

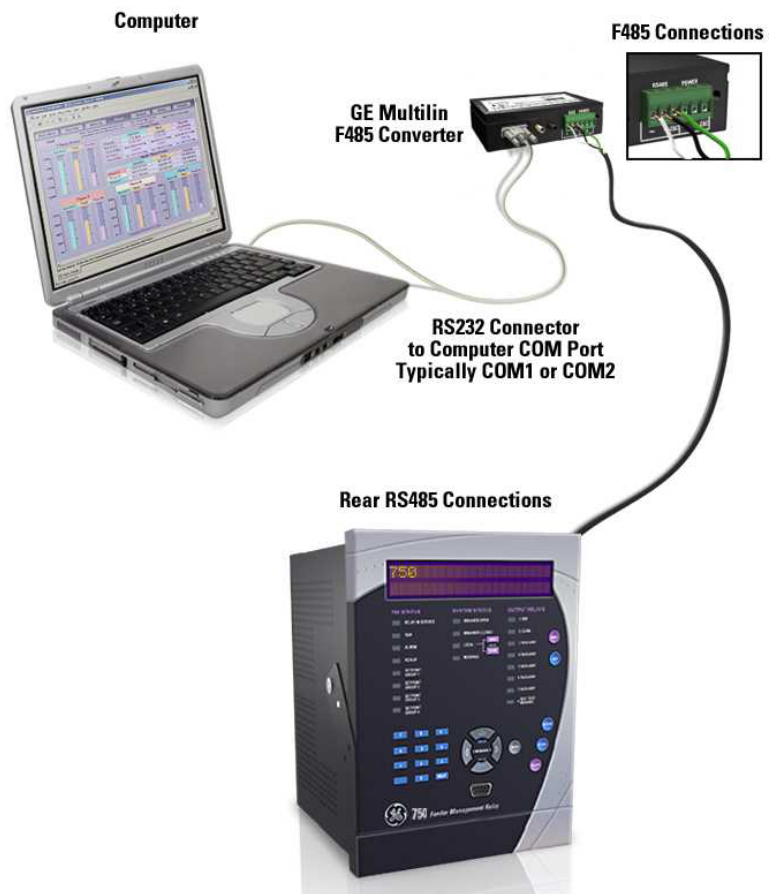
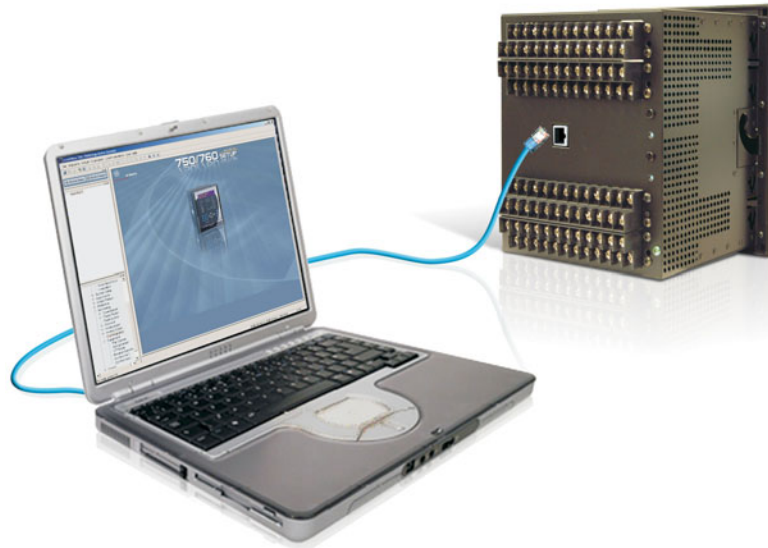


FIGURE 4-4: Communications using Rear RS485 Port



RS485 COM2 is disabled when the Ethernet option is ordered.



996711A1.CDR

FIGURE 4-5: Communications using Rear Ethernet Port

#### 4.4.3 Installing the EnerVista 750/760 Setup Software

The following minimum requirements must be met for the EnerVista 750/760 Setup software to operate on your computer.

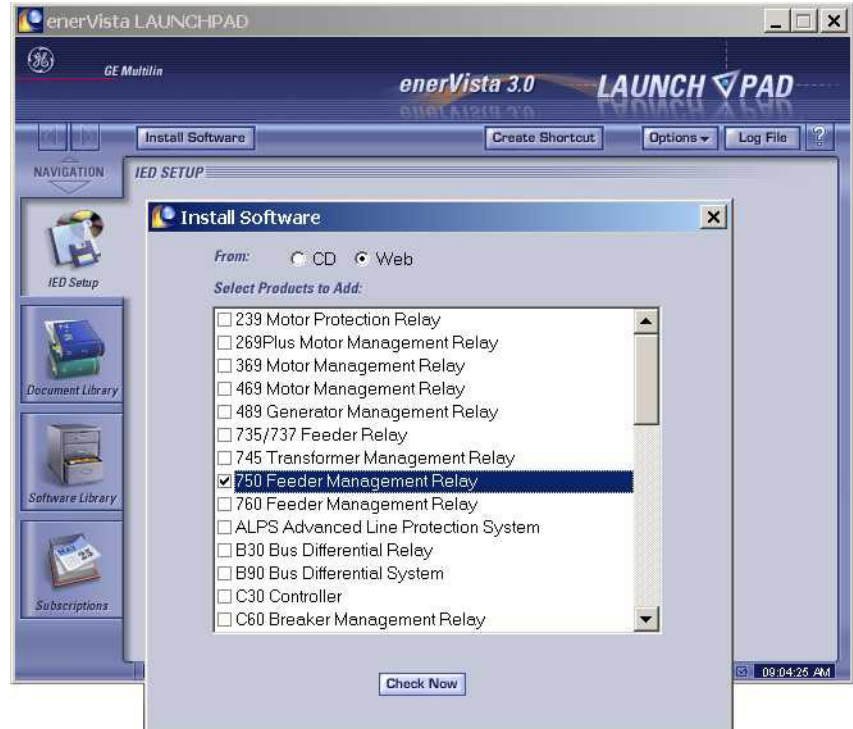
- Pentium class or higher processor (Pentium II 300 MHz or better recommended)
- Microsoft Windows 95, 98, 98SE, ME, NT 4.0 (SP4 or higher), 2000, XP
- 64 MB of RAM (256 MB recommended)
- Minimum of 50 MB hard disk space (200 MB recommended)

After ensuring these minimum requirements, use the following procedure to install the EnerVista 750/760 Setup software from the enclosed GE EnerVista CD.

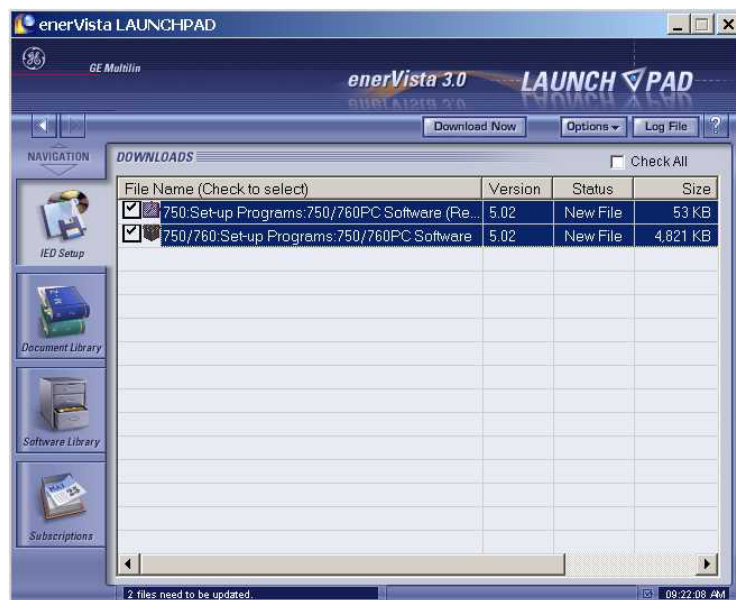
1. Insert the GE EnerVista CD into your CD-ROM drive.
2. Click the **Install Now** button and follow the installation instructions to install the no-charge EnerVista software on the local PC.
3. When installation is complete, start the EnerVista Launchpad application.
4. Click the **IED Setup** section of the **Launch Pad** window.



- In the EnerVista Launch Pad window, click the **Install Software** button and select the “750 Feeder Management Relay” or “760 Feeder Management Relay” from the Install Software window as shown below. Select the “Web” option to ensure the most recent software release, or select “CD” if you do not have a web connection, then click the **Check Now** button to list software items for the 750/760.



- Select the EnerVista 750/760 Setup software and release notes (if desired) from the list and click the **Download Now** button to obtain the installation program.





7. EnerVista Launchpad will obtain the installation program from the Web or CD. Once the download is complete, double-click the installation program to install the EnerVista 750/760 Setup software.
8. The program will request the user to create a backup 3.5" floppy-disk set. If this is desired, click on the **Start Copying** button; otherwise, click on the **CONTINUE WITH 750/760 INSTALLATION** button.
9. Select the complete path, including the new directory name, where the EnerVista 750/760 Setup software will be installed.
10. Click on **Next** to begin the installation. The files will be installed in the directory indicated and the installation program will automatically create icons and add EnerVista 750/760 Setup software to the Windows start menu.
11. Click **Finish** to end the installation. The 750/760 device will be added to the list of installed IEDs in the EnerVista Launchpad window, as shown below.





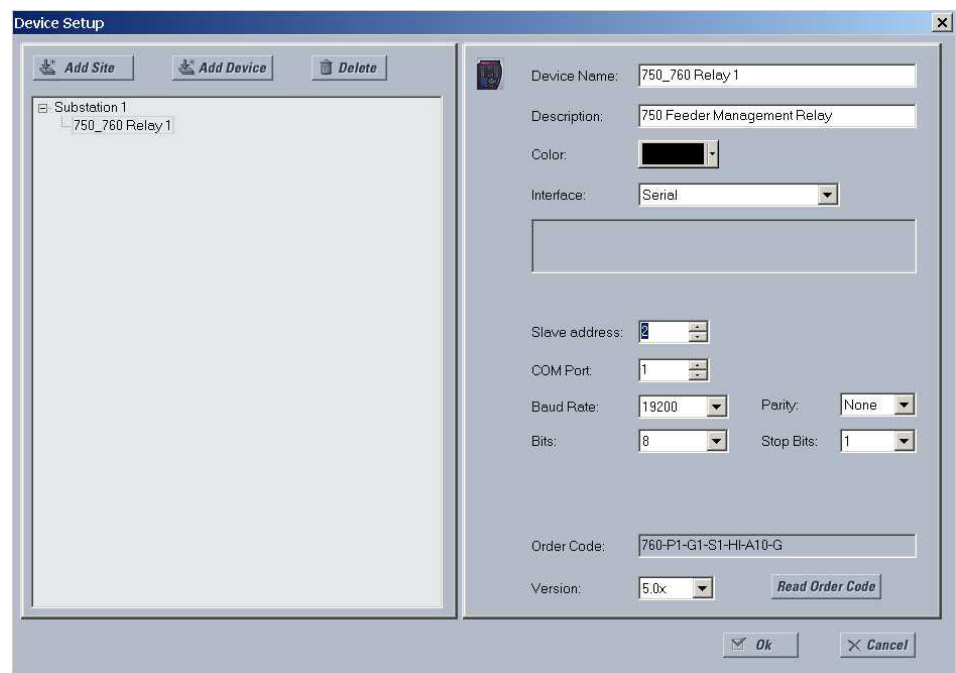
## 4.5 Connecting EnerVista 750/760 Setup to the Relay

### 4.5.1 Configuring Serial Communications

Before starting, verify that the serial cable is properly connected to either the RS232 port on the front panel of the device (for RS232 communications) or to the RS485 terminals on the back of the device (for RS485 communications). See *Hardware* on page 4–12 for connection details.

This example demonstrates an RS232 connection. For RS485 relay communications, the GE Multilin F485 converter will be required. Refer to the F485 manual for additional details. To configure the relay for Ethernet communications, see *Configuring Ethernet Communications* on page 4–19.

1. Install and start the latest version of the EnerVista 750/760 Setup software (available from the GE EnerVista CD). See the previous section for the installation procedure.
2. Click on the **Device Setup** button to open the Device Setup window and click the **Add Site** button to define a new site.
3. Enter the desired site name in the **Site Name** field. If desired, a short description of site can also be entered along with the display order of devices defined for the site. In this example, we will use “Substation 1” as the site name. Click the **OK** button when complete.
4. The new site will appear in the upper-left list in the EnerVista 750/760 Setup window.
5. Click the **Add Device** button to define the new device.
6. Enter the desired name in the **Device Name** field and a description (optional) of the site.
7. Select “Serial” from the Interface drop-down list. This will display a number of interface parameters that must be entered for proper RS232 functionality.

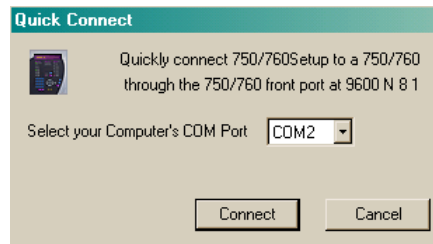


- Enter the slave address and COM port values (from the **S1 RELAY SETUP** ▷ ▾ **COMMUNICATIONS** ▷ ▾ **PORT SETUP** menu) in the Slave Address and COM Port fields.
  - Enter the physical communications parameters (baud rate and parity settings) in their respective fields.
8. Click the **Read Order Code** button to connect to the 750/760 device and upload the order code. If an communications error occurs, ensure that the 750/760 serial communications values entered in the previous step correspond to the relay setting values.
  9. Click **OK** when the relay order code has been received. The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista 750/760 Setup window.

The 750/760 Site Device has now been configured for serial communications. Proceed to *Connecting to the Relay* on page 4–20 to begin communications.

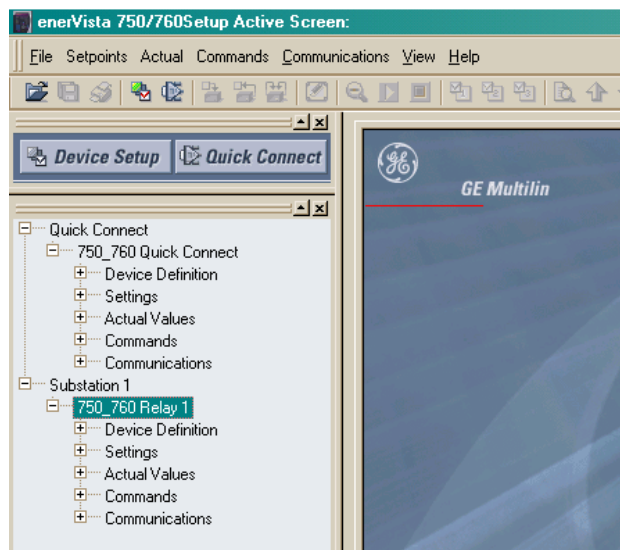
#### 4.5.2 Using the Quick Connect Feature

The Quick Connect button can be used to establish a fast connection through the front panel RS232 port of a 750/760 relay. The following window will appear when the Quick Connect button is pressed:



As indicated by the window, the Quick Connect feature quickly connects the EnerVista 750/760 Setup software to a 750/760 front port with the following settings: 9600 baud, no parity, 8 bits, 1 stop bit. Select the PC communications port connected to the relay and press the **Connect** button.

The EnerVista 750/760 Setup software will display a window indicating the status of communications with the relay. When connected, a new Site called “Quick Connect” will appear in the Site List window. *The properties of this new site cannot be changed.*



The 750/760 Site Device has now been configured via the Quick Connect feature for serial communications. Proceed to *Connecting to the Relay* on page 4-20 to begin communications.

### 4.5.3 Configuring Ethernet Communications

Before starting, verify that the Ethernet cable is properly connected to the RJ-45 Ethernet port.



**750/760 supports a maximum of 4 TCP/IP sessions.**

1. Install and start the latest version of the EnerVista 750/760 Setup software (available from the GE EnerVista CD). See the previous section for the installation procedure.
2. Click on the **Device Setup** button to open the Device Setup window and click the **Add Site** button to define a new site.
3. Enter the desired site name in the **Site Name** field. If desired, a short description of site can also be entered along with the display order of devices defined for the site. In this example, we will use “Substation 2” as the site name. Click the **OK** button when complete.
4. The new site will appear in the upper-left list.
5. Click the **Add Device** button to define the new device.
6. Enter the desired name in the **Device Name** field and a description (optional).
7. Select “Ethernet” from the Interface drop-down list. This will display a number of interface parameters that must be entered for proper Ethernet functionality.

Enter the IP address, slave address, and Modbus port values assigned to the 750/760 relay (from the **SI RELAY SETUP** > **COMMUNICATIONS** > **NETWORK CONFIGURATION** menu).

8. Click the **Read Order Code** button to connect to the 750/760 and upload the order code. If an communications error occurs, ensure that the Ethernet communications values correspond to the relay setting values.
9. Click **OK** when the relay order code has been received. The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista 750/760 Setup window.

The 750/760 Site Device has now been configured for Ethernet communications. Proceed to the following section to begin communications.

#### 4.5.4 Connecting to the Relay

Now that the communications parameters have been properly configured, the user can easily communicate with the relay.

1. Expand the Site list by double clicking on the site name or clicking on the «+» box to list the available devices for the given site (for example, in the “Substation 1” site shown below).
2. Desired device trees can be expanded by clicking the «+» box. The following list of headers is shown for each device:

- Device Definitions
- Settings
- Actual Values
- Commands
- Communications

3. Expand the Settings > Relay Setup list item and double click on Front Panel to open the Front Panel settings window as shown below:

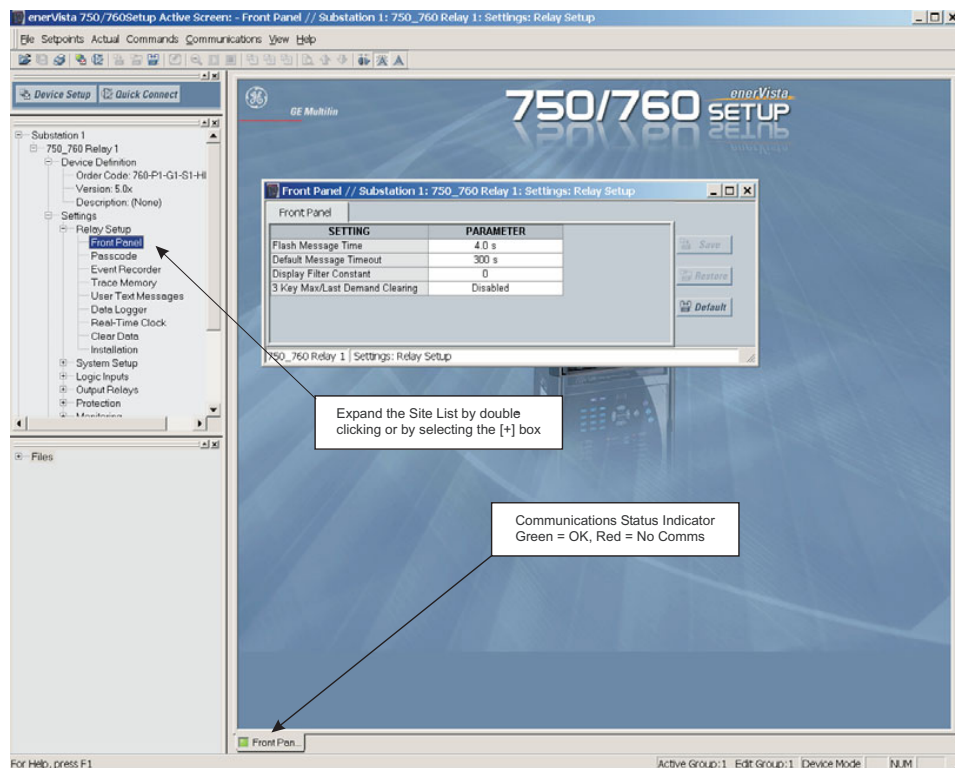


FIGURE 4-6: Main Window After Connection

4. The Front Panel settings window will open with a corresponding status indicator on the lower left of the EnerVista 750/760 Setup window.
5. If the status indicator is red, verify that the serial or Ethernet cable is properly connected to the relay, and that the relay has been properly configured for communications (steps described earlier).

The Front Panel settings can now be edited, printed, or changed according to user specifications. Other setpoint and commands windows can be displayed and edited in a similar manner. Actual values windows are also available for display. These windows can be locked, arranged, and resized at will.



**Refer to the EnerVista 750/760 Setup Help File for additional information about the using the software.**

NOTE

## 4.6 Working with Setpoints and Setpoint Files

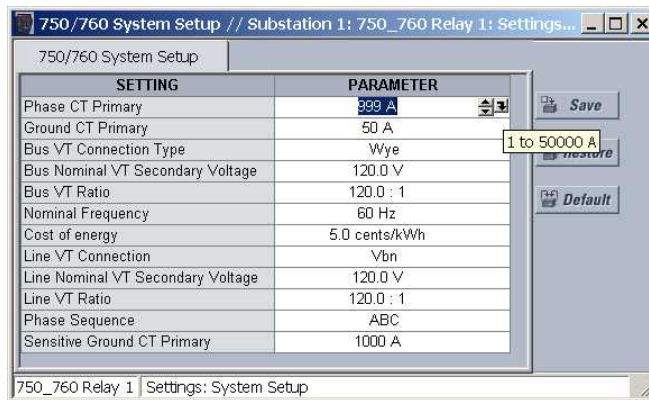
### 4.6.1 Engaging a Device

The EnerVista 750/760 Setup software may be used in on-line mode (relay connected) to directly communicate with a 750/760 relay. Communicating relays are organized and grouped by communication interfaces and into sites.

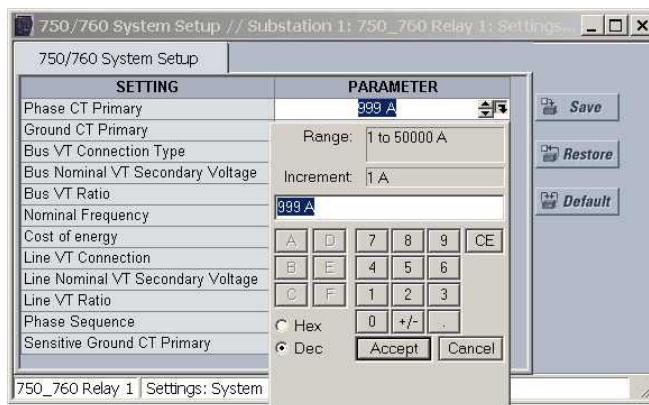
### 4.6.2 Entering Setpoints

The System Setup page will be used as an example to illustrate the entering of setpoints. In this example, we will be changing the current sensing setpoints.

1. Establish communications with the relay.
2. Select the **Setpoint > System Setup** menu item. This can be selected from the device setpoint tree or the main window menu bar.
3. Select the **PHASE CT PRIMARY** setpoint by clicking anywhere in the parameter box. This will display three arrows: two to increment/decrement the value and another to launch the numerical calculator.

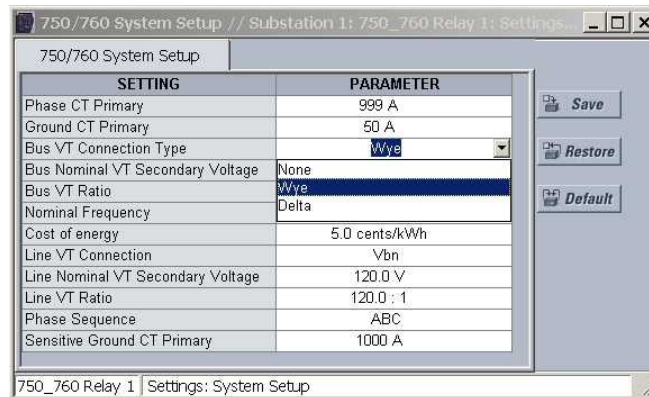


4. Clicking the arrow at the end of the box displays a numerical keypad interface that allows the user to enter a value within the setpoint range displayed near the top of the keypad:



Click **Accept** to exit from the keypad and keep the new value. Click on **Cancel** to exit from the keypad and retain the old value.

- For setpoints requiring non-numerical pre-set values (e.g. **BUS VT CONNECTION TYPE** above), clicking anywhere within the setpoint value box displays a drop-down selection menu arrow. Select the desired value from this list.



- For setpoints requiring an alphanumeric text string (e.g. message scratchpad messages), the value may be entered directly within the setpoint value box.
- In the Setpoint / System Setup dialog box, click on **Store** to save the values into the 750/760. Click **OK** to accept any changes and exit the window. Click **Cancel** to retain previous values and exit.

### 4.6.3 File Support

Opening any EnerVista 750/760 Setup file will automatically launch the application or provide focus to the already opened application. If the file is a settings file (has a '750' or '760' extension) which had been removed from the Settings List tree menu, it will be added back to the Settings List tree.

New files will be automatically added to the tree, which is sorted alphabetically with respect to settings file names.

### 4.6.4 Using Setpoints Files

#### Overview

The EnerVista 750/760 Setup software interface supports three ways of handling changes to relay settings:

- In *off-line* mode (relay disconnected) to create or edit relay settings files for later download to communicating relays.
- Directly modifying relay settings while *connected* to a communicating relay, then saving the settings when complete.
- Creating/editing settings files while *connected* to a communicating relay, then saving them to the relay when complete.

Settings files are organized on the basis of file names assigned by the user. A settings file contains data pertaining to the following types of relay settings:

- Device Definition
- Product Setup
- System Setup
- Grouped Elements
- Control Elements

- Inputs/Outputs
- Testing

Factory default values are supplied and can be restored after any changes.

The EnerVista 750/760 Setup display relay setpoints with the same hierarchy as the front panel display. For specific details on setpoints, refer to Chapter 5.

### Downloading and Saving Setpoints Files

Setpoints must be saved to a file on the local PC before performing any firmware upgrades. Saving setpoints is also highly recommended before making any setpoint changes or creating new setpoint files.

The EnerVista 750/760 Setup window, setpoint files are accessed in the Settings List control bar window or the Files Window. Use the following procedure to download and save setpoint files to a local PC.

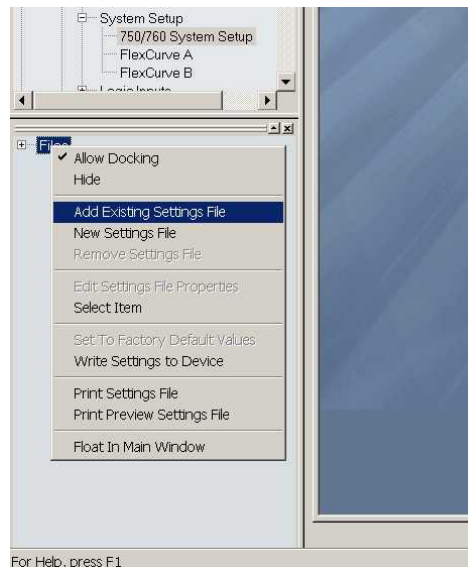
1. Ensure that the site and corresponding device(s) have been properly defined and configured as shown in *Connecting EnerVista 750/760 Setup to the Relay* on page 4-17.
2. Select the desired device from the site list.
3. Select the **File > Read Settings from Device** menu item to obtain settings information from the device.
4. After a few seconds of data retrieval, the software will request the name and destination path of the setpoint file. The corresponding file extension will be automatically assigned. Press **Save** to complete the process. A new entry will be added to the tree, in the File pane, showing path and file name for the setpoint file.

### Adding Setpoints Files to the Environment

The EnerVista 750/760 Setup software provides the capability to review and manage a large group of setpoint files. Use the following procedure to add a new or existing file to the list.



1. In the files pane, right-click on 'Files' and select the **Add Existing Setting File** item as shown:

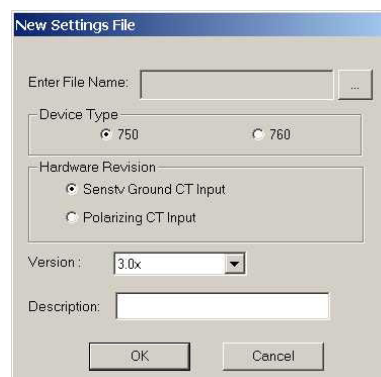


2. The Open dialog box will appear, prompting the user to select a previously saved setpoint file. As for any other MS Windows® application, browse for the file to be added then click **Open**. The new file and complete path will be added to the file list.

### Creating a New Setpoint File

The EnerVista 750/760 Setup software allows the user to create new setpoint files independent of a connected device. These can be uploaded to a relay at a later date. The following procedure illustrates how to create new setpoint files.

1. In the File pane, right click on 'File' and select the **New Settings File** item. The EnerVista 750/760 Setup software displays the following box will appear, allowing for the configuration of the setpoint file for the correct firmware version. It is important to define the correct firmware version to ensure that setpoints not available in a particular version are not downloaded into the relay.



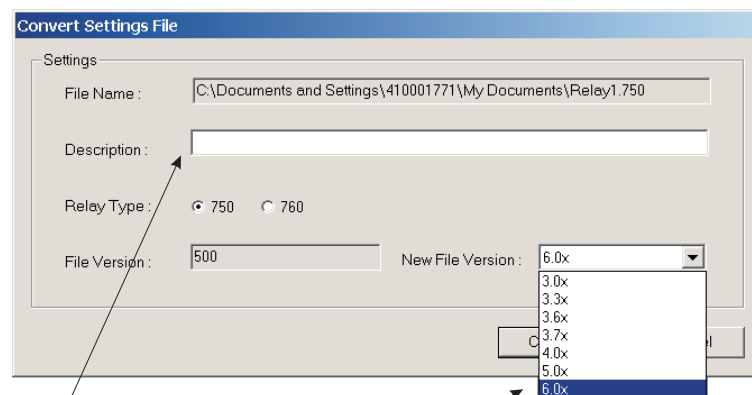
2. Select the Device Type, Hardware Revision, and Firmware Version for the new setpoint file.
3. For future reference, enter some useful information in the Description box to facilitate the identification of the device and the purpose of the file.

4. To select a file name and path for the new file, click the button beside the **Enter File Name** box.
5. Select the file name and path to store the file, or select any displayed file name to update an existing file. All 750/760 setpoint files should have the extension '750' or '760' (for example, 'feeder1.750').
6. Click **Save** and **OK** to complete the process. Once this step is completed, the new file, with a complete path, will be added to the EnerVista 750/760 Setup software environment.

### Upgrading Setpoint Files to a New Revision

It is often necessary to upgrade the revision code for a previously saved setpoint file after the 750/760 firmware has been upgraded (for example, this is required for firmware upgrades). This is illustrated in the following procedure.

1. Establish communications with the 750/760 relay.
2. Select the **Actual > A5 Product** Info menu item and record the Software Revision identifier of the relay firmware.
3. Load the setpoint file to be upgraded into the EnerVista 750/760 Setup environment as described in *Adding Setpoints Files to the Environment* on page 4–24.
4. In the File pane, select the saved setpoint file.
5. From the main window menu bar, select the **File > Properties** menu item and note the **File Version** of the setpoint file. If this version (e.g. 5.00 shown below) is different than the Software Revision code noted in step 2, select a **New File Version** that matches the Software Revision code from the pull-down menu.
6. For example, if the firmware revision is 27L720A5.000 (software revision 7.20) and the current setpoint file revision is 5.00, change the setpoint file revision to "7.2x".



Enter any special comments about the setpoint file here.

Select the desired setpoint version from this menu. The 6.0x indicates versions 6.00, 6.01, 6.02, etc.

7. When complete, click **Convert** to convert the setpoint file to the desired revision. A dialog box will request confirmation. See *Loading Setpoints from a File* on page 4–27 for instructions on loading this setpoint file into the 750/760.

## Printing Setpoints and Actual Values

The EnerVista 750/760 Setup software allows the user to print partial or complete lists of setpoints and actual values. Use the following procedure to print a list of setpoints:

1. Select a previously saved setpoints file in the File pane or establish communications with a 750/760 device.
2. From the main window, select the **File > Print Settings** menu item.
3. The Print/Export Options dialog box will appear. Select **Settings** in the upper section and select either **Include All Features** (for a complete list) or **Include Only Enabled Features** (for a list of only those features which are currently used) in the filtering section and click **OK**.



4. The process for **File > Print Preview Settings** is identical to the steps above.
5. Setpoints lists can be printed in the same manner by right clicking on the desired file (in the file list) or device (in the device list) and selecting the **Print Device Information** or **Print Settings File** options.

A complete list of actual values can also be printed from a connected device with the following procedure:

1. Establish communications with the desired 750/760 device.
2. From the main window, select the **File > Print Settings** menu item.
3. The Print/Export Options dialog box will appear. Select **Actual Values** in the upper section and select either **Include All Features** (for a complete list) or **Include Only Enabled Features** (for a list of only those features which are currently used) in the filtering section and click **OK**.

Actual values lists can be printed in the same manner by right clicking on the desired device (in the device list) and selecting the **Print Device Information** option.

## Loading Setpoints from a File



An error message will occur when attempting to download a setpoint file with a revision number that does not match the relay firmware. If the firmware has been upgraded since saving the setpoint file, see *Upgrading Setpoint Files to a New Revision* on page 4–26 for instructions on changing the revision number of a setpoint file.

The following procedure illustrates how to load setpoints from a file. Before loading a setpoints file, it must first be added to the EnerVista 750/760 Setup environment as described in *Adding Setpoints Files to the Environment* on page 4–24.

1. Select the previously saved setpoints file from the File pane of the EnerVista 750/760 Setup software main window.
2. Select the **File > Properties** menu item and verify that the corresponding file is fully compatible with the hardware and firmware version of the target relay. If the versions are not identical, see *Upgrading Setpoint Files to a New Revision* on page 4–26 for details on changing the setpoints file version.
3. Right-click on the selected file and select the **Write Settings to Device** item.
4. Select the target relay from the list of devices shown and click **Send**. If there is an incompatibility, an error of following type will occur:



5. If there are no incompatibilities between the target device and the settings file, the data will be transferred to the relay. An indication of the percentage completed will be shown in the bottom of the main window.

## 4.7 Upgrading Relay Firmware

### 4.7.1 Description

To upgrade the 750/760 firmware, follow the procedures listed in this section. Upon successful completion of this procedure, the 750/760 will have new firmware installed with the original setpoints.

The latest firmware files are available from the GE Multilin website at <http://www.gegridsolutions.com>.



Energvista 750/760 Software prevents incompatible firmware from being loaded into a 750/760 relay.

Firmware version 7.20 is compatible only with hardware version 'L\*'. Firmware version 7.01 or older is not compatible with hardware version 'L'.

\* However, firmware version 7.21 is compatible with both Hardware revs K and L.

Relay Hardware Version	Bootware Version	Compatible Application Firmware Versions
"K"	500	7.00 7.01 7.21
"L"	600	7.20
"L"	601	7.21



Units with bootware versions earlier than 3.00 must be set to a baud rate of 9600 with a Slave Address of 1 before downloading new firmware. The bootware version can be checked in the **A5 PRODUCT INFO** > **REVISION CODES** > **BOOTWARE REVISION** actual value.

### WARNING

It is recommended not to downgrade the firmware revision of the 750/760. Downgrading an 750/760 with Ethernet option from higher firmware revision to FW revision 7.20 can lose the Ethernet functionality in the relay. Please contact Multilin Technical Support team for more details.

### 4.7.2 Saving Setpoints To A File

Before upgrading firmware, it is very important to save the current 750/760 settings to a file on your PC. After the firmware has been upgraded, it will be necessary to load this file back into the 750/760.

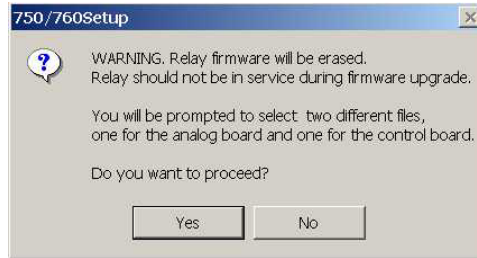
Refer to *Downloading and Saving Setpoints Files* on page 4–24 for details on saving relay setpoints to a file.

### 4.7.3 Loading New Firmware

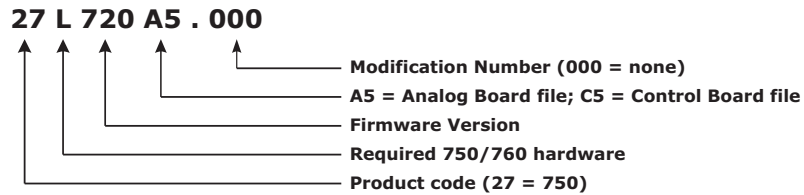
Loading new firmware into the 750/760 flash memory is accomplished as follows:

1. Connect the relay to the local PC and save the setpoints to a file as shown in *Downloading and Saving Setpoints Files* on page 4–24.
2. Select the **Communications > Update Firmware** menu item.

- 3. The following warning message will appear. Select **Yes** to proceed or **No** to cancel the process. *Do not proceed unless you have saved the current setpoints.*



- 4. The EnerVista 750/760 Setup software will request the new firmware file. Locate the firmware file to load into the 750/760. The firmware filename has the following format:



- 5. The 750/760PC software automatically lists all filenames beginning with '27'. Select the appropriate file and click **OK** to continue. This will be the Analog Board file.
- 6. A second file request will be prompted. This will be for the Control Board file.

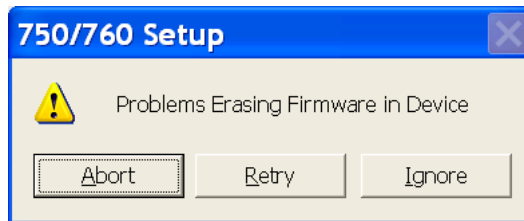


**Both analog and control board files must have the same firmware versions.**

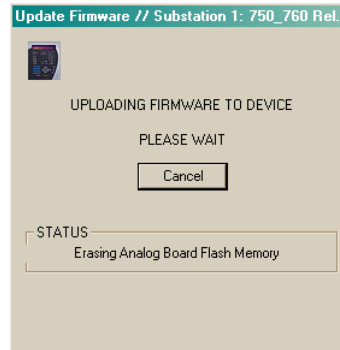
- 7. EnerVista 750/760 Setup software now prepares the 750/760 to receive the new firmware file. The 750/760 front panel will momentarily display "Code Programming Mode Ready," indicating that it is in upload mode. The 750/760 front panel continues with display "Erasing Analog Board Flash Memory."



With hardware revision 'K' and earlier, at this point EverVista 750/760 Setup software may occasionally display the prompt shown below. If this occurs, select "Retry". It may require up to 5 attempts.



8. While the file is being loaded into the 750/760, a status box appears showing how much of the new firmware file has been transferred and how much is remaining, as well as the upgrade status. The entire transfer process takes approximately 15 minutes if communicating at 19200 baud..



9. The EnerVista 750/760 Setup software will notify the user when the 750/760 has finished loading the file. Carefully read any displayed messages and click **OK** to return the main screen.



NOTE

Cycling power to the relay is recommended after a firmware upgrade.

After successfully updating the 750/760 firmware, the relay will not be in service and will require setpoint programming. To communicate with the relay, the following settings will have to be manually programmed.

**MODBUS COMMUNICATION ADDRESS**

**BAUD RATE**

**PARITY** (if applicable)

When communications is established, the saved setpoints must be reloaded back into the relay. See *Loading Setpoints from a File* on page 4–27 for details.

Modbus addresses assigned to firmware modules, features, settings, and corresponding data items (i.e. default values, min/max values, data type, and item size) may change slightly from version to version of firmware.

The addresses are rearranged when new features are added or existing features are enhanced or modified. The **EEPROM DATA ERROR** message displayed after upgrading/downgrading the firmware is a resettable, self-test message intended to inform users that the Modbus addresses have changed with the upgraded firmware. This message does not signal any problems when appearing after firmware upgrades.

## 4.8 Advanced EnerVista 750/760 Setup Features

### 4.8.1 Triggered Events

While the interface is in either on-line or off-line mode, data generated by triggered specified parameters can be viewed and analyzed via one of the following features:

- **Event Recorder:** The event recorder captures contextual data associated with the last 512 events, listed in chronological order from most recent to the oldest.
- **Oscillography:** The oscillography waveform traces and digital states provide a visual display of power system and relay operation data captured during specific triggered events.

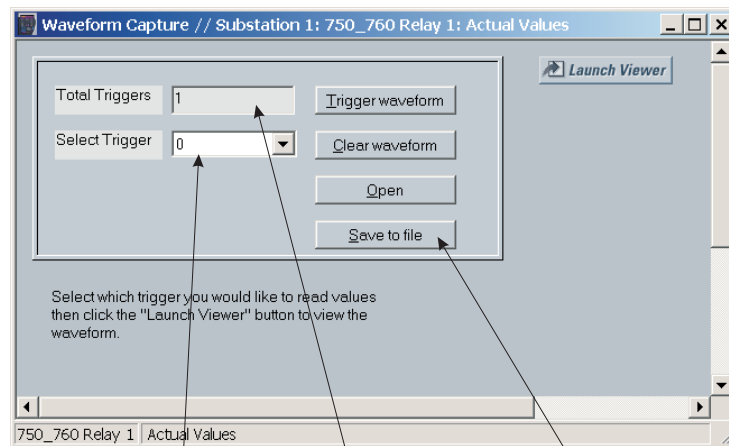
### 4.8.2 Waveform Capture (Trace Memory)

The EnerVista 750/760 Setup software can be used to capture waveforms (or view trace memory) from the 750/760 relay at the instance of a trip. A maximum of 512 cycles can be captured and the trigger point can be adjusted to anywhere within the set cycles. A maximum of 16 waveforms can be buffered (stored) with the buffer/cycle trade-off.

The following waveforms can be captured:

- Phase A, B, and C currents ( $I_a$ ,  $I_b$ , and  $I_c$ )
- Ground and Sensitive ground currents ( $I_g$  and  $I_{sg}$ )
- Phase A-N, B-N, and C-N voltages ( $V_a$ ,  $V_b$ , and  $V_c$ )
- Digital data for output relays and contact input states.

1. With EnerVista 750/760 Setup running and communications established, select the **Actual > Waveform Capture** menu item to open the waveform capture setup window:



Files to be saved or viewed  
 Number of available files  
 Save waveform to a file

Click on **Trigger Waveform** to trigger a waveform capture.

The waveform file numbering starts with the number zero in the 750/760; therefore, the maximum trigger number will always be one less than the total number triggers available.



- Click on the **Save to File** button to save the selected waveform to the local PC. A new window will appear requesting for file name and path.
- The file is saved as a comma separated values file, with the extension 'CSV'. A CSV file can be viewed and manipulated with compatible third-party software, such as Microsoft Excel.
- To view a previously saved file, click the **Open** button and select the corresponding CSV file.
- To view the captured waveforms, click the **Launch Viewer** button. A detailed Waveform Capture window will appear as shown below:

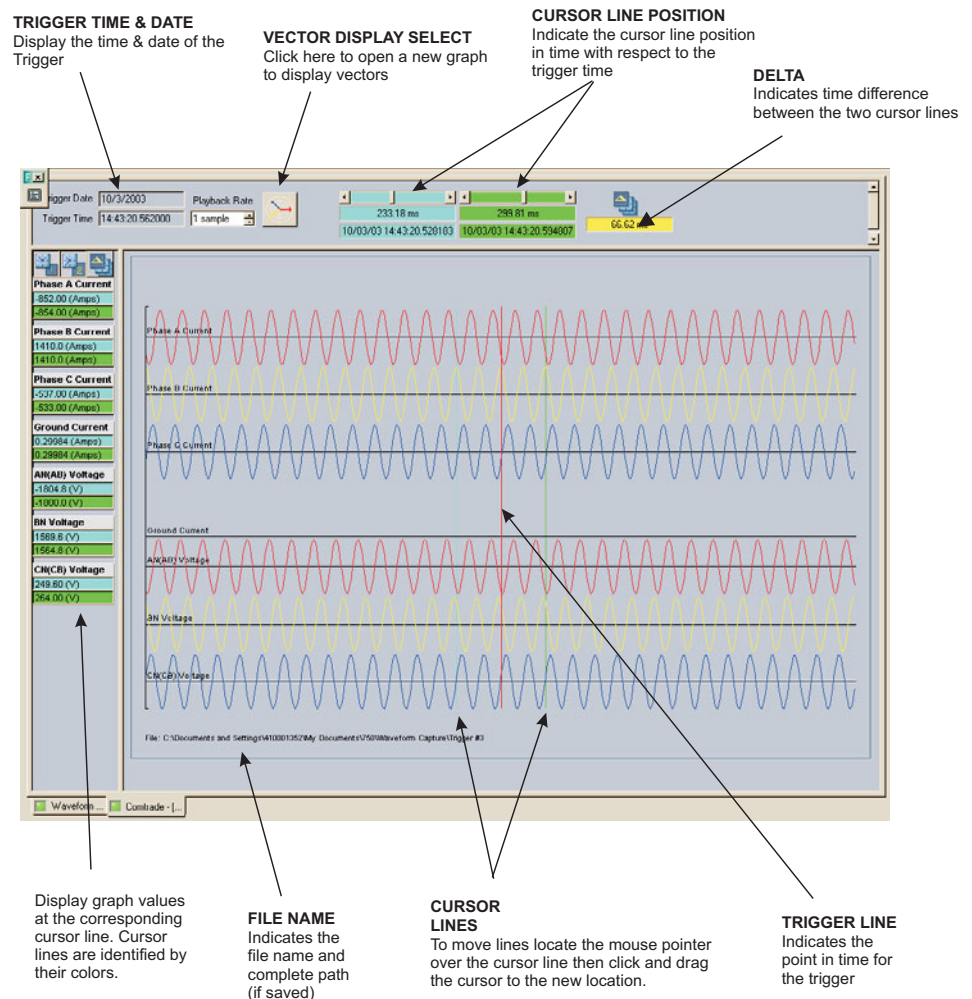


FIGURE 4-7: Waveform Capture Window Attributes

- The red vertical line indicates the trigger point of the relay.
- The date and time of the trip is displayed at the top left corner of the window. To match the captured waveform with the event that triggered it, make note of the time and date shown in the graph. Then, find the event that matches the same time and date in the event recorder. The event record will provide additional information on the cause and the system conditions at the time of the event. Additional information on

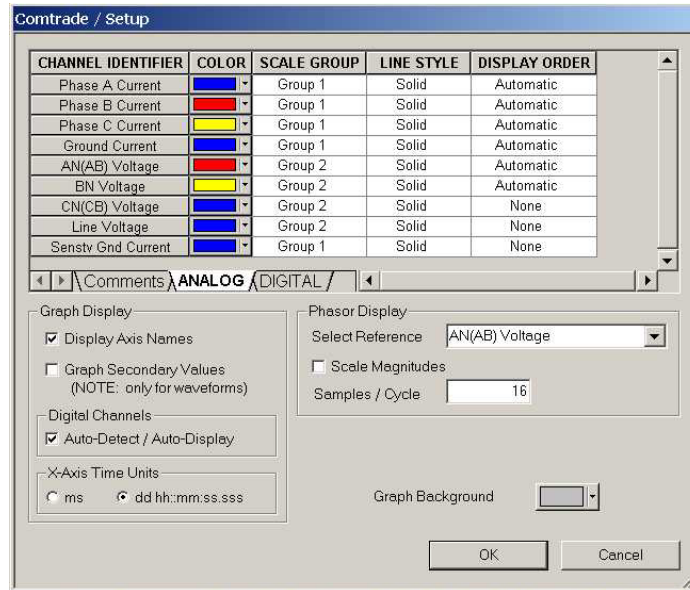
how to download and save events is shown in *Event Recorder* on page 4–35.

8. From the window main menu bar, press the Preference button to open the Graph Setup page to change the graph attributes.



Preference button

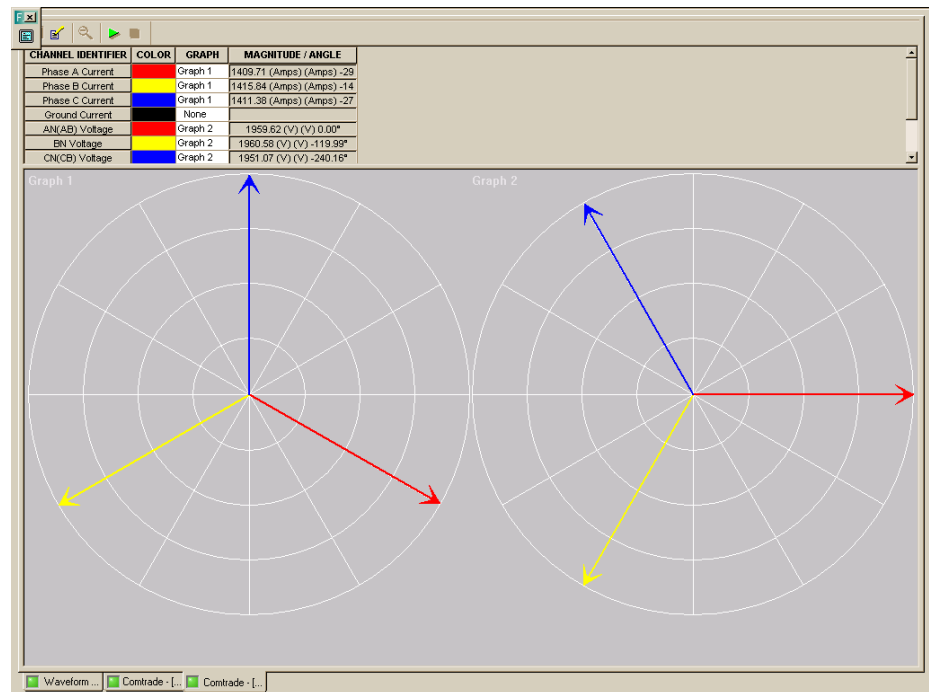
9. The following window will appear:



Change the Color of each graph as desired, and select other options as required, by checking the appropriate boxes. Click **OK** to store these graph attributes, and to close the window.

10. The Waveform Capture window will reappear with the selected graph attributes available for use.

11. To view a vector graph of the quantities contained in the waveform capture, press the Vector display button (see FIGURE 4-7: *Waveform Capture Window Attributes* on page 4-33) to display the following window:



12. Use the graph attribute utility described in step 7 to change the vector colors.

### 4.8.3 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 *Event Recorder* on page 5-14 for additional details. The Data Logger window behaves in the same manner as the Waveform Capture described above.

### 4.8.4 Event Recorder

The 750/760 event recorder can be viewed through the EnerVista 750/760 Setup software. The event recorder stores generator and system information each time an event occurs (e.g. breaker failure). A maximum of 512 events can be stored, where E512 is the most recent event and E001 is the oldest event. E001 is overwritten whenever a new event occurs. Refer to *Event Records* on page 6-20 for additional information on the event recorder.

Use the following procedure to view the event recorder with EnerVista 750/760 Setup:

1. With EnerVista 750/760 Setup running and communications established, select the **Actual > A4 Event Recorder** item from the main menu. This displays the Event Recorder window indicating the list of recorded events, with the most current event displayed first.

**EVENT LISTING**  
Lists the last 512 events with the most recent displayed at top of list.

**EVENT SELECT BUTTONS**  
Click the All button to select all events; click the None button to clear all selections.

**EVENT NUMBER**  
The event data information is related to the event number shown here.

**CLEAR EVENTS**  
Click the Clear Events button to clear the event list from memory.

The screenshot shows the Event Recorder window for '750\_760 Relay 1'. It features a table of events, selection controls, a detailed event parameter table, and control buttons. Annotations with arrows point to specific elements: 'EVENT LISTING' points to the event table; 'EVENT SELECT BUTTONS' points to the 'All' and 'None' buttons; 'EVENT NUMBER' points to the 'Select Events' dropdown showing '108'; 'CLEAR EVENTS' points to the 'Clear Events' button; 'DEVICE ID' points to the '750\_760 Relay 1' label; 'EVENT DATA' points to the 'Event Parameter' table; and 'SAVE EVENTS' points to the 'Save Events' button.

Event	Select	Date	Time	Cause of Event
98	<input checked="" type="checkbox"/>	10/6/2003	10:42:57.345	Alarm: Out Of Synchronization
97	<input checked="" type="checkbox"/>	10/6/2003	10:41:31.645	Logic Input: Phase AB - Block Ground OC
96	<input checked="" type="checkbox"/>	10/6/2003	10:41:25.249	Setpoint Group 3 Active
95	<input checked="" type="checkbox"/>	10/6/2003	10:41:25.242	Logic Input: Phase AB - Setpoint Group 3
94	<input checked="" type="checkbox"/>	10/6/2003	10:41:24.732	Setpoint Group 2 Active
93	<input checked="" type="checkbox"/>	10/6/2003	10:41:24.726	Logic Input: Phase AB - Setpoint Group 2
92	<input checked="" type="checkbox"/>	10/6/2003	09:52:48.516	Warning: Relay Not Ready
91	<input checked="" type="checkbox"/>	10/6/2003	09:52:38.293	Setpoint Group 1 Active
90	<input checked="" type="checkbox"/>	10/6/2003	09:52:38.287	Input On: Contact

Event Parameter	Value
Date of Event	10/7/2003
Time of Event	14:40:56.462
Cause of Event	Trigger Trace Memory
Phase A Current Magnitude	0 A
Phase A Current Angle	0 ° Lag
Phase B Current Magnitude	0 A
Phase B Current Angle	0 ° Lag
Phase C Current Magnitude	0 A
Phase C Current Angle	0 ° Lag
Ground Current Magnitude	0 A
Ground Current Angle	0 ° Lag
A-N (A-B) Voltage Magnitude	0.00 kV
A-N (A-B) Voltage Angle	0 ° Lag

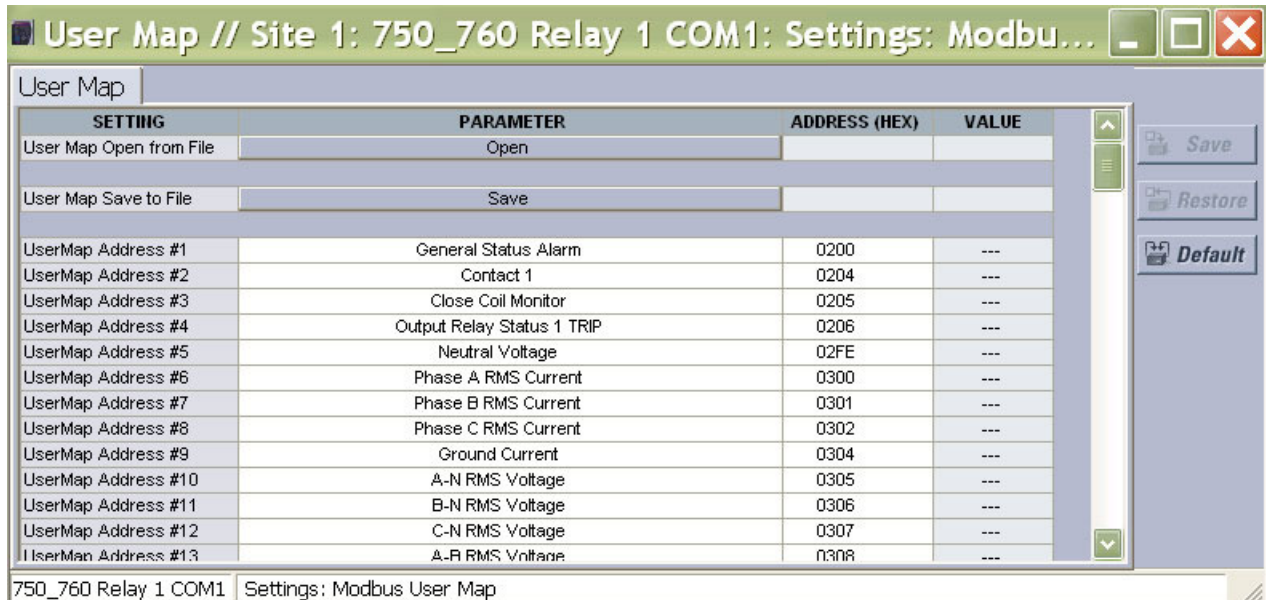
2. To view detailed information for a given event and the system information at the moment of the event occurrence, change the event number on the **Select Event** box.

### 4.8.5 Modbus User Map

The EnerVista 750/760 Setup software provides a means to program the 750/760 User Map (Modbus addresses 0180h to 01F7h). Refer to GE Publication GEK-106473: *750/760 Communications Guide* for additional information on the User Map.

1. Select a connected device in EnerVista 750/760 Setup.

2. Select the **Setpoint > User Map** menu item to open the following window.



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.

#### 4.8.6 Viewing Actual Values

You can view real-time relay data such as input/output status and measured parameters. From the main window menu bar, selecting Actual Values opens a window with tabs, each tab containing data in accordance to the following list:

- **Status:** Virtual Inputs, Hardware Inputs, Last Trip Data, Fault Locations, and Autoreclose (760 Only)
- **Metering:** Current, Voltage, Frequency, Synchrocheck Voltage, Power, Energy, Demand, and Analog Inputs
- **Maintenance:** Trip Counters and Arcing Current
- **Product Information:** Revision Codes and Calibration Dates

Selecting an actual values window also opens the actual values tree from the corresponding device in the site list and highlights the current location in the hierarchy.

For complete details on actual values, refer to Chapter 6.

To view a separate window for each group of actual values, select the desired item from the tree, and double click with the left mouse button. Each group will be opened on a separate tab. The windows can be re-arranged to maximize data viewing as shown in the following figure (showing actual current, voltage, and power values tiled in the same window):

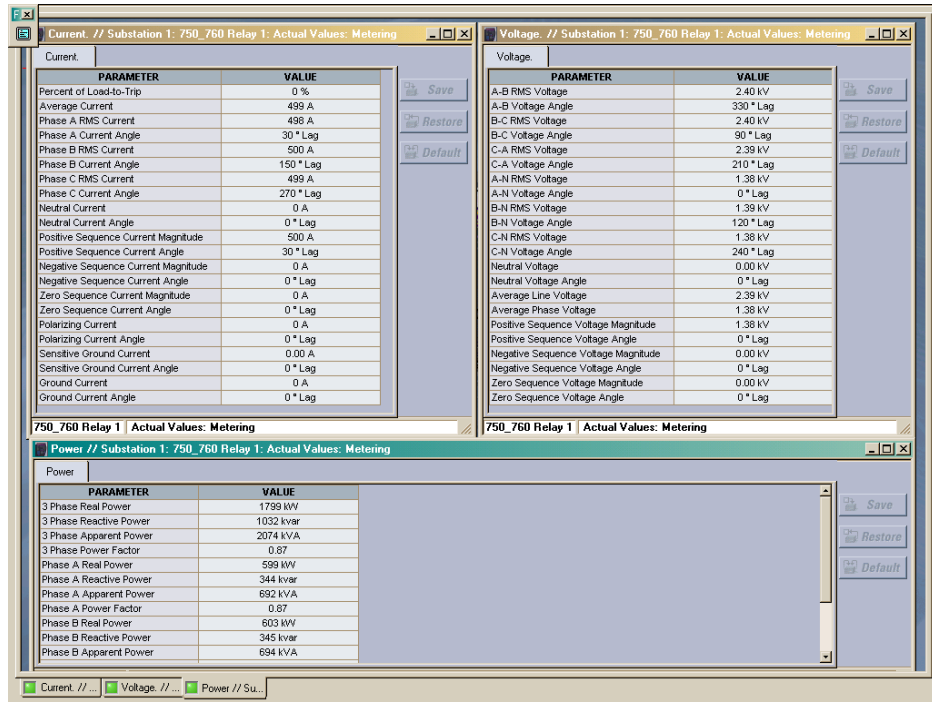


FIGURE 4-8: Actual Values Display

## 4.9 Using EnerVista Viewpoint with the 750/760

### 4.9.1 Plug and Play Example

EnerVista Viewpoint is an optional software package that puts critical 750/760 information onto any PC with plug-and-play simplicity. EnerVista Viewpoint connects instantly to the 750/760 via serial, ethernet or modem and automatically generates detailed overview, metering, power, demand, energy and analysis screens. Installing EnerVista Launchpad (see previous section) allows the user to install a fifteen-day trial version of EnerVista Viewpoint. After the fifteen day trial period you will need to purchase a license to continue using EnerVista Viewpoint. Information on license pricing can be found at <http://www.EnerVista.com>.

1. Install the EnerVista Viewpoint software from the GE EnerVista CD.
2. Ensure that the 750/760 device has been properly configured for either serial or Ethernet communications (see previous sections for details).
3. Click the **Viewpoint** window in EnerVista to log into EnerVista Viewpoint. At this point, you will be required to provide a login and password if you have not already done so.



FIGURE 4-9: EnerVista Viewpoint Main Window

4. Click the **Device Setup** button to open the Device Setup window, then click the **Add Site** button to define a new site.
5. Enter the desired site name in the **Site Name** field. If desired, a short description of site can also be entered along with the display order of devices defined for the site. Click the **OK** button when complete. The new site will appear in the upper-left list in the EnerVista 750/760 Setup window.
6. Click the **Add Device** button to define the new device.
7. Enter the desired name in the **Device Name** field and a description (optional) of the site.
8. Select the appropriate communications interface (Ethernet or Serial) and fill in the required information for the 750/760. See *Connecting EnerVista 750/760 Setup to the Relay* on page 4-17 for details.



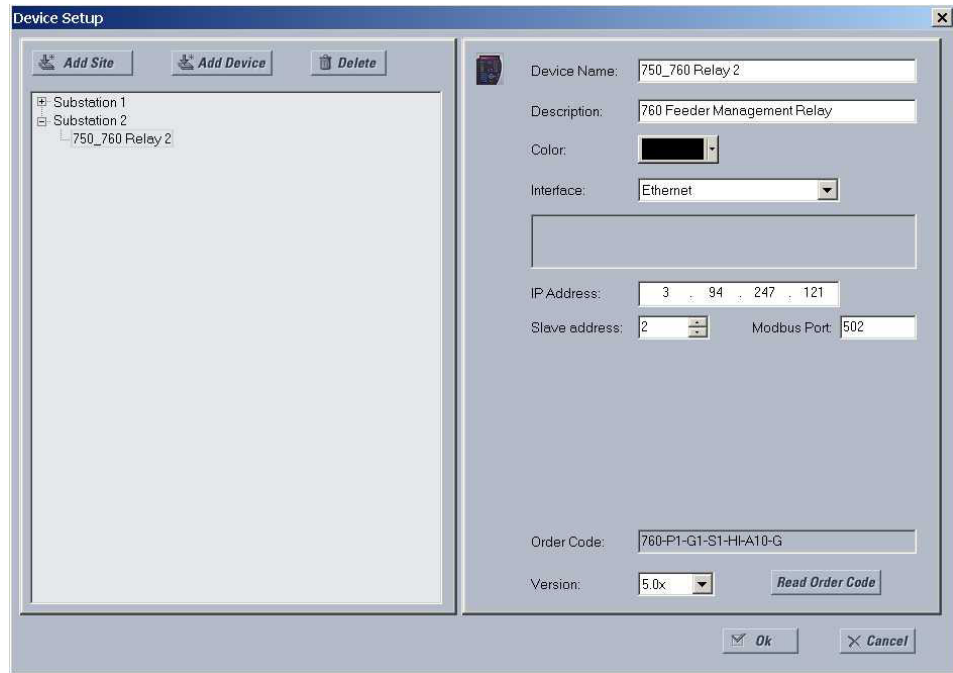


FIGURE 4–10: Device Setup Screen (Example)

9. Click the **Read Order Code** button to connect to the 750/760 device and upload the order code. If an communications error occurs, ensure that communications values entered in the previous step correspond to the relay setting values.
10. Click **OK** when complete.
11. From the EnerVista main window, select the **IED Dashboard** item to open the Plug and Play IED dashboard. An icon for the 750/760 will be shown.

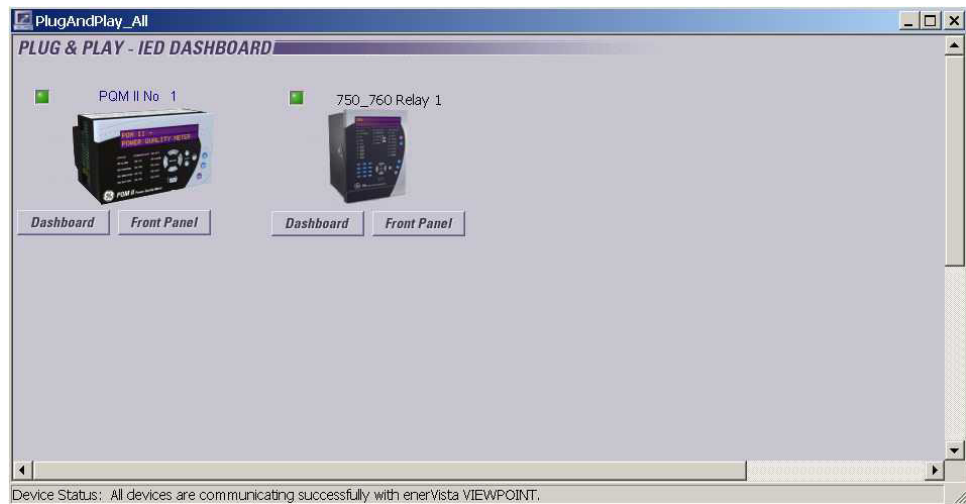


FIGURE 4–11: 'Plug and Play' Dashboard



- Click the **Dashboard** button below the 750/760 icon to view the device information. We have now successfully accessed our 750/760 through EnerVista Viewpoint.

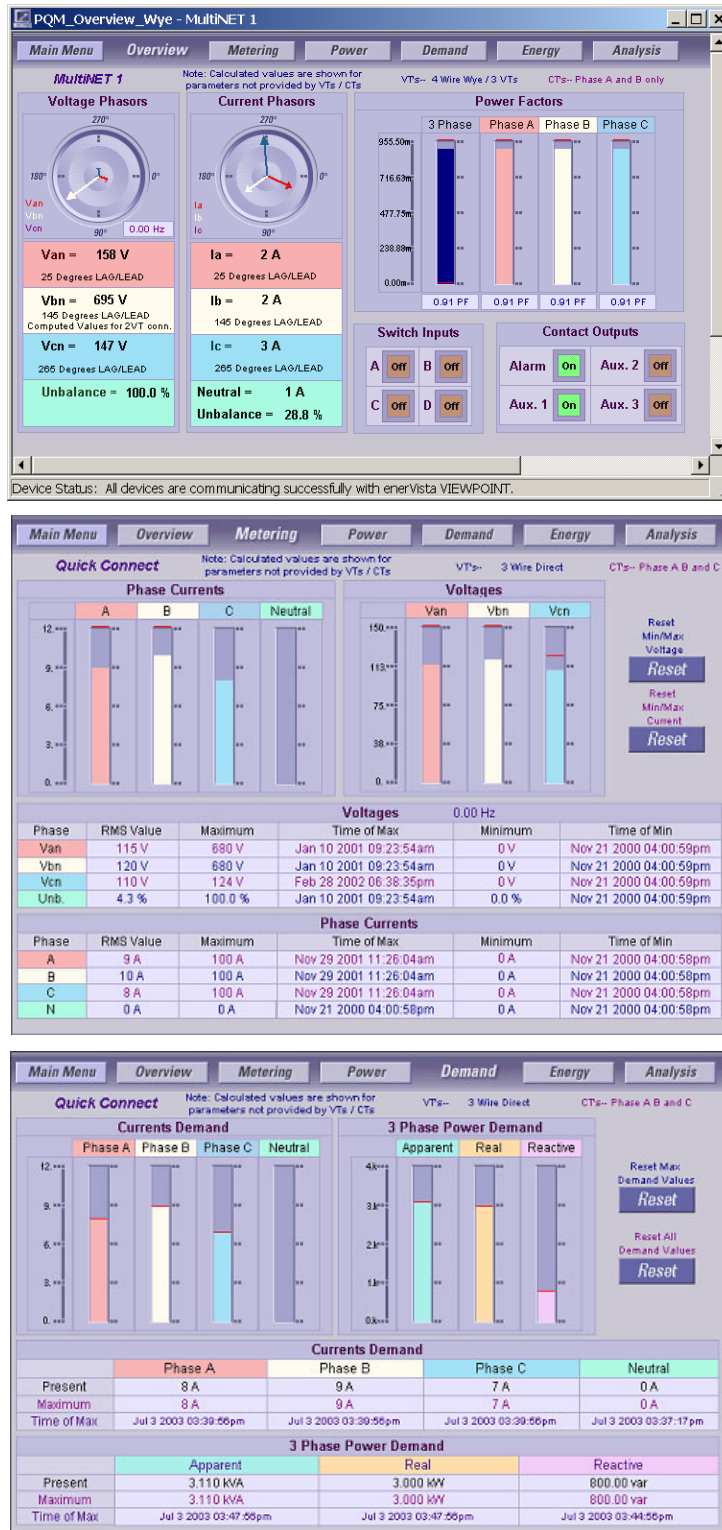


FIGURE 4–12: EnerVista Plug and Play Screens

For additional information on EnerVista viewpoint, please visit the EnerVista website at <http://www.EnerVista.com>.


















# 750/760 Feeder Management Relay






















## Chapter 5: Setpoints






















### 5.1 Overview






















#### 5.1.1 Setpoints Main Menu

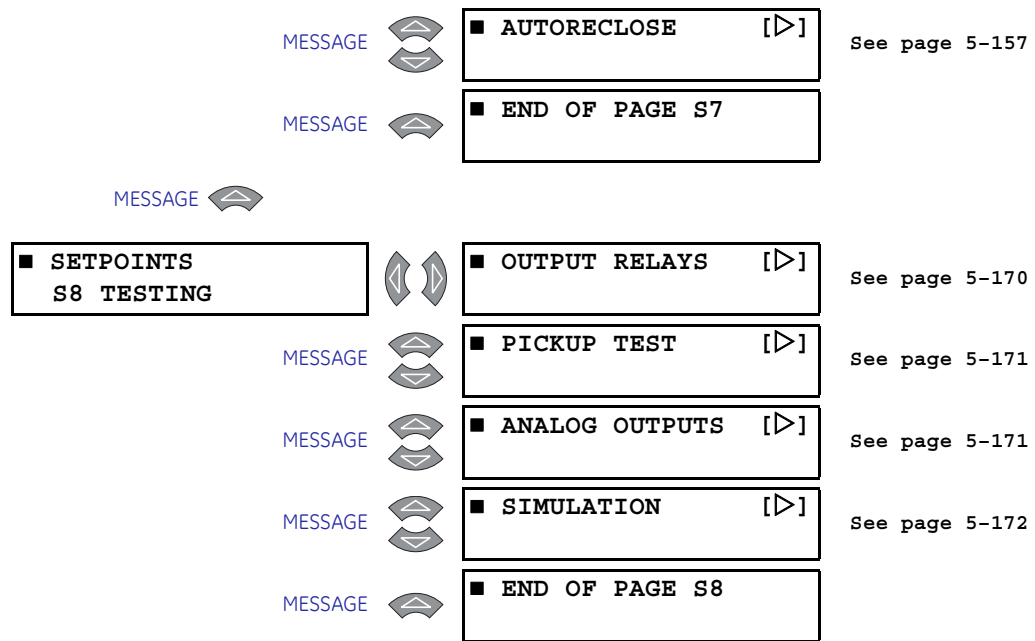
The 750/760 has a considerable number of programmable setpoints which makes it extremely flexible. The setpoints have been grouped into a number of pages and sub-pages as shown below. Each page of setpoints (e.g. **S2 SYSTEM SETUP**) has a section which describes in detail all the setpoints found on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

<p>■ <b>SETPOINTS</b> [▷]</p> <p><b>S1 RELAY SETUP</b></p>	 	<p>■ <b>PASSCODE</b> [▷]</p>	See page 5-9
MESSAGE	 	<p>■ <b>COMMUNICATIONS</b> [▷]</p>	See page 5-9
MESSAGE	 	<p>■ <b>CLOCK</b> [▷]</p>	See page 5-13
MESSAGE	 	<p>■ <b>EVENT RECORDER</b> [▷]</p>	See page 5-14
MESSAGE	 	<p>■ <b>TRACE MEMORY</b> [▷]</p>	See page 5-15
MESSAGE	 	<p>■ <b>DATA LOGGER</b> [▷]</p>	See page 5-16
MESSAGE	 	<p>■ <b>FRONT PANEL</b> [▷]</p>	See page 5-17
MESSAGE	 	<p>■ <b>DEFAULT MESSAGES</b> [▷]</p>	See page 5-18
MESSAGE	 	<p>■ <b>USER TEXT MESSAGES</b> [▷]</p>	See page 5-19

MESSAGE		■ CLEAR DATA [▷]	See page 5-20
MESSAGE		■ INSTALLATION [▷]	See page 5-20
MESSAGE		■ MOD VERSION UPGRADE [▷]	See page 5-21
MESSAGE		■ SERVICE COMMAND [▷]	See page 5-21
MESSAGE		■ END OF PAGE S1	
MESSAGE			
		■ SETPOINTS S2 SYSTEM SETUP [▷]	
		■ CURRENT SENSING [▷]	See page 5-22
MESSAGE		■ BUS VT SENSING [▷]	See page 5-22
MESSAGE		■ LINE VT SENSING [▷]	See page 5-23
MESSAGE		■ POWER SYSTEM [▷]	See page 5-23
MESSAGE		■ FLEXCURVE A [▷]	See page 5-24
MESSAGE		■ FLEXCURVE B [▷]	See page 5-24
MESSAGE		■ END OF PAGE S2	
MESSAGE			
		■ SETPOINTS S3 LOGIC INPUTS [▷]	
		■ LOGIC INPUTS SETUP [▷]	See page 5-27
MESSAGE		■ BREAKER FUNCTIONS [▷]	See page 5-28
MESSAGE		■ CONTROL FUNCTIONS [▷]	See page 5-30
MESSAGE		■ USER INPUTS [▷]	See page 5-31
MESSAGE		■ BLOCK FUNCTIONS [▷]	See page 5-32
MESSAGE		■ BLOCK OC FUNCTIONS [▷]	See page 5-34
MESSAGE		■ TRANSFER FUNCTIONS [▷]	See page 5-35

MESSAGE		■ <b>RECLOSE FUNCTIONS</b> [▷]	See page 5-36
MESSAGE		■ <b>MISC FUNCTIONS</b> [▷]	See page 5-36
MESSAGE		■ <b>END OF PAGE S3</b>	
MESSAGE			
■ <b>SETPOINTS</b> [▷]		■ <b>1 TRIP RELAY</b> [▷]	See page 5-39
MESSAGE		■ <b>2 CLOSE RELAY</b> [▷]	See page 5-40
MESSAGE		■ <b>3 AUXILIARY</b> [▷]	See page 5-41
MESSAGE		■ <b>4 AUXILIARY</b> [▷]	See page 5-41
MESSAGE		■ <b>5 AUXILIARY</b> [▷]	See page 5-41
MESSAGE		■ <b>6 AUXILIARY</b> [▷]	See page 5-41
MESSAGE		■ <b>7 AUXILIARY</b> [▷]	See page 5-41
MESSAGE		■ <b>END OF PAGE S4</b>	
MESSAGE			
■ <b>SETPOINTS S5 PROTECTION</b> [▷]		■ <b>PHASE CURRENT</b> [▷]	See page 5-50
MESSAGE		■ <b>NEUTRAL CURRENT</b> [▷]	See page 5-58
MESSAGE		■ <b>GROUND CURRENT</b> [▷]	See page 5-64
MESSAGE		■ <b>SENSIV GND CURRENT</b> [▷]	See page 5-68
MESSAGE		■ <b>NEGATIVE SEQUENCE</b> [▷]	See page 5-76
MESSAGE		■ <b>VOLTAGE</b> [▷]	See page 5-82
MESSAGE		■ <b>FREQUENCY</b> [▷]	See page 5-87
MESSAGE		■ <b>BREAKER FAILURE</b> [▷]	See page 5-90

	MESSAGE		■ REVERSE POWER [▷]	See page 5-92
	MESSAGE		■ END OF PAGE S5	
	MESSAGE			
■ SETPOINTS S6 MONITORING			■ CURRENT LEVEL [▷]	See page 5-94
	MESSAGE		■ POWER FACTOR [▷]	See page 5-95
	MESSAGE		■ FAULT LOCATOR [▷]	See page 5-97
	MESSAGE		■ DEMAND [▷]	See page 5-99
	MESSAGE		■ ANALOG INPUT [▷]	See page 5-106
	MESSAGE		■ ANALOG OUTPUTS [▷]	See page 5-110
	MESSAGE		■ OVERFREQUENCY [▷]	See page 5-113
	MESSAGE		■ EQUIPMENT [▷]	See page 5-114
	MESSAGE		■ PULSED OUTPUT [▷]	See page 5-121
	MESSAGE		■ END OF PAGE S6	
	MESSAGE			
■ SETPOINTS S7 CONTROL			■ SETPOINT GROUPS [▷]	See page 5-123
	MESSAGE		■ SYNCHROCHECK [▷]	See page 5-127
	MESSAGE		■ MANUAL CLOSE [▷]	See page 5-129
	MESSAGE		■ COLD LOAD PICKUP [▷]	See page 5-131
	MESSAGE		■ UNDERVOLTAGE RESTORATION [▷]	See page 5-133
	MESSAGE		■ UNDERFREQUENCY RESTORATION [▷]	See page 5-134
	MESSAGE		■ TRANSFER [▷]	See page 5-136



### 5.1.2 Setpoint Entry Methods

Prior to placing the relay in operation, setpoints defining system characteristics, inputs, relay outputs, and protection settings must be entered, via one of the following methods:

- Front panel, using the keys and display.
- Front program port, and a portable computer running the EnerVista 750/760 Setup software supplied with the relay.
- 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, the GE EnerVista CD with the EnerVista 750/760 Setup software 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.

#### **⚠ WARNING**

At a minimum, the **S2 SYSTEM SETUP** setpoints must be entered for the system to function correctly. To safeguard against the installation of a relay whose setpoints have not been entered, the relay **Relay Not Ready** self-test warning is displayed. In addition, the Self-Test Warning relay will be de-energized. Once the relay has been programmed for the intended application, the **S1 RELAY SETUP ▷ ▽ INSTALLATION ▷ 760 OPERATION** setpoint should be changed from “Not Ready” (the default) to “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.

### 5.1.3 Setpoint Access Security

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

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.

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 eight (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 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 can disable setpoint access once all modifications are complete. For the communications ports, access is 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 for thirty minutes.

The EnerVista 750/760 Setup software 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.

### 5.1.4 Common Setpoints

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.

- **FUNCTION setpoint:** The **<ELEMENT\_NAME> FUNCTION** setpoint determines the operational characteristics of each feature. The range for these setpoints is two or more of: "Disabled", "Enabled", "Trip", "Trip & AR", "Alarm", "Latched Alarm", and "Control".

If **<ELEMENT\_NAME> FUNCTION:** "Disabled", then the feature is not operational. If **<ELEMENT\_NAME> FUNCTION:** "Enabled", then the feature is operational.



If **<ELEMENT\_NAME> FUNCTION: "Trip"**, then the feature is operational. When an output is generated the feature declares a Trip condition, which operates the 1 Trip relay and any other selected output relays, and displays the appropriate trip message. If **<ELEMENT\_NAME> FUNCTION: "Trip & AR"** (overcurrent features of 760 only), then the feature is operational. When an output is generated, the feature declares a Trip condition which operates the 1 Trip relay and any other selected output relays, signals an Initiate to the autoreclose feature, and displays the appropriate trip message.

If **<ELEMENT\_NAME> FUNCTION: "Alarm"** or **"Latched Alarm"**, then the feature is operational. When an output is generated, the feature declares an "Alarm" condition which operates any selected output relays and displays the appropriate alarm message.

If **<ELEMENT\_NAME> FUNCTION: "Control"** the feature is operational. When an output is generated, the feature operates any selected output relays.

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

- **RELAYS (3–7) setpoint:** The **<ELEMENT\_NAME> RELAYS (3-7)** setpoint selects the relays required to operate when the feature generates an output. The range is any combination of the 3 to 7 Auxiliary relays.
- **PICKUP setpoint:** The **<ELEMENT\_NAME> PICKUP** setpoint selects the threshold above (for over elements) or below (for under elements) which the measured parameter causes an output from the measuring element.
- **DELAY setpoint:** The **<ELEMENT\_NAME> DELAY** setpoint selects a fixed time interval to delay an input signal 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.

- **DIRECTION setpoint:** The **<ELEMENT\_NAME> DIRECTION** setpoint is available for overcurrent features which are subject to control from a directional element. The range is "Disabled", "Forward", and "Reverse".

If set to "Disabled", the element is allowed to operate for current flow in any direction. There is no supervision from the directional element. If set to "Forward", the element is allowed to operate for current flow in the forward direction only, as determined by the directional element. If set to "Reverse", the element is allowed to operate for current flow in the reverse direction only, as determined by the directional element.

- **PHASES REQUIRED FOR ANY OPERATION setpoint:** This setpoint is available for those features which measure each phase parameter individually.

If set to "Any One", then an output is generated if any one or more phase parameters are beyond the pickup value. If set to "Any Two", then an output is generated if any combination of two or more phase parameters are beyond the pickup value. If set to "All Three", then an output is generated if all three phase parameters are beyond the pickup value.

### 5.1.5 Logic Diagrams





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.

- **Setpoints:** Shown as a block with a 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.
- **Measurement Units:** Shown as a block with an inset box labeled 'RUN' with the associated pickup/dropout setpoint 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 the following symbols: "<" (less than), ">" (greater than), etc. The ANSI device number (if one exists) is indicated above the block.
- **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.
- **LED Indicators:** Shown as the following schematic symbol, ⊗. The exact wording of the front panel label identifies the indicator.
- **Logic:** Described with basic logic gates (AND, OR, XOR, NAND, NOR). The inverter (logical NOT), is shown as a circle: ○.
- **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.

## 5.2 S1 Relay Setup

### 5.2.1 Passcode

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ PASSCODE

■ <b>PASSCODE</b> [▷]		<b>SETPOINT ACCESS:</b> Allowed	Range: Allowed, Restricted
MESSAGE		<b>RESTRICT ACCESS TO SETPOINTS:</b> No	Range: Yes, No.
MESSAGE		<b>ALLOW ACCESS TO SETPOINTS:</b> No	Range: Yes, No.
MESSAGE		<b>CHANGE PASSCODE?</b> No	Range: Yes, No.

If the passcode security feature is enabled, the setpoint access jumper must be installed on the rear terminals and a passcode must also be entered to program setpoints. 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.




The **RESTRICT ACCESS TO SETPOINTS** setpoint is seen only if the passcode is not “0” and **SETPOINT ACCESS** is “Allowed”

The **ALLOW ACCESS TO SETPOINTS** setpoint is only displayed when **SETPOINT ACCESS** is “Restricted”. In this state, new setpoints cannot be entered. To regain setpoint access, select “Yes” and follow directions to enter the previously programmed passcode. If the passcode is correctly entered, entering new setpoints will be allowed. If no keys are pressed for longer than 30 minutes, setpoint access automatically becomes restricted. Removing the setpoint access jumper immediately restricts setpoint access. If passcode protection is active but the passcode is not known, contact GE Multilin.

### 5.2.2 Communications

#### Main Menu

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ ▾ COMMUNICATIONS

■ <b>COMMUNICATIONS</b> [▷]		■ <b>PORT SETUP</b> [▷]	See page 5-10
MESSAGE		■ <b>DNP CONFIGURATION</b> [▷]	See page 5-11
MESSAGE		■ <b>NETWORK CONFIGURATION</b> [▷]	See page 5-12

The 750/760 relay has setpoints to enable communications through its RS232, RS485/422, and Ethernet ports. Setpoints are also provided for configuring DNP communications through one of these ports. The **NETWORK CONFIGURATION** menu is seen only if the Ethernet option is ordered.

RS485 COM2 is disabled when the Ethernet option is ordered.

### Port Setup

PATH: SETPOINTS > S1 RELAY SETUP > COMMUNICATIONS > PORT SETUP

<b>PORT SETUP</b> [▶]		<b>SLAVE ADDRESS:</b> 1	Range: 1 to 254 in steps of 1
MESSAGE		<b>COM1 RS485/422</b> <b>BAUD RATE: 9600</b>	Range: 300, 1200, 2400, 4800, 9600, 19200
MESSAGE		<b>COM1 RS485/422</b> <b>PARITY: None</b>	Range: None, Odd, Even
MESSAGE		<b>COM1 RS485/422</b> <b>HARDWARE: RS485</b>	Range: RS485, RS422
MESSAGE		<b>COM2 RS485</b> <b>BAUD RATE: 9600</b>	Range: 300, 1200, 2400, 4800, 9600, 19200. Not shown for units with Ethernet option.
MESSAGE		<b>COM2 RS485</b> <b>PARITY: None</b>	Range: None, Odd, Even. Not shown for units with Ethernet option.
MESSAGE		<b>FRONT RS232</b> <b>BAUD RATE: 9600</b>	Range: 300, 1200, 2400, 4800, 9600, 19200
MESSAGE		<b>FRONT RS232</b> <b>PARITY: None</b>	Range: None, Odd, Even



For additional details on the implementation of the Modbus protocol in the 750/760 relay, and for complete memory map information, refer to GE Publication *GEK-106473: 750/760 Communications Guide*.










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.

- **SLAVE ADDRESS:** This setpoint selects the serial communications slave address of the relay. Both COM1 and COM2 use this same address. The front panel RS232 port accepts 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 and COM2 RS485 BAUD RATE:** Selects the baud rate for the COM1/2 communication ports. All relays on the communication link, and the computer connecting them, must run at the same baud rate. The fastest response is 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 and COM2 PARITY:** Selects the parity for COM1 and COM2 communications ports.
- **COM1 RS485/422 HARDWARE:** Selects the COM1 hardware configuration to be either two-wire RS485 or four-wire RS422 communications.
- **FRONT PANEL RS232 BAUD RATE and PARITY:** These setpoints select the baud rate and parity for front panel RS232 serial communications port. When upgrading the relay firmware, the baud rate should be set to 9600.

## DNP Configuration

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ ▾ COMMUNICATIONS ▷ ▾ DNP CONFIGURATION

■ DNP CONFIGURATION [▷]		<b>DNP PORT:</b> None	Range: None, COM1, COM2, Front
MESSAGE		<b>DNP POINT MAPPING:</b> Disabled	Range: Disabled, Enabled
MESSAGE		<b>TRANS DELAY:</b> 0 ms	Range: 0 to 65000 ms in steps of 1
MESSAGE		<b>DATA LINK CONFIRM MODE:</b> Never	Range: Never, Sometimes, Always
MESSAGE		<b>DATA LINK CONFIRM TIMEOUT:</b> 1000 ms	Range: 0 to 65000 ms in steps of 1
MESSAGE		<b>DATA LINK CONFIRM RETRIES:</b> 3	Range: 0 to 100 in steps of 1
MESSAGE		<b>SELECT/OPERATE ARM TIMEOUT:</b> 10000 ms	Range: 1 to 65000 ms in steps of 1
MESSAGE		<b>WRITE TIME INTERVAL:</b> 0 min	Range: 0 to 65000 min. in steps of 1
MESSAGE		<b>COLD RESTART INHIBIT:</b> Disabled	Range: Disabled, Enabled

The relay can be programmed to communicate using the DNP Protocol through one of its ports. Refer to GE publication *GEK-106473: 750/760 Communications Guide* for additional details. The following setpoints are used to configure the DNP Protocol.

- **DNP PORT:** Select which communications port will use the DNP protocol for communication. The 750/760 defaults to the Modbus protocol on all ports.
- **DNP POINT MAPPING:** 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. Refer to GE publication *GEK-106473* for details.
- **TRANS DELAY:** 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:** Select the data link confirmation mode 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:** Select a desired timeout. If no confirmation response is received within this time, the 750/760 re-sends the frame if retries are still available.
- **DATA LINK CONFIRM RETRIES:** Select the number of retries that will be issued for a given data link frame.
- **SELECT/OPERATE ARM TIMEOUT:** Select the duration of the select / operate arm timer.
- **WRITE TIME INTERVAL:** 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:** 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 **COLD START INHIBIT** is “Disabled”, a cold restart request causes loss of protection until the 750/760 reset completes.

### Network Configuration

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ COMMUNICATIONS ▷ NETWORK CONFIGURATION

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>NETWORK CONFIGURATION</b> [▷]             </div>		<b>IP ADDRESS :</b> 000.000.000.000	<i>Range: standard IP address format</i>
	MESSAGE	<b>SUBNET IP MASK :</b> 255.255.255.000	<i>Range: standard IP address format</i>
	MESSAGE	<b>GATEWAY IP ADDRESS :</b> 000.000.000.000	<i>Range: standard IP address format</i>

These messages appear only if the 750/760 is ordered with the Ethernet option. The IP addresses are used with the Modbus protocol. Enter the dedicated IP, subnet IP, and gateway IP addresses provided by your network administrator.

### TCP/IP Connection Management

750/760 supports a **maximum of four TCP/IP connections**. When four or fewer connections are maintained, 750 will never initiate a close.

In case there are four connections and 750/760 receives a fifth connection request over TCP/IP, then the relay will close the oldest unused connection. The new connection request is accepted and Modbus communication proceeds.




To ensure optimal response from the relay, the typical connection timeout should be set as indicated in the following table:

TCP/IP sessions	Timeout setting
up to 2	2 seconds
up to 4	3 seconds

## 5.2.3 Clock

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ ▾ CLOCK

■ <b>CLOCK</b> [▷]		<b>DATE (MM/DD/YYYY) :</b> 10/23/2003	<i>Range: 1 to 12 / 1 to 31 / 2000 to 2089</i>
		<b>TIME (HH:MM:SS) :</b> 16:30:00	<i>Range: 0 to 23 : 0 to 59 : 0 to 59</i>
		<b>IRIG-B SIGNAL TYPE:</b> None	<i>Range: None, DC Shift, Amplitude</i>









The relay has an internal real time clock that performs 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  $\pm 5$  ms with the use of an IRIG-B input. The clock has a supercap 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.

Enter the current date and time here. The new date and time take effect the instant the ENTER key is pressed.

The **IRIG-B SIGNAL TYPE** setpoint enables the IRIG-B time synchronization and selects the type of IRIG-B signal to use. The IRIG-B signal contains all necessary time and date stamping data except for the year. The year must be entered with the date. 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. If IRIG-B is enabled but the signal cannot be decoded, the **IRIG-B Failure** self-test warning is generated. See *IRIG-B* on page 3–21 for additional details on IRIG-B.

### 5.2.4 Event Recorder

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ ▾ EVENT RECORDER

<div style="border: 1px solid black; padding: 2px;"> <span style="font-size: 1.2em;">■</span> <b>EVENT RECORDER</b> <span style="float: right;">[▷]</span> </div>			<b>EVENT RECORDER</b> <b>FUNCTION: Enabled</b>	<i>Range: Enabled, Disabled</i>
MESSAGE		<b>RECORD PICKUP</b> <b>EVENTS: Enabled</b>	<i>Range: Enabled, Disabled</i>	
MESSAGE		<b>RECORD DROPOUT</b> <b>EVENTS: Enabled</b>	<i>Range: Enabled, Disabled</i>	
MESSAGE		<b>RECORD TRIP</b> <b>EVENTS: Enabled</b>	<i>Range: Enabled, Disabled</i>	
MESSAGE		<b>RECORD ALARM</b> <b>EVENTS: Enabled</b>	<i>Range: Enabled, Disabled</i>	
MESSAGE		<b>RECORD CONTROL</b> <b>EVENTS: Enabled</b>	<i>Range: Enabled, Disabled</i>	
MESSAGE		<b>RECORD LOGIC INPUT</b> <b>EVENTS: Enabled</b>	<i>Range: Enabled, Disabled</i>	
MESSAGE		<b>RECORD DATE/TIME</b> <b>EVENTS: Enabled</b>	<i>Range: Enabled, Disabled</i>	

The relay captures a wide variety of events and stores the last 512 in non-volatile memory. See *Event Records* on page 6–20 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.

**⚠ WARNING**

The setpoint "Record Date/Time Events" should be set to "Enabled" to record date/time synchronization only when such events occur **no more than once per hour**. A date/time event recording rate greater than once per hour will cause flooding of the Event Record and will, in turn, wear out the EEPROM. This will eventually generate the self-test warning "Self-test warning: EEPROM corrupted," resulting in the EEPROM having to be replaced. Ideally the date/time should be recorded no more than twice a day.



## 5.2.5 Trace Memory

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ ▾ TRACE MEMORY

■ TRACE MEMORY [▷]		<b>BUFFER ORGANIZATION:</b> 16 x 512	Range: 2 x 4096, 4 x 2048, 8 x 1024, 6 x 512
MESSAGE		<b>TRIGGER POSITION:</b> 25%	Range: 0 to 100% in steps of 1
MESSAGE		<b>TRIGGER ON PICKUP:</b> Enabled	Range: Enabled, Disabled
MESSAGE		<b>TRIGGER ON DROPOUT:</b> Disabled	Range: Enabled, Disabled
MESSAGE		<b>TRIGGER ON TRIP:</b> Enabled	Range: Enabled, Disabled
MESSAGE		<b>TRIGGER ON ALARM:</b> Enabled	Range: Enabled, Disabled
MESSAGE		<b>TRIGGER ON CONTROL:</b> Enabled	Range: Enabled, Disabled

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 (Ia, Ib, Ic, Ig, Isg, Va, Vb, Vc, Vs) as well as digital data for the output relays and input contact states. The trace memory data can be downloaded to the EnerVista 750/760 Setup software 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.

- **BUFFER ORGANIZATION:** 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 2048 indicates that the last three events with 2048 data samples per channel (128 cycles) can be stored in memory. Note that one buffer must be reserved for capturing the next event.

- **TRIGGER POSITION:** Selects the amount of data captured before the trigger point. For example, if the **TRIGGER POSITION** is set to "25%" and the **BUFFER ORGANIZATION** is set to "2 x 4096", then there will be 1024 samples (64 cycles) captured before the trigger point.















NOTE

Changing any setpoint affecting trace memory operation clears any data that is currently in the log.

The **TRIGGER ON <EVENT\_TYPE>** setpoints select specific event types to trigger new waveform captures.

### 5.2.6 Data Logger

PATH: SETPOINTS > S1 RELAY SETUP > DATA LOGGER

<div style="border: 1px solid black; padding: 2px; display: inline-block;"> <span style="font-weight: bold;">■ DATA LOGGER</span> <span style="float: right;">[&gt;]</span> </div>			<div style="border: 1px solid black; padding: 2px;"> <b>SAMPLE RATE:</b>                  1 cycle             </div>	<i>Range: 1 cycle; 1 second; 1, 5, 10, 15, 20, 30, 60</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>CONTINUOUS MODE:</b>                  Disabled             </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>BUFFER ORGANIZATION:</b>                  16 x 256             </div>	<i>Range: 2 x 2048, 4 x 1024, 8 x 512, 16 x 256.</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>TRIGGER POSITION:</b>                  25%             </div>	<i>Range: 0 to 100% in steps of 1</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>TRIGGER ON PICKUP:</b>                  Enabled             </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>TRIGGER ON DROPOUT:</b>                  Enabled             </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>TRIGGER ON TRIP:</b>                  Enabled             </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>TRIGGER ON ALARM:</b>                  Enabled             </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>TRIGGER ON CONTROL:</b>                  Enabled             </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>CHNL 1 SOURCE:</b>                  Phase A Current             </div>	<i>Range: Refer to the Analog Output Parameters</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>CHNL 2 SOURCE:</b>                  Phase B Current             </div>	<i>Range: Refer to the Analog Output Parameters</i>
		↓		
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>CHNL 8 SOURCE:</b>                  Frequency             </div>	<i>Range: Refer to the Analog Output Parameters</i>



The **BUFFER ORGANIZATION**, **TRIGGER POSITION**, and **TRIGGER ON <EVENT\_TYPE>** setpoints are seen only if **CONTINUOUS MODE** is "Disabled".

The data logger samples and records up to eight (8) actual values at user-defined intervals. This recorded data may be downloaded to the EnerVista 750/760 Setup software 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. Changing any setpoint affecting data logger operation clears any data that is currently in the log.

The **SAMPLE RATE** setpoint selects the time interval to record the actual value data. 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. × 4096 = 61440 min. = 42 days.

There are two basic modes of operation defined by the **CONTINUOUS MODE** setpoint:

- Continuous Mode: Enabled by setting **CONTINUOUS MODE** to “Enabled”. 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: Enabled by setting **CONTINUOUS MODE** to “Disabled”. The programmed actual value(s) for up to the last 15 events are recorded, each in a separate buffer. The amount of pre-trigger data to record 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.

The **BUFFER ORGANIZATION** and **TRIGGER POSITION** setpoints are only applicable in trigger mode. The **BUFFER ORGANIZATION** selects the number triggers stored and the 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. The **TRIGGER POSITION** setpoint selects the amount of each buffer to be allocated for pre-trigger data. If set to “0%”, data collection effectively starts once the trigger occurs. If set to 100%, only pre-trigger data will be recorded in the buffer.



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.

The **TRIGGER ON <EVENT\_TYPE>** setpoints select specific event types to trigger new waveform captures and are applicable only when the data logger is operating in trigger mode. The **CHNL 1 SOURCE** to **CHNL 8 SOURCE** setpoints can be assigned any value assignable as an Analog Output parameter. See *Analog Output Parameters* on page 5-111 for a list of values.



If all Channel Sources (1 through 8) are set to “Disabled”, then the data logger will not collect data in continuous mode or respond to triggers in trigger mode.

### 5.2.7 Front Panel

PATH: SETPOINTS ▸ S1 RELAY SETUP ▾ ▽ FRONT PANEL

<b>FRONT PANEL</b> [▷]		<b>FLASH MSG TIME:</b> 4.0 s	Range: 0.5 to 10.0 s in steps of 0.1
MESSAGE		<b>DEFAULT MSG TIME:</b> 300 s	Range: 10 to 900 s in steps of 1
MESSAGE		<b>DISPLAY FILTER CONSTANT:</b> 0	Range: 0 to 255 in steps of 1
MESSAGE		<b>3 KEY MAX/LAST DMND CLEARING:</b> Disabled	Range: Enabled, Disabled

These setpoints modify front panel characteristics to suit different situations.

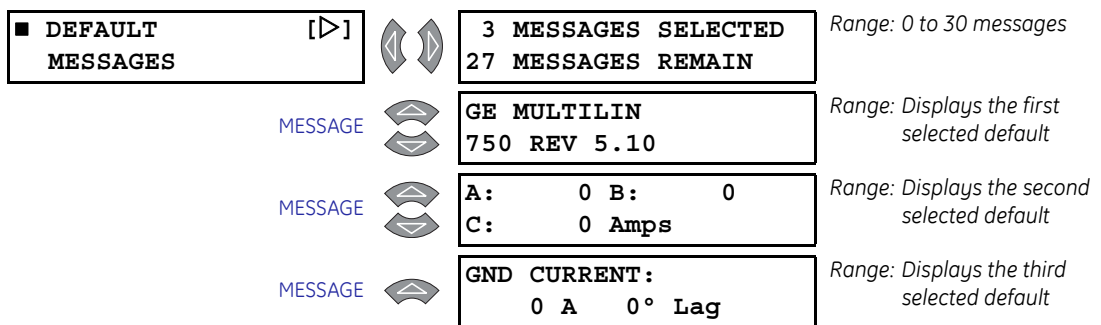


Firmware versions 3.70 and higher do not support a keypad beeper as did previous firmware versions. The EnerVista 750/760 Setup software does not support keypad beeper operation.

- FLASH MSG TIME:** 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 MSG TIME:** 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.
- DISPLAY FILTER CONSTANT:** 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/LAST DMND CLEARING:** For increased ease of maximum demand clearing, this setpoint enables the «MENU, decimal, MESSAGE ◀» key sequence to force the maximum 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 maximum demand values.

### 5.2.8 Default Messages

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ ▾ DEFAULT MESSAGES



Under normal conditions, if no front panel keys have been within the time specified by the **S1 RELAY SETUP ▷ ▾ FRONT PANEL ▷ ▾ DEFAULT MSG TIME** setpoint, the screen begins to sequentially display up to 30 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 value. 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.

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

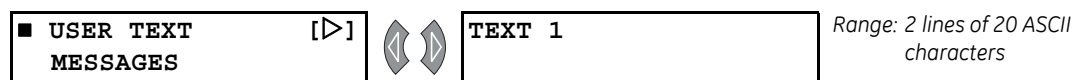
1. Allow access to setpoints by installing the setpoint access jumper and entering the correct passcode.
2. Select the setpoint or actual value message to display as a default message.
3. Press the decimal key followed by the ENTER key while the message is displayed. The screen will display **PRESS [ENTER] 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.

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 to remove from the **S1 RELAY SETUP ▷ ▾ DEFAULT MESSAGES** default message list.
3. Press the decimal 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.

## 5.2.9 User Text Messages

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ ▾ USER TEXT MESSAGES



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.




To add user text messages, first allow access to setpoints by installing the setpoint access jumper and entering the correct passcode, then use the following procedure:

1. Select the user text message from the **S1 RELAY SETUP ▷ ▾ USER TEXT MESSAGES** setpoints subgroup.
2. Press the ENTER key. A solid cursor will appear over the first character position.
3. Use the VALUE keys to change the character. A space is selected like a character.
4. Press the ENTER key to store the character and advance the cursor. Press ENTER to skip a character.

5. 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.
6. Press either of the MESSAGE keys when editing is complete. To select this message as a default message, follow the instructions in the section on adding default messages.

### 5.2.10 Clear Data

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ CLEAR DATA






<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>CLEAR DATA</b> [▷]         </div>		<b>CLEAR ENERGY USE DATA? No</b>	Range: Yes, No
		<b>CLEAR MAX DEMAND DATA? No</b>	Range: Yes, No
		<b>CLEAR EVENT RECORDER DATA: No</b>	Range: Yes, No

These setpoints clear specific memory functions after the data has been read by an operator. The **CLEAR ENERGY USE DATA** setpoint clears all accumulated power consumption data and updates the **A2 METERING ▷ ENERGY ▷ ENERGY USE DATA LAST RESET** date. The **CLEAR MAX DEMAND DATA** setpoint clears all maximum demand data values and updates the **A2 METERING ▷ DEMAND ▷ DMND DATA LAST RESET** date.

The event recorder saves the most recent 512 events, automatically overwriting the oldest event. The **CLEAR EVENT RECORDER** setpoint clears all recorded event data and updates **A4 EVENT RECORDER ▷ LAST RESET DATE ▷ EVENT RECORDER LAST RESET**.

### 5.2.11 Installation

PATH: SETPOINTS ▷ S1 RELAY SETUP ▷ INSTALLATION

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>INSTALLATION</b> [▷]         </div>		<b>760 OPERATION: Not Ready</b>	Range: Ready, Not Ready. Reads as 750
		<b>RESET TRIP COUNTER DATA? No</b>	Range: Yes, No
		<b>RESET ARCING CURRENT DATA? No</b>	Range: Yes, No
		<b>RESET AR COUNT DATA? No</b>	Range: Yes, No. Message is only seen in 760
		<b>RESET AR RATE DATA? No</b>	Range: Yes, No. Message is only seen in 760



The **Relay Not Ready** self-test warning message will be displayed until **S1 RELAY SETUP** **INSTALLATION** **760 OPERATION** is set to “Ready”. This warns against the installation of a relay whose setpoints have not been entered for the required application. This setpoint is defaulted to “Not Ready” when the relay leaves the factory.

These setpoints should be used on a new installation or after new equipment has been installed.

The **RESET TRIP COUNTER DATA** setpoint clears all accumulated trip counter values and updates the **A3 MAINTENANCE** **TRIP COUNTERS** **TRIP COUNTERS LAST RESET** actual value. The **RESET ARCING CURRENT** setpoint clears all arcing current data and updates the **A3 MAINTENANCE** **ARCING CURRENT** **ARCING CURRENT LAST RESET** date.

The **RESET AR COUNT DATA** setpoint clears the autoreclose shot count value and updates the **A1 STATUS** **AR** **AR SHOT COUNT LAST RESET** date. The **RESET AR RATE DATA** setpoint clears the autoreclose shot rate value and updates the **ARCING CURRENT LAST RESET** date. These two setpoints are applicable to the 760 only.

### 5.2.12 Mod Version Upgrade

PATH: SETPOINTS **S1 RELAY SETUP** **MOD VERSION UPGRADE**

<b>MOD VERSION UPGRADE</b> [▷]		<b>ENABLE MOD VERSION:</b> 000	<i>Range: 000, 005, 008, 010</i>
		<b>ENTER PASSCODE:</b> 0000000000000000	<i>Range: 16 alphanumeric characters</i>
		<b>UPGRADE OPTIONS?</b> No	<i>Range: Yes, No.</i>

If the Mod 008 (Reverse Power) option has been ordered with the 750/760 relay then the setpoints in *Reverse Power* on page 8–1 are shown. To order this option, please contact GE Multilin with the serial number of the relay. Refer to *Reverse Power* on page 8–1 for the complete procedure for installing and verifying the Reverse Power element.

The Reverse Power setpoints are shown only if the Mod 008 feature has been enabled.

### 5.2.13 Service Command

PATH: SETPOINTS **S1 RELAY SETUP** **SERVICE COMMAND**

<b>SERVICE COMMAND</b> ▷]		<b>ENTER COMMAND CODE:</b>	<i>Range: 0 to 99999999</i>
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Service commands are not used under normal operation.

The GE Customer Support team may provide a command code in order to resolve a support request.

## 5.3 S2 System Setup

### 5.3.1 Current Sensing

PATH: SETPOINTS ▾ ▾ S2 SYSTEM SETUP ▾ CURRENT SENSING

<b>■ CURRENT SENSING</b> [▶]		<b>PHASE CT PRIMARY:</b> 1000 A	Range: 1 to 50000 A in steps of 1
	MESSAGE 	<b>GND CT PRIMARY:</b> 50 A	Range: 1 to 50000 A in steps of 1
	MESSAGE 	<b>SENSITV GND CT PRIMARY:</b> 1000 A	Range: 1 to 50000 A in steps of 1




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 A or 5 A.

As the phase CTs are connected in wye (star), the calculated phasor sum of the three phase currents ( $I_a + I_b + I_c = \text{Neutral Current} = 3I_0$ ) 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 *Electrical Installation* on page 3–10 for details.

The setpoint entries are the same for Ground and Phase CTs with 1 A and 5 A secondaries. 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).

### 5.3.2 Bus VT Sensing

PATH: SETPOINTS ▾ ▾ S2 SYSTEM SETUP ▾ ▾ BUS VT SENSING

<b>■ BUS VT SENSING</b> [▶]		<b>VT CONNECTION TYPE:</b> Wye	Range: None, Wye, Delta
	MESSAGE 	<b>NOMINAL VT SECONDARY VOLTAGE:</b> 120.0 V	Range: 50.0 to 240.0 V in steps of 0.1
	MESSAGE 	<b>VT RATIO:</b> 120.0:1	Range: 1.0 to 5000.0 in steps of 0.1

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




- **VT CONNECTION TYPE:** Enter “None” if Bus VTs are not used. If Bus VTs are used, enter the VT connection made to the system as “Wye” or “Delta”. An open-delta connection is entered as “Delta”. See FIGURE 3–8: *Typical Wiring Diagram* on page 3–10 for details on Delta and Wye wiring.



- **NOMINAL VT SECONDARY VOLTAGE:** This setpoint represents 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 V VT in the Delta connection, the voltage to be entered is “115 V”. For the Wye connection, the voltage to be entered is  $115 / \sqrt{3} = 66.4$  V.
- **VT RATIO:** Enter the VT primary to secondary turns ratio with this setpoint. For a 14400:120 VT, the entry would be “120:1” (since  $14400 / 120 = 120.0$ ).

### 5.3.3 Line VT Sensing

PATH: SETPOINTS ▾ ▾ S2 SYSTEM SETUP ▾ ▾ LINE VT SENSING




■ <b>LINE VT SENSING</b> [▶] MESSAGE MESSAGE		<b>VT CONNECTION TYPE:</b> Vbn	Range: Van, Vbn, Vcn, Vab, Vcb
		<b>NOMINAL VT SECONDARY VOLTAGE:</b> 120.0 V	Range: 50.0 to 240.0 V in steps of 0.1
		<b>VT RATIO:</b> 120.0:1	Range: 1.0 to 5000.0 in steps of 0.1

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.

- **VT CONNECTION:** 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 3–13: *Line VT Connections* on page 3–14 for the system connection to match this setpoint.
- **NOMINAL VT SECONDARY VOLTAGE:** This setpoint represents 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 V VT in the Delta connection, the voltage to be entered is 115 V. For the Wye connection, the voltage to be entered is  $115 / \sqrt{3} = 66.4$  V.
- **VT RATIO:** Enter the VT primary to secondary turns ratio with this setpoint. For a 14400:120 VT, the entry would be “120:1” (since  $14400 / 120 = 120.0$ ).

### 5.3.4 Power System

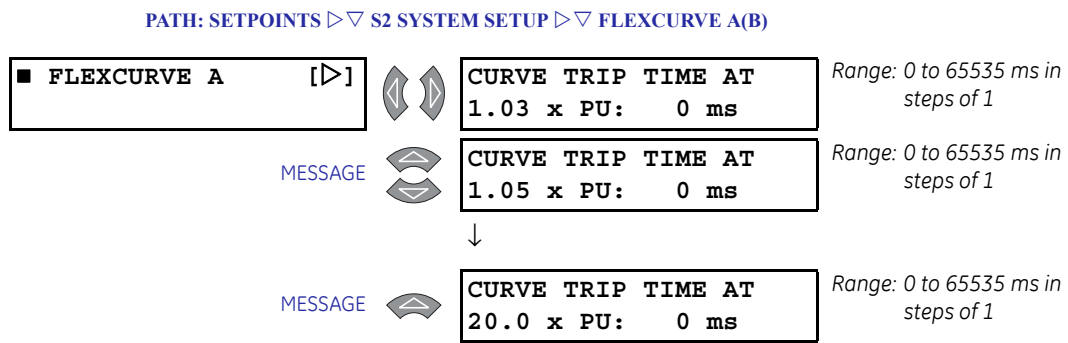
PATH: SETPOINTS ▾ ▾ S2 SYSTEM SETUP ▾ ▾ POWER SYSTEM

■ <b>POWER SYSTEM</b> [▶] MESSAGE MESSAGE		<b>NOMINAL FREQ:</b> 60 Hz	Range: 25 to 60 Hz in steps of 1
		<b>PHASE SEQUENCE:</b> ABC	Range: ABC, ACB
		<b>COST OF ENERGY:</b> 5.0 ¢/kWh	Range: 1.0 to 25.0 ¢/kWh in steps of 0.1

The power system data is entered in this setpoint subgroup.

- **NOMINAL FREQ:** 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:** Enter the phase sequence of the power system.
- **COST OF ENERGY:** 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.

### 5.3.5 FlexCurves™



Two programmable FlexCurves™ can be stored in the relay. These can be used for time overcurrent protection in the same way as ANSI, IAC, and IEC curves. The FlexCurve™ has setpoints for entering trip times 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 converts these points to a continuous curve by linear interpolation.

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

Table 5-1: FlexCurve™ Trip Times

Pickup (I/I <sub>pu</sub> )	Trip Time (ms)	Pickup (I/I <sub>pu</sub> )	Trip Time (ms)	Pickup (I/I <sub>pu</sub> )	Trip Time (ms)	Pickup (I/I <sub>pu</sub> )	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	

Table 5-1: FlexCurve™ Trip Times

Pickup (I/I <sub>pu</sub> )	Trip Time (ms)	Pickup (I/I <sub>pu</sub> )	Trip Time (ms)	Pickup (I/I <sub>pu</sub> )	Trip Time (ms)	Pickup (I/I <sub>pu</sub> )	Trip Time (ms)
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	

## 5.4 S3 Logic Inputs

### 5.4.1 Overview

The 750/760 relay has twenty (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 *Logic Inputs* on page 3-17 for typical wiring of the logic input contacts). External contacts are either open or closed and are de-bounced 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.

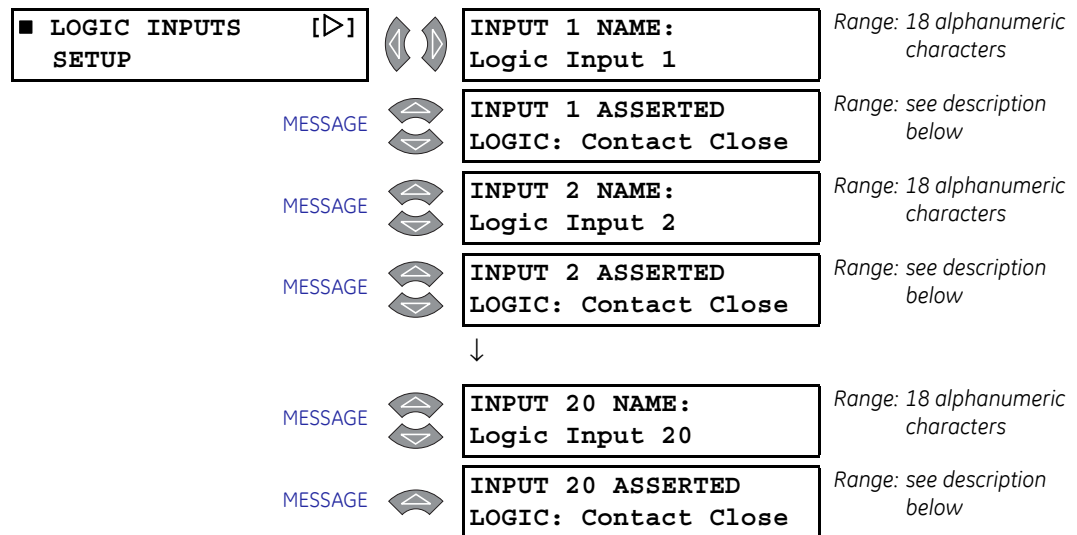
The relay also has twenty (20) virtual inputs which are analogous to software switches. They allow all the functionality of logic inputs to be invoked via serial communications or from the front panel. This has the following advantages over contact inputs only:

- The number of logic inputs can be increased without introducing additional hardware.
- Logic functions can be invoked from a remote location over a single RS485 communications channel.
- The same logic function can be invoked both locally via contact input or 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 **A1 STATUS ▾ ▽ VIRTUAL INPUTS** actual values menu. 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 memory map 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.

## 5.4.2 Logic Inputs Setup

PATH: SETPOINTS ▾ ▾ S3 LOGIC INPUTS ▾ LOGIC INPUTS SETUP



Each logic input has two setpoints representing the name and asserted logic. The following terms apply to all 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 from serial communications or the **A1 STATUS ▾ VIRTUAL INPUTS** actual values menu.
- The state of a logic input is either “Asserted” or “Not-Asserted”.
- The state of Logic Input  $n$  (where  $n = 1$  to 14) is determined by combining the state of Contact Input  $n$  with the state of Virtual Input  $n$  according to the **INPUT N ASSERTED LOGIC** setpoint; this is a limited form of programmable logic.
- The state of Logic Input  $x$  (where  $x = 15$  to 20) is determined by the state of Virtual Input  $x$  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.

The **LOGIC INPUT N NAME** setpoint allows the operator to assign a user-friendly description to logic inputs when replacing panel switches with a virtual switch. This name will be displayed in the **A1 STATUS ▾ VIRTUAL INPUTS** actual values menu.

The **LOGIC INPUT N ASSERTED** setpoint determines how to combine the Contact and Virtual Input states to determine the Logic Input state. For Logic inputs 1 through 14, this setpoint may be assigned the following values:

Value	Logic Input Asserted When:
Disabled	Never
Contact Close	Contact is closed
Contact Open	Contact is open
Virtual On	Virtual input is on

Value	Logic Input Asserted When:
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 through 20, this setpoint may be assigned the following values:

Value	Logic Input Asserted When:
Disabled	Never
Virtual On	Virtual input is on
Virtual Off	Virtual input is off

### 5.4.3 Breaker Functions


PATH: SETPOINTS ▾ ▾ S3 LOGIC INPUTS ▾ ▾ BREAKER FUNCTIONS

■ **BREAKER FUNCTIONS** [▷]




**52a CONTACT:**  
**Disabled**

*Range: Input 1 to Input 20, Disabled*

MESSAGE 

**52b CONTACT:**  
**Disabled**

*Range: Input 1 to Input 20, Disabled*

MESSAGE 

**BRKR CONNECTED:**  
**Disabled**

*Range: Input 1 to Input 20, Disabled*

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 Trip (Output Relay 1) and Close (Output Relay 2) relays
- Trip/Close Coil Supervision Without Permissive
- Manual close feature blocking

- Autoreclose
- Transfer

**⚠ CAUTION**

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

**⚠ CAUTION**

Breaker logic functions must be assigned to Logic Inputs 1 to 14 as they must only be contacts.









The **52A CONTACT** and **52B CONTACT** setpoints are used to monitor the 52/a and 52/b contacts. The following table determines how these contacts affect the breaker state:

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

When asserted, the logic input assigned by the **BRKR CONNECTED** setpoint 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. For further information regarding operation with only one auxiliary breaker contact, see *System Status LED Indicators* on page 4–3.

### 5.4.4 Control Functions

PATH: SETPOINTS ▾ ▾ S3 LOGIC INPUTS ▾ ▾ CONTROL FUNCTIONS

<p>■ CONTROL FUNCTIONS [▷]</p>		<p><b>LOCAL MODE:</b> Disabled</p>	<p>Range: Input 1 to Input 20, Disabled</p>
<p>MESSAGE</p>		<p><b>RESET:</b> Disabled</p>	<p>Range: Input 1 to Input 20, Disabled</p>
<p>MESSAGE</p>		<p><b>REMOTE OPEN:</b> Disabled</p>	<p>Range: Input 1 to Input 20, Disabled</p>
<p>MESSAGE</p>		<p><b>REMOTE CLOSE:</b> Disabled</p>	<p>Range: Input 1 to Input 20, Disabled</p>
<p>MESSAGE</p>		<p><b>COLD LOAD PICKUP:</b> Disabled</p>	<p>Range: Input 1 to Input 20, Disabled</p>
<p>MESSAGE</p>		<p><b>SETPOINT GROUP 2:</b> Disabled</p>	<p>Range: Input 1 to Input 20, Disabled</p>
<p>MESSAGE</p>		<p><b>SETPOINT GROUP 3:</b> Disabled</p>	<p>Range: Input 1 to Input 20, Disabled</p>
<p>MESSAGE</p>		<p><b>SETPOINT GROUP 4:</b> Disabled</p>	<p>Range: Input 1 to Input 20, Disabled</p>






The **LOCAL MODE** setpoint places the relay in local mode. The relay is in remote mode if not forced into local mode by this setpoint. The **RESET** setpoint resets the last trip indicator and latched relays. With the 760, it also resets the autoreclose lockout. The **COLD LOAD PICKUP** setpoint initiates the Cold Load Pickup blocking feature. The **SETPOINT GROUP 2** through **SETPOINT GROUP 4** setpoints signal the relay to make Group 2, 3, or 4 the active setpoint group.

The **REMOTE OPEN** and **REMOTE CLOSE** setpoints initiate a breaker opening via the Trip Relay and a breaker closure via the Close Relay, respectively. These setpoints are operational only when the relay is in remote mode (i.e., when **LOCAL MODE** is set to “Disabled”).



### 5.4.5 User Inputs

PATH: SETPOINTS ▾ ▾ S3 LOGIC INPUTS ▾ ▾ USER INPUTS ▾ USER INPUT A(T)

















<b>USER INPUT A</b> Press [▶] for more		<b>USER INPUT A NAME:</b> User Input A	Range: 18 alphanumeric characters
MESSAGE		<b>USER INPUT A SOURCE:</b> Disabled	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>USER INPUT A FUNCTION:</b> Disabled	Range: Disabled, Trip, Trip & AR, Alarm, Latched
MESSAGE		<b>USER INPUT A RELAYS (3-7):</b> -----	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>USER INPUT A DELAY:</b> 0.00 s	Range: 0.00 to 600.00 s in steps of 0.01

There are twenty (20) general purpose user input functions (User Inputs 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 a contact operation 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; and provide a contact multiplier for an external contact by operating multiple relays.

The setpoints for User Input A are shown above; setpoints for User Inputs B through T are identical.

### 5.4.6 Block Functions

PATH: SETPOINTS ▾ ▾ S3 LOGIC INPUTS ▾ ▾ BLOCK FUNCTIONS

<div style="border: 1px solid black; padding: 2px;"> <span style="color: blue;">■</span> <b>BLOCK FUNCTIONS</b> <span style="float: right;">[&gt;]</span> </div>			<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK 1 TRIP RELAY:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK 2 CLOSE RELAY:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK RESET:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK UNDERVOLT 1:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK UNDERVOLT 2:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK UNDERVOLT 3:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK UNDERVOLT 4:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK UNDERFREQ 1:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK UNDERFREQ 2:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK FREQ DECAY:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BYPASS SYNCHROCHECK:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK BREAKER STATISTICS:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK NEG SEQ VOLTAGE:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLCK NTR DISPLACEMNT:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK RESTORATION:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
	MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK REV POWER:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled

The logic input functions shown above block various operations within the relay. Protection elements will *not* detect faults, send messages, or illuminate indicators when blocked, except for the **BLOCK TRIP 1 RELAY** setpoint.

A system condition monitor such as Synchrocheck or Closing Spring Charged can be connected to the relay for close supervision. If **BLOCK CLOSE 2 RELAY** is selected, this input must be de-asserted to permit operation of the Close Relay.




















The **BYPASS SYNCHROCHECK** setpoint provides a manual override of the synchrocheck monitor, so an operator can close the feeder breaker without the programmed synchrocheck condition.

The **BLOCK BRKR STATISTICS** setpoint blocks the accumulation of breaker statistical data found on the **A3 MAINTENANCE ▷ TRIP COUNTERS** and **A3 MAINTENANCE ▷ ▽ ARCING CURRENT** actual values pages. 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.

The **BLOCK REV POWER** setpoint is only visible when Mod 008 is enabled.

### 5.4.7 Block Overcurrent












PATH: SETPOINTS ▾ ▾ S3 LOGIC INPUTS ▾ ▾ BLOCK OC FUNCTIONS

<div style="border: 1px solid black; padding: 2px;"> <span style="font-size: 1.2em;">■</span> <b>BLOCK OC FUNCTIONS</b> <span style="float: right; font-size: 1.2em;">[&gt;]</span> </div>			<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK ALL OC:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK PHASE OC:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK NEUTRAL OC:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK GND OC:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK SENSTV GND OC:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK PHASE TIME 1:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK PHASE TIME 2:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK PHASE INST 1:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK PHASE INST 2:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK NEUTRAL TIME 1:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK NEUTRAL TIME 2:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK NEUTRAL INST 1:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK NEUTRAL INST 2:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK GND TIME:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK GND INST:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLK SENSTV GND TIME:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLK SENSTV GND INST:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK NEG SEQ TIME:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>BLOCK NEG SEQ INST:</b>                  Disabled             </div>	Range: Input 1 to Input 20, Disabled	

These setpoints block overcurrent protection elements. 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 other supervision; block overcurrent operation during initial feeder loading when the inrush currents are not know; block neutral operation during single-phase switching or fault burn-off attempts; and block timed phase and neutral operation during deliberate emergency overload operating situations.

## 5.4.8 Transfer Functions

PATH: SETPOINTS ▾ S3 LOGIC INPUTS ▾ TRANSFER FUNCTIONS

■ <b>TRANSFER FUNCTIONS</b> [▷]		<b>SELECT TO TRIP:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>UNDervOLT ON OTHER SOURCE:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>INCOMER 1 BREAKER CLOSED:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>INCOMER 2 BREAKER CLOSED:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>TIE BREAKER CONNECTED:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>TIE BREAKER CLOSED:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>BLOCK TRANSFER:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>TRANSFORMER LOCKOUT:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>SOURCE TRIP:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>CLOSE FROM INCOMER1:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled
MESSAGE		<b>CLOSE FROM INCOMER2:</b> <b>Disabled</b>	Range: Input 1 to Input 20, Disabled

The following logic input functions are used exclusively for the bus transfer scheme. Refer to *Transfer Scheme* on page 5-136 for details on implementing the bus transfer scheme.



If the bus transfer feature is required, 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.

The **INCOMER I(2) BREAKER CLOSED** setpoints are used to track breaker state, for prevent-parallel or permission-to-transfer logic. **THE CLOSE FROM INCOMER I(2)** setpoints signal the bus tie breaker to begin a close operation.

The **TIE BREAKER CONNECTED** setpoint is 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. The **TIE BREAKER CLOSED** setpoint is used to track breaker state, for prevent-parallel or permission-to-transfer logic.

The **TRANSFORMER LOCKOUT** and **SOURCE TRIP** setpoints are used to initiate a transfer as Source 1(2) is about to be lost. The **BLOCK TRANSFER** setpoint disables the transfer scheme.

### 5.4.9 Reclose (760 Only)

PATH: SETPOINTS ▾ ▾ S3 LOGIC INPUTS ▾ ▾ RECLOSE FUNCTIONS

<b>■ RECLOSE FUNCTIONS</b> [ <b>&gt;</b> ]		<b>INITIATE RECLOSURE:</b> <b>Disabled</b>	<i>Range: Input 1 to Input 20, Disabled</i>
	MESSAGE	<b>CANCEL RECLOSURE:</b> <b>Disabled</b>	<i>Range: Input 1 to Input 20, Disabled</i>
	MESSAGE	<b>BLOCK RECLOSURE:</b> <b>Disabled</b>	<i>Range: Input 1 to Input 20, Disabled</i>

These logic input setpoints are used in the autoreclose scheme and are applicable to the 760 relay only. Refer to *Autoreclose (760 only)* on page 5–157 for more detail.

- **INITIATE RECLOSURE:** Initiates an autoreclose sequence leading to an operation of the Close Relay. This input will *not* cause the 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:** Cancels a reclosure sequence in progress and blocks autoreclose scheme from operating.
- **BLOCK RECLOSURE:** Cancels a reclosure sequence in progress and blocks the autoreclose scheme from operating.

### 5.4.10 Miscellaneous

PATH: SETPOINTS ▾ ▾ S3 LOGIC INPUTS ▾ ▾ MISC FUNCTIONS

<b>■ MISC FUNCTIONS</b> [ <b>&gt;</b> ]		<b>TRIGGER TRACE MEMORY:</b> <b>Disabled</b>	<i>Range: Input 1 to Input 20, Disabled</i>
	MESSAGE	<b>TRIGGER DATA LOGGER:</b> <b>Disabled</b>	<i>Range: Input 1 to Input 20, Disabled</i>
	MESSAGE	<b>SIMULATE FAULT:</b> <b>Disabled</b>	<i>Range: Input 1 to Input 20, Disabled</i>
	MESSAGE	<b>START DMND INTERVAL:</b> <b>Disabled</b>	<i>Range: Input 1 to Input 20, Disabled</i>

The **SIMULATE FAULT** 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.

## 5.5 S4 Output Relays

### 5.5.1 Relay Operation

#### Description

The 750/760 relay is equipped with eight electromechanical output relays: three special purpose (Trip Relay 1, Close Relay 2, and Self-test Warning Relay 8) and five general purpose (Auxiliary Relays 3 to 7). 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.

#### Trip and Close Relays

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 Trip Relay is de-energized after either the delay programmed in the Breaker Failure feature or a default interval of 100 ms after the initiating input resets and the Close Relay is de-energized after 200 ms. 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 5-2: Breaker Auxiliary Contacts and Relay Operation**

<b>52a CONTACT INSTALLED?</b>	<b>52b CONTACT INSTALLED?</b>	<b>RELAY OPERATION</b>
Yes	Yes	Trip Relay remains operating until 52b indicates an open breaker. Close Relay remains operating until 52a indicates a closed breaker.
Yes	No	Trip Relay remains operating until 52a indicates an open breaker. Close Relay remains operating until 52a indicates a closed breaker.
No	Yes	Trip Relay remains operating until 52b indicates an open breaker. Close Relay remains operating until 52b indicates a closed breaker.
No	No	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. Close Relay operates for 200 ms.



### Auxiliary Relays 3 to 7

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 5-3: 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 <b>PULSED OUTPUT DWELL TIME</b> . The dwell timer is started when the first feature causes operation of the output relay.

### 5.5.2 Trip Relay

PATH: SETPOINTS ▷ ▾ S4 OUTPUT RELAYS ▷ 1 TRIP RELAY

■ 1 TRIP RELAY [▷]



TRIP RELAY SEAL IN  
 TIME: 0.04 s

Range: 0.00 to 9.99 s in steps of 0.01

A **TRIP RELAY SEAL IN TIME** can be programmed for the Trip Relay. This time is added to the reset time of the 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.

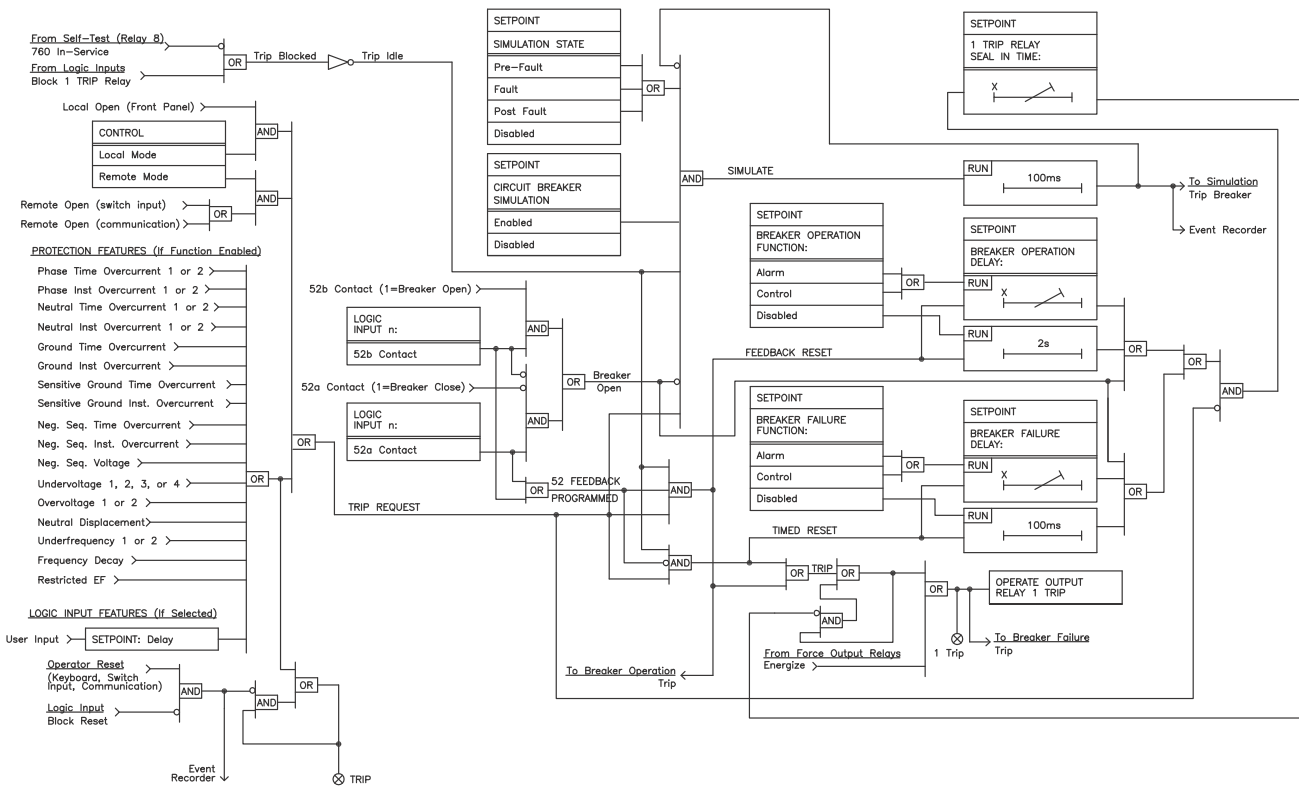


FIGURE 5-1: Output Relay 1 Trip Logic

### 5.5.3 Close Relay

PATH: SETPOINTS ▾ ▾ S4 OUTPUT RELAYS ▾ ▾ 2 CLOSE RELAY

<b>2 CLOSE RELAY</b> [▷]		<b>CLOSE RELAY SEAL IN TIME: 0.04 s</b>	<i>Range: 0.00 to 9.99 s in steps of 0.01</i>
--------------------------	--	-----------------------------------------	-----------------------------------------------

A **CLOSE RELAY SEAL IN TIME** can be programmed for the Close Relay. This time is added to the reset time of the 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.

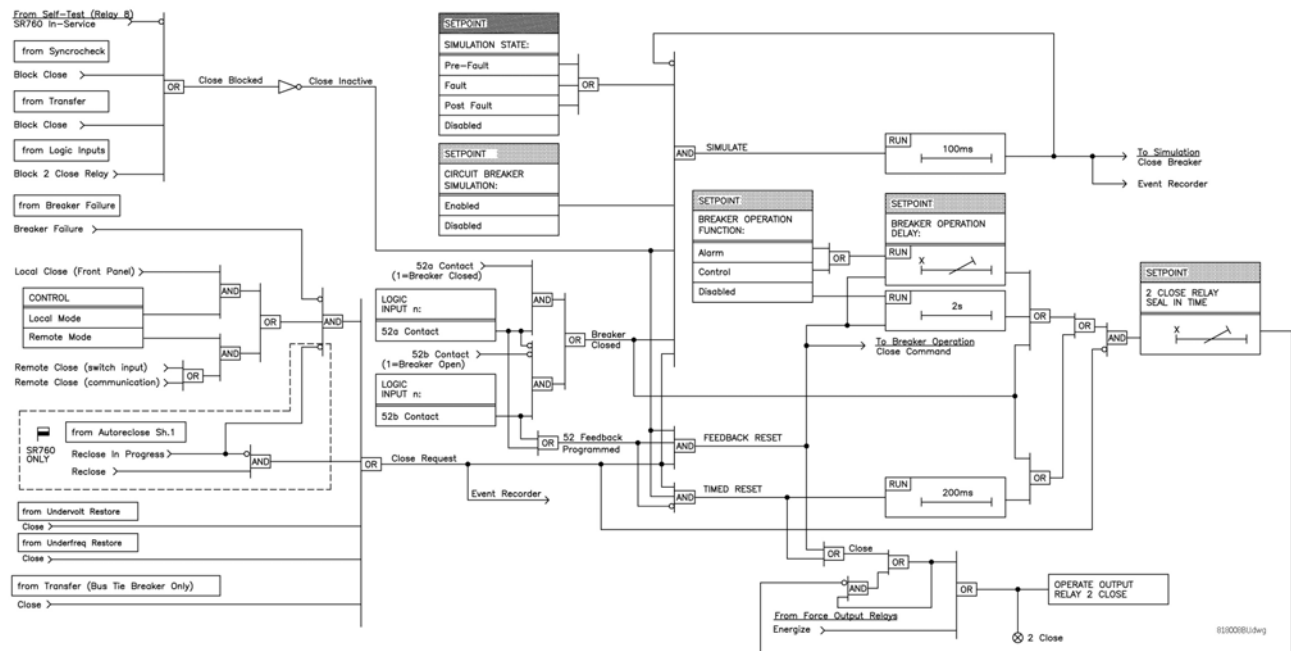


FIGURE 5-2: Output Relay 2 Close Logic

### 5.5.4 Auxiliary Relays

PATH: SETPOINTS ▾ ▾ S4 OUTPUT RELAYS ▾ ▾ 3(7) AUX RELAY

<b>3 AUXILIARY</b> [ <b>&gt;</b> ]		<b>RELAY 3 NAME:</b> <b>Auxiliary</b>	Range: 16 alphanumeric characters
MESSAGE		<b>RELAY 3 NON-OPERATED STATE:</b> <b>De-energized</b>	Range: Energized, De-energized
MESSAGE		<b>RELAY 3 OUTPUT TYPE:</b> <b>Self-Resetting</b>	Range: Self-Resetting, Latched, Pulsed
MESSAGE		<b>PULSED OUTPUT DWELL TIME:</b> <b>0.1 s</b>	Range: 0.1 to 6000.0 s in steps of 0.1

The *Typical Wiring Diagram* on page 3-10 shows relay contacts with no control power applied. If the **RELAY 3(7) NON-OPERATED STATE** setpoint is “De-energized”, then the state of the relay contacts is as shown in the wiring diagram. If the non-operated state is “Energized”, then the state of the relay contacts is opposite to that shown in the wiring diagram.

This **PULSED OUTPUT DWELL TIME** setpoint is only displayed if the **RELAY 3 OUTPUT TYPE** is selected as "Pulsed". This setpoint determines the minimum time interval during which the pulsed contacts remain in the operated state. The actual time interval may be for as long as the controlling function is asserted, this interval being whichever of the above two time intervals is longer.

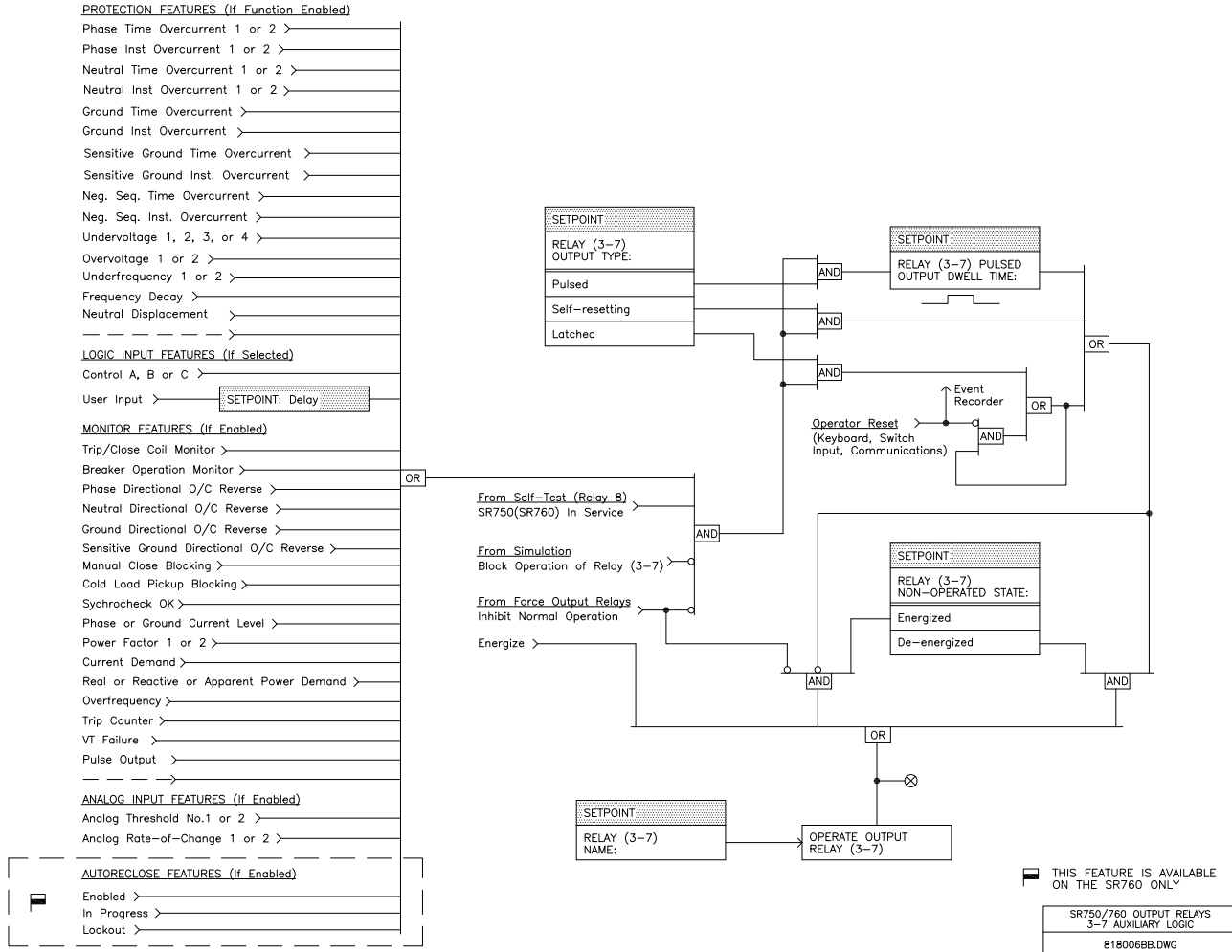


FIGURE 5-3: Output Relays 3 to 7 Auxiliary Logic

### 5.5.5 Self-Test Warning Relay

There are no user-programmable setpoints associated with the Self-Test Warning Relay (Output Relay 8). The logic for this relay is shown below:



## 5.6 S5 Protection

### 5.6.1 Overview

#### 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 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 value. 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:** 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:** 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. **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. The available curves are shown in the table below.

Table 5–4: TOC Curve Selections

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	

- **<Element\_Name> MULTIPLIER:** 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 setpoint. 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.

- **<Element\_Name> RESET:** 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 setpoint, the energy capacity variable is decremented according to the following equation.

$$T_{RESET} = E \times M \times C_R \quad \text{(EQ 5.1)}$$

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)



When the setpoint group changes, the setpoints for pickup, curve, multiplier and reset may change. Accumulated 'energy capacity' continues to accumulate, using the new setpoint group parameters. For example, assume the following conditions:

- Setpoint group 1 had curve "Definite time" set for 4 seconds.
- Setpoint group 2 had curve "Definite time" set for 8 seconds.
- Initially group 1 was active.
- Current rose above threshold at time  $T = 0$  seconds.
- Setpoint group changed from group 1 to group 2 at time  $T = 1$  seconds. At this time the 'energy capacity' accumulator was at 25% = (1 second  $\times$  (100% / 4 seconds)).
- Current remained above the threshold.
- Using the new multiplier setpoint and continuing from 25% accumulated, the time remaining after setpoint group change was 6 seconds = (100% - 25%)  $\times$  8 seconds.
- Timed element operated at time  $T = 7$  seconds.



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

## 5.6.2 Time Overcurrent Curve Characteristics

### Definite Time Curve:

Definite Time curves 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 adjusts this delay from 0.00 to 10.00 seconds in steps of 0.01.

**ANSI Curves:**

The ANSI time overcurrent curve shapes conform to industry standards and the ANSI C37.90 curve classifications for extremely, very, and moderately inverse. The ANSI curves are derived from the following formula:

$$T = M \times \left( A + \frac{B}{(I/I_{pickup}) - C} + \frac{D}{((I/I_{pickup}) - C)^2} + \frac{E}{((I/I_{pickup}) - C)^3} \right) \tag{EQ 5.2}$$

where:  $T$  = trip time (seconds);  $M$  = multiplier value;  $I$  = input current;  $I_{pickup}$  = pickup current setpoint;  $A, B, C, D, E$  = constants

**Table 5-5: ANSI Curve Constants**

ANSI Curve Shape	A	B	C	D	E
ANSI Extremely Inverse	0.0399	0.2294	0.5000	3.0094	0.7222
ANSI Very Inverse	0.0615	0.7989	0.3400	-0.2840	4.0505
ANSI Normally Inverse	0.0274	2.2614	0.3000	-4.1899	9.1272
ANSI Moderately Inverse	0.1735	0.6791	0.8000	-0.0800	0.1271

**Table 5-6: ANSI Curve Trip Times (in seconds)**

Multiplier (TDM)	Current ( $I / I_{pickup}$ )									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
<b>ANSI Extremely Inverse</b>										
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
<b>ANSI Very Inverse</b>										
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
<b>ANSI Normally Inverse</b>										
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



Table 5-6: ANSI Curve Trip Times (in seconds)

Multiplier (TDM)	Current ( $I/I_{pickup}$ )									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
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
<b>ANSI Moderately Inverse</b>										
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

**IEC Curves:**

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 formulae for these curves are:

$$T = M \times \left( \frac{K}{(I/I_{pu})^E - 1} \right) \quad \text{(EQ 5.3)}$$

where:  $T$  = trip time (seconds),  $M$  = multiplier setpoint,  $I$  = input current,  $I_{pickup}$  = pickup current setpoint,  $K$ ,  $E$  = constants.

Table 5-7: IEC (BS) Inverse Time Curve Constants

IEC (BS) Curve Shape	K	E
IEC Curve A (BS142)	0.140	0.020
IEC Curve B (BS142)	13.500	1.000
IEC Curve C (BS142)	80.000	2.000
IEC Short Inverse	0.050	0.040

Table 5-8: IEC Curve Trip Times (in seconds)

Multiplier (TDM)	Current ( $I/I_{pickup}$ )									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
<b>IEC Curve A</b>										
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

Table 5-8: IEC Curve Trip Times (in seconds)

Multiplier (TDM)	Current ( $I / I_{pickup}$ )									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
<b>IEC Curve B</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
<b>IEC Curve C</b>										
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
<b>IEC Short Time</b>										
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

**IAC Curves:**

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

$$T = M \times \left( A + \frac{B}{(I/I_{pu}) - C} + \frac{D}{((I/I_{pu}) - C)^2} + \frac{E}{((I/I_{pu}) - C)^3} \right) \tag{EQ 5.4}$$

where:  $T$  = trip time (seconds),  $M$  = multiplier setpoint,  $I$  = input current,  $I_{pickup}$  = pickup current setpoint,  $A$  to  $E$  = constants.

Table 5-9: GE Type IAC Inverse Curve Constants

IAC Curve Shape	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 5-10: IAC Curve Trip Times

Multiplier (TDM)	Current ( $I / I_{pickup}$ )									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
<b>IAC Extremely Inverse</b>										
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
<b>IAC Very Inverse</b>										
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
<b>IAC Inverse</b>										
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
<b>IAC Short Inverse</b>										
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

### 5.6.3 Phase Current

#### Main Menu

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ PHASE CURRENT

■ PHASE CURRENT [▷]		■ PHASE TIME OVERCURRENT 1 [▷]	See below
MESSAGE		■ PHASE TIME OVERCURRENT 2 [▷]	
MESSAGE		■ PHASE INST OVERCURRENT 1 [▷]	See page 5-53
MESSAGE		■ PHASE INST OVERCURRENT 2 [▷]	
MESSAGE		■ PHASE DIRECTIONAL [▷]	See page 5-54

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 'lo-set' and 'hi-set' 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.

#### Phase Time Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ PHASE CURRENT ▾ PHASE TIME OVERCURRENT 1(2)

■ PHASE TIME OVERCURRENT 1 [▷]		PHASE TIME OC 1 FUNCTION: Trip	Range: Disabled, Trip, Trip & AR, Alarm, Latched
MESSAGE		PHASE TIME OC 1 RELAYS (3-7): -----	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		PHASE TIME OC 1 PICKUP: 1.00 x CT	Range: 0.05 to 20.00 x CT in steps of 0.01
MESSAGE		PHASE TIME OC 1 CURVE: Ext. Inverse	Range: see Table 5-4: TOC Curve Selections on
MESSAGE		PHASE TIME OC 1 MULTIPLIER: 1.00	Range: 0.00 to 100.00 in steps of 0.01
MESSAGE		PHASE TIME OC 1 RESET: Instantaneous	Range: Instantaneous, Linear
MESSAGE		PHASE TIME OC 1 DIRECTION: Disabled	Range: Disabled, Forward, Reverse
MESSAGE		PHASE TIME OC 1 VOLT RESTRAINT: Disabled	Range: Enabled, Disabled

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.

Select “Disabled” for the **PHASE TIME OC 1 VOLT RESTRAINT** setpoint if voltage restraint is not required. When set to “Enabled”, this feature lowers the pickup value of each individual phase time overcurrent 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.

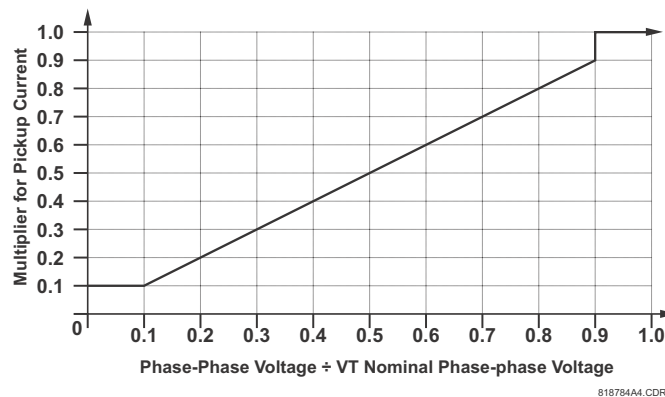


FIGURE 5-5: Voltage Restraint Characteristic for Phase TOC



NOTE

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

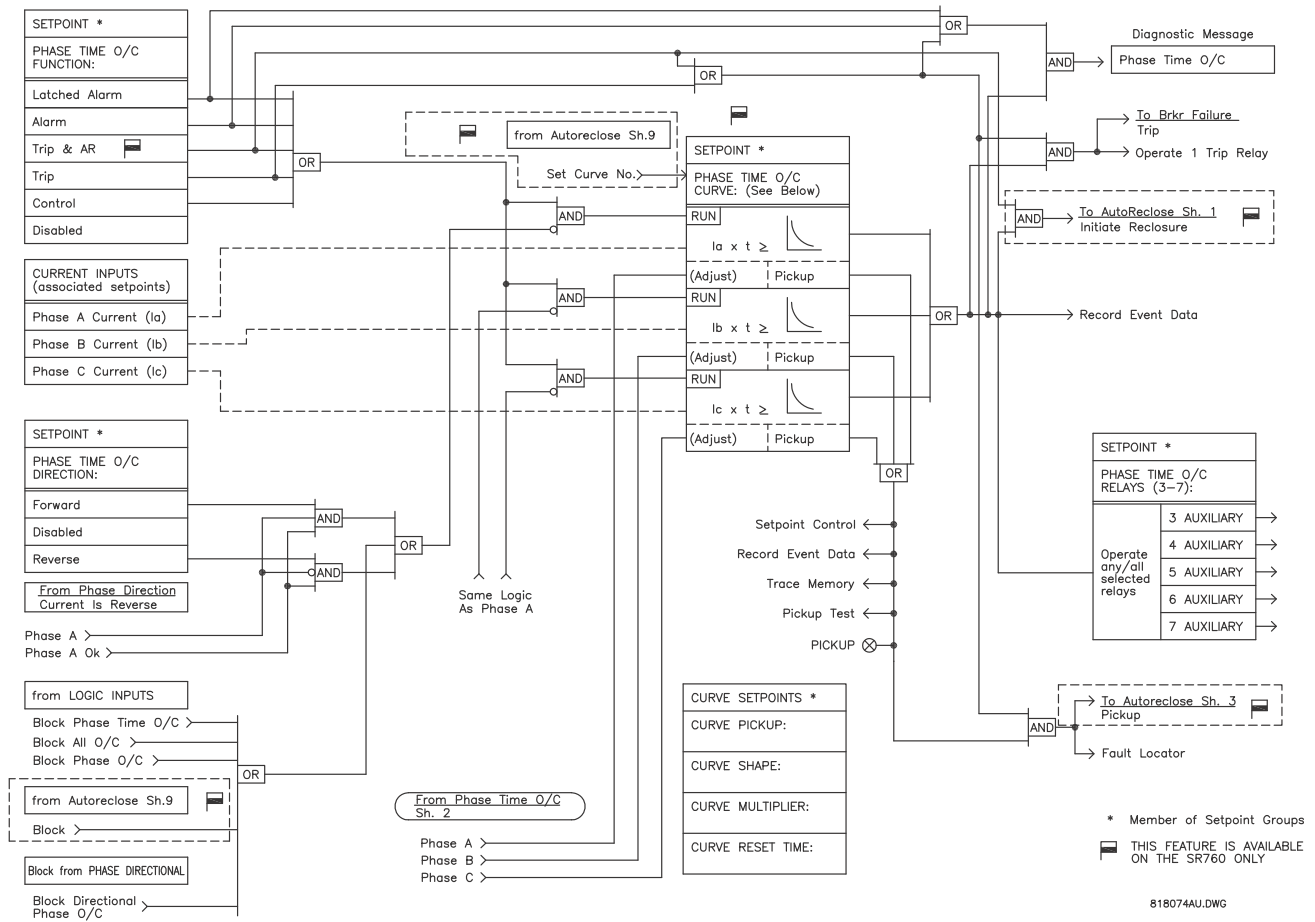


FIGURE 5-6: Phase TOC Logic (1 of 2)

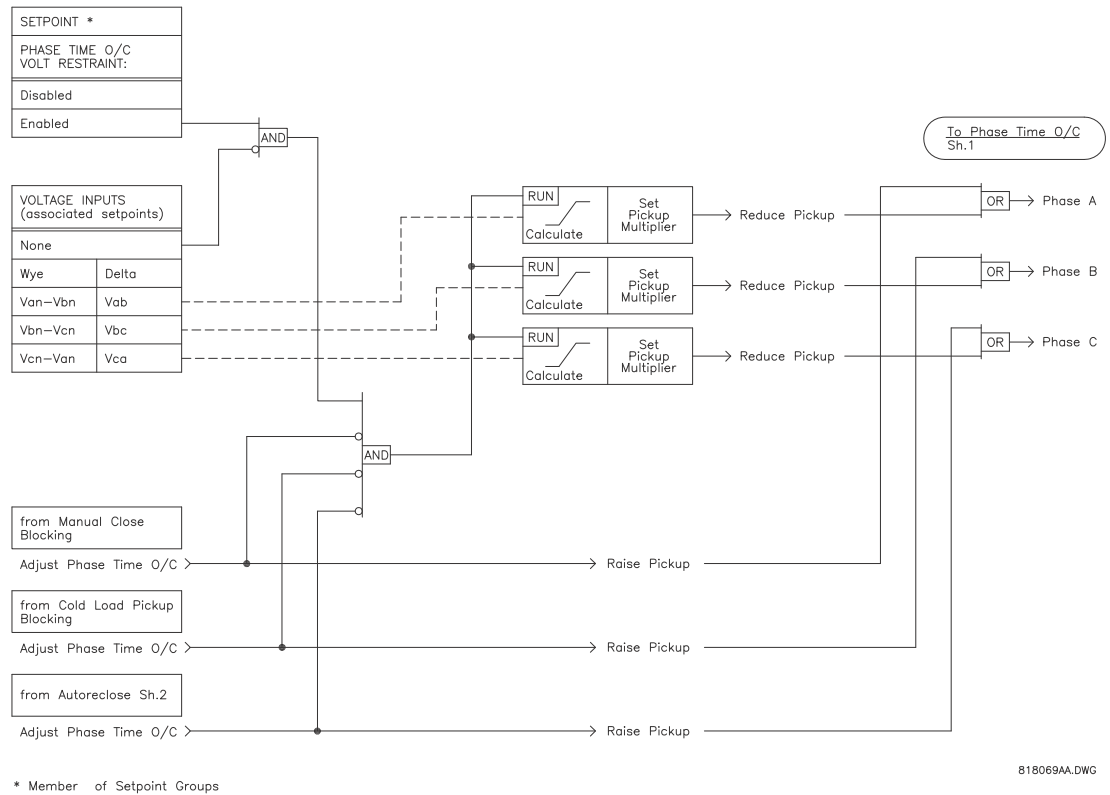


FIGURE 5-7: Phase TOC Logic (2 of 2)

### Phase Instantaneous Overcurrent

PATH: SETPOINTS ▾ S5 PROTECTION ▾ PHASE CURRENT ▾ PHASE INST OVERCURRENT 1(2)

<b>■ PHASE INST OVERCURRENT 1</b> [▷]		<b>PHASE INST OC 1</b> <b>FUNCTION: Trip</b>	Range: Disabled, Trip, Trip & AR, Alarm, Latched Alarm, Control
	MESSAGE	<b>PHASE INST OC 1</b> <b>RELAYS (3-7): - - - -</b>	Range: Any combination of 3 to 7 Auxiliary relays
	MESSAGE	<b>PHASE INST OC 1</b> <b>PICKUP: 1.00 x CT</b>	Range: 0.05 to 20.00 x CT in steps of 0.01
	MESSAGE	<b>PHASE INST OC 1</b> <b>DELAY: 0.00 s</b>	Range: 0.00 to 600.00 s in steps of 0.01
	MESSAGE	<b>PHASES REQUIRED FOR OPERATION: Any One</b>	Range: Any One, Any Two, All Three
	MESSAGE	<b>PHASE INST OC 1</b> <b>DIRECTION: Disabled</b>	Range: Disabled, Forward, Reverse

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.

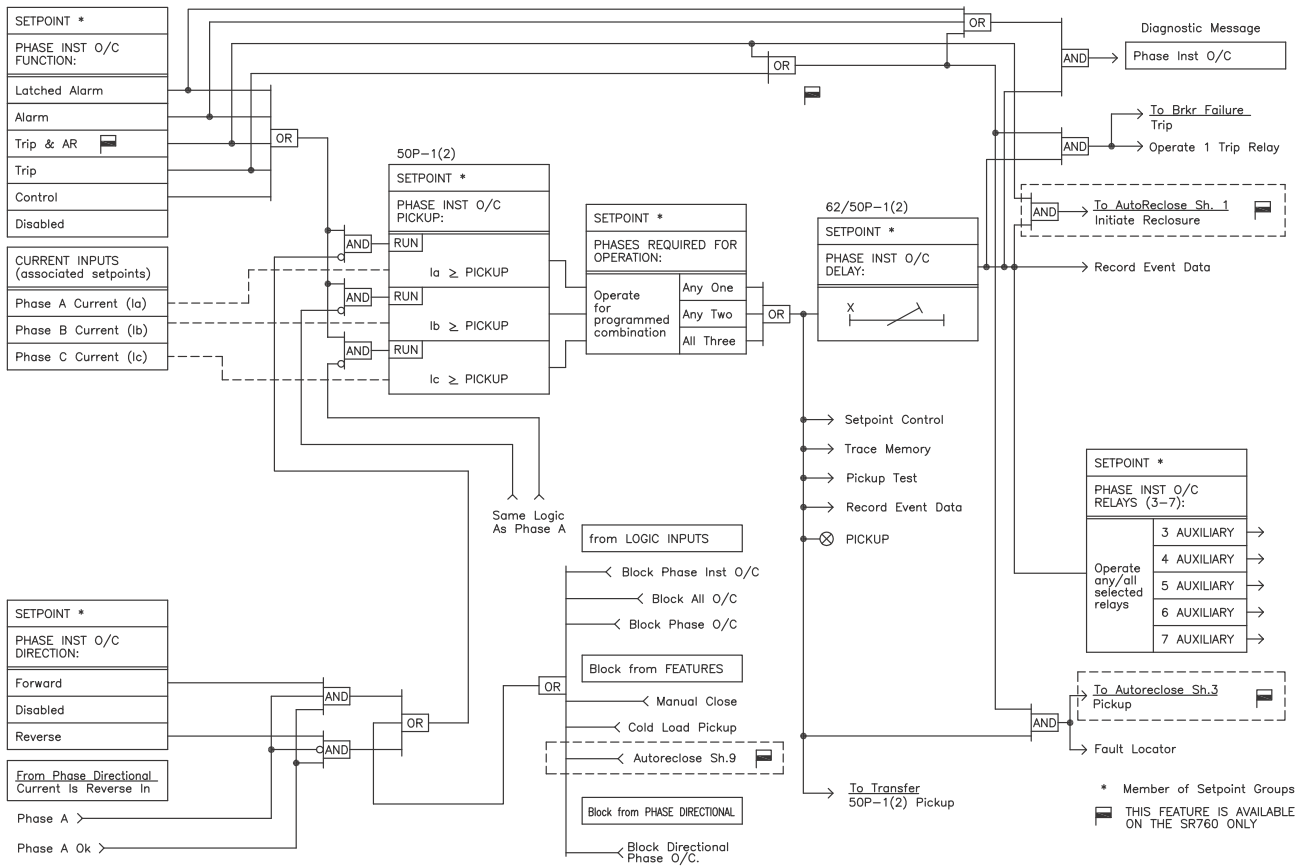


FIGURE 5-8: Phase IOC Logic

### Phase Directional Overcurrent

PATH: SETPOINTS ▷ ▽ S5 PROTECTION ▷ PHASE CURRENT ▷ ▽ PHASE DIRECTIONAL

<b>■ PHASE DIRECTIONAL</b> [▷]		<b>PHASE DIRECTIONAL FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm, Control
MESSAGE		<b>PHASE DIRECTIONAL RELAYS (3-7): -----</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>PHASE DIRECTIONAL MTA: 30° Lead</b>	Range: 0 to 359° in steps of 1
MESSAGE		<b>MIN POLARIZING VOLTAGE: 0.05 x VT</b>	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE		<b>BLK OC WHEN VOLT MEM EXPIRES: Disabled</b>	Range: Disabled, Enabled

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 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 shows the phasors involved for Phase A directional polarization, but the general principles can be applied to all directional elements.

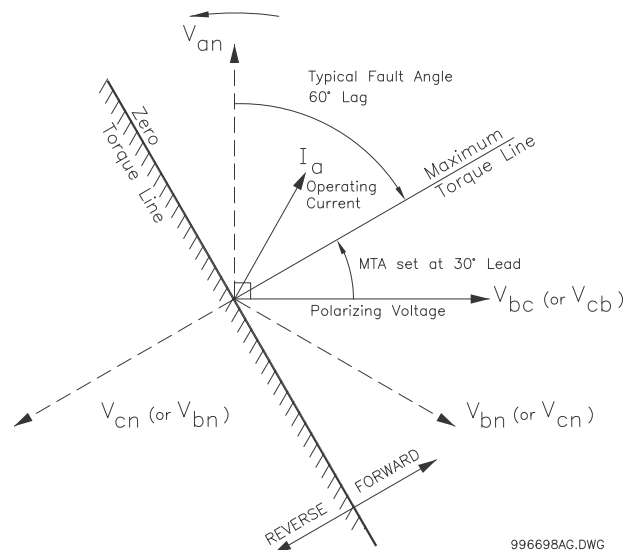


FIGURE 5–9: Phase A Directional Overcurrent Polarization

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.

Table 5–11: Phase Directional Operating Characteristics

Quantity	Operating Current	polarizing voltage	
		ABC Phase Sequence	ACB Phase Sequence
Phase A	Ia	Vbc	Vcb
Phase B	Ib	Vca	Vac
Phase C	Ic	Vab	Vba

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 **MIN POLARIZING VOLTAGE** value 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 **BLOCK OC WHEN VOLT MEM EXPIRES** setpoint 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 **MIN POLARIZING VOLTAGE** setpoint.



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.

### Settings:

- PHASE DIRECTIONAL FUNCTION:** The directional element function must be selected as “Control”, “Alarm” or “Latched Alarm” to enable the directionality check to the TOC and IOC elements as per programmed directional parameters and as described in this section. When the “Alarm” function is selected, the 750/760 will flash the “Alarm” LED while the direction is “REVERSE”, and will turn it off when the condition disappears. When the “Latched Alarm” function is selected, the 750/760 will flash the “Alarm” LED while the direction is “REVERSE”. In this case the “Alarm” LED will remain illuminated after the condition has cleared, until the 750/760 RESET button is pressed.
- PHASE DIRECTIONAL RELAYS:** Select auxiliary contacts (3 to 7) to enable the operation of the output contacts (3 to 7) when the current is in REVERSE DIRECTION. If under Output Relay Settings, the “Output Type” of the Auxiliary relays (3 to 7) is set to “Latched”, they will remain in the operated state, regardless of the status of the “Alarm” LED, until pressing the RESET button.

- **PHASE DIRECTIONAL MTA:** 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 the Phase A Directional Overcurrent Polarization figure for more information.
- **MINIMUM POLARIZING VOLTAGE:** This setting defines the minimum phase-to-phase voltage used for voltage polarization of the current phase directional element. This setting applies either to the **measured** phases-to-phase voltage when delta (open delta) PTs are connected to the relay, or to the **computed** phase-to-phase voltage, when “wye” PTs are connected to the relay. The type of PT connection “Delta” or “Wye” need be set accordingly.  
For example in the case of “Wye” VT connection, and the 66.4 V setting selected under BUS NOMINAL SECONDARY VOLTAGE, the minimum polarizing voltage of  $0.5 \times VT$  will result into  $0.5 \times (66.4V \times \sqrt{3}) = 57.5 V$ . For Delta VT connection and a BUS NOMINAL SECONDARY VOLTAGE setting of 115 V, the minimum polarizing voltage is computed as  $0.5 \times VT$  or  $0.5 \times 115 V = 57.5 V$ .
- **BLOCK OC WHEN VOLT MEM EXPIRES:** Select the required operation upon expiration of voltage memory. When set to “Enabled”, all Phase OC elements under directional control are blocked from operating when voltage memory expires. When set to “Disabled”, all phase overcurrent elements are be inhibited by directional control. This setpoint also determines the operation of phase overcurrent elements under directional control upon ‘Close Into Fault’ (CIF).

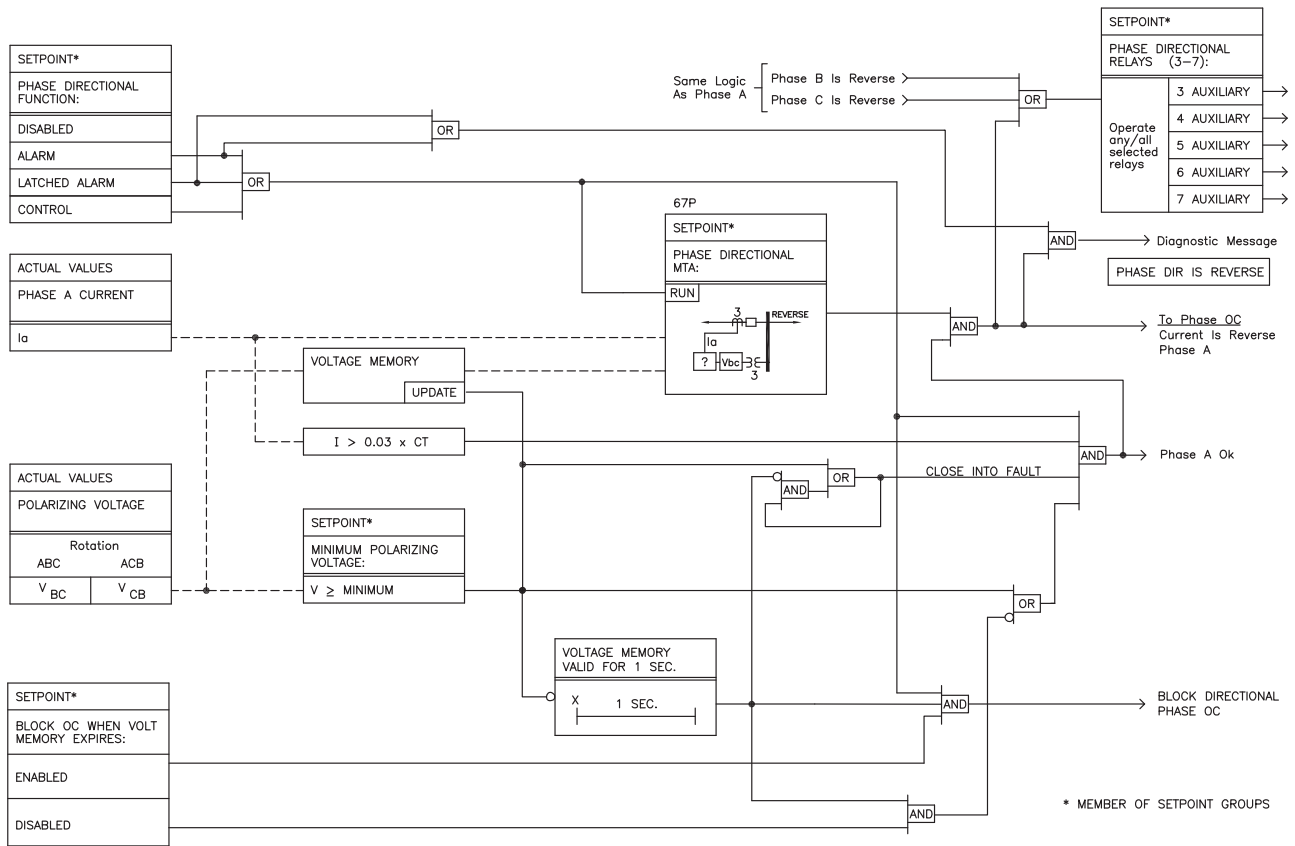


FIGURE 5-10: Phase Directional Logic

### 5.6.4 Neutral Current

#### Main Menu

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ NEUTRAL CURRENT








■ NEUTRAL CURRENT [▷]	⏏	■ NEUTRAL TIME OVERCURRENT 1 [▷]	See page 5-59
MESSAGE	⏏	■ NEUTRAL TIME OVERCURRENT 2 [▷]	See page 5-59
MESSAGE	⏏	■ NEUTRAL INST OVERCURRENT 1 [▷]	See page 5-60
MESSAGE	⏏	■ NEUTRAL INST OVERCURRENT 2 [▷]	See page 5-60
MESSAGE	⏏	■ NEUTRAL DIRECTIONAL [▷]	See page 5-61

Four neutral overcurrent protection elements are provided. Two time overcurrent elements and two instantaneous overcurrent elements. They all monitor the calculated neutral current ( $3I_0 = I_a + I_b + I_c$ ) 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.

### Neutral Time Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ NEUTRAL CURRENT ▾ NEUTRAL TIME... 1(2)

<p>■ <b>NEUTRAL TIME OVERCURRENT 1</b> [▷]</p>		<p><b>NEUTRAL TIME OC 1</b> <b>FUNCTION: Disabled</b></p>	<p>Range: Disabled, Trip, Trip &amp; AR, Alarm, Latched</p>
<p>MESSAGE</p>		<p><b>NEUTRAL TIME OC 1</b> <b>RELAYS (3-7): -----</b></p>	<p>Range: Any combination of 3 to 7 Auxiliary relays</p>
<p>MESSAGE</p>		<p><b>NEUTRAL TIME OC 1</b> <b>PICKUP: 1.00 x CT</b></p>	<p>Range: 0.05 to 20.00 x CT in steps of 0.01</p>
<p>MESSAGE</p>		<p><b>NEUTRAL TIME OC 1</b> <b>CURVE: Ext. Inverse</b></p>	<p>Range: See Table 5-4: TOC Curve Selections on</p>
<p>MESSAGE</p>		<p><b>NEUTRAL TIME OC 1</b> <b>MULTIPLIER: 1.00</b></p>	<p>Range: 0.00 to 100.00 in steps of 0.01</p>
<p>MESSAGE</p>		<p><b>NEUTRAL TIME OC 1</b> <b>RESET: Instantaneous</b></p>	<p>Range: Instantaneous, Linear</p>
<p>MESSAGE</p>		<p><b>NEUTRAL TIME OC 1</b> <b>DIRECTION: Disabled</b></p>	<p>Range: Disabled, Forward, Reverse</p>

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.

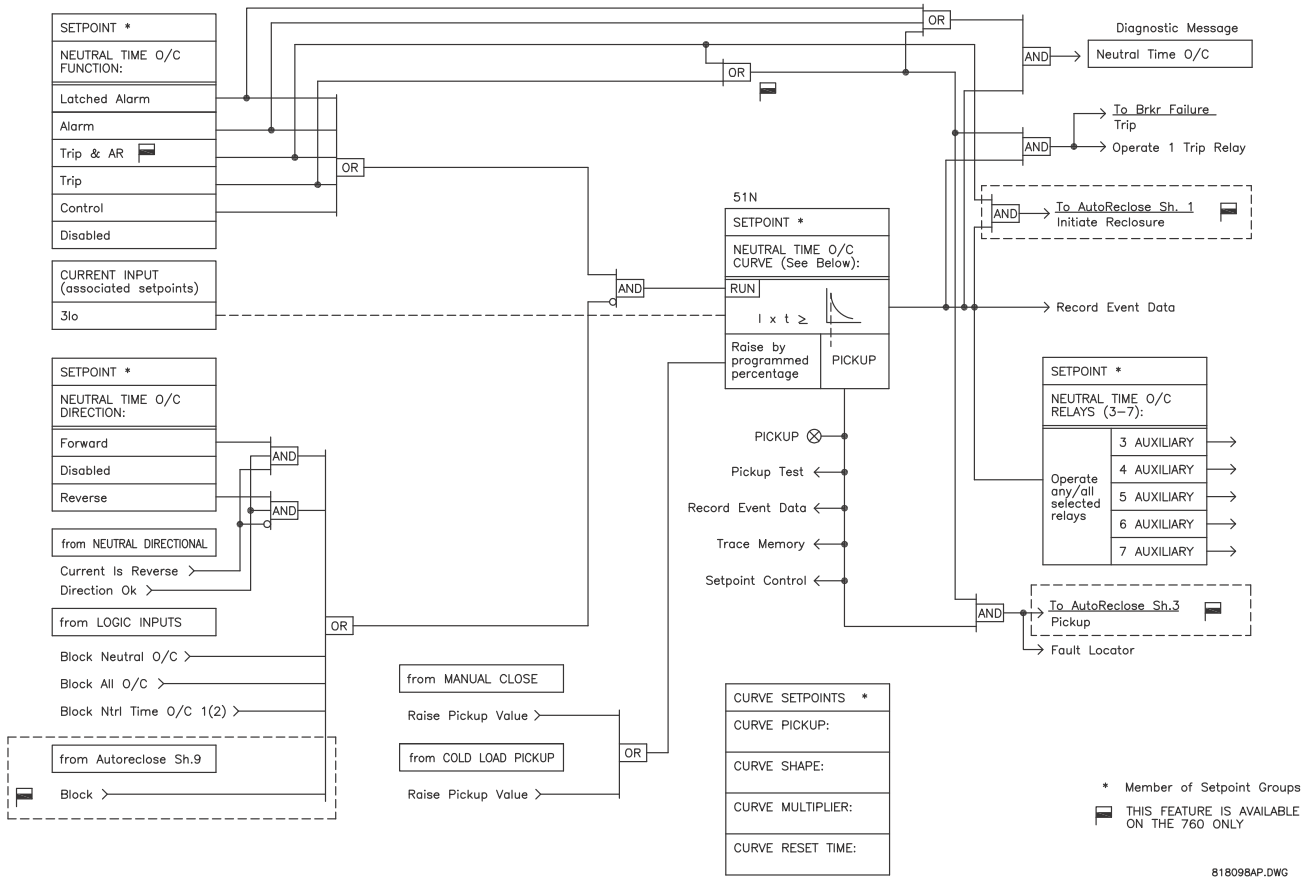


FIGURE 5-11: Neutral TOC Logic

### Neutral Instantaneous OC

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ NEUTRAL CURRENT ▾ ▾ NEUTRAL INST... 1(2)

<b>NEUTRAL INST OVERCURRENT 1</b> [ <b>&gt;</b> ]		<b>NEUTRAL INST OC 1 FUNCTION: Disabled</b>	Range: Disabled, Trip, Trip & AR, Alarm, Latched
MESSAGE		<b>NEUTRAL INST OC 1 RELAYS (3-7): -----</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>NEUTRAL INST OC 1 PICKUP: 1.00 x CT</b>	Range: 0.05 to 20.00 x CT in steps of 0.01
MESSAGE		<b>NEUTRAL INST OC 1 DELAY: 0.00 s</b>	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE		<b>NEUTRAL INST OC 1 DIRECTION: Disabled</b>	Range: Disabled, Forward, Reverse

The 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.

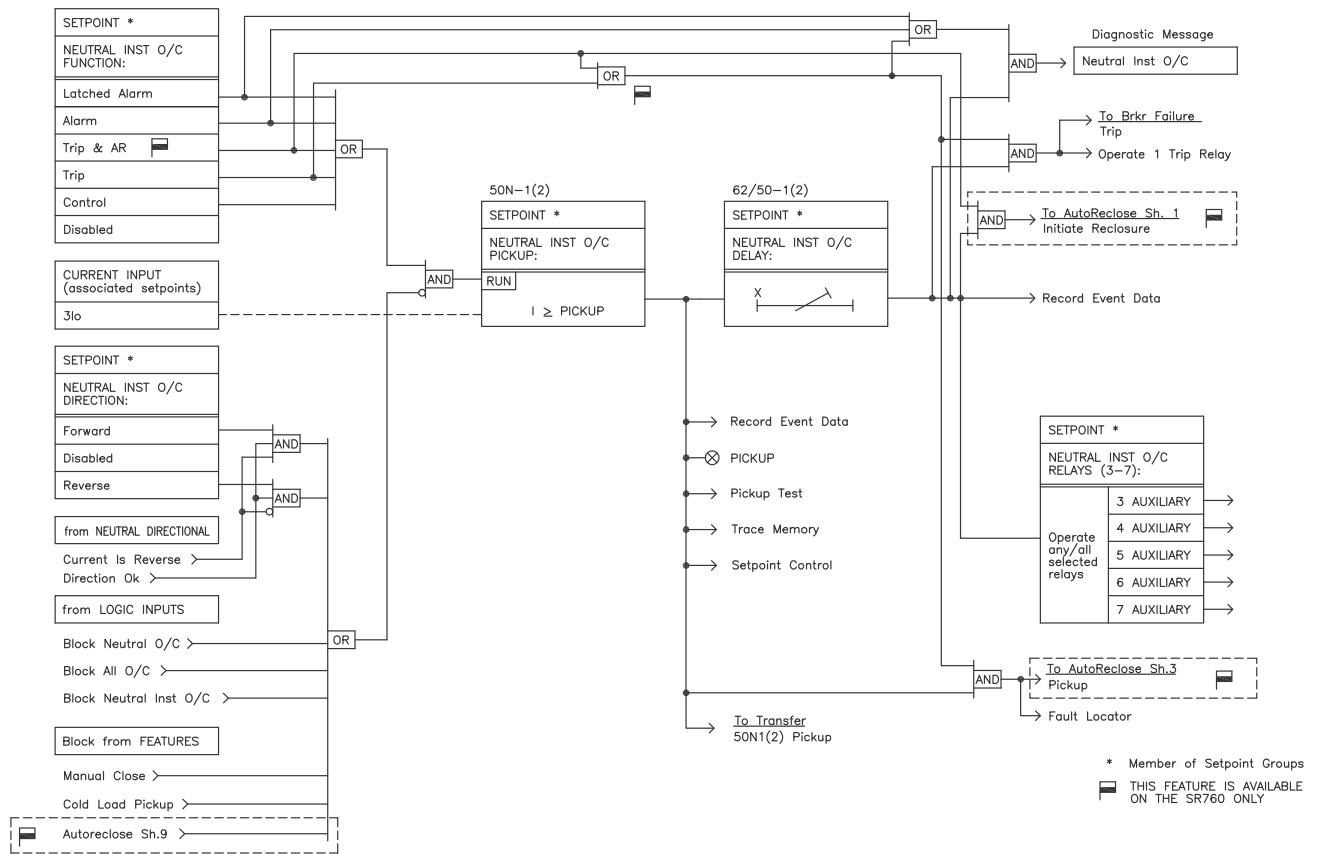


FIGURE 5-12: Neutral IOC Logic

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### Neutral Directional Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ NEUTRAL CURRENT ▾ ▾ NEUTRAL DIRECTIONAL

<b>NEUTRAL DIRECTIONAL</b> [▶]		<b>NEUTRAL DIRECTIONAL FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm,
MESSAGE		<b>NEUTRAL DIRECTIONAL RELAYS (3-7): - - - -</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>NEUTRAL POLARIZING: Voltage</b>	Range: Voltage, Current, Dual
MESSAGE		<b>NEUTRAL DIRECTIONAL MTA: 315° Lead</b>	Range: 0 to 359° Lead in steps of 1
MESSAGE		<b>MIN POLARIZING VOLTAGE: 0.05 x VT</b>	Range: 0.00 to 1.25 x VT in steps of 0.01

The Neutral Directional feature controls the operation of all neutral overcurrent elements and allows them to discriminate between forward or reverse faults. Refer to *Phase Directional Overcurrent* on page 5-54 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 **MIN OPERATING VOLTAGE** value, the direction defaults to forward. The following table shows the operating current and polarizing voltage used for neutral directional control

**Table 5-12: Neutral Directional Characteristics**

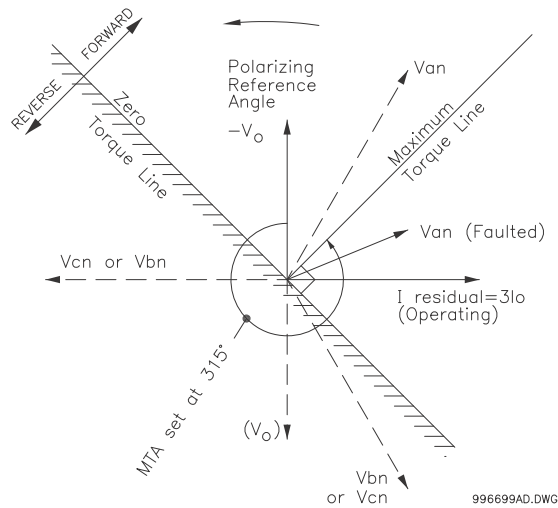
Quantity	Operating Current	Polarizing Voltage (VT connection = Wye)	Polarizing Current
Neutral	$3I_o = I_a + I_b + I_c$	$-V_o = -(V_a + V_b + V_c) / 3$	$I_g$ (see note below)



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 *Current Inputs* on page 3-11 for additional details.

When current polarized the Ground CT Input (Terminals G10 and 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  $\pm 90^\circ$  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 5-13: Neutral Directional Voltage Polarization**

The Neutral Directional specific setpoints are described below.

- **NEUTRAL POLARIZING:** 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:** Enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity. This setpoint affects voltage polarizing only. Additional information is provided in the figure above.
- MIN POLARIZING VOLTAGE:** This setpoint 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 × VT" is appropriate for most solidly grounded systems.

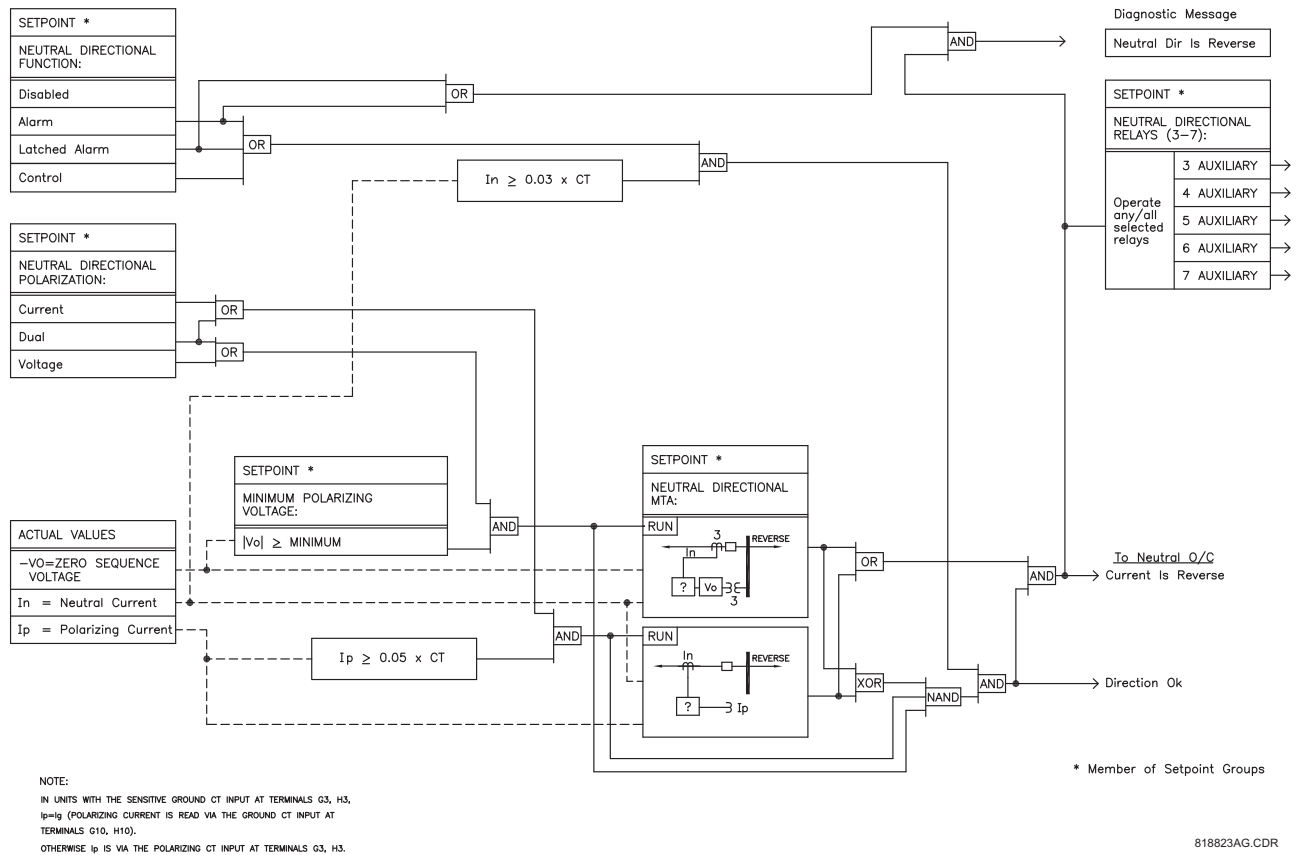


FIGURE 5-14: Neutral Directional Logic

### 5.6.5 Ground Current

#### Main Menu

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ GROUND CURRENT

■ GROUND CURRENT [▷]	◀ ▶	■ GROUND TIME OVERCURRENT [▷]	See page 5-64
MESSAGE	◀ ▶	■ GROUND INST OVERCURRENT [▷]	See page 5-65
MESSAGE	◀ ▶	■ GROUND DIRECTIONAL [▷]	See page 5-66

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.

#### Ground Time Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ GROUND CURRENT ▾ GROUND TIME OVERCURRENT

■ GROUND TIME OVERCURRENT [▷]	◀ ▶	GND TIME OC FUNCTION: Disabled	Range: Disabled, Trip, Trip & AR, Alarm, Latched
MESSAGE	◀ ▶	GND TIME OC RELAYS (3-7): - - - - -	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE	◀ ▶	GND TIME OC PICKUP: 1.00 x CT	Range: 0.05 to 20.00 x CT in steps of 0.01
MESSAGE	◀ ▶	GND TIME OC CURVE: Ext. Inverse	Range: See TOC Curve Selections on page
MESSAGE	◀ ▶	GND TIME OC MULTIPLIER: 1.00	Range: 0.00 to 100.00 in steps of 0.01
MESSAGE	◀ ▶	GND TIME OC RESET: Instantaneous	Range: Instantaneous, Linear
MESSAGE	◀ ▶	GND TIME OC DIRECTION: Disabled	Range: Disabled, Forward, Reverse

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

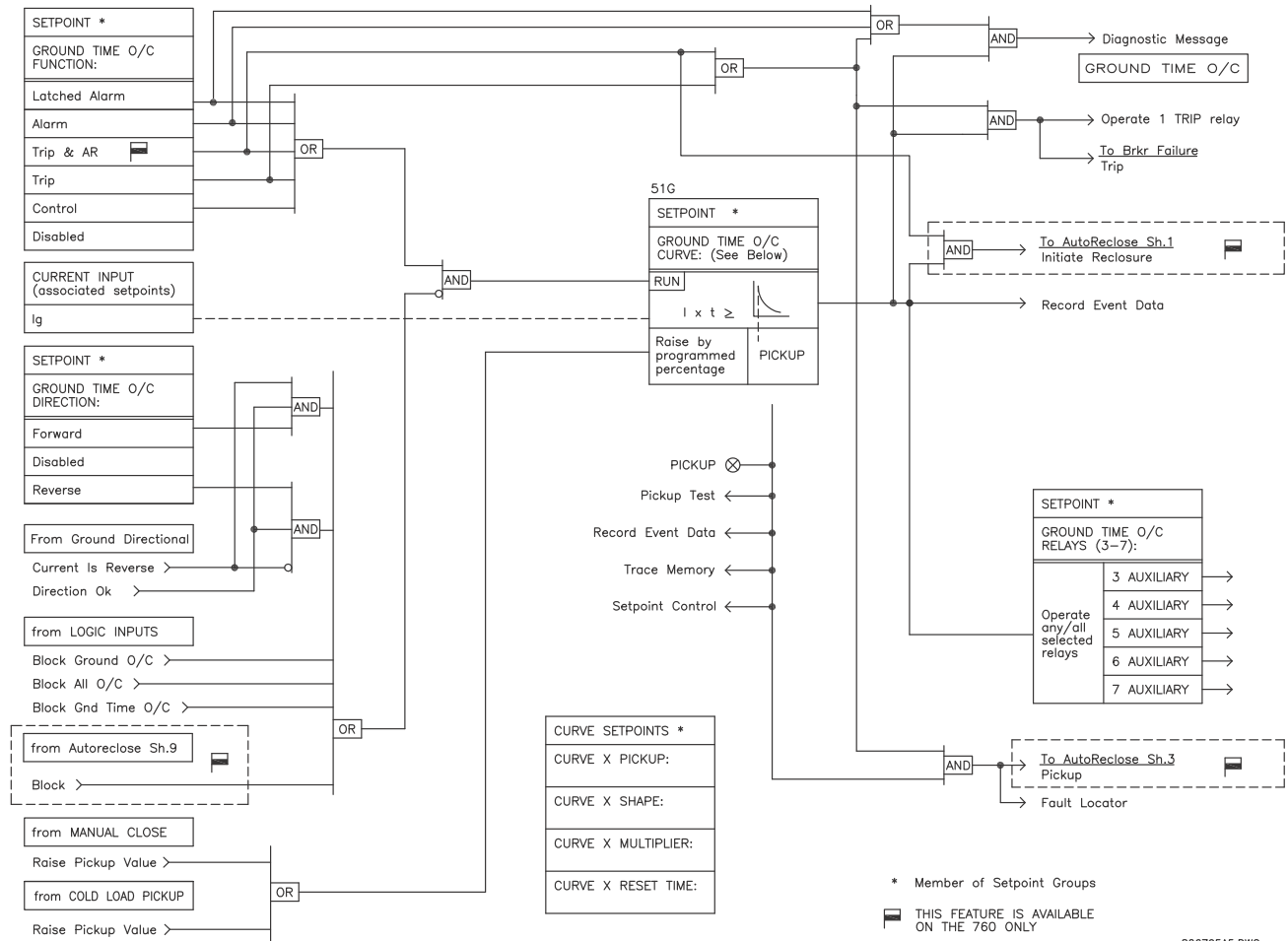


FIGURE 5-15: Ground TOC Logic

### Ground Instantaneous Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ GROUND CURRENT ▾ ▾ GRND INST OVERCURRENT

<b>■ GROUND INST OVERCURRENT</b> [▷]		<b>GND INST OC FUNCTION: Disabled</b>	Range: Disabled, Trip, Trip & AR, Alarm, Latched
MESSAGE		<b>GND INST OC RELAYS (3-7): -----</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>GND INST OC PICKUP: 1.00 x CT</b>	Range: 0.05 to 20.00 x CT in steps of 0.01
MESSAGE		<b>GND INST OC DELAY: 0.00 s</b>	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE		<b>GND INST OC DIRECTION: Disabled</b>	Range: Disabled, Forward, Reverse

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

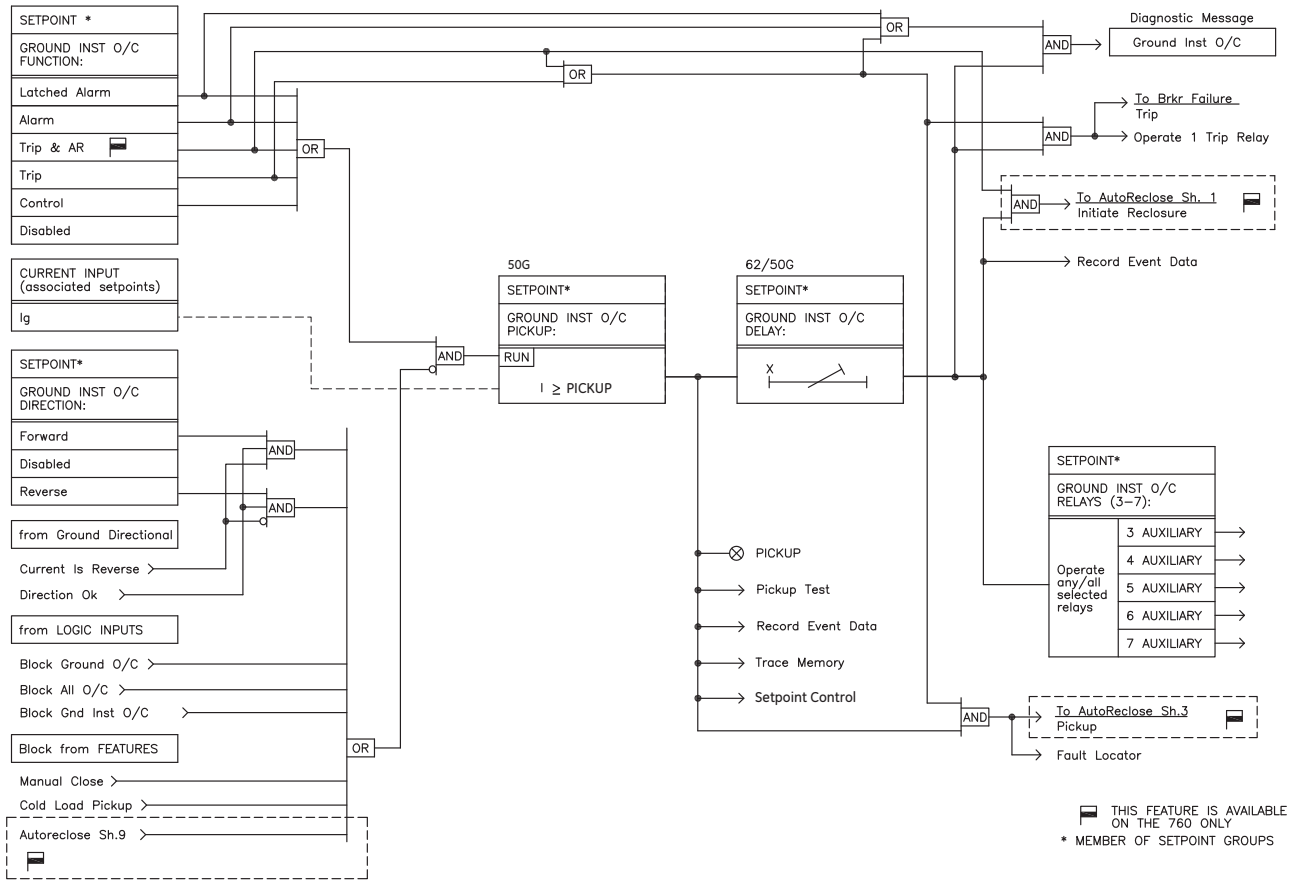


FIGURE 5-16: Ground IOC Logic

### Ground Directional Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ GROUND CURRENT ▾ ▾ GROUND DIRECTIONAL

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>GROUND DIRECTIONAL</b> [▷]         </div>	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>GND DIRECTIONAL FUNCTION: Disabled</b> </div>	<i>Range: Disabled, Alarm, Latched Alarm,</i>
MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>GND DIRECTIONAL RELAYS (3-7): -----</b> </div>	<i>Range: Any combination of 3 to 7 Auxiliary relays</i>
MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>GND POLARIZING Voltage</b> </div>	<i>Range: Voltage, Current, Dual</i>
MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>GND DIRECTIONAL MTA: 315° Lead</b> </div>	<i>Range: 0 to 359° Lead in steps of 1</i>
MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>MIN POLARIZING VOLTAGE: 0.05 x VT</b> </div>	<i>Range: 0.00 to 1.25 x VT in steps of 0.01</i>

The Ground Directional feature controls operation of all ground overcurrent elements and allows them to discriminate between forward or reverse faults. Refer to *Phase Directional Overcurrent* on page 5–54 for additional 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 **MIN OPERATING VOLTAGE** value, the direction defaults to forward. The following table shows the operating current and polarizing quantities used for ground directional control.

**Table 5–13: Ground Directional Characteristics**

Quantity	Operating Current	Polarizing Voltage (VT connection = Wye)	Polarizing Current
Ground	$I_g$	$-V_0 = -(V_a + V_b + V_c) / 3$	$I_{pol}$ (see note below)



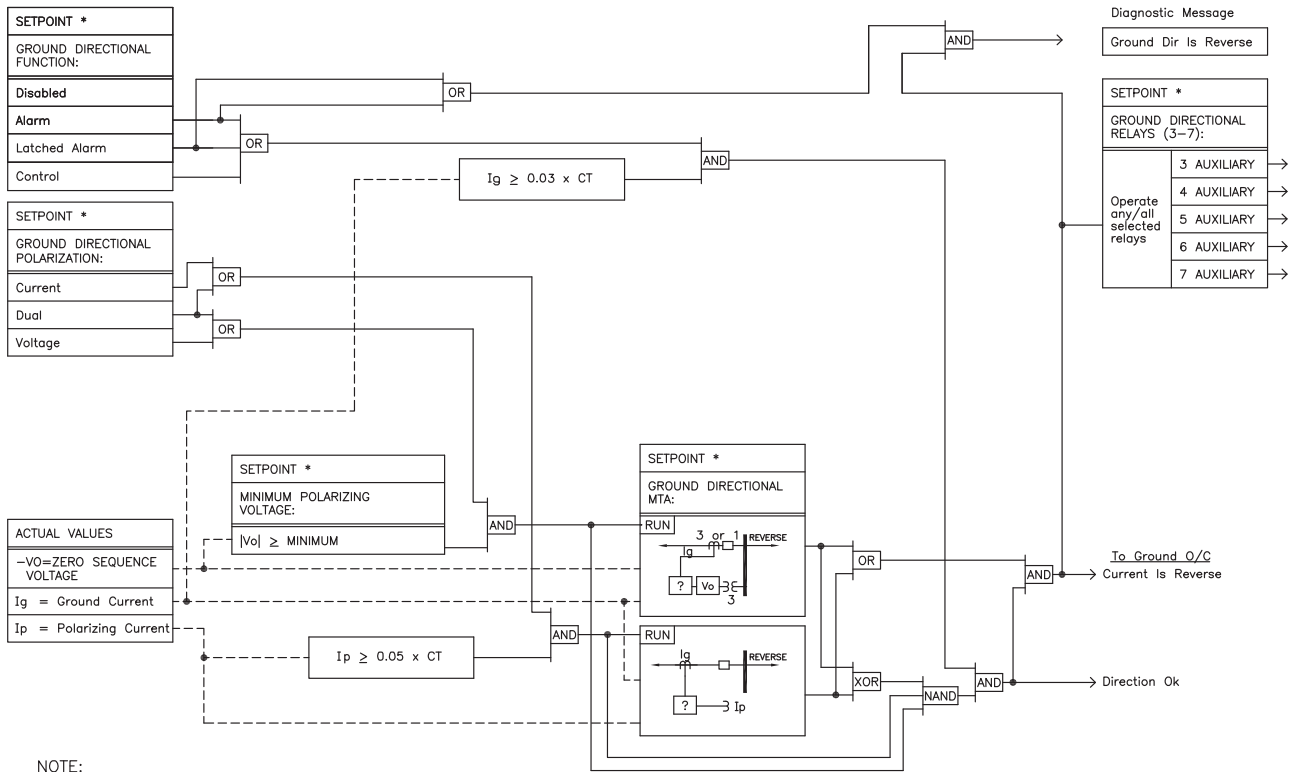
NOTE

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 *Current Inputs* on page 3–11 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 ground current is within  $\pm 90^\circ$  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.

- **GND POLARIZING:** 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”.
- **GND DIRECTIONAL MTA:** Enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity. This setpoint affects voltage polarizing only.
- **MIN POLARIZING VOLTAGE:** This setpoint 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.



NOTE:

CURRENT AND DUAL POLARIZATION ARE NOT AVAILABLE WITHOUT THE POLARIZING CT INPUT (TERMINALS G3, H3). IF THE SENSITIVE GROUND CT INPUT IS AT G3, H3 GROUND DIRECTIONAL CAN ONLY BE VOLTAGE POLARIZED.

\* Member of Setpoint Groups

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FIGURE 5-17: Ground Directional Overcurrent Logic

### 5.6.6 Sensitive Ground

#### Main Menu

PATH: SETPOINTS ▷ S5 PROTECTION ▷ SENSITIVE GND CURRENT

<b>SENSITIVE GND CURRENT</b> [▷]	◀ ▶	<b>SENSITIVE GND TIME OVERCURRENT</b> [▷]	See page 5-69
MESSAGE	⌌	<b>SENSITIVE GND INST OVERCURRENT</b> [▷]	See page 5-70
MESSAGE	⌌	<b>SENSITIVE GND DIRECTIONAL</b> [▷]	See page 5-71
MESSAGE	⌌	<b>RESTRICTED EARTH FAULT</b> [▷]	See page 5-73

Two sensitive ground overcurrent elements and a restricted earth fault element 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.

### Sensitive Ground Time Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ SENSITIVE GND CURRENT ▾ SENSITIVE GND TIME...

<p>■ SENSITIVE GND TIME OVERCURRENT [▷]</p>		<p>SENSTV GND TIME OC FUNCTION: Disabled</p>	<p>Range: Disabled, Trip, Trip &amp; AR, Alarm, Latched</p>
<p>MESSAGE</p>		<p>SENSTV GND TIME OC RELAYS (3-7): -----</p>	<p>Range: Any combination of 3 to 7 Auxiliary relays</p>
<p>MESSAGE</p>		<p>SENSTV GND TIME OC PICKUP: 1.000 x CT</p>	<p>Range: 0.005 to 1.000 x CT in steps of 0.001</p>
<p>MESSAGE</p>		<p>SENSTV GND TIME OC CURVE: Ext. Inverse</p>	<p>Range: See Table 5-4: TOC Curve Selections on</p>
<p>MESSAGE</p>		<p>SENSTV GND TIME OC MULTIPLIER: 1.00</p>	<p>Range: 0.00 to 100.00 in steps of 0.01</p>
<p>MESSAGE</p>		<p>SENSTV GND TIME OC RESET: Instantaneous</p>	<p>Range: Instantaneous, Linear</p>
<p>MESSAGE</p>		<p>SENSTV GND TIME OC DIRECTION: Disabled</p>	<p>Range: Disabled, Forward, Reverse</p>

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

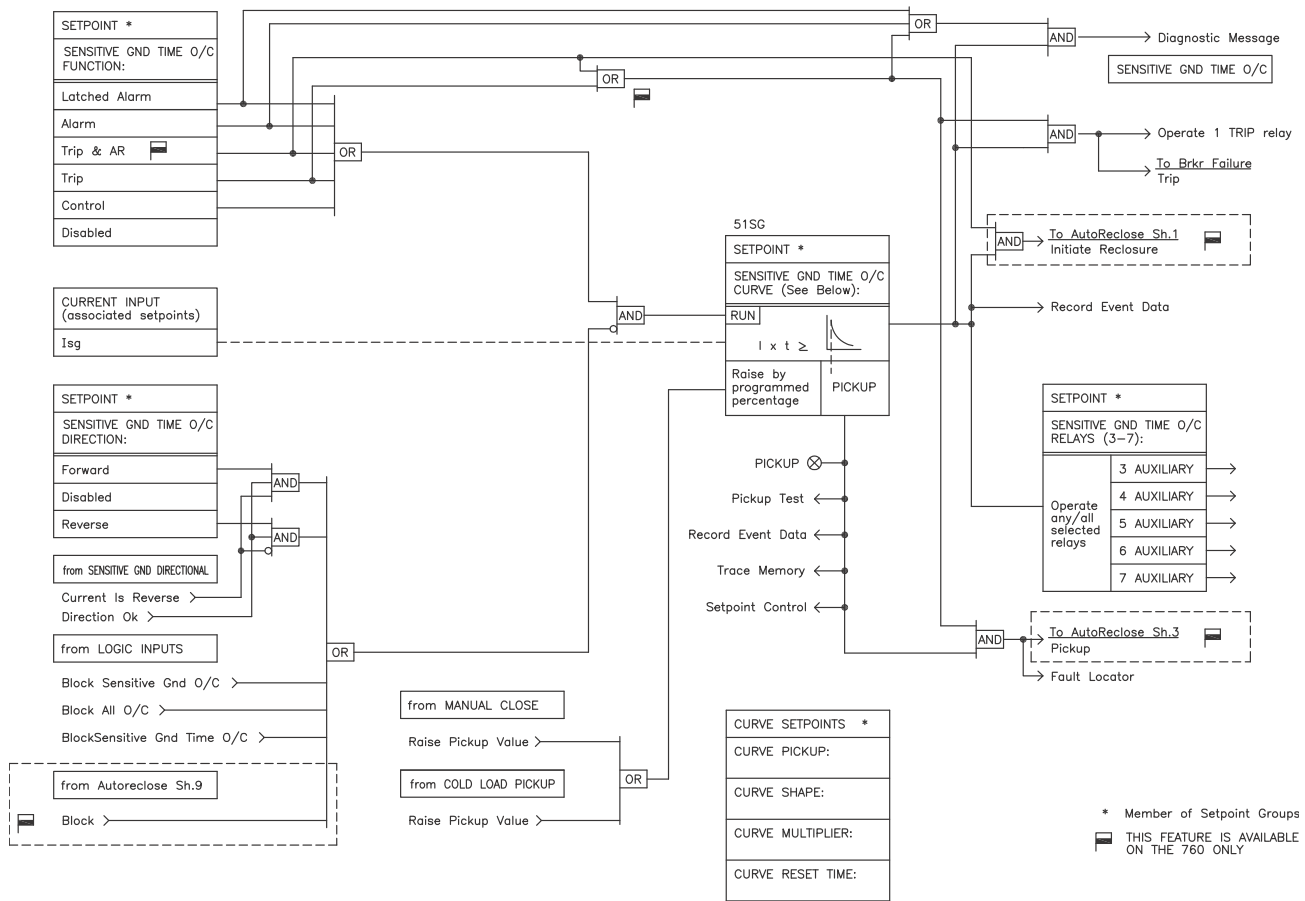


FIGURE 5-18: Sensitive Ground TOC Logic

### Sensitive Ground Instantaneous Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ SENSITIVE GND... ▾ ▾ SENSITIVE GND INST...

<p><b>SENSITIVE GND INST OVERCURRENT</b> [▷]</p>	<p><b>SENSTV GND INST OC FUNCTION: Disabled</b></p>	<p>Range: Disabled, Trip, Trip &amp; AR, Alarm, Latched</p>
<p>MESSAGE</p>	<p><b>SENSTV GND INST OC RELAYS (3-7): -----</b></p>	<p>Range: Any combination of 3 to 7 Auxiliary relays</p>
<p>MESSAGE</p>	<p><b>SENSTV GND INST OC PICKUP: 1.000 x CT</b></p>	<p>Range: 0.005 to 1.000 x CT in steps of 0.001</p>
<p>MESSAGE</p>	<p><b>SENSTV GND INST OC DELAY: 0.00 s</b></p>	<p>Range: 0.00 to 600.00 s in steps of 0.01</p>
<p>MESSAGE</p>	<p><b>SENSTV GND INST OC DIRECTION: Disabled</b></p>	<p>Range: Disabled, Forward, Reverse</p>

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



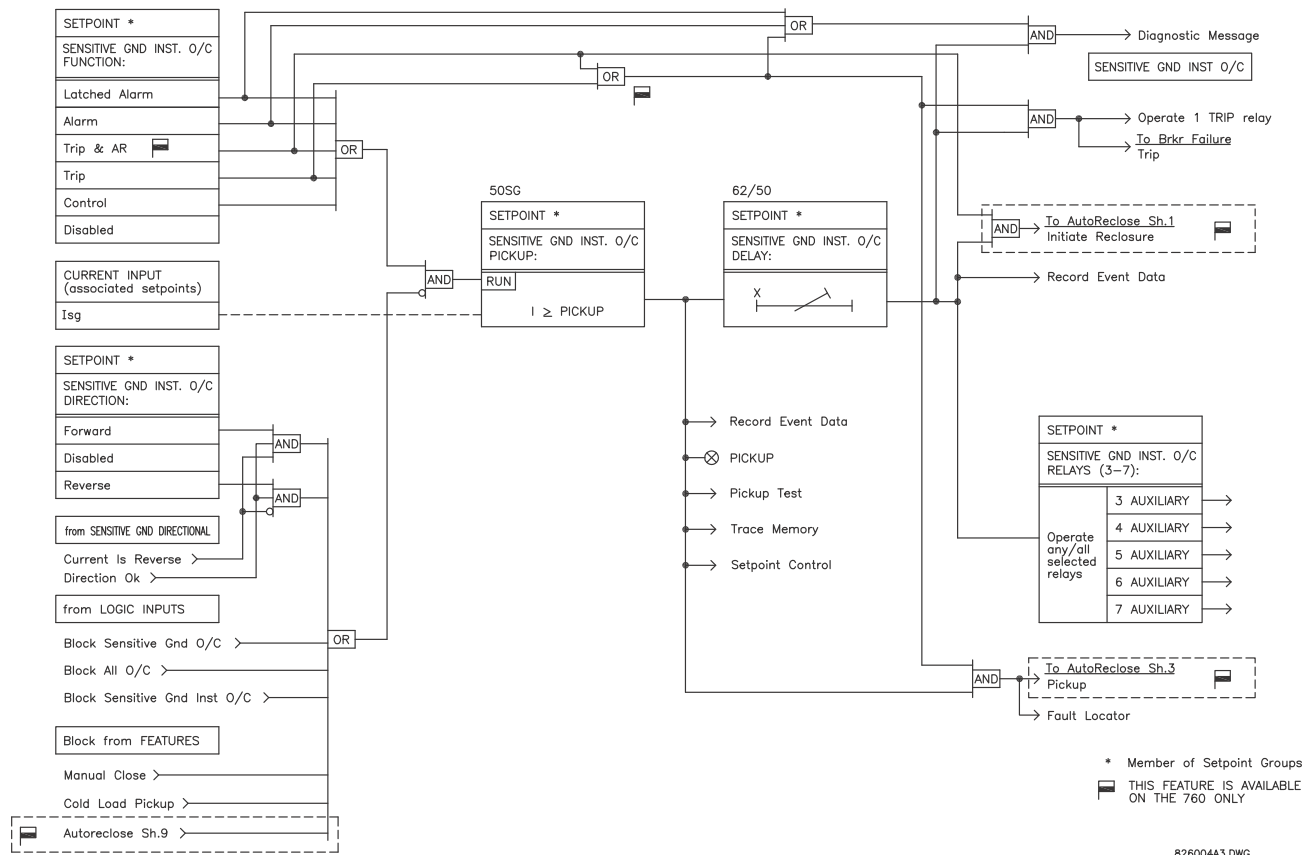


FIGURE 5-19: Sensitive Ground IOC Logic

### Sensitive Ground Directional Overcurrent

PATH: SETPOINTS ▾ ▽ S5 PROTECTION ▾ ▽ SENSITIVE GND... ▾ ▽ SENSITIVE GND DIRECTIONAL

<b>SENSITIVE GND DIRECTIONAL</b> [▷]		<b>SENSIV GND DIRECTN FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm,
MESSAGE		<b>SENSIV GND DIRECTN RELAYS (3-7): -----</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>SENS GND POLARIZING Voltage</b>	Range: Voltage, Current, Dual
MESSAGE		<b>SENSIV GND DIRECTN MTA: 315° Lead</b>	Range: 0 to 359° Lead in steps of 1
MESSAGE		<b>MIN POLARIZING VOLTAGE: 0.05 x VT</b>	Range: 0.00 to 1.25 x VT in steps of 0.01

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 *Phase Directional Overcurrent* on page 5-54 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 **MIN OPERATING VOLTAGE** value, the direction defaults to forward. The following table shows the operating current and polarizing quantities used for sensitive ground directional control.

**Table 5-14: Sensitive Ground Directional Characteristics**

Quantity	Operating Current	Polarizing Voltage (VT connection = Wye)	Polarizing Current
Sensitive Ground	$I_{sg}$	$-V_o = -(V_a + V_b + V_c) / 3$	$I_g$ (see note below)



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 *Current Inputs* on page 3-11 for more details.

When current polarized, the Ground 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  $\pm 90^\circ$  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.

- **SENS GND POLARIZING:** If sensitive ground directional control with both voltage and current polarized elements is desired, enter “Dual”. With this setpoint, 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:** Enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity. This setpoint affects voltage polarizing only.
- **MIN POLARIZING VOLTAGE:** This setpoint 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.

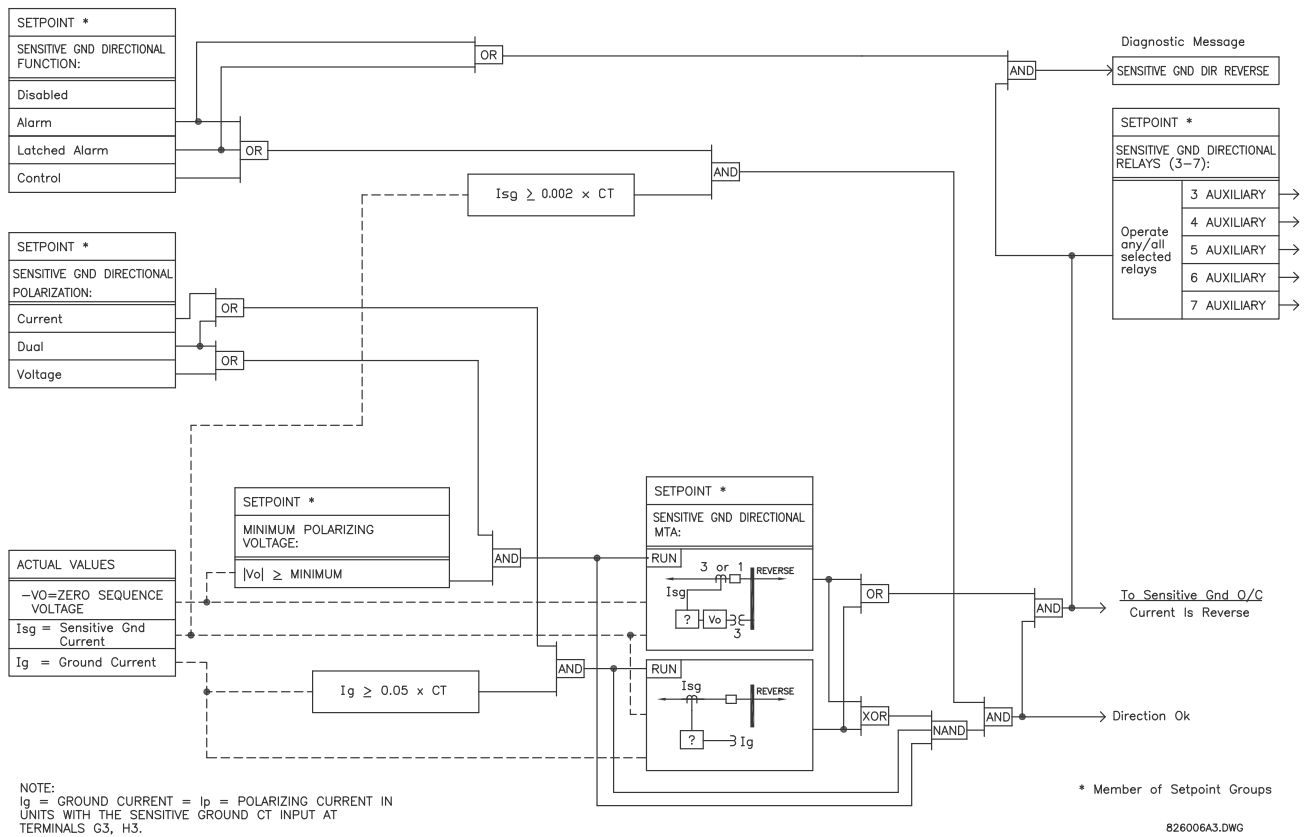


FIGURE 5-20: Sensitive Ground Directional Logic

### Restricted Earth Fault

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ SENSTV GND CURRENT ▾ ▾ RESTRICTED EARTH...

<b>RESTRICTED EARTH FAULT</b> [▷]	◀ ▶	<b>RESTRICTED EARTH FLT FUNCTION: Disabled</b>	Range: Disabled, Trip, Alarm, Latched Alarm,
MESSAGE	◀ ▶	<b>RESTRICTED EARTH FLT RELAYS (3-7): - - - - -</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE	◀ ▶	<b>RESTRICTED EARTH FLT PICKUP: 0.100 x CT</b>	Range: 0.005 to 1.000 x CT in steps of 0.001
MESSAGE	◀ ▶	<b>RESTRICTED EARTH FLT DELAY: 0.00 s</b>	Range: 0.00 to 600.00 s in steps of 0.01

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 V. Refer to *Restricted Earth Fault Inputs* on page 3–12 for the connections required to use the 750/760 to perform Restricted Earth Fault protection.

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

$$R_S = \frac{V_S}{I_S} = \frac{I_F \cdot (R_{CT} + 2R_L)}{I_S} \quad \text{(EQ 5.5)}$$

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, and  $R_L$  = resistance of attached wire leads

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,

$$V_K = 2V_S \quad \text{(EQ 5.6)}$$

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

$$V_f = I_f \cdot (R_{CT} + 2R_L + R_S) \quad \text{(EQ 5.7)}$$

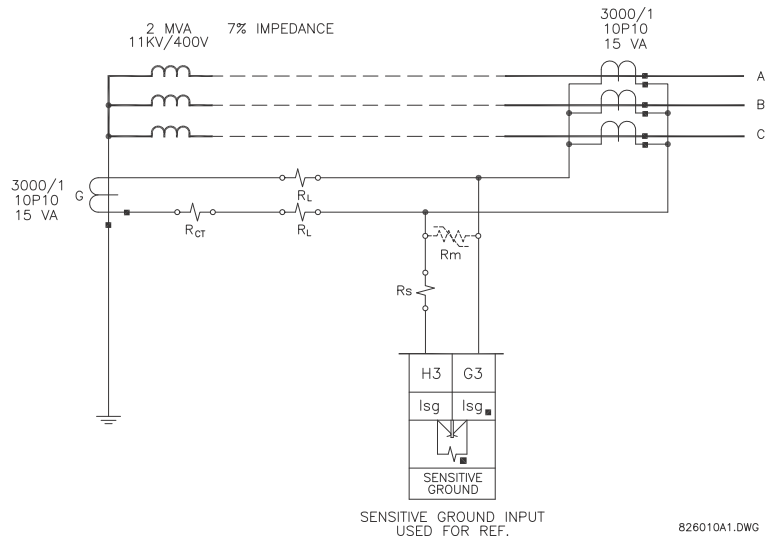
The peak value of this fault voltage would be:

$$V_p = 2\sqrt{2} \cdot \sqrt{V_K \cdot (V_f - V_K)} \quad \text{(EQ 5.8)}$$

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

### 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 / 400 V, 2000 kVA. At 10P10 the voltage at which the CT will saturate will be  $10 \times 15 = 150$  V. An equivalent IEEE description for this CT would be 3000/1, C150.



**FIGURE 5-21: Restricted Earth Fault Sample Application**

We have:  $R_{CT} = 3.7 \Omega$ ,  $R_L = 0.954 \Omega$  (assuming 600 feet of #12 wire), and  $X(\%) =$  impedance of transformer =  $7\% = 0.07$

The rated transformer current through wye windings is given as:

$$I_P = \frac{2000 \text{ kVA}}{\sqrt{3} \cdot 400 \text{ V}} = 2887 \text{ A} \quad \text{(EQ 5.9)}$$

and the maximum fault current is:

$$I_{MAXf} = \frac{I_P}{X(\%)} = \frac{2887 \text{ A}}{0.07} = 41243 \text{ A} \quad \text{(EQ 5.10)}$$

Therefore, the secondary full load current is:

$$I_{SFLC} = \frac{2887 \text{ A}}{3000} = 0.962 \text{ A} \quad \text{(EQ 5.11)}$$

and the maximum secondary fault current is:

$$I_{Smax} = \frac{0.962 \text{ A}}{0.07} = 13.74 \text{ A} = I_f \quad \text{(EQ 5.12)}$$

A  $V_K / V_S$  ratio of 2 is assumed to ensure operation. As such,

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

$$V_K = 2V_S = 154.1 \text{ V}$$

To calculate the size of the stabilizing resistor, assume  $I_{PICKUP}$  to be 30% rated transformer current, that is:

$$I_{PICKUP} = 0.3 \times 2887 \text{ A} = 866 \text{ A (Primary)} \quad \text{(EQ 5.13)}$$

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

$$I_{RELAY PICKUP} = \frac{866 \text{ A}}{3000} - (4 \times 0.01) = 0.248 \text{ A} = I_S \quad \text{(EQ 5.14)}$$

and therefore:

$$R_s = \frac{V_s}{I_s} = \frac{77.05 \Omega}{0.248 A} = 311 \Omega \tag{EQ 5.15}$$

To determine whether a non-linear resistor is required, we have:

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

$$V_p = 2\sqrt{2} \cdot \sqrt{V_K \cdot (V_f - V_K)} \rightarrow \text{use } 150 V \text{ as value for } V_K \tag{EQ 5.16}$$

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

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

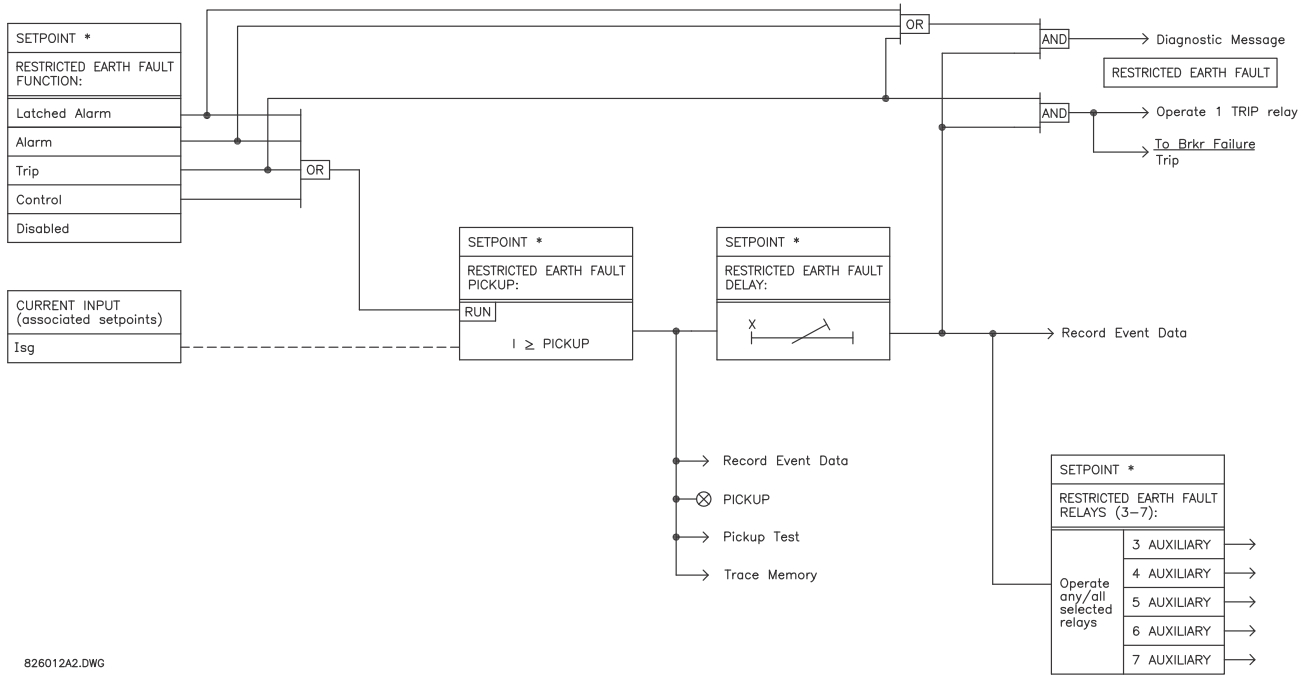


FIGURE 5-22: Restricted Earth Fault Logic

### 5.6.7 Negative Sequence

#### Main Menu

PATH: SETPOINTS ▾ S5 PROTECTION ▾ NEGATIVE SEQUENCE

■ <b>NEGATIVE SEQUENCE</b> [▷]	◀ ▶	■ <b>NEG SEQUENCE TIME OVERCURRENT</b> [▷]	See page 5-77
MESSAGE	◀ ▶	■ <b>NEG SEQUENCE INST OVERCURRENT</b> [▷]	See page 5-78
MESSAGE	◀ ▶	■ <b>NEG SEQUENCE DIRECTIONAL</b> [▷]	See page 5-79
MESSAGE	◀ ▶	■ <b>NEG SEQUENCE VOLTAGE</b> [▷]	See page 5-81

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.

### Negative Sequence Time Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ NEGATIVE SEQUENCE ▾ NEG SEQUENCE TIME...

<p>■ <b>NEG SEQUENCE TIME OVERCURRENT</b> [▷]</p>		<p><b>NEG SEQ TIME OC</b> <b>FUNCTION: Disabled</b></p>	<p>Range: Disabled, Trip, Trip &amp; AR, Alarm, Latched</p>
<p>MESSAGE</p>		<p><b>NEG SEQ TIME OC</b> <b>RELAYS (3-7): -----</b></p>	<p>Range: Any combination of 3 to 7 Auxiliary relays</p>
<p>MESSAGE</p>		<p><b>NEG SEQ TIME OC</b> <b>PICKUP: 1.00 x CT</b></p>	<p>Range: 0.05 to 20.00 x CT in steps of 0.01</p>
<p>MESSAGE</p>		<p><b>NEG SEQ TIME OC</b> <b>CURVE: Ext. Inverse</b></p>	<p>Range: See Table 5-4: TOC Curve Selections on</p>
<p>MESSAGE</p>		<p><b>NEG SEQ TIME OC</b> <b>MULTIPLIER: 1.00</b></p>	<p>Range: 0.00 to 100.00 in steps of 0.01</p>
<p>MESSAGE</p>		<p><b>NEG SEQ TIME OC</b> <b>RESET: Instantaneous</b></p>	<p>Range: Instantaneous, Linear</p>
<p>MESSAGE</p>		<p><b>NEG SEQ TIME OC</b> <b>DIRECTION: Disabled</b></p>	<p>Range: Disabled, Forward, Reverse</p>

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

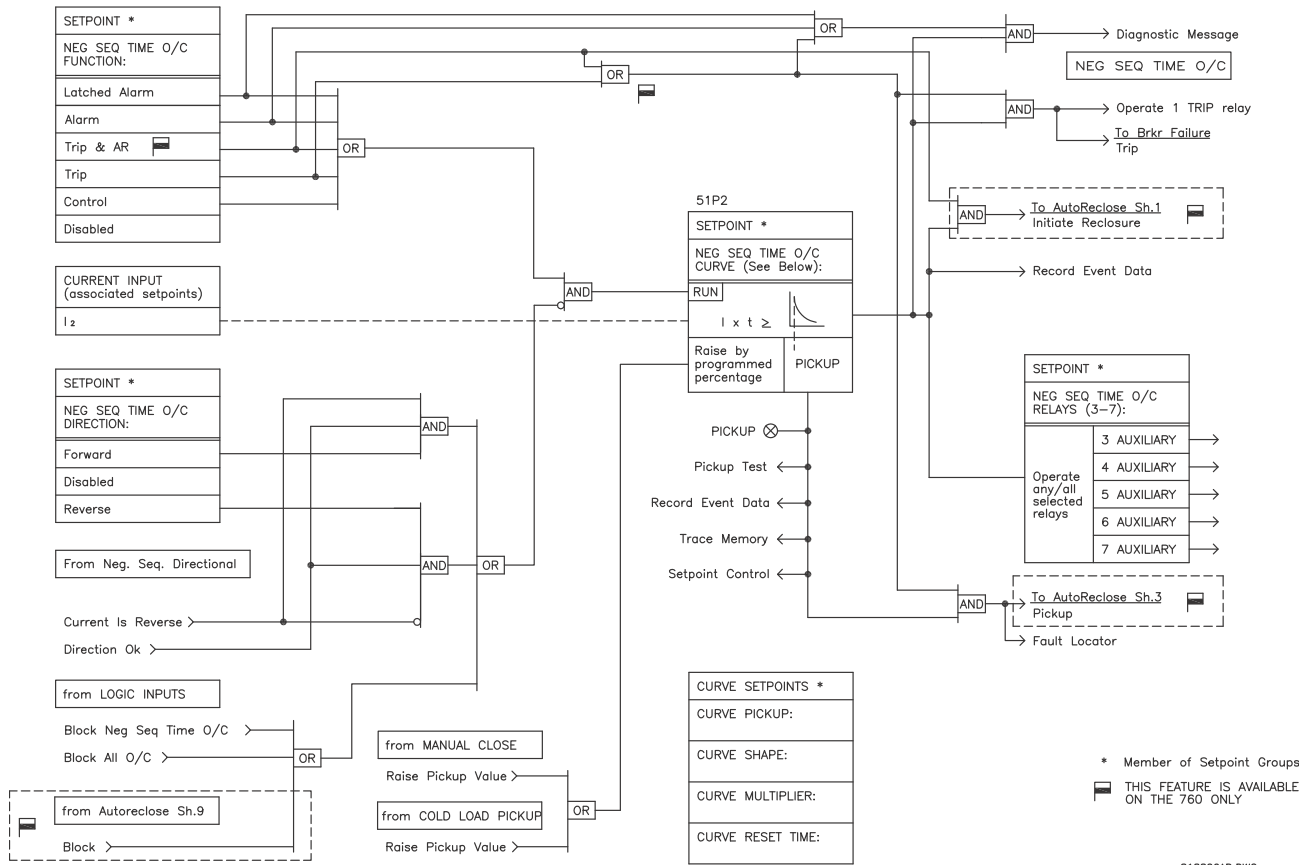


FIGURE 5-23: Negative Sequence TOC Logic

### Negative Sequence Instantaneous Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ NEGATIVE SEQUENCE ▾ ▾ NEG SEQUENCE INST...

<p><b>■ NEG SEQUENCE INST OVERCURRENT</b> [▷]</p>		<p><b>NEG SEQ INST OC FUNCTION: Disabled</b></p>	<p>Range: Disabled, Trip, Trip &amp; AR, Alarm, Latched</p>
<p>MESSAGE</p>		<p><b>NEG SEQ INST OC RELAYS (3-7): - - - -</b></p>	<p>Range: Any combination of 3 to 7 Auxiliary relays</p>
<p>MESSAGE</p>		<p><b>NEG SEQ INST OC PICKUP: 1.000 x CT</b></p>	<p>Range: 0.05 to 20.00 x CT in steps of 0.001</p>
<p>MESSAGE</p>		<p><b>NEG SEQ INST OC DELAY: 0.00 s</b></p>	<p>Range: 0.00 to 600.00 s in steps of 0.01</p>
<p>MESSAGE</p>		<p><b>NEG SEQ INST OC DIRECTION: Disabled</b></p>	<p>Range: Disabled, Forward, Reverse</p>

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



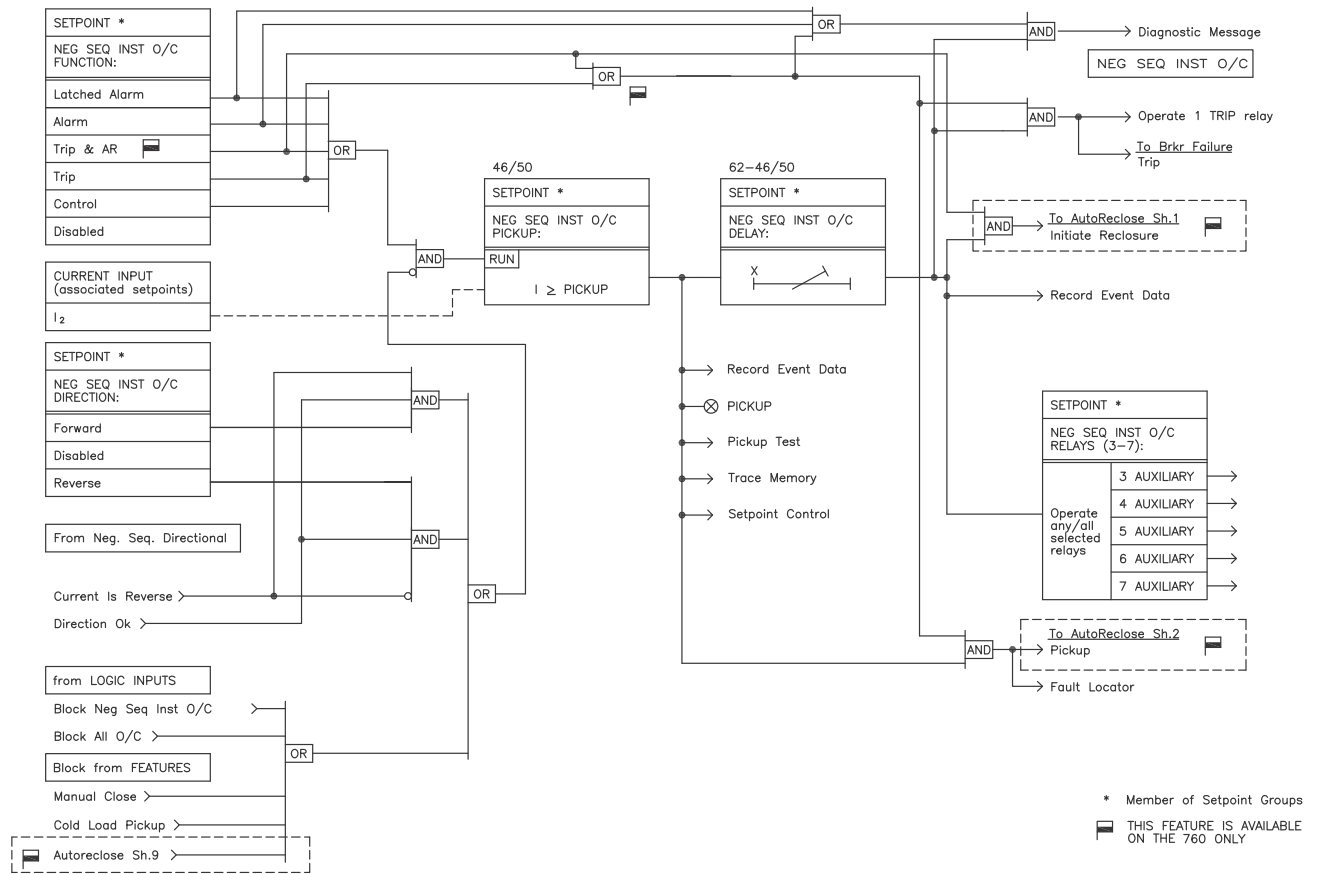


FIGURE 5-24: Negative Sequence IOC Logic

### Negative Sequence Directional Overcurrent

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ NEGATIVE SEQUENCE ▾ ▾ NEG SEQUENCE DIR...

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>NEG SEQUENCE DIRECTIONAL</b> [▷]         </div>		<b>NEG SEQ DIRECTIONAL FUNCTION: Disabled</b>	<i>Range: Disabled, Alarm, Latched Alarm, Control</i>
MESSAGE		<b>NEG SEQ DIRECTIONAL RELAYS (3-7): -----</b>	<i>Range: Any combination of 3 to 7 Auxiliary relays</i>
MESSAGE		<b>NEG SEQ DIRECTIONAL MTA: 315° Lead</b>	<i>Range: 0 to 359° Lead in steps of 1</i>
MESSAGE		<b>MIN POLARIZING VOLTAGE: 0.05 x VT</b>	<i>Range: 0.00 to 1.25 x VT in steps of 0.01</i>

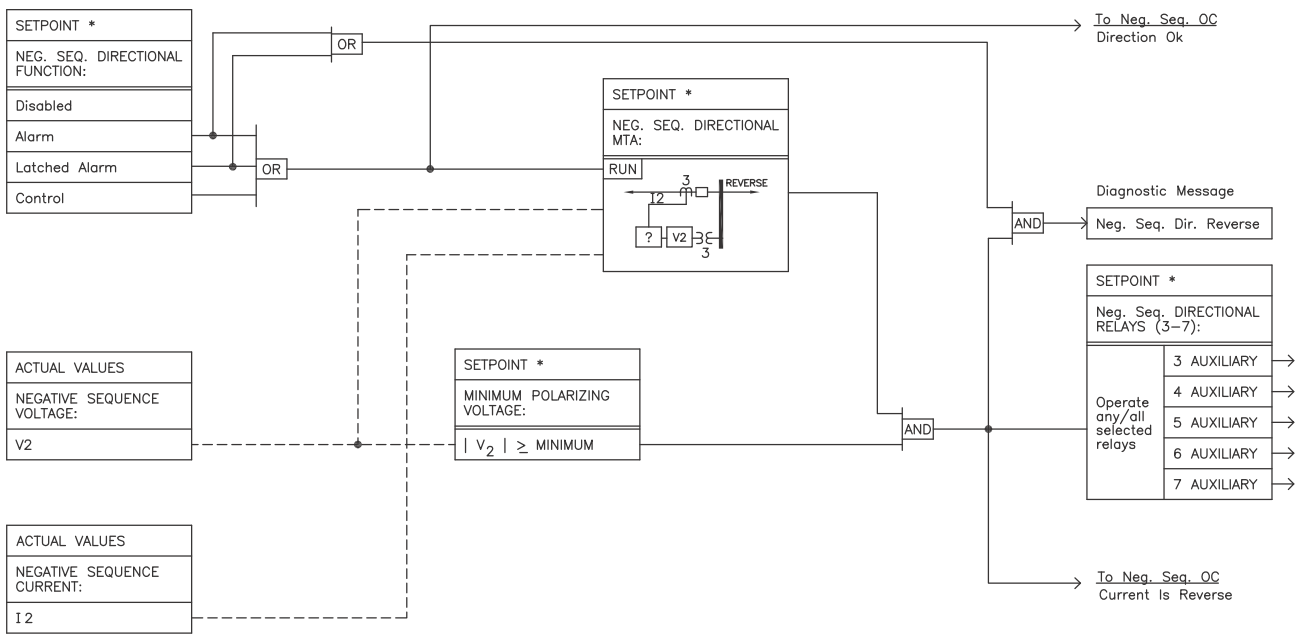
The negative sequence directional feature controls the operation of all negative sequence overcurrent elements and allows them to discriminate between forward or reverse faults. Refer to *Phase Directional Overcurrent* on page 5-54 for more details on directional principles. The operating current and polarizing voltage is shown in the following table. If the polarizing voltage drops below the **MIN OPERATING VOLTAGE** value, the direction defaults to forward.

Table 5–15: 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 described below.

- **NEG SEQ DIRECTIONAL MTA:** Enter the maximum torque angle by which the operating current leads the polarizing voltage. This is the angle of maximum sensitivity.
- **MIN POLARIZING VOLTAGE:** 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.



\* Member Of Setpoint Groups

826001A4.DWG

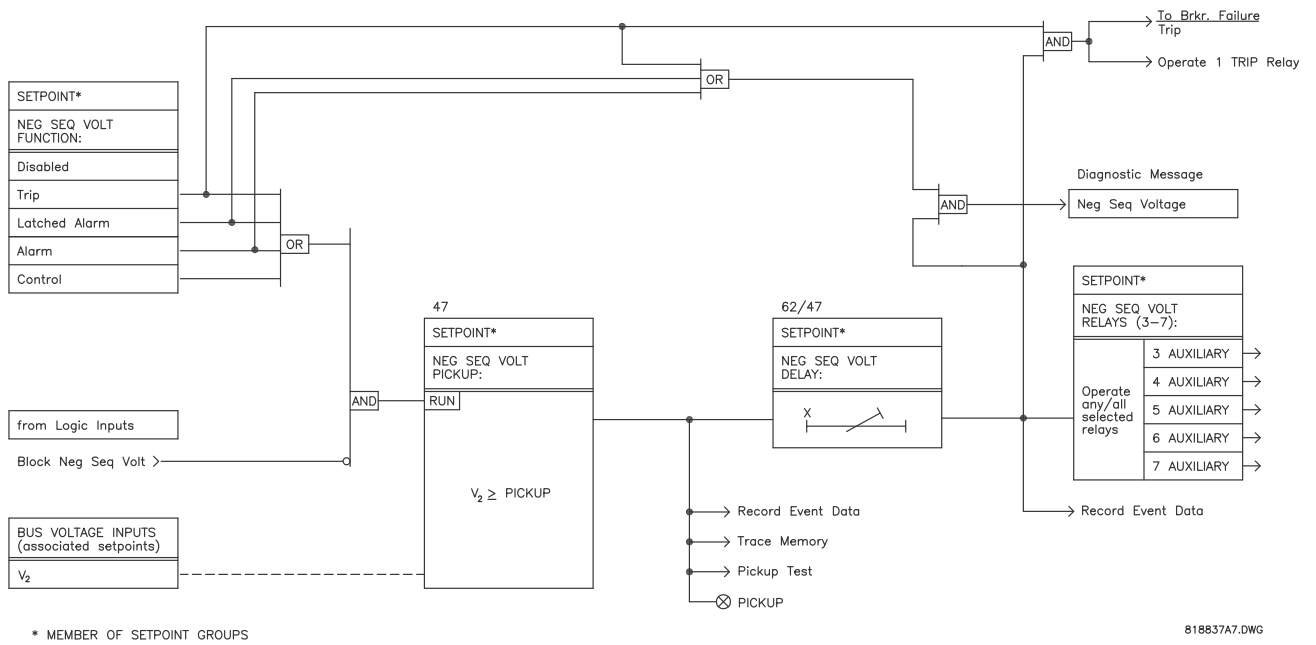
FIGURE 5–25: Negative Sequence Directional Logic

### Negative Sequence Voltage

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ NEGATIVE SEQUENCE ▾ ▾ NEG SEQUENCE VOLTAGE

<div style="border: 1px solid black; padding: 2px;"> <b>■ NEG SEQUENCE VOLTAGE</b> [▶]             </div>		<div style="border: 1px solid black; padding: 2px;"> <b>NEG SEQ VOLTAGE FUNCTION: Disabled</b> </div>	<i>Range: Disabled, Trip, Alarm, Latched Alarm,</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>NEG SEQ VOLTAGE RELAYS (3-7): -----</b> </div>	<i>Range: Any combination of 3 to 7 Auxiliary relays</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>NEG SEQ VOLTAGE PICKUP: 0.10 x VT</b> </div>	<i>Range: 0.00 to 1.25 x VT in steps of 0.01</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>NEG SEQ VOLTAGE DELAY: 2.0 s</b> </div>	<i>Range: 0.0 to 6000.0 s in steps of 0.1</i>

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.










\* MEMBER OF SETPOINT GROUPS

FIGURE 5-26: Negative Sequence Voltage Logic

### 5.6.8 Voltage

#### Main Menu

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ VOLTAGE

■ VOLTAGE [▷]		■ BUS UNDERVOLTAGE 1 [▷]	See page 5-83
MESSAGE 		■ BUS UNDERVOLTAGE 2 [▷]	See page 5-83
MESSAGE 		■ LINE UNDERVOLTAGE 3 [▷]	See page 5-84
MESSAGE 		■ LINE UNDERVOLTAGE 4 [▷]	See page 5-84
MESSAGE 		■ OVERVOLTAGE 1 [▷]	See page 5-85
MESSAGE 		■ OVERVOLTAGE 2 [▷]	See page 5-85
MESSAGE 		■ NEUTRAL DISPLACEMENT [▷]	See page 5-86

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.

The undervoltage elements can be programmed to have an inverse time delay characteristic. The undervoltage delay setpoint defines a family of curves as shown below. The operating time is given by:

$$T = \frac{D}{1 - V/V_{pu}} \tag{EQ 5.17}$$

where:  $T$  = Operating Time

$D$  = Undervoltage Delay setpoint

$V$  = Voltage as a fraction of the nominal VT Secondary Voltage

$V_{pu}$  = Pickup Level



At 0% of pickup, the operating time equals the Undervoltage Delay setpoint.

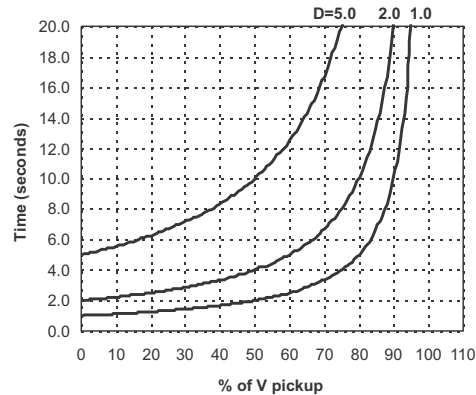


FIGURE 5-27: Inverse Time Undervoltage Curves

### Bus Undervoltage

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ VOLTAGE ▾ BUS UNDERVOLTAGE 1(2)

<div style="border: 1px solid black; padding: 2px;"> <b>■ BUS UNDERVOLTAGE 1</b> [▷]             </div>		<div style="border: 1px solid black; padding: 2px;"> <b>BUS UNDERVOLTAGE 1</b>  <b>FUNCTION: Disabled</b> </div>	<i>Range: Disabled, Trip, Alarm, Latched Alarm,</i>
MESSAGE	 	<div style="border: 1px solid black; padding: 2px;"> <b>BUS UNDERVOLTAGE 1</b>  <b>RELAYS (3-7): - - - - -</b> </div>	<i>Range: Any combination of 3 to 7 Auxiliary relays</i>
MESSAGE	 	<div style="border: 1px solid black; padding: 2px;"> <b>BUS UNDERVOLTAGE 1</b>  <b>PICKUP: 0.75 x VT</b> </div>	<i>Range: 0.00 to 1.25 x VT in steps of 0.01</i>
MESSAGE	 	<div style="border: 1px solid black; padding: 2px;"> <b>BUS UNDERVOLTAGE 1</b>  <b>CURVE: Definite Time</b> </div>	<i>Range: Definite Time, Inverse Time.</i>
MESSAGE	 	<div style="border: 1px solid black; padding: 2px;"> <b>BUS UNDERVOLTAGE 1</b>  <b>DELAY: 2.0 s</b> </div>	<i>Range: 0.0 to 6000.0 s in steps of 0.1</i>
MESSAGE	 	<div style="border: 1px solid black; padding: 2px;"> <b>PHASES REQUIRED FOR OPERATION: All Three</b> </div>	<i>Range: Any One, Any Two, All Three</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>MIN OPERATING VOLTAGE: 0.30 x VT</b> </div>	<i>Range: 0.00 to 1.25 x VT in steps of 0.01</i>

Bus Undervoltage 1 and 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 Bus Undervoltage 1 are shown above; the Bus Undervoltage 2 setpoints are identical.

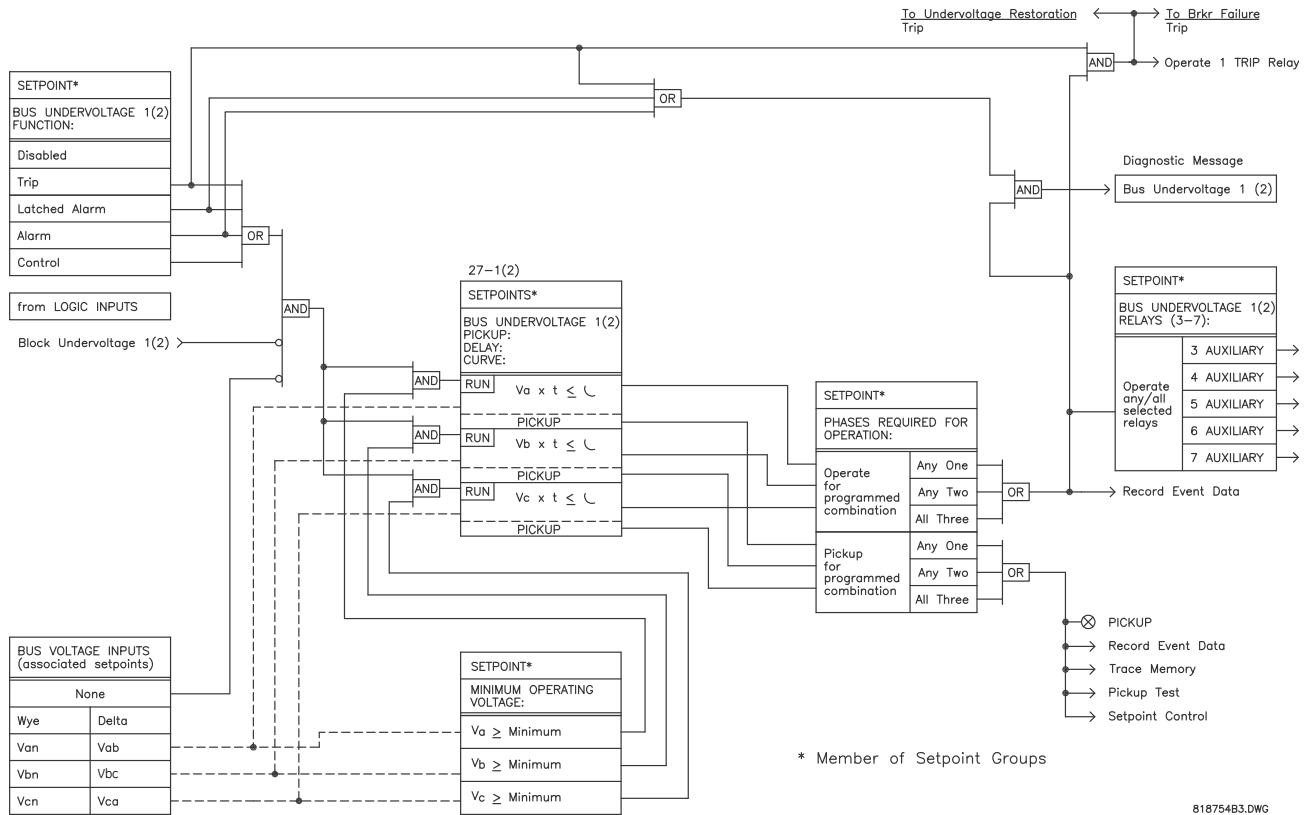


FIGURE 5-28: Bus Undervoltage Logic

## Line Undervoltage

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ VOLTAGE ▾ ▾ LINE UNDERVOLT AGE 3(4)

<p>■ <b>LINE UNDERVOLTAGE 3</b> [▶]</p>	<p><b>LINE UNDERVOLT 3 FUNCTION: Disabled</b></p>	<p>Range: Disabled, Trip, Alarm, Latched Alarm,</p>
<p>MESSAGE</p>	<p><b>LINE UNDERVOLT 3 RELAYS (3-7): -----</b></p>	<p>Range: Any combination of 3 to 7 Auxiliary relays</p>
<p>MESSAGE</p>	<p><b>LINE UNDERVOLT 3 PICKUP: 0.75 x VT</b></p>	<p>Range: 0.00 to 1.25 x VT in steps of 0.01</p>
<p>MESSAGE</p>	<p><b>LINE UNDERVOLT 3 CURVE: Definite Time</b></p>	<p>Range: Definite Time, Inverse Time.</p>
<p>MESSAGE</p>	<p><b>LINE UNDERVOLT 3 DELAY: 2.0 s</b></p>	<p>Range: 0.0 to 6000.0 s in steps of 0.1</p>
<p>MESSAGE</p>	<p><b>MIN OPERATING VOLTAGE: 0.30 x VT</b></p>	<p>Range: 0.00 to 1.25 x VT in steps of 0.01</p>

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 Line Undervoltage 3 element are shown above; the Line Undervoltage 4 setpoints are identical.

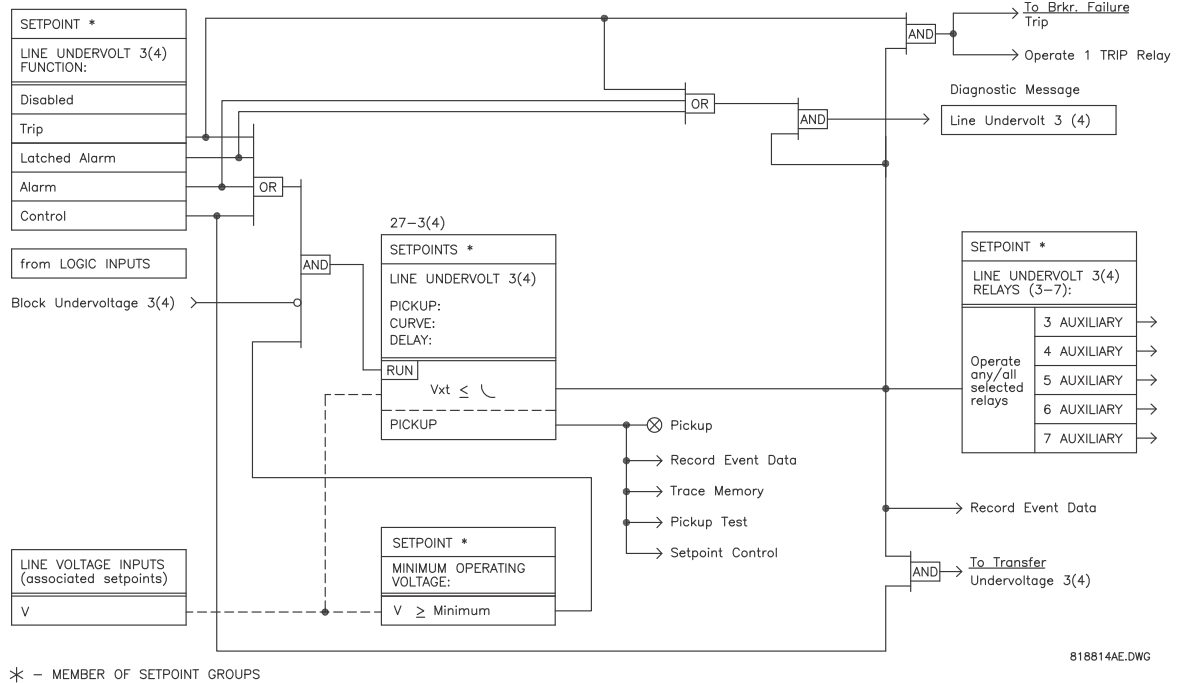


FIGURE 5-29: Line Undervoltage Logic

### Overvoltage

PATH: SETPOINTS ▾ S5 PROTECTION ▾ VOLTAGE ▾ OVERVOLTAGE 1(2)

<b>OVERVOLTAGE 1</b> [▷]	<b>OVERVOLTAGE 1</b> <b>FUNCTION: Disabled</b>	Range: Disabled, Trip, Alarm, Latched Alarm,
MESSAGE	<b>OVERVOLTAGE 1</b> <b>RELAYS (3-7): -----</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE	<b>OVERVOLTAGE 1</b> <b>PICKUP: 1.25 x VT</b>	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE	<b>OVERVOLTAGE 1</b> <b>DELAY: 2.0 s</b>	Range: 0.0 to 6000.0 s in steps of 0.1
MESSAGE	<b>PHASES REQUIRED FOR OPERATION: All Three</b>	Range: Any One, Any Two, All Three

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 value for a specified time delay. The setpoints above are repeated for both Overvoltage 1 and 2.

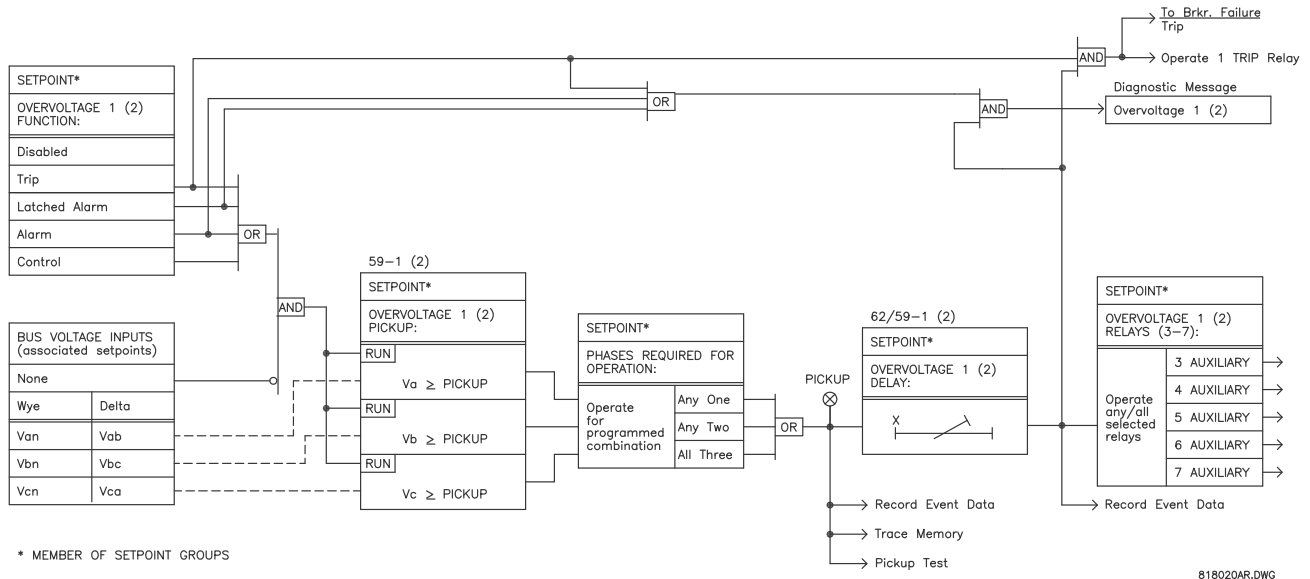


FIGURE 5-30: Overvoltage Logic

### Neutral Displacement

PATH: SETPOINTS ▾ S5 PROTECTION ▾ VOLTAGE ▾ NEUTRAL DISPLACEMENT

<b>NEUTRAL DISPLACEMENT</b> [▶]		<b>NTR DISPLACEMENT FUNCTION: Disabled</b>	Range: Disabled, Trip, Alarm, Latched Alarm,
MESSAGE		<b>NTR DISPLACEMENT RELAYS (3-7): - - - - -</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>NTR DISPLACEMENT PICKUP: 1.00 x VT</b>	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE		<b>NTR DISPLACEMENT CURVE: Ext. Inverse</b>	Range: See Table 5-4: TOC Curve Selections on
MESSAGE		<b>NTR DISPLACEMENT MULTIPLIER: 1.0 s</b>	Range: 0.00 to 100.00 in steps of 0.01
MESSAGE		<b>NTR DISPLACEMENT RESET: Instantaneous</b>	Range: Instantaneous, Linear

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.



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.



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.

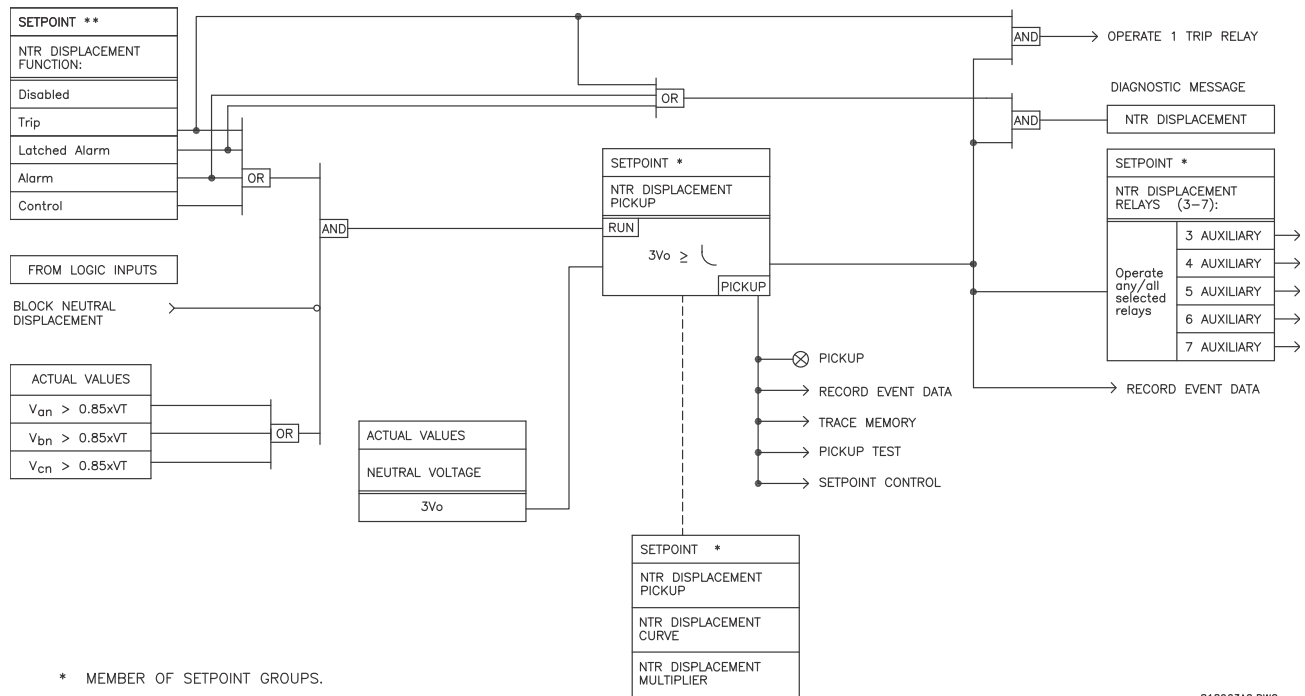


FIGURE 5-31: Neutral Displacement Logic

### 5.6.9 Frequency

#### Main Menu

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ FREQUENCY

<div style="display: flex; justify-content: space-between;"> <span>■ <b>FREQUENCY</b></span> <span>[▶]</span> </div>	⏪ ⏩	<div style="display: flex; justify-content: space-between;"> <span>■ <b>UNDERFREQ 1</b></span> <span>[▶]</span> </div>	See page 5-88
MESSAGE	⏪ ⏩	<div style="display: flex; justify-content: space-between;"> <span>■ <b>UNDERFREQ 2</b></span> <span>[▶]</span> </div>	See page 5-88
MESSAGE	⏪ ⏩	<div style="display: flex; justify-content: space-between;"> <span>■ <b>FREQUENCY DECAY</b></span> <span>[▶]</span> </div>	See page 5-89

The 750/760 can be used as the primary detecting relay in automatic load shedding schemes based on underfrequency. The need for 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.

### Underfrequency

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ FREQUENCY ▾ ▾ UNDERFREQ 1(2)

■ UNDERFREQ 1	[▷]		UNDEFREQUENCY 1 FUNCTION: Disabled	Range: Disabled, Trip, Alarm, Latched Alarm,
MESSAGE			UNDEFREQUENCY 1 RELAYS (3-7): -----	Range: Any combination of 3 to 7 Auxiliary relays.
MESSAGE			UNDEFREQUENCY 1 PICKUP: 59.00 Hz	Range: 20.00 to 65.00 Hz in steps of 0.01
MESSAGE			UNDEFREQUENCY 1 DELAY: 2.00 s	Range: 0.00 to 600.00 s in steps of 0.1
MESSAGE			MINIMUM OPERATING VOLTAGE: 0.70 x VT	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE			MINIMUM OPERATING CURRENT: 0.20 x CT	Range: 0.00 to 1.25 x CT in steps of 0.01

There are two identical underfrequency protection elements, ANSI devices 81U-1 and 81U-2. The setpoints for the Underfrequency 1 element are shown above; the Underfrequency 2 setpoints are identical. See *Overview* on page 5-44 for additional setting details.

- **MINIMUM OPERATING VOLTAGE:** Enter the minimum voltage required for underfrequency element operation. This setpoint prevents incorrect operation before energization of the source to the relay location, and during voltage dips.
- **MINIMUM OPERATING CURRENT:** Enter the minimum value of current required on any phase to allow the underfrequency element to operate. This setpoint is used to prevent underfrequency tripping during periods of light load, when this action would have an insignificant effect on the system.

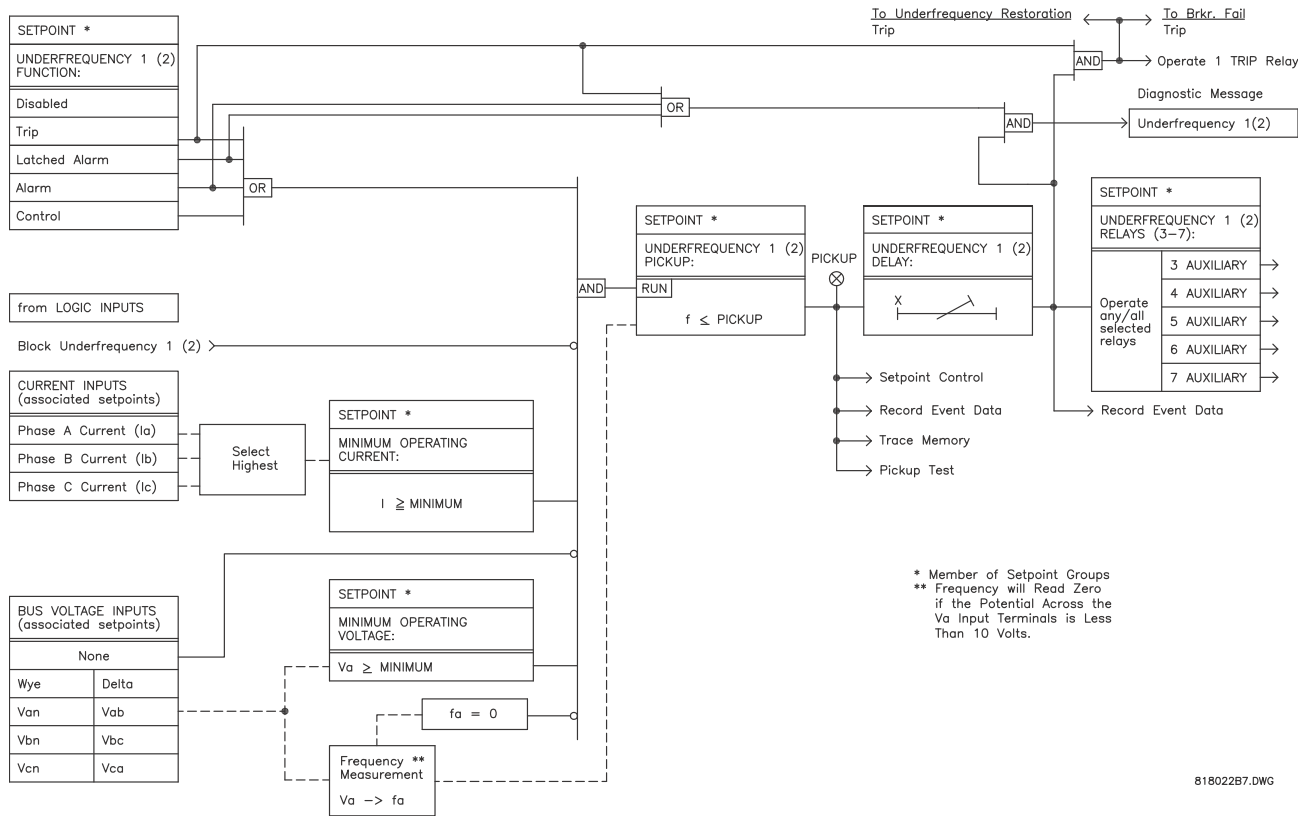


FIGURE 5-32: Underfrequency Logic

### Frequency Decay

PATH: SETPOINTS ▾ S5 PROTECTION ▾ FREQUENCY ▾ FREQUENCY DECAY

<b>FREQUENCY DECAY</b> [▶]		<b>FREQ DECAY FUNCTION: Disabled</b>	Range: Disabled, Trip, Alarm, Latched Alarm,
MESSAGE		<b>FREQ DECAY RELAYS (3-7): - - - -</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>FREQ DECAY RATE: 1.0 Hz/s</b>	Range: 0.1 to 5.0 Hz/s in steps of 0.1
MESSAGE		<b>FREQ DECAY PICKUP: 59.00 Hz</b>	Range: 20.00 to 65.00 Hz in steps of 0.01
MESSAGE		<b>FREQ DECAY DELAY: 2.00 s</b>	Range: 0.00 to 600.00 s in steps of 0.01
MESSAGE		<b>MIN OPERATING VOLTAGE: 0.70 x VT</b>	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE		<b>MIN OPERATING CURRENT: 0.00 x CT</b>	Range: 0.00 to 1.25 x CT in steps of 0.01

There is one frequency decay protection element, ANSI device 81D which can provide a faster response to system disturbances than the underfrequency elements. See the previous section for descriptions of the **MIN OPERATING CURRENT** and **MIN OPERATING VOLTAGE** setpoints. See *Overview* on page 5-44 for additional setting details

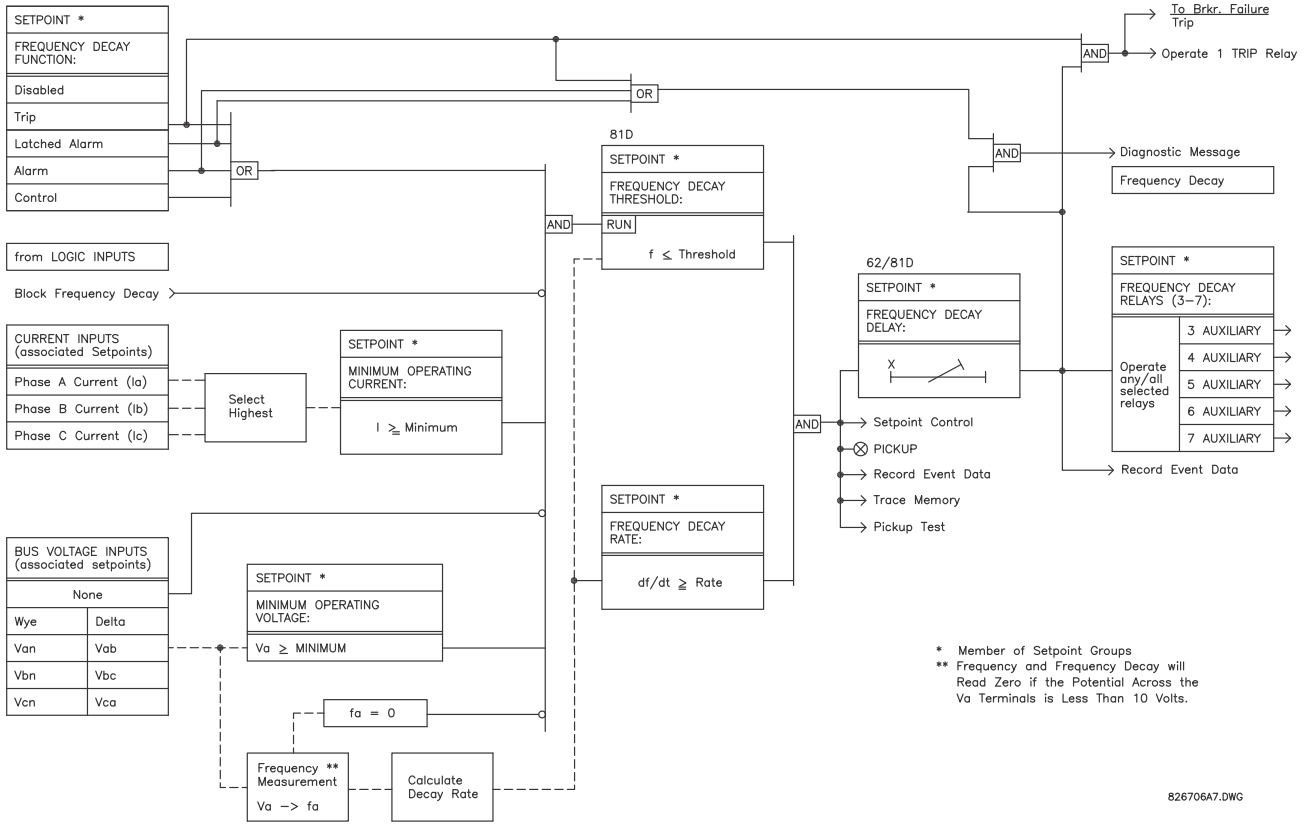


FIGURE 5-33: Frequency Decay Logic

### 5.6.10 Breaker Failure

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ BREAKER FAILURE

<b>■ BREAKER FAILURE</b> [ <b>&gt;</b> ]		<b>BRKR FAILURE FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm,
MESSAGE		<b>BRKR FAILURE RELAYS (3-7): -----</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>BRKR FAILURE DELAY 1: 0.10 s</b>	Range: 0.03 to 1.00 s in steps of 0.01
MESSAGE		<b>BRKR FAILURE DELAY 2: 0.00 s</b>	Range: 0.00 to 1.00 s in steps of 0.01
MESSAGE		<b>BRKR FAILURE CURRENT: 1.00 x CT</b>	Range: 0.05 to 20.00 x CT in steps of 0.01

Breaker failure monitors the phase currents while a trip command exists. If any phase current is above the set level after the **BRKR FAILURE DELAY** time expires, a breaker failure will be declared, which will operate the selected output relays and force the 750/760 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. **BRKR FAILURE DELAY 1** starts counting down from the user programmed delay setpoint once a Trip condition is recognized. On the other hand, **BRKR FAILURE 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 **BRKR FAILURE CURRENT** setpoint. If one of the delays is not required, simply program the unwanted timer to its minimum value.



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 the **BRKR FAILURE DELAY 1** and **BRKR FAILURE DELAY 2** setpoints.

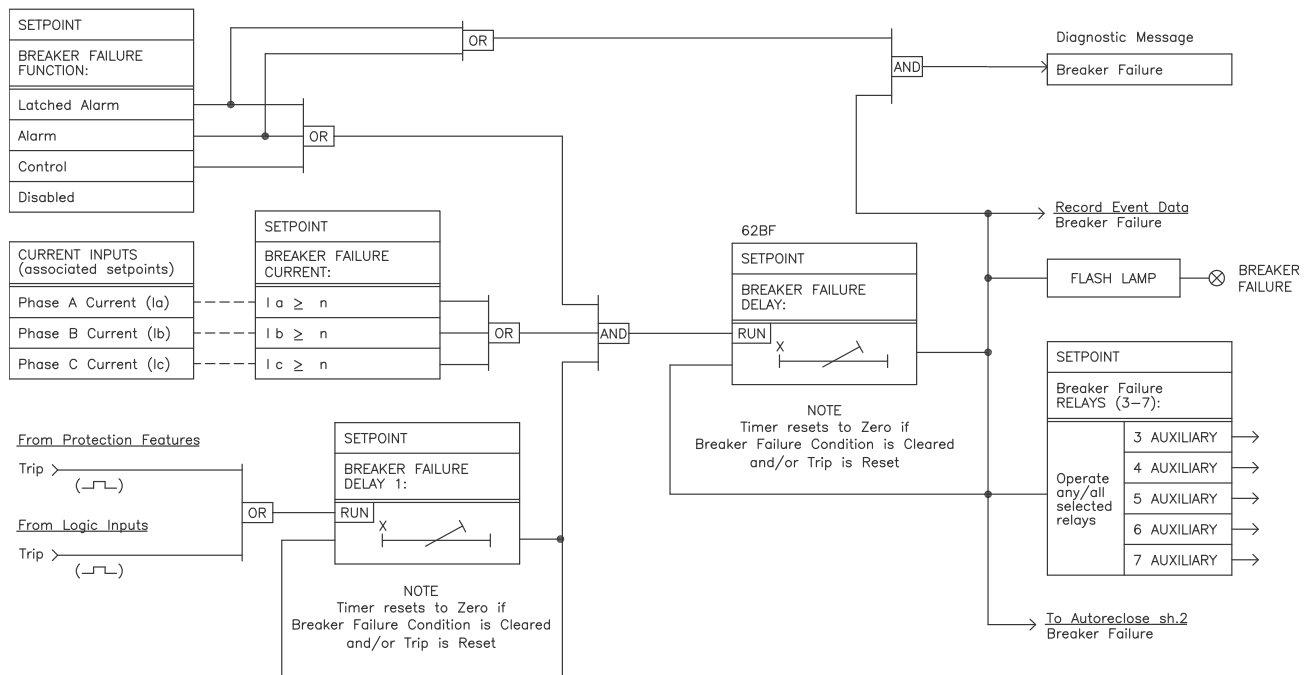


FIGURE 5-34: Breaker Failure Logic

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### 5.6.11 Reverse Power

PATH: SETPOINTS ▾ ▾ S5 PROTECTION ▾ ▾ REVERSE POWER

<div style="display: flex; justify-content: space-between; align-items: center;"> <span>■ REVERSE POWER</span> <span>[▷]</span> </div>		REVERSE POWER <b>FUNCTION: Disabled</b>	<i>Range: Disabled, Trip, Alarm, Control</i>
MESSAGE		REVERSE POWER <b>RELAYS (3-7): -----</b>	<i>Range: Any combination of 3 to 7 Auxiliary relays</i>
MESSAGE		REVERSE POWER <b>PICKUP: 0.050 xRATED</b>	<i>Range: 0.015 to 0.600 x RATED in steps of</i>
MESSAGE		REVERSE POWER <b>DELAY: 10.0 s</b>	<i>Range: 0.0 to 6000.0 s in steps of 0.1</i>

A Reverse Power element is generally associated with generator protection. Such an element is used to detect loss of mechanical power coming into the turbine and to trip the unit to prevent turbine blade heating or other adverse effects in turbo-generator sets. The **REVERSE POWER PICKUP** setting is usually set as low as the relay can measure, but no higher than one-half the electrical power required to motor the generator with total loss of mechanical power. The Reverse Power element is not normally used in conventional feeder protection applications.

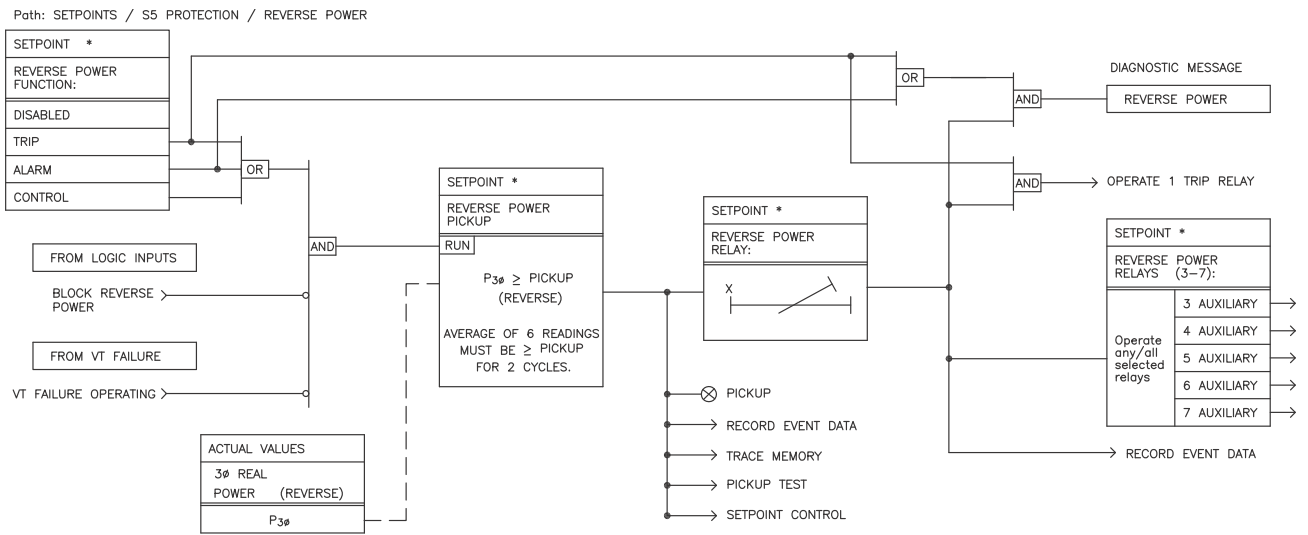
The Reverse Power element generates an output when the three-phase reverse real power is greater than the **REVERSE POWER PICKUP** setting. It is recommended to set **REVERSE POWER DELAY** to 1 second or higher to avoid problems with power oscillations that may be experienced on synchronization; a setting in the range of 10 to 15 seconds is typical. Recall that the rated power is calculated as follows:

$$\text{Rated Power} = \sqrt{3} \times V_{\text{sec(line-line)}} \times \text{VT Ratio} \times I_{\text{sec(rated)}} \times \text{CT Ratio} \quad \text{(EQ 5.18)}$$



The sensitivity of this element and the requirement to have two times pickup limits its range of application. The motoring power cannot be less than 3% of rated, and the angle away from the 180° angle of maximum sensitivity should not be greater than ±85 to 87° due to reactive loading on the generator.

This element is optional and available from GE Multilin as Mod 008. To order, please contact the factory with the serial number of the 750/760 relay. Refer to *Reverse Power* on page 8-1 for the complete procedure for installing and verifying the Reverse Power element.



\* MEMBER OF SETPOINT GROUPS.

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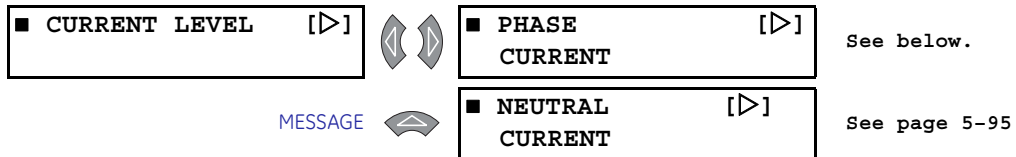
FIGURE 5-35: Reverse Power Logic

## 5.7 S6 Monitoring

### 5.7.1 Current Level

#### Main Menu

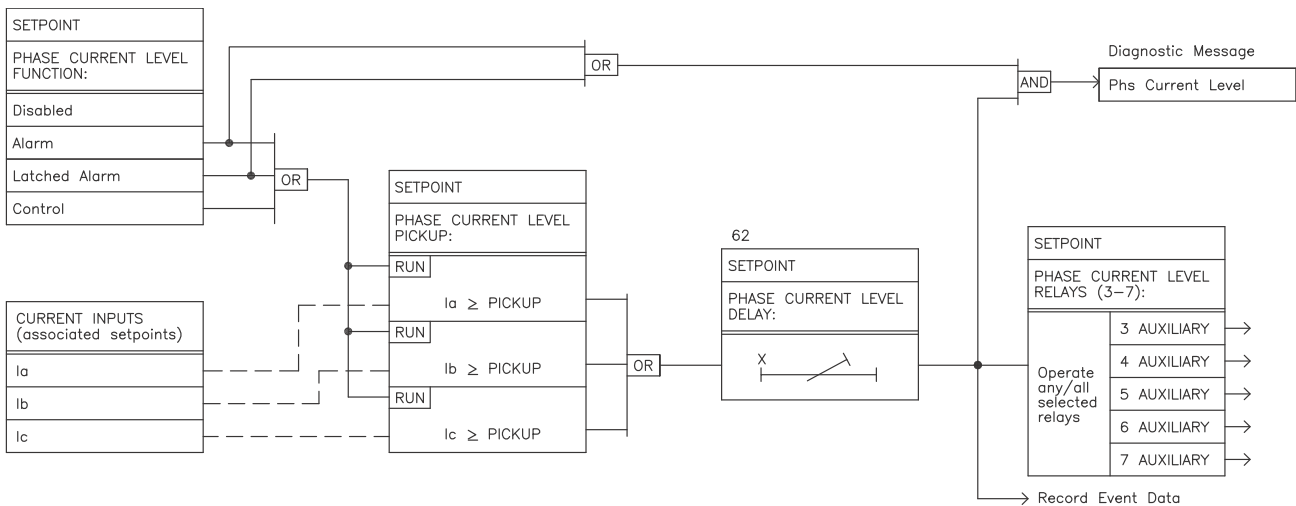
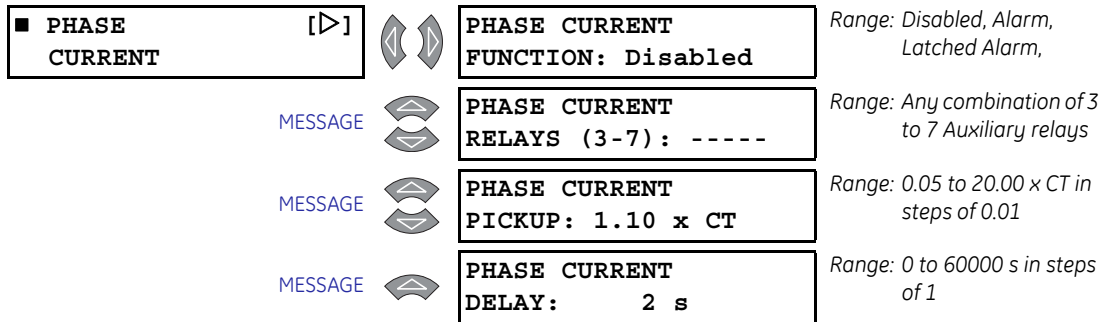
PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ CURRENT LEVEL



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.

#### Phase Current Level

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ CURRENT LEVEL ▾ PHASE CURRENT



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FIGURE 5-36: Phase Current Level Logic

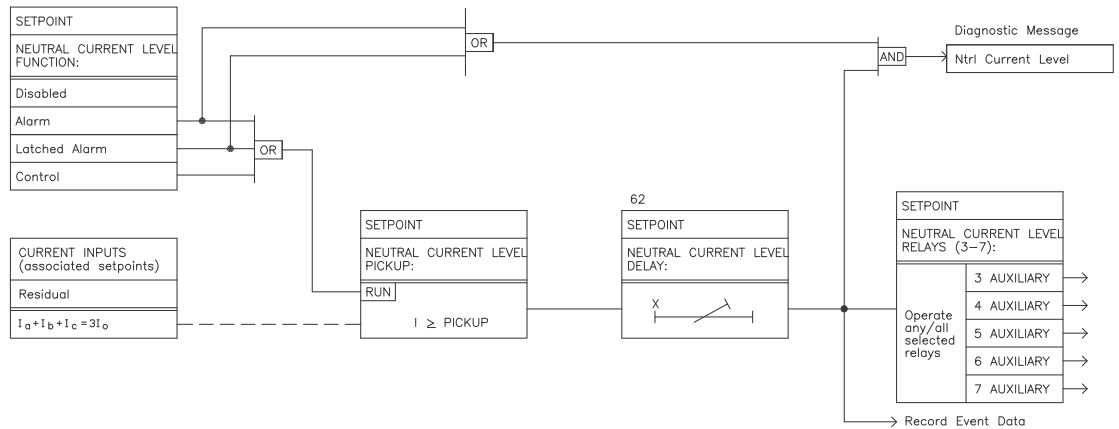


### Neutral Current Level

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ CURRENT LEVEL ▾ ▾ NEUTRAL CURRENT

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>NEUTRAL CURRENT</b> [▶]             </div>		<div style="border: 1px solid black; padding: 5px;"> <b>NEUTRAL CURRENT FUNCTION: Disabled</b> </div>	<i>Range: Disabled, Alarm, Latched Alarm,</i>
MESSAGE		<div style="border: 1px solid black; padding: 5px;"> <b>NEUTRAL CURRENT RELAYS (3-7): - - - - -</b> </div>	<i>Range: Any combination of 3 to 7 Auxiliary relays</i>
MESSAGE		<div style="border: 1px solid black; padding: 5px;"> <b>NEUTRAL CURRENT PICKUP: 1.00 x CT</b> </div>	<i>Range: 0.05 to 20.00 x CT in steps of 0.01</i>
MESSAGE		<div style="border: 1px solid black; padding: 5px;"> <b>NEUTRAL CURRENT DELAY: 2 s</b> </div>	<i>Range: 0 to 60000 s in steps of 1</i>

See *Common Setpoints* on page 5–6 for additional setting details.



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FIGURE 5–37: Neutral Current Level Logic

### 5.7.2 Power Factor

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ POWER FACTOR ▾ ▾ POWER FACTOR 1(2)

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>POWER FACTOR 1</b> [▶]             </div>		<div style="border: 1px solid black; padding: 5px;"> <b>PWR FACTOR 1 FUNCTION: Disabled</b> </div>	<i>Range: Disabled, Alarm, Latched Alarm,</i>
MESSAGE		<div style="border: 1px solid black; padding: 5px;"> <b>PWR FACTOR 1 RELAYS (3-7): - - - - -</b> </div>	<i>Range: Any combination of 3 to 7 Auxiliary relays</i>
MESSAGE		<div style="border: 1px solid black; padding: 5px;"> <b>PWR FACTOR 1 PICKUP: 0.80</b> </div>	<i>Range: -0.99 to 1.00 in steps of 0.01</i>
MESSAGE		<div style="border: 1px solid black; padding: 5px;"> <b>PWR FACTOR 1 DROPOUT: 1.00</b> </div>	<i>Range: -0.99 to 1.00 in steps of 0.01</i>
MESSAGE		<div style="border: 1px solid black; padding: 5px;"> <b>PWR FACTOR 1 DELAY: 50 s</b> </div>	<i>Range: 0 to 60000 s in steps of 1</i>

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.

The relay calculates the average power factor in the three phases as follows:

$$\text{Average Power Factor} = \frac{\text{Total 3 Phase Real Power}}{\text{Total 3 Phase Apparent Power}} \quad \text{(EQ 5.19)}$$

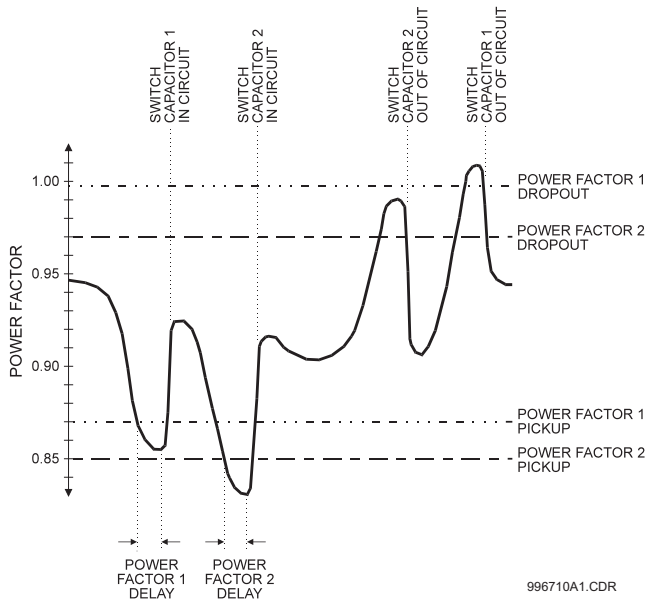


FIGURE 5-38: Capacitor Bank Switching

Two independent elements are available for monitoring power factor, 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 operates 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.

The power factor feature is 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.

For the **PWR FACTOR 1(2) PICKUP** and **PWR FACTOR 1(2) DROPOUT** setpoints, positive values indicate lagging power factor.

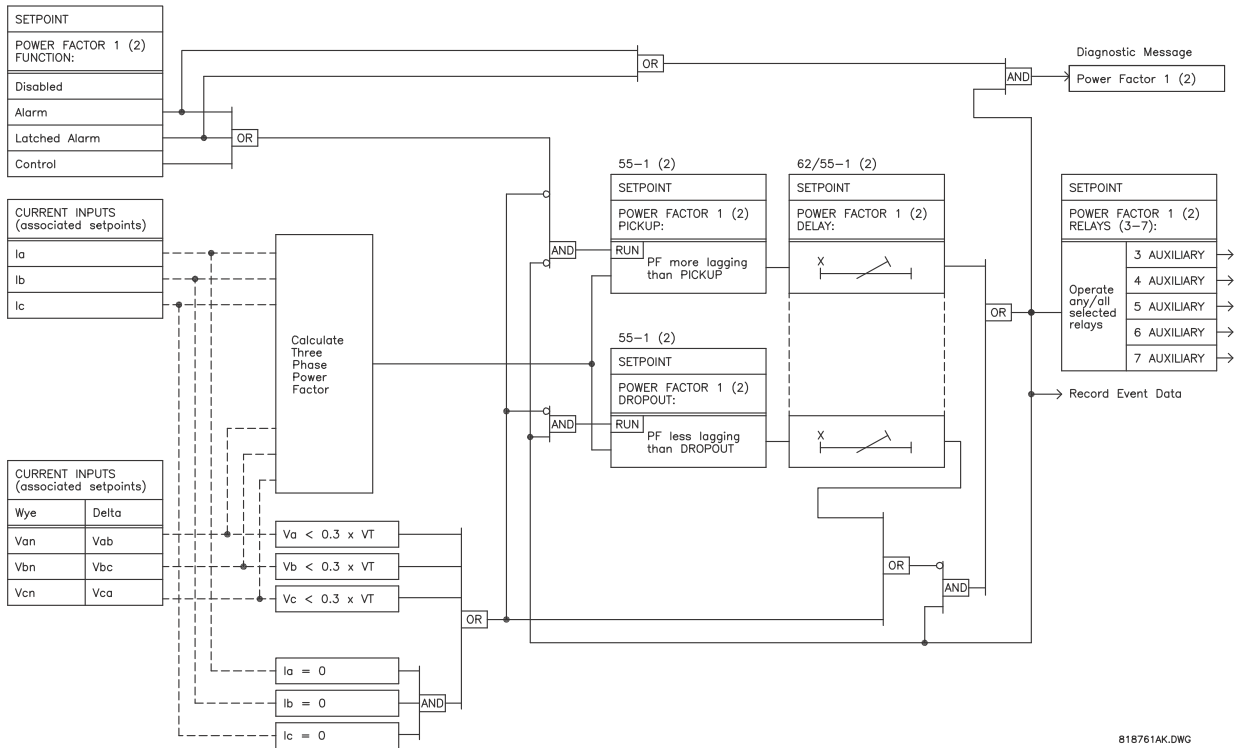


FIGURE 5-39: Power Factor Logic

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### 5.7.3 Fault Locator

PATH: SETPOINTS ▾ S6 MONITORING ▾ FAULT LOCATOR

<b>■ FAULT LOCATOR</b> [▶]		<b>LENGTH OF FEEDER:</b> 0.1 km	Range: 0.1 to 99.9 km/Miles in steps of 0.1
MESSAGE		<b>UNITS OF LENGTH:</b> km	Range: km, Miles
MESSAGE		<b>Zpos (RESISTIVE) OF FEEDER:</b> 0.01 Ω	Range: 0.01 to 99.99 Ω in steps of 0.01
MESSAGE		<b>Zpos (INDUCTIVE) OF FEEDER:</b> 0.01 Ω	Range: 0.01 to 99.99 Ω in steps of 0.01
MESSAGE		<b>Zzero (RESISTIVE) OF FEEDER:</b> 0.01 Ω	Range: 0.01 to 99.99 Ω in steps of 0.01
MESSAGE		<b>Zzero (INDUCTIVE) OF FEEDER:</b> 0.01 Ω	Range: 0.01 to 99.99 Ω in steps of 0.01
MESSAGE		<b>FAULT TYPE OUTPUT TO RELAYS 4-7:</b> Disabled	Range: Disabled, Enabled
MESSAGE		<b>FAULT LOCATION AFTER TRIP:</b> Disabled	Range: Disabled, Enabled

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:

1. The feeder positive and zero sequence impedances are a constant per unit distance, and
2. 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 **AI STATUS** > **FAULT LOCATIONS**.



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 **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.

- **LENGTH OF FEEDER:** Enter the total length of the feeder, in kilometers or miles as selected by the **UNITS OF LENGTH** setpoint.
- **UNITS OF LENGTH:** Enter the units of measurement, in kilometers or miles.
- **Zpos (RESISTIVE/INDUCTIVE) OF FEEDER:** Enter the total real/imaginary component of the feeder positive sequence impedance, in actual ohms.

- **Zzero (RESISTIVE/INDUCTIVE) OF FEEDER:** Enter the total real/imaginary component of the feeder zero sequence impedance, in actual ohms.
- **FAULT TYPE OUTPUT TO RELAYS 4-7:** Selects whether fault type indication on output relays 4 to 7 is enabled. When enabled, relays 4 to 7 will operate to indicate the most recent fault type (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, with outputs as shown below:  
 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:** Users utilizing the Fault Distance feature may define a fault distance message to display along with other active conditions. When set to “Enabled”, a fault distance message will be displayed when a trip has occurred. 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).

## 5.7.4 Demand

### Main Menu

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ DEMAND

■ DEMAND [▷]	◀ ▶	■ CURRENT [▷]	See page 5-101
MESSAGE	⌈ ⌋	■ REAL POWER [▷]	See page 5-102
MESSAGE	⌈ ⌋	■ REACTIVE POWER [▷]	See page 5-103
MESSAGE	⌈ ⌋	■ APPARENT POWER [▷]	See page 5-104

Current demand is measured on each phase, and on three phases for real, reactive, and apparent power. Setpoints allow the user to emulate some common electrical utility demand measuring techniques for statistical or control purposes.



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.

- **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:

$$d(t) = D(1 - e^{-kt}) \quad (\text{EQ 5.20})$$

where  $d$  = demand value after applying input quantity for time  $t$  (in minutes),  
 $D$  = input quantity (constant),  $k = 2.3 /$  thermal 90% response time.

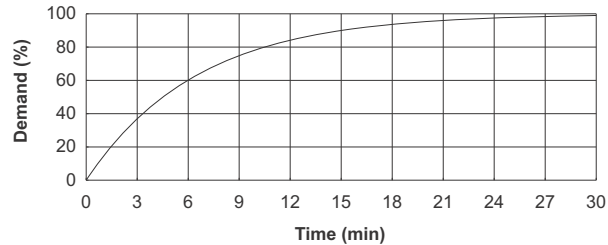


FIGURE 5-40: Thermal Demand Characteristic (15 minute response)

The 90% thermal response time characteristic defaults to 15 minutes. 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.

The Block Interval with Start Demand Interval Logic Input 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. The [S3 LOGIC INPUTS](#) ▾ ▽ [MISC FUNCTIONS](#) ▾ ▽ [START DMND INTERVAL](#) setpoint programs 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.

### Current Demand

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ DEMAND ▾ CURRENT

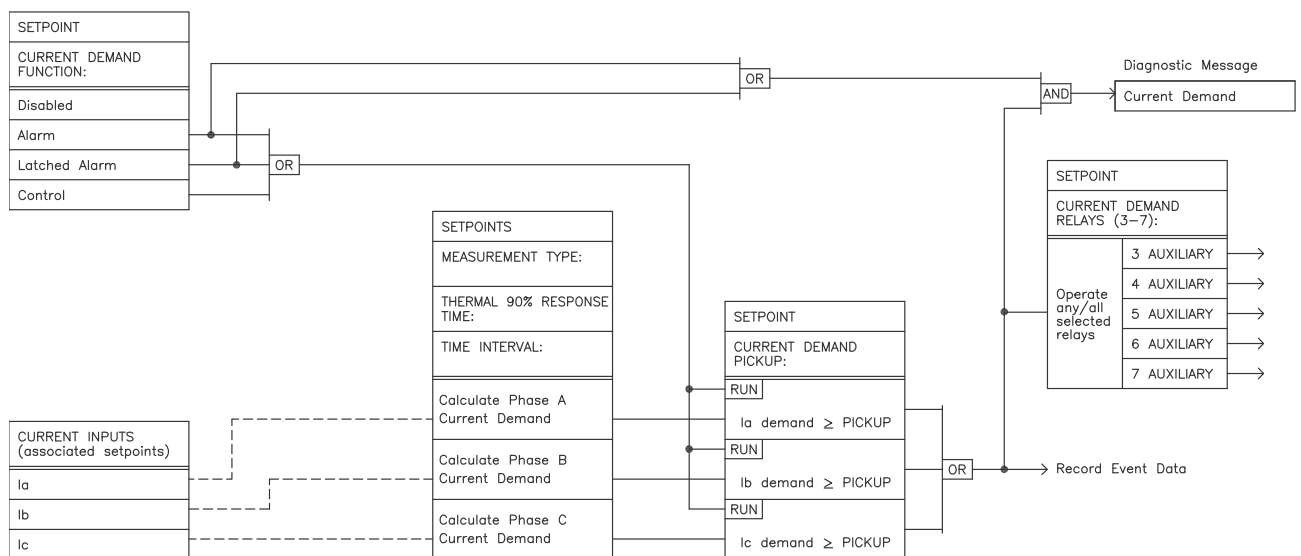
<div style="border: 1px solid black; padding: 2px;"> <span style="background-color: black; color: white; padding: 2px;">CURRENT</span> <span style="float: right;">[▶]</span> </div>		<div style="border: 1px solid black; padding: 2px;"> <b>CURRENT DEMAND</b>  <b>FUNCTION: Disabled</b> </div>	<i>Range: Disabled, Alarm, Latched Alarm,</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>MEASUREMENT TYPE:</b>  <b>Thermal Exponential</b> </div>	<i>Range: Thermal Exponential, Block Interval, Rolling</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>THERMAL 90% RESPONSE TIME:</b>  <b>15 min</b> </div>	<i>Range: 5 min, 10 min, 15 min, 20 min, 30 min,</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>TIME INTERVAL:</b>  <b>20 min</b> </div>	<i>Range: 5 min, 10 min, 15 min, 20 min, 30 min,</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>CURRENT DEMAND RELAYS (3-7):</b> - - - - -                 </div>	<i>Range: Any combination of the 3 to 7 Auxiliary</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>CURRENT DEMAND PICKUP:</b> 1000 A                 </div>	<i>Range: 10 to 10000 A in steps of 1</i>

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 equaled or exceeded by any phase, the relay can cause an alarm or signal an output relay.

For the **THERMAL 90% RESPONSE TIME** setpoint, 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. This setpoint is visible only if **MEASUREMENT TYPE** is “Thermal Exponential”.

For the **TIME INTERVAL** setpoint, enter the time period over which the current demand calculation is to be performed. This setpoint is visible only if **MEASUREMENT TYPE** is “Block Interval” or “Rolling Demand”.

See *Common Setpoints* on page 5–6 for additional setting details.









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FIGURE 5-41: Current Demand Logic

**Real Power Demand**

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ DEMAND ▾ ▾ REAL POWER

<div style="display: flex; justify-content: space-between; align-items: center;"> <span>■ REAL POWER</span> <span>[▷]</span> </div>		<b>REAL PWR DEMAND FUNCTION: Disabled</b>	<i>Range: Disabled, Alarm, Latched Alarm,</i>
MESSAGE		<b>MEASUREMENT TYPE: Block Interval</b>	<i>Range: Thermal Exponential, Block Interval, Rolling</i>
MESSAGE		<b>THERMAL 90% RESPONSE TIME: 15 min</b>	<i>Range: 5 min, 10 min, 15 min, 20 min, 30 min,</i>
MESSAGE		<b>TIME INTERVAL: 20 min</b>	<i>Range: 5 min, 10 min, 15 min, 20 min, 30 min,</i>
MESSAGE		<b>REAL PWR DEMAND RELAYS (3-7): -----</b>	<i>Range: Any combination of the 3 to 7 Auxiliary</i>
MESSAGE		<b>REAL PWR DEMAND PICKUP: 10.0 MW</b>	<i>Range: 1 to 30000 kW. Auto- ranging; see table</i>

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

See page -99 for details on the **MEASUREMENT TYPE** setting.

For the **THERMAL 90% RESPONSE TIME** setpoint, enter the time required for a steady state power to indicate 90% of the actual value. This setpoint allows the user to approximately match the response of the relay to analog instruments. This setpoint is visible only if **MEASUREMENT TYPE** is "Thermal Exponential".

For the **TIME INTERVAL**, enter the time over which the real power demand calculation is to be performed. For the **REAL POWER DEMAND PICKUP**, power quantities auto-range to show units appropriate to the power system size (see table below). This setpoint is visible only if **MEASUREMENT TYPE** is "Block Interval" or "Rolling Demand".

**Table 5-16: Auto-Ranging Units**

Nominal Power (P <sub>N</sub> )	Power Units	Resolution
P <sub>N</sub> < 1 MVA	kW	1
1 MVA ≤ P <sub>N</sub> < 10 MVA	MW	0.01
10 MVA ≤ P <sub>N</sub>	MW	0.1



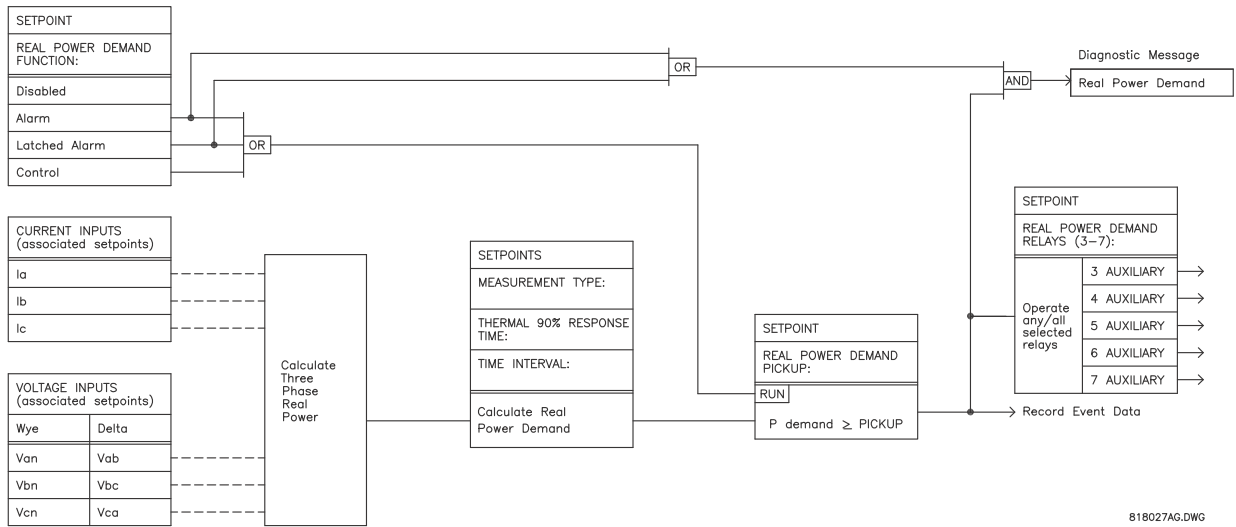


FIGURE 5-42: Real Power Demand Logic

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## Reactive Power Demand

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ DEMAND ▾ ▾ REACTIVE POWER

■ <b>REACTIVE POWER</b> [▷]		<b>REACTIVE PWR DMND FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm,
MESSAGE		<b>MEASUREMENT TYPE: Block Interval</b>	Range: Thermal Exponential, Block Interval, Rolling
MESSAGE		<b>THERMAL 90% RESPONSE TIME: 15 min</b>	Range: 5 min, 10 min, 15 min, 20 min, 30 min,
MESSAGE		<b>TIME INTERVAL: 20 min</b>	Range: 5 min, 10 min, 15 min, 20 min, 30 min,
MESSAGE		<b>REACTIVE PWR DMND RELAYS (3-7): - - - - -</b>	Range: Any combination of the 3 to 7 Auxiliary
MESSAGE		<b>REACTIVE PWR DMND PICKUP: 10.0 Mvar</b>	Range: 1 to 30000 kvar. Auto-ranging; see

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

See page -99 for details on the **MEASUREMENT TYPE** setting.

For the **THERMAL 90% RESPONSE TIME** setpoint, 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. This setpoint is visible only if **MEASUREMENT TYPE** is “Thermal Exponential”.

For the **TIME INTERVAL**, enter the time period to perform the reactive power demand calculation. For the **REACTIVE PWR DEMAND PICKUP**, the power quantities auto-range to show units appropriate to the power system size (see table below). This setpoint is visible only if **MEASUREMENT TYPE** is “Block Interval” or “Rolling Demand”.

Table 5-17: Auto-Ranging Units

Nominal Power ( $P_N$ )	Power Units	Resolution
$P_N < 1$ MVA	kvar	1
$1 \text{ MVA} \leq P_N < 10 \text{ MVA}$	Mvar	0.01
$10 \text{ MVA} \leq P_N$	Mvar	0.1

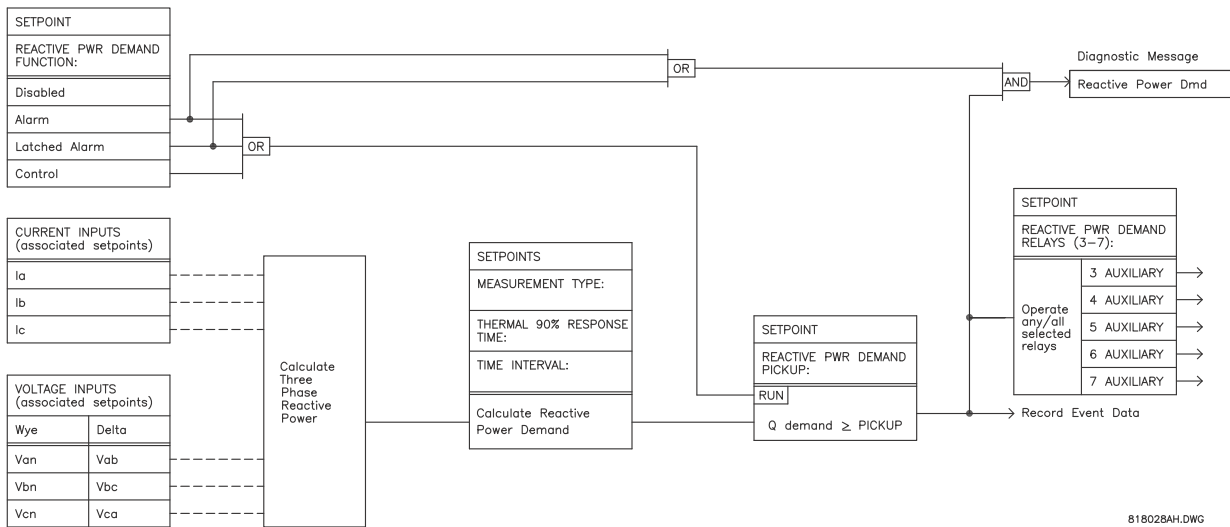


FIGURE 5-43: Reactive Power Demand Logic

### Apparent Power Demand

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ DEMAND ▾ ▾ APPARENT POWER

■ APPARENT POWER [▷]	APPARENT PWR DMND FUNCTION: Disabled	Range: Disabled, Alarm, Latched Alarm,
MESSAGE	MEASUREMENT TYPE: Block Interval	Range: Thermal Exponential, Block Interval, Rolling
MESSAGE	THERMAL 90% RESPONSE TIME: 15 min	Range: 5 min, 10 min, 15 min, 20 min, 30 min,
MESSAGE	TIME INTERVAL: 20 min	Range: 5 min, 10 min, 15 min, 20 min, 30 min,
MESSAGE	APPARENT PWR DMND RELAYS (3-7): -----	Range: Any combination of the 3 to 7 Auxiliary
MESSAGE	APPARENT PWR DMND PICKUP: 10.0 MVA	Range: 1 to 30000 kVA. Auto- ranging; see table

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

See page -99 for details on the **MEASUREMENT TYPE** setting.

For the **THERMAL 90% RESPONSE TIME** setpoint, 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. This setpoint is visible only if **MEASUREMENT TYPE** is "Thermal Exponential".

For the **TIME INTERVAL**, enter the time period to perform the apparent power demand calculation. For the **APPARENT PWR DMND PICKUP**, the power quantities auto-range to show units appropriate to the power system size (see table below). This setpoint is visible only if **MEASUREMENT TYPE** is "Block Interval" or "Rolling Demand".

Table 5-18: Auto-Ranging Units

Nominal Power ( $P_N$ )	Power Units	Resolution
$P_N < 1$ MVA	kVA	1
$1 \text{ MVA} \leq P_N < 10$ MVA	MVA	0.01
$10 \text{ MVA} \leq P_N$	MVA	0.1

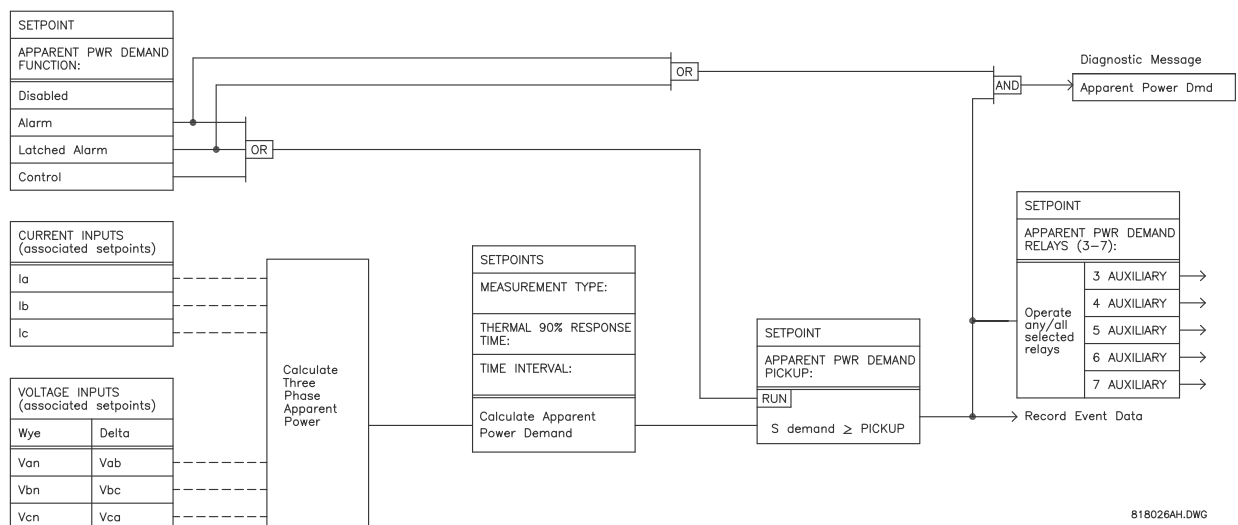







FIGURE 5-44: Apparent Power Demand Logic

### 5.7.5 Analog Input

#### Main Menu

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ ANALOG INPUT






■ ANALOG INPUT [▷]		■ ANALOG INPUT SETUP [▷]	See page 5-106
MESSAGE 		■ ANALOG THRESHOLD 1 [▷]	See page 5-107
MESSAGE 		■ ANALOG THRESHOLD 2 [▷]	See page 5-107
MESSAGE 		■ ANALOG INPUT RATE 1 [▷]	See page 5-109
MESSAGE 		■ ANALOG INPUT RATE 2 [▷]	See page 5-109

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 to 1 mA, 0 to 5 mA, 0 to 10 mA, 0 to 20 mA, or 4 to 20 mA can be connected to the analog input terminals.

Two independent elements are available for monitoring the analog input level, Analog Threshold 1 and 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 and 2, which operate in a similar fashion.

#### Analog Input Setup

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ ANALOG INPUT ▾ ANALOG INPUT SETUP

■ ANALOG INPUT SETUP [▷]		A/I NAME: ANALOG INPUT	Range: Any combination of 20 alphanumeric
MESSAGE 		A/I UNITS: μA	Range: Any combination of 6 alphanumeric
MESSAGE 		A/I RANGE: 0-20 mA	Range: 0-1 mA, 0-5 mA, 4-20 mA, 0-20 mA, 0-10
MESSAGE 		A/I MIN VALUE: 0 μA	Range: 0 to 65535 units in steps of 1.
MESSAGE 		A/I MAX VALUE: 20000 μA	Range: 0 to 65535 units in steps of 1.

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 mA is to be represented via the 0 to 20 mA analog input, an input of 4.5 mA will translate to a 5 mA 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 mA was programmed to be represented via the 0 to 20 mA input, 4.5 mA will result in a 45 mA actual value.

For the **A/I MIN VALUE** and **A/I MAX VALUE** setpoints, enter the value which corresponds to the minimum/maximum 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” for **A/I MIN VALUE**. The relay then interprets 4 mA as representing 0°C. Intermediate values between the minimum and maximum are scaled linearly.

### Analog Threshold

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ ANALOG INPUT ▾ ▾ ANALOG THRESHOLD 1(2)

<p>■ <b>ANALOG THRESHOLD 1</b> [▶]</p>		<p><b>A/I THRESHLD 1 NAME:</b> <b>ANALOG THRESHLD1</b></p>	<p>Range: Any combination of 18 alphanumeric</p>
<p>MESSAGE</p>		<p><b>ANALOG THRESHLD 1 FUNCTION:</b> Disabled</p>	<p>Range: Disabled, Trip, Alarm, Latched Alarm, Control, Blk Thrsh 1. See Note below.</p>
<p>MESSAGE</p>		<p><b>ANALOG THRESHLD 1 RELAYS (3-7):</b> - - - - -</p>	<p>Range: Any combination of the 3 to 7 Auxiliary</p>
<p>MESSAGE</p>		<p><b>ANALOG THRESHLD 1 PICKUP:</b> 100 μA</p>	<p>Range: 0 to 65535 units in steps of 1</p>
<p>MESSAGE</p>		<p><b>ANALOG THRESHLD 1 DROP OUT RATIO:</b> 5%</p>	<p>Range: 2 to 20% in steps of 1</p>
<p>MESSAGE</p>		<p><b>ANALOG THRESHLD 1 PICKUP TYPE:</b> Over</p>	<p>Range: Over, Under</p>
<p>MESSAGE</p>		<p><b>ANALOG THRESHLD 1 DELAY:</b> 100 s</p>	<p>Range: 0 to 60000 s in steps of 1</p>

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. For user flexibility, independent user names can also be programmed for each Analog Threshold.

Note that connected analog input will still be read and displayed in **A2 METERING** ▾ ▾ **ANALOG INPUT** if both **ANALOG THRESHLD 1 FUNCTION** and **ANALOG THRESHLD 2 FUNCTION** are set to “Disabled”.



NOTE

The **Blk Thrsh 1** value applies to the **ANALOG THRESHLD 2 FUNCTION** setpoint only.

The units for the **ANALOG THRESHLD 1 PICKUP** setpoint are determined by the **A/I UNITS** setpoint.

The **ANALOG THRESHLD 1 PICKUP TYPE** setpoint determines if pickup will occur when the analog input is over or under the programmed threshold.

The value programmed in the **ANALOG THRESHLD 1 DROP OUT RATIO** setpoint represents the variation of pickup value, in percentage of pickup, at which the element will effectively drop out. The drop out ratio is defined as follows:

$$\text{Drop Out} = \text{pickup} - \frac{\text{pickup} \times \text{dropout ratio}}{100} \quad \text{when PICKUP TYPE is Over}$$

$$\text{Drop Out} = \text{pickup} + \frac{\text{pickup} \times \text{dropout ratio}}{100} \quad \text{when PICKUP TYPE is Under}$$

**(EQ 5.21)**

For example, if the pickup level is 5000  $\mu\text{A}$ , then a **ANALOG THRESHLD 1 PICKUP TYPE** set to "Over" and a **ANALOG THRESHLD 1 DROP OUT RATIO** set to "10%" results in a drop out of 4500  $\mu\text{A}$ . Conversely, if the **ANALOG THRESHLD 1 PICKUP TYPE** is "Under" with the same drop out ratio, the actual drop out will be 5500  $\mu\text{A}$ .

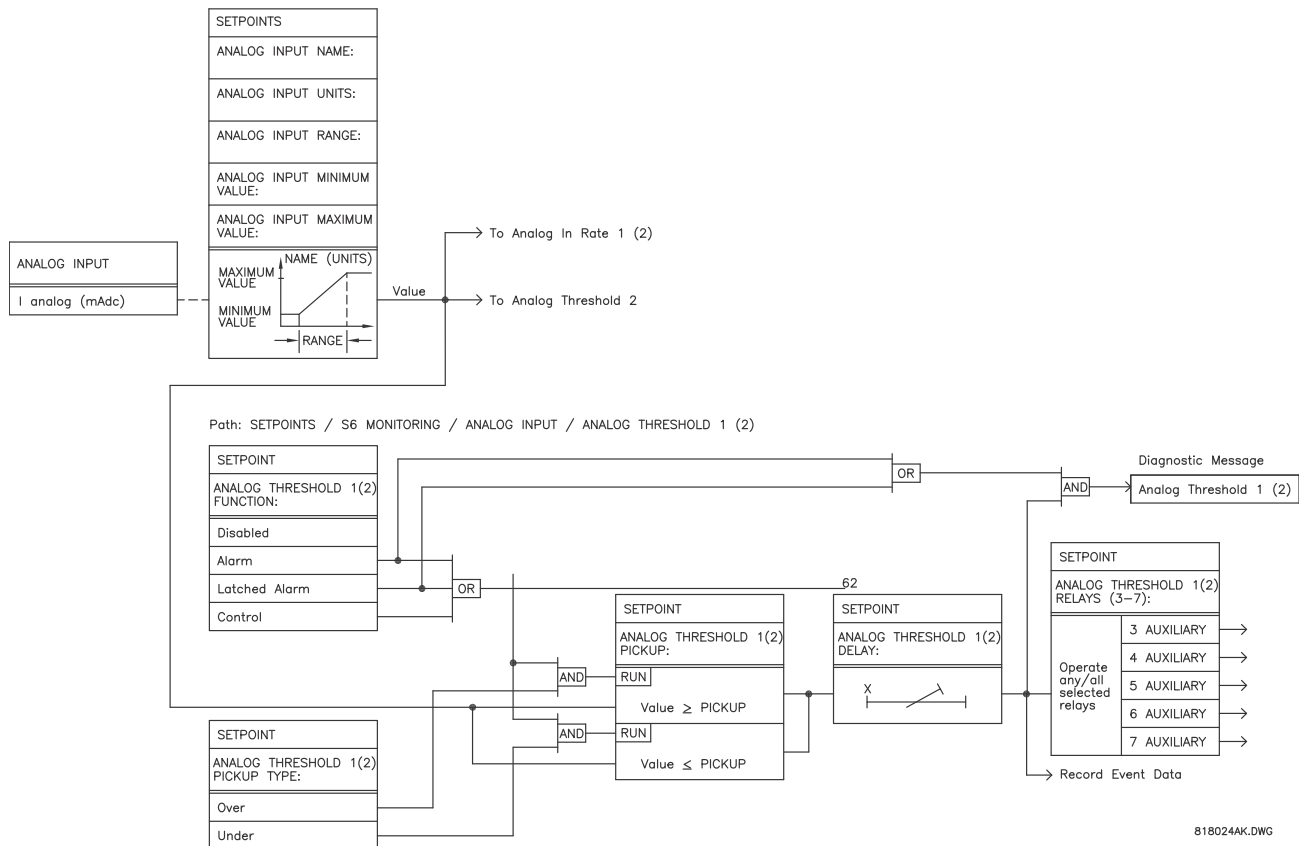


FIGURE 5-45: Analog Input Threshold Logic

### Analog Input Rate of Change

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ ANALOG INPUT ▾ ▾ ANALOG INPUT RATE 1(2)

<b>■ ANALOG INPUT RATE 1</b> [▷]	<b>A/I RATE 1</b> <b>FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm,
MESSAGE	<b>A/I RATE 1</b> <b>RELAYS (3-7): -----</b>	Range: Any combination of the 3 to 7 Auxiliary
MESSAGE	<b>A/I RATE 1 PICKUP:</b> <b>10.0 μA /hour</b>	Range: -1000.0 to 1000.0 units in steps of 1
MESSAGE	<b>A/I RATE 1</b> <b>DELAY: 0 s</b>	Range: 0 to 60000 s in steps of 1

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.

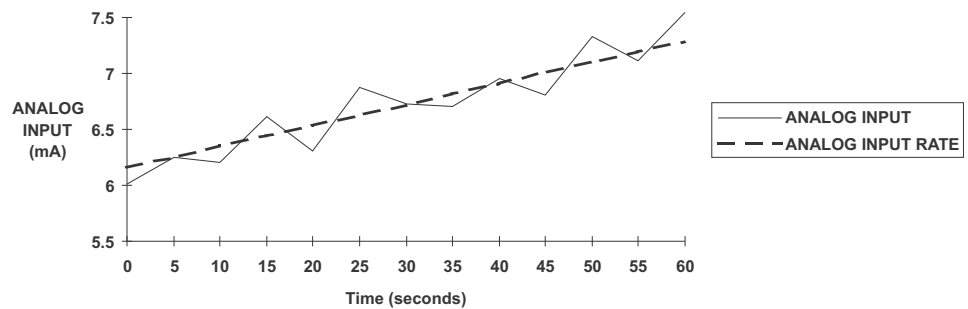


FIGURE 5-46: Analog Input Rate of Change Measurement

Note that connected analog input will still be read and displayed in **A2 METERING ▾ A/I** if both **A/I RATE 1 FUNCTION** and **A/I RATE 2 FUNCTION** are set to "Disabled".

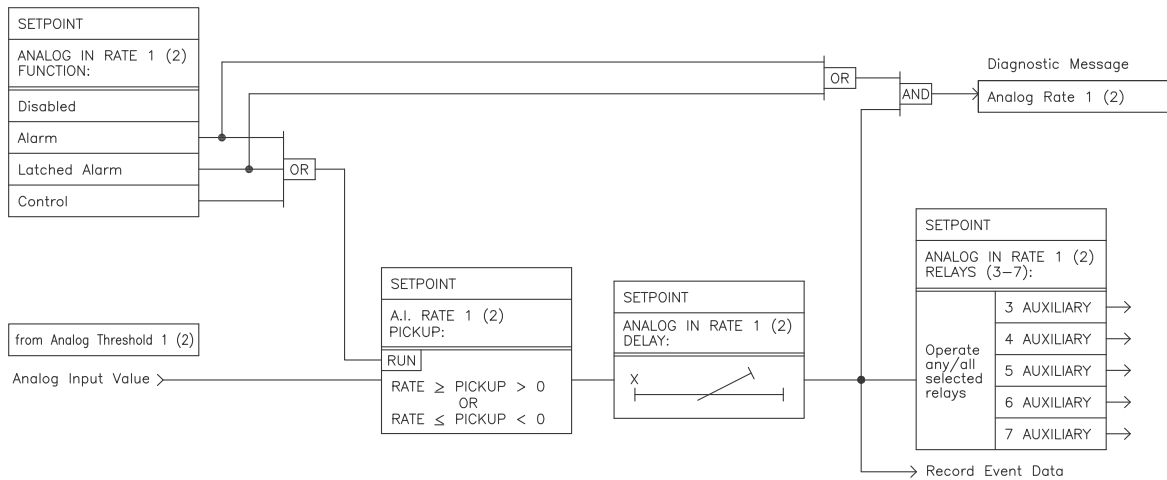


FIGURE 5-47: Analog Input Rate of Change Logic

### 5.7.6 Analog Outputs

PATH: SETPOINTS ▾ S6 MONITORING ▾ ANALOG OUTPUTS ▾ ANALOG OUTPUT 1(8)

<b>ANALOG OUTPUTS</b>		<b>A/O 1 SOURCE:</b> Disabled	Range: See Table 5-19: Analog Output
	MESSAGE	<b>A/O 1 MIN:</b> -100.0 MW	Range: See Table 5-19: Analog Output
	MESSAGE	<b>A/O 1 MAX:</b> 100.0 MW	Range: See Table 5-19: Analog Output

There are three analog output channel types: A, B, and C (see Table 5-19: Analog Output Parameters on page 5-111 for parameter-channel correspondence). Type A channel ranges extend from a minimum of 0 units. Type B channels range between definite boundaries. Type C channels include the direction of flow. The following diagram illustrates these characteristics.

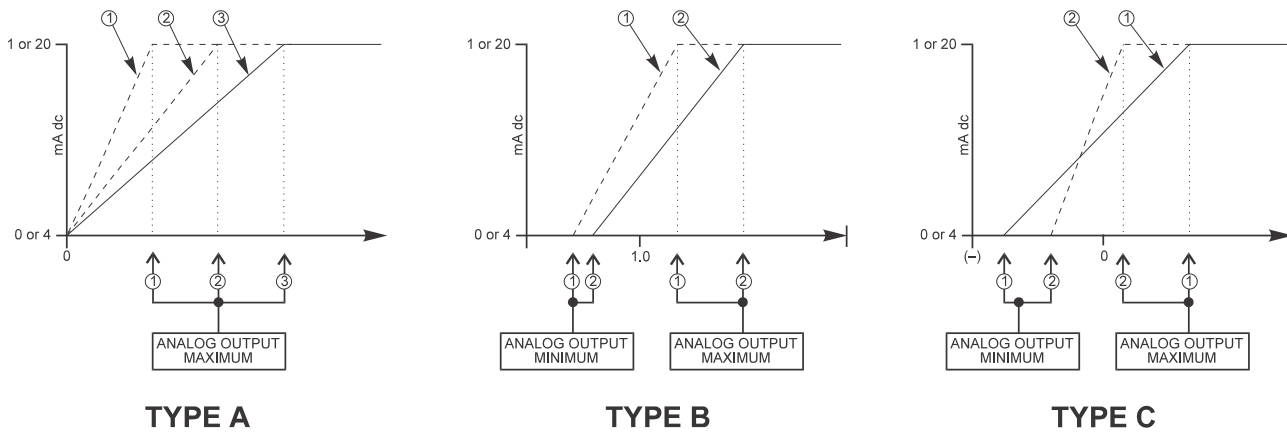


FIGURE 5-48: Analog Outputs Channel Characteristics



Each channel can be programmed to represent a parameter from the following table:

**Table 5–19: Analog Output Parameters (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
3 $\phi$ Real Power	-3000.0 to 3000.0 MW <sup>1</sup>	0.1	-100.0	100.0	C
3 $\phi$ Reactive Power	-3000.0 to 3000.0 Mvar <sup>1</sup>	0.1	-100.0	100.0	C
3 $\phi$ Apparent Power	0.0 to 3000.0 MVA <sup>1</sup>	0.1	0.0	100.0	A
3 $\phi$ 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 <sup>1</sup>	0.1	-100.0	100.0	C
Last Var Demand	-3000.0 to 3000.0 Mvar <sup>1</sup>	0.1	-100.0	100.0	C
Last VA Demand	0.0 to 3000.0 MVA <sup>1</sup>	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/mi	0.01	-50.00	50.00	C
Positive Watthours	0.0 to 6553.5 MWh <sup>1</sup>	0.1	0.0	1000.0	A
Negative Watthours	0.0 to 6553.5 MWh <sup>1</sup>	0.1	0.0	1000.0	A
Positive Varhours	0.0 to 6553.5 Mvarh <sup>1</sup>	0.1	0.0	1000.0	A
Negative Varhours	0.0 to 6553.5 Mvarh <sup>1</sup>	0.1	0.0	1000.0	A

<sup>1</sup> Power and energy quantities auto-range to display units appropriate to power system size.

Table 5–19: Analog Output Parameters (Sheet 2 of 2)

Parameter Name	Range / Units	Step	Defaults		Channel Type
			Min.	Max.	
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 <sup>1</sup>	0.1	-100.0	100.0	C
φA/φB/φC Reactive Power	-3000.0 to 3000.0 Mvar <sup>1</sup>	0.1	-100.0	100.0	C
φA/φB/φC Apparent Power	0.0 to 3000.0 MVA <sup>1</sup>	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
Pos/Neg/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
Pos/Neg/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

<sup>1</sup> Power and energy quantities auto-range to display units appropriate to power system size.

### 5.7.7 Overfrequency

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ OVERFREQUENCY

<div style="border: 1px solid black; padding: 2px;"> <span style="background-color: black; color: white; padding: 2px;">OVERFREQUENCY</span> [▶]             </div>		<div style="border: 1px solid black; padding: 2px;"> <b>OVERFREQUENCY</b>  <b>FUNCTION: Disabled</b> </div>	<i>Range: Disabled, Alarm, Latched Alarm,</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>OVERFREQUENCY</b>  <b>RELAYS (3-7): -----</b> </div>	<i>Range: Any combination of 3 to 7 Auxiliary relays</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>OVERFREQUENCY</b>  <b>PICKUP: 60.50 Hz</b> </div>	<i>Range: 20.00 to 65.00 Hz in steps of 0.01</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>OVERFREQUENCY</b>  <b>DELAY: 5.0 s</b> </div>	<i>Range: 0.0 to 6000.0 s in steps of 0.1</i>

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.

Note that the system frequency will still be measured and displayed in **A2 METERING** ▾ ▾ **FREQ** if both the Overfrequency and Underfrequency functions are set to “Disabled”.

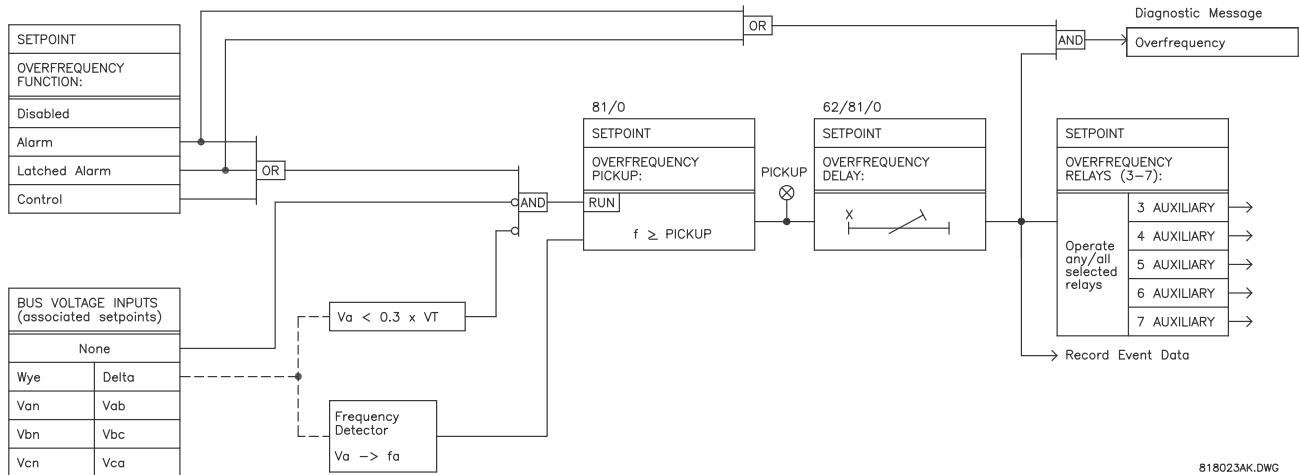








FIGURE 5-49: Overfrequency Logic

818023AK.DWG

### 5.7.8 Equipment

#### Main Menu




PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ EQUIPMENT

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <span style="font-size: 1.2em;">■</span> <b>EQUIPMENT</b> <span style="float: right;">[▷]</span> </div>		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <span style="font-size: 1.2em;">■</span> <b>TRIP COUNTER</b> <span style="float: right;">[▷]</span> </div>	<p>See page 5-114</p>
MESSAGE		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <span style="font-size: 1.2em;">■</span> <b>ARCING CURRENT</b> <span style="float: right;">[▷]</span> </div>	<p>See page 5-115</p>
MESSAGE		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <span style="font-size: 1.2em;">■</span> <b>BREAKER OPERATION</b> <span style="float: right;">[▷]</span> </div>	<p>See page 5-117</p>
MESSAGE		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <span style="font-size: 1.2em;">■</span> <b>COIL MONITOR 1</b> <span style="float: right;">[▷]</span> </div>	<p>See page 5-118</p>
MESSAGE		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <span style="font-size: 1.2em;">■</span> <b>COIL MONITOR 2</b> <span style="float: right;">[▷]</span> </div>	<p>See page 5-118</p>
MESSAGE		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <span style="font-size: 1.2em;">■</span> <b>VT FAILURE</b> <span style="float: right;">[▷]</span> </div>	<p>See page 5-119</p>

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

#### Trip Counter

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ EQUIPMENT ▾ TRIP COUNTER

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <span style="font-size: 1.2em;">■</span> <b>TRIP COUNTER</b> <span style="float: right;">[▷]</span> </div>		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>TRIP COUNTER FUNCTION: Disabled</b> </div>	<p>Range: Disabled, Alarm, Latched Alarm,</p>
MESSAGE		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>TRIP COUNTER RELAYS (3-7): - - - - -</b> </div>	<p>Range: Any combination of 3 to 7 Auxiliary relays</p>
MESSAGE		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>TRIP COUNTER LIMIT: 10000 Trips</b> </div>	<p>Range: 1 to 10000 Trips in steps of 1</p>

When the total number of **BREAKER TRIPS** detected reaches the **TRIP COUNTER LIMIT** setpoint, an output will occur. The **BREAKER TRIPS** value can be viewed in the **A3 MAINTENANCE ▾ TRIP COUNTERS** menu.

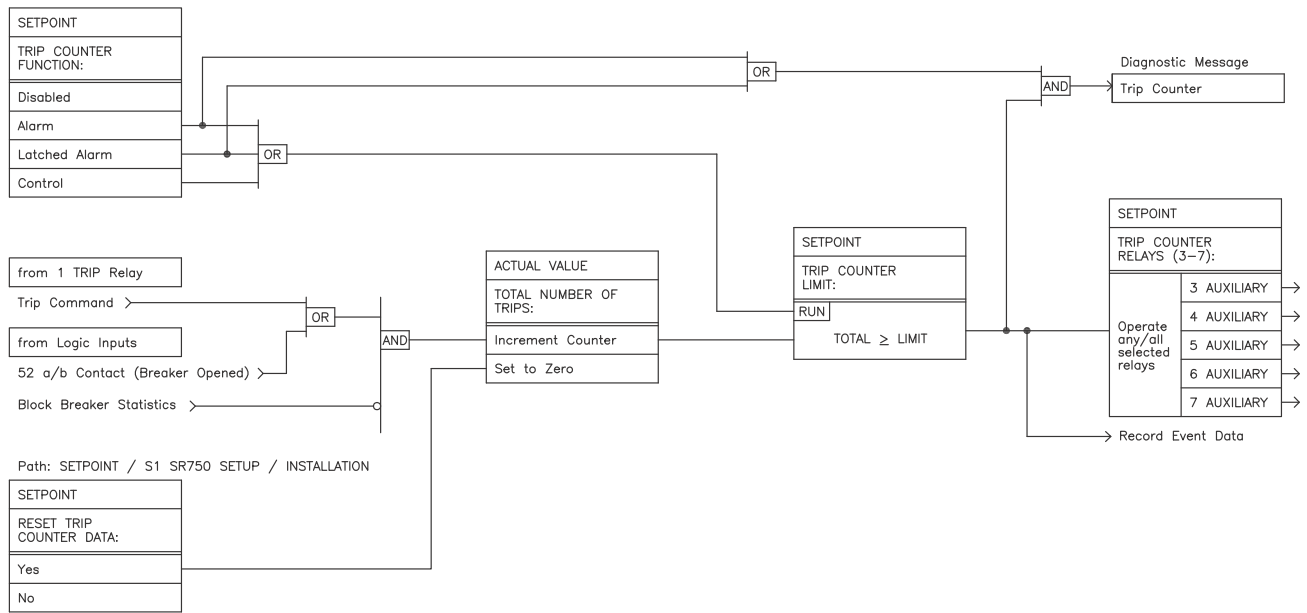


FIGURE 5-50: Trip Counter Logic

818758AM.DWG

## Arcing Current

PATH: SETPOINTS ▾ S6 MONITORING ▾ EQUIPMENT ▾ ARCING CURRENT

<p>■ <b>ARCING CURRENT</b> [▷]</p>	<p><b>ARCING CURRENT</b> <b>FUNCTION: Disabled</b></p>	<p>Range: Disabled, Alarm, Latched Alarm,</p>
<p>MESSAGE</p>	<p><b>ARCING CURRENT</b> <b>RELAYS (3-7): - - - -</b></p>	<p>Range: Any combination of 3 to 7 Auxiliary relays</p>
<p>MESSAGE</p>	<p><b>ARCING CURRENT</b> <b>START DELAY: 32 ms</b></p>	<p>Range: 0 to 100 ms in steps of 1</p>
<p>MESSAGE</p>	<p><b>TOTAL ARCING CURRENT</b> <b>LIMIT: 1000 kA<sup>2</sup>-cyc</b></p>	<p>Range: 1 to 50000 kA<sup>2</sup>-cyc in steps of 1</p>

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 met or 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.

For the **TOTAL ARCING CURRENT START DELAY** setpoint, 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.

For the **TOTAL ARCING CURRENT LIMIT**, enter the total arcing current in  $\text{kA}^2\text{-cycle}$ , 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 equals or exceeds  $1000 \text{ kA}^2\text{-cycle}$ , enter "1000" for this setpoint. An output will occur when the total arcing current in any phase reaches this setpoint.

Note that the total arcing current for each phase will still be available for display under **A3 MAINTENANCE**  $\triangleright \nabla$  **ARCING CURRENT** if the **ARCING CURRENT FUNCTION** set to "Disabled".

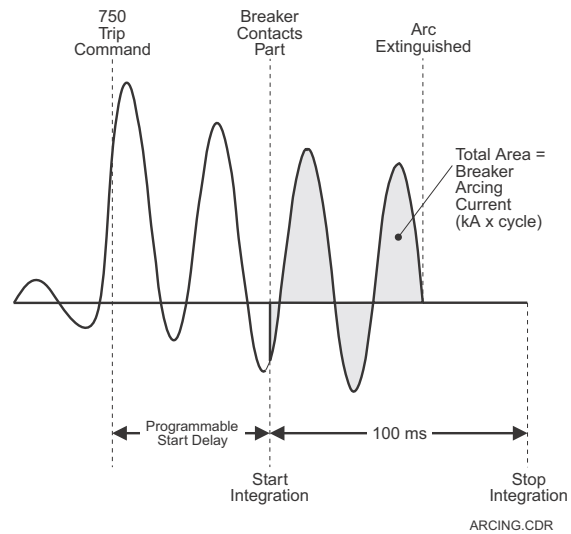


FIGURE 5-51: Arcing Current Measurement

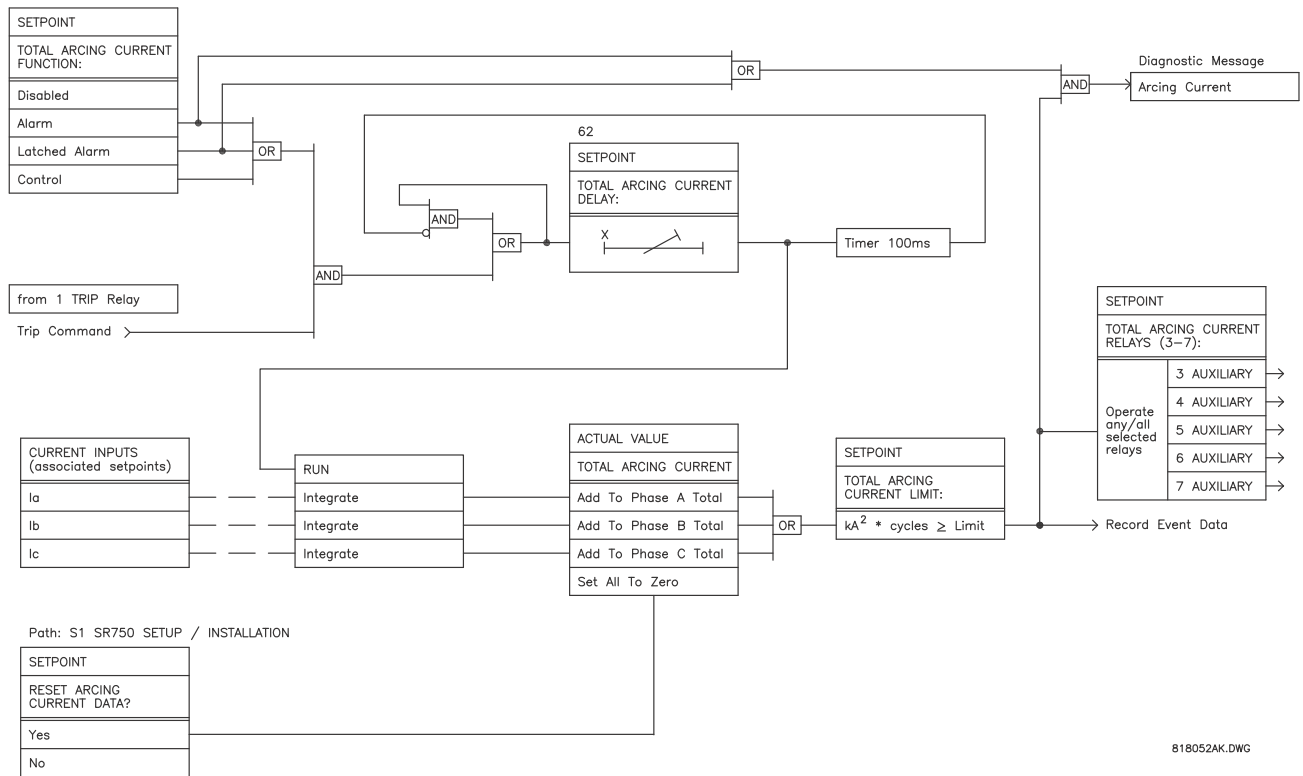


FIGURE 5-52: Arcing Current Logic

### Breaker Operation

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ EQUIPMENT ▾ ▾ BREAKER OPERATION

<b>BREAKER OPERATION</b> [▶]		<b>BRKR OPERATION FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm, Control
	MESSAGE	<b>BRKR OPERATION RELAYS (3-7): -----</b>	Range: Any combination of 3 to 7 Auxiliary relays
	MESSAGE	<b>BRKR OPERATION DELAY: 0.10 s</b>	Range: 0.03 to 1.00 s in steps of 0.01

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 *System Status LED Indicators* on page 4-3 and *Breaker Functions* on page 5-28 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 **BRKR 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 Close Relay and 760 autoreclosure will be inhibited. If the 760 already has a reclosure scheme in progress, it will be sent to lockout.

A Breaker Operation failure condition results if the breaker does not respond within the **BRKR OPERATION DELAY** time. This time is a characteristic of the breaker being used.

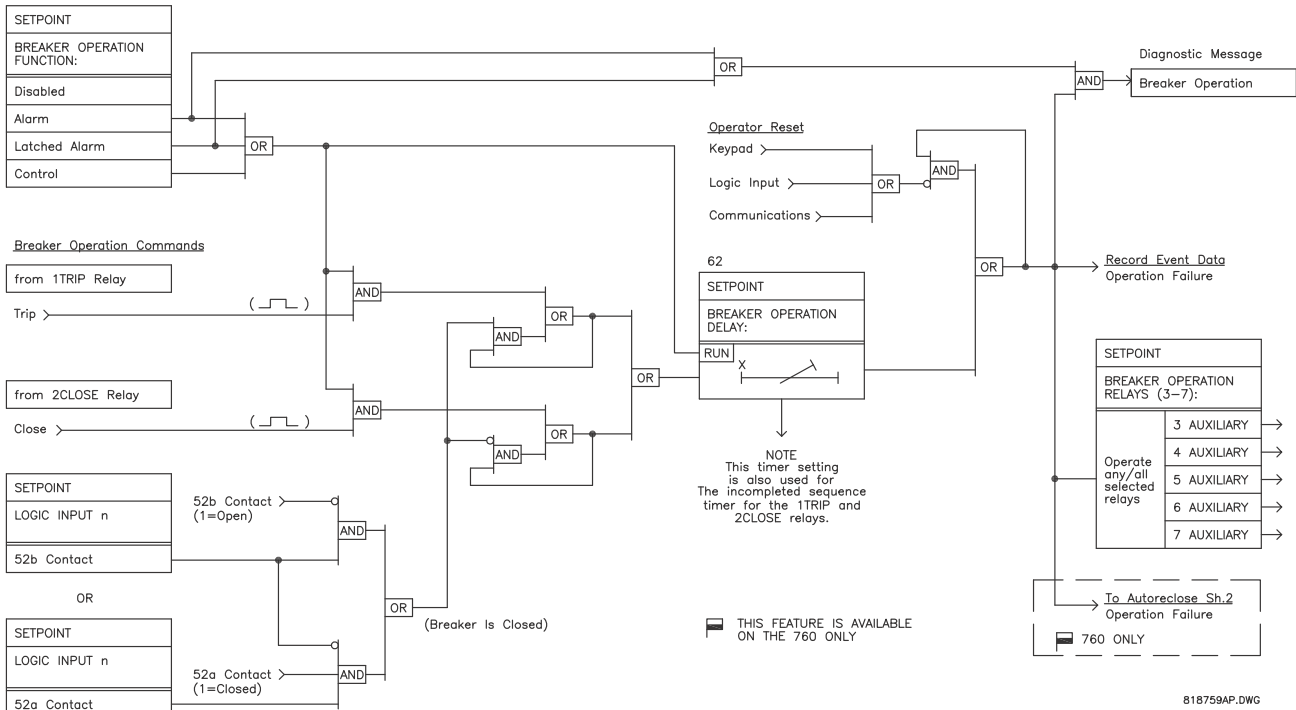


FIGURE 5-53: Breaker Operation Logic

### Coil Monitor

PATH: SETPOINTS ▾ S6 MONITORING ▾ EQUIPMENT ▾ COIL MONITOR 1(2)

■ COIL MONITOR 1 [▶]		<b>COIL MON 1 NAME:</b> <b>Trip Coil Monitor</b>	Range: Any combination of 18 alphanumeric
MESSAGE		<b>COIL MON 1</b> <b>FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm, Control
MESSAGE		<b>COIL MON 1</b> <b>RELAYS (3-7): - - - - -</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>BREAKER STATE</b> <b>BYPASS: Disabled</b>	Range: Enabled, Disabled
MESSAGE		<b>COIL MON 1</b> <b>DELAY: 5 s</b>	Range: 5 to 100 s in steps of 1
MESSAGE		<b>COIL MON 1</b> <b>TYPE: Trip</b>	Range: Trip, Close



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 *Trip/Close Coil Supervision* on page 3–15.

Detection of a failed circuit regardless of the breaker state (i.e. detection of a failed trip circuit when the breaker is open) requires **BRKR STATE BYPASS** to be “Enabled”. Generally, this selection will require a wiring modification of the breaker, as detailed in *Trip/Close Coil Supervision* on page 3–15.



Upon detection of failure in the Trip/Close coil circuit the "Trip/Close Coil Monitor" output is latched when set for the Alarm function. Operator intervention is required for the reset.

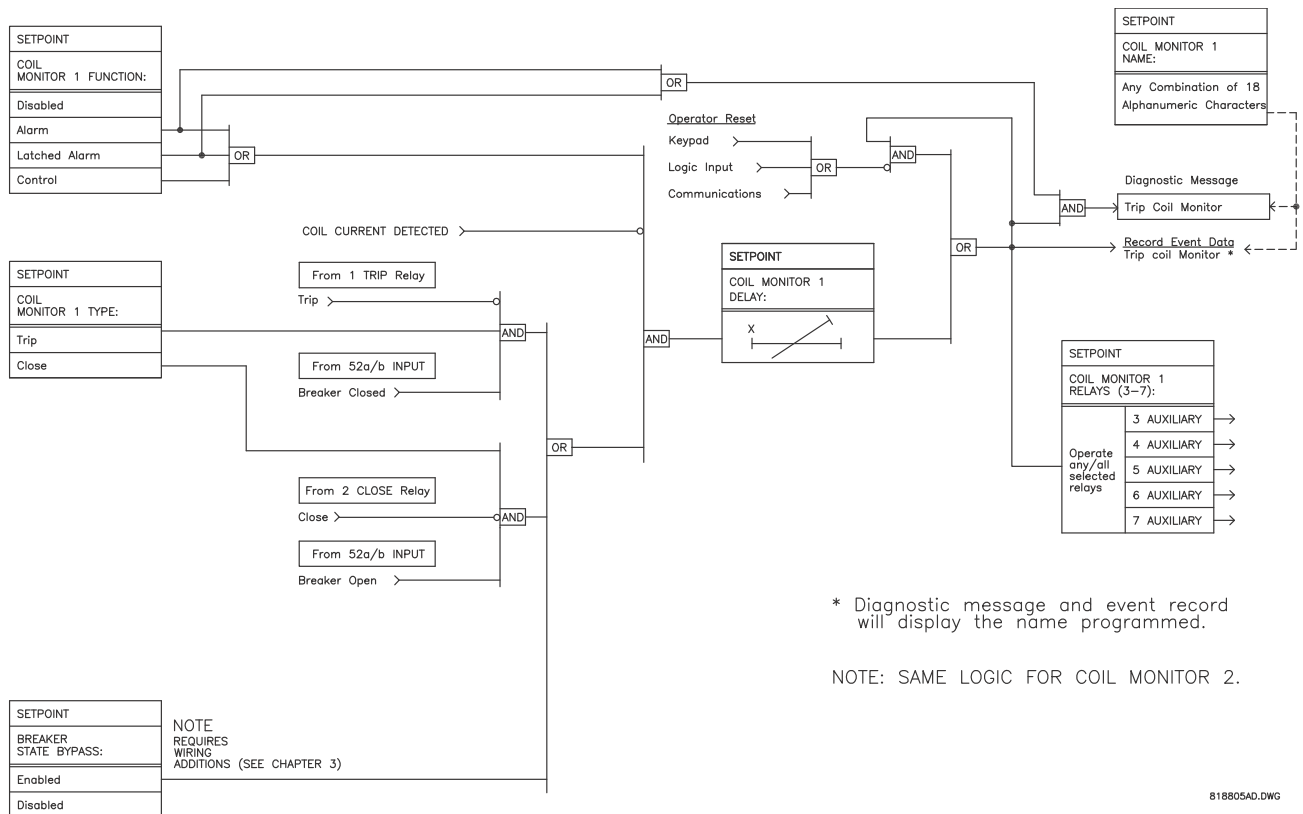


FIGURE 5–54: Coil Monitor Logic

### VT Failure

PATH: SETPOINTS ▾ ▾ S6 MONITORING ▾ ▾ EQUIPMENT ▾ ▾ VT FAILURE

<p>■ <b>VT FAILURE</b> [▶]</p>		<p><b>VT FAILURE</b> <b>FUNCTION: Disabled</b></p>	<p>Range: Disabled, Alarm, Latched Alarm,</p>
<p>MESSAGE</p>		<p><b>VT FAILURE</b> <b>RELAYS (3-7): -----</b></p>	<p>Range: Any combination of 3 to 7 Auxiliary relays</p>
<p>MESSAGE</p>		<p><b>VT FAILURE</b> <b>DELAY: 10 s</b></p>	<p>Range: 0 to 60000 s in steps of 1</p>

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.

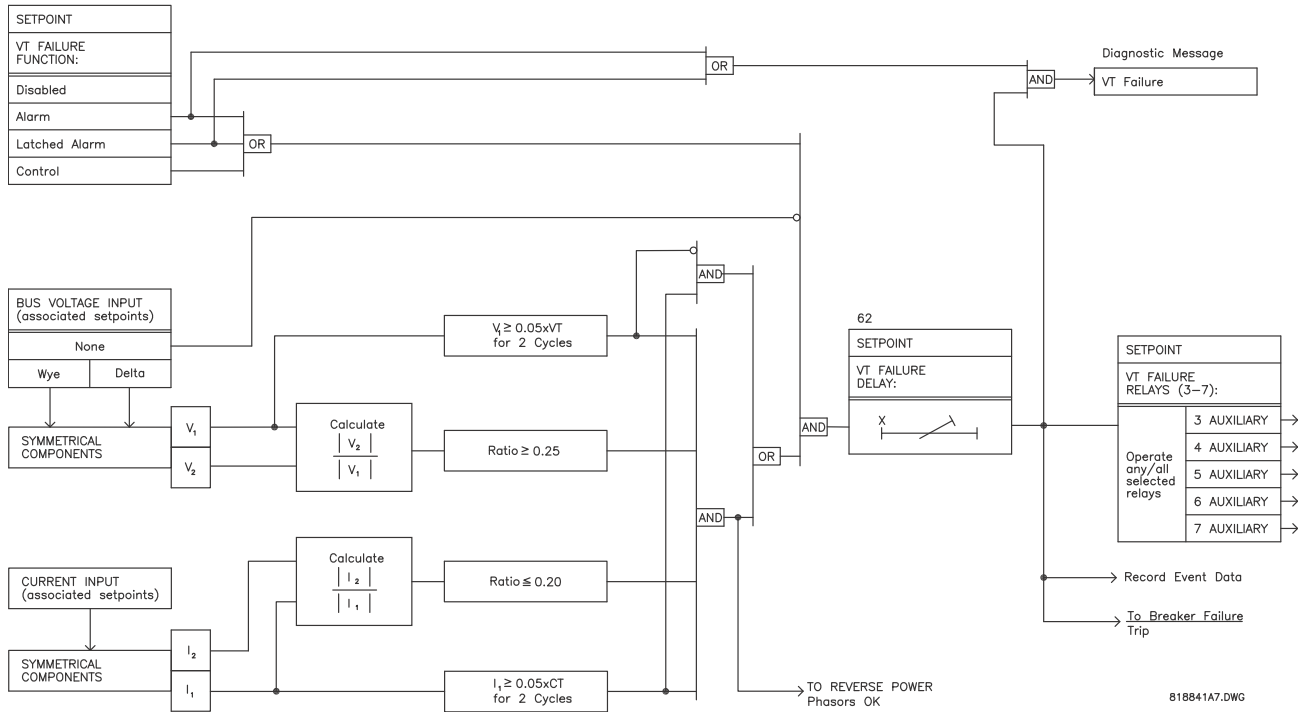











FIGURE 5-55: VT Failure Logic

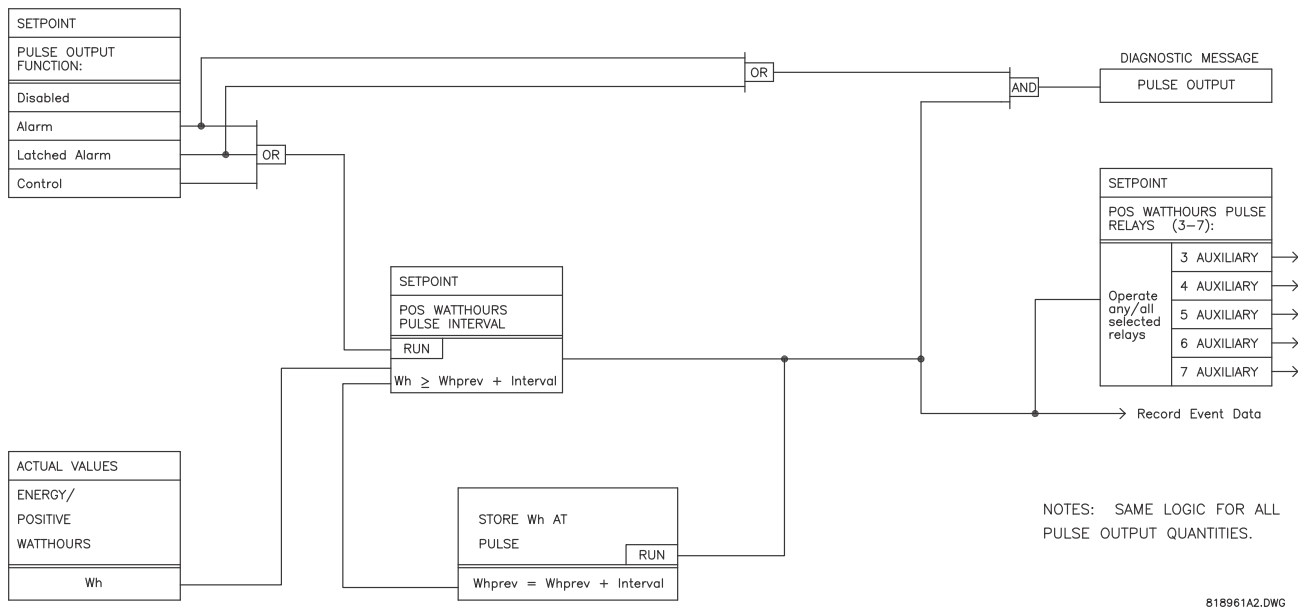
### 5.7.9 Pulse Output

PATH: SETPOINTS ▾ S6 MONITORING ▾ PULSED OUTPUT

<div style="border: 1px solid black; padding: 2px; display: inline-block;"> <span style="color: blue;">■</span> <b>PULSED OUTPUT</b> <span style="font-size: 1.2em;">[▷]</span> </div>			<div style="border: 1px solid black; padding: 2px;"> <b>PULSED OUTPUT</b>  <b>FUNCTION: Disabled</b> </div>	<i>Range: Disabled, Alarm, Latched Alarm,</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>POS WATTHOURS PULSED</b>  <b>RELAYS (3-7): -----</b> </div>	<i>Range: Any combination of the 3 to 7 Auxiliary</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>POS WATTHOURS PULSED</b>  <b>INTERVAL: 10.0 MWh</b> </div>	<i>Range: 0.0 to 6553.5 MWh in steps of 0.1 (auto-</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>NEG WATTHOURS PULSED</b>  <b>RELAYS (3-7): -----</b> </div>	<i>Range: Any combination of the 3 to 7 Auxiliary</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>NEG WATTHOURS PULSED</b>  <b>INTERVAL: 10.0 MWh</b> </div>	<i>Range: 0.0 to 6553.5 MWh in steps of 0.1 (auto-</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>POS VARHOURS PULSED</b>  <b>RELAYS (3-7): -----</b> </div>	<i>Range: Any combination of the 3 to 7 Auxiliary</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>POS VARHOURS PULSED</b>  <b>INTERVAL: 10.0 Mvarh</b> </div>	<i>Range: 0.0 to 6553.5 Mvarh in steps of 0.1 (auto-</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>NEG VARHOURS PULSED</b>  <b>RELAYS (3-7): -----</b> </div>	<i>Range: Any combination of the 3 to 7 Auxiliary</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>NEG VARHOURS PULSED</b>  <b>INTERVAL: 10.0 Mvarh</b> </div>	<i>Range: 0.0 to 6553.5 Mvarh in steps of 0.1 (auto-</i>	

The 750/760 can operate selected auxiliary relays after an adjustable interval for the quantities shown above. 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.



NOTES: SAME LOGIC FOR ALL PULSE OUTPUT QUANTITIES.








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FIGURE 5-56: Pulsed Output Logic

## 5.8 S7 Control

### 5.8.1 Setpoint Groups

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ SETPOINT GROUPS

■ SETPOINT GROUPS [▷]		<b>ACTIVE SETPOINT GROUP: Group 1</b>	<i>Range: Group 1, Group 2, Group 3, Group 4</i>
MESSAGE		<b>EDIT SETPOINT GROUP: Active Group</b>	<i>Range: Group 1, Group 2, Group 3, Group 4</i>
MESSAGE		<b>OPEN BREAKER INHIBIT: Disabled</b>	<i>Range: Enabled, Disabled</i>
MESSAGE		<b>OVERCURRENT PICKUP INHIBIT: Disabled</b>	<i>Range: Enabled, Disabled</i>
MESSAGE		<b>OVERVOLTAGE PICKUP INHIBIT: Disabled</b>	<i>Range: Enabled, Disabled</i>
MESSAGE		<b>UNDERVOLTAGE PICKUP INHIBIT: Disabled</b>	<i>Range: Enabled, Disabled</i>
MESSAGE		<b>UNDERFREQ PICKUP INHIBIT: Disabled</b>	<i>Range: Enabled, Disabled</i>

All setpoints contained under the **S5 PROTECTION** setpoints page 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, different settings may be used depending the tie breaker state. 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 is selected through the **EDIT SETPOINT GROUP** setpoint. Group 1 is the default for the "Active Group" and will be used unless another group is requested to become active. The active group can be selected with the **ACTIVE SETPOINT GROUP** 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.



Pickup of a protection element is possible when set to any value except "Disabled", so elements not used to perform tripping can also inhibit setpoint changes. A setpoint 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.

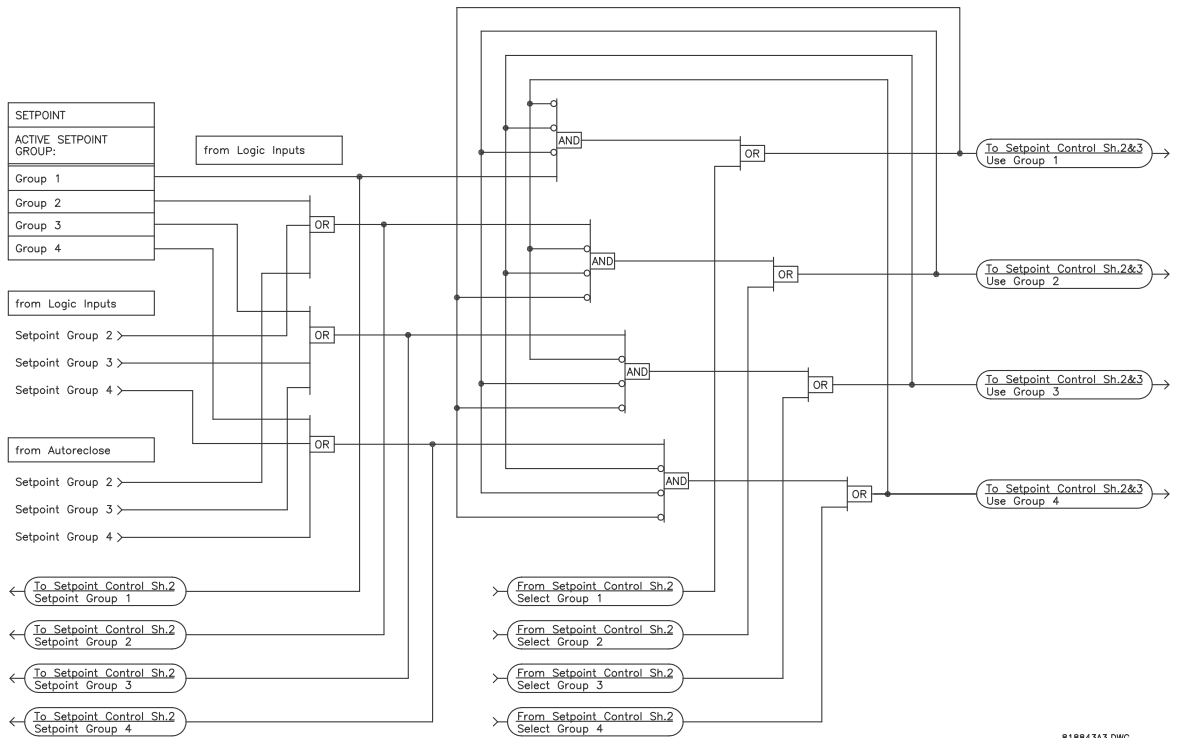


FIGURE 5-57: Setpoint Control (1 of 3)

818843A3.DWG

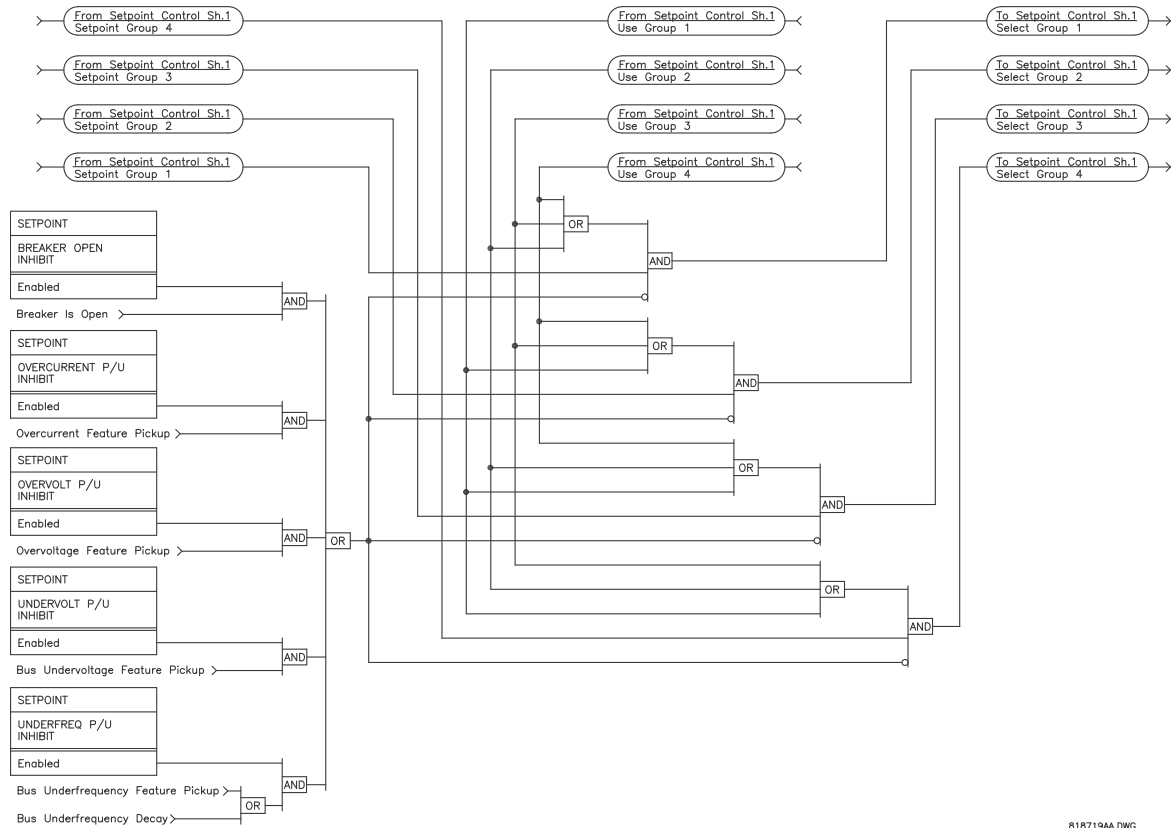


FIGURE 5-58: Setpoint Control (2 of 3)

818719AA.DWG

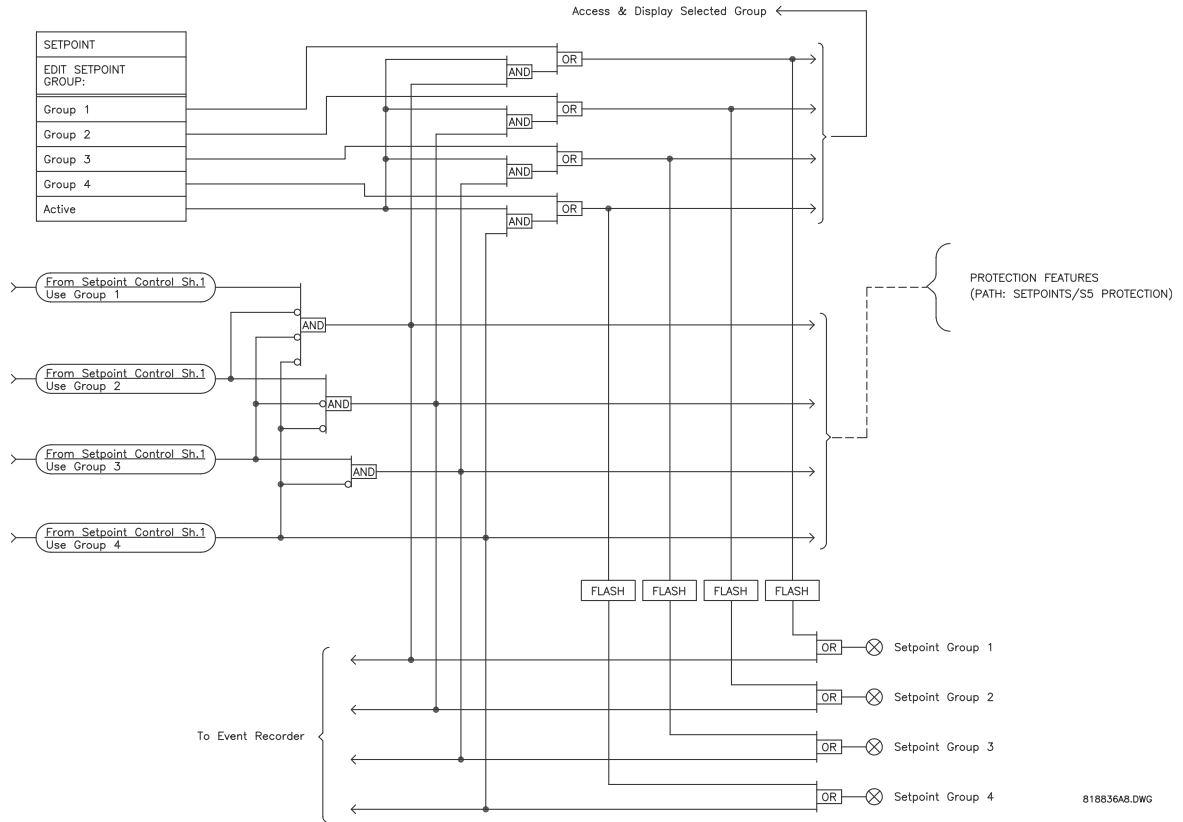


FIGURE 5-59: Setpoint Control (3 of 3)



Each setpoint group includes the selection of Auxiliary Output Relays 3 to 7 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.



## 5.8.2 Synchrocheck

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ SYNCHROCHECK

■ SYNCHROCHECK	[▷]		SYNCHROCHECK FUNCTION: Disabled	Range: Disabled, Alarm, Latched Alarm,
MESSAGE			SYNCHROCHECK RELAYS (3-7): -----	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE			DEAD SOURCE PERMISSIVE: Off	Range: Off, DB&DL, LL&DB, DL&LB, DL DB,
MESSAGE			DEAD BUS MAX VOLTAGE: 0.20 x VT	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE			DEAD LINE MAX VOLTAGE: 0.20 x VT	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE			LIVE BUS MIN VOLTAGE: 0.80 x VT	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE			LIVE LINE MIN VOLTAGE: 0.80 x VT	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE			MAX VOLTAGE DIFFERENCE: 2.00 kV	Range: 0.01 to 100.00 kV in steps of 0.01
MESSAGE			MAX ANGLE DIFFERENCE: 24°	Range: 0 to 100° in steps of 1
MESSAGE			MAX FREQ DIFFERENCE: 2.00 Hz	Range: 0.00 to 5.00 Hz in steps of 0.01

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 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 V. 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.

The **DEAD SOURCE PERMISSIVE** setpoint 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 four setpoints following this one. The **DEAD SOURCE PERMISSIVE** range is as follows:

- “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).

For the **DEAD BUS MAX VOLTAGE** and **DEAD LINE MAX VOLTAGE** setpoints, enter the voltage magnitude as a fraction of the bus or line VT input nominal voltage. If the bus or line voltage falls below these values, the single bus/line voltage input used for synchrocheck will be considered ‘dead’, or de-energized.

For the **LIVE BUS MIN VOLTAGE** and **LIVE LINE MIN VOLTAGE** setpoints, enter the voltage magnitude as a fraction of the bus or line VT input nominal voltage. If the bus or line voltage rises above the respective setting, the single bus or line voltage input used for synchrocheck is established as ‘live’, or energized.

The voltage, angular, and frequency differences of the primary systems are also entered through the **MAX VOLTAGE DIFFERENCE**, **MAX ANGLE DIFFERENCE**, and **MAX FREQ DIFFERENCE** setpoints, respectively. A voltage magnitude, angular, or frequency differential on the two input voltages below the values entered here is within the permissible limit for synchronism.

DSD – Dead Source Decision

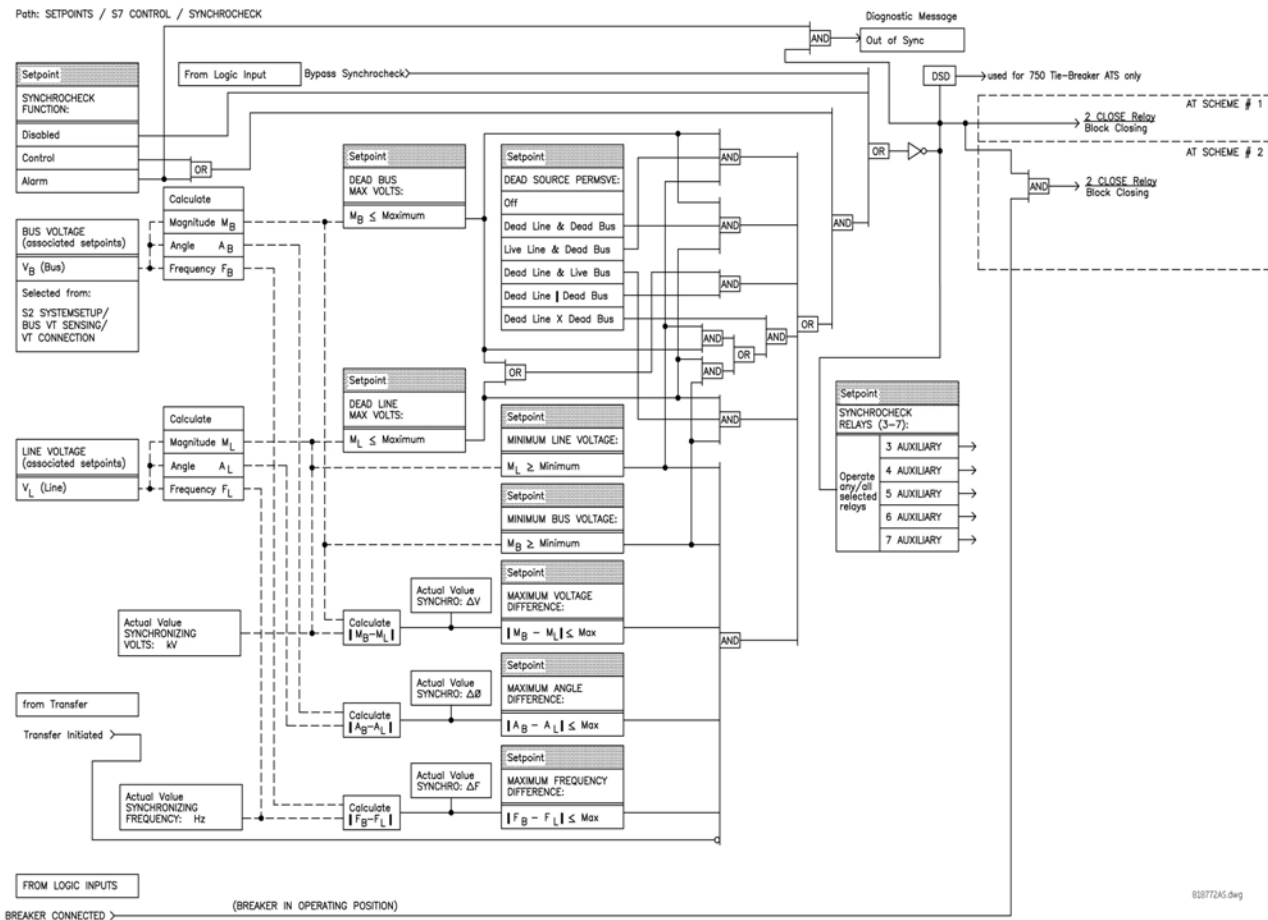


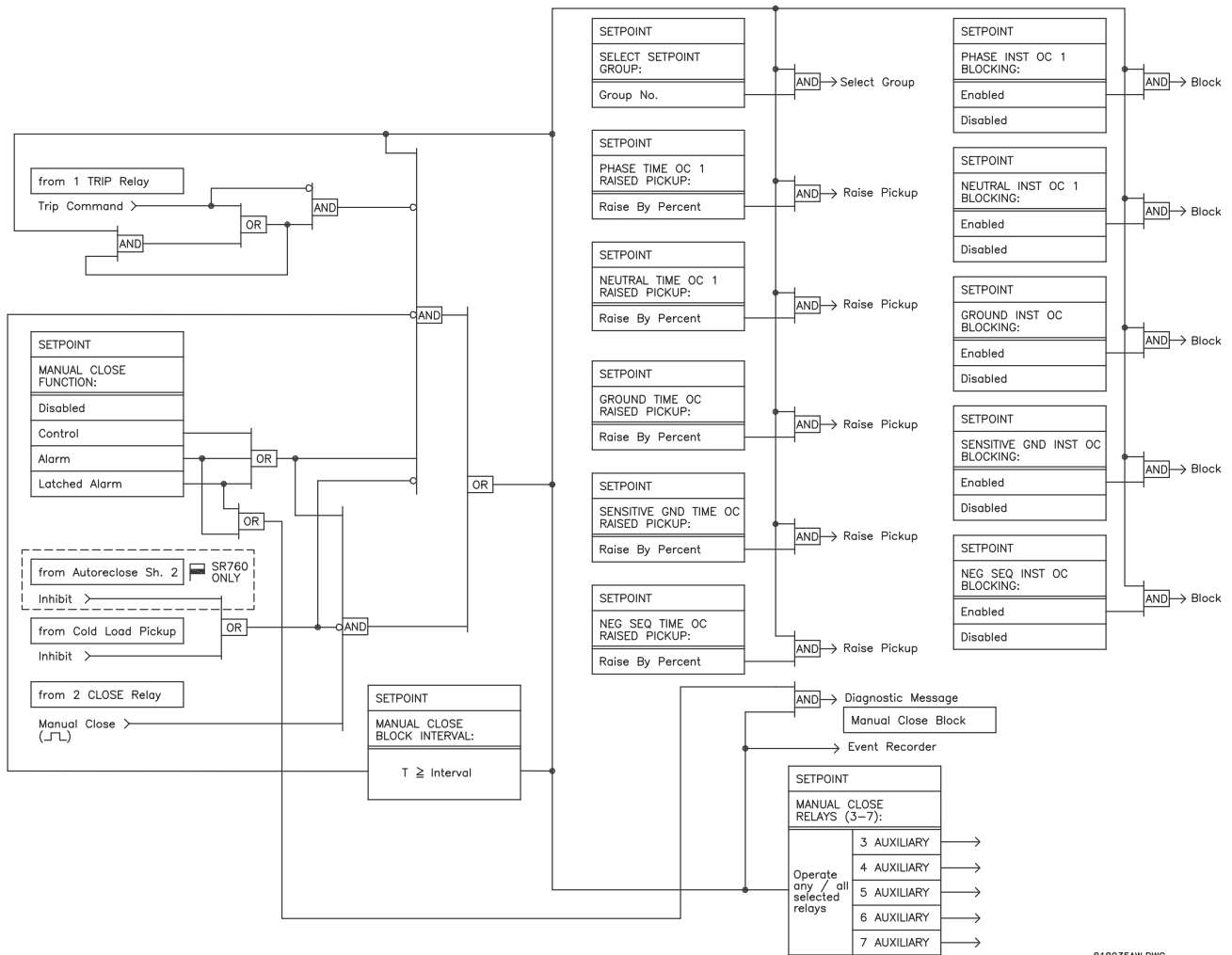
FIGURE 5-60: Synchrocheck Logic

### 5.8.3 Manual Close Blocking

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ MANUAL CLOSE

■ <b>MANUAL CLOSE</b> [▷]		<b>MANUAL CLOSE</b> <b>FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm,
MESSAGE		<b>MANUAL CLOSE</b> <b>RELAYS (3-7): -----</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>MANUAL CLOSE BLOCK</b> <b>TIME: 5 s</b>	Range: 1 to 1000 s in steps of 1
MESSAGE		<b>PHASE INST OC 1</b> <b>BLOCKING: Disabled</b>	Range: Disabled, Enabled
MESSAGE		<b>NEUTRAL INST OC 1</b> <b>BLOCKING: Disabled</b>	Range: Disabled, Enabled
MESSAGE		<b>GND INST OC</b> <b>BLOCKING: Disabled</b>	Range: Disabled, Enabled
MESSAGE		<b>SENSTV GND INST OC</b> <b>BLOCKING: Disabled</b>	Range: Disabled, Enabled
MESSAGE		<b>NEG SEQ INST OC</b> <b>BLOCKING: Disabled</b>	Range: Disabled, Enabled
MESSAGE		<b>PHASE TIME OC 1</b> <b>RAISED PICKUP: 0%</b>	Range: 0 to 100% in steps of 1
MESSAGE		<b>NEUTRAL TIME OC 1</b> <b>RAISED PICKUP: 0%</b>	Range: 0 to 100% in steps of 1
MESSAGE		<b>GND TIME OC</b> <b>RAISED PICKUP: 0%</b>	Range: 0 to 100% in steps of 1
MESSAGE		<b>SENSTV GND TIME OC</b> <b>RAISED PICKUP: 0%</b>	Range: 0 to 100% in steps of 1
MESSAGE		<b>NEG SEQ TIME OC</b> <b>RAISED PICKUP: 0%</b>	Range: 0 to 100% in steps of 1
MESSAGE		<b>SELECT SETPOINT</b> <b>GROUP: Active Group</b>	Range: Group 1, Group 2, Group 3, Group 4,

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.



818035AW.DWG

FIGURE 5-61: Manual Close Blocking Logic

### 5.8.4 Cold Load Pickup

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ COLD LOAD PICKUP

■ COLD LOAD PICKUP	[▷]		COLD LOAD PICKUP FUNCTION: Disabled	Range: Disabled, Alarm, Latched Alarm,
MESSAGE			COLD LOAD PICKUP RELAYS (3-7): -----	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE			OUTAGE TIME BEFORE COLD LOAD: 100 min	Range: 1 to 1000 min. in steps of 1
MESSAGE			COLD LOAD PICKUP BLOCK TIME: 5 s	Range: 1 to 1000 s in steps of 1
MESSAGE			PHASE INST OC 1 BLOCKING: Disabled	Range: Disabled, Enabled
MESSAGE			NEUTRAL INST OC 1 BLOCKING: Disabled	Range: Disabled, Enabled
MESSAGE			GND INST OC BLOCKING: Disabled	Range: Disabled, Enabled
MESSAGE			SENSTV GND INST OC BLOCKING: Disabled	Range: Disabled, Enabled
MESSAGE			NEG SEQ INST OC BLOCKING: Disabled	Range: Disabled, Enabled
MESSAGE			PHASE TIME OC 1 RAISED PICKUP: 0%	Range: 0 to 100% in steps of 1
MESSAGE			NEUTRAL TIME OC 1 RAISED PICKUP: 0%	Range: 0 to 100% in steps of 1
MESSAGE			GND TIME OC RAISED PICKUP: 0%	Range: 0 to 100% in steps of 1
MESSAGE			SENSTV GND TIME OC RAISED PICKUP: 0%	Range: 0 to 100% in steps of 1
MESSAGE			NEG SEQ TIME OC RAISED PICKUP: 0%	Range: 0 to 100% in steps of 1
MESSAGE			SELECT SETPOINT GROUP: Active Group	Range: Group 1, Group 2, Group 3, Group 4,

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 3 seconds. See the following figure for details.

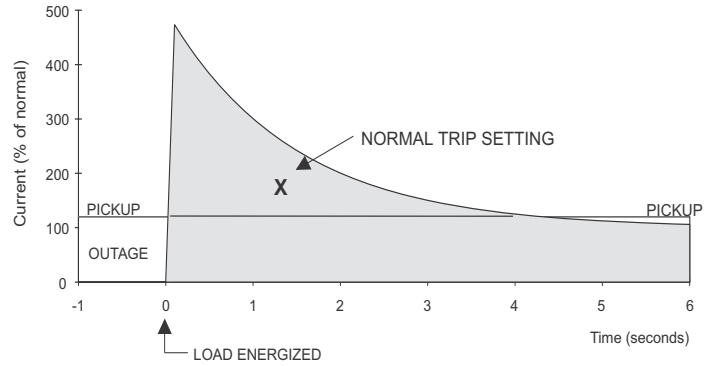
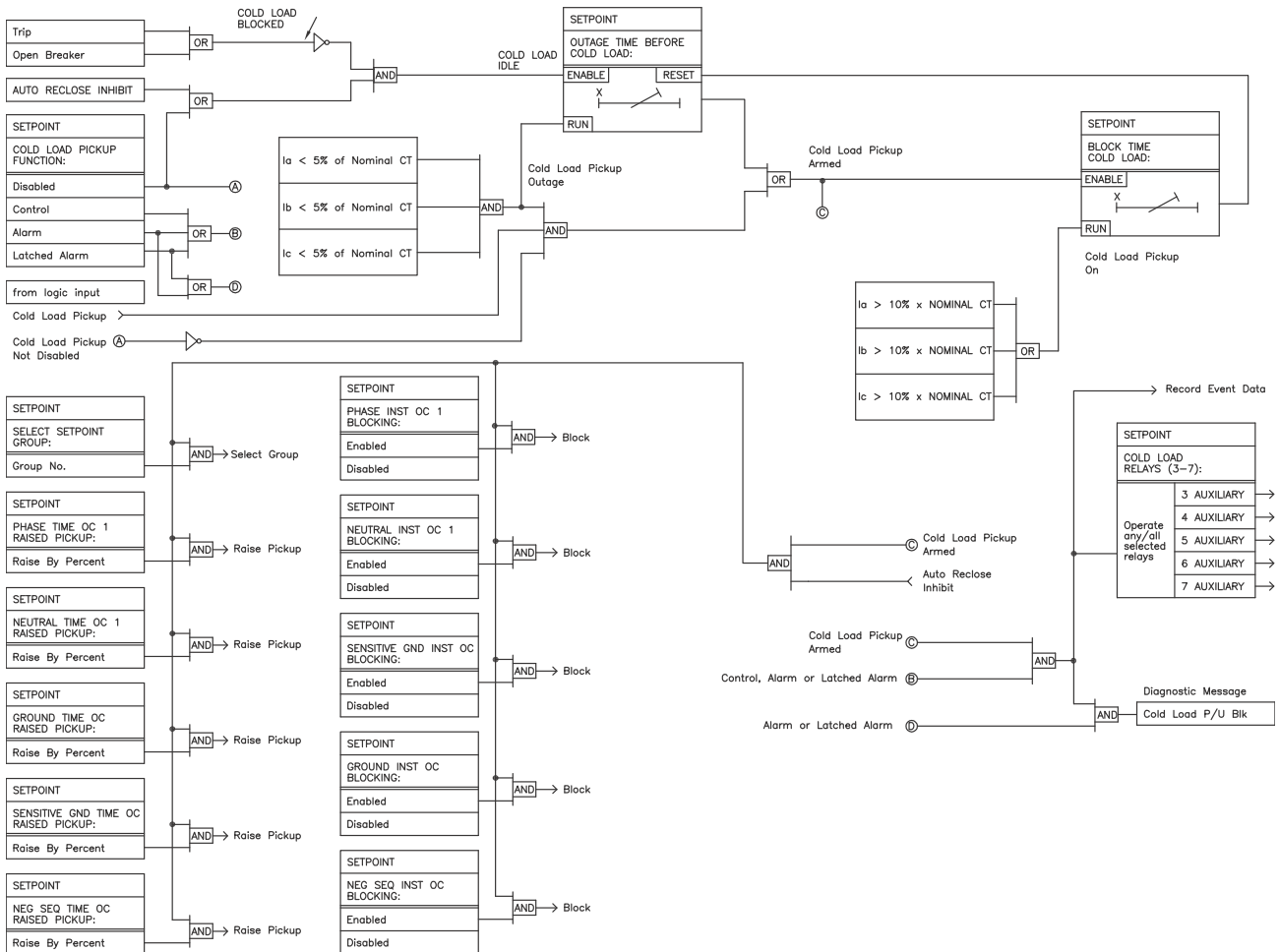


FIGURE 5-62: Cold Load Pickup

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** setpoint. 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.










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FIGURE 5-63: Cold Load Pickup Logic

## 5.8.5 Undervoltage Restoration

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ UNDERVOLTAGE RESTORATION

■ <b>UNDERVOLTAGE RESTORATION</b> [▷]		<b>UNDERVOLT RESTORE FUNCTION: Disabled</b>	Range: Disabled, Alarm, Latched Alarm,
MESSAGE		<b>UNDERVOLT RESTORE RELAYS (3-7): -----</b>	Range: Any combination of 3 to 7 Auxiliary relays
MESSAGE		<b>UNDERVOLT RESTORE SOURCE: Bus</b>	Range: Bus, Line
MESSAGE		<b>PHASES REQUIRED FOR OPERATION: All Three</b>	Range: Any One, Any Two, All Three.
MESSAGE		<b>UNDERVOLT RESTORE MIN VOLTS: 0.90 x VT</b>	Range: 0.00 to 1.25 x VT in steps of 0.01
MESSAGE		<b>UNDERVOLT RESTORE DELAY: 10 s</b>	Range: 0 to 10000 s in steps of 1
MESSAGE		<b>INCOMPLETE SEQUENCE TIME: 100 min</b>	Range: 1 to 10000 min. in steps of 1

This scheme is initiated by either the Bus or Line Undervoltage elements. After the feeder breaker has been tripped, it will display the **UVolt Restore Init** message (if the function is set to “Alarm” or “Latched Alarm”) and operate any programmed output relays. Once initiated it will monitor the bus voltage level, and send a close command to the 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.

The **PHASES REQUIRED FOR OPERATION** setpoint is seen only if **UNDERVOLT RESTORE SOURCE** is “Bus”.

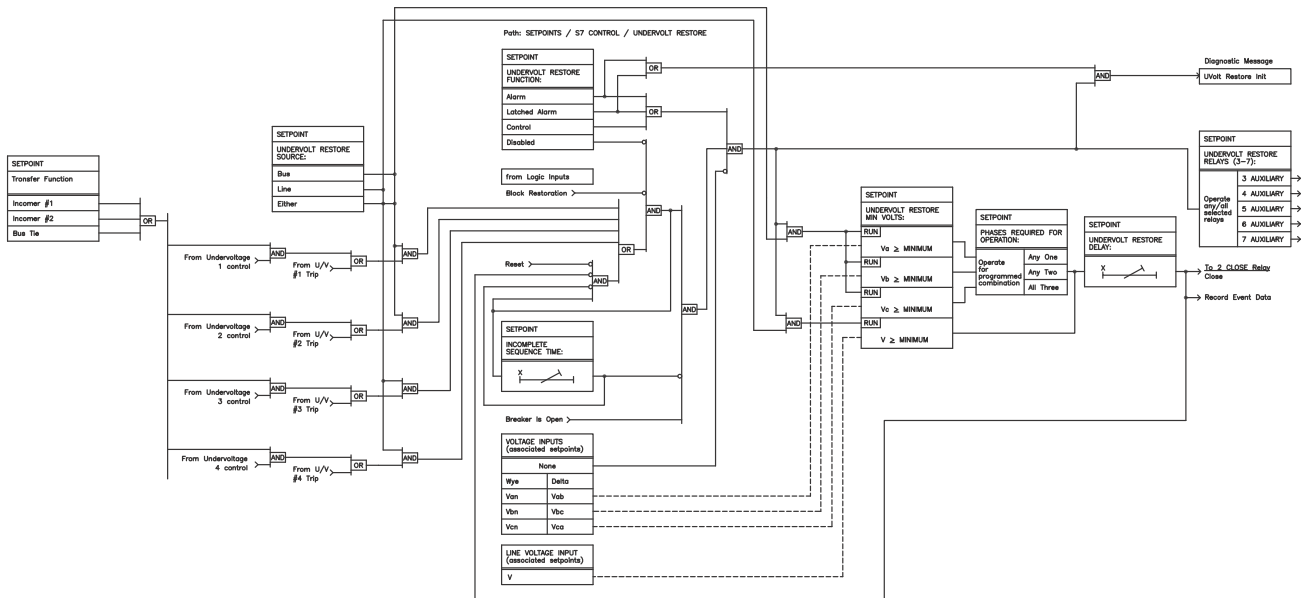


FIGURE 5-64: Undervoltage Restoration Logic

### 5.8.6 Underfrequency Restore

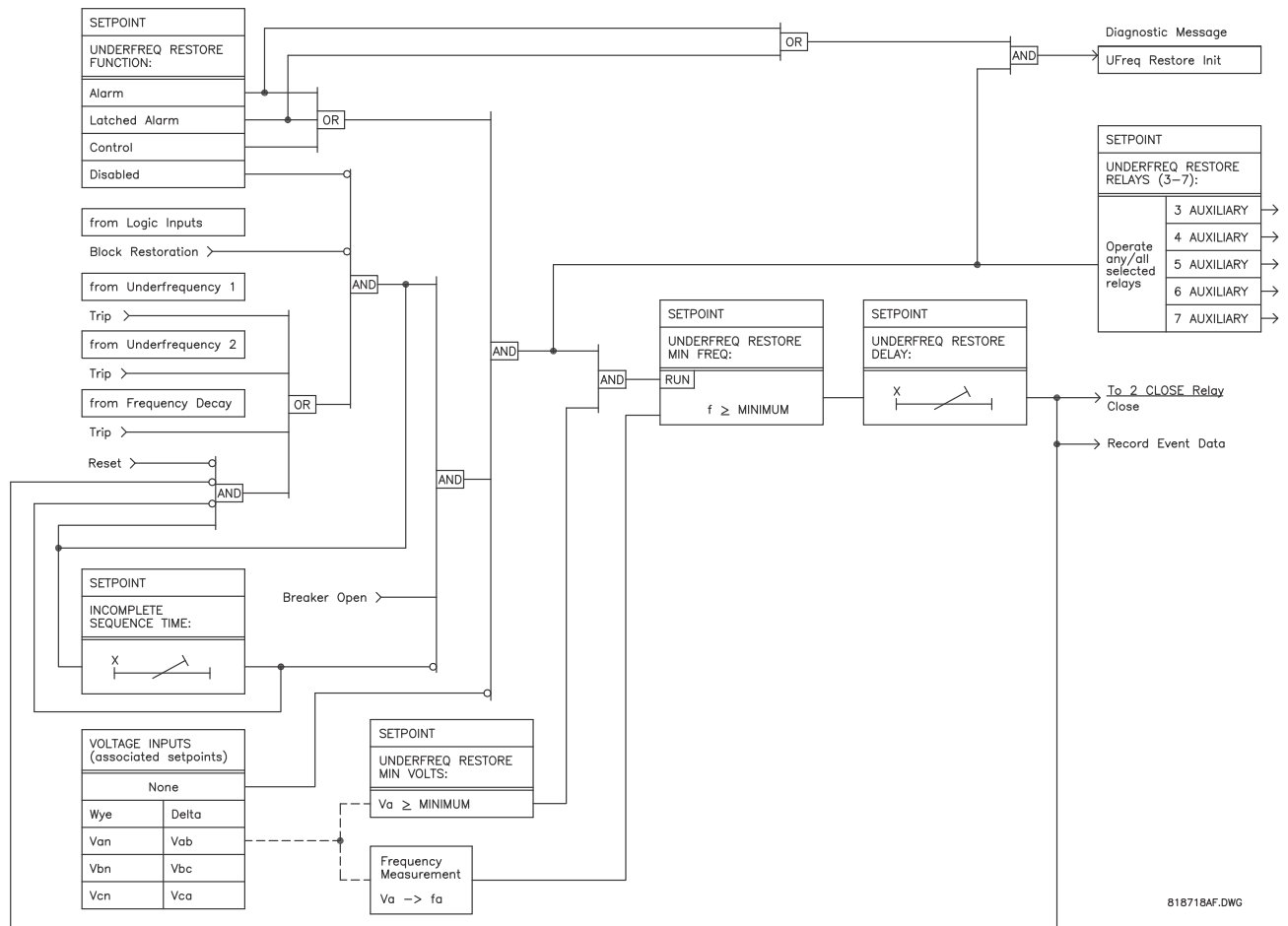
PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ UNDERFREQUENCY RESTORATION

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>■ UNDERFREQUENCY RESTORATION</b> [▶]         </div>		<b>UNDERFREQ RESTORE FUNCTION: Disabled</b>	<i>Range: Disabled, Alarm, Latched Alarm,</i>
MESSAGE		<b>UNDERFREQ RESTORE RELAYS (3-7): -----</b>	<i>Range: Any combination of 3 to 7 Auxiliary relays</i>
MESSAGE		<b>UNDERFREQ RESTORE MIN VOLTS: 0.90 x VT</b>	<i>Range: 0.00 to 1.25 x VT in steps of 0.01</i>
MESSAGE		<b>UNDERFREQ RESTORE MIN FREQ: 59.90 Hz</b>	<i>Range: 20.00 to 65.00 Hz in steps of 0.01</i>
MESSAGE		<b>UNDERFREQ RESTORE DELAY: 10 s</b>	<i>Range: 0 to 10000 s in steps of 1</i>
MESSAGE		<b>INCOMPLETE SEQUENCE TIME: 100 min</b>	<i>Range: 1 to 10000 min. in steps of 1</i>

This scheme is initiated by a trip of either the Bus Underfrequency elements. After the feeder breaker has been tripped, it will display the **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 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.










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FIGURE 5-65: Underfrequency Restoration Logic

### 5.8.7 Transfer Scheme

#### Settings

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ TRANSFER

<div style="display: flex; justify-content: space-between; align-items: center;"> <span>■ TRANSFER</span> <span>[▷]</span> </div>		<b>TRANSFER FUNCTION:</b> Disabled	Range: Disabled, Incomer 1, Incomer 2, Bus Tie
MESSAGE		<b>BUS TRANSFER LOGIC:</b> Scheme 1	Range: Scheme1, Scheme 2
MESSAGE		<b>TRANSFER DELAY THIS SOURCE:</b> 1.0 s	Range: 0.0 to 10.0 s in steps of 0.1
MESSAGE		<b>TRANSFER DELAY OTHER SOURCE:</b> 3.0 s	Range: 0.0 to 10.0 s in steps of 0.1
MESSAGE		<b>BLOCK TRIP ON DOUBLE LOSS:</b> Disabled	Range: Disabled, Enabled
MESSAGE		<b>TRANSFER DELAY SELECT TO TRIP:</b> 0.0 s	Range: 0.0 to 10.0 s in steps of 0.1
MESSAGE		<b>TRANSFER READY RELAY 3:</b> Disabled	Range: Disabled, Enabled

The Transfer scheme is intended for application to a set of three circuit breakers on a Main-Tie-Main arrangement, two of which (Incomers 1 and 2) connect sources of electrical energy to two busses which could be paralleled through the Bus Tie breaker. The normal system configuration is with both incoming breakers closed and the bus tie breaker open. The transfer scheme implemented in the 750/760 is known as Open Transfer, with an “Open before Close” operation sequence; this means that the faulty incomer is removed from service before the tie breaker is closed. FIGURE 5-66: *Transfer Scheme One Line Diagram* on page 5-146 shows this arrangement. The equipment designations on this drawing will be used in the discussion.

The transfer scheme minimizes 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 (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 methods are manual and one is automatic.

- Manual Method 1, when 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.
- Manual Method 2, when 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. If the bus tie breaker is 'Selected To Trip', it will be tripped by the system and will open.

- Automatic method:

The automatic method of returning the system to normal configuration uses the undervoltage tripped portion of the restoration scheme. Undervoltage restoration will work only if the relay has issued a trip signal during the tripping process of the faulty incomer. The required trip signal is not issued if the Line Undervoltage 4 Element (27-4) is set for Alarm or Control.



If Undervoltage Restoration is used to restore the system, Line Undervoltage 4 (27-4) must be set to Trip, instead of Control or Alarm, and the feature Block Trip on Double Loss will not function properly.

In addition to the relay required for each of the three circuit breakers, the system requires two manual operated control switches or equivalent devices.

#### 1. **Device 43/10: Select to Trip Control Switch.**

This is a three-position switch with at least three contacts, one for each relay, which obey the following table:

Contact No.	Position		
	1: Incomer 1	2: Incomer 2	3: Tie Breaker
1	X		
2		X	
3			X

It is required to connect one contact to each relay. This switch selects the breaker that will trip in the eventuality that all three breakers become closed, to prevent the two incoming systems to remain connected in parallel. The contacts can be either normally-open or normally-closed, depending on the asserted logic of the corresponding logic input used for this purpose.

**Discussion:** Typically this switch is always asserted, even when the selected breaker is open, and the other two breakers are closed. In this mode, the switch energizes the Trip contact and activates the Trip LED on the relay front panel. To avoid this, a breaker 52A contact can be wired in series with the 43/10 switch.

**Advantage:** Connecting the breaker 52A contact in series with this switch will prevent energization of the Trip contact and turning of Trip LED "ON". When the breaker is opened, the 52A contact stays open and prevents asserting of the logic input when the switch is positioned to the relay with the open breaker.

**Disadvantage:** In certain conditions, connecting the breaker 52A contact in series with this switch can facilitate accidental momentary breaker closing (i.e., breaker bumping) due to human error, while in the transfer scheme the other two breakers are still closed. When this switch is connected to the relay without a 52A contact in series, breaker closing is inhibited internally.

## 2. Device 43/83: Block - Enable Transfer.

This is an optional two-position switch or equivalent device, with at least three contacts (one for each relay) that obeys the following table:

Contact No.	Position	
	1: Block	2: Enable
1: Incomer 1	X	
2: Incomer 2	X	
3: Tie Breaker	X	

One contact must be connected to each relay. This switch selects either the transfer scheme in Block position or the transfer scheme in Enable position. The contacts are either normally-open or normally-closed, depending on the asserted logic of the corresponding logic input used for this purpose.

When Device 43/83 is in the “Block” position, the contact connected to 750/760 places the corresponding logic input in the “Asserted Position”, blocking the operation of the Auto Transfer Scheme. At this point in time, a system condition that might trip one of the incomers will not initiate the transfer sequence.

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 750/760 relay offers a selection of two Transfer Schemes for Bus Transfer Logic: Scheme 1 and Scheme 2. Each 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 racked in and in the “Connected” position, and therefore ready for operation. Fixed breaker installations can use contacts on the associated isolating disconnect switches (if available) for this purpose.

Either of the selected Auto Transfer Schemes can be applied to any one of the following systems: The scheme design can be applied to:

1. Substations with no signaling from upstream equipment. The initiating signal is generated by one of the two 750/760 relays protecting the Incomers.
2. Substations with an upstream circuit breaker equipped with a trip signal (Device 94). In addition to the local 750/760 relays, the signal triggering the transfer sequence can be originated from the upstream protection. An auxiliary contact from the tripping device (94) is fed to one of the 750/760 logic inputs, which is programmed as “Source Trip”.
3. Substations with a source transformer and transformer fault detection signal (Device 86T). In addition to the local 750/760 relays, the signal triggering the transfer sequence can be originated from the protection of the upstream transformers. An auxiliary contact from the tripping device (86T) is fed to one of the 750/760 logic inputs, which is programmed as “Lockout Trip”.
4. Both 2 and 3 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 overcurrent (Device 50P-1 or 2),
- Neutral overcurrent (Device 50N-1 or 2),
- Both line undervoltage elements (Devices 27-3 and 27-4),
- The synchrocheck (Device 25) features of the relays.

Schematic diagrams of the DC connections required by both Scheme 1 and Scheme 2 are presented in the schematics on pages –148 to –149. Logic for each relay of the scheme is presented in the logic diagrams on pages –150 to –152 for Scheme 1 and pages –154 to –156 for Scheme 2. Connections that are not required for configurations other than Configuration 4 above are indicated as “optional” on the schematic diagrams.



NOTE

1. All connections for AC voltage and current are outlined in Chapter 3.
2. The scheme design requires that the AC voltage connections for ‘Line’ and ‘Bus’ sources on the incomer relays be in accordance with FIGURE 5–66: *Transfer Scheme One Line Diagram* on page 5–146 regardless of configuration.
3. The connection of AC voltage to the relay on the bus tie does not affect operation of the scheme.

The connection to the line voltage input terminals **must be** phase-phase voltage if the bus voltage input terminals are connected in an open-delta AC voltage configuration (Voltage Transformer (VT) configuration).

For increased stability, the recommended connection to the line voltage terminals is phase-phase voltage. Connecting line voltage input terminals to phase-phase voltage allows the relay to sense two voltage phases, and use the synchrocheck function to ensure stable system conditions based on two inputs instead of only one.

For the following discussion assume 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 Bus Tie closing) from Relay 1 can be initiated by:

- Operation of transformer 1 lockout relay (Device 86T1).
- Operation of the Source 1 breaker auxiliary trip device (Device 94-1).
- Time out of Relay 1 line voltage inverse time undervoltage element (Device 27-4) caused by 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.
- Devices 50P-1 or 2, or 50N-1 or 2, detect an overcurrent condition on bus 1, to prevent a faulted bus from being transferred to a healthy source.
- The line definite time Undervoltage element (Device 27-3) on Source 2 is operated, indicating low voltage on the other source.

If any one of the above conditions is present, the **TRANSFER NOT READY** message will be displayed by the relays.

Once a condition has caused the 750/760 relay on Incomer 1 (Relay 1) to initiate a transfer, the following sequence of events will take place:

1. Relay 1 trips Incomer 1 breaker (Breaker 1).
2. Relay 1 issues a close signal to the 750/760 on the Bus Tie breaker (Relay 3).
3. The trip command is maintained until Relay 1 determines that Breaker 1 has opened.
4. When Relay 3 receives the close command from Relay 1, it is captured and retained until either the Bus Tie breaker (Breaker 3) closes or the Block Transfer logic input is received.
5. Relay 3 is inhibited from initiating a close command to Breaker 3 by its synchrocheck element.
6. Synchrocheck monitors the voltage on the disconnected bus, and provides the bus decayed (residual) voltage permission-to-close 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'.

### Additional Setpoints for Transfer Scheme

The following settings are required for the proper operation of the Auto Transfer Scheme:

- Logic inputs definition: Refer to *Logic Inputs Setup* on page 5–27 for additional information. In this step, the Logic Inputs are identified and the asserted logic is defined.
- Logic inputs for breaker functions: Refer to *Breaker Functions* on page 5–28 for additional information. Since the scheme monitors the status of the breaker, it is necessary to set a digital input for that purpose.
- Logic inputs for control functions: Refer to *Control Functions* on page 5–30 for additional information. These settings are required to define how the relay will receive external commands.
- Logic inputs for transfer functions: Refer to *Transfer Functions* on page 5–35 for additional information. These are the settings that relate the Logic Inputs defined above, with their specific functions within the scheme.



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

- Line Undervoltage 3 (27-3): Required to block transfer initiation from the other relay, as the other source is experiencing low voltage. Also, Device 27-3 is enabled by instantaneous overcurrent to block transfer initiation.
- Line Undervoltage 4 (27-4): Required to initiate a transfer on loss-of-source.
- Instantaneous phase (50P1 or 50P2), and neutral overcurrent (50N1 or 50N2). Fault detectors, used as inputs to the transfer scheme logic, to block a transfer while a fault is present on the load side of the breaker.

- Synchrocheck (25) to supervise the initial closing of the incoming breakers, to provide synchronism check supervision when paralleling the busses, or measure the residual voltage on the bus that has lost source.
- Transfer function: Specific settings related to the Auto Transfer Scheme



**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 no operated state of “De-energized” with the output type as “Self-reset”. These are the default settings.

### Setting the Transfer Scheme

If the transfer scheme is not required, set **TRANSFER FUNCTION** to “Disabled”. If not disabled, this setpoint assigns the function of the associated circuit breaker to the relay. 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.

The **BUS TRANSFER LOGIC** setpoint selects the desired transfer scheme: Scheme 1, or Scheme 2. The default setting of this setpoint is set to “Scheme 1”. The 750 relay provides two different transfer scheme: Scheme 1 and Scheme 2. Refer to the related section in this chapter for scheme description and logic diagrams.



**The setting for the **BUS TRANSFER LOGIC** for all three relays performing bus auto transfer must be set to the same scheme number, or else the transfer will not be performed correctly.**

The **TRANSFER DELAY THIS SOURCE** time establishes an interval from the reset of an operated instantaneous overcurrent element on this source, during which the line instantaneous undervoltage element (Device 27-3) is allowed to block a transfer. The **TRANSFER DELAY OTHER SOURCE** 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.

The **BLOCK TRIP ON DOUBLE LOSS** 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.

The **TRANSFER DELAY SELECT TO TRIP** setpoint provides selection of time delay to be applied to the 750/760 trip output relay, and trip the “Selected to Trip” breaker, such as when all three breakers are detected closed. The following conditions must be met to start the **TRANSFER DELAY SELECT TO TRIP** setpoint provides selection of time delay to be applied to the 750/760 trip output relay, and trip the “Selected to Trip” breaker, such as when all three breakers are detected closed. The following conditions must be met to start the **TRANSFER DELAY SELECT TO TRIP** time delay:

#### Incomer 1 (Incomer 2)

- Incomer 1 breaker connected

- Incomer 2 breaker closed
- Tie-breaker connected
- Tie-breaker closed
- Selected to Trip input set to Incomer 1 breaker
- Transfer scheme not blocked

**Tie-Breaker (750-3)**

- Incomer 1 breaker closed
- Incomer 2 breaker closed
- Tie-breaker connected
- Tie-breaker closed
- Selected to Trip input set to Tie-breaker
- Transfer scheme not blocked

The **TRANSFER READY RELAY (3)** setpoint selects the setting “Enabled” to operate auxiliary output relay # 3 upon transfer ready conditions, or “Disabled” when such operation is not required.



Practical scheme for overall **TRANSFER READY** indication can be developed by selecting the setting “Enabled” from all three 750 relays to operate the aux. output relay # 3, and wiring the relays in series with a DC source to turn on a single light bulb (“white light”). The aux. 3 output relay from each 750 relay can be wired to turn on an individual light bulb as well. Refer to the DC ratings of the aux. output relays before wiring to a DC source.

The **TRANSFER READY** flag will be high, if all of the following conditions are met:

**Incomer 1: 750/760-1 (Incomer 2: 750/760-2) relays:**

- The “Incomer 1” setting selected under TRANSFER FUNCTION setpoint
- The transfer scheme is not blocked from “Block Transfer” input
- Bus Tie Breaker is open (52a/b contacts)
- Incomer 1 breaker is connected and closed
- Incomer 2 breaker is connected and closed
- No transformer lockout, or source trip is present
- No undervoltage is detected on any of the two sources

**Tie-breaker 750/760 relay:**

- The “Bus Tie” setting is selected under TRANSFER FUNCTION setpoint
- The transfer is not blocked from “Block Transfer” input
- Bus Tie Breaker is connected and open (52a/b contacts)
- Incomer 1 breaker is closed
- Incomer 2 breaker is closed



NOTE

If Undervoltage Restoration is used to restore the system automatically, Line Undervoltage 4 (27-4) must be set to “Trip”, instead of “Control” or “Alarm”, and the Block Trip on Double Loss feature will not work properly.

The settings and functions of other elements associated with the transfer scheme are shown below:

- **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 not operated state of ‘De-energized’ with the output type as ‘Self-reset’. These are the default settings.
- **Instantaneous Phase (50P1 or 2) and Neutral (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 Device 50P is set properly, during this event it will allow Device 27-4 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.
- **Line Undervoltage 3 (27-3) [Incomers 1 and 2 only]:** Since this element is used as an input to transfer scheme logic in this application, set **LINE UNDERVOLTAGE 3 FUNCTION**

to “Control”. An Undervoltage 3 operation signals Relay 2 to block transfer initiation from that relay, as Source 1 is experiencing low voltage. Also, Device 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 Device 27-3 pickup setting should be below the minimum expected normal (low) voltage, usually around 0.9 of pickup voltage. A Definite Time curve with the delay set to zero provides instantaneous operation. The minimum operating voltage must be set to zero.

**Line Undervoltage 4 (27-4) [Incomers 1 and 2 only]:** Since this element is used as a transfer scheme logic input in this application, set **LINE UNDERVOLTAGE 4 FUNCTION** to “Control”. An Undervoltage 4 operation initiates a transfer on loss-of-source. Typical settings have a pickup about 0.7 to 0.8 of pickup voltage, an “Inverse Time” curve setting, and a delay setting to provide operation in 0.7 to 1.4 seconds at 0 V. The minimum operating voltage must be set to zero.



NOTE

The pickup voltage for both Undervoltage features must not be equal, or transfer will not take place, since both elements will pickup at the same time, causing 27-3 to block transfer.

- **Synchrocheck (25) [Incomers 1 and 2 only]:** The synchrocheck function can be selected as either Control or Alarm. It is imperative that the **DEAD SOURCE PERMISSIVE** setpoint be “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 the **DEAD SOURCE PERMISSIVE** setpoint be 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 MAX VOLTAGE** and **DEAD LINE MIN VOLTAGE** setpoints establish the level of decayed voltage above which transfers are inhibited. A normal setting for this element is about 0.25 of pickup 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 setpoint causes a delay of transfer presenting problems, it is occasionally raised to a maximum of 0.40 of pickup. The user establishes all other setpoints for this element.

The Logic Inputs for Incomers 1 and 2 and the Bus Tie relays are programmed 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.

Table 5–20: Logic Inputs for Incomer 1, 2, and Bus Tie Relays

Input	Incomer #1		Incomer #2		Bus Tie	
	Name	Asserted Logic	Name	Asserted Logic	Name	Asserted Logic
1	Local Mode	Contact Close	Local Mode	Contact Close	Local Mode	Contact Close
2	Remote Close	Contact Close	Remote Close	Contact Close	Remote Close	Contact Close
3	Remote Open	Contact Close	Remote Open	Contact Close	Remote Open	Contact Close
4	52a or 52b Contact	Contact Close	52a or 52b Contact	Contact Close	52a or 52b Contact	Contact Close
5	Breaker Connected	Contact Close	Breaker Connected	Contact Close	Breaker Connected	Contact Close
6	Selected To Trip	Contact Close	Selected To Trip	Contact Close	Selected To Trip	Contact Close
7	Undervoltage On Other Source	Contact Close	Undervoltage On Other Source	Contact Close	Close From Incomer 1	Contact Close
8	Incomer 2 Breaker Closed	Contact Close	Incomer 1 Breaker Closed	Contact Close	Incomer 1 Breaker Closed	Contact Close
9	Tie Breaker Connected	Contact Close	Tie Breaker Connected	Contact Close	Close from Incomer 2	Contact Close
10	Tie Breaker Closed	Contact Close	Tie Breaker Closed	Contact Close	Incomer 2 Breaker Closed	Contact Close
11 optional	Block Transfer	Contact Close	Block Transfer	Contact Close	Block Transfer	Contact Close
12 optional	Transformer Lockout	Contact Close	Transformer Lockout	Contact Close		
13 optional	Source Trip	Contact Close	Source Trip	Contact Close		



NOTE

The asserted logic in the above table is based on the specific requirements of the application example in this section to illustrate the transfer scheme function and in accordance to the type of contacts shown in the *Transfer Scheme Incomer No. 1 DC Schematic* on page 5–147, the *Transfer Scheme Incomer No. 2 DC Schematic* on page 5–148, and the *Transfer Scheme Bus Tie Breaker DC Schematic* on page 5–149, which are all normally open. For additional information refer to *S3 Logic Inputs* on page 5–26.

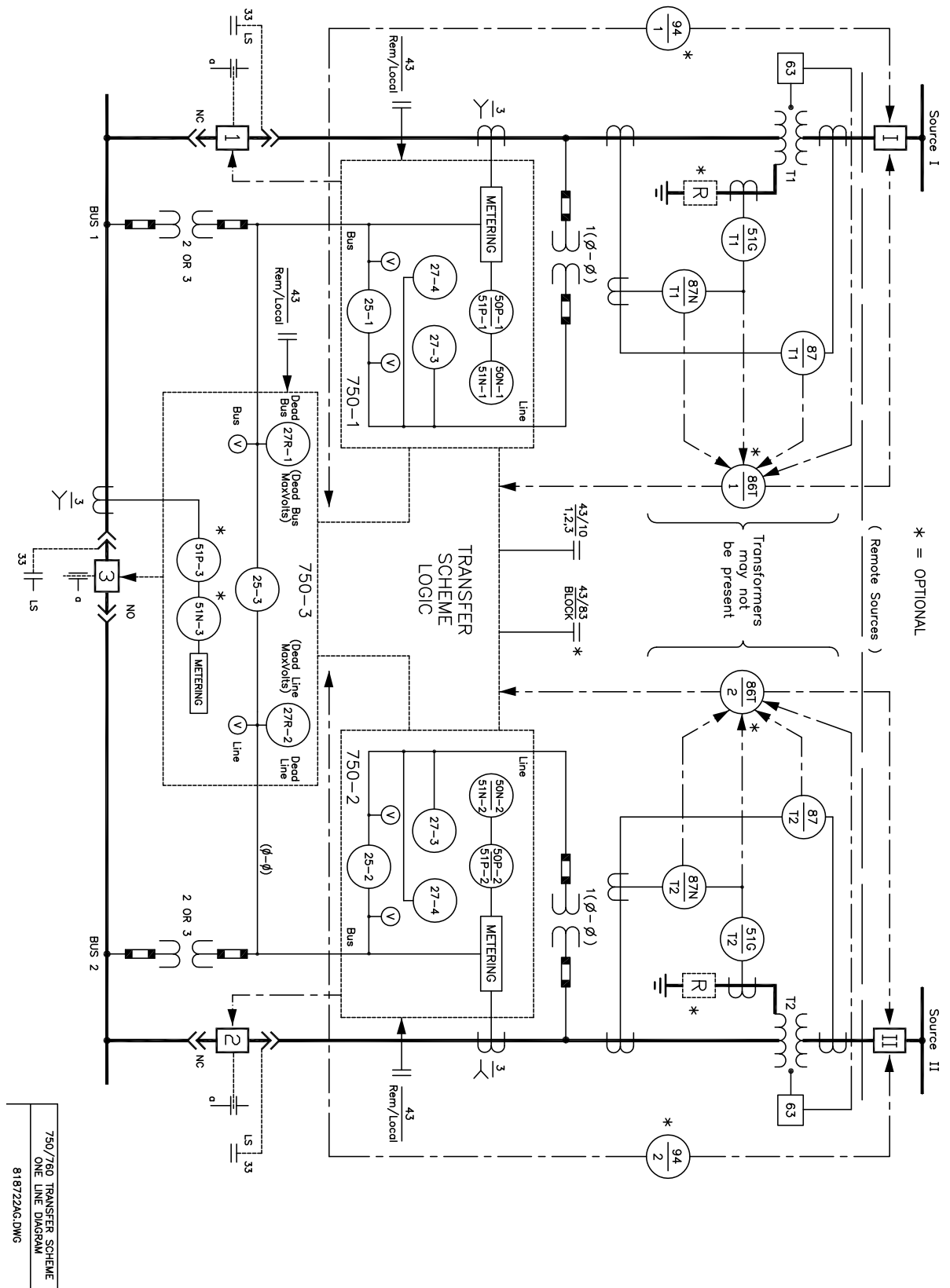


FIGURE 5-66: Transfer Scheme One Line Diagram

750/760 TRANSFER SCHEME  
ONE LINE DIAGRAM  
818722A6.DWG

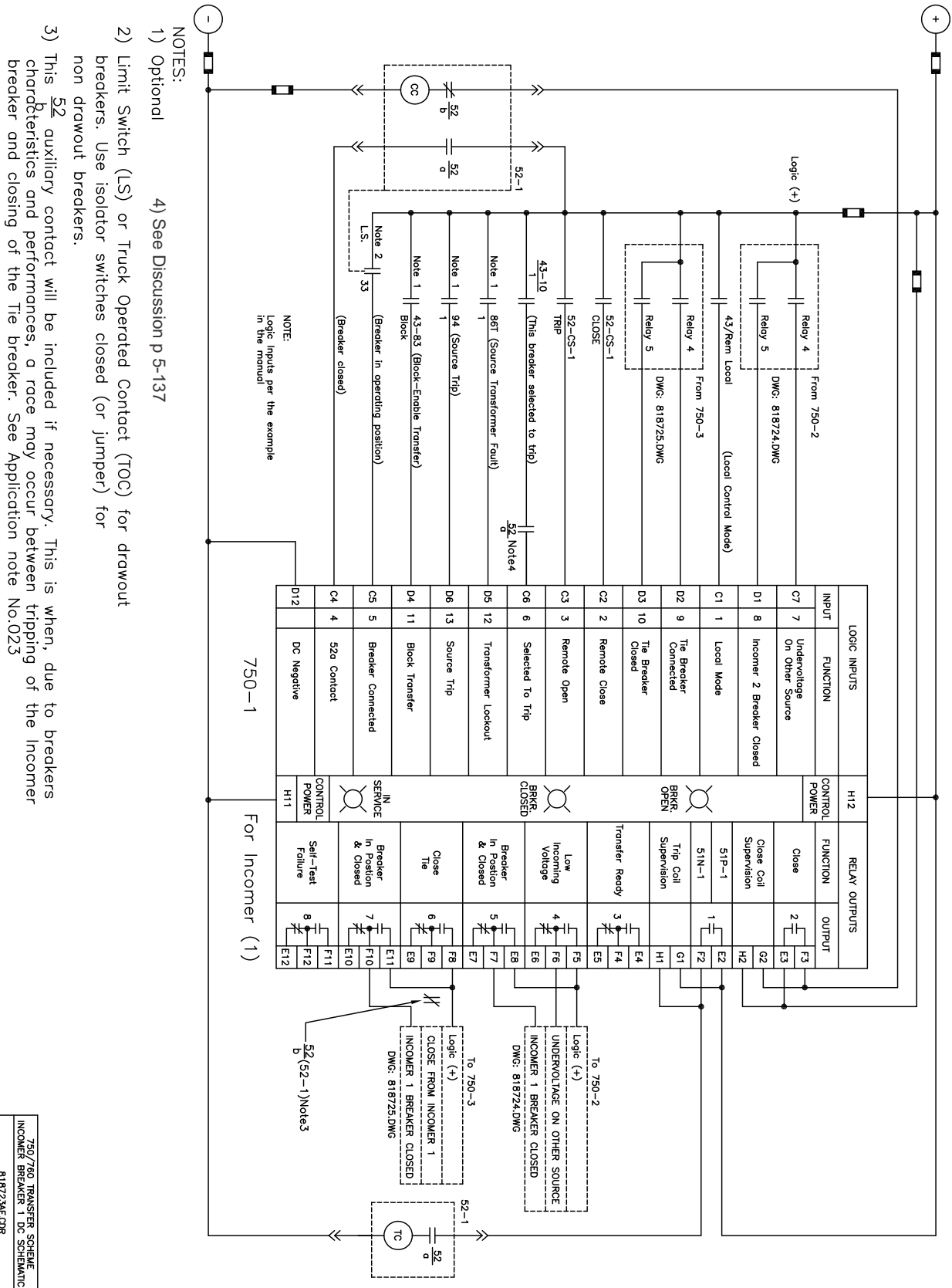


FIGURE 5-67: Transfer Scheme Incomer No. 1 DC Schematic

NOTES:

- 1) Optional
- 2) Limit Switch (LS) or Truck Operated Contact (TOC) for drawout breakers. Use isolator switches closed (or jumper) for non drawout breakers.
- 3) This 52 auxiliary contact will be included if necessary. This is when, due to breakers characteristics and performances, a race may occur between tripping of the Incomer breaker and closing of the Tie breaker. See Application note No.023
- 4) See Discussion p 5-137

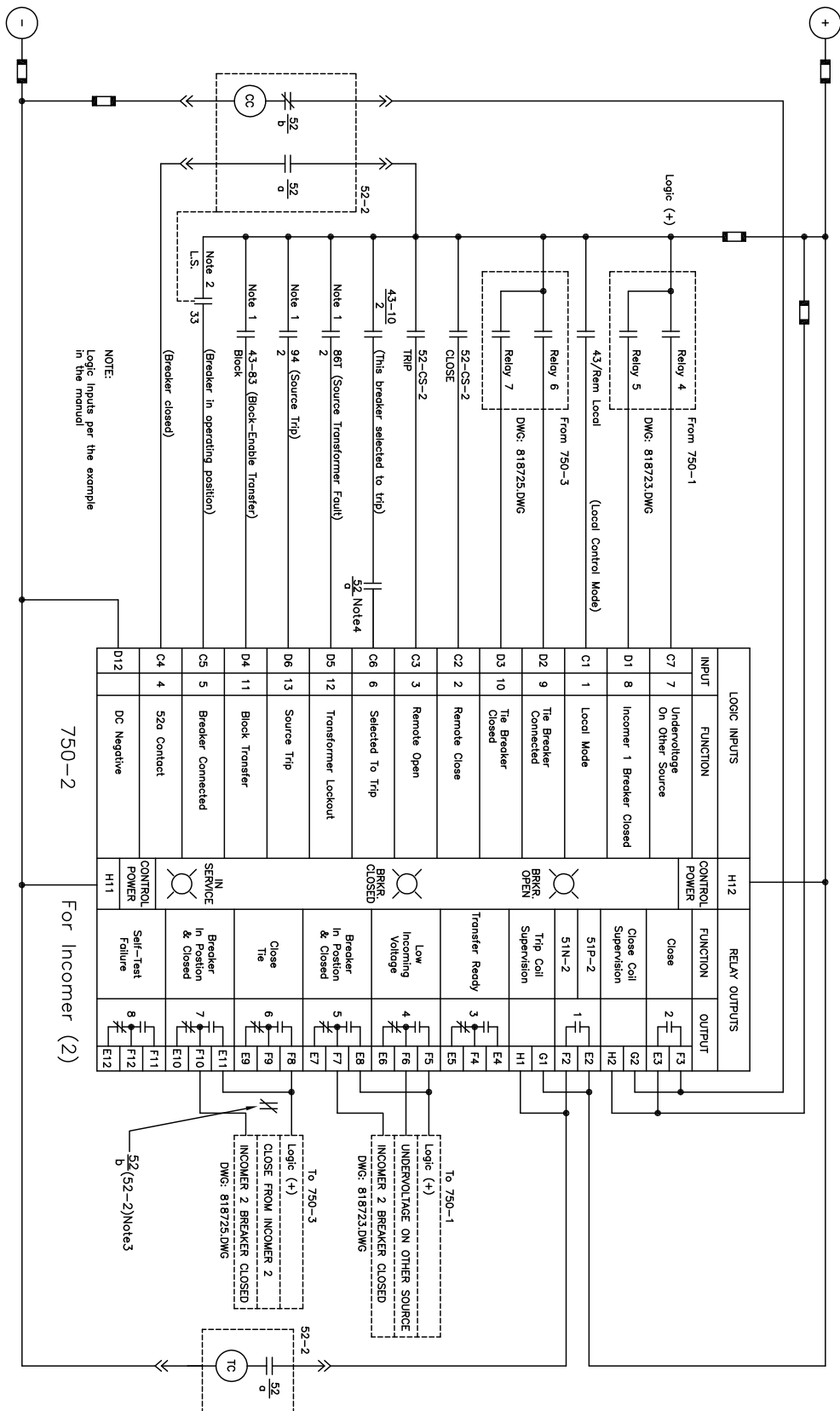


FIGURE 5-68: Transfer Scheme Incomer No. 2 DC Schematic

750/760 TRANSFER SCHEME  
INCOMER BREAKER 2 SCHEMATIC  
818724AF.DDR

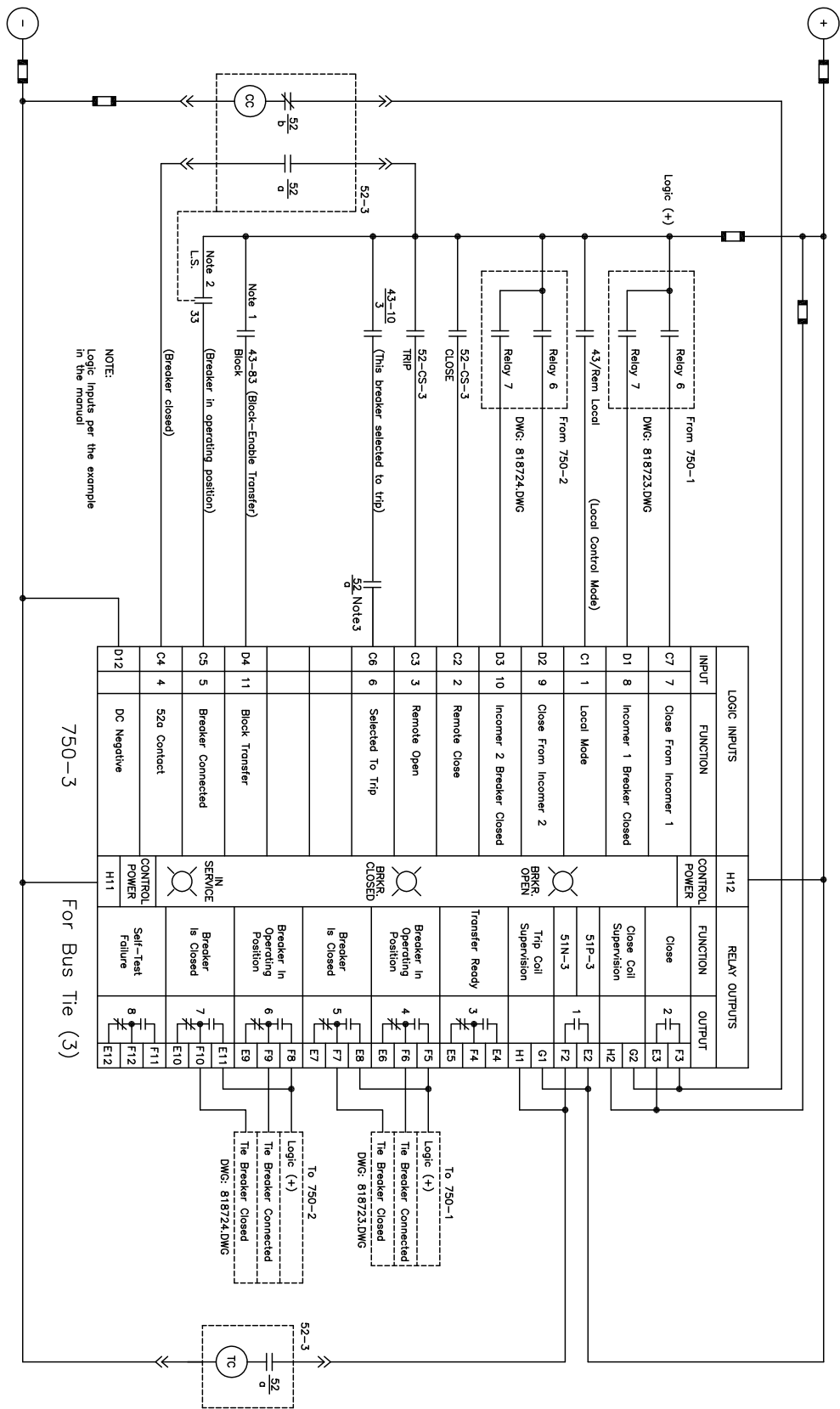
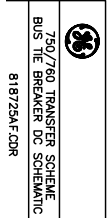


FIGURE 5-69: Transfer Scheme Bus Tie Breaker DC Schematic

- NOTES:**
- 1) Optional
  - 2) Limit Switch (LS) or Truck Operated Contact (TOC) for drawout breakers. Use isolator switches closed (or jumper) for non drawout breakers.
  - 3) See Discussion p 5-137



# AT Scheme 1

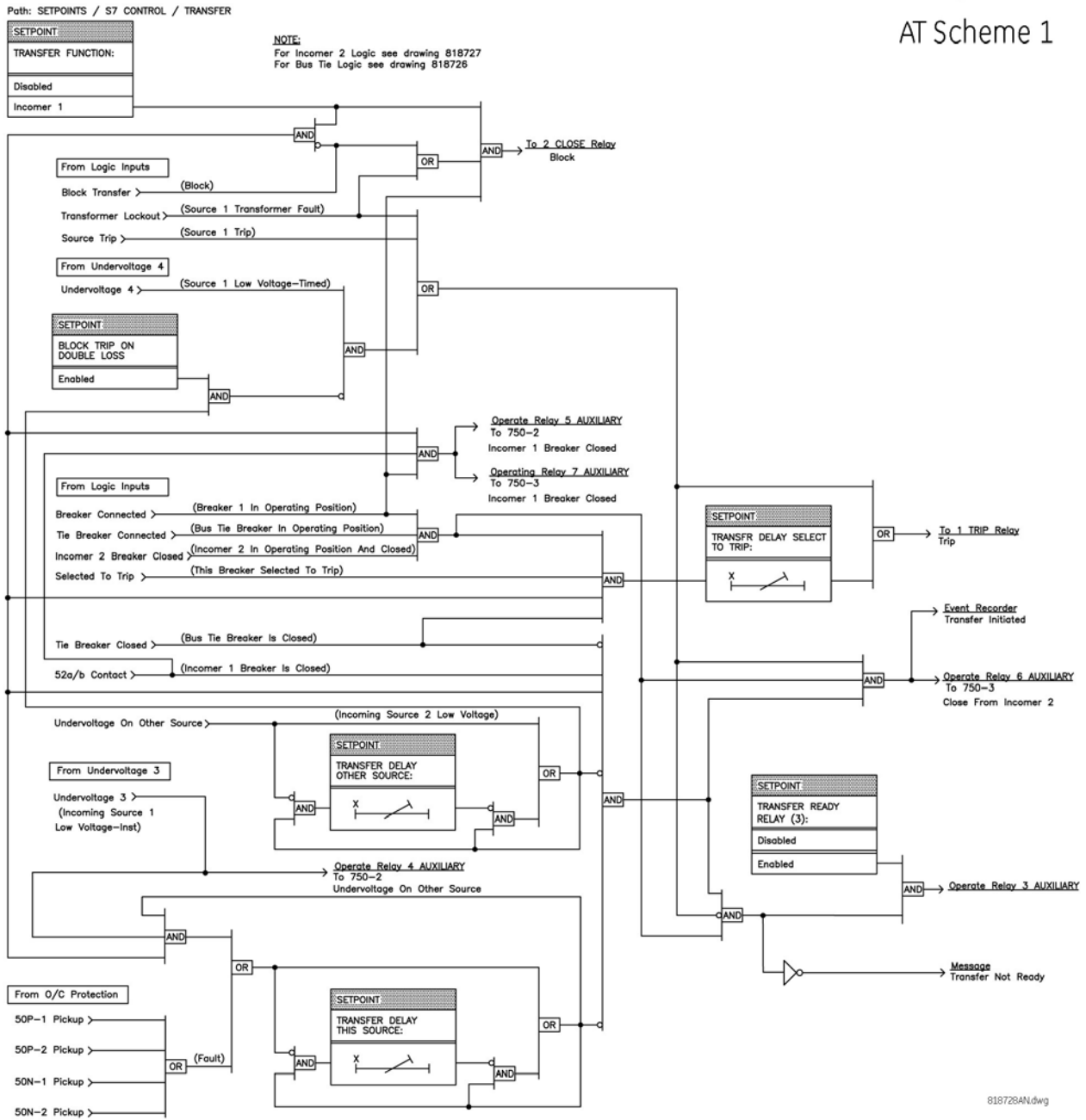


FIGURE 5-70: Transfer Scheme 1 Incomer No. 1 Logic



AT Scheme 1

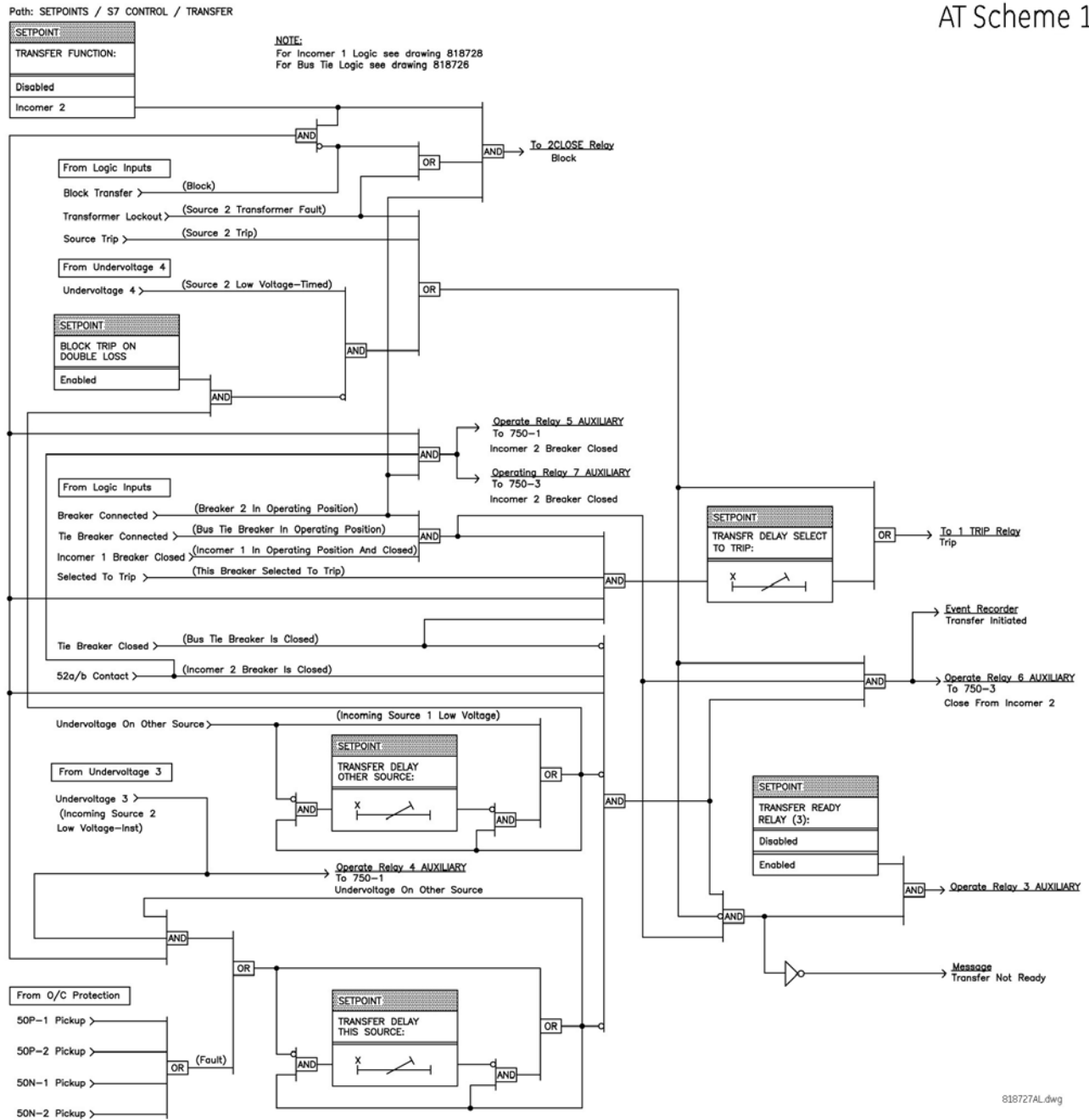


FIGURE 5-71: Transfer Scheme 1 Incomer No. 2 Logic

AT Scheme 1

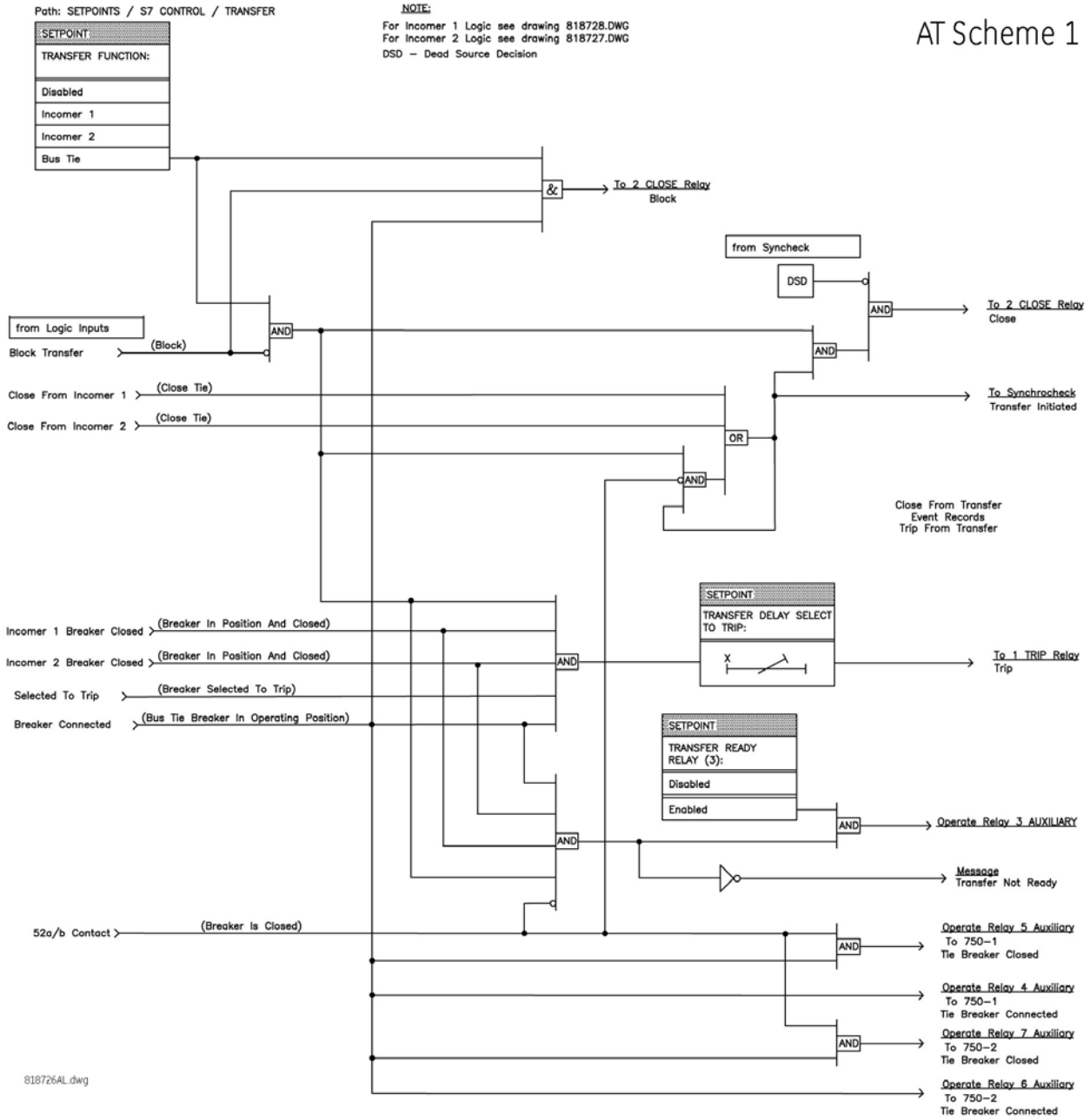


FIGURE 5-72: Transfer Scheme 1 Bus Tie Breaker Logic

## Transfer Scheme 2

The performance of Transfer Scheme 2 logic is similar to Transfer Scheme 1 logic except during the following conditions:

1. The detection of transformer trip (86T), or Source trip (94) will result into tripping the Incomer breaker if all of the following conditions check true:
  - a. The local Incomer breaker is connected,
  - b. The tie breaker is open
  - c. The other Incomer breaker is closed
  - d. No Undervoltage condition on Other Source
  - e. No overcurrent conditions
2. The detection of Line Undervoltage conditions (UV4 - usually set with time delay), will trip the Incomer breaker if all of the following conditions check true:
  - a. The local Incomer breaker is connected,
  - b. The tie breaker is open
  - c. The other Incomer breaker is closed
  - d. No Undervoltage condition on Other Source
  - e. No overcurrent conditions

In addition to the above logic, the logic for each breaker relay per scheme 2 provides an output to the synchrocheck logic, where a block to 2 Close Relay is formed. Please refer to Synchrocheck logic diagram for details.

Scheme 2 logic provides for the following power system conditions:

1. Tripping of the Incomer breaker during transformer lockout 86T, Source trip 94, or Undervoltage (UV4) is blocked, if this breaker is the only one supplying power to both buses, such as in single ended configuration – the other Incomer breaker open and the tie-breaker closed. A fault on any of the buses is detected by Coordinated Timed Over-Current protection, which is not part of the transfer scheme.
2. Any of the three breakers can be closed when in racked-out (disconnected) position such as during breaker maintenance.
3. Tripping of an Incomer breaker is blocked by the detection of over-current condition during source under-voltage. The block is held until the voltage is detected above the UV3 pickup level after the Transfer Delay This Source timer expires.

AT Scheme 2

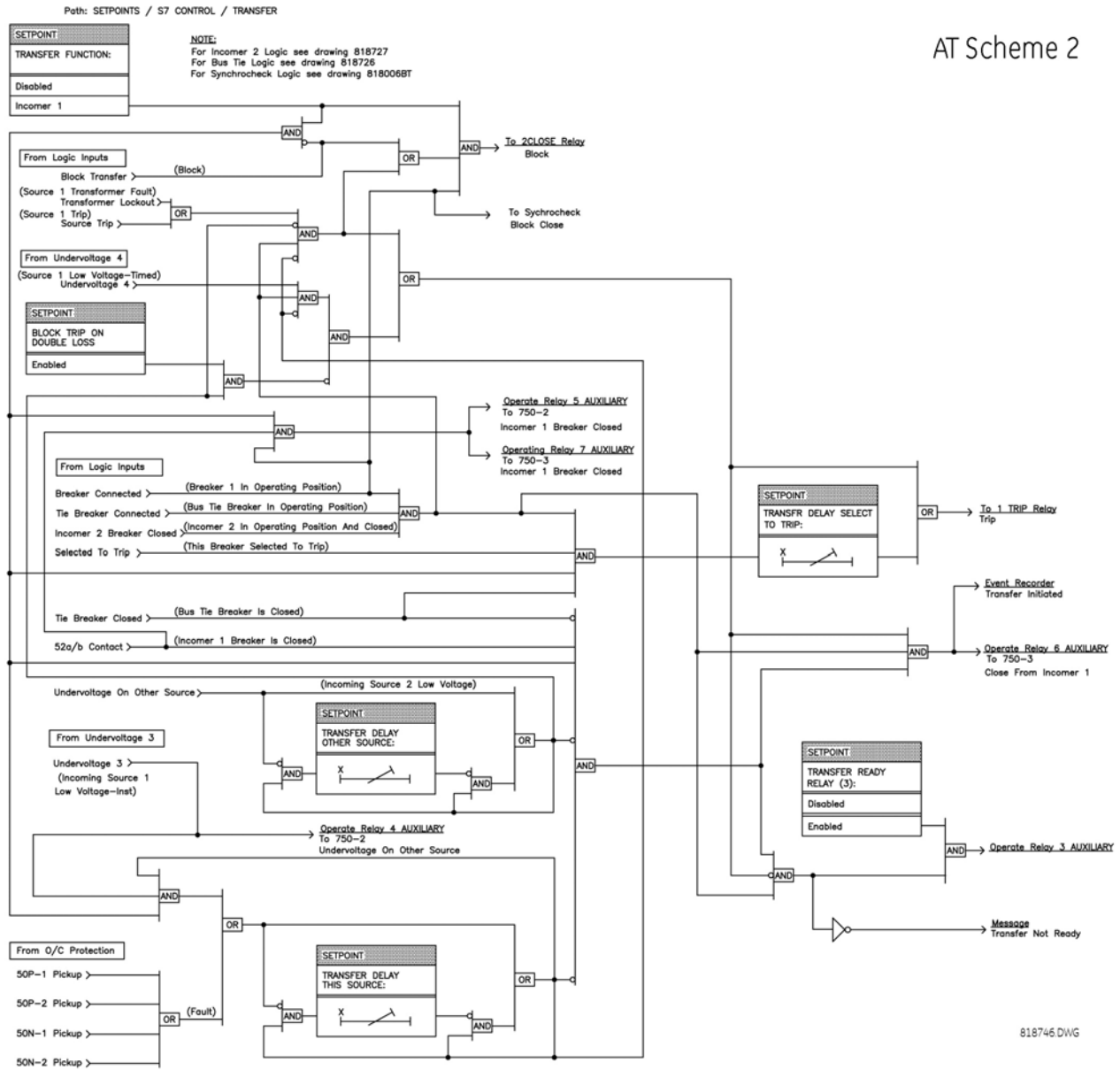


FIGURE 5-73: Transfer Scheme 2 Incomer No. 1 Logic

AT Scheme 2

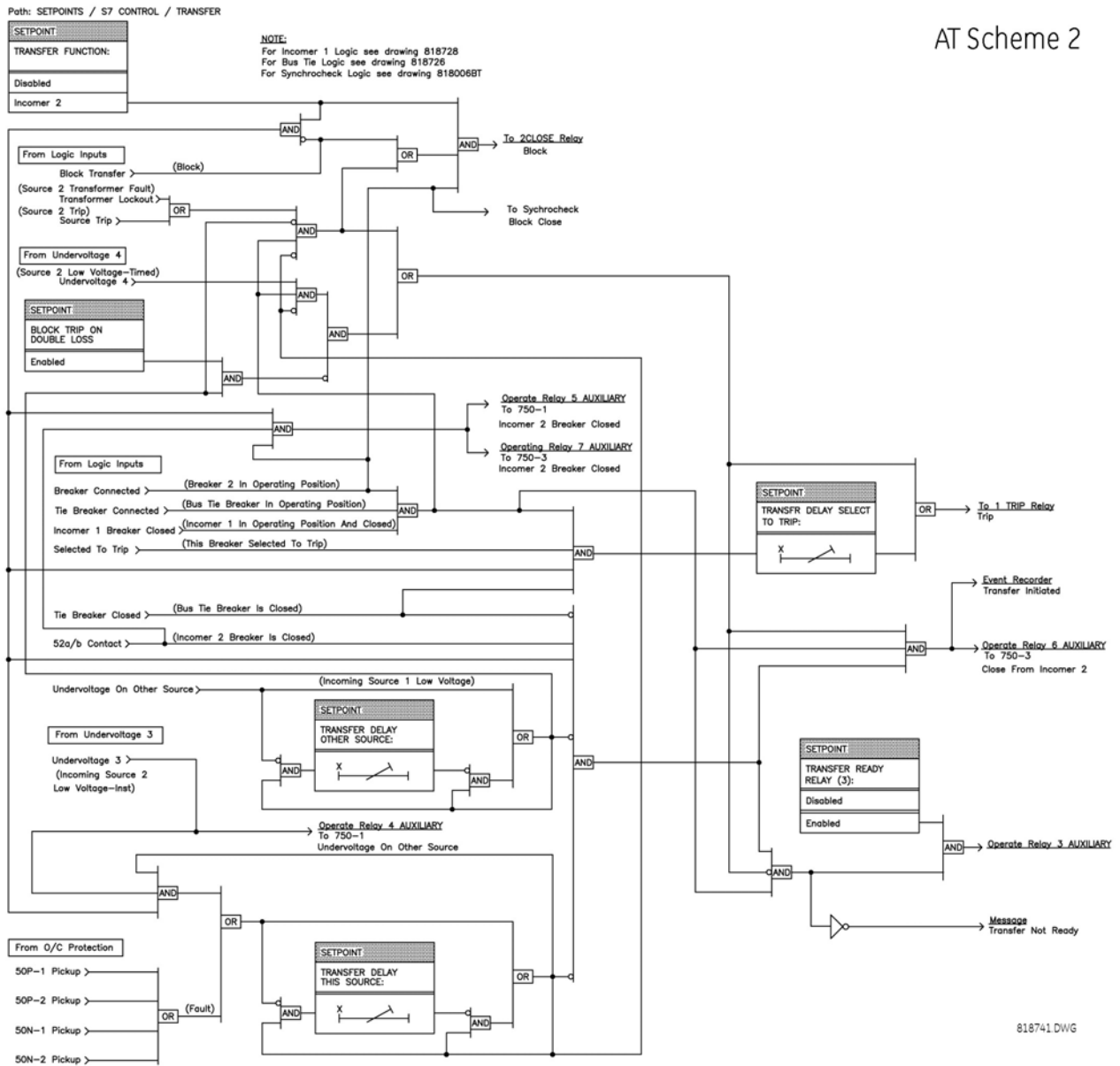


FIGURE 5-74: Transfer Scheme 2 Incomer No. 2 Logic

AT Scheme 2

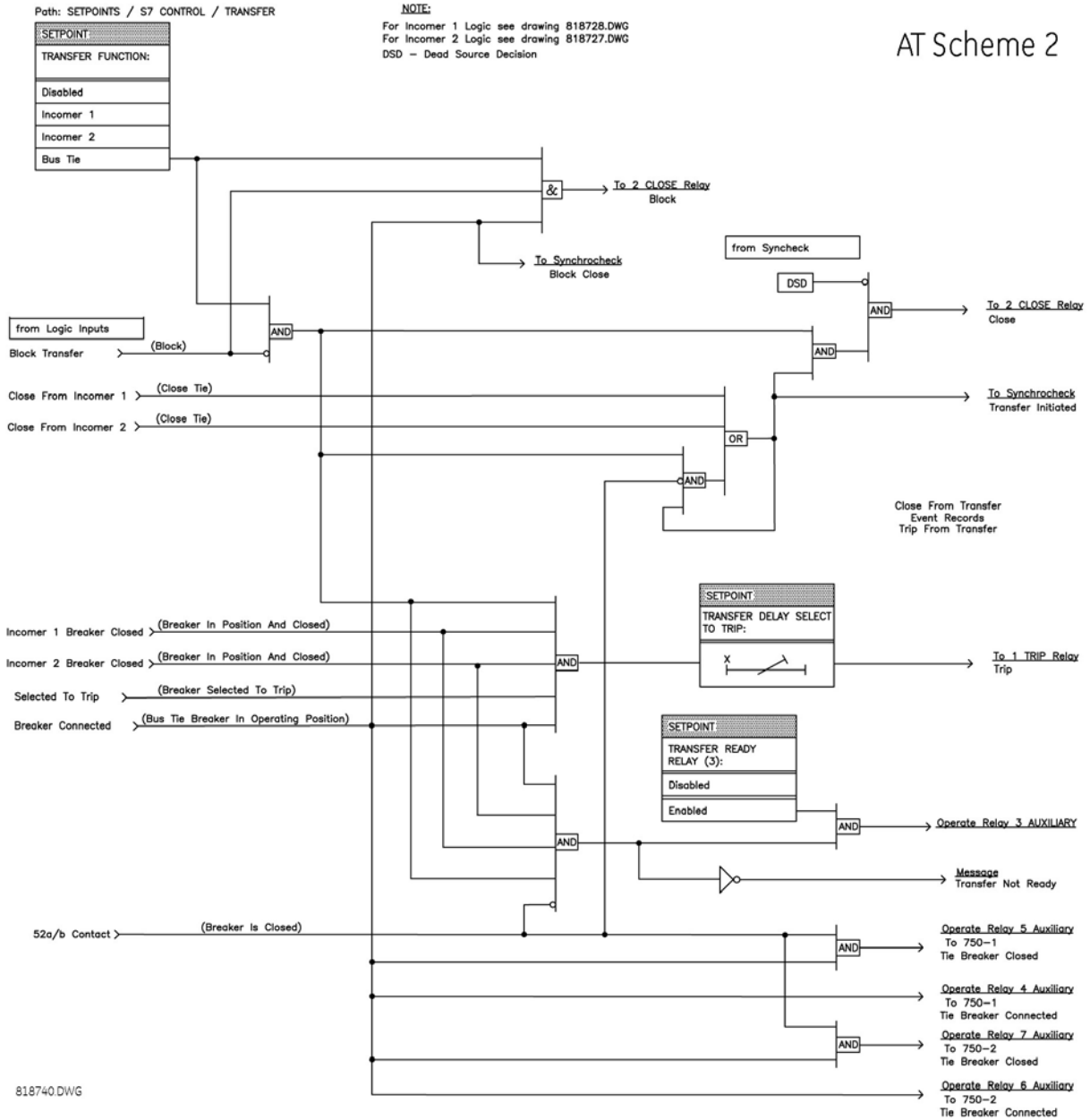










FIGURE 5-75: Transfer Scheme 2 Bus Tie Breaker Logic

## 5.8.8 Autoreclose (760 only)

### Main Menu

PATH: SETPOINTS ▷ S7 CONTROL ▷ ▽ AUTORECLOSE

■ AUTORECLOSE [▷]		■ SCHEME SETUP [▷]	See page 5-159
MESSAGE 		■ RATE SUPERVISION [▷]	See page 5-162
MESSAGE 		■ CURRENT SUPERVISION [▷]	See page 5-163
MESSAGE 		■ ZONE COORDINATION [▷]	See page 5-164
MESSAGE 		■ RECLOSURE 1 [▷]	See page 5-167
MESSAGE 		■ RECLOSURE 2 [▷]	
MESSAGE 		■ RECLOSURE 3 [▷]	
MESSAGE 		■ RECLOSURE 4 [▷]	

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 setpoints 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 reclosures are permitted.

The scheme is considered enabled when all of the following five conditions are true:

1. The **AUTORECLOSE 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.

A simplified description of how the autoreclose scheme works follows. Refer to the *Autoreclosure Application Example* on page 5-168 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 **DEAD TIME BEFORE RECLOSURE** Reclosure 1 setpoint, 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 **MAX 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 setpoints 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 active.

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 **AR RESET TIME** setpoint value. This autoreclosure reset returns the shot counter to zero and all protection setpoints 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 setpoints to their initial values without resetting the shot counter. The relay will then continue to trip and reclose until lockout is reached.



## Scheme Setup

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ AUTORECLOSE ▾ SCHEME SETUP

■ SCHEME SETUP [▷]		AUTORECLOSE FUNCTION: Disabled	Range: Enabled, Disabled
MESSAGE		MAX NUMBER OF RECLOSURE SHOTS: 1	Range: 1 to 4 in steps of 1
MESSAGE		AR RESET TIME: 60 s	Range: 1 to 1000 s in steps of 1
MESSAGE		AR BLOCK TIME UPON MANUAL CLOSE: 10 s	Range: 0 to 200 s in steps of 1
MESSAGE		AR EXTERNAL CLOSE LOGIC: Disabled	Range: Enabled, Disabled
MESSAGE		INCOMPLETE SEQUENCE TIME: 30 s	Range: 1 to 1000 s in steps of 1
MESSAGE		RECLOSURE ENABLED RELAYS (3-7): -----	Range: Any combination of the 3 to 7 Auxiliary
MESSAGE		RECLOSURE IN PROGRESS RELAYS (3-7): -----	Range: Any combination of the 3 to 7 Auxiliary
MESSAGE		RECLOSURE LOCKOUT RELAYS (3-7): -----	Range: Any combination of the 3 to 7 Auxiliary

The setpoints shown above setup the general characteristics of the scheme. The **AR FUNCTION** and **MAX NUMBER OF RECLOSURE SHOTS** setpoints are critical and must be set appropriately.



NOTE

For an overcurrent element to initiate a reclosure it must be programmed to the “Trip & AR” function.

- **MAX NUMBER OF RECLOSURE SHOTS:** This setpoint specifies 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** to **RECLOSURE 4**.
- **AR RESET TIME:** 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 the AR RESET TIME timer to a delay longer than the INCOMPLETE SEQUENCE timer.

- **AR BLOCK TIME UPON MANUAL CLOSE:** 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 elements activate 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

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.

- **AR EXTERNAL CLOSE LOGIC:** 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 set to “Disabled”, only close commands sent via the 760 will be considered as a manual close for the autoreclose scheme logic.

- **INCOMPLETE SEQUENCE TIME:** This timer sets 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) fail to report the breaker has opened;
  - The “Block 2 Close Relay” logic input function is asserted;
  - The synchrocheck feature is blocking breaker closes.

This timer must be set to a delay less than the AR RESET TIME timer.



NOTE

- **RECLOSURE ENABLED RELAYS:** Select the relays required to operate while the front panel Reclosure Enabled indicator is on.
- **RECLOSURE IN PROGRESS 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:** 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.

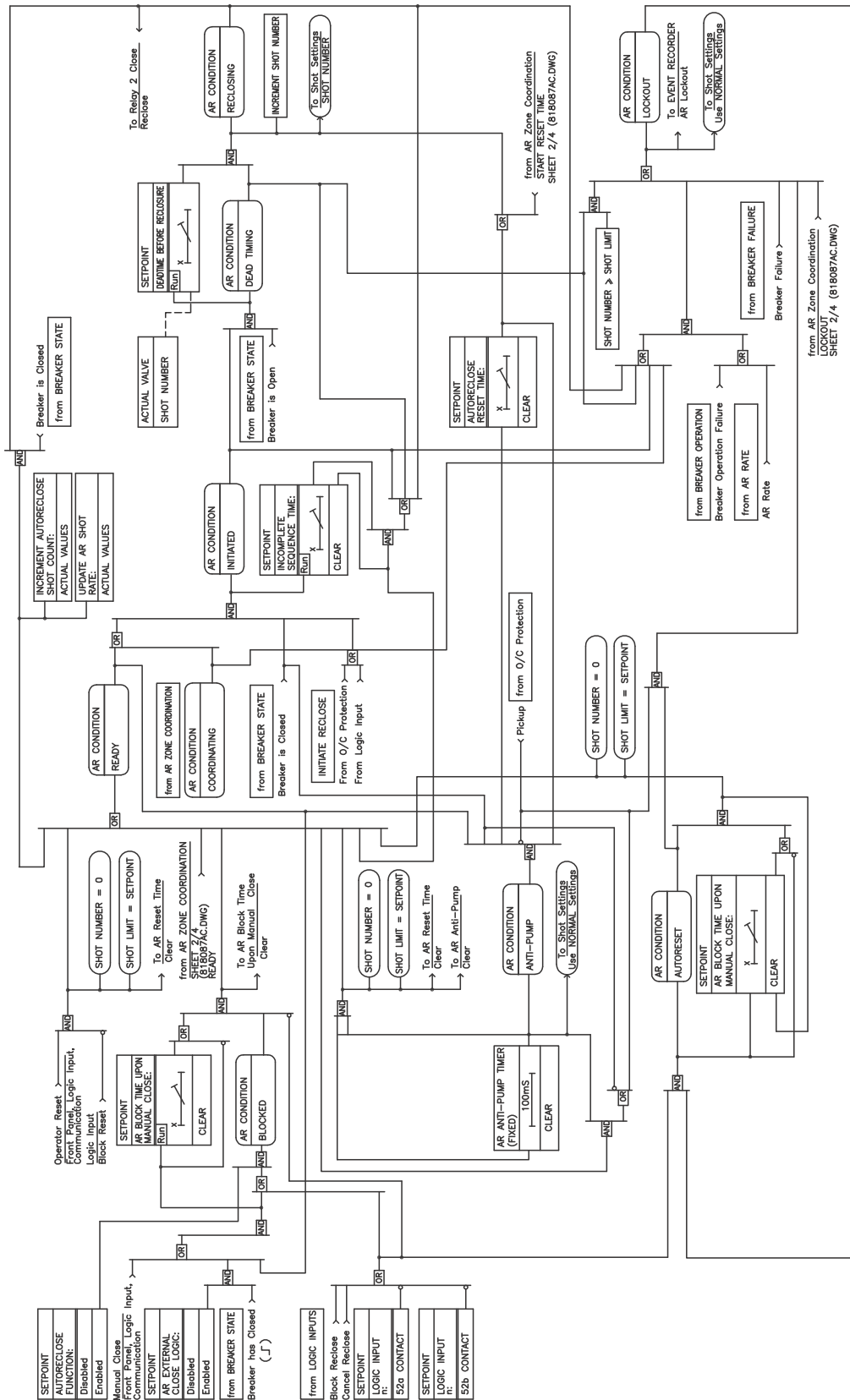


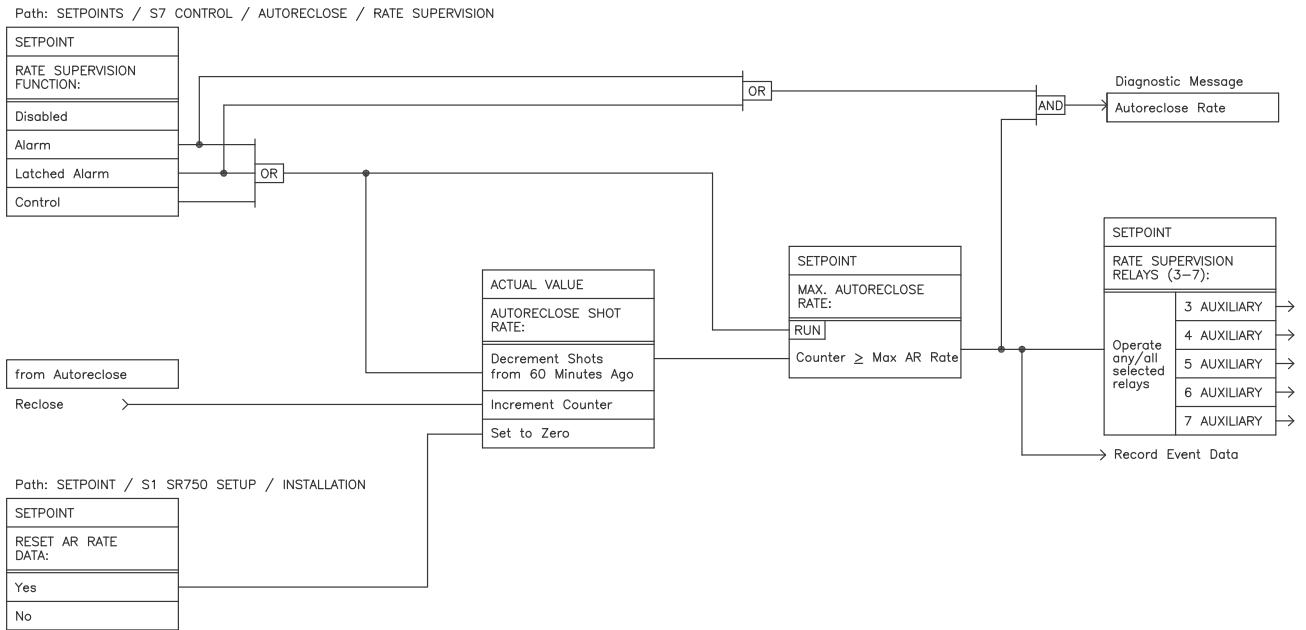
FIGURE 5-76: Autoreclose Scheme Setup Logic

### Autoreclose Rate Supervision

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ AUTORECLOSE ▾ ▾ RATE SUPERVISION

<b>■ RATE SUPERVISION</b> <span style="float: right;">[&gt;]</span>		<b>RATE SUPERVISION FUNCTION: Disabled</b>	<i>Range: Disabled, Alarm, Latched Alarm,</i>
MESSAGE		<b>RATE SUPERVISION RELAYS (3-7): -----</b>	<i>Range: Any combination of the 3 to 7 Auxiliary</i>
MESSAGE		<b>MAX AUTORECLOSE RATE: 25 /hr.</b>	<i>Range: 1 to 50/hr. in steps of 1</i>

The autoreclose rate supervision feature monitors the number of reclosures per hour. Once the number of reclosures within one hour exceeds the **MAX AUTORECLOSE RATE** setpoint, the autoreclose scheme is sent to lockout.









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FIGURE 5-77: Autoreclose Rate Supervision Logic

## Autoreclose Current Supervision

PATH: SETPOINTS ▾ S7 CONTROL ▾ AUTORECLOSE ▾ CURRENT SUPERVISION

<div style="border: 1px solid black; padding: 2px;"> <b>■ CURRENT SUPERVISION</b> [▷]         </div>		<div style="border: 1px solid black; padding: 2px;"> <b>CURRENT SUPERVISION FUNCTION: Disabled</b> </div>	<i>Range: Enabled, Disabled</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>3 SHOTS FOR CURRENT ABOVE: 17.00 x CT</b> </div>	<i>Range: 0.00 to 20.00 x CT in steps of 0.01</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>2 SHOTS FOR CURRENT ABOVE: 18.00 x CT</b> </div>	<i>Range: 0.00 to 20.00 x CT in steps of 0.01</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>1 SHOTS FOR CURRENT ABOVE: 19.00 x CT</b> </div>	<i>Range: 0.00 to 20.00 x CT in steps of 0.01</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>CURRENT SUPERVISION TO LOCKOUT: Disabled</b> </div>	<i>Range: Enabled, Disabled</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>LOCKOUT FOR CURRENT ABOVE: 20.00 x CT</b> </div>	<i>Range: 0.00 to 20.00 x CT in steps of 0.01</i>

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 **MAX 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.

The fault current level above which the number of autoreclosure shots will be reduced to one, two, or three shots can be selected. If the autoreclose scheme is to be taken directly to lockout without reclosing, set the **CURRENT SUPERVISION TO LOCKOUT** setpoint to “Enabled”

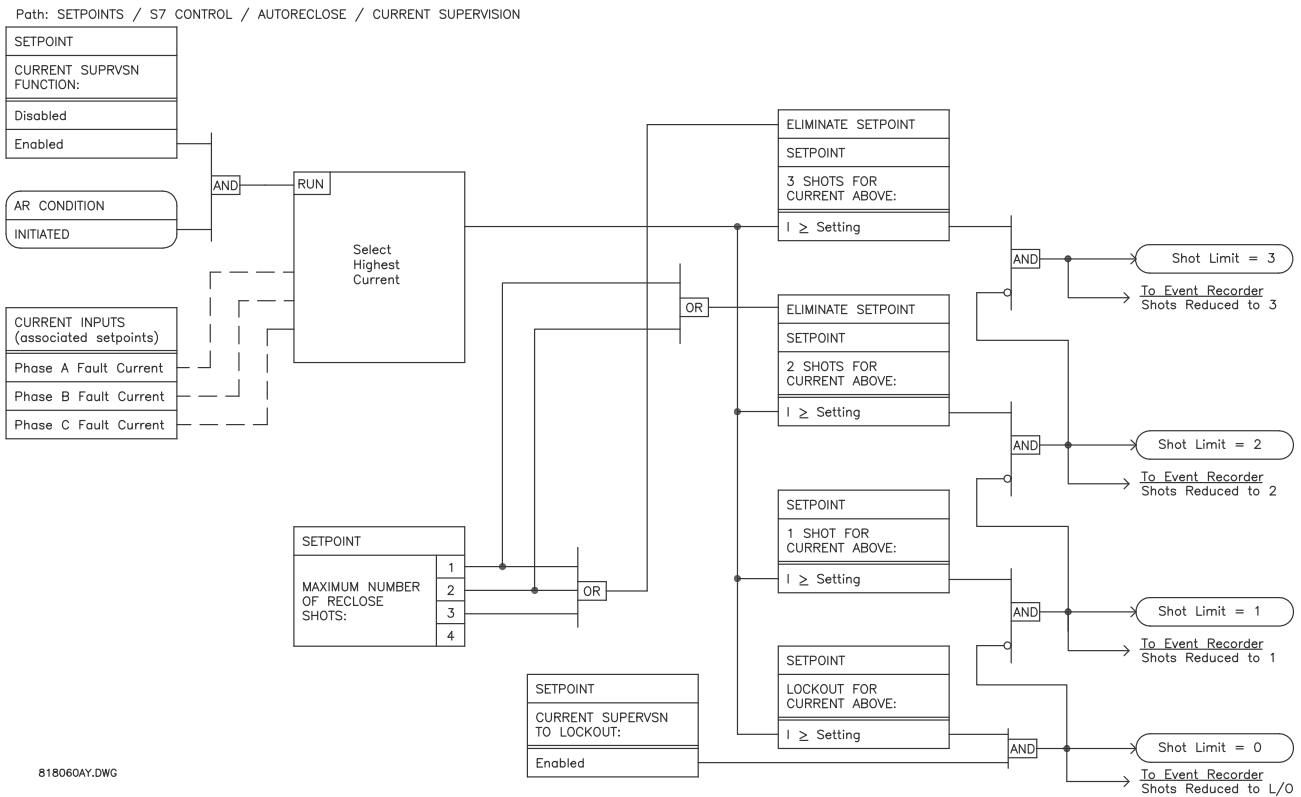


FIGURE 5-78: Autoreclose Current Supervision Logic

### Autoreclose Zone Coordination

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ AUTORECLOSE ▾ ▾ ZONE COORDINATION

<b>■ ZONE COORDINATION</b> [▶]		<b>ZONE COORDINATION FUNCTION: Disabled</b>	<i>Range: Enabled, Disabled</i>
MESSAGE		<b>PHASE CURRENT INCREASE: 1.00 x CT</b>	<i>Range: 0.05 to 20.00 x CT in steps of 0.01</i>
MESSAGE		<b>NEUTRAL CURRENT INCREASE: 1.00 x CT</b>	<i>Range: 0.05 to 20.00 x CT in steps of 0.01</i>
MESSAGE		<b>MAX FAULT CLEARING TIME: 10 s</b>	<i>Range: 1 to 1000 s in steps of 1</i>

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 setpoints 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 setpoints are changed, and the autoreclose scheme reset timer is initiated.

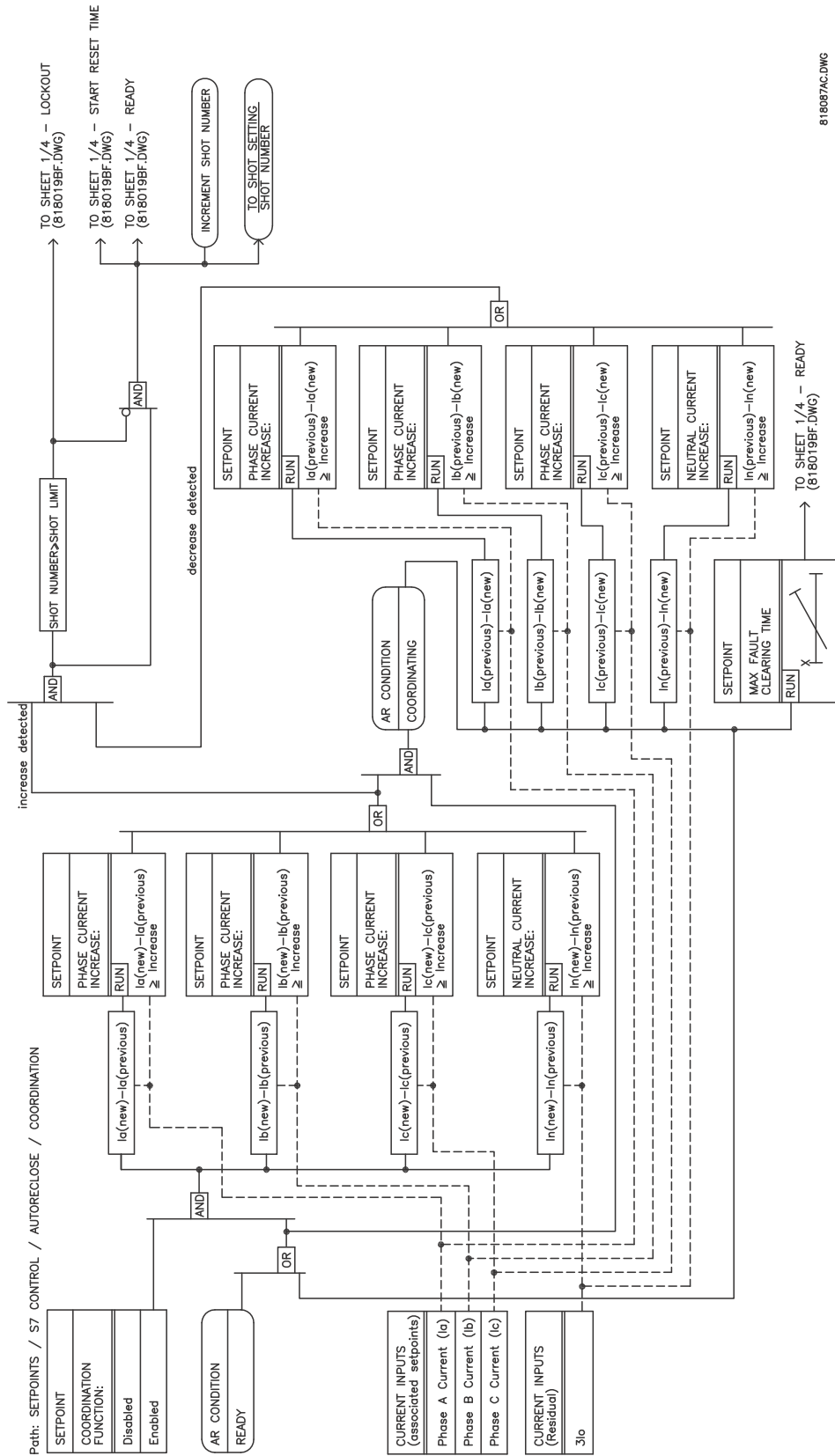
If the fault is permanent and the recloser continues to trip and reclose, the coordination feature will continue to increment the shot counter. If this continues to the maximum number of shots programmed in the 760, the autoreclose scheme will go to lockout. If the fault is transient, then the autoreclose scheme and shot counter will eventually be reset by the normal reset mechanism.

The **PHASE CURRENT INCREASE** and **NEUTRAL CURRENT INCREASE** setpoints select the minimum phase and neutral current step increases that signify downstream faults. These currents may be quite low for an end fault on a long feeder with a weak source. The **MAX FAULT CLEARING TIME** setpoint 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.



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.















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FIGURE 5-79: Autoreclose Zone Coordination Logic



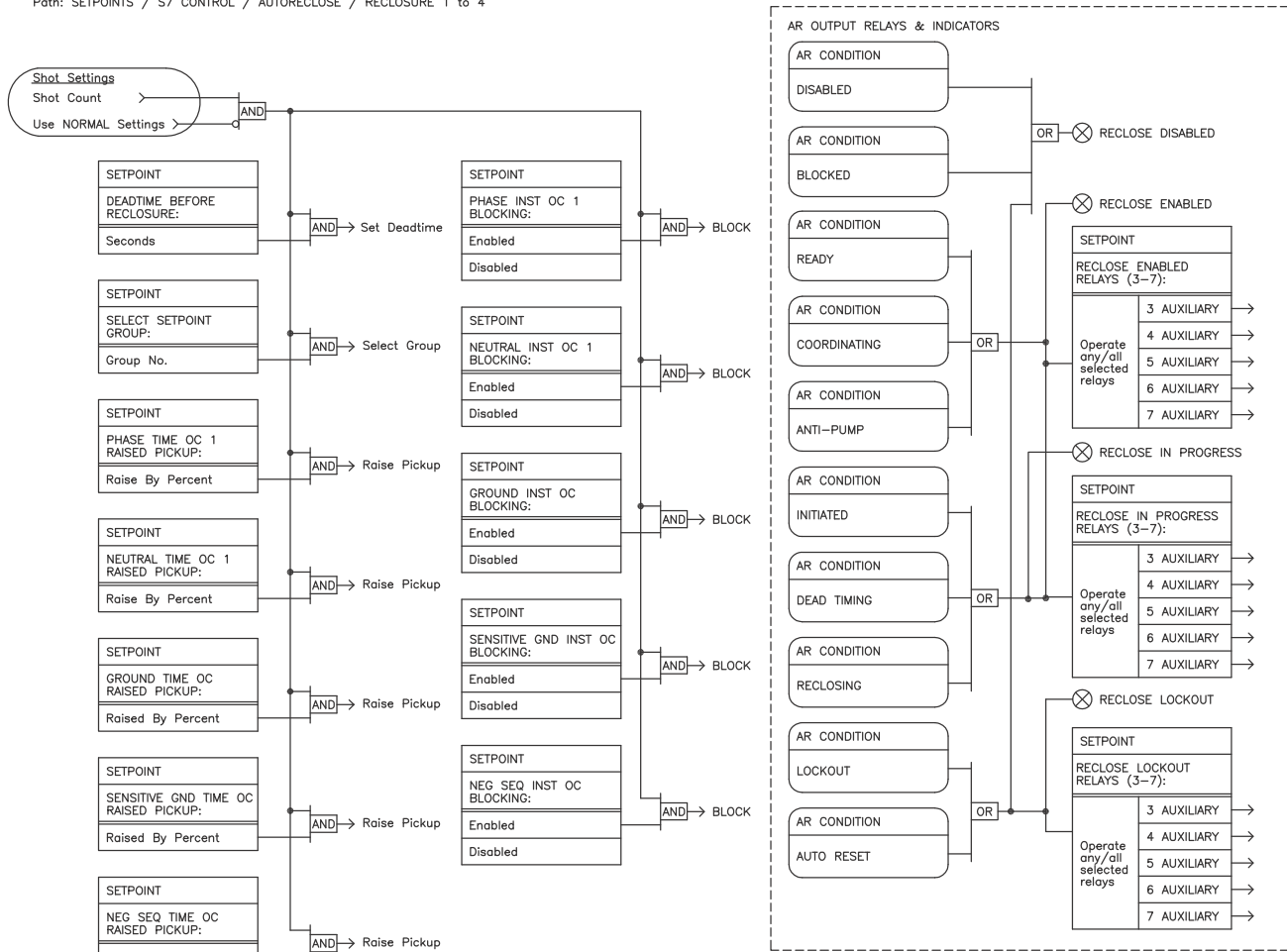
### Reclosure Shots 1 to 4

PATH: SETPOINTS ▾ ▾ S7 CONTROL ▾ ▾ AUTORECLOSE ▾ ▾ RECLOSURE 1(4)

<div style="border: 1px solid black; padding: 2px;"> <span style="font-size: 1.2em;">■</span> <b>RECLOSURE 1</b> <span style="float: right;">[▷]</span> </div>			<div style="border: 1px solid black; padding: 2px;"> <b>DEADTIME BEFORE RECLOSURE:</b> 0.50 s                 </div>	<i>Range: 0.00 to 300.00 s in steps of 0.01</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>PHASE INST OC 1 BLOCKING:</b> Disabled                 </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>NEUTRAL INST OC 1 BLOCKING:</b> Disabled                 </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>GND INST OC BLOCKING:</b> Disabled                 </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>SENSTV GND INST OC BLOCKING:</b> Disabled                 </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>NEG SEQ INST OC BLOCKING:</b> Disabled                 </div>	<i>Range: Enabled, Disabled</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>PHASE TIME OC 1 RAISED PICKUP:</b> 0%                 </div>	<i>Range: 0 to 100% in steps of 1</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>NEUTRAL TIME OC 1 RAISED PICKUP:</b> 0%                 </div>	<i>Range: 0 to 100% in steps of 1</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>GND TIME OC RAISED PICKUP:</b> 0%                 </div>	<i>Range: 0 to 100% in steps of 1</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>SENSTV GND TIME OC RAISED PICKUP:</b> 0%                 </div>	<i>Range: 0 to 100% in steps of 1</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>NEG SEQ TIME OC RAISED PICKUP:</b> 0%                 </div>	<i>Range: 0 to 100% in steps of 1</i>
MESSAGE			<div style="border: 1px solid black; padding: 2px;"> <b>SELECT SETPOINT GROUP:</b> Active                 </div>	<i>Range: Group 1, Group 2, Group 3, Group 4,</i>

The above setpoints are programmed independently and are repeated for each of the Reclosure Shots 1 through 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.

Path: SETPOINTS / S7 CONTROL / AUTORECLOSE / RECLOSURE 1 to 4



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FIGURE 5-80: Autoreclosure Shots 1 to 4 Logic

### Autoreclosure 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 setpoints that will detect faults out to the most distant (in impedance terms) point of the feeder and provide fast operation. Typically 'lo-set' 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. Lo-set elements would then be re-enabled after the scheme is reset. 'Hi-

set' 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 Overcurrent 1 (I<sub>o</sub>-set) and Time Overcurrent 1 elements.
2. The Time Overcurrent element begins to time, and the Instantaneous Overcurrent 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 Overcurrent 1 and Time Overcurrent 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 setpoints block the Instantaneous Overcurrent 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 Overcurrent 1 and the Time Overcurrent 1 elements is produced. However, the Instantaneous Overcurrent 1 element is blocked from operating.
8. While the Time Overcurrent 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 Overcurrent 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 setpoints for the current shot.
11. If the shot counter has reached its maximum then the scheme goes to lockout.

## 5.9 S8 Testing

### 5.9.1 Output Relays

PATH: SETPOINTS ▾ ▾ S8 TESTING ▾ OUTPUT RELAYS

<span style="color: blue;">■</span> <b>OUTPUT RELAYS</b> [▷]		<b>FORCE OUTPUT RELAYS FUNCTION: Disabled</b>	<i>Range: Enabled, Disabled</i>
MESSAGE		<b>FORCE 1 TRIP RELAY: De-energized</b>	<i>Range: Energized, De-energized</i>
MESSAGE		<b>FORCE 2 CLOSE RELAY: De-energized</b>	<i>Range: Energized, De-energized</i>
MESSAGE		<b>FORCE 3 AUX RELAY: De-energized</b>	<i>Range: Energized, De-energized</i>
MESSAGE		<b>FORCE 4 AUX RELAY: De-energized</b>	<i>Range: Energized, De-energized</i>
MESSAGE		<b>FORCE 5 AUX RELAY: De-energized</b>	<i>Range: Energized, De-energized</i>
MESSAGE		<b>FORCE 6 AUX RELAY: De-energized</b>	<i>Range: Energized, De-energized</i>
MESSAGE		<b>FORCE 7 AUX RELAY: De-energized</b>	<i>Range: Energized, De-energized</i>
MESSAGE		<b>FORCE 8 SELF-TEST RELAY: De-energized</b>	<i>Range: Energized, De-energized</i>
MESSAGE		<b>FORCE SOLID STATE OUTPUT: De-energized</b>	<i>Range: Energized, De-energized</i>

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.

Set **FORCE OUTPUT RELAYS FUNCTION** to “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.

Select “De-energized” for the remaining setpoints to force the output relays to the de-energized state while **FORCE OUTPUT RELAYS FUNCTION** is set to “Enabled”. Selecting “Energized” forces the output relay to the energized state while the **FORCE OUTPUT RELAYS FUNCTION** setpoint is “Enabled”.

### 5.9.2 Pickup Test

PATH: SETPOINTS ▾ ▾ S8 TESTING ▾ ▾ PICKUP TEST

<b>PICKUP TEST</b> [▶]		<b>PICKUP TEST</b> <b>FUNCTION: Disabled</b>	<i>Range: Enabled, Disabled.</i> <i>Defaults to "Disabled"</i>
		<b>PICKUP TEST</b> <b>RELAYS (3-7): -----</b>	<i>Range: Any combination of</i> <i>the 3 to 7 Auxiliary</i>

The relay provides the ability to operate any or all of the 3 to 7 Auxiliary output relays 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.

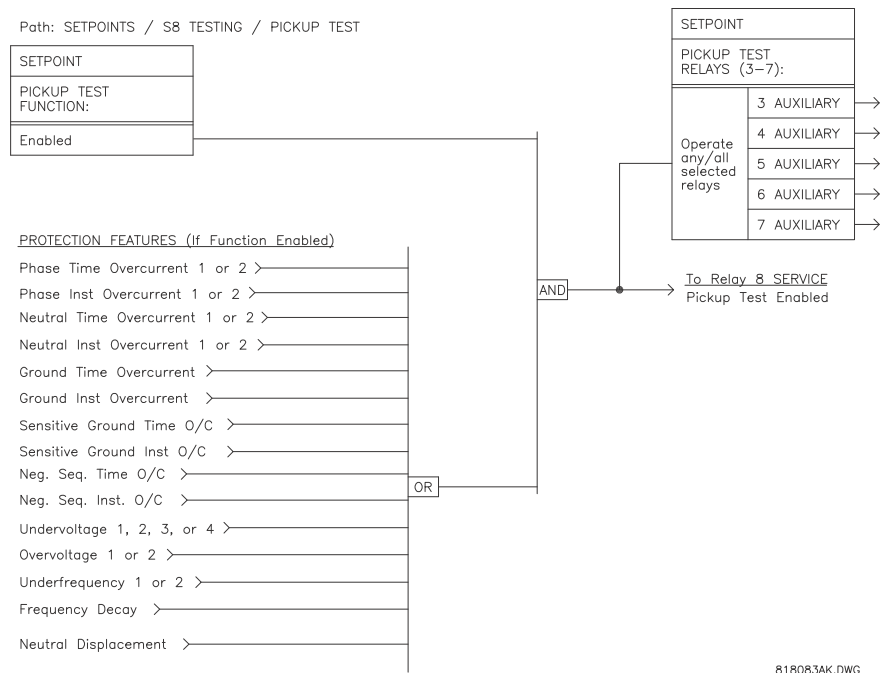


FIGURE 5-81: Pickup Test Logic

### 5.9.3 Analog Outputs

PATH: SETPOINTS ▾ ▾ S8 TESTING ▾ ▾ ANALOG OUTPUTS

<b>ANALOG OUTPUTS</b> [▶]		<b>FORCE ANALOG OUTPUTS</b> <b>FUNCTION: Disabled</b>	<i>Range: Enabled, Disabled</i>
		<b>FORCE A/O 1</b> <b>0%</b>	<i>Range: 0 to 100% in steps of</i> <i>1</i>
		<b>FORCE A/O 8</b> <b>0%</b>	<i>Range: 0 to 100% in steps of</i> <i>1</i>

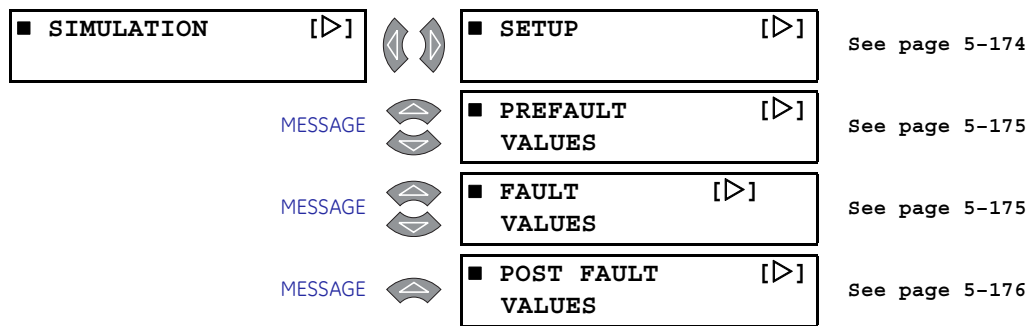
The relay provides the ability to override the normal function of analog outputs, forcing each to any level from 0 to 100% of the output range. Enter the percentage of the DC mA output range to be signaled by the Analog Output 1 (2 to 8) for the **FORCE A/O 1(8)** setpoints. For example, if the relay has been ordered with 4 to 20 mA analog outputs, setting this value to “100%” will output 20 mA, “0%” will output 4 mA, and “50%” will output 12 mA.

The **FORCE A/O FUNCTION** Always defaults to “Disabled” on power-up

### 5.9.4 Simulation

#### Main Menu

PATH: SETPOINTS ▾ ▾ S8 TESTING ▾ ▾ SIMULATION



### ⚠ 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 PWR FACTOR ANGLE** setpoint. The frequency of voltages and currents are automatically set to the values programmed in the **NOMINAL FREQ** 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 A. 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 BRKR 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 setting the **SIMULATION STATE** setpoint to the Fault State, or 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 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.

The relay remains in the Postfault State until either a close command received 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 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 Method 1 above except that the Trip Relay will operate if a trip condition is declared and the 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.

### Setup

PATH: SETPOINTS ▷ ▾ S8 TESTING ▷ ▾ SIMULATION ▷ SETUP

<b>■ SETUP</b> [▷]		<b>SIMULATION STATE:</b> <b>Disabled</b>	<i>Range: Disabled, Prefault, Fault, Postfault</i>
	MESSAGE	<b>CIRCUIT BRKR SIMULATION:</b> <b>Enabled</b>	<i>Range: Enabled, Disabled</i>
	MESSAGE	<b>ALLOW OPERATION OF RELAYS (3-7):</b> -----	<i>Range: Any combination of the 3 to 7 Auxiliary</i>

Program **SIMULATION STATE** to “Disabled” if actual system inputs are to be monitored. If programmed to any other value, 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 Fault Values setpoints on page –175.



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”.


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. Set **CIRCUIT BRKR SIMULATION** to “Enabled” to block the Trip and Close Relays from operating, and ignore the 52a/52b auxiliary contacts, even if installed. In this mode, the circuit breaker will be simulated. Set **CIRCUIT BRKR SIMULATION** to “Disabled” to allow the Trip and 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.

The Trip and Close relays are allowed to operate by setting **CIRCUIT BRKR SIMULATION** to “Disabled”. Auxiliary Relays 3 to 7 can also be allowed to operate if selected by the **ALLOW OPERATION OF RELAYS (3-7)** setpoint. The 8 Self-Test Warning relay is always allowed to operate. Note that the default value 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.



### Prefault Values


PATH: SETPOINTS ▾ ▾ S8 TESTING ▾ ▾ SIMULATION ▾ ▾ PREFault VALUES

<b>■ PREFault VALUES</b> [ <b>&gt;</b> ]		<b>PHASE A/B/C CURRENT LEVEL: 0.50 x CT</b>	<i>Range: 0.00 to 20.00 x CT in steps of 0.01</i>
		<b>PWR FACTOR ANGLE: 0° Lag</b>	<i>Range: 0 to 359° Lag in steps of 1</i>

For proper 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.

### Fault Values

PATH: SETPOINTS ▾ ▾ S8 TESTING ▾ ▾ SIMULATION ▾ ▾ FAULT VALUES

<b>■ FAULT VALUES</b> [ <b>&gt;</b> ]		<b>PHASE A-N VOLTAGE LEVEL: 1.00 x VT</b>	<i>Range: 0.00 to 2.00 x VT in steps of 0.01</i>
		<b>PHASE A-N VOLTAGE POSITION: 0° Lag</b>	<i>Range: 0 to 359° Lag in steps of 1</i>
		<b>PHASE B-N VOLTAGE LEVEL: 1.00 x VT</b>	<i>Range: 0.00 to 2.00 x VT in steps of 0.01</i>
		<b>PHASE B-N VOLTAGE POSITION: 120° Lag</b>	<i>Range: 0 to 359° Lag in steps of 1</i>
		<b>PHASE C-N VOLTAGE LEVEL: 1.00 x VT</b>	<i>Range: 0.00 to 2.00 x VT in steps of 0.01</i>
		<b>PHASE C-N VOLTAGE POSITION: 240° Lag</b>	<i>Range: 0 to 359° Lag in steps of 1</i>
		<b>PHASE A CURRENT LEVEL: 1.00 x CT</b>	<i>Range: 0.00 to 20.00 x CT in steps of 0.01</i>
		<b>PHASE A CURRENT POSITION: 60° Lag</b>	<i>Range: 0 to 359° Lag in steps of 1</i>
		<b>PHASE B CURRENT LEVEL: 1.00 x CT</b>	<i>Range: 0.00 to 20.00 x CT in steps of 0.01</i>
		<b>PHASE B CURRENT POSITION: 180° Lag</b>	<i>Range: 0 to 359° Lag in steps of 1</i>
		<b>PHASE C CURRENT LEVEL: 1.00 x CT</b>	<i>Range: 0.00 to 20.00 x CT in steps of 0.01</i>
		<b>PHASE C CURRENT POSITION: 300° Lag</b>	<i>Range: 0 to 359° Lag in steps of 1</i>
		<b>GND CURRENT LEVEL: 0.00 x CT</b>	<i>Range: 0.00 to 20.00 x CT in steps of 0.01</i>

MESSAGE		<b>GND CURRENT POSITION: 0° Lag</b>	Range: 0 to 359° Lag in steps of 1
MESSAGE		<b>SENSTV GND CURRENT LEVEL: 0.100 x CT</b>	Range: 0.000 to 1.000 x CT in steps of 0.001
MESSAGE		<b>SENSTV GND CURRENT POSITION: 0° Lag</b>	Range: 0 to 359° Lag in steps of 1
MESSAGE		<b>SYSTEM FREQ: 60.00 Hz</b>	Range: 20.00 to 65.00 Hz in steps of 0.01
MESSAGE		<b>A/I CURRENT: 0.00 mA</b>	Range: 0.00 to 20.00 mA in steps of 0.01

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 **NOMINAL VT SECONDARY VOLTAGE** and **VT RATIO** setpoints. Phase current magnitudes are entered in per unit values relative to the nominal system current that is defined by the **PHASE CT PRIMARY** setpoint. All phasor angles are referenced to the pre-fault A-N bus voltage at 0°.

### Postfault Values

PATH: SETPOINTS > S8 TESTING > SIMULATION > POSTFAULT VALUES

<b>POST FAULT VALUES</b> [ <b>&gt;</b> ]		<b>BUS VOLTAGE LEVEL: 1.00 x VT</b>	Range: 0.00 to 2.00 x VT in steps of 0.01
MESSAGE		<b>BUS VOLTAGE FREQ: 60.00 Hz</b>	Range: 20.00 to 65.00 Hz in steps of 0.01
MESSAGE		<b>SYNC VOLTAGE LEVEL: 1.00 x VT</b>	Range: 0.00 to 2.00 x VT in steps of 0.01
MESSAGE		<b>SYNC VOLTAGE POSITION: 0° Lag</b>	Range: 0 to 359° Lag in steps of 1
MESSAGE		<b>SYNC VOLTAGE FREQ: 60.00 Hz</b>	Range: 20.00 to 65.00 Hz in steps of 0.01

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 pre-fault A-N bus voltage at 0°.

### 5.9.5 Factory Service

PATH: SETPOINTS > S8 TESTING > FACTORY SERVICE

<b>FACTORY SERVICE</b> [ <b>&gt;</b> ]		<b>ENTER FACTORY PASSCODE: ■</b>	Range: Restricted access for GE personnel only
----------------------------------------	--	----------------------------------	------------------------------------------------

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.





# 750/760 Feeder Management Relay

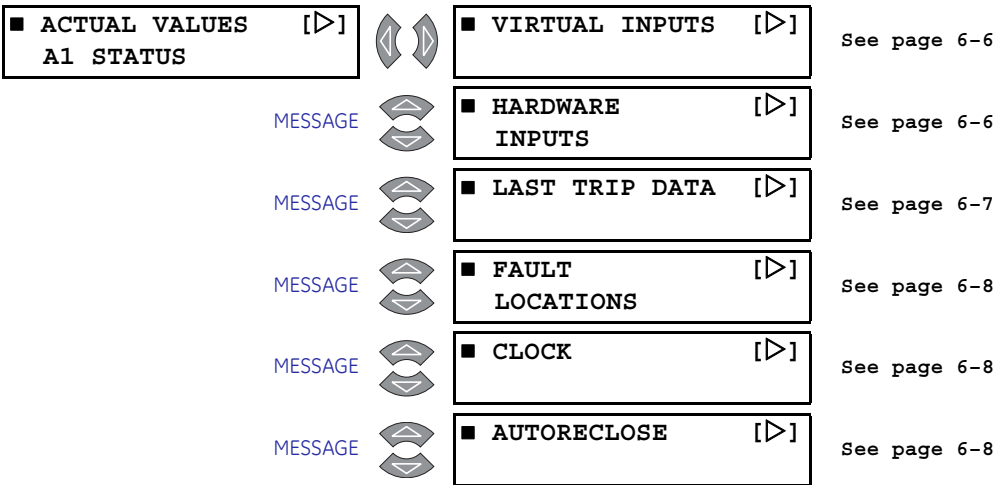
## Chapter 6: Actual Values

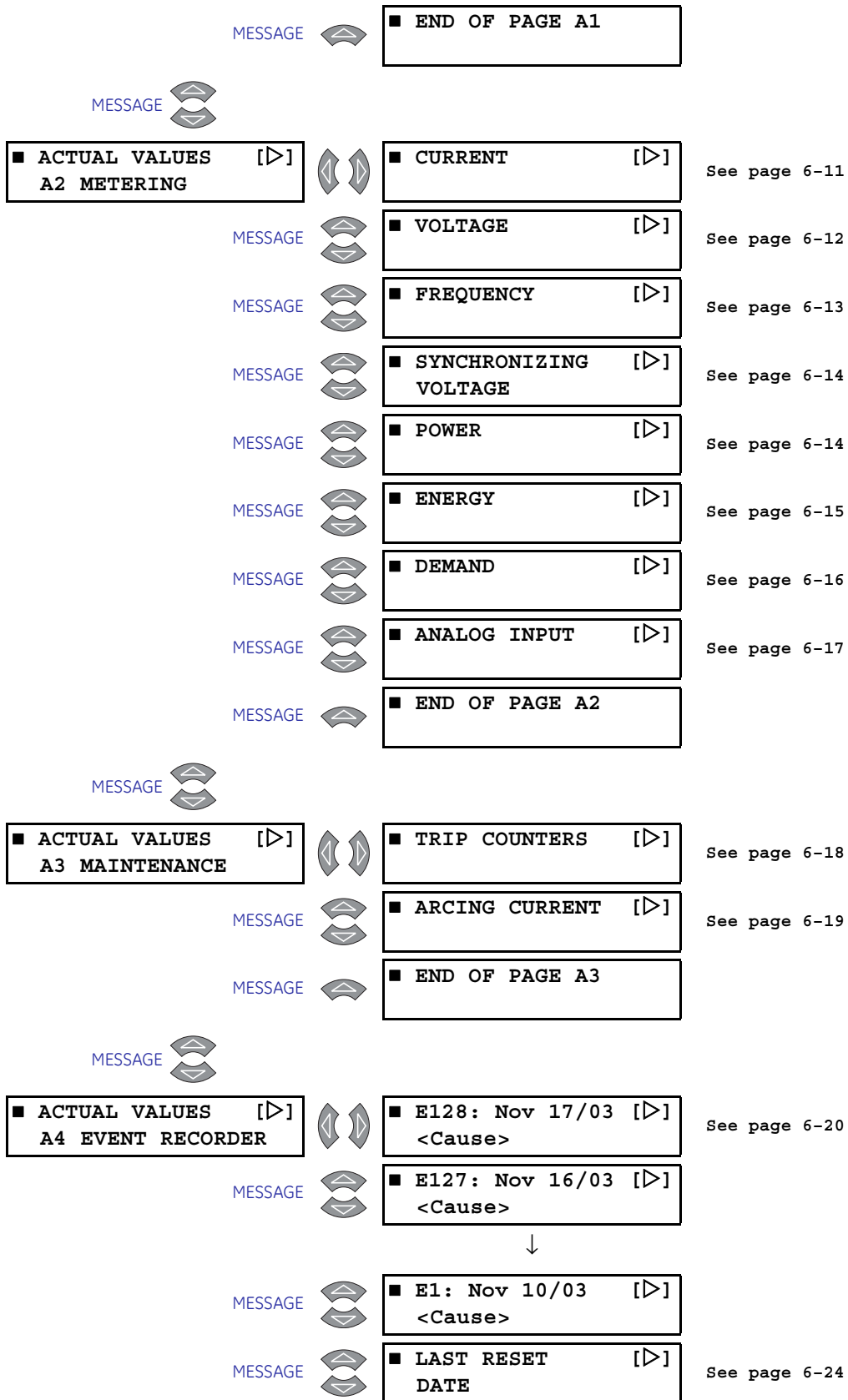
### 6.1 Overview

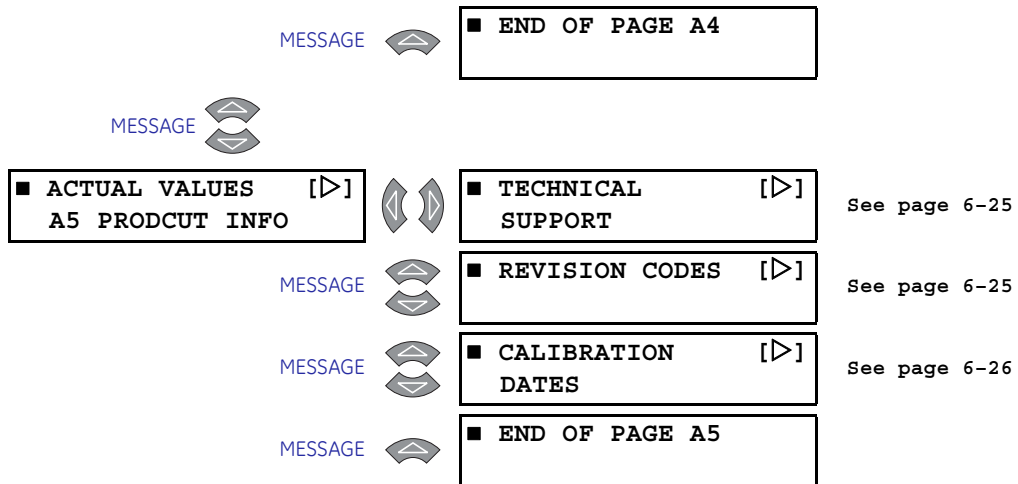
#### 6.1.1 Actual Values Main Menu

Measured values, maintenance, and fault analysis information are accessed in actual values mode. Actual value messages are organized into logical groups for easy reference as shown below. Actual values may be accessed as follows:

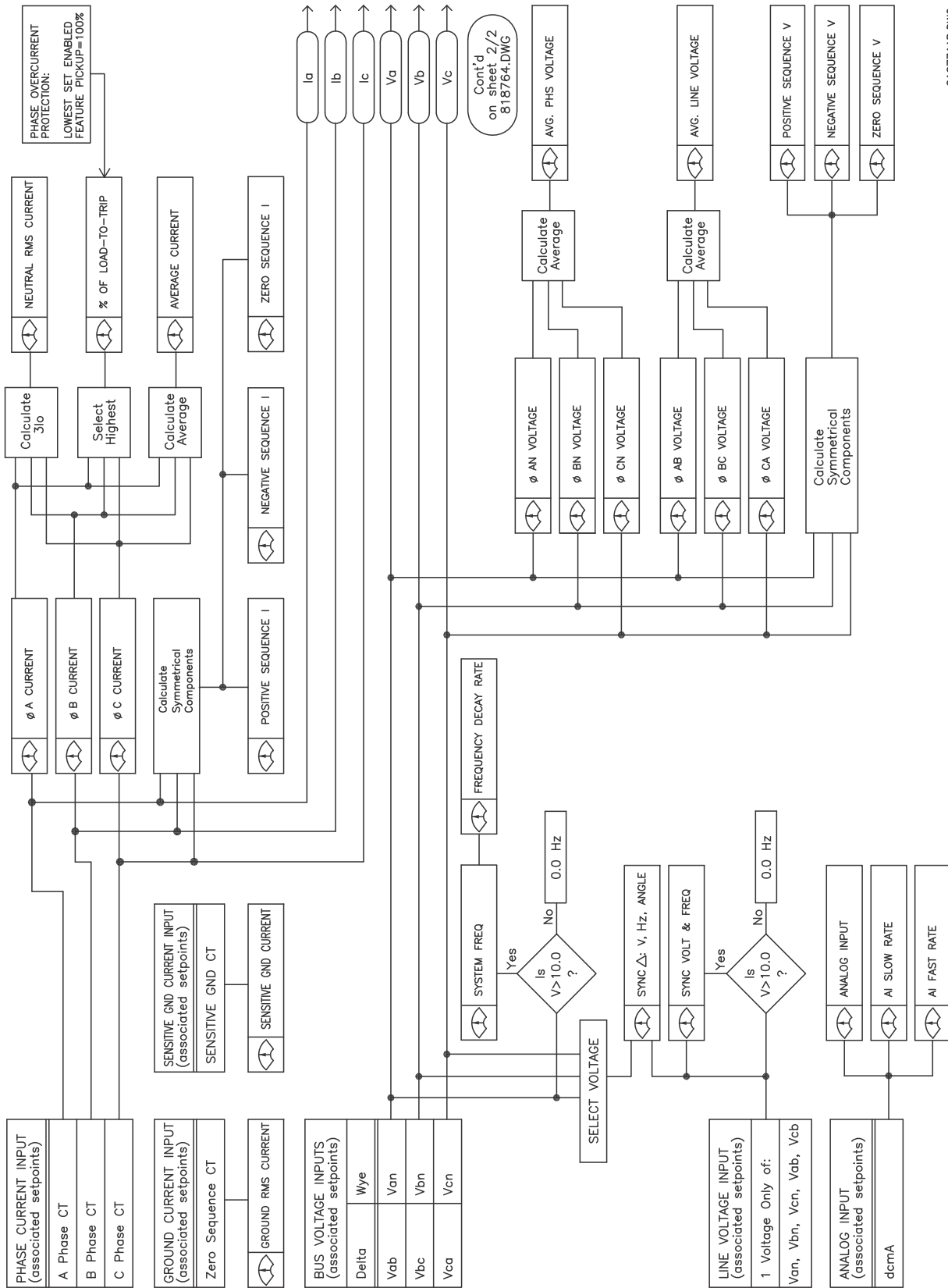
1. Front panel, using the keys and display.
2. Front program port, and a portable computer running the EnerVista 750/760 Setup software supplied with the relay.
3. Rear RS485/RS422 COM 1 port or RS485 COM 2 port with a SCADA system running user-designed software.
4. Ethernet network connection to the rear RJ-45 port and a computer running the EnerVista 750/760 Setup software supplied with the relay.







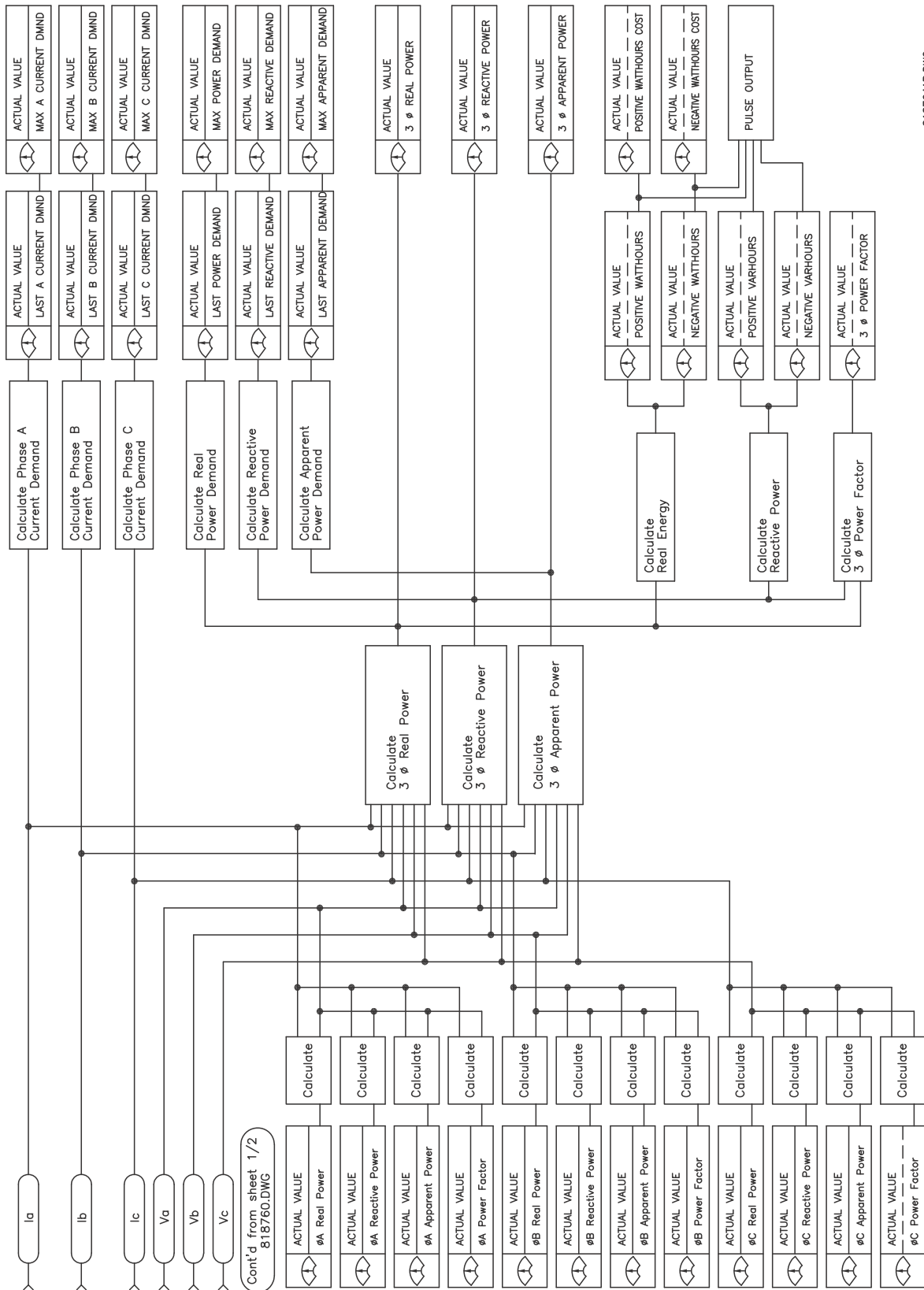
The following two figures show block diagrams from the Actual Values messages.



818771AR.DWG

FIGURE 6-1: Actual Values Block Diagram (1 of 2)







818764AB.DWG

FIGURE 6-2: Actual Values Block Diagram (2 of 2)

## 6.2 A1 Status







### 6.2.1 Virtual Inputs PATH: ACTUAL VALUES ▷ A1 STATUS ▷ VIRTUAL INPUTS

<div style="border: 1px solid black; padding: 2px;"> <span style="font-size: 0.8em;">■ VIRTUAL INPUTS</span> <span style="float: right; font-size: 0.8em;">[▷]</span> </div>		<div style="border: 1px solid black; padding: 2px;"> <b>2 VIRTUAL INPUTS ARE ACTIVE</b> </div>	<i>Range: 0 to 20 Virtual Inputs</i>
		<div style="border: 1px solid black; padding: 2px;"> <b>Logic Input 1</b>                  Off             </div>	<i>Range: On, Off. Reflects the user-programmed name.</i>

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 *S3 Logic Inputs* on page 5–26 for complete details on virtual inputs, their setpoints and application.













The first value displays how many logic inputs have a virtual condition selected as part of their asserted logic. The states of Virtual Inputs 1 through 20 are displayed in this menu. The **Logic Input 1** display heading is user-programmable. Note that only ‘active’ virtual inputs are displayed; active virtual inputs are those that have their **INPUT N ASSERTED LOGIC** setpoint programmed to monitor the state of the virtual input. There are subsequent displays for the remaining virtual inputs.

### 6.2.2 Hardware Inputs PATH: ACTUAL VALUES ▷ A1 STATUS ▷ ▾ HARDWARE INPUTS

<div style="border: 1px solid black; padding: 2px;"> <span style="font-size: 0.8em;">■ HARDWARE INPUTS</span> <span style="float: right; font-size: 0.8em;">[▷]</span> </div>		<div style="border: 1px solid black; padding: 2px;"> <b>CONTACT 1 STATE:</b>                  Open             </div>	<i>Range: Open, Closed</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>CONTACT 2 STATE:</b>                  Open             </div>	<i>Range: Open, Closed</i>
	↓		
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>CONTACT 14 STATE:</b>                  Open             </div>	<i>Range: Open, Closed</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>SETPOINT ACCESS STATE:</b> Restricted             </div>	<i>Range: Restricted, Allowed</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>Trip Coil Monitor STATE:</b> Open             </div>	<i>Range: Open, Closed</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>Close Coil Monitor STATE:</b> Open             </div>	<i>Range: Open, Closed</i>

These messages display the state of all hardware inputs. The top line in the last two values above reflect the names programmed in the **S6 MONITORING ▷ ▾ EQUIPMENT ▷ ▾ COIL MONITOR 1 ▷ COIL 1 MON NAME** and **COIL 2 MON NAME** setpoints, respectively.

**6.2.3 Last Trip Data**      PATH: ACTUAL VALUES ▷ A1 STATUS ▷ ▾ LAST TRIP DATA

<div style="border: 1px solid black; padding: 2px;"> <span style="font-weight: bold;">■ LAST TRIP DATA</span> [▷]             </div>			<div style="border: 1px solid black; padding: 2px;"> <b>DATE OF LAST TRIP:</b>                  Nov 17 2003             </div>	<i>Range: Date in format shown</i>
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>TIME OF LAST TRIP:</b>                  12:34:56.789             </div>	<i>Range: Time in format shown</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>TRIP: &lt;Φ&gt;</b>  <b>&lt;Cause&gt;</b> </div>	<i>Range: See A4 Event Recorder on page 6-20.</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>A:        0    B:        0</b>  <b>C:        0    Amps</b> </div>	<i>Range: 0 to 65535 A</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>GND CURRENT:</b>                  0 A             </div>	<i>Range: 0 to 65535 A</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>SENSTV GND CURRENT:</b>                  0.00 A             </div>	<i>Range: 0 to 655.35 A</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>NEUTRAL CURRENT:</b>                  0 A             </div>	<i>Range: 0 to 65535 A</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>AN:  0.00    BN:  0.00</b>  <b>CN:  0.00    kVolts</b> </div>	<i>Range: 0 to 655.35 kV</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>AB:  0.00    BC:  0.00</b>  <b>CA:  0.00    kVolts</b> </div>	<i>Range: 0 to 655.35 kV</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>NEUTRAL VOLTAGE:</b>                  0.00 kV             </div>	<i>Range: 0 to 655.35 kV</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>SYSTEM FREQ:</b>                  0.00 Hz             </div>	<i>Range: 0.00 to 65.00 Hz</i>	
MESSAGE		<div style="border: 1px solid black; padding: 2px;"> <b>ANALOG INPUT:</b>                  0 μA             </div>	<i>Range: 0 to 65535 units.</i>	

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 (for example, both the Phase and Neutral Instantaneous Overcurrent 1 elements) 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.

The AN, BN, and CN voltage values are seen only if the **S2 SYSTEM SETUP ▷ ▾ BUS VT SENSING ▷ VT CONNECTION TYPE** setting is "Wye". The AB, BC, and CA voltage values are seen only if this setpoint is "Delta" or "None". The units for **ANALOG INPUT** are set by the **S6 MONITORING ▷ ▾ ANALOG INPUT ▷ ▾ ANALOG INPUT SETUP ▷ ▾ A1 UNITS** setting.

### 6.2.4 Fault Locations

PATH: ACTUAL VALUES > A1 STATUS > ▾ FAULT LOCATIONS > FAULT LOCATION 0(9)

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>FAULT LOCATION 0</b> [▷]             </div>		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>DATE OF FAULT 0:</b>                  Nov 17 2003             </div>	Range: Date in format shown
	MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>TIME OF FAULT 0:</b>                  12:34:56.789             </div>	Range: Time in format shown
	MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>TYPE OF FAULT:</b>                  n/a             </div>	Range: Phase A, Phase B, Phase C, Ground
	MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>DISTANCE TO FAULT:</b>                  0.00 km             </div>	Range: -327.68 to 327.68 km/mi
	MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>Zpos (INDUCTIVE) OHM TO FAULT:</b> 0.00             </div>	Range: 0.00 to 655.35 Ω

The data for 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.

The **DISTANCE TO FAULT** and **Zpos (INDUCTIVE) OHM TO FAULT** values are seen only if a fault location calculation has been performed.

### 6.2.5 Clock

PATH: ACTUAL VALUES > A1 STATUS > ▾ CLOCK

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>CLOCK</b> [▷]             </div>		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>CURRENT DATE:</b>                  November 17 2003             </div>	Range: Date in format shown
	MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>CURRENT TIME:</b>                  16:30:00             </div>	Range: Time in format shown

The date and time are displayed in the format shown. These values are shown as "Unavailable" if the date and/or time has not been programmed.

### 6.2.6 Autoreclose (760 only)

PATH: ACTUAL VALUES > A1 STATUS > ▾ AUTORECLOSE

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>AUTORECLOSE</b> [▷]             </div>		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>AR SHOT NUMBER IN EFFECT:</b> 0             </div>	Range: 0 to 4
	MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>AR SHOTS REMAINING:</b> 4             </div>	Range: 0 to 4
	MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>AR SHOT RATE:</b> 0 /hr             </div>	Range: 0 to 4
	MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>AR SHOT COUNT:</b> 0             </div>	Range: 0 to 4
	MESSAGE	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>AR SHOT COUNT LAST RESET:</b> Nov 17 2003             </div>	Range: Date in format shown

The present shot number which the autoreclose scheme is using to control protection settings is displayed in the **AR SHOT NUMBER IN EFFECT** value. If the scheme has reached Lockout, the display is the shot number after which a trip caused lockout. The **AR SHOTS REMAINING** value 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 is 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.

The number of reclosures in the past hour is shown in the **AR SHOT RATE** value. This value will be cleared by a **RESET AR RATE DATA** command via the front panel or communications.

The **AR SHOT COUNT** value shows the total number of reclosures since the **AR SHOT COUNT LAST RESET** date. The **AR SHOT COUNT LAST RESET** displays "Unavailable" if the date has never been programmed.

### 6.3 A2 Metering

#### 6.3.1 Metering Conventions

The relay measures all RMS currents and voltages, frequency, and an auxiliary analog input. Other values like average and neutral current, average line and phase voltage, symmetrical components, frequency decay rate, synchrocheck delta, power factor, power (real, reactive, apparent), energy (real, reactive), running and 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 three (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.

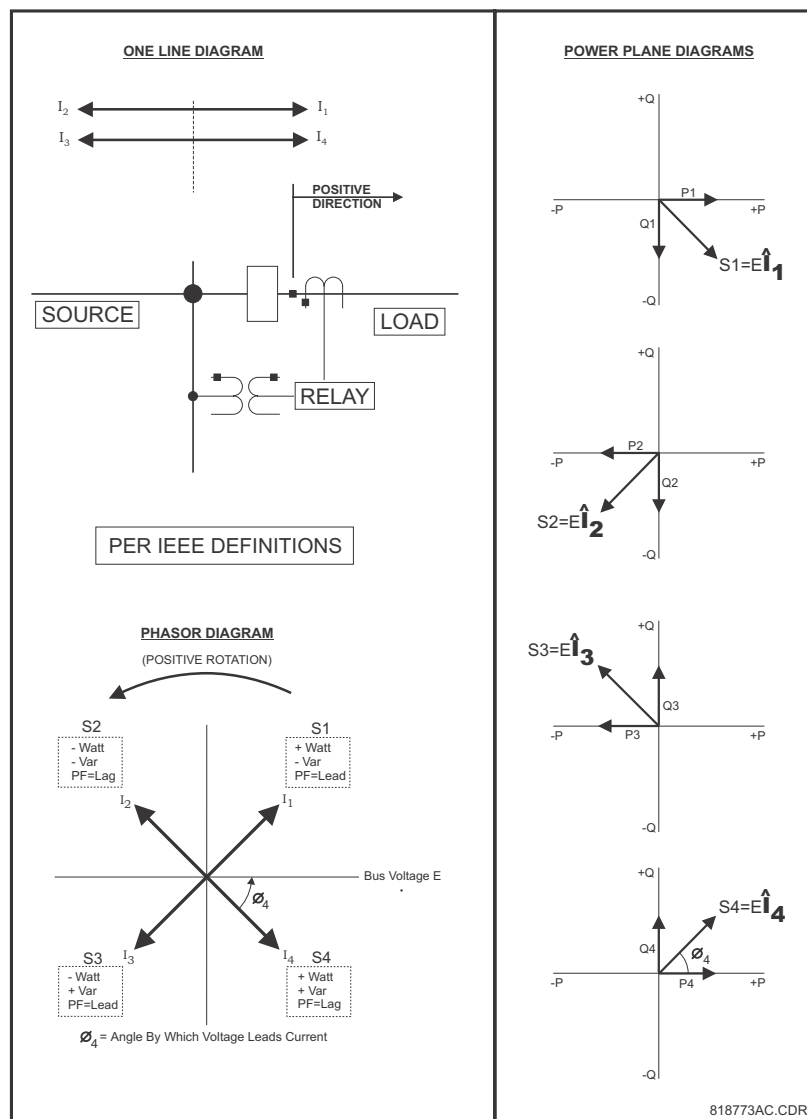


FIGURE 6-3: Power Quantity Relationships

## 6.3.2 Current

PATH: ACTUAL VALUES ▾ ▾ A2 METERING ▾ CURRENT

■ CURRENT [▷]		A: 0 B: 0 C: 0 Amps	Range: 0 to 65535 A
MESSAGE		% OF LOAD-TO-TRIP: 0%	Range: 0 to 2000%
MESSAGE		AVERAGE CURRENT: 0 A	Range: 0 to 65535 A
MESSAGE		PHASE A CURRENT: 0 A 0° Lag	Range: 0 to 65535 A, 0 to 359° Lag
MESSAGE		PHASE B CURRENT: 0 A 0° Lag	Range: 0 to 65535 A, 0 to 359° Lag
MESSAGE		PHASE C CURRENT: 0 A 0° Lag	Range: 0 to 65535 A, 0 to 359° Lag
MESSAGE		NEUTRAL CURRENT: 0 A 0° Lag	Range: 0 to 65535 A, 0 to 359° Lag
MESSAGE		GND CURRENT: 0 A 0° Lag	Range: 0 to 65535 A, 0 to 359° Lag
MESSAGE		SENSTV GND CURRENT: 0.00 A 0° Lag	Range: 0 to 655.35 A, 0 to 359° Lag
MESSAGE		POS SEQ CURRENT: 0 A 0° Lag	Range: 0 to 65535 A, 0 to 359° Lag
MESSAGE		NEG SEQ CURRENT: 0 A 0° Lag	Range: 0 to 65535 A, 0 to 359° Lag
MESSAGE		ZERO SEQ CURRENT: 0 A 0° Lag	Range: 0 to 65535 A, 0 to 359° Lag
MESSAGE		POLARIZING CURRENT: 0 A 0° Lag	Range: 0 to 65535 A, 0 to 359° Lag

Measured values of phase current magnitudes and phasors are displayed here. In addition, several calculated values are also displayed. The **AVERAGE CURRENT** displays the calculated averages of the Phase A, B, and C RMS currents:

$$I_{avg} = \frac{(|I_a| + |I_b| + |I_c|)}{3} \quad (\text{EQ 6.1})$$

The **NEUTRAL CURRENT** value displays the calculated neutral current RMS phasor given by:

$$3I_0 = I_a + I_b + I_c \quad (\text{EQ 6.2})$$

The **POS SEQ CURRENT** displays the calculated positive-sequence current RMS phasor as given by:

$$I_{a1} = \frac{I_a + aI_b + a^2I_c}{3} \quad \text{for ABC phase sequence} \quad (\text{EQ 6.3})$$

$$I_{a1} = \frac{I_a + a^2I_b + aI_c}{3} \quad \text{for ACB phase sequence}$$

The **NEG SEQ CURRENT** displays the calculated negative-sequence current RMS phasor as given by:

$$I_{a2} = \frac{I_a + a^2 I_b + a I_c}{3} \text{ for ABC phase sequence} \tag{EQ 6.4}$$















$$I_{a2} = \frac{I_a + a I_b + a^2 I_c}{3} \text{ for ACB phase sequence}$$

The **ZERO SEQ CURRENT** displays the calculated zero-sequence current RMS phasor:

$$I_{a0} = \frac{I_a + I_b + I_c}{3} \tag{EQ 6.5}$$

### 6.3.3 Voltage

PATH: ACTUAL VALUES ▾ ▾ A2 METERING ▾ ▾ VOLTAGE

<div style="border: 1px solid black; padding: 2px; display: inline-block;"> <span style="background-color: black; color: white; padding: 0 5px;">■</span> <b>VOLTAGE</b> </div> <span style="font-size: 24px; vertical-align: middle;">[&gt;]</span>			<b>AB: 0.00 BC: 0.00</b> <b>CA: 0.00 kV</b>	<i>Range: 0 to 655.35 kV</i>
MESSAGE		<b>AVERAGE LINE VOLTAGE:</b>	<b>0.00 kV</b>	<i>Range: 0 to 655.35 kV</i>
MESSAGE		<b>AN: 0.00 BN: 0.00</b> <b>CN: 0.00 kV</b>		<i>Range: 0 to 655.35 kV</i>
MESSAGE		<b>AVERAGE PHASE VOLTAGE:</b>	<b>0.00 kV</b>	<i>Range: 0 to 655.35 kV</i>
MESSAGE		<b>LINE A-B VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>
MESSAGE		<b>LINE B-C VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>
MESSAGE		<b>LINE C-A VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>
MESSAGE		<b>LINE A-N VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>
MESSAGE		<b>LINE B-N VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>
MESSAGE		<b>LINE C-N VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>
MESSAGE		<b>NEUTRAL VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>
MESSAGE		<b>POS SEQ VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>
MESSAGE		<b>NEG SEQ VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>
MESSAGE		<b>ZERO SEQ VOLTAGE:</b>	<b>0.00 kV 0° Lag</b>	<i>Range: 0 to 655.35 kV, 0 to 359° Lag</i>



The measured values of line and phase voltage magnitudes and phasors for the Bus VT inputs are displayed along with sequence components. In addition, several calculated values are also displayed. The **AVERAGE LINE VOLTAGE** displays the calculated averages of the RMS line voltages given by:

$$V_{avg} = \frac{(|V_{ab}| + |V_{bc}| + |V_{ca}|)}{3} \quad (\text{EQ 6.6})$$

The **AVERAGE PHASE VOLTAGE** displays the calculated average of the RMS phase voltages given by:

$$V_{avg} = \frac{(|V_{an}| + |V_{bn}| + |V_{cn}|)}{3} \quad (\text{EQ 6.7})$$

The **NEUTRAL VOLTAGE** displays the calculated neutral RMS phasor given by:

$$3V_0 = V_a + V_b + V_c \quad (\text{EQ 6.8})$$

The **POS SEQ VOLTAGE** shows the calculated positive-sequence voltage RMS phasor:

$$V_{a1} = \frac{(V_a + aV_b + a^2V_c)}{3} \quad \text{for ABC phase sequence} \quad (\text{EQ 6.9})$$

$$V_{a1} = \frac{(V_a + a^2V_b + aV_c)}{3} \quad \text{for ACB phase sequence}$$

The **NEG SEQ VOLTAGE** shows the calculated negative-sequence voltage RMS phasor:

$$V_{a2} = \frac{(V_a + a^2V_b + aV_c)}{3} \quad \text{for ABC phase sequence} \quad (\text{EQ 6.10})$$

$$V_{a2} = \frac{(V_a + aV_b + a^2V_c)}{3} \quad \text{for ACB phase sequence}$$

The **ZERO SEQ VOLTAGE** value shows the calculated zero-sequence current RMS phasor:

$$V_{a0} = (V_a + V_b + V_c)/3 \quad (\text{EQ 6.11})$$

The **AN, BN, CN, AVERAGE PHASE VOLTAGE, LINE A-N VOLTAGE, LINE B-N VOLTAGE, and LINE C-N VOLTAGE** values are seen only if the **VT CONNECTION TYPE** setting is "Wye".

### 6.3.4 Frequency




PATH: ACTUAL VALUES ▷ ▾ A2 METERING ▷ ▾ FREQUENCY

■ <b>FREQUENCY</b> [▷]		<b>SYSTEM FREQ:</b> 0.00 Hz	Range: 0 to 65.00 Hz
		<b>FREQ DECAY RATE:</b> 0.00 Hz/s	Range: -10.00 to 10.00 Hz/s

Frequency is measured with a zero-crossing detector from the  $V_a$  voltage. This measured frequency is used for Frequency Tracking (see page *Theory of Operation* on page 2-5 for details). Both of these values will read zero if the potential across the  $V_a$  input terminals is less than 10 V. When the **FREQ DECAY RATE** is positive, the frequency is decreasing; when it is negative, the frequency is increasing.

### 6.3.5 Synchronizing Voltage









PATH: ACTUAL VALUES ▾ ▾ A2 METERING ▾ ▾ SYNCHRO VOLTAGE

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>SYNCHRONIZING VOLTAGE</b> [▷]             </div>		<b>SYNCHRO VOLTAGE:</b> 0.00 kV 0° Lag	Range: 0 to 655.35 kV, 0 to 359° Lag
	MESSAGE 	<b>SYNCHRO FREQ:</b> 0.00 Hz	Range: 0 to 65.00 Hz
	MESSAGE 	<b>SYNCHRO DELTA:</b> 0° 0.00 kV 0.00 Hz	Range: 0 to 359°, 0 to 655.35 kV, 0 to 65.00 Hz

The voltage magnitude, phase angle, frequency, and delta values for the line VT synchronizing voltage input are displayed as shown above. The **SYNCHRO FREQ** value displays the measured frequency of the line VT input; it will be zero if the potential across the line VT input terminals is less than 10.0 V. The **SYNCHRO DELTA** value displays the differences of phase position, voltage magnitude, and frequency between the line VT input and its corresponding bus VT input.

### 6.3.6 Power

PATH: ACTUAL VALUES ▾ ▾ A2 METERING ▾ ▾ POWER

<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <b>POWER</b> [▷]             </div>		<b>3Φ REAL POWER:</b> 0.0 MW	Range: -30000 to 30000 kW. See the table below for details.
	MESSAGE 	<b>3Φ REACTIVE POWER:</b> 0.0 Mvar	Range: -30000 to 30000 kvar. See the table below for details.
	MESSAGE 	<b>3Φ APPARENT POWER:</b> 0.0 MVA	Range: 0 to 30000 kVA. See the table below for details.
	MESSAGE 	<b>3Φ POWER FACTOR:</b> 0.00	Range: -0.99 to 1.00
	MESSAGE 	<b>ΦA REAL POWER:</b> 0.0 MW	Range: -30000 to 30000 kW. See the table below for details.
	MESSAGE 	<b>ΦA REACTIVE POWER:</b> 0.0 Mvar	Range: -30000 to 30000 kvar. See the table below for details.
	MESSAGE 	<b>ΦA APPARENT POWER:</b> 0.0 MVA	Range: 0 to 30000 kVA. See the table below for details.
	MESSAGE 	<b>ΦA POWER FACTOR:</b> 0.00	Range: -0.99 to 1.00

The actual values messages for three-phase and Phase A power are shown above. Similar power messages follow for Phases B and C.

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 **VT CONNECTION TYPE** setpoint "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:








$$P_N = \text{Phase CT Primary} \times \text{VT Secondary Voltage} \times \text{VT Ratio} \tag{EQ 6.12}$$

Table 6-4: Power Quantities

Nominal Power ( $P_N$ )	Power Units	Resolution
$P_N < 1 \text{ MVA}$	kW, kvar, kVA, kWhr, kvarhr	1
$1 \text{ MVA} \leq P_N < 10 \text{ MVA}$	MW, Mvar, MVA, MWhr, Mvarh	0.01
$10 \text{ MVA} \leq P_N$	MW, Mvar, MVA, MWhr, Mvarh	0.1

6.3.7 Energy

PATH: ACTUAL VALUES ▾ ▾ A2 METERING ▾ ▾ ENERGY

<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">■ ENERGY</div> <div style="border: 1px solid black; padding: 2px;">[▷]</div> </div>		<b>POSITIVE WATTHOURS:</b> 0.0 MWh	<i>Range: 0 to <math>4 \times 10^6</math> MWh. See table above for details.</i>
MESSAGE		<b>POSITIVE WATTHOUR COST: \$</b> 0	<i>Range: 0 to <math>\\$4 \times 10^9</math></i>
MESSAGE		<b>NEGATIVE WATTHOURS:</b> 0.0 MWh	<i>Range: 0 to <math>4 \times 10^6</math> MWh. See table above for details.</i>
MESSAGE		<b>NEGATIVE WATTHOUR COST: \$</b> 0	<i>Range: 0 to <math>\\$4 \times 10^9</math></i>
MESSAGE		<b>POSITIVE VARHOURS:</b> 0.0 Mvarh	<i>Range: 0 to <math>4 \times 10^6</math> Mvarh. See table above for details.</i>
MESSAGE		<b>NEGATIVE VARHOURS:</b> 0.0 Mvarh	<i>Range: 0 to <math>4 \times 10^6</math> Mvarh. See table above for details.</i>
MESSAGE		<b>ENERGY USE DATA LAST RESET: Nov 17 2003</b>	<i>Range: Date in format shown</i>

The relay uses three phase power quantities to determine total energy consumption. All energy quantities can be reset to zero with the **S1 RELAY SETUP ▾ CLEAR DATA ▾ CLEAR ENERGY USE DATA** setpoint command. Energy cost is also calculated based on the average billing rate programmed in the **S2 SYSTEM SETUP ▾ PWR SYSTEM ▾ COST OF ENERGY** setpoint. 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.

Power quantities in the positive direction are added to the positive values; power quantities in the opposite direction are added to the negative values.



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

### 6.3.8 Demand

#### Main Menu

PATH: ACTUAL VALUES ▾ ▾ A2 METERING ▾ ▾ DEMAND

■ DEMAND [▷]		■ PHASE A CURRENT [▷]	See page 6-16
MESSAGE		■ PHASE B CURRENT [▷]	See page 6-16
MESSAGE		■ PHASE C CURRENT [▷]	See page 6-16
MESSAGE		■ REAL POWER [▷]	See page 6-16
MESSAGE		■ REACTIVE POWER [▷]	See page 6-16
MESSAGE		■ APPARENT POWER [▷]	See page 6-16
MESSAGE		■ LAST RESET [▷]	See page 6-16

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 [S1 RELAY SETUP ▾ ▾ CLEAR DATA ▾ ▾ CLEAR MAX DEMAND DATA](#) setpoint command.

#### Phase A Current to Apparent Power demand

PATH: ACTUAL VALUES ▾ ▾ A2 METERING ▾ ▾ DEMAND ▾ PHASE A CURRENT(APPARENT PWR)

■ PHASE A CURRENT [▷]		LAST PHASE A CURRENT DEMAND: 0 A	Range: 0 to 65535 A
MESSAGE		MAX PHASE A CURRENT DEMAND: 0 A	Range: 0 to 65535 A
MESSAGE		LAST PHASE A CURRENT DATE: Mar 16 1997	Range: Date in format shown
MESSAGE		LAST PHASE A CURRENT TIME: 16:30:00	Range: Time in format shown

The actual values for Phase A Current Demand are shown above. The actual values displays for Phase B Current, Phase C Current, Real Power, Reactive Power, and Apparent Power Demand are similar to those above.

#### Last Reset Date

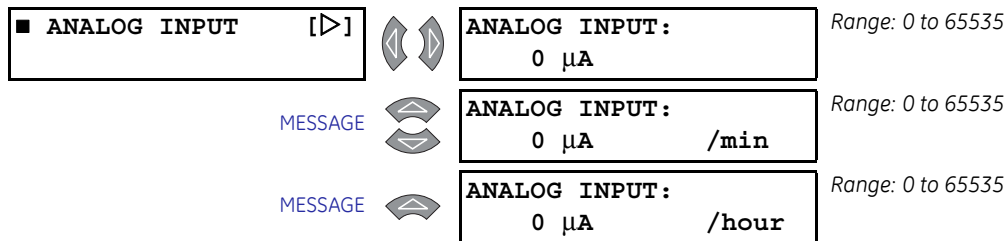
PATH: ACTUAL VALUES ▾ ▾ A2 METERING ▾ ▾ DEMAND ▾ ▾ LAST RESET DATE

■ LAST RESET [▷]		DEMAND DATA LAST RESET: Mar 16 1997	Range: Date in format shown
------------------	--	-------------------------------------	-----------------------------

This message displays the last date the maximum demand data was cleared. If the date has never been programmed, this relay will display “Unavailable”.

### 6.3.9 Analog Input

PATH: ACTUAL VALUES ▾ ▾ A2 METERING ▾ ▾ ANALOG INPUT



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










These first actual value 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 ▾ A/I NAME](#) will be displayed instead of the factory default “A/I”. The name of the units programmed in the setpoint message [S6 MONITORING ▾ ▾ ANALOG INPUT ▾ ANALOG INPUT SETUP ▾ A/I UNITS](#) will be displayed instead of the factory default “μA”.

The subsequent actual value messages display the analog input rate of change in per minutes and per hour.

## 6.4 A3 Maintenance

### 6.4.1 Trip Counters





PATH: ACTUAL VALUES ▾ ▾ A3 MAINTENANCE ▾ TRIP COUNTERS

<div style="border: 1px solid black; padding: 2px;"> <span style="font-size: 1.2em;">■</span> <b>TRIP COUNTERS</b> <span style="float: right;">[▷]</span> </div>			<b>BREAKER TRIPS:</b> 0	<i>Range: 0 to 65535</i>
MESSAGE		<b>GND OC TRIPS:</b> 0	<i>Range: 0 to 65535</i>	
MESSAGE		<b>SENSTV GND OC TRIPS:</b> 0	<i>Range: 0 to 65535</i>	
MESSAGE		<b>NEUTRAL OC TRIPS:</b> 0	<i>Range: 0 to 65535</i>	
MESSAGE		<b>NEG SEQ OC TRIPS:</b> 0	<i>Range: 0 to 65535</i>	
MESSAGE		<b>1Φ PHASE OC TRIPS:</b> 0	<i>Range: 0 to 65535</i>	
MESSAGE		<b>2Φ PHASE OC TRIPS:</b> 0	<i>Range: 0 to 65535</i>	
MESSAGE		<b>3Φ PHASE OC TRIPS:</b> 0	<i>Range: 0 to 65535</i>	
		<b>TRIP COUNTERS LAST RESET: Nov 17 2003</b>	<i>Range: Date in format shown</i>	

The total number of trips since the **TRIP COUNTERS LAST RESET** date are displayed. Trip counters are used for scheduling inspections on equipment, for performing qualitative analysis of system problems, and for spotting trends. The **BREAKER TRIPS** counter is incremented every time an open breaker status is detected. If applicable, one of the more specific trip counters available will accumulate when a Trip condition is generated. A trip condition is generated by any feature or input which signals the 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 **SI RELAY SETUP ▾ ▾ INSTALLATION ▾ ▾ RESET TRIP COUNTER DATA** setpoint.

## 6.4.2 Arcing Current


















PATH: ACTUAL VALUES ▷ ▾ A3 MAINTENANCE ▷ ▾ ARCING CURRENT

■ <b>ARCING CURRENT</b> [▷]		<b>TOTAL ARCING CURRENT</b> ΦA: 0 kA <sup>2</sup> -cycle	Range: 0 to 65535 kA <sup>2</sup> -cycle
MESSAGE		<b>TOTAL ARCING CURRENT</b> ΦB: 0 kA <sup>2</sup> -cycle	Range: 0 to 65535 kA <sup>2</sup> -cycle
MESSAGE		<b>TOTAL ARCING CURRENT</b> ΦC: 0 kA <sup>2</sup> -cycle	Range: 0 to 65535 kA <sup>2</sup> -cycle
		<b>ARCING CURRENT LAST</b> RESET: Nov 17 2003	Range: Date in format shown

The accumulated Phase A, B, and C arcing currents (in kA<sup>2</sup>-cycles) since the **ARCING CURRENT LAST RESET** date are displayed. The relay calculates an estimate of the per-phase wear on the breaker contacts. Arcing current data can be reset to zero with the **SI RELAY SETUP ▷ ▾ INSTALLATION ▷ ▾ RESET ARCING CURRENT DATA** setpoint command.

## 6.5 A4 Event Recorder

### 6.5.1 Event Records PATH: ACTUAL VALUES ▾ ▾ A4 EVENT RECORDER ▾ E001(128)

<div style="border: 1px solid black; padding: 2px;"> <span style="color: blue;">■</span> <b>E128: Nov 17/03</b> [<b>&gt;</b>]                 </div>			<b>TIME OF EVENT:</b> 16:30:00.000	<i>Range: Time in format shown</i>
MESSAGE		<b>&lt;Event_Type&gt;:</b> <b>&lt;Cause_of_Event&gt;</b>	<i>Range: See tables on pages -21 and -22.</i>	
MESSAGE		<b>PHASE A CURRENT:</b> 0 A    0° Lag	<i>Range: 0 to 65535 A, 0 to 359° Lag</i>	
MESSAGE		<b>PHASE B CURRENT:</b> 0 A    0° Lag	<i>Range: 0 to 65535 A, 0 to 359° Lag</i>	
MESSAGE		<b>PHASE C CURRENT:</b> 0 A    0° Lag	<i>Range: 0 to 65535 A, 0 to 359° Lag</i>	
MESSAGE		<b>GND CURRENT:</b> 0 A    0° Lag	<i>Range: 0 to 65535 A, 0 to 359° Lag</i>	
MESSAGE		<b>SENSTV GND CURRENT:</b> 0.00 A    0° Lag	<i>Range: 0 to 655.35 A, 0 to 359° Lag</i>	
MESSAGE		<b>LINE A-B VOLTAGE:</b> 0.00 kV    0° Lag	<i>Range: 0 to 65535 kV, 0 to 359° Lag</i>	
MESSAGE		<b>LINE B-C VOLTAGE:</b> 0.00 kV    0° Lag	<i>Range: 0 to 65535 kV, 0 to 359° Lag</i>	
MESSAGE		<b>LINE C-A VOLTAGE:</b> 0.00 kV    0° Lag	<i>Range: 0 to 65535 kV, 0 to 359° Lag</i>	
MESSAGE		<b>PHASE A-N VOLTAGE:</b> 0.00 kV    0° Lag	<i>Range: 0 to 65535 kV, 0 to 359° Lag</i>	
MESSAGE		<b>PHASE B-N VOLTAGE:</b> 0.00 kV    0° Lag	<i>Range: 0 to 65535 kV, 0 to 359° Lag</i>	
MESSAGE		<b>PHASE C-N VOLTAGE:</b> 0.00 kV    0° Lag	<i>Range: 0 to 65535 kV, 0 to 359° Lag</i>	
MESSAGE		<b>SYSTEM FREQUENCY:</b> 0.00 Hz	<i>Range: 0 to 90.00 Hz</i>	
MESSAGE		<b>SYNCHRO VOLTAGE:</b> 0.00 kV    0° Lag	<i>Range: 0 to 65535 kV, 0 to 359° Lag</i>	
MESSAGE		<b>SYNCHRO FREQUENCY:</b> 0.00 Hz	<i>Range: 0 to 90.00 Hz</i>	
		<b>ANALOG INPUT:</b> 0 μA	<i>Range: 0 to 65535 Analog Input Units</i>	

The 750/760 has an event recorder which runs continuously, capturing and storing the last 512 events. All event recorder information is stored in non-volatile memory so the information is maintained after losing relay control power. The last 512 events are displayed from newest to oldest event. Each event has a header message containing 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 **SI RELAY SETUP** ▸ ▽ **CLEAR DATA** ▸ ▽ **CLEAR EVENT RECORDER DATA** setpoint.

Event information is gathered at the instant the event occurs; as such, 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 AN, BN, and CN are only displayed if **VT CONNECTION TYPE** is programmed to "Wye". If **VT CONNECTION TYPE** is programmed to "Delta", line voltages AB, BC, and CA are displayed.

Events are organized into several different types as shown in the table below. Several event types can be filtered out in order to save space in the event recorder (see *Event Recorder* on page 5-14 for additional details on event filtering). For every event type there are a number of possible causes. The Cause of Events table lists all the event causes according to which event types they can generate.

The following symbols are used in the description of the event messages: **<Φ>** represents the phases involved (e.g. ΦBC) in the event if applicable and **<ON>** represents whether the logic input is asserted (ON) or not asserted (OFF)

**Table 6-5: Event Types**

<b>Event Type</b>	<b>Display</b>	<b>Description</b>
General Events	None	Events that occur when a specific operation takes place
Pickup Events	<b>PICKUP:</b> <Φ>	These are events that occur when a protection element picks up and starts timing
Trip Events	<b>TRIP:</b> <Φ>	These are events that occur when an element whose function has been programmed to "Trip" or "Trip & AR" operates.
Alarm Events	<b>ALARM:</b> <Φ>	These are events that occur when an element whose function has been programmed to "Alarm" operates or drops out.
Latched Alarm Events	<b>LATCHED ALARM:</b> <Φ>	These are events that occur when an element whose function has been programmed to "Latched Alarm" operates or drops out.
Control Events	<b>CONTROL:</b> <Φ>	These are events that occur when an element whose function has been programmed to "Control" operates or drops out.
Dropout Events	<b>DROPOUT:</b>	These are events that occur when a protection element drops out after a corresponding pickup event.
Contact Events	<b>INPUT C &lt;ON&gt;:</b>	These are events that occur when a contact input is either asserted or de-asserted.

**Table 6-5: Event Types**

Event Type	Display	Description
Virtual Input Events	<b>INPUT V &lt;ON&gt; :</b>	These are events that occur when a virtual input is either asserted or de-asserted.
Contact and Virtual Input Events	<b>INPUT CV &lt;ON&gt; :</b>	These are events that occur when both a contact input and virtual input is either asserted or de-asserted.
Self-Test Warning Events	<b>SELF-TEST WARNING :</b>	These are events that occur when a self-test warning is detected or one of the manual testing

The event causes are listed alphabetically by type of event in the following table.

**Table 6-6: Cause of Events**

General Event Causes				
Autoreclose Reset	Breaker Closed	Breaker Not Connected	Breaker Open	Clear Energy Use
Clear Event Record	Clear Max Demand	Close Breaker	Clis From Transfer	Control Power Off
Control Power On	Group 1 to 4 Active	Open Breaker	Reclosure 1 to 4	Reclosure Lockout
Reset	Reset AR Count	Reset AR Shot Rate	Reset Arc Current	Reset Trip Counter
Set Date	Set Time	Shots Reduced to 1(3)	Shots Reduced to L/ O	Transfer Initiated
Transfer Not Ready	Trigger Data Log	Trigger Trace	Trip From Transfer	
Pickup, Trip, Alarm, Latched Alarm, and Control Event Causes				
Analog Rate 1 to 2	Analog Threshold 1/ 2	Apparent Power Demand	Arcing Current	Autoreclose Rate
Breaker Failure	Breaker Operation	Bus Undervoltage 1 to 2	Close Coil Monitor <sup>1</sup>	Cold Load P/U Block
Current Demand	Frequency Decay	Ground Dir Reverse	Ground Inst OC	Ground Time OC
Line Undervoltage 3 to 4	Manual Close Block	Neg Seq Dir Reverse	Neg Seq Inst OC	Neg Seq Time OC
Neg Seq Voltage	Neutral Current Level	Neutral Dir Reverse	Neutral Displacement	Neutral Inst OC 1/2
Neutral Time OC 1/ 2	Out of Sync	Overfrequency	Overvoltage 1 and 2	Phase Current Level

<sup>1</sup> The coil monitor name as programmed is displayed.

<sup>2</sup> The pulse output quantity name as programmed is displayed.

<sup>3</sup> For User Inputs A through T, the user-defined name is displayed

Table 6-6: Cause of Events

General Event Causes				
Phase Dir Reverse	Phase Inst OC 1 and 2	Phase Time OC 1	Phase Time OC 2	Power Factor 1
Power Factor 2	Pulse Output <sup>2</sup>	Reactive Power Demand	Real Power Demand	Sens Gnd Dir Reverse
Sensv Gnd Time OC	Sensv Gnd Inst OC	Trip Coil Monitor	Trip Counter	UFreq Restore Init
Underfrequency 1	Underfrequency 2	User Input A to T <sup>3</sup>	UVolt Restore Init	VT Failure
Logic Input Event Causes				
52a Contact	52b Contact	Block 1 Trip	Block 2 Close	Block All OC
Block Freq Decay	Block Gnd Inst OC	Block Gnd Time OC	Block Ground OC	Block Neg Seq Inst
Block Neg Seq Time	Block Neg Seq Volt	Block Neutral Disp	Block Neutral Inst OC 1	Block Neutral Inst OC 2
Block Neutral OC	Block Neutral Time OC 1	Block Neutral Time OC 2	Block Phase Inst OC 1	Block Phase Inst OC 2
Block Phase OC	Block Phase Time OC 1	Block Phase Time OC 2	Block Reclosure	Block Reset
Block Restoration	Block Sens Gnd Inst OC	Block Sens Gnd OC	Block Sens Gnd Time OC	Block Transfer
Block Trip Count	Block Undervolt 1 to 4	Block Underfreq 1 and 2	Breaker Connected	Bus Tie Closed
Bus Tie Connected	Bypass Synchrocheck	Cancel Reclosure	Cls From Incomer 1	Cls From Incomer 2
Cold Load Pickup	Incomer 1 Closed	Incomer 2 Closed	Initiate Reclosure	Local Mode
Remote Close	Remote Open	Remote Reset	Selected To Trip	Setpoint Group 2
Setpoint Group 3	Setpoint Group 4	Simulate Fault	Source Trip	Start Demand Interval
Trigger Data Log	Trigger Trace	User Input A to T <sup>3</sup>	UV On Other Source	Xfmr Lockout
Warning Event Causes				
A/D Virtual Ground	Analog Output +32V	Clock Not Set	Dry Contact +32V	EEPROM Corrupt
Factory Service	FLASH Corrupt	Force Analog Out	Force Relays	Internal RS485
Internal Temp	IRIG-B Failure	Not Calibrated	Pickup Test	Prototype Software

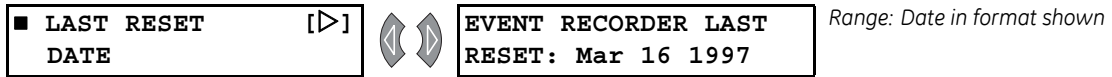
<sup>1</sup> The coil monitor name as programmed is displayed.

<sup>2</sup> The pulse output quantity name as programmed is displayed.

<sup>3</sup> For User Inputs A through T, the user-defined name is displayed

### 6.5.2 Last Reset Date

PATH: ACTUAL VALUES ▾ ▾ A4 EVENT RECORDER ▾ ▾ LAST RESET DATE







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

## 6.6 A5 Product Info

### 6.6.1 Technical Support









PATH: ACTUAL VALUES ▾ ▾ A5 PRODUCT INFO ▾ TECHNICAL SUPPORT

<b>■ TECHNICAL SUPPORT</b> [ <b>▷</b> ]		<b>GE Grid Solutions 650 Markland Street</b>	<i>Range: The address for GE Grid Solutions is indicated here.</i>
	MESSAGE 	<b>Markham, Ontario Canada, L6C 0M1</b>	
	MESSAGE 	<b>Tel: +1 905 927 7070 Fax: +1 905 927 5098</b>	<i>Range: Telephone and fax numbers for GE Grid Solutions are shown.</i>
		<b>Internet Address: www.gegridsolutions.com</b>	<i>Range: The GE Grid Solutions web page address is indicated here.</i>

This page has information on where to obtain technical support for your relay.

### 6.6.2 Revision Codes


PATH: ACTUAL VALUES ▾ ▾ A5 PRODUCT INFO ▾ REVISION CODES

<b>■ REVISION CODES</b> [ <b>▷</b> ]		<b>GE Grid Solutions 750 REVISION 7.00</b>	<i>Range: The product name and software revision are indicated.</i>
	MESSAGE 	<b>HARDWARE REVISION: K</b>	<i>Range: Hardware revision of the relay.</i>
	MESSAGE 	<b>SOFTWARE REVISION: 700</b>	<i>Range: Displays the software revision of the relay.</i>
	MESSAGE 	<b>VERSION NUMBER: 000</b>	<i>Range: Displays the version number and any relay modifications</i>
	MESSAGE 	<b>ORDER CODE: 760- P5-G5-S5-HI-A20-R-E</b>	<i>Range: Displays the relay order code and installed options.</i>
	MESSAGE 	<b>BOOTWARE REVISION: 500</b>	<i>Range: Displays the relay's boot software revision</i>
	MESSAGE 	<b>SERIAL NUMBER: A2831234</b>	<i>Range: Displays the serial number of the relay.</i>
		<b>MANUFACTURING DATE: Nov 17 2004</b>	<i>Range: Displays the manufacture date in the format shown.</i>

This page specifies hardware revision and configuration, software revision, and serial number. This information is primarily intended for GE Grid Solutions service personnel.

### 6.6.3 Calibration Dates

PATH: ACTUAL VALUES ▾ ▾ A5 PRODUCT INFO ▾ ▾ CALIBRATION DATES

<p>■ CALIBRATION DATES [▶]</p>		<p>FACTORY CALIBRATION DATE: Nov 17 2004</p>	<p><i>Range: Displays the initial calibration date in the format shown.</i></p>
		<p>LAST CALIBRATION DATE: Nov 17 2004</p>	<p><i>Range: Displays the last calibration date in the format shown.</i></p>

This information is primarily intended for GE Multilin service personnel.



# 750/760 Feeder Management Relay

## Chapter 7: Commissioning

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### 7.1 Overview

#### 7.1.1 Safety Precautions

Pay special attention to all the safety precautions listed below.



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



Dangerously high voltages are present on the rear terminals of the relay. The voltages are capable of causing **DEATH** or **SERIOUS INJURY**. Use extreme caution and follow all safety rules when handling, testing, or adjusting the equipment.



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.



The relay uses components that are sensitive to electrostatic discharges. When handling the unit, care must be taken to avoid contact with terminals at the rear of the relay.



Ensure that the control power applied to the relay, and the AC current and voltage input, match the ratings specified on the relay nameplate. Do not apply current to the CT inputs in excess of the Time  $\times$  Current specified limits.



Ensure that the Logic Input wet contacts are connected to voltages less than the maximum voltage specification of 300 V DC.

### 7.1.2 Requirements

The following procedures can be used to verify the proper operation of the 750/760 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 which provides important information about wiring, mounting, and safety concerns. One should also become familiar with the relay as described in Chapters 2 and 5.

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 considered for the measurement of parameters and the operation of features 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”, “Alarm”, or “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 *Placing the Relay In Service* on page 7–92 be performed for all installations to verify proper operation and function of the equipment.

### 7.1.3 Conventions

The following conventions are used for the remainder of this chapter:

- It is assumed the VT and CT inputs are wired in accordance with the *Typical Wiring Diagram* on page 3–10. With these connections, and assumed where phase angles are noted, a unity power factor current in the primary circuit flows into the relay marked terminal, with no phase shift with respect to the corresponding phase-neutral voltage.
- The phase rotation of the relay test set is ABC.
- A current that 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 FIGURE 6–3: *Power Quantity Relationships* on page 6–10.
- 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 the relative location of a particular message with regards to its parent messages. 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**.

#### 7.1.4 Test Equipment

Excluding data acquisition testing, tests may be performed using the simulation feature, eliminating the need of external AC voltage and current inputs. System parameters, such as current and voltage 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 that 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 simulation is that all metering calculations can be verified without the inaccuracies associated with current and voltage sources.

If simulation is not used, the following equipment is necessary to perform any test included in this chapter:

##### General Purpose:

- Three-phase variable AC current and voltage source (V, A, phase, Hz).
- Three-phase power multimeter (V, A, phase, Hz, W, var, VA, Wh, varh, PF).
- Variable DC mA source.
- An accurate timing device and 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 durations from 1 minute to 2 hours, and from 0 to 20 mA.

##### Optional:

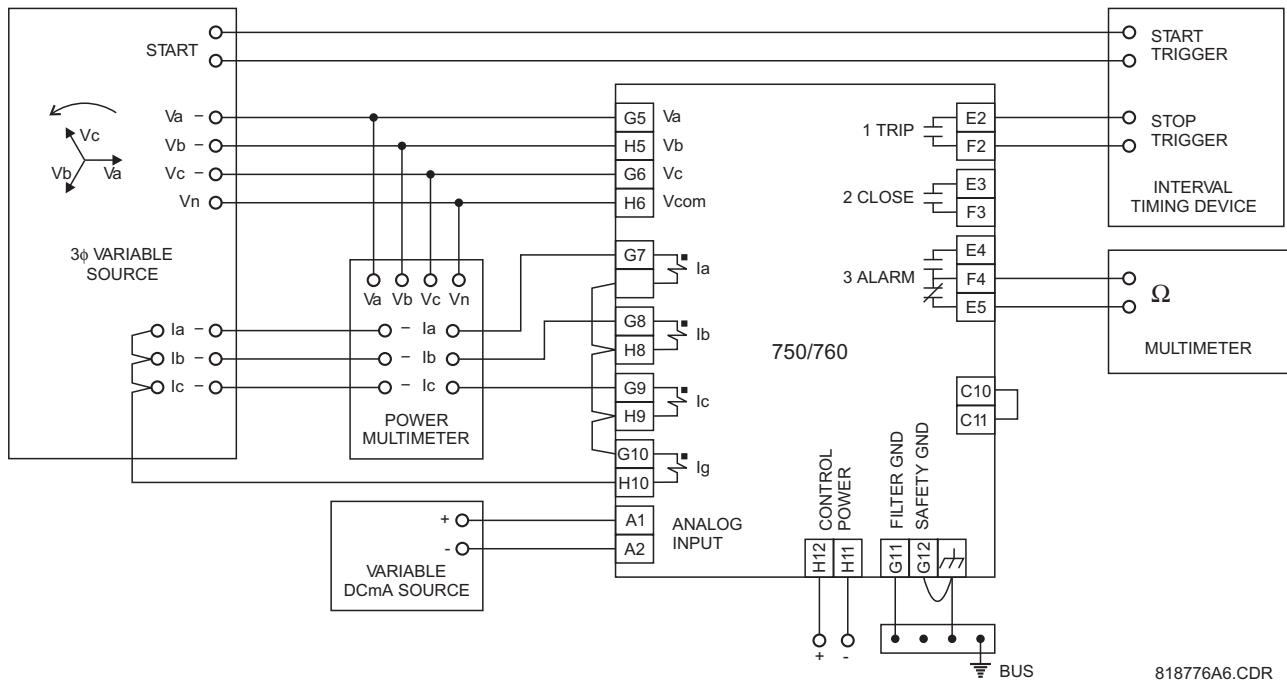
- PC running the EnerVista 750/760 Setup software.

### 7.1.5 Installation Checks

- ▷ Check the relay phase current inputs, specified on the nameplate, are correct for the connected current transformers.
- ▷ Check the relay ground current input, specified on the nameplate, is correct for the connected CT (if applicable).
- ▷ Check that the relay auxiliary voltage, specified on the nameplate, is correct for the supplied voltage.
- ▷ Check that the installed relay agrees with the drawings, particularly the Analog Output range.
- ▷ Check that the external wiring is correct.
- ▷ Check that all grounding terminals of the relay are properly connected to the ground bus.

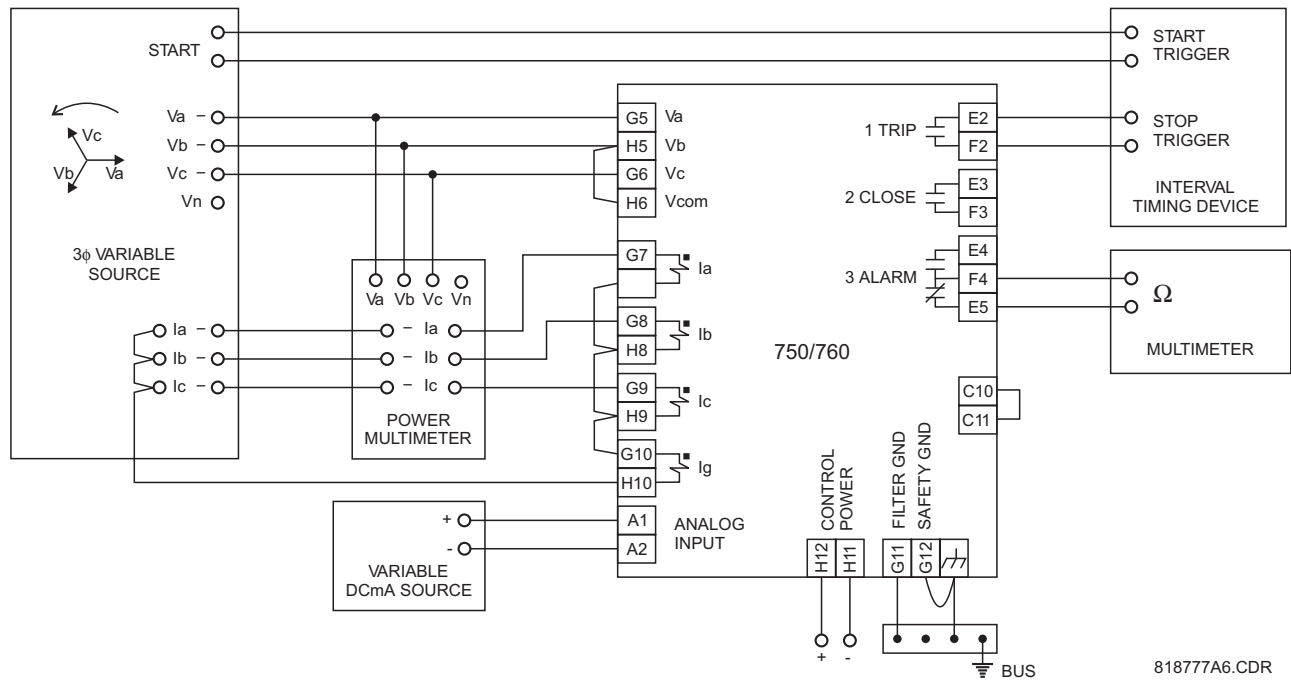
### 7.1.6 Wiring Diagrams

The relay test wiring for both “Delta” and “Wye” connections are shown below.



818776A6.CDR

FIGURE 7-1: Relay Test Wiring – Wye Connection



818777A6.CDR

FIGURE 7-2: Relay Test Wiring – Delta Connection

## 7.2 Inputs/Outputs

### 7.2.1 Logic / Virtual Inputs 1 to 14

#### Actual Values Display

For these first tests, the **INPUT 1 (14) ASSERTED LOGIC** setpoints should be programmed as "Closed | Von". Under the **A1 STATUS** ▾ ▾ **VIRTUAL INPUTS** ▾ **LOGIC INPUT 1 (14)** subheading,

- ▷ Turn on this input and check that the display shows this state.
- ▷ Turn off this input and check that the display shows this state.

Under the **A1 STATUS** ▾ ▾ **HARDWARE INPUTS** ▾ **CONTACT 1 (14) STATE** subheading:

- ▷ Close the contact connected to this input and check that the display shows this state.
- ▷ Open the contact connected to this input and check that the display shows this state.

#### User Input A Setpoint set to "Alarm"

- ▷ Set all inputs 1 through 14, both contact and virtual, to the de-asserted state.
- ▷ 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"

1. For **INPUT ASSERTED LOGIC** setpoints set to "Contact Close",
  - ▷ Check that there is no logic input diagnostic message on the display.
  - ▷ 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.
  - ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
  - ▷ 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.
  - ▷ Check that the diagnostic message is removed from the display with the Auxiliary LED and relay deactivated.
  - ▷ Repeat the last 3 steps for all functions programmed to be asserted by a Contact Close input.
2. For **INPUT ASSERTED LOGIC** setpoints set to "Contact Open":
  - ▷ Check that there is no logic input diagnostic message on the display.

- ▷ Set the monitored contact for the logic input programmed in the **USER INPUT A SOURCE** setpoint to the open state.  
Note that the corresponding virtual input will have no affect.
  - ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
  - ▷ 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.
  - ▷ Check that the diagnostic message is removed from the display with the Auxiliary LED and relay deactivated.
  - ▷ Repeat the last 3 steps for all functions programmed to be asserted by a Contact Open input.
3. For **INPUT ASSERTED LOGIC** setpoints set to "Virtual On":
- ▷ Check that there is no logic input diagnostic message on the display.
  - ▷ 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.
  - ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
  - ▷ 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.
  - ▷ Check that the diagnostic message is removed from the display with the Auxiliary LED and relay deactivated.
  - ▷ Repeat last 3 steps for all functions programmed to be asserted by a Virtual On input.
4. For **INPUT ASSERTED LOGIC** setpoints set to "Virtual Off":
- ▷ Check that there is no logic input diagnostic message on the display.
  - ▷ 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.
  - ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.

- ▷ 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 effect.
  - ▷ Check that the diagnostic message is removed from the display with the Auxiliary LED and relay deactivated.
  - ▷ Repeat the last 3 steps for all functions programmed to be asserted by a Virtual Off input.
5. For **INPUT ASSERTED LOGIC** setpoints set to "Closed & Von":
- ▷ Check that there is no logic input diagnostic message on the display.
  - ▷ 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.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ 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 **USER INPUT A NAME**, appears on the display with the Auxiliary LED and relay activated.  
Check the event recorder that the selected function has been invoked.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ Repeat last 3 steps for all functions programmed to be asserted by a "Closed & Von" input.
6. For **INPUT ASSERTED LOGIC** setpoints set to "Closed & Voff":
- ▷ Check that there is no logic input diagnostic message on the display.
  - ▷ 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.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ 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 Auxiliary LED and relay activated.

Check in the Event Recorder that the selected function has been invoked.

- ▷ 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 Auxiliary LED and relay deactivated.
- ▷ Repeat last 3 steps for all functions programmed to be asserted by a Closed & Voff input.

7. For **INPUT ASSERTED LOGIC** setpoints set to "Open & Von":

- ▷ Check that there is no logic input diagnostic message on the display.
- ▷ 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 Auxiliary LED and relay deactivated.
- ▷ 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 Auxiliary LED and relay deactivated.
- ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
- ▷ 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 Auxiliary LED and relay deactivated.
- ▷ Repeat last 3 steps for all functions programmed to be asserted by a Open & Von input.

8. For **INPUT ASSERTED LOGIC** setpoints set to "Open & Voff":

- ▷ Check that there is no logic input diagnostic message on the display.
- ▷ 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.
- ▷ 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 Auxiliary LED and relay deactivated.

- ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ Repeat steps 10.3 through 10.5 for all functions programmed to be asserted by a Open & Voff input.
9. For **INPUT ASSERTED LOGIC** setpoints set to "Closed | Von":
- ▷ Check that there is no logic input diagnostic message on the display.
  - ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
  - ▷ Leave the monitored contact in the closed state and put the virtual input in the on state.  
Check that the diagnostic message, the Auxiliary LED and relay remain activated.
  - ▷ Set the monitored contact to the open state and leave the virtual input in the on state.  
Check that the diagnostic message, the Auxiliary LED and relay remain activated.
  - ▷ 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.
  - ▷ Repeat last 3 steps for all functions programmed to be asserted by a Closed | Von input.
10. For **INPUT ASSERTED LOGIC** setpoints set to "Closed | Voff":
- ▷ Check that there is no logic input diagnostic message on the display.
  - ▷ 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 Auxiliary LED and relay activated.

Check in the Event Recorder that the selected function has been invoked.

- ▷ Leave the monitored contact in the closed state and put the virtual input in the off state.  
Check that the diagnostic message, the Auxiliary LED and relay remain activated.
- ▷ Set the monitored contact to the open state and leave the virtual input in the off state.  
Check that the diagnostic message, the Auxiliary LED and relay remain activated.
- ▷ 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 Auxiliary LED and relay deactivated.
- ▷ Repeat last 3 steps for all functions programmed to be asserted by a Closed | Voff input.

11. For **INPUT ASSERTED LOGIC** setpoints set to "Open | Von":

- ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
- ▷ Leave the monitored contact in the open state and put the virtual input in the on state.  
Check that the diagnostic message, the Auxiliary LED and relay remain activated.
- ▷ Set the monitored contact to the closed state and leave the virtual input in the on state.  
Check that the diagnostic message, the Auxiliary LED and relay remain activated.
- ▷ 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 Auxiliary LED and relay deactivated.
- ▷ Repeat last 3 steps for all functions programmed to be asserted by a Open | Von input.

12. For **INPUT ASSERTED LOGIC** setpoints set to "Open | Voff":

- ▷ Check that there is no logic input diagnostic message on the display.
- ▷ 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 Auxiliary LED and relay activated.

Check in the Event Recorder that the selected function has been invoked.

- ▷ Leave the monitored contact in the open state and put the virtual input in the off state.  
Check that the diagnostic message, the Auxiliary LED and relay remain activated.
- ▷ Set the monitored contact to the closed state and leave the virtual input in the off state.  
Check that the diagnostic message, the Auxiliary LED and relay remain activated.
- ▷ 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 Auxiliary LED and relay deactivated.
- ▷ Repeat last 3 steps for all functions programmed to be asserted by a Open| Voff input.

13. For **INPUT ASSERTED LOGIC** setpoints set to "Closed X Von":

- ▷ Check that there is no logic input diagnostic message on the display.
- ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
- ▷ 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 Auxiliary LED and relay deactivated.
- ▷ 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 Auxiliary LED and relay activated.
- ▷ 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 Auxiliary LED and relay deactivated.
- ▷ Repeat last 3 steps for all functions programmed to be asserted by a Closed X Von input.

14. For **INPUT ASSERTED LOGIC** setpoints set to "Closed X Voff":

- ▷ Check that there is no logic input diagnostic message on the display.

- ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ 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 Auxiliary LED and relay activated.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ Repeat last 3 steps for all functions programmed to be asserted by a Closed X Voff input.
15. For **INPUT ASSERTED LOGIC** setpoints set to Open X Von:
- ▷ Check that there is no logic input diagnostic message on the display.
  - ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ 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 Auxiliary LED and relay activated.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ Repeat last 3 steps for all functions programmed to be asserted by a Open X Von input.

16. For **INPUT ASSERTED LOGIC** setpoints set to "Open X Voff":
- ▷ Check that there is no logic input diagnostic message on the display.
  - ▷ 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 Auxiliary LED and relay activated.  
Check in the Event Recorder that the selected function has been invoked.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ 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 Auxiliary LED and relay activated.
  - ▷ 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 Auxiliary LED and relay deactivated.
  - ▷ Repeat last 3 steps for all functions programmed to be asserted by a Open X Voff input.

### User Input A Function 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.

### User Input A Function 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 Trip Relay and LED will activate along with the 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 LED.

## 7.2.2 Virtual Inputs 15 to 20

Follow the Virtual On and Virtual Off Input Asserted Logic procedures outlined for Logic/Virtual Inputs 1 to 14 in the previous section.

## 7.2.3 Output Relays

- ▷ Enter the following settings under the **S8 TESTING** ▷ ▽ **OUTPUT RELAYS** subheading:

**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"

- ▷ Using a multimeter, check that all output relays are de-energized (i.e. N.O. contacts open, N.C. contacts closed).
- ▷ Make the following setting change: **S8 TESTING ▷ OUTPUT RELAYS ▷ FORCE 1 TRIP RELAY:** "Energized".
- ▷ Check that the Trip output is energized (i.e. N.O. contacts closed), and the Trip LED is illuminated.
- ▷ Make the following setting change: **S8 TESTING ▷ OUTPUT RELAYS ▷ FORCE 1 TRIP RELAY:** "De-energized".
- ▷ Repeat Steps 3 through 5 for Output Relays 2 through 8 inclusive.
- ▷ Observing polarity, connect a minimum 5 V DC source 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.
- ▷ Change setting to: **S8 TESTING ▷ OUTPUT RELAYS ▷ FORCE SOLID STATE OUTPUT:** "Energized".
- ▷ Check that a voltage has appeared on the voltmeter.  
Turn off the source and disconnect the test wiring.
- ▷ Change setting to: **S8 TESTING ▷ OUTPUT RELAYS ▷ FORCE SOLID STATE OUTPUT:** "De-energized".
- ▷ Change setting to: **S8 TESTING ▷ OUTPUT RELAYS ▷ FORCE OUTPUT RELAYS FUNCTION:** "Disabled".

## 7.3 Metering

### 7.3.1 Current Metering

#### Phase Current Inputs

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

For 1 A CTs:  $\pm 0.01$  A for 0.01 to 1.99 A;  $\pm 0.2$  A for 2.00 to 20.00 A

For 5 A CTs:  $\pm 0.05$  A for 0.05 to 9.99 A;  $\pm 1.0$  A for 10.00 to 100.00 A

#### Use the following procedure to test Phase and Neutral Current Inputs:

The relevant actual values displays are located under subheading **A2 METERING**  $\triangleright$  **CURRENT** and are:

**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)

- $\triangleright$  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.
- $\triangleright$  Inject 3-phase current of various values and angles into the relay phase current input and note the measured current phasors and symmetrical components.

#### Use the following procedure for Ground and Sensitive Ground Current Inputs:

The relevant actual values displays are located under subheading **A2 METERING**  $\triangleright$  **CURRENT** as follows:

**GND CURRENT:** (Phasor)  
**SENSV GND CURRENT:** (Phasor)

- $\triangleright$  Inject current of various values into the relay ground input, Terminals G10–H10, and note the current.
- $\triangleright$  Inject current of various values into the relay sensitive ground input, Terminals G3–H3, and note the current.

#### Percent of Load-to-Trip

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

Expected Accuracy: equivalent to that of phase current inputs

**The relevant actual values displays are shown below:**

**A2 METERING ▷ CURRENT ▷ % OF LOAD-TO-TRIP**

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”.

- ▷ Inject current of various values into Phase A.
- ▷ Verify that percent load-to-trip is calculated as the correct percentage of the most sensitive operational Phase Overcurrent element and displayed.
- ▷ Repeat for phases B and C.

### 7.3.2 Voltage Metering

#### Bus Voltage

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

- Phase-neutral voltages:  $\pm 0.68$  V for 50 to 130 V;  $\pm 2.18$  V for other voltages within specified limits
- Phase-phase voltages ( $V_{ab}$  and  $V_{cb}$ ):  $\pm 0.68$  V for 50 to 130 V;  $\pm 2.18$  V for all other voltages within the specified limits.
- Phase-phase voltages (calculated  $V_{ac}$ ):  $\pm 1.36$  V for 50 to 130 V;  $\pm 4.36$  V for other voltages within the specified limits.

The procedure for testing the metered bus voltage is as follows:

**The relevant actual values displays are located under subheading**

**A2 METERING ▷ VOLTAGE and are:**

**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)

- ▷ 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  $\sqrt{3}$  of the line voltage magnitude.

- ▷ 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.

### Bus Voltage Frequency

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

Frequency:  $\pm 0.02$  Hz of injected value within the range 16.00 to 90.00 Hz  
Undervoltage Inhibit: 10 V secondary

The procedure for testing the metered bus voltage frequency is as follows:

**The relevant actual values display is located as follows:**

**A2 METERING ▷ FREQ ▷ SYSTEM FREQ.**

- ▷ Inject a voltage of nominal value at nominal frequency into Phase A. Check that the frequency is measured and displayed.
- ▷ Check the undervoltage inhibit level by slowly reducing the voltage until the frequency is no longer measured, and “0.00 Hz” is displayed.
- ▷ Return the voltage to nominal. Adjust the frequency above and below nominal, and note the frequency measured by the relay.

The procedure for testing the metered frequency decay rate is as follows:

**The relevant actual values display is located as follows:**

**A2 METERING ▷ FREQ ▷ FREQ DECAY RATE**

- ▷ Vary the frequency of the phase A voltage and verify the measured frequency decay rate.

### Synchro Voltage and Frequency

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

Voltage:  $\pm 0.68$  V for 50 to 130 V  
Frequency:  $\pm 0.02$  Hz of injected value within the range 16.00 to 90.00 Hz

The procedure for testing the metered synchro voltage and frequency is as follows:

**The relevant actual values displays are located under subheading**

**A2 METERING ⇄ SYNCHRO VOLTAGE and are:**

**SYNCHRO VOLTAGE:** (Phasor)

**SYNCHRO FREQ:**

**SYNCHRO DELTA DF: DV: DF:**

- ▷ Inject voltage of various magnitudes and frequencies into the line voltage input and verify the displays.

## 7.3.3 Power Metering

### Real Power and Watthours

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:



Real Power:  $\pm 1\%$  of full scale at currents 5 to 199% of nominal and voltages from 50 to 130 V

Watt-hours:  $\pm 2\%$  of full scale at currents 5 to 199% of nominal and voltages from 50 to 130 V

The procedure for testing the metered real power and watt-hours is as follows.

**The relevant actual values displays are located as shown below:**

**A2 METERING ▷ PWR ▷ 3Φ REAL PWR:**

**A2 METERING ▷ PWR ▷ ΦA REAL PWR:** (not available when connected Delta)

**A2 METERING ▷ PWR ▷ ΦB REAL PWR:** (not available when connected Delta)

**A2 METERING ▷ PWR ▷ ΦC REAL PWR:** (not available when connected Delta)

**A2 METERING ▷ ENERGY ▷ POSITIVE WATTHOURS:**

**A2 METERING ▷ ENERGY ▷ NEGATIVE WATTHOURS:**

- ▷ To reduce the time required for watt-hour 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.
- ▷ Maintain voltage and current at various settings for a time sufficient to achieve a minimum of 20 MWh for each test interval.
- ▷ Check that watt-hours is measured and displayed.
- ▷ Note that watt-hours for load in the positive direction and negative directions are stored in separate registers.
- ▷ The procedure should be performed for loads in each direction.

### Reactive Power and Varhours

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

- Reactive Power:  $\pm 1\%$  of full scale, currents 5 to 199% of nominal, voltages 50 to 130 V
- Varhours:  $\pm 2\%$  of full scale, currents 5 to 199% of nominal, voltages 50 to 130 V

The procedure for metered reactive power and energy is as follows:

The relevant actual values displays are shown below:

**A2 METERING ▷ PWR ▷ 3Φ REACTIVE PWR:**

**A2 METERING ▷ PWR ▷ ΦA REACTIVE PWR:** (not available when connected Delta)

**A2 METERING ▷ PWR ▷ ΦB REACTIVE PWR:** (not available when connected Delta)

**A2 METERING ▷ PWR ▷ ΦC REACTIVE PWR:** (not available when connected Delta)

**A2 METERING ▷ ENERGY ▷ POSITIVE VARHOURS:**

**A2 METERING ▷ ENERGY ▷ NEGATIVE VARHOURS:**

- ▷ To reduce the time required for varhour 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 reactive power is measured and displayed.
- ▷ Maintain voltage and current at various settings for a time sufficient to achieve a minimum of 20 Mvarh for each test interval.
- ▷ Check that varhours are measured and displayed.
- ▷ Note that varhours for load in the positive direction and negative directions are stored in separate registers.
- ▷ The procedure should be performed for loads in each direction.

### Apparent Power

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

Apparent Power:  $\pm 1\%$  of full scale, currents 5 to 199% of nominal, voltages 50 to 130 V

The procedure for metered apparent power is as follows:

The relevant actual values displays are shown below:

**A2 METERING ▷ PWR ▷ 3Φ APPARENT PWR:**

**A2 METERING ▷ PWR ▷ ΦA APPARENT PWR:** (not available when connected Delta)

**A2 METERING ▷ PWR ▷ ΦB APPARENT PWR:** (not available when connected Delta)

**A2 METERING ▷ PWR ▷ ΦC APPARENT PWR:** (not available when connected Delta)

- ▷ Inject 3-phase voltage and current of various values and angles into the relay. Note that reactive power is measured and displayed.

### Power Factor

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

Power Factor:  $\pm 0.02$  of injected values, currents 5 to 199% of nominal, voltages 50 to 130 V

The procedure for metered apparent power is as follows:

The relevant actual values displays are shown below:

**A2 METERING ▷ PWR ▷ 3Φ PWR FACTOR:**

**A2 METERING ▷ PWR ▷ ΦA PWR FACTOR:** (not available when connected Delta)

**A2 METERING ▷ PWR ▷ ΦB PWR FACTOR:** (not available when connected Delta)

**A2 METERING ▷ PWR ▷ ΦC PWR FACTOR:** (not available when connected Delta)

- ▷ Inject 3-phase voltage and current of various values and angles into the relay.

Verify that the power factor is measured and displayed correctly for each phase. Note that:

$$\text{3-phase PF} = \frac{\text{total 3-phase real power}}{\text{total 3-phase apparent power}} \quad \text{(EQ 7.1)}$$

### 7.3.4 Demand Metering

#### Current Demand

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

Expected Accuracy: ±2.0% of full scale

To reset the “Last Demand” reading to 0 between tests, cycle the relay power source off and then 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 EnerVista 750/760 Setup software) 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.

The relevant actual values displays are shown below:

**A2 METERING ▷ DMND ▷ PHASE A CURRENT ▷ LAST PHASE A CURRENT DMND**

**A2 METERING ▷ DMND ▷ PHASE A CURRENT ▷ MAX PHASE A CURRENT DMND**

**A2 METERING ▷ DMND ▷ PHASE A CURRENT ▷ MAX PHASE A CURRENT DATE**

**A2 METERING ▷ DMND ▷ PHASE A CURRENT ▷ MAX PHASE A CURRENT TIME**

**A2 METERING ▷ DMND ▷ PHASE B CURRENT ▷ LAST PHASE B CURRENT DMND**

**A2 METERING ▷ DMND ▷ PHASE B CURRENT ▷ MAX PHASE B CURRENT DMND**

**A2 METERING ▷ DMND ▷ PHASE B CURRENT ▷ MAX PHASE B CURRENT DATE**

**A2 METERING ▷ DMND ▷ PHASE B CURRENT ▷ MAX PHASE B CURRENT TIME**

**A2 METERING ▷ DMND ▷ PHASE C CURRENT ▷ LAST PHASE C CURRENT DMND**

**A2 METERING ▷ DMND ▷ PHASE C CURRENT ▷ MAX PHASE C CURRENT DMND**

**A2 METERING ▷ DMND ▷ PHASE B CURRENT ▷ MAX PHASE C CURRENT DATE**

**A2 METERING ▷ DMND ▷ PHASE B CURRENT ▷ MAX PHASE C CURRENT TIME**

For Thermal Exponential Demand (for example, a response time setting of 5 minutes), the procedure is as follows:

- ▷ Clear demand data registers by setting **S1 RELAY SETUP ▷ CLEAR DATA ▷ CLEAR MAX DMND DATA** to “Yes”.

- ▷ Inject a fixed value of current into Phase A.  
Record the measured current demand at 1, 2, 3, 4, 5 and 10 minutes 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

- ▷ For other response time settings, multiply the Row 1 times above by [selected response time / 5].
- ▷ Check that the maximum current demand, including date and time of occurrence, is recorded and displayed.
- ▷ Repeat last 3 steps for Phases B and C.

For Block Interval Demand (for example, a time interval setting of 5 minutes), the procedure is as follows:

- ▷ Repeat last 4 steps above.
- ▷ Record the measured current demand at 1, 2, 3, 4, 5 and 6 minutes 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

For Rolling Demand (for example, a time interval setting of 5 minutes), the procedure is as follows:

- ▷ Repeat Steps 2 to 5 above from Thermal Exponential Demand above.
- ▷ Record the measured current demand at 1, 2, 3, 4, 5 and 6 minutes 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

### Real Power Demand

For these tests, refer to the figures in section 7.1.6 for test connections. The expected accuracy is as follows:

Expected Accuracy: ±2.0% of full scale

The relevant actual values displays are shown below:

- A2 METERING ▷ DMND ▷ REAL PWR ▷ LAST REAL PWR DMND
- A2 METERING ▷ DMND ▷ REAL PWR ▷ MAX REAL PWR DMND
- A2 METERING ▷ DMND ▷ REAL PWR ▷ MAX REAL PWR DATE
- A2 METERING ▷ DMND ▷ REAL PWR ▷ MAX REAL PWR TIME

- ▷ Follow the procedure in *Current Demand* on page 7–21, except that the injected and monitored parameter is watts.

## Reactive Power Demand

For these tests, refer to the figures in section 7.1.6 for test connections. The expected accuracy is as follows:

Expected Accuracy:  $\pm 2.0\%$  of full scale

**The relevant actual values displays are shown below:**

A2 METERING ▷ DMND ▷ REACTIVE PWR ▷ LAST REACTIVE PWR DMND  
 A2 METERING ▷ DMND ▷ REACTIVE PWR ▷ MAX REACTIVE PWR DMND  
 A2 METERING ▷ DMND ▷ REACTIVE PWR ▷ MAX REACTIVE PWR DATE  
 A2 METERING ▷ DMND ▷ REACTIVE PWR ▷ MAX REACTIVE PWR TIME

- ▷ Follow the procedure in *Current Demand* on page 7–21, except that the injected and monitored parameter is vars.

## Apparent Power Demand

For these tests, refer to the figures in section 7.1.6 for test connections. The expected accuracy is as follows:

Expected Accuracy:  $\pm 2.0\%$  of full scale

**The relevant actual values displays are shown below:**

A2 METERING ▷ DMND ▷ APPARENT PWR ▷ LAST APPARENT PWR DMND  
 A2 METERING ▷ DMND ▷ APPARENT PWR ▷ MAX APPARENT PWR DMND  
 A2 METERING ▷ DMND ▷ APPARENT PWR ▷ MAX APPARENT PWR DATE  
 A2 METERING ▷ DMND ▷ APPARENT PWR ▷ MAX APPARENT PWR TIME

Follow the procedure in *Current Demand* on page 7–21, except that the injected and monitored parameter is VA.

### 7.3.5 Analog Input Metering

For these tests, refer to the figures on page –4 for test connections. The expected accuracy is as follows:

Expected Accuracy:  $\pm 1.0\%$  of full scale

**The relevant actual values displays are shown below:**

A2 METERING ▷ A/I ▷ A/I  
 A2 METERING ▷ A/I ▷ A/I (MIN)  
 A2 METERING ▷ A/I ▷ A/I (HOUR)

The procedure for testing the Analog Input metering is shown below:

- ▷ Inject steady values of DC current (in mA) of various values into relay terminals A1(+) and A2(–).
- ▷ Verify that the analog input is correctly measured and displayed in the **A/I** value.
- ▷ 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, verify that the analog input is correctly measured and displayed in the **A/I (MIN)** value.
- ▷ 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, verify that the analog input is correctly measured and displayed in the **AI (HOUR)** value.

## 7.4 Protection Schemes

### 7.4.1 Setpoint Groups

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.

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:

- Test any one protection element that has different settings in different groups
- Test a random selection of protection elements in different groups
- 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.

### 7.4.2 Phase Overcurrent

#### Phase TOC 1

For these tests, refer to the figures on section 7.1.6 for test connections.



The following procedures, other than the check for Linear Reset Timing, are based on the “Instantaneous” reset time characteristic. If the “Linear” reset time characteristic is required, ensure that there is sufficient time between test current injections, or cycle relay power OFF and ON to discharge the energy measurement accumulator to 0.

The following procedure checks Pickup with one phase for operation:

- ▷ Inject current at a level below the pickup level into Phase A.
- ▷ Slowly increase the current until the Pickup LED comes on.  
Note the pickup value.
- ▷ Slowly reduce the current until the Pickup LED goes out.  
Note the dropout level, which should be 2% of CT less than pickup when pickup  $\leq$  CT or 97 to 98% of pickup when pickup  $>$  CT.
- ▷ Repeat last 3 steps for Phases B and C.

The following procedure checks indications and operations caused by a Trip function, with front panel RESET key resetting:

- ▷ Inject current to cause a pickup and wait until the element times to Trip.
- ▷ Check that the Trip and Message LEDs are flashing, the Last Trip message is displayed, and the Output Relay 1 and any others programmed to operate (as well as their associated LED indicators) operate.
- ▷ Slowly reduce the current until the Pickup LED goes out.  
Check that the Trip and Message LEDs are flashing, and that the Output Relay 1 and any others programmed to operate (as well as their associated LEDs) reset.

- ▷ Press the front panel RESET key.  
Check that the Trip and Message LEDs go off, and the Last Trip message is no longer displayed.
- ▷ Turn current off.

The following procedure checks indications and operations caused by a Trip function, with Logic Input resetting:

- ▷ Ensure that the reset logic input control function has been assigned to a logic input.
- ▷ Inject current to cause a pickup and wait until the element times to Trip.
- ▷ Check that the Trip and Message LEDs are flashing, the Last Trip message is displayed, and the Output Relay 1 and any others programmed to operate (as well as their associated LED indicators) operate.
- ▷ Slowly reduce the current until the Pickup LED goes out.  
Check that the Trip and Message LEDs are flashing, and that the Output Relay 1 and any others programmed to operate (as well as their associated LEDs) reset.
- ▷ Assert a logic input to provide a reset.  
Check that the Trip and Message LEDs are now off, and the Last Trip message is no longer displayed.
- ▷ Turn current off.

The following procedure checks indications and operations caused by an Alarm function:

- ▷ Inject current to cause a pickup and wait until the element times to Alarm.
- ▷ Check that the Alarm and Message LEDs are flashing, the Active Alarm message is displayed, and any output relays programmed to operate (as well as their associated LEDs) operate.
- ▷ Slowly reduce the current until the Pickup LED goes out.
- ▷ Verify that the Alarm and Message LEDs go off, and that any output relays programmed to operate (as well as their associated LEDs) reset, and the Active Alarm message is no longer displayed.
- ▷ Turn current off.

The following procedure checks indications and operations caused by a Control function:

- ▷ 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.
- ▷ Slowly reduce the current until the Pickup LED goes out.  
Check that any output relays programmed to operate (as well as their associated LED indicators) reset.
- ▷ Turn current off.

The following procedure checks indications and operations caused by a Latched Alarm function, with RESET key resetting:



- ▷ Inject current to cause a pickup and wait until the element times to Alarm.
- ▷ Check that the Alarm and Message LEDs are flashing, the Active Alarm message is displayed, and any output relays programmed to operate (as well as their associated LEDs) operate.
- ▷ Slowly reduce the current until the Pickup LED goes out. Check that the Alarm and Message LEDs are flashing, and that any output relays programmed to operate (as well as their associated LEDs) reset.
- ▷ Press the front panel RESET key.  
Check that the Alarm and Message LEDs go off, and the Active Alarm message is no longer displayed.
- ▷ Turn current off.

The following procedure checks blocking From Logic Inputs. Note that this procedure is different for Phase TOC2; see the next section for details.

- ▷ Inject current to cause a pickup.
- ▷ Assert a logic input to provide a “Block Phase Time 1”.  
The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic inputs “Block Phase O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

The following procedure checks timing:

- ▷ Connect the Stop Trigger.
- ▷ Preset the injection current level to  $2.0 \times$  pickup.  
Turn the current off, and reset the timer.
- ▷ Inject the preset current into Phase A and note the measured delay time.  
Check this time against the time established by the settings and reset the timer.
- ▷ Preset the injection current level to  $4.0 \times$  pickup.  
Turn the current off, and reset the timer.
- ▷ Inject the preset current into Phase B and note the measured delay time.  
Check this time against the time established by the settings and reset the timer.
- ▷ Preset the injection current level to  $7.0 \times$  pickup.  
Turn the current off, and reset the timer.
- ▷ Inject the preset current into Phase C and note the measured delay time.  
Check this time against the time established by the settings.
- ▷ Turn current off and disconnect the Stop Trigger.

The following procedure checks Linear Reset Timing:

- ▷ To confirm that the TOC 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.

The following procedure checks the voltage restrained Phase TOC function:

- ▷ Apply three-phase nominal voltage to the relay.
- ▷ Inject current below the pickup level into Phase A and slowly increase until the Pickup LED is on.  
Note the pickup value is the pickup current of the Curve in use.
- ▷ Slowly reduce the current into Phase A until the Pickup LED goes off and note the dropout level, which should be 2% of CT less than pickup when pickup  $\leq$  CT or 97 to 98% of pickup when pickup  $>$  CT.
- ▷ Reduce the current to zero.
- ▷ Repeat Steps 2 to 4 for current injected into Phases B and C.
- ▷ Set all input voltages to 0 and slowly increase Phase A current until the Pickup LED comes on.  
Check that this current is 9 to 11% of the measured full voltage pickup current.
- ▷ Increase input voltage  $V_{ab}$  until the Pickup LED goes out.  
This should be at 9 to 11% of the nominal phase-phase voltage. This test establishes the lower knee of the operating characteristic.
- ▷ With the Pickup LED still off, increase voltage  $V_{ab}$  to 60% of the nominal phase-phase voltage.
- ▷ Increase the Phase A current until the Pickup LED comes on.  
This should be at 59 to 61% of the full voltage measured pickup current.
- ▷ With the Pickup LED still off, increase voltage  $V_{ab}$  to 130% of nominal.
- ▷ Increase Phase A current to 90% of normal pickup and hold this value.  
Slowly decrease  $V_{ab}$  until the Pickup LED just comes on. This should be at 89 to 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.
- ▷ Repeat last 7 steps for current injected in Phase B and controlling voltage  $V_{cb}$ .
- ▷ Repeat last 7 steps for current injected in Phase C and controlling voltage  $V_{ca}$ .

To check trip timing with voltage restraint, set the input voltage to a given level, establishing a new pickup current, and then following the procedure outlined earlier under Timing.

## Phase TOC 2

The procedure to test this element is identical to that for Phase TOC 1, except for the blocking from logic inputs, in which case the following procedure should be used:

- ▷ Inject current to cause a Pickup.

- ▷ Assert a logic input to provide a “Block Phase Time 2”.  
The Pickup LED should immediately go out.
- ▷ Repeat Steps 1 and 2 for logic inputs “Block Phase O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

### Phase IOC 1

The procedure to test this element is identical for Phase TOC 1, except for the procedures below. Pickup, indication and operation are subject to the “phases required for operation” test, but not subject to the “linear reset timing” and “voltage restrained Phase TOC” tests.

The following procedure checks pickup with two phases for operation:

- ▷ Inject current into Phase B at 150% of pickup.
- ▷ Inject current at a level below the pickup level into Phase A.
- ▷ Slowly increase the Phase A current until the Pickup LED comes on and note the pickup value.
- ▷ Slowly reduce the Phase A current until the Pickup LED goes out.  
Note the dropout level, which should be 2% of CT less than pickup when pickup  $\leq$  CT or 97 to 98% of pickup when pickup  $>$  CT.
- ▷ Repeat last 4 steps for phase pair B and C and phase pair C and A.

The following procedure checks pickup with three phases for operation:

- ▷ Inject current into Phases B and C at 150% of pickup.
- ▷ Inject current at a level below the pickup level into Phase A.
- ▷ Slowly increase the Phase A current until the Pickup LED comes on and note the pickup value.
- ▷ Slowly reduce the Phase A current until the Pickup LED goes out and note the dropout level, which should be 2% of CT less than pickup when pickup  $\leq$  CT, or 97 to 98% of pickup when pickup  $>$  CT.
- ▷ Repeat last 4 steps for current at 150% in Phases C and A and adjusted in B.
- ▷ Repeat last 4 steps for current at 150% in Phases B and A and adjusted in C.

The following procedure checks the blocking from logic inputs:

- ▷ Inject current into the required number of phases to cause a pickup.
- ▷ Assert a logic input to provide a “Block Phase Inst 1”.  
The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic inputs “Block Phase O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

The following procedure checks Phase IOC 1 timing:

- ▷ Connect the Stop Trigger to the interval timer.
- ▷ Preset the current source to a minimum of 110% of pickup current, then turn the current off and reset the timer.

- ▷ Inject the preset current into the required number of phases and note the delay time, then reset the timer.
- ▷ Repeat the last step four more times and obtain an average of the time intervals.
- ▷ Reset the relay and disconnect the “Stop Trigger.”

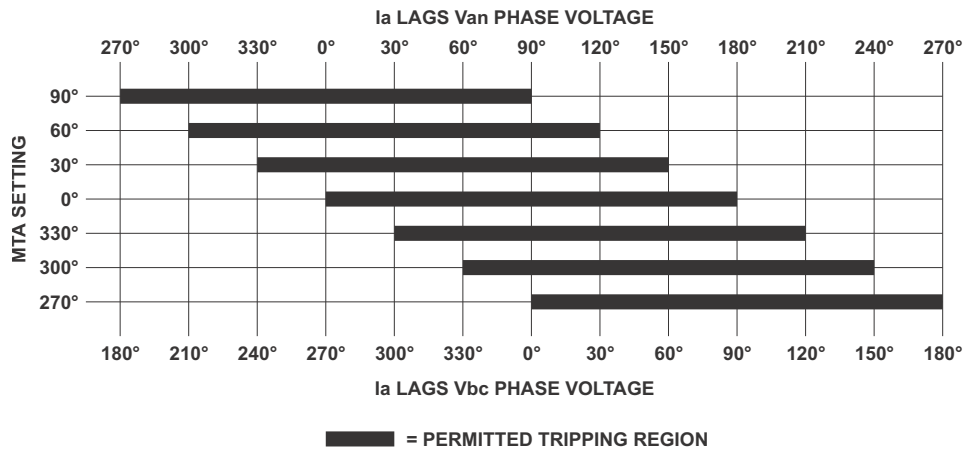
**Phase IOC 2**

The procedures to test this element are identical to those outlined for Phase IOC 1 above, with the exception of the blocking from logic inputs check, which is performed as follows:

- ▷ Inject current into the required number of phases to cause a pickup.
- ▷ Assert a logic input to provide a “Block Phase Inst 2” and verify the Pickup LED immediately turns off.
- ▷ Repeat last 2 steps for logic inputs “Block Phase O/C”, “Block All O/C” and “Block 1 TRIP Relay” as required.

**Phase Directional OC**

A plot of the operating characteristic of the phase directional feature for various settings of MTA for Phase A is shown below. 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 Phases B and C are  $V_{ca}$  and  $V_{ab}$  respectively).



**FIGURE 7-3: Phase Directional – Phase A Forward Operating Regions**



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.

For forward tripping and Wye connected VTs, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* on page 7-4 and use the following procedure:

- ▷ Set  $V_{an} = V_{bn} = V_{cn} > \text{MIN POLARIZING VOLTAGE}$  setpoint at 0°, 120°, and 240°, respectively.

- ▷ Inject Phase A current of  $0.2 \times CT$  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 LEDs are flashing, the correct Phase Directional Reverse alarm message is displayed, and any output relays programmed for this condition are operated.
- ▷ 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  $90^\circ \pm 2^\circ$ .  
The alarm and output relays should reset.
- ▷ 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  $270^\circ \pm 2^\circ$ .
- ▷ Continue to increase the angle until the Phase A current is once again in phase with the polarizing voltage.  
The alarm should remain.
- ▷ Repeat the last 5 steps for current angle adjusted in each of Phases B and C.

For forward tripping and Delta connected VTs, use the test connections specified in FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5 and use the following procedure:

- ▷ Set  $V_{ab} = V_{bc} = V_{ca} > \text{MIN POLARIZING VOLTAGE}$  setpoint at  $0^\circ$ ,  $120^\circ$ , and  $240^\circ$ , respectively.
- ▷ Inject Phase A current of  $0.2 \times CT$  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 LEDs are flashing, the correct Phase Directional Reverse alarm message is displayed, and any output relays programmed for this condition are operated.
- ▷ 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  $90^\circ \pm 2^\circ$ .  
The alarm and output relays should reset.
- ▷ 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  $270^\circ \pm 2^\circ$ .
- ▷ Continue to increase the angle until the Phase A current is once again in phase with the polarizing voltage.  
The alarm should remain.

- ▷ Repeat the last 5 steps for current angle adjusted in each of Phases B and C.

### 7.4.3 Neutral Overcurrent

#### Neutral TOC 1

The procedure to test this element is identical to that outlined in *Phase TOC 1* on page 7–25, except that current is injected into any one phase, and the element is not subject to the “phases required for operation” and “voltage restrained time overcurrent” tests.

The blocking from logic inputs check is different from that for Phase TOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert logic input to provide a “Block Neutral Time 1”.  
The Pickup LED should immediately turn off.
- ▷ Repeat Steps 1 and 2 for logic inputs “Block Neutral O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

#### Neutral TOC 2

The procedure to test this element is identical to that outlined in *Phase TOC 1* on page 7–25, except that current is injected into any one phase, and the element is not subject to the “phases required for operation” and “voltage restrained time overcurrent” checks.

The blocking from logic inputs check is different from that for Phase TOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert logic input to provide a “Block Neutral Time 2”.  
The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic inputs “Block Neutral O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

#### Neutral IOC 1

The procedure to test this element is identical to that outlined in *Phase TOC 1* on page 7–25, except that current is injected into any one phase, and the element is not subject to the “phases required for operation”, “linear reset timing”, and “voltage restrained time overcurrent” tests.

The blocking from logic inputs check is different from that for Phase TOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert a logic input to provide a “Block Neutral Inst 1”.  
The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic inputs “Block Neutral O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

## Neutral IOC 2

The procedure to test this element is identical to that outlined in *Phase TOC 1* on page 7–25, except that current is injected into any one phase, and the element is not subject to the “phases required for operation”, “linear reset timing”, and “voltage restrained time overcurrent” checks.

The blocking from logic inputs check is different from that for Phase TOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert a logic input to provide a “Block Neutral Inst 2”.  
The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic inputs “Block Neutral O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

## Neutral Directional OC

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 plot of the operating characteristic of the voltage polarized neutral directional feature for various settings of MTA is shown below. 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.

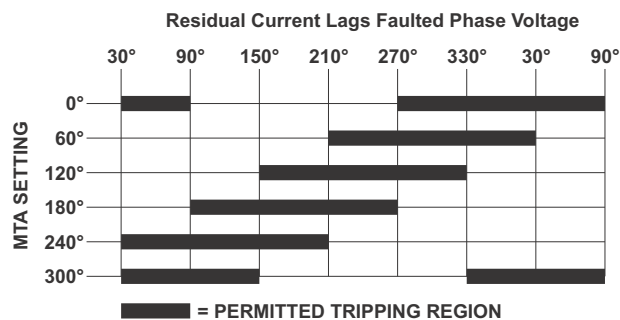


FIGURE 7-4: Neutral Directional Voltage Polarized Fwd Operating Regions



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.

To test forward tripping with voltage polarization, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* on page 7-4 and follow the procedure below:

- ▷ 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° (in the tripping direction) and inject into Phase A. Note that  $-V_0$  is less than the **MIN POLARIZING VOLTAGE**.
- ▷ Reduce  $V_{an}$  until  $-V_0$  is greater than the **MIN POLARIZING VOLTAGE**.

- ▷ Slowly increase the angle of the Phase A current in the lagging direction.  
At an angle lagging  $V_{an}$  by  $270^\circ \pm 2^\circ$ , 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 LEDs are flashing, the Neutral Directional Reverse alarm message is displayed, and any output relays programmed for this condition are operated.
- ▷ Continue to increase the lagging angle through  $0^\circ$ , until the block message disappears at an angle lagging  $V_{an}$  by  $90^\circ \pm 2^\circ$ .
- ▷ Turn the current off.
- ▷ If desired, repeat the above Steps for Phases B and C using  $I_b$  with faulted phase voltage  $V_{bn}$  and  $I_c$  with faulted phase voltage  $V_{cn}$ .

To test forward tripping with current polarization, use the test connections specified and procedure specified below:

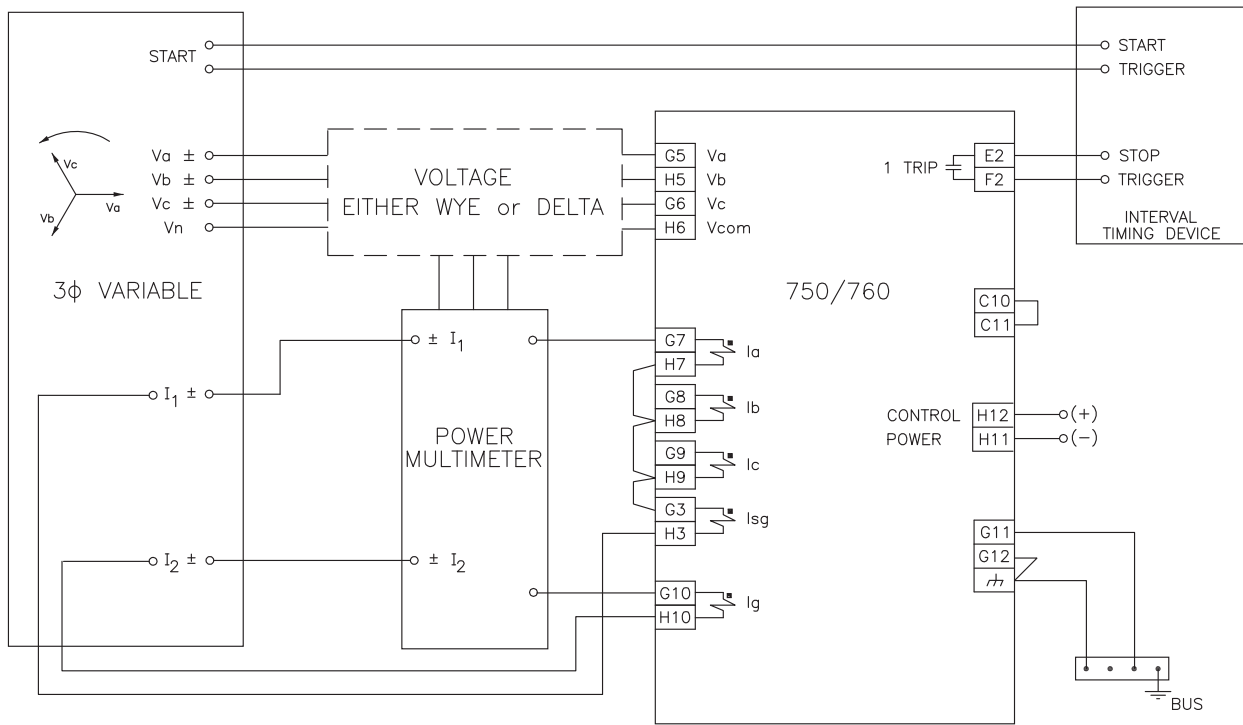


FIGURE 7-5: Neutral Directional Test Connection for Polarizing Current



The following description presents angles with reference to the polarizing current.

- ▷ Set a current of 0.2 of nominal and inject into the ground current input (Terminals G10 and H10).
- ▷ 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.



- ▷ Increase the lagging angle of  $3I_0$ .  
At an angle lagging the ground current by  $90^\circ \pm 2^\circ$ , 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 LEDs are flashing, the Neutral Directional Reverse alarm message is displayed, and any output relays programmed for this condition are operated.
- ▷ Continue to increase the lagging angle until the block message disappears at an angle lagging the ground current by  $270^\circ \pm 2^\circ$ . Turn the current off.

To check forward tripping with dual polarization, use the test connections specified in FIGURE 7-5: *Neutral Directional Test Connection for Polarizing Current* on page 7-34 and follow the procedure below. 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.

- ▷ Set  $V_{an}$  to 60%, and  $V_{bn} = V_{cn}$  to 100% nominal voltage at phase angles of  $0^\circ$ ,  $120^\circ$ , and  $240^\circ$ , respectively.
- ▷ Inject a current of  $0.2 \times$  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.
- ▷ Inject a current of  $0.2 \times$  nominal, lagging the  $3I_0$  current by  $180^\circ$ , into the ground current input.  
The block alarm should remain.
- ▷ Increase the angle of the ground current lagging  $3I_0$  current through a complete  $360^\circ$  rotation back to the original angle of lagging by  $180^\circ$ .  
The block alarm should remain throughout the rotation as the voltage polarized element is still blocking.
- ▷ Maintaining the ground current angle lagging  $3I_0$  by  $180^\circ$  increase the angle of  $3I_0$  lagging the  $V_{an}$  voltage through a complete  $360^\circ$  rotation back to the original angle.  
The block alarm should remain throughout the rotation as the current polarized element is still blocking.
- ▷ Increase the angle of the ground current lagging  $3I_0$  current until the currents are in-phase.  
The block alarm should remain.
- ▷ 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.

#### 7.4.4 Ground Overcurrent

##### Ground TOC

The procedure to test this element is identical to that outlined in *Phase TOC 1* on page 7–25, except that 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” checks.

The blocking from logic inputs check is different from that for Phase TOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert a logic input to provide a “Block Ground Time”.  
The Pickup LED should immediately go out.
- ▷ Repeat Steps 1 and 2 for logic inputs “Block Ground O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

##### Ground IOC

The procedure to test this element is identical to that outlined in *Phase TOC 1* on page 7–25, except that current is injected into the ground input terminals, and the element is not subject to the “phases required for operation”, “linear reset timing”, and “voltage restrained time overcurrent” tests.

The blocking from logic inputs check is different from that for Phase TOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert a logic input to provide a “Block Ground Inst”.  
The Pickup LED should immediately go out.
- ▷ Repeat Steps 1 and 2 for logic inputs “Block Ground O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

##### Ground Directional OC

The procedure to test this element is identical to that outlined in *Neutral Directional OC* on page 7–33, except that the operating current is the ground current. Also, Ground Directional may only be voltage polarized.

##### Sensitive Ground TOC

The procedure to test this element is identical to that outlined in *Phase TOC 1* on page 7–25, except that 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.

The blocking from logic inputs check is different from that for Phase TOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert a logic input to provide a “Blk Sens Gnd Time”.  
The Pickup LED should immediately go out.
- ▷ Repeat Steps 1 and 2 for logic inputs “Block Sens Gnd O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

### Sensitive Ground IOC

The procedure to test this element is identical to that outlined in *Phase IOC 1* on page 7–29, except that the current is injected into the sensitive ground input terminals, and the element is not subject to the “phases required for operation”, “linear reset timing”, and “voltage restrained time overcurrent” tests.

The blocking from logic inputs check is different from that for Phase IOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert a logic input to provide a “Blk Sens Gnd Inst”.  
The Pickup LED should immediately go out.
- ▷ Repeat Steps 1 and 2 for logic inputs “Block Sens Gnd O/C”, “Block All O/C” and “Block 1 Trip Relay” as required.

### Sensitive Ground Directional OC

The procedure to test this element is identical to that outlined in *Neutral Directional OC* on page 7–33, except that the operating current is the sensitive ground current.

#### 7.4.5 Negative-Sequence Overcurrent and Voltage

### Negative-Sequence TOC

The procedure to test this element is identical to that outlined in *Phase TOC 1* on page 7–25, except that current is injected into any one phase of the phase input terminals and the negative sequence current magnitude is 1/3rd of the injected current. The element is not subject to the “phases required for operation” or “voltage restrained time overcurrent” tests.

The blocking from logic inputs check is different from that for Phase TOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert a logic input to provide a “Block Neg Seq Time”.  
The Pickup LED should immediately go out.
- ▷ Repeat Steps 1 and 2 for logic input “Block All O/C” and “Block 1 Trip Relay” as required.

### Negative-Sequence IOC

The procedure to test this element is identical to that outlined in *Phase IOC 1* on page 7–29, except that current is injected into any one phase of the phase input terminals and the negative sequence current magnitude is 1/3rd of the injected current. The element is not subject to the “phases required for operation”, “linear reset timing”, and “voltage restrained time overcurrent” tests.

The blocking from logic inputs check is different from that for Phase IOC 1 and is performed as follows:

- ▷ Inject current to cause a pickup.
- ▷ Assert a logic input to provide a “Block Neg Seq Inst”.  
The Pickup LED should immediately go out.
- ▷ Repeat Steps 1 and 2 for logic input “Block All O/C” and “Block 1 Trip Relay” as required.

## Negative-Sequence Directional OC

The procedure to test this element is identical to that outlined in *Phase Directional OC* on page 7-30, except the injected current must be a negative sequence current.

## Negative-Sequence Voltage

For Wye VTs, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* on page 7-4. 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.

To test pickup for Wye VTs, use the following procedure:

- ▷ Inject a negative sequence voltage of 0 into the bus voltage input of the relay.  
The Pickup LED should be off.
- ▷ Slowly raise the voltage until the Pickup LED comes on.  
This is the pickup level.
- ▷ Lower the voltage until the Pickup LED goes out.  
This is the reset voltage, which should be 2% of VT less than the pickup level.

For Delta VTs, use the test connections specified in FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. 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  $\sqrt{3}$ .

To test Pickup for Delta VTs, use the following procedure:

- ▷ Inject a negative sequence voltage of 0 into the bus voltage input of the relay.  
The Pickup LED should be off.
- ▷ Slowly raise the voltage until the Pickup LED comes on.  
This is the pickup level.
- ▷ Lower the voltage until the Pickup LED goes out.  
This is the reset voltage, which should be 2% of VT less than the pickup level.

Indications and Operations are the same as those outlined in *Phase TOC 1* on page 7-25.

The following procedure checks blocking from logic inputs for Delta VTs:

- ▷ Inject voltage to cause a pickup.
- ▷ Assert a logic input to provide a “Block Neg Seq Voltage”.  
The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic input “Block 1 TRIP Relay” as required.

The following procedure checks negative-sequence voltage timing for Delta VTs:

- ▷ Connect the “Stop Trigger”.
- ▷ Set the voltage source to the required test voltage, then turn off the voltage.

- ▷ Reset the timer.
- ▷ Turn the voltage on and measure the operating time.
- ▷ Repeat last 3 steps four more times and obtain an average of the time intervals.
- ▷ Reset the relay and disconnect the “Stop Trigger”.

## 7.4.6 Voltage

### Bus Undervoltage (Wye VTs only)

To test Bus Undervoltage for Wye VTs, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* on page 7-4.

The following procedure checks Pickup with One Phase For Operation:

- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.  
The Pickup LED should be off.
- ▷ Slowly lower  $V_{an}$  until the Pickup LED comes on.  
This is the pickup voltage.
- ▷ Continue to lower  $V_{an}$  until the Pickup LED goes out.  
This is the **MIN OPERATING VOLTAGE** level minus 2% of VT.
- ▷ Raise  $V_{an}$  until the Pickup LED 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.
- ▷ Repeat last 4 steps, except adjust  $V_{bn}$  and  $V_{cn}$  in turn.

The following procedure checks Pickup with Two Phases For Operation:

- ▷ Inject  $V_{cn} =$  nominal voltage and  $V_{an} = V_{bn} =$  a voltage between the **MIN OPERATING VOLTAGE** and the pickup voltage into the bus voltage input of the relay.  
The Pickup LED should be on.
- ▷ Slowly raise  $V_{an}$  until the Pickup LED goes out.  
This is the reset voltage, which should be the pickup plus 2% of VT.
- ▷ Reduce  $V_{an}$  until the Pickup LED comes on.  
This is the pickup voltage of  $V_{an}$ .
- ▷ Continue to lower  $V_{an}$  until the Pickup LED goes out.  
This is the **MIN OPERATING VOLTAGE** of  $V_{an}$  minus 2% of VT.
- ▷ Slowly raise  $V_{an}$  until the Pickup LED comes on, then reduce  $V_{bn}$  until the Pickup LED goes out.  
This is the programmed **MIN OPERATING VOLTAGE** of  $V_{bn}$  minus 2% VT.
- ▷ Slowly raise  $V_{bn}$  until the Pickup LED first comes on and then goes out.  
This is the reset voltage, which should be the pickup value plus 2% of VT.
- ▷ Lower  $V_{bn}$  until the Pickup LED comes on.  
This is the pickup voltage of  $V_{bn}$ .

- ▷ Repeat last 7 steps, substituting  $V_{cn}$  for  $V_{an}$ ,  $V_{an}$  for  $V_{bn}$  and  $V_{bn}$  for  $V_{cn}$ .
- ▷ Repeat last 7 steps, substituting  $V_{bn}$  for  $V_{an}$ ,  $V_{cn}$  for  $V_{bn}$  and  $V_{an}$  for  $V_{cn}$ .

The following procedure checks Pickup with Three Phases For Operation:

- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  a voltage between the **MIN OPERATING VOLTAGE** and the pickup voltage into the bus voltage input of the relay. The Pickup LED should be on.
- ▷ Slowly raise  $V_{an}$  until the Pickup LED goes out. This reset voltage should be the pickup value plus 2% of VT.
- ▷ Reduce  $V_{an}$  until the Pickup LED comes on. This is the pickup voltage of  $V_{an}$ .
- ▷ Slowly raise  $V_{bn}$  until the Pickup LED goes out. This reset voltage should be the pickup value plus 2% of VT.
- ▷ Reduce  $V_{bn}$  until the Pickup LED comes on. This is the pickup voltage of  $V_{bn}$ .
- ▷ Slowly raise  $V_{cn}$  until the Pickup LED goes out. This reset voltage should be the pickup value plus 2% of VT.
- ▷ Reduce  $V_{cn}$  until the Pickup LED comes on. This is the pickup voltage of  $V_{cn}$ .
- ▷ Lower  $V_{an}$  until the Pickup LED goes out. This is the **MIN OPERATING VOLTAGE** of  $V_{an}$  minus 2% of VT.
- ▷ Slowly raise  $V_{an}$  until the Pickup LED comes on. This is the **MIN OPERATING VOLTAGE** level.
- ▷ Reduce  $V_{bn}$  until the Pickup LED goes out. This is the **MIN OPERATING VOLTAGE** of  $V_{bn}$  minus 2% of VT.
- ▷ Slowly raise  $V_{bn}$  until the Pickup LED comes on. This is the **MIN OPERATING VOLTAGE** level.
- ▷ Reduce  $V_{cn}$  until the Pickup LED goes out. This is the **MIN OPERATING VOLTAGE** of  $V_{cn}$  minus 2% of VT.
- ▷ Slowly raise  $V_{cn}$  until the Pickup LED comes on. This is the **MIN OPERATING VOLTAGE** level.

### Bus Undervoltage (Delta VTs only)

To test Bus Undervoltage for Delta VTs, use the test connections specified in FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5.

The following procedure tests Pickup with One Phase For Operation:

- ▷ Inject  $V_{ab} = V_{cb} =$  nominal voltage into the bus voltage input of the relay. The Pickup LED should be off.
- ▷ Slowly lower  $V_{ab}$  until the Pickup LED comes on. This is the pickup voltage.
- ▷ Continue to lower  $V_{ab}$  until the Pickup LED goes out. This is the **MIN OPERATING VOLTAGE** minus 2% of VT.

- ▷ Raise  $V_{ab}$  until the Pickup LED 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.
- ▷ Repeat last 4 steps except adjust  $V_{bc}$ .

The following procedure tests Pickup with Two or Three Phases For Operation:

- ▷ Inject  $V_{ab}$  = nominal voltage and  $V_{cb}$  = a voltage between the **MIN OPERATING VOLTAGE** and the pickup voltage into the bus voltage input of the relay.  
The Pickup LED should be on.
- ▷ Slowly raise  $V_{cb}$  until the Pickup LED goes out.  
This reset voltage should be the pickup value plus 2% of VT.
- ▷ Reduce  $V_{cb}$  until the Pickup LED comes on.  
This is the pickup voltage of  $V_{cb}$ .
- ▷ Continue to lower  $V_{cb}$  until the Pickup LED goes out.  
This is the **MIN OPERATING VOLTAGE** of  $V_{cb}$  minus 2% of VT.
- ▷ Slowly raise  $V_{cb}$  until the Pickup LED comes on.  
This is the **MIN OPERATING VOLTAGE** level.
- ▷ Reduce  $V_{ab}$  until the Pickup LED goes out.  
This is the **MIN OPERATING VOLTAGE** of  $V_{ab}$  minus 2% of VT.
- ▷ Slowly raise  $V_{ab}$  until the Pickup LED first comes on and then goes out.  
This is the reset voltage, which should be the pickup value plus 2% of VT.
- ▷ Lower  $V_{ab}$  until the Pickup LED comes on.  
This is the pickup voltage of  $V_{ab}$ .

### Bus Undervoltage (Wye and Delta VTs)

To test Bus Undervoltage for Wye and Delta VTs, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5.

The procedures for testing Indications and Operations are the same as those outlined for *Phase TOC 1* on page 7-25.

The following procedure tests Blocking From Logic Inputs:

- ▷ Inject voltage into the required number of phases to cause a pickup.
- ▷ Assert a logic input to provide a “Block Undervolt 1(2)”.  
The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic input “Block 1 Trip Relay” as required.

The following procedure tests the Bus Undervoltage element timing:

- ▷ Connect the “Stop Trigger.”
- ▷ Set the voltage source to nominal voltage.
- ▷ Reset the timer.

- ▷ Turn the voltage off in the required number of phases, and measure the operating time.
- ▷ Repeat last 3 steps four more times and obtain an average of the time intervals.
- ▷ Reset the relay and disconnect the “Stop Trigger.”

### Line Undervoltage

The following procedure tests the Line Undervoltage pickup:

- ▷ Inject nominal voltage into the line voltage input of the relay. The Pickup LED should be off.
- ▷ Slowly lower the voltage until the Pickup LED comes on. This is the pickup voltage.
- ▷ Continue to lower the voltage until the Pickup LED goes out. This is the **MIN OPERATING VOLTAGE** minus 2% of VT.
- ▷ Raise the voltage until the Pickup LED 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.

The procedures for testing Indications and Operations are the same as those outlined for *Phase TOC 1* on page 7-25.

The following procedure tests the Blocking From Logic Inputs:

- ▷ Inject voltage to cause a pickup.
- ▷ Assert a logic input to provide a “Block Undervolt 3(4)”. The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic input “Block 1 Trip Relay” as required.

The following procedure tests the Line Undervoltage element Timing:

- ▷ Connect the “Stop Trigger”.
- ▷ Set the voltage source to nominal voltage.
- ▷ Reset the timer.
- ▷ Turn on the voltage, and measure the operating time.
- ▷ Repeat last 3 steps four more times and obtain an average of the time intervals.
- ▷ Reset the relay and disconnect the “Stop Trigger”.

### Overvoltage (Wye VTs only)

To test Overvoltage for Wye VTs, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* on page 7-4. The following procedure tests Pickup with One Phase For Operation:

- ▷ Inject  $V_{an} = V_{bn} = V_{cn} = 0$  into the bus voltage input of the relay. The Pickup LED should be off.
- ▷ Slowly raise  $V_{an}$  until the Pickup LED comes on. This is the pickup voltage.



- ▷ Lower  $V_{an}$  until the Pickup LED goes out.  
This is the reset voltage, which should be the pickup value minus 2% of VT.
- ▷ Repeat last 3 steps except adjust  $V_{bn}$  and  $V_{cn}$  in turn.

The following procedure tests Pickup with Two Phases For Operation:

- ▷ 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 LED should be off.
- ▷ Slowly raise  $V_{an}$  until the Pickup LED goes on.  
This is the pickup voltage of  $V_{an}$ .
- ▷ Reduce  $V_{an}$  until the Pickup LED goes off.  
This reset voltage of  $V_{an}$  should be the pickup value minus 2% of VT.
- ▷ Raise  $V_{an}$  until the Pickup LED comes on.
- ▷ Repeat last 4 steps, substituting  $V_{cn}$  for  $V_{an}$ ,  $V_{an}$  for  $V_{bn}$  and  $V_{bn}$  for  $V_{cn}$ .
- ▷ Repeat last 4 steps, substituting  $V_{bn}$  for  $V_{an}$ ,  $V_{cn}$  for  $V_{bn}$  and  $V_{an}$  for  $V_{cn}$ .

The following procedure tests Pickup with Three Phases For Operation:

- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  a voltage above the pickup voltage into the bus voltage input of the relay.  
The Pickup LED should be on.
- ▷ Slowly lower  $V_{an}$  until the Pickup LED goes out.  
This reset voltage should be the pickup value minus 2% of VT.
- ▷ Raise  $V_{an}$  until the Pickup LED comes on.  
This is the pickup voltage of  $V_{an}$ .
- ▷ Slowly lower  $V_{bn}$  until the Pickup LED goes out.  
This reset voltage should be the pickup value minus 2% of VT.
- ▷ Raise  $V_{bn}$  until the Pickup LED comes on.  
This is the pickup voltage of  $V_{bn}$ .
- ▷ Slowly lower  $V_{cn}$  until the Pickup LED goes out.  
This reset voltage should be the pickup value minus 2% of VT.
- ▷ Raise  $V_{cn}$  until the Pickup LED comes on.  
This is the pickup voltage of  $V_{cn}$ .

### Overvoltage (Delta VTs only)

To test Overvoltage for Delta VTs, use the test connections specified in FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The following procedure tests Pickup with One Phase For Operation:

- ▷ Inject  $V_{ab} = V_{cb} = 0$  into the bus voltage input of the relay.  
The Pickup LED should be off.
- ▷ Slowly raise  $V_{ab}$  until the Pickup LED comes on.  
This is the pickup voltage.

- ▷ Lower  $V_{ab}$  until the Pickup LED goes out.  
This is the reset voltage, which should be the pickup value minus 2% of VT.
- ▷ Repeat last 3 steps, except adjust  $V_{bc}$ .

The following procedure tests Pickup with Two or Three Phases For Operation:

- ▷ Inject  $V_{ab} = V_{cb} >$  pickup into the bus voltage input.  
The Pickup LED should be on.
- ▷ Lower  $V_{ab}$  until the Pickup LED goes out.  
This is the reset voltage, which should be the pickup value minus 2% of VT.
- ▷ Slowly raise  $V_{ab}$  until the Pickup LED comes on.  
This is the pickup voltage.
- ▷ Repeat last 3 steps, except adjust  $V_{bc}$ .

### Overvoltage (Wye and Delta VTs)

To test Overvoltage for Delta and Wye VTs, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* and FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25.

The following procedure tests Blocking From Logic Inputs:

- ▷ Inject voltage to cause a pickup.
- ▷ Assert a logic input to provide a “Block 1 Trip Relay”.

The following procedure tests the element Timing:

- ▷ Connect the “Stop Trigger”.
- ▷ Set the voltage source to the required test voltage, then turn off voltage.
- ▷ Reset the timer.
- ▷ Turn the voltage on in the required number of phases, and measure the operating time.
- ▷ Repeat Steps 2, 3 and 4 four more times and obtain an average of the time intervals.
- ▷ Reset the relay and disconnect the “Stop Trigger”.

### Neutral Displacement (Wye VTs Only)

To test Neutral Displacement (Wye VTs only), use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* on page 7-4.

The following procedure tests the Pickup Level:

- ▷ Apply a three phase balanced nominal voltage to the relay.
- ▷ Reduce one phase voltage slowly until the Neutral Displacement element operates and note this voltage.
- ▷ Calculate the  $3V_0$  (neutral voltage, i.e. residual voltage) being supplied to the relay using the formula:

$$3V_0 = V_a + V_b + V_c \quad (\text{EQ 7.2})$$

- ▷ Repeat last 3 steps, except adjust  $V_{bn}$  and  $V_{cn}$  in turn.

The following procedure tests Blocking From Logic Inputs:

- ▷ Cause a pickup of the Neutral Displacement element.
- ▷ Assert a logic input to provide a “Blk Ntr Displacement”. The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic input “Block 1 Trip Relay” as required.

The following procedure tests element Timing:

- ▷ Connect the Stop Trigger.
- ▷ Preset the neutral (residual) voltage to be 150% of the pickup setting.
- ▷ Inject the preset neutral (residual) voltage into the relay and note the delay time.
- ▷ Reset the timer.
- ▷ Repeat steps 3 and 4 four more times and obtain an average of the time intervals.
- ▷ Disconnect the stop trigger when finished.

## 7.4.7 Frequency

### Underfrequency

To test Underfrequency, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25.

The following procedure checks Minimum Operating Voltage Supervision:

- ▷ 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 LED should be off.
- ▷ Slowly increase the voltage in Phase A until the Pickup LED comes on. Check that the pickup voltage is the selected Minimum Operating Voltage.
- ▷ Slowly reduce the voltage. Note the voltage at which the Pickup LED goes out. Check that this dropout voltage is the pickup voltage minus 2 x VT nominal.
- ▷ Turn the injection voltage off.

The following procedure checks Minimum Operating Current Supervision:

- ▷ 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 LED should be off.

- ▷ Slowly increase the voltage in Phase A above the selected Minimum Operating Voltage.  
The Pickup LED should remain off.
- ▷ Slowly increase the Phase A current until the Pickup LED turns on.  
This is the Minimum Operating Current level.
- ▷ Now reduce the current until the Pickup LED turns off.  
Note the dropout level, which should be 2% of CT less than the Minimum Operating Current level when the level is  $\leq$  CT.  
When the Minimum Operating Current level is  $>$  CT, the dropout level should be 97 to 98% of the Minimum Operating Current level.
- ▷ Slowly increase the Phase B current until the Pickup LED turns on.  
This is the Minimum Operating Current level.
- ▷ Now reduce the current until the Pickup LED turns off.  
Note the dropout level, which should be 2% of CT less than the Minimum Operating Current level when the level is  $\leq$  CT.  
When the Minimum Operating Current level is  $>$  CT, the dropout level should be 97 to 98% of the Minimum Operating Current level.
- ▷ Slowly increase the Phase C current until the Pickup LED turns on.  
This is the Minimum Operating Current level.
- ▷ Now reduce the current until the Pickup LED turns off.  
Note the dropout level, which should be 2% of CT less than the Minimum Operating Current level when the level is  $\leq$  CT.  
When the Minimum Operating Current level is  $>$  CT, the dropout level should be 97 to 98% of the Minimum Operating Current level.



For the following Underfrequency test procedures, the injected voltage and currents are always above the minimum operating levels.

The following procedure tests the Underfrequency Pickup:

- ▷ Inject voltage at a frequency above the pickup level into phase  $V_a$ .
- ▷ Slowly decrease the frequency until the Pickup LED comes on.  
Note the pickup value.
- ▷ Slowly increase the frequency until the Pickup LED goes out.  
Note the dropout level, which should be the pickup plus 0.03 Hz.

The following procedure tests Blocking From Logic Inputs:

- ▷ Inject voltage and current above minimum at a frequency that causes a pickup.
- ▷ Assert a logic input to provide a “Block Underfreq 1(2)”.  
The Pickup LED should immediately go out.
- ▷ Repeat last 2 steps for logic input “Block 1 Trip Relay” as required.

The following procedure tests the Underfrequency element Timing:

- ▷ Connect the “Stop Trigger”.
- ▷ Set the voltage source pre-fault mode to nominal voltage, current and frequency.

- ▷ Set the voltage source fault mode to nominal voltage and current, but with a frequency below pickup.
- ▷ Set the source to pre-fault mode, reset the timer, and apply to the relay.
- ▷ Jump the source to fault mode and measure the operating time.
- ▷ Repeat last 2 steps four more times and obtain an average of the time intervals.
- ▷ Reset the relay and disconnect the “Stop Trigger”.

### Frequency Decay

To test Frequency Decay, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25.

The following procedure checks Minimum Operating Voltage Supervision:

- ▷ 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 **FREQ DECAY PICKUP**, drop the frequency of  $V_a$  at a speed greater than the **FREQ DECAY RATE** setting.  
The pickup indicator should remain off.
- ▷ 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 **FREQ DECAY PICKUP**, drop the frequency of  $V_a$  at a speed greater than the **FREQ DECAY RATE** setting.  
The pickup indicator should come on while the  $V_a$  frequency is dropping.

The following procedure checks the Minimum Operating Current Supervision:

- ▷ 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 LED should remain off.
- ▷ 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 **FREQ DECAY PICKUP**, drop the frequency of  $V_a$  at a speed greater than the **FREQ DECAY RATE** setting.

The Pickup LED should come on while the  $V_a$  frequency is dropping.

- ▷ 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 **FREQ DECAY PICKUP**, drop the frequency of  $V_a$  at a speed greater than the **FREQ DECAY RATE** setting.

The Pickup LED should come on while the  $V_a$  frequency is dropping.

- ▷ 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 **FREQ DECAY PICKUP**, drop the frequency of  $V_a$  at a speed greater than the **FREQ DECAY RATE** setting.

The Pickup LED should come on while the  $V_a$  frequency is dropping.



For the following Frequency Decay test procedures, the injected voltage and currents are always above the minimum operating levels.

The following procedure checks the Frequency Decay Pickup:

- ▷ Starting with the  $V_a$  frequency at a level well above the **FREQ DECAY PICKUP**, drop the frequency of  $V_a$  at a speed greater than the **FREQ DECAY RATE** setting, to a level still well above the **FREQ DECAY PICKUP**. The Pickup LED should remain off.
- ▷ Continue dropping the  $V_a$  frequency at a speed greater than the **FREQ DECAY RATE**. When the frequency drops below the **FREQ DECAY PICKUP**, the Pickup LED will come on.

The following procedure checks the Frequency Decay Rate:

- ▷ With the  $V_a$  frequency at a level well below the **FREQ DECAY PICKUP**, drop the frequency of  $V_a$  at a speed less than the **FREQ DECAY RATE** setting. The pickup indicator should remain off.
- ▷ With the  $V_a$  frequency at a level well below the **FREQ DECAY PICKUP**, drop the frequency of  $V_a$  at a speed greater than the **FREQ DECAY RATE** setting. The pickup indicator will come on.

The following procedure checks Blocking From Logic Inputs:

- ▷ Decrease the  $V_a$  frequency at a rate to cause a pickup.
- ▷ Assert a logic input to provide a “Block Frequency Decay”. The Pickup LED should immediately go out.

- ▷ Repeat Steps 1 and 2 for logic input “Block 1 Trip Relay” as required.

The following procedure checks the Frequency Decay Timing:

- ▷ Connect the Stop Trigger.
- ▷ Preset the ramp-rate to a minimum of 110% of the pickup and reset the timer.
- ▷ Inject the preset voltage into the  $V_a$  bus voltage input and note the measured delay time. Reset the timer.
- ▷ Repeat the last step four more times and obtain an average of the time intervals.
- ▷ Disconnect the Stop Trigger.

#### 7.4.8 Breaker Failure

To test Breaker Failure, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25. This element has no Trip function.

- ▷ Ensure the wiring to the circuit breaker trip and close circuits is complete.
- ▷ Energize the breaker trip and close circuits and close the breaker.
- ▷ Carefully disconnect a wire to open the trip circuit.
- ▷ Set a test current level 3% above the **BRKR FAILURE CURRENT** setpoint and inject current into a phase current input (all overcurrent protection features are “Disabled”).
- ▷ 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.
- ▷ Reduce the current magnitude to 3% below the **BRKR 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.

#### 7.4.9 Reverse Power

To test the Reverse Power element, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25.

The following procedure tests Pickup for the Reverse Power element:

- ▷ Apply a three phase nominal voltage to the relay.
- ▷ Adjust the phase angle between the voltage and current to be 180°.
- ▷ Inject current into all three phases and increase slowly until Reverse Power operates.  
Note the pickup value.

- ▷ Calculate the power value from the following formula:  
 $P = \sqrt{3} \times VI \cos(\theta)$ , where  $V$  is the primary line to line voltage,  $I$  is the pickup value expressed as a primary value, and  $\cos(\theta)$  is  $\cos 180^\circ$  (in this case, 1.0).
- ▷ Express the measured power as a percentage of the rated power calculated using rated values in the above equation.  
The value should be within specifications for this element.
- ▷ Adjust the phase angle to  $100^\circ$ ,  $120^\circ$ ,  $240^\circ$ , and  $260^\circ$ , checking the current pickup value for each angle.  
Calculate the relay pickup power for each angle using the formula given above.

The following procedure tests the Blocking From Logic Inputs for Reverse Power:

- ▷ Cause the reverse power element to pickup.
- ▷ Assert a logic input to provide a “Block Reverse Power”.  
The Pickup LED should immediately go out.
- ▷ Repeat Steps 1 and 2 for logic input “Block 1 Trip Relay” as required.

The following procedure checks Timing for the Reverse Power Element:

- ▷ Connect the Stop Trigger.
- ▷ Preset the input voltage and current to provide a reverse real power which is 150% of pickup.
- ▷ Inject the preset voltage and current and note the measured delay time.
- ▷ Reset the timer.
- ▷ Repeat last 2 steps four more times and obtain an average of the time intervals.
- ▷ Disconnect the Stop Trigger.



## 7.5 Monitoring

### 7.5.1 Current Monitoring

#### Phase Current Level

To test Phase Current monitoring, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25, except that this element has no Trip function.

- ▷ Set the Delay time to 0.
- ▷ Inject current at a level below the pickup level into Phase A.
- ▷ Slowly increase the current until pickup is reached and the element generates an output.
- ▷ Slowly reduce the current until the element resets, which should be 2% of CT less than pickup when pickup  $\leq$  CT or 97 to 98% of pickup when pickup  $>$  CT.
- ▷ Repeat Steps 2 to 4 for phase B and C current.
- ▷ Set the Delay timer to the required setting.

The following procedure checks the Phase Current Level Timing:

- ▷ Set the test source to a current at least 110% of pickup.  
Turn off and reset the timer.
- ▷ Inject current into the relay and measure the time to operate.
- ▷ Repeat Step 2 four more times and obtain an average of the time intervals
- ▷ Disconnect the Stop Trigger.

#### Neutral Current Level

To test Neutral Current monitoring, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The testing for this element is the same as outlined above for Phase Current Level, except that current is the residual current injected into the phase current inputs.

### 7.5.2 Fault Locator

To test the Fault Locator, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5.



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 A 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 A unit.

Model Impedances ( $\Omega$ )	$Z_{POS} = Z_{NEG}$	$Z_{ZERO}$
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 $\angle$ 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.

- ▷ Program the test set with the following pre-fault voltages and currents.
- ▷  $V_{an} = 67.8\angle 0^\circ$ ;  $V_{bn} = 67.8\angle 240^\circ$ ;  $V_{cn} = 67.8\angle 120^\circ$ ;  $I_a = 2.9\angle 330^\circ$ ;  $I_b = 2.9\angle 210^\circ$ ;  $I_c = 2.9\angle 90^\circ$
- ▷ Program the test set with the following fault voltages and currents.  
This fault is from Phase A to ground, placed 5.0 km from the relay.
- ▷  $V_{an} = 59.0\angle 0^\circ$ ;  $V_{bn} = 67.4\angle 241^\circ$ ;  $V_{cn} = 67.4\angle 121^\circ$ ;  $I_a = 13.0\angle 286^\circ$ ;  $I_b = 2.9\angle 210^\circ$ ;  $I_c = 2.9\angle 90^\circ$
- ▷ Inject the pre-fault 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  $\Omega$ ).
- ▷ Program the test set with the following fault voltages and currents.  
This fault is Phase B to ground, 6.0 km from the relay.
- ▷  $V_{an} = 67.4\angle 2^\circ$ ;  $V_{bn} = 60.3\angle 242^\circ$ ;  $V_{cn} = 67.4\angle 122^\circ$ ;  $I_a = 2.9\angle 330^\circ$ ;  $I_b = 12.0\angle 166^\circ$ ;  $I_c = 2.9\angle 90^\circ$
- ▷ Inject the pre-fault 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  $\Omega$ ).
- ▷ Program the test set with the following fault voltages and currents.  
This fault is Phase C to ground, placed 7.0 km from the relay.
- ▷  $V_{an} = 67.4\angle 2^\circ$ ;  $V_{bn} = 67.4\angle 242^\circ$ ;  $V_{cn} = 61.3\angle 120^\circ$ ;  $I_a = 2.9\angle 330^\circ$ ;  $I_b = 2.9\angle 210^\circ$ ;  $I_c = 9.9\angle 47^\circ$
- ▷ Inject the pre-fault 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  $\Omega$ ).
- ▷ Program the test set with the following fault voltages and currents.  
This fault is Phase A to C, 8.0 km from the relay.
- ▷  $V_{an} = 60.4\angle 4^\circ$ ;  $V_{bn} = 67.4\angle 242^\circ$ ;  $V_{cn} = 61.7\angle 117^\circ$ ;  $I_a = 11.4\angle 253^\circ$ ;  $I_b = 2.9\angle 210^\circ$ ;  $I_c = 11.4\angle 73^\circ$
- ▷ Inject the pre-fault 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  $\Omega$ ).
- ▷ Program the test with the following fault voltages and currents.  
This fault is Phase A to B, placed 9.0 km from the relay.
- ▷  $V_{an} = 62.2\angle 358^\circ$ ;  $V_{bn} = 61.0\angle 244^\circ$ ;  $V_{cn} = 67.4\angle 122^\circ$ ;  $I_a = 10.3\angle 313^\circ$ ;  $I_b = 10.3\angle 133^\circ$ ;  $I_c = 2.9\angle 90^\circ$

- ▷ 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  $\Omega$ ).
- ▷ Program the test with the following fault voltages and currents.  
This fault is Phase A to B to C, 10.0 km from the relay.
- ▷  $V_{an} = 60.3\angle 0^\circ$ ;  $V_{bn} = 60.3\angle 240^\circ$ ;  $V_{cn} = 60.3\angle 120^\circ$ ;  $I_a = 10.8\angle 283^\circ$ ;  $I_b = 10.8\angle 163^\circ$ ;  $I_c = 10.8\angle 43^\circ$
- ▷ 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  $\Omega$ ).

### 7.5.3 Demand Monitoring

#### Current Demand

To test Current Demand, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25, except that this element has no Trip function.

- ▷ Clear demand data registers before starting this test.
- ▷ 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.

#### Real Power Demand

To test Real Power Demand, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25, except that this element has no Trip function.

- ▷ Clear demand data registers before starting this test.
- ▷ 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.

#### Reactive Power Demand

To test Reactive Power Demand, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25, except that this element has no Trip function.

- ▷ Clear demand data registers before starting this test.
- ▷ 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.

### Apparent Power Demand

To test Apparent Power Demand, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25, except that this element has no Trip function.

- ▷ Clear demand data registers before starting this test.
- ▷ 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.

## 7.5.4 Analog Inputs

### Analog Threshold

- ▷ Inject DC mA current at a level below the pickup level into the analog input.
- ▷ Slowly increase the current until the element generates an output. Slowly reduce the current until the element reset.

The following procedure tests Analog Threshold Timing:

- ▷ Connect the Stop Trigger.
- ▷ Preset the DC mA current source to a minimum of 110% of the pickup current.
- ▷ Turn the current off, and reset the timer.
- ▷ Inject the preset current into the analog input and note the measured delay time.
- ▷ Reset the timer.
- ▷ Repeat Step 3 four more times and obtain an average of the time intervals.
- ▷ Disconnect the Stop Trigger.

### Analog In Rate

The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25, except that this element has no Trip function.

- ▷ Connect the output of a DC ramping-current generator to the analog input.
- ▷ Remove the power supply from the relay to ensure the analog input memory is set to zero, then re-apply power.
- ▷ 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.
- ▷ 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.

The following procedure tests Analog Input Rate Timing:

- ▷ Connect the Stop Trigger.
- ▷ Preset the ramp-rate to a minimum of 110% of the pickup.
- ▷ Turn the current off, and reset the timer.
- ▷ Inject the preset current into the analog input and note the measured delay time.
- ▷ Reset the timer.
- ▷ Repeat Step 3 four more times and obtain an average of the time intervals.
- ▷ Disconnect the Stop Trigger.

### 7.5.5 Overfrequency Monitoring

To test Overfrequency monitoring, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25, except that this element has no Trip function.

- ▷ Inject voltage at a frequency below the pickup level into Phase A.
- ▷ Slowly increase the frequency until the element generates an output.
- ▷ Slowly reduce the frequency until the element resets.

The following procedure checks the Overfrequency monitoring Timing:

- ▷ Connect the Stop Trigger.
- ▷ Preset the voltage source frequency to a minimum of 110% of pickup.
- ▷ Turn voltage off and reset the timer.
- ▷ Inject the preset voltage into phase A and note the measured delay time.
- ▷ Reset the timer.
- ▷ Repeat Step 3 four more times and obtain an average of the time intervals.
- ▷ Disconnect the “Stop Trigger”.

### 7.5.6 Power Factor

To test Power Factor monitoring, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The Indications and Operations are as outlined for *Phase TOC 1* on page 7-25, except that this element has no Trip function.

The following procedure checks Minimum Operating Voltage/Current Supervision:

- ▷ Inject fixed values of voltage and current at about nominal values, at unity power factor.
- ▷ Slowly increase the lagging current angle, waiting for a time longer than the delay before each adjustment, until the element generates an output.
- ▷ 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.
- ▷ Repeat step 3 for  $V_b$ .
- ▷ Repeat step 3 for  $V_c$ .
- ▷ Slowly reduce  $I_a$  and  $I_b$  magnitude to 0.  
The power factor feature should remain operated.
- ▷ Slowly reduce  $I_c$  magnitude to 0.  
The power factor feature should reset.
- ▷ Return  $I_a$  to nominal.  
The power factor feature should operate again. Return  $I_b$  and  $I_c$  to nominal.
- ▷ Decrease the angle of lagging (balanced) current until the feature drops-out and resets the output relays.

The following procedure checks Power Factor Timing:

- ▷ Connect the Stop Trigger.
- ▷ 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.
- ▷ Inject the preset voltage and current and note the measured delay time.
- ▷ Reset the timer.
- ▷ Repeat step 3 four more times and obtain an average of the time intervals.
- ▷ Disconnect the “Stop Trigger”.

### 7.5.7 VT Failure

To test VT Failure monitoring, use the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5.

- ▷ Set  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage at  $0^\circ$ ,  $120^\circ$ , and  $240^\circ$  respectively, and inject into the relay.  
With these balanced voltages  $120^\circ$  apart, the positive sequence voltage ( $V_1$ ) is greater than  $0.05 \times VT$ .
- ▷ Set  $I_a = I_b = I_c = 1 \times CT$  at  $0^\circ$ ,  $120^\circ$ , and  $240^\circ$  respectively, and inject into the relay.  
With these balanced currents  $120^\circ$  apart, the positive sequence current ( $I_1$ ) is greater than  $0.05 \times CT$ .

- ▷ Remove the balanced voltages so the positive sequence voltage ( $V_1$ ) is less than  $0.05 \times V_T$ .  
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 LEDs are flashing, the VT Failure alarm message is displayed, and any output relays programmed for this condition are operated.
- ▷ Apply the balanced voltages and the VT Failure condition should reset.
- ▷ 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 last 3 steps for  $V_{bn}$  and  $V_{cn}$ .
- ▷ With  $V_{an} = V_{bn} = V_{cn}$  returned to nominal voltage at  $0^\circ$ ,  $120^\circ$ , and  $240^\circ$  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 last 3 steps for  $I_b$  and  $I_c$ .

### 7.5.8 Trip Coil Monitor

The Indications and Operations for the Trip Coil Monitor are as outlined for *Phase TOC 1* on page 7–25, except that this element has no Trip function.

- ▷ Ensure the wiring to the circuit breaker trip and close circuits is complete.
- ▷ Energize the breaker trip and close circuits and close the breaker.
- ▷ Carefully disconnect a wire to open the trip circuit.  
After 5 seconds the element should generate an output.
- ▷ Restore the open circuit and the element should reset.
- ▷ If the Open Breaker permissive is “Enabled”, and the trip circuit wiring has been arranged to permit this operation, open the breaker.
- ▷ Repeat last 2 steps.

### 7.5.9 Close Coil Monitor

The Indications and Operations for the Close Coil Monitor are as outlined for *Phase TOC 1* on page 7–25, except that this element has no Trip function.

- ▷ Ensure the wiring to the circuit breaker trip and close circuits is complete.
- ▷ Energize the breaker trip and close circuits and open the breaker.
- ▷ Carefully disconnect a wire to open the close circuit.  
After 5 seconds the element should generate an output.

- ▷ Restore the open circuit and the element should reset.
- ▷ If the Closed Breaker permissive is “Enabled”, and the close circuit wiring has been arranged to permit this operation, close the breaker.
- ▷ Repeat last 2 steps.

### 7.5.10 Breaker Operation Failure

The Indications and Operations for the Breaker Operation Failure are as outlined for *Phase TOC 1* on page 7–25, except that this element has no Trip function.

- ▷ Ensure the wiring to the circuit breaker trip and close circuits is complete.
- ▷ Energize the breaker trip and close circuits and open the breaker.
- ▷ 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).
- ▷ Restore the open circuit and reset the relay.
- ▷ Close the breaker.
- ▷ 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)
- ▷ Restore the open circuit and reset the relay.
- ▷ 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.

### 7.5.11 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 from GE Multilin for those users wishing to perform this test. We suggest the following procedure to confirm this element is operational.

The Indications and Operations for the Arcing Current are as outlined for *Phase TOC 1* on page 7–25, except that this element has no Trip function.

- ▷ 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 overcurrent element tests, with current maintained after the Trip command, until this element generates an output.
- ▷ Be sure to reset the Total Arcing Current memory and setpoint at the end of this test.



### 7.5.12 Analog Output Channels

- ▷ Connect a milli-ammeter to channel output terminals as required.
- ▷ Follow the test procedures previously outlined for the channel parameter observing the output on the milli-ammeter.

### 7.5.13 IRIG-B

- ▷ Disconnect the IRIG-B input to the relay from the signal source.
- ▷ Under **SI RELAY SETUP** ▷ **CLOCK** manually set the relay date and time to incorrect values.
- ▷ Under **AI STATUS** ▷ **CLOCK** check that the relay has accepted the programmed date and time.
- ▷ Set the **IRIG-B TIME SYNC** setpoint to the required signal type - the relay should display the **IRIG-B FAILURE** self-test warning.
- ▷ Connect the IRIG-B input from the signal source to the relay and check the signal is available at the relay terminals.
- ▷ The **IRIG-B FAILURE** self-test warning should be removed from the display.
- ▷ Under **AI STATUS** ▷ **CLOCK** check that the relay clock now displays the correct date and time.

### 7.5.14 Pulse Output

- ▷ Inject quantity to be used to provide a pulse output.
- ▷ 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.

## 7.6 Control Schemes

### 7.6.1 Setpoint Group Control

Make the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5.



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 initially uses Group 1 as indicated by the faceplate LED.

- ▷ Change the **S7 CONTROL** ▷ **SETPOINT GROUPS** ▷ **ACTIVE SETPOINT GROUP** setpoint to “Group 2” and the **EDIT SETPOINT GROUP** setpoint in the same menu to “Active Group”.  
The faceplate LEDs should now indicate the relay is using Setpoint Group 2.
- ▷ Change at least one protection element setpoint from the setting in Group 1.
- ▷ 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.
- ▷ Check that the operation of the protection feature programmed is controlled by the setting in group 4.
- ▷ Change the **S7 CONTROL** ▷ **SETPOINT GROUPS** ▷ **ACTIVE SETPOINT GROUP** setpoint to “Group 3”.  
The LED on the faceplate should now indicate the relay is using Setpoint Group 3.
- ▷ Check that the operation of the protection feature programmed is controlled by the setting in Group 3.
- ▷ Change the **S7 CONTROL** ▷ **SETPOINT GROUPS** ▷ **ACTIVE SETPOINT GROUP** setpoint to “Group 2”.  
The LED on the faceplate should now indicate the relay is using Setpoint Group 2.
- ▷ Check that the operation of the protection feature programmed is controlled by the setting in Group 2.
- ▷ Change the **S7 CONTROL** ▷ **SETPOINT GROUPS** ▷ **ACTIVE SETPOINT GROUP** setpoint to Group 1.  
The LED on the faceplate should now indicate the relay is using Setpoint Group 1.
- ▷ Check that the operation of the protection feature programmed is controlled by the setting in Group 1.
- ▷ Assert logic input Setpoint Group 2, and check that the LED indicator shows Setpoint Group 2.
- ▷ Assert logic input Setpoint Group 3, and check that the LED indicator shows Setpoint Group 3.

- ▷ Assert logic input Setpoint Group 4, and check that the LED indicator shows Setpoint Group 4.
- ▷ De-assert logic input Setpoint Group 4, and check that the LED indicator shows Setpoint Group 3.
- ▷ De-assert logic input Setpoint Group 3, and check that the LED indicator shows Setpoint Group 2.
- ▷ De-assert logic input Setpoint Group 2, and check that the LED indicator shows Setpoint Group 1.
- ▷ Check that the changing of setpoint groups is placed in the event recorder.

If the **BRKR OPEN INHIBIT** setpoint is to be “Enabled”:

- ▷ Assert a breaker state logic input so that the relay determines the breaker is closed.
- ▷ Assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is using Setpoint Group 2.
- ▷ De-assert the breaker state logic input so that the relay determines the breaker is open.
- ▷ De-assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is still using Setpoint Group 2.
- ▷ Assert the breaker state logic input so that the relay determines the breaker is closed.  
The faceplate LED should indicate the relay is now using Setpoint Group 1.

If the **OVERCURRENT P/U INHIBIT** setpoint is to be “Enabled”:

- ▷ Assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is using Setpoint Group 2.
- ▷ Inject current above the pickup setting of an overcurrent element that is not Disabled.
- ▷ De-assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is still using Setpoint Group 2.
- ▷ Reduce the injected current until the overcurrent element resets.  
The LED on the faceplate should indicate the relay is now using Setpoint Group 1.
- ▷ Turn current off.

If the **OVERVOLT P/U INHIBIT** setpoint is to be “Enabled”:

- ▷ Assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is using Setpoint Group 2.
- ▷ Inject voltage above the pickup setting of an overvoltage element that is not Disabled.

- ▷ De-assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is still using Setpoint Group 2.
- ▷ Reduce the injected voltage until the overvoltage element resets.  
The LED on the faceplate should indicate the relay is now using Setpoint Group 1.
- ▷ Turn voltage off.

If the **UNDERVOLT P/U INHIBIT** setpoint is to be “Enabled”:

- ▷ Inject voltage above the pickup setting of an undervoltage element that is not Disabled.
- ▷ Assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is using Setpoint Group 2.
- ▷ Reduce voltage below the pickup setting of an undervoltage element that is not Disabled.
- ▷ De-assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is still using Setpoint Group 2.
- ▷ Increase the injected voltage until the undervoltage element resets.  
The LED on the faceplate should indicate the relay is now using Setpoint Group 1.
- ▷ Turn voltage off.

If the **UNDERFREQ P/U INHIBIT** setpoint is to be “Enabled”:

- ▷ Inject voltage with frequency above the pickup setting of an underfrequency element that is not Disabled.
- ▷ Assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is using Setpoint Group 2.
- ▷ Reduce frequency below the pickup setting of an underfrequency element that is not Disabled.
- ▷ De-assert logic input Setpoint Group 2.  
The faceplate LED should indicate the relay is still using Setpoint Group 2.
- ▷ Increase the injected frequency until the underfrequency element resets.  
The LED on the faceplate should indicate the relay is now using Setpoint Group 1.
- ▷ Turn voltage off.

## 7.6.2 Synchrocheck

- ▷ Make the test connections specified in FIGURE 7–1: *Relay Test Wiring – Wye Connection* or FIGURE 7–2: *Relay Test Wiring – Delta Connection* on page 7–5 and also connect a variable voltage source to the line voltage input.

- ▷ Initially set the function setpoint to Control, the Dead Source Permissive setpoint to Off and the Maximum Voltage Difference setpoint to 100 kV.
- ▷ As there are no input voltages, any selected output relays should now be operated along with the Out Of Sync control message.
- ▷ Change the function setting to Alarm.  
The alarm message and LED should be displayed, and any selected output relays should remain operated.
- ▷ Inject a balanced three-phase voltage at nominal voltage and frequency into the bus voltage input.
- ▷ 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  $\Delta V$  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.
- ▷ 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**.
- ▷ Inject voltage and frequency into the line voltage input and adjust this voltage until  $\Delta V$ ,  $\Delta F$  and  $\Delta F$  as shown under subheading **A2 METERING ▷ VOLTAGE ▷ SYNCHRO DELTA** are all 0.
- ▷ Reduce the line voltage magnitude to 0.  
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.
- ▷ 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.
- ▷ Enter the required setting of **MAX VOLTAGE DIFFERENCE**.  
The “Out of Sync” alarm will be displayed as the voltage difference is above the maximum difference requirement.

- ▷ While monitoring  $\Delta V$  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.
- ▷ Set the bus voltage magnitude to nominal, and the line voltage to a level above the minimum required voltage.
- ▷ The “Out of Sync” alarm will be displayed as the voltage difference is above the maximum difference requirement.
- ▷ While monitoring  $\Delta V$  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.
- ▷ Set both line and bus voltage magnitude and frequency to nominal.  
Adjust the line voltage phase position to lag the bus voltage by  $180^\circ$ .
- ▷ The “Out of Sync” alarm will be displayed as the angle difference is above the maximum difference requirement.
- ▷ While monitoring  $\Delta F$  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  $0^\circ$ .
- ▷ Set the line voltage frequency to a value lower than allowed by the maximum frequency difference.
- ▷ While monitoring  $\Delta F$  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.
- ▷ Set the line voltage to a frequency higher than permitted by the maximum frequency difference.
- ▷ The “Out of Sync” alarm will be displayed as the frequency difference is above the maximum difference requirement.
- ▷ While monitoring  $\Delta F$  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 **MAX VOLTAGE DIFFERENCE**, **MAX ANGLE DIFFERENCE**, and **MAX FREQ DIFFERENCE** setpoints to the minimum values; and the **DEAD SOURCE PERMISSIVE**, **DEAD BUS MAX VOLTAGE**, **DEAD LINE MAX VOLTAGE**, **LIVE BUS MIN VOLTAGE**, and **LIVE LINE MIN VOLTAGE** setpoints to the required settings.

For a **DEAD SOURCE PERMISSIVE** setpoint of “DB & DL”, perform the following steps:

- ▷ Set the bus voltage to a magnitude above the dead-bus level, and nominal frequency and inject into the relay.
- ▷ Set the line voltage to a magnitude above the dead-line level,  $180^\circ$  out-of-phase with the bus voltage, at the same frequency, and inject into the relay.  
This ensures that 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.

- ▷ Turn the bus voltage off.  
The “Out of Sync” alarm will be displayed as line voltage is above the dead limit.
- ▷ 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.
- ▷ The “Out of Sync” alarm will be displayed as both the bus and line voltages are above their dead-setting limits.
- ▷ Turn the line voltage off.  
The “Out of Sync” alarm will be displayed.
- ▷ 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:

- ▷ 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.
- ▷ The “Out of Sync” alarm will be displayed as the bus voltage is above its dead-setting limit.
- ▷ 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.
- ▷ 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.

For a **DEAD SOURCE PERMISSIVE** setpoint of “DL & LB”, perform the following steps:

- ▷ 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.
- ▷ The “Out of Sync” alarm will be displayed as the line voltage is above its dead-setting limit.

- ▷ Slowly reduce the line voltage magnitude until the “Out of Sync” alarm is no longer displayed.  
This should be at the **DEAD LINE MAX VOLTAGE** limit.
- ▷ Turn both voltages off.
- ▷ The “Out of Sync” alarm will be displayed as the bus voltage is below its minimum voltage setting limit.
- ▷ 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:

- ▷ 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 that synchronism cannot be achieved.
- ▷ The “Out of Sync” alarm will be displayed as both voltages are above the dead-setting limits.
- ▷ Slowly reduce the line voltage magnitude until the “Out of Sync” alarm is no longer displayed.  
This should be at the **DEAD LINE MAX VOLTAGE** limit.
- ▷ Increase the line voltage to nominal magnitude.
- ▷ 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:

- ▷ Set the bus voltage to a magnitude above the **DEAD BUS MAX VOLTAGE** limit and below the **LIVE BUS MIN VOLTAGE** limit at nominal frequency and inject into the relay.
- ▷ Set the line voltage to a magnitude above the minimum live-line limit, 180° out-of-phase with the bus voltage, at the same frequency, and inject into the relay.  
This ensures that synchronism cannot be achieved.  
The “Out of Sync” alarm will be displayed.
- ▷ Slowly decrease the bus voltage magnitude until the “Out of Sync” alarm is no longer displayed.  
This should be just below the **DEAD BUS MAX VOLTAGE** limit.
- ▷ Slowly decrease the line voltage magnitude until the “Out of Sync” alarm is again displayed.  
This should be just below the **LIVE BUS MIN VOLTAGE** limit.



- ▷ Decrease the line voltage magnitude to below the **DEAD LINE MAX VOLTAGE** limit.  
The “Out of Sync” alarm should remain displayed.
- ▷ Increase the bus voltage magnitude to above the **LIVE LINE MIN VOLTAGE** limit at which point the “Out of Sync” alarm is no longer displayed.
- ▷ 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.

### 7.6.3 Manual Close Feature Blocking

Make the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The following procedure checks the Manual Close Function and Timer Control:

- ▷ Assert the 52a (or 52b) Contact logic input to simulate an open breaker.
- ▷ 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.
- ▷ 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.

The procedures below check the control of overcurrent protection features. Use the following procedure to check Phase IOC 1 Blocking:

- ▷ 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.
- ▷ 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 LED coming on, at the end of the programmed Manual Close Block Time.
- ▷ Turn the current off.  
The time interval can be checked in the Event Recorder.

For Neutral IOC 1 Blocking, Ground IOC Blocking, Sensitive Ground IOC Blocking, and Neg Seq IOC Blocking, follow the procedure described for Phase IOC 1 Blocking above, injecting current as appropriate.

The following procedure checks Phase TOC 1 Raised Pickup:

- ▷ Ensure all other overcurrent features are “Disabled”.  
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.
- ▷ Apply a Close command, as described above, and immediately inject the test current into the relay.  
Phase TOC will not pickup as the pickup current is raised.
- ▷ Increase the injection current until the Pickup LED 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.
- ▷ Set a test current to a level between the normal pickup setting and the raised setting, then turn the current off.
- ▷ Apply a Close command, as described above, and immediately inject the test current into the relay.  
Phase TOC will not pickup as the pickup current is raised.
- ▷ At the end of the programmed **MANUAL CLOSE BLOCK TIME**, the Pickup LED should come on, as the pickup setting has returned to normal.  
When this happens, reduce the injection current until the Pickup LED goes out.  
The **MANUAL CLOSE BLOCK TIME** can be checked in the Event Recorder.

For Neutral TOC 1 Raised Pickup, Ground TOC Raised Pickup, Sensitive Ground TOC Raised Pickup, and Neg Seq TOC Raised Pickup, follow the procedure outlined for Phase TOC 1 Raised Pickup above, injecting current as appropriate.

To check the Select Setpoint Group function, 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.

#### 7.6.4 Cold Load Pickup Blocking

Make the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The following procedure checks the Cold Load Pickup Function and Timer Control:

- ▷ Enable the **COLD LOAD PICKUP** setpoint to cause the relay to go into cold load pickup operation after the **OUTAGE TIME BEFORE COLD LOAD** setpoint 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.
- ▷ 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.

- ▷ 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.

The procedures below check the control of overcurrent protection features. The following checks Phase IOC 1 Blocking:

- ▷ 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.
- ▷ 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 LED coming on at the end of the programmed **COLD LOAD PICKUP BLOCK** time.
- ▷ Turn the current off.  
The time interval can be checked in the Event Recorder.

For Neutral IOC 1 Blocking, Ground IOC Blocking, Sensitive Ground IOC Blocking, and Neg Seq IOC Blocking, follow the procedure described above for Phase IOC 1 Blocking, injecting current as appropriate.

The following procedure checks Phase TOC 1 Raised Pickup for Cold Load Blocking:

- ▷ Ensure all other overcurrent features are “Disabled”.  
  
(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.
- ▷ Assert a Cold Load Pickup logic input and immediately inject the test current into the relay.  
Phase TOC 1 will not pickup as the pickup current is raised.
- ▷ Increase the injection current until the Pickup LED 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.
- ▷ Set a test current to a level between the normal pickup setting and the raised setting, then turn the current off.
- ▷ Assert a Cold Load Pickup logic input and immediately inject the test current into the relay.  
Phase TOC 1 will not pickup as the pickup current is raised.  
At the end of the programmed **COLD LOAD PICKUP BLOCK TIME** the Pickup LED should come on, as the pickup setting has returned to normal.

- ▷ When this happens, reduce the injection current until the Pickup LED goes out.  
The **COLD LOAD PICKUP BLOCK TIME** interval can be checked in the Event Recorder.

For Neutral TOC 1 Raised Pickup, Ground TOC Raised Pickup, Sensitive Ground TOC Raised Pickup, and Neg Seq TOC Raised Pickup, follow the procedure outlined for Phase TOC 1 Raised Pickup, injecting current as appropriate.

To check the Select Setpoint Group for Cold Load Blocking, 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.

### 7.6.5 Undervoltage Restoration

#### Description

Make the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The following procedure checks Logic and Timers for Undervoltage Restoration:

- ▷ Program the Undervoltage 1 function as “Trip” and the Undervoltage 2 function as “Disabled”.
- ▷ Assert or De-assert a logic input to simulate a closed breaker.
- ▷ Inject a balanced three-phase voltage at nominal voltage and frequency into the bus voltage input.
- ▷ Initially set the undervoltage restoration function setpoint to Alarm, and other setpoints as required.
- ▷ 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.
- ▷ Assert or De-assert a logic input to simulate an open breaker, initiating undervoltage restoration.  
The diagnostic alarm message and LED should be displayed, and output relays programmed to operate for this condition should operate.
- ▷ 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.
- ▷ 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.
- ▷ 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.

- ▷ Return the reduced voltage to nominal, resetting both the undervoltage trip condition and undervoltage restoration.
- ▷ 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.
- ▷ 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.
- ▷ Arrange the interval timer to start on appearance of voltage and stop when the Close Relay operates.
- ▷ Turn the voltage off to cause an Undervoltage 1 trip, then reset the timer.
- ▷ Turn the voltage on.  
The Close Relay should operate after the delay programmed in setpoint Undervolt Restore Delay.
- ▷ If the 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 2 through 7.

### For Wye VTs

Make the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* on page 7-4. The following procedure checks Minimum Voltage with One Phase For Operation:

- ▷ Assert or De-assert a logic input to simulate an open breaker.
- ▷ Set **UNDervOLT RESTORE DELAY** to “0”.
- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{bn}$  and  $V_{cn}$  to “0”.
- ▷ Slowly raise  $V_{an}$  until the Close Relay operates.  
This is the operating level of the **UNDervOLT RESTORE MIN VOLTS** setpoint for  $V_{an}$ .
- ▷ Repeat last 3 steps, except adjust  $V_{bn}$  and  $V_{cn}$  in turn.

The following procedure checks Minimum Voltage with Two Phases For Operation:

- ▷ Assert or De-assert a logic input to simulate an open breaker.
- ▷ Set **UNDervOLT RESTORE DELAY** to “0”.
- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{bn}$  to 0 and  $V_{cn}$  to nominal.

- ▷ Slowly raise  $V_{an}$  until the Close Relay operates.  
This is the operating level of the **UNDervOLT RESTORE MIN VOLTS** setpoint for  $V_{an}$  with  $V_{cn}$ .
- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{cn}$  to 0 and  $V_{bn}$  to nominal.
- ▷ Slowly raise  $V_{an}$  until the Close Relay operates.  
This is the operating level of the **UNDervOLT RESTORE MIN VOLTS** setpoint for  $V_{an}$  with  $V_{bn}$ .
- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{cn}$  to 0 and  $V_{an}$  to nominal.
- ▷ Slowly raise  $V_{bn}$  until the Close Relay operates.  
This is the operating level of the **UNDervOLT RESTORE MIN VOLTS** setpoint for  $V_{bn}$  with  $V_{an}$ .
- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{an}$  to 0 and  $V_{cn}$  to nominal.
- ▷ Slowly raise  $V_{bn}$  until the Close Relay operates.  
This is the operating level of the **UNDervOLT RESTORE MIN VOLTS** setpoint for  $V_{bn}$  with  $V_{cn}$ .
- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{an}$  to 0 and  $V_{bn}$  to nominal.
- ▷ Slowly raise  $V_{cn}$  until the Close Relay operates.  
This is the operating level of the **UNDervOLT RESTORE MIN VOLTS** setpoint for  $V_{cn}$  with  $V_{bn}$ .
- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{bn}$  to 0 and  $V_{an}$  to nominal.
- ▷ Slowly raise  $V_{cn}$  until the Close Relay operates.  
This is the operating level of the **UNDervOLT RESTORE MIN VOLTS** setpoint for  $V_{cn}$  with  $V_{an}$ .

The following procedure checks Minimum Voltage with Three Phases For Operation:

- ▷ Assert or De-assert a logic input to simulate an open breaker.
- ▷ Set **UNDervOLT RESTORE DELAY** to “0”.

- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{an}$  and  $V_{cn}$  to nominal.
- ▷ Slowly raise  $V_{an}$  until the Close Relay operates.  
This is the operating level of **UNDervOLT RESTORE MIN VOLTS** for  $V_{an}$ .
- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{an}$  and  $V_{cn}$  to nominal.
- ▷ Slowly raise  $V_{bn}$  until the Close Relay operates.  
This is the operating level of **UNDervOLT RESTORE MIN VOLTS** for  $V_{bn}$ .
- ▷ Inject  $V_{an} = V_{bn} = V_{cn} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{an}$  and  $V_{bn}$  to nominal.
- ▷ Slowly raise  $V_{cn}$  until the Close Relay operates.  
This is the operating level of **UNDervOLT RESTORE MIN VOLTS** for  $V_{cn}$ .

### For Delta VTs

Make the test connections specified in FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The following procedure checks Minimum Voltage with One Phase For Operation:

- ▷ Assert or De-assert a logic input to simulate an open breaker.
- ▷ Set **UNDervOLT RESTORE DELAY** to 0.
- ▷ Inject  $V_{ab} = V_{cb} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{cb}$  to 0 V.
- ▷ Slowly raise  $V_{ab}$  until the Close Relay operates.  
This is the operating level of **UNDervOLT RESTORE MIN VOLTS** for  $V_{ab}$ .
- ▷ Repeat Steps 3 through 5 except adjust  $V_{cb}$ .

The following procedure checks Pickup with Two or Three Phases For Operation:

- ▷ Assert or De-assert a logic input to simulate an open breaker.
- ▷ Set **UNDervOLT RESTORE DELAY** to 0.
- ▷ Inject  $V_{ab} = V_{cb} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{cb}$  to nominal.
- ▷ Slowly raise  $V_{ab}$  until the Close Relay operates.  
This is the operating level of **UNDervOLT RESTORE MIN VOLTS** for  $V_{ab}$ .

- ▷ Inject  $V_{ab} = V_{cb} =$  nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected voltages to cause an undervoltage trip, then set  $V_{ab}$  to nominal.
- ▷ Slowly raise  $V_{cb}$  until the Close Relay operates.  
This is the operating level of **UNDERVOLT RESTORE MIN VOLTS** for  $V_{cb}$ .

### 7.6.6 Underfrequency Restoration

Make the test connections specified in FIGURE 7-1: *Relay Test Wiring – Wye Connection* or FIGURE 7-2: *Relay Test Wiring – Delta Connection* on page 7-5. The following procedure checks Logic and Timers for Underfrequency Restoration:

- ▷ Program the **UNDERFREQ 1 FUNCTION** as “Trip”, **MIN VOLTAGE** as “0”, and **UNDERFREQ 2 FUNCTION** as “Disabled”.
- ▷ Assert or De-assert a logic input to simulate a closed breaker.
- ▷ Inject a voltage at nominal voltage and frequency into the bus voltage Phase A input.
- ▷ Initially set **UNDERFREQ RESTORATION** setpoint to Alarm, and other setpoints as required.
- ▷ 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.
- ▷ 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.
- ▷ Change the **UNDERFREQ RESTORE FUNCTION** setpoint to “Control”, and the diagnostic message should change to control and the Alarm LED should turn off.  
Return this setpoint to “Alarm”.
- ▷ 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.
- ▷ 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.
- ▷ Return the reduced frequency to nominal, resetting both the underfrequency trip condition and underfrequency restoration.
- ▷ 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.



- ▷ 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.
- ▷ Arrange the interval timer to start on appearance of voltage and stop when the Close Relay operates.
- ▷ Turn the voltage, of a frequency to cause an Underfrequency 1 trip, off.
- ▷ Reset the timer.
- ▷ Turn the voltage on. The Close Relay should operate after the delay programmed in **UNDERFREQ RESTORE DELAY**.
- ▷ If Underfrequency 2 initiation is to be checked, change Underfrequency Restoration to Disabled, Underfrequency 1 to Disabled, Underfrequency 2 to Trip and repeat steps 2 through 8 in this procedure.

The following procedure checks the minimum voltage for underfrequency restoration:

- ▷ Assert or De-assert a logic input to simulate an open breaker.
- ▷ Set **UNDERFREQ RESTORE DELAY** to 0.
- ▷ Inject a voltage below the **UNDERFREQ RESTORE MIN VOLTS** level into the bus voltage input of the relay.
- ▷ Reduce the injected frequency to cause an underfrequency trip, then increase the frequency to nominal.
- ▷ Slowly raise  $V_a$  until the Close relay operates.  
This is the operating level of setpoint Underfreq Restore Min Volts.

The following procedure checks the minimum frequency for underfrequency restoration:

- ▷ Assert or De-assert a logic input to simulate an open breaker.
- ▷ Set **UNDERFREQ RESTORE DELAY** to 0.
- ▷ Inject nominal voltage into the bus voltage input of the relay.
- ▷ Reduce the injected frequency to cause an underfrequency trip.
- ▷ Slowly increase the frequency until the Close Relay operates.  
This is the operating level of the **UNDERFREQ RESTORE MIN FREQ** setpoint.

### 7.6.7 Transfer Scheme

#### Common Logic

- ▷ 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.
- ▷ Ensure that the Synchrocheck and Logic Input features in the relay programmed as Bus Tie has been tested and is “Enabled”.
- ▷ 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.
- ▷ 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.

- ▷ At this time both of the Incomer relays should have Output Relays 1 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).
- ▷ 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.
- ▷ 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.
- ▷ Assert Logic Input 5 (Breaker Connected) at the Bus Tie relay; Output Relays 4 and 6 on the Bus Tie relay should operate.
- ▷ Assert Logic Input 5 (Breaker Connected) at the Incomer 1 relay.  
Nothing should happen.
- ▷ 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 Output Relays 5 and 7 on the Incomer 1 relay should operate.
- ▷ Assert Logic Input 5 (Breaker Connected) at the Incomer 2 relay.  
Nothing should happen.
- ▷ 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 Output Relays 5 and 7 on the Incomer 2 relay should operate.
- ▷ 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.
- ▷ 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.
- ▷ 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.
- ▷ 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.

- ▷ 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.
- ▷ 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.
- ▷ 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.
- ▷ 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.
- ▷ 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.
- ▷ 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 Transfer Not Ready message should disappear.
- ▷ 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.
- ▷ 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, and at both Incomer relays the Transfer Not Ready message should disappear.
- ▷ 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.
- ▷ 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.
- ▷ 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.
- ▷ 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.

- ▷ Check the Event Recorders in the Incomer 1 and 2 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

### Low Voltage Logic

- ▷ 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.
- ▷ 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.
- ▷ 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.
- ▷ 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.
- ▷ Check the Event Recorders in both Incomers and the Bus Tie relay for the correct messages and sequences, then clear the recorders.

### Transfer Initiated by Lockout 86-1

- ▷ 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.
- ▷ At the Incomer 1 relay assert Logic Input 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.
- ▷ 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.
- ▷ At the Incomer 1 relay de-assert Logic Input No. 12 (Transformer Lockout).
- ▷ Momentarily assert Logic Input 3 (Remote Open) at the Bus Tie relay. The Bus Tie breaker should open.
- ▷ Momentarily assert Logic Input 2 (Remote Close) at the Incomer 1 relay. The Incomer 1 breaker should close.
- ▷ Check the Event Recorders in the Incomer 1 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

### Transfer Initiated by Lockout 86-2

- ▷ Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
- ▷ At the Incomer 2 relay assert Logic Input 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.
- ▷ 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.
- ▷ At the Incomer 2 relay de-assert Logic Input No. 12 (Transformer Lockout).
- ▷ Momentarily assert Logic Input 3 (Remote Open) at the Bus Tie relay. The Bus Tie breaker should open.
- ▷ 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.

### Transfer Initiated by Source Trip No. 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.
- ▷ At the Incomer 1 relay assert Logic Input 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.

- ▷ 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.
- ▷ At the Incomer 1 relay de-assert Logic Input No. 13 (Source Trip).
- ▷ Momentarily assert Logic Input 3 (Remote Open) at the Bus Tie relay.  
The Bus Tie breaker should open.
- ▷ Momentarily assert Logic Input 2 (Remote Close) at the Incomer 1 relay.  
The Incomer 1 breaker should close.
- ▷ Check the Event Recorders in the Incomer 1 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

### Transfer Initiated by Source Trip No. 2

- ▷ Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
- ▷ At the Incomer 2 relay assert Logic Input 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.
- ▷ 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.
- ▷ At the Incomer 2 relay de-assert Logic Input No. 13 (Source Trip).
- ▷ Momentarily assert Logic Input 3 (Remote Open) at the Bus Tie relay.  
The Bus Tie breaker should open.
- ▷ 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.

### Transfer Initiated by Undervoltage on Source 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.
- ▷ Turn test Source 1 off.  
The Undervoltage 3 feature of the Incomer 1 relay should operate Output Relay 4 immediately. At Incomer 2, Output Relay 3 operates and the Transfer Not Ready message is 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, the Bus Tie relay should close the Bus Tie Breaker.
- ▷ Check the Event Recorders in the Incomer 1 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

### Manual Restoration of Incomer 1

- ▷ Turn test Source 1 on and adjust Source 1 to be out-of-synchronism with Source 2.
- ▷ At the Bus Tie relay assert Logic Input 6 (Selected To Trip).
- ▷ At the Incomer 1 relay assert Logic Input 2 (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.
- ▷ At the Bus Tie relay de-assert Logic Input 6 (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.

### Transfer Initiated by Undervoltage on Source 2

- ▷ Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
- ▷ 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.

- ▷ Check the Event Recorders in the Incomer 2 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

### Manual Restoration of Incomer 2

- ▷ Turn test Source 2 on and adjust Source 2 to be out-of-synchronism with Source 1.
- ▷ At the Bus Tie relay assert Logic Input 6 (Selected To Trip).
- ▷ At the Incomer 2 relay assert Logic Input 2 (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.
- ▷ At the Bus Tie relay de-assert Logic Input 6 (Selected To Trip).
- ▷ Check the Event Recorders in the Incomer 2 and Bus Tie relays for the correct messages and sequences, then clear the recorders.

### Simultaneous Loss of Both Sources

- ▷ 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.
- ▷ 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 the **BLOCK TRIP ON DOUBLE LOSS** setpoint is set to “Disabled”:
  - When the Undervoltage 4 element times out, the incomer relays should trip the incomer breakers.  
The bus tie breaker should not close.
  - Check the event recorders in both incomer relays for the correct sequences, then clear the recorders.
- ▷ If the **BLOCK TRIP ON DOUBLE LOSS** setpoint is set to “Enabled”:
  - When the Undervoltage 4 element times out, the incomer relays should not trip the incomer breakers.  
The bus tie breaker should not close.
  - Check the event recorders in both incomer relays for the correct sequences, then clear the recorders.

### After-Parallel Tripping of Selected Incomer

- ▷ 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.



- ▷ At the Incomer 1 relay assert Logic Input 6 (Selected To Trip.)
- ▷ At the Bus Tie relay assert Logic Input 2 (Remote Close.)  
The Bus Tie breaker should close as the voltages are in-synchronism.  
After this the Incomer 1 breaker should trip.
- ▷ At the Incomer 1 relay de-assert Logic Input 6 (Selected To Trip.)
- ▷ At the Incomer 2 relay assert Logic Input 6 (Selected To Trip.)
- ▷ At the Incomer 1 relay assert Logic Input 2 (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.
- ▷ Check the Event Recorders in the Incomer 1 and 2 and Bus Tie relays  
for the correct messages and sequences, then clear the recorders.

### Transfer Blocked by Overcurrent on Incomer 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.
- ▷ Disable the Neutral IOC 1 feature.
- ▷ Inject a current into the phase current input of the Incomer 1 relay.
- ▷ Slowly increase this current until the Phase IOC 1 element operates.  
At the Incomer 1 relay and the Transfer Not Ready message should be displayed.
- ▷ Slowly decrease the injected current until the Phase IOC 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.
- ▷ Enable the Neutral IOC 1 feature and Disable the Phase IOC 1 feature.
- ▷ Inject a current into the phase current input of the Incomer 1 relay.
- ▷ Slowly increase this current until the Neutral IOC 1 element operates.  
At the Incomer 1 relay the Transfer Not Ready message should be displayed.
- ▷ Slowly decrease the injected current until the Neutral IOC 1 element resets.  
At the Incomer 1 relay after the delay time of the **TRANSFER DELAY THIS SOURCE** setpoint and the Transfer Not Ready message should disappear from the display.

### Transfer Blocked by Overcurrent on Incomer 2

- ▷ Energize both test sources at nominal voltage, and wait until the Transfer Not Ready message is removed from the display of both Incomer relays.
- ▷ Disable the Neutral IOC 1 feature.

- ▷ Inject a current into the phase current input of the Incomer 2 relay.
- ▷ Slowly increase this current until the Phase IOC 1 element operates. At the Incomer 2 relay the Transfer Not Ready message should be displayed.
- ▷ Slowly decrease the injected current until the Phase IOC 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.
- ▷ Enable the Neutral IOC 1 feature and Disable the Phase IOC 1 feature.
- ▷ Inject a current into the phase current input of the Incomer 2 relay.
- ▷ Slowly increase this current until the Neutral IOC 1 element operates. At the Incomer 2 relay the Transfer Not Ready message should be displayed.
- ▷ Slowly decrease the injected current until the Neutral IOC 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.

### 7.6.8 Autoreclose (760 only)

For autoreclose testing, make the test connections specified in FIGURE 7-6: *Autoreclose Test Connections* below.



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.

The following procedure tests overall operation of the Autoreclose feature:

- ▷ Check that the relay is in the local control mode, and the Local LED is on.
- ▷ Open and close the breaker by pressing the OPEN and CLOSE keys.
- ▷ Check that the Breaker Open and Breaker Closed LEDs are correctly displaying the state of the breaker. Leave the breaker open.
- ▷ Check that Reclosure Enabled LED is lit and the Reclosure Disabled LED is off.
- ▷ Close the breaker by pressing the CLOSE key. The Reclosure Enabled LED should go out, and the Reclosure Disabled LED should come on during the **AR BLOCK TIME UPON MANUAL CLOSE** value.
- ▷ Immediately after this interval, check that Reclosure Enabled LED is on, and the Reclosure in Progress and Reclosure Disabled LEDs are off. Any output relays programmed to operate for “Reclose Enabled” should now be operated.

- ▷ Check the interval of the ‘AR block time upon manual close’ by observing the Reclosure Enabled LED.

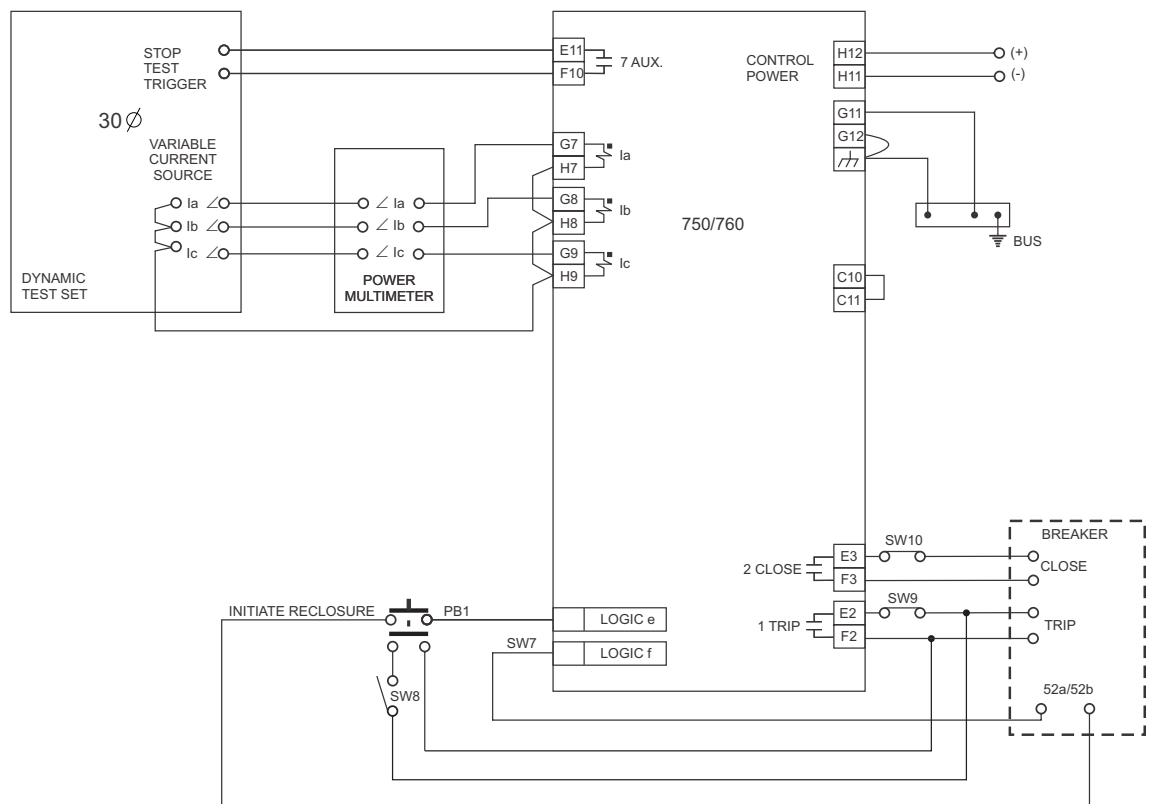


For all further testing, ensure that a reclose is not initiated until after the **AR BLOCK TIME UPON MANUAL CLOSE** value has elapsed, after a manual close.

Assert a Block Reclosure logic input.

The Reclosure Enabled LED should go out and the Reclosure Disabled LED come on.

- ▷ De-assert the Block Reclosure logic input.  
The Reclosure Enabled LED should come on and the Reclosure Disabled LED should go out.



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FIGURE 7-6: Autoreclose Test Connections

- ▷ Assert a Cancel Reclosure logic input.  
The Reclosure Enabled LED should go out and the Reclosure Disabled LED come on.
- ▷ De-assert the Cancel Reclosure logic input.  
The Reclosure Enabled LED should come on and the Reclosure Disabled LED should go out.
- ▷ Verify that the **A1 STATUS** ▷ **AR** ▷ **AR SHOT NUMBER IN EFFECT** value is “0”.

- ▷ Momentarily assert the Initiate Reclosure logic input.  
The Reclosure In Progress LED should come on immediately, and any output relays programmed to operate for Reclose In Progress should now be operated.  
After the delay programmed for **INCOMPLETE SEQUENCE TIME**, the Reclosure In Progress LED 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.
- ▷ 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.
- ▷ 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.
- ▷ 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 LED is now on).
- ▷ Verify that the **AR SHOT NUMBER IN EFFECT** value is “0”.
- ▷ Before the programmed dead-time interval for Reclosure 1 has elapsed, press the CLOSE key.  
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, verify that the **A1 STATUS ▷ AR ▷ AR SHOTS REMAINING** value 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.
- ▷ \*\* 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 that 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 has been performed.
- ▷ \*\* Initiate Reclosure once more and the scheme should go to lockout; the Reclosure Lockout, Reclosure Disabled LEDs should now be on, and the Reclosure Enabled LED should be off.  
Any output relays programmed to operate for Lockout should now be operated.  
The event recorder should have recorded each logic input for Initiate Reclosure, each Reclose, and Reclosure Lockout.
- ▷ Check the interval of dead time for each shot in the event recorder.
- ▷ Press the RESET key.  
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 Reclosure Lockout and Reclosure Disabled LEDs are off, and the Reclosure Enabled LED is now on.  
Any output relays operated above should now be de-energized.
- ▷ Close the breaker.
- ▷ Repeat the above 5 steps marked \*\*.  
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** setpoint, with indications as above.
- ▷ Set a current level above the pickup threshold of any time overcurrent element and turn the current off.
- ▷ Repeat the above 5 steps marked \*\*.  
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, use the following procedure:

- ▷ Open test switch SW9 to prevent a trip command from the relay from operating the breaker.
- ▷ Enable one of the overcurrent elements by setting its function to “Trip + AR”.
- ▷ Inject a current above the pickup level of both the operational overcurrent 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 LED on.

- ▷ Turn the injected current off and Reset the relay.  
Disable the overcurrent element and close both the breaker and SW9.

Use the following procedure to test Autoreclose Current Supervision. Note that the number of reclosure shots setting controls the messages in this group. If four (4) shots are programmed, all messages are available. If three (3) shots are programmed, the **3 SHOTS FOR CURRENT ABOVE** setpoint is not available on the relay. If two (2) shots are programmed, the **3 SHOTS FOR CURRENT ABOVE** and **2 SHOTS FOR CURRENT ABOVE** setpoints are not available. This procedure assumes four (4) shots are programmed.

- ▷ Close the breaker and wait until reclosure is enabled.
- ▷ Verify that the **A1 STATUS ▷ AR ▷ AR SHOTS REMAINING** value is “0”.
- ▷ 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).
- ▷ 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.

Use the following procedure to test Autoreclose Zone Coordination:

- ▷ Set the **MAX NUMBER OF RECLOSURE SHOTS** to “4”.
- ▷ Set the test set to a current level above the **PHASE CURRENT INCREASE** setpoint, and ensure that the neutral current is below the **NEUTRAL CURRENT INCREASE** setpoint by making this value larger.
- ▷ Turn on the current, then before the **MAX FAULT CLEARING TIME** has elapsed, turn off the current.  
The **AR 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 **AR SHOT NUMBER IN EFFECT** should not have been incremented.
- ▷ Reset the relay.
- ▷ Set the current level below the **PHASE CURRENT INCREASE** setpoint value.
- ▷ Turn the current on and then off.  
The **AR SHOT NUMBER IN EFFECT** value should not change.
- ▷ Set the current level above the **PHASE CURRENT INCREASE** setpoint value, but below the **NEUTRAL CURRENT INCREASE** setpoint value.

- ▷ Turn the current on and then off.  
The **AR SHOT NUMBER IN EFFECT** value should increment by one. Repeatedly turning the current on and then off should continue to increment the **AR SHOT NUMBER IN EFFECT** to the **MAX NUMBER OF RECLOSURE SHOTS**, and the Autoreclose scheme will go into lockout.
- ▷ Set the current level so the neutral current is below the **NEUTRAL CURRENT INCREASE** setpoint and the phase current below the **PHASE CURRENT INCREASE** setpoint.
- ▷ Turn the current on and then off.  
The **AR SHOT NUMBER IN EFFECT** value should not change.
- ▷ 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 **AR SHOT NUMBER IN EFFECT** value should increment as above.

Use the following procedure to test Instantaneous Overcurrent Blocking for Autoreclose:

- ▷ 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.
- ▷ 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 and the Pickup LED off.  
Once the **AR 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.
- ▷ 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 LED will be off.
- ▷ Turn off the current and reset the relay.
- ▷ Repeat Step 3 using Phase Inst OC 1 Blocking for each of the 4 Reclosure Shot settings.
- ▷ Repeat Steps 1 through 4 for each Instantaneous OC Blocking setpoint, disabling each instantaneous overcurrent element before moving on to the next.

Use the following procedure to test Raised Pickup of TOC Elements for Autoreclose:

- ▷ Keep the **MAX 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.
- ▷ 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.
- ▷ 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 and the Pickup LED off.  
Once the **AR 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.
- ▷ 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 LED will be off.
- ▷ Turn off the current and reset the relay.
- ▷ Repeat the last 3 steps using Phase Time OC 1 Blocking for each of the 4 Reclosure Shot settings.
- ▷ Repeat the last 12 steps (ie - from the beginning of this procedure to the previous step) for each **TIME OC RAISED PICKUP** setpoint, disabling each time overcurrent element before moving on to the next.

The following procedure tests the Select Setpoint Group function for Autoreclose:

- ▷ Keep the **MAX NUMBER OF RECLOSURE SHOTS** at 4.  
In Setpoint Group 1, set **PHASE TIME OC 1 FUNCTION** to “Trip + AR”.  
In Setpoint Group 2, set **PHASE TIME OC 2 FUNCTION** to “Trip + AR”.  
In Setpoint Group 3, set **PHASE INST OC 1 FUNCTION** to “Trip + AR”.  
In Setpoint Group 4, set **PHASE INST OC 2 FUNCTION** to “Trip + AR”.  
Select the same pickup level for each element.
- ▷ 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.
- ▷ 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.



- ▷ Turn on the current.  
The relay will Trip and Autoreclose four times due to the following elements, in order: Phase TOC 1, Phase TOC 2, Phase IOC 1, Phase IOC 2, Phase TOC 1.  
The event recorder will show this sequence of events.
- ▷ Turn off the current, and reset the relay.

## 7.7 Placing the Relay In Service

### 7.7.1 Description



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.

- ▷ Cycle through the relay setpoints and set each setpoint in each group to the required value.
- ▷ Save all the relay setpoints to a file (or print them) for a final inspection to confirm that all setpoints are correct.
- ▷ Set the relay clock (date and time) if IRIG-B is not used or unavailable.
- ▷ Clear all historical values stored in the relay.  
Under subheading **SI RELAY SETUP ▷ CLEAR DATA**, set **CLEAR ENERGY USE DATA**, **CLEAR MAX DMND DATA**, and **CLEAR EVENT RECORDER DATA** to “Yes”.  
Under subheading **SI RELAY SETUP ▷ INSTALLATION**, also set **RESET TRIP COUNTER DATA** and **RESET ARCING CURRENT DATA** to “Yes”.
- ▷ 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.
- ▷ 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 LED is on, and that the Self-Test Warning LED is off, establishing that the relay is operating normally.
- ▷ 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 confirm 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 energizing.
- ▷ 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 **A2 METERING ▷ VOLTAGE**, verify the following:

**AB: BC: CA:** <Magnitude>, **AVERAGE LINE VOLTAGE:** <Magnitude>, **AN: BN: CN:** <Magnitude>, **AVERAGE PHASE VOLTAGE:** <Magnitude in kV>, **LINE A-B VOLTAGE:** <Phasor>, **LINE B-C VOLTAGE:** <Phasor>, **LINE C-A**

### 7.7.2 On-Load Testing

**VOLTAGE:** <Phasor>, **PHASE A-N VOLTAGE:** <Phasor>, **PHASE B-N VOLTAGE:** <Phasor>, **PHASE C-N VOLTAGE:** <Phasor>, **POS SEQ VOLTAGE:** <Phasor>, **NEG SEQ VOLTAGE:** <Phasor>, and **ZERO SEQ VOLTAGE:** <Phasor>

- ▷ 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 **A2 METERING ▷ CURRENT ▷ % OF LOAD-TO-TRIP** actual value.
- ▷ 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**, verify the following actual values:

**A: B: C:** <Magnitude>, **AVERAGE CURRENT:** <Magnitude>, **PHASE A(C) CURRENT:** <Phasor>, **NEUTRAL CURRENT:** <Phasor>, **GND CURRENT:** <Phasor>, **SENSV GND CURRENT:** <Phasor>, **POS SEQ CURRENT:** <Phasor>, **NEG SEQ CURRENT:** <Phasor>, and **ZERO SEQ CURRENT:** <Phasor>

- ▷ Under subheading **A2 METERING ⇒ PWR**, verify that **REAL PWR**, **REACTIVE PWR**, **APPARENT PWR**, and **PWR FACTOR** values (for single and three-phase values) are as expected.
- ▷ Verify that the **A2 METERING ▷ FREQ ▷ SYSTEM FREQ** actual value is as expected.
- ▷ 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 6–10, to the known feeder load characteristics.
- ▷ After some time has passed, depending on feeder load and demand time interval settings, check the following measured values:

Under **A2 METERING ⇒ ENERGY**, verify the **POSITIVE WATTHOURS**, **POSITIVE WATTHOUR COST**, **NEGATIVE WATTHOURS**, **NEGATIVE WATTHOUR COST**, **POSITIVE VARHOURS**, and **NEGATIVE VARHOURS** values.

- ▷ Under subheading **A2 METERING ▷ DMND ▷ PHASE A(C) CURRENT**, verify the **LAST PHASE A(C) CURRENT DMND** and **MAX PHASE A CURRENT DMND** values.
- ▷ Under subheading **A2 METERING ▷ DMND ▷ REAL PWR**, verify the **LAST REAL PWR DMND** and **MAX REAL PWR DMND** values.
- ▷ Under subheading **A2 METERING ▷ DMND ▷ REACTIVE PWR**, verify the **LAST REACTIVE PWR DMND** and **MAX REACTIVE PWR DMND** values.

- ▷ Under subheading **A2 METERING** ▷ **DMND** ▷ **APPARENT PWR**, verify the **LAST APPARENT PWR DMND** and **MAX APPARENT PWR DMND** values.

### 7.7.3 Dielectric Strength Testing

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 1.6 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.



- ✗ DO NOT HIPOT TEST
- ✓ HIPOT TEST AT: 1900 VAC for 1 Second OR 1600 V AC FOR 1 MINUTE (AS PER UL 508)

REMOVE FILTER GROUND (G11) FROM SAFETY GROUND DURING TEST

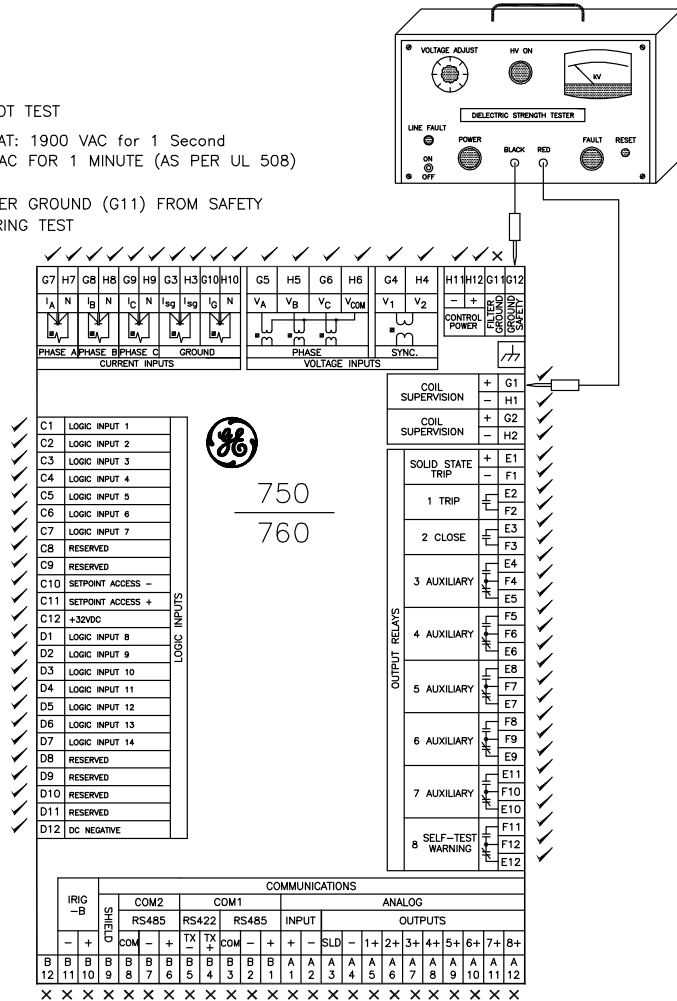


FIGURE 7-7: Dielectric Strength Wiring



# 750/760 Feeder Management Relay

## Chapter 8: Appendix

### 8.1 Relay Mods

#### 8.1.1 Reverse Power

To upgrade the 750/760 to include Mod 008 (Reverse Power), a special 16-digit passcode must be purchased from the GE Multilin Sales Department. As well, the firmware version must be 5.00 or higher. The latest firmware for the 750/760 can be obtained from the GE Multilin website at <http://www.gegridsolutions.com>. Refer to *Upgrading Relay Firmware* on page 4–29 for details on the firmware upgrade procedure.

To enable Mod 008:

- ▷ Press the SETPOINT key to display enter the relay setup menu:

```
■ SETPOINTS [▷]
S1 RELAY SETUP
```

- ▷ Press the MESSAGE ▼ key until the following message appears:

```
■ MOD 008 [▷]
UPGRADE
```

- ▷ Press the ENTER key to display the following message:

```
ENABLE MOD 008?
Disabled
```

- ▷ Press the VALUE ▼ key once to change the setpoint value to “Enabled”:

```
ENABLE MOD 008?
Enabled
```

- ▷ Press the ENTER key to save the setpoint value.

The following message will be displayed:

```
NEW SETPOINT
STORED
```

- ▷ Press the MESSAGE ▼ key once.

The following message appears:

```
ENTER PASSCODE:
0000000000000000
```

- ▷ Press the ENTER key to edit this passcode.  
Use the VALUE keys to change each digit to match the 16-digit passcode supplied by GE Multilin.  
Press ENTER to move to the next digit.  
After entering the last digit, the cursor will return to the first digit of the code.

- ▷ Press the MESSAGE ▼ key once.

The following message will be displayed:

```
UPGRADE OPTIONS?
No
```

- ▷ Press the VALUE ▼ key once to change the message to:

```
UPGRADE OPTIONS?
Yes
```

- ▷ Press the ENTER key to save the new passcode.

The following message will be displayed:

```
NEW SETPOINT
STORED
```

- ▷ Wait at least 30 seconds and then cycle power to the relay by turning it off then back on.

After power-up, verify that the following message is displayed:

```
GE Multilin
760 REV 7.00 MOD 008
```

The Reverse Power element is now Enabled. For details on using this element, refer to Section 5.6.11: Reverse Power on page -92.

Should assistance be required at any time during this procedure, please contact GE Multilin technical support at 1-800-547-8629 (within the U.S. and Canada) or +1(905) 927-7070 (outside U.S. or Canada). You can also send an e-mail to our technical support department at [multilin.tech@ge.com](mailto:multilin.tech@ge.com).

## 8.2 Revision History

### 8.2.1 Release Dates

Table 8-1: Release Dates

MANUAL	GE PART NO.	750/760 REVISION	RELEASE DATE
GEK-106471	1601-0120-A1	6.0x	05 January 2004
GEK-106471A	1601-0120-A2	6.0x	07 January 2004
GEK-106471B	1601-0120-A3	6.0x	17 May 2004
GEK-106471C	1601-0120-A4	7.0x	04 February 2005
GEK-106471D	1601-0120-A5	7.0x	31 August 2005
GEK-106471E	1601-0120-A6	7.0x	21 July 2006
GEK-106471F	1601-0120-A7	7.0x	9 February 2007
GEK-106471G	1601-0120-A8	7.2x	19 December 2007
GEK-106471H	1601-0120-A9	7.2x	24 March 2008
GEK-106471J	1601-0120-AA	7.2x	27 May 2008
GEK-106471K	1601-0120-AB	7.2x	28 November 2008
GEK-106471L	1601-0120-AC	7.2x	21 April 2009
GEK-106471M	1601-0120-AD	7.3x	15 January 2010
GEK-106471N	1601-0120-AE	7.4x	15 September 2011
GEK-106471P	1601-0120-AF	7.4x	23 January 2013
GEK-106471Q	1601-0120-AG	7.4x	5 November 2013
GEK-106471R	1601-0120-AH	7.4x	16 May 2014
GEK-106471S	1601-0120-AJ	7.4x	12 November 2014
GEK-106471T	1601-0120-AK	7.4x	12 February 2015
GEK-106471U	1601-0120-AL	7.4x	21 December 2015
GEK-106471V	1601-0120-AM	7.4x	15 June 2016
GEK-106471W	1601-0120-AN	7.4x	31 Oct 2016

8.2.2 Release Notes

Table 8–2: Major Updates for GEK-106471W

SECT (AL)	SECT (AM)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AN
n/a	5.2.1	Updated Passcode.
n/a	5.2.13	Added Service Command.
5.8.7	5.8.7	Updated Figure 5-67, Figure 5-68, and Figure 5-69.
8.2	n/a	Removed EU Declaration of Conformity. (A printed copy ships with the product.)

Table 8–3: Major Updates for GEK-106471V

SECT (AL)	SECT (AM)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AM Updated branding to Grid Solutions throughout
5.8.7	5.8.7	Changed note 3 on p 5-139.

Table 8–4: Major Updates for GEK-106471U

SECT (AK)	SECT (AL)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AL Added General Safety Precautions section
1.1.1	1.1.1	Added exclamation symbol and definition
2.4.2	2.4.2	Updated Control Power specifications
2.4.11	2.4.11	Updated type test table
2.4.12	2.4.12	Updated Approvals
n/a	n/a	Removed SR references throughout



Table 8–5: Major Updates for GEK-106471T

SECT (AH)	SECT (AK)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AK
5.6.3	5.6.3	Updated Figure 5-10: Phase Directional Logic
5.6.4	5.6.4	Updated Figure 5-14: Neutral Directional Logic
5.6.5	5.6.5	Updated Figure 5-17: Ground Directional Overcurrent Logic

Table 8–6: Major Updates for GEK-106471S

SECT (AG)	SECT (AH)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AJ
2.4.11	2.4.11	Updated the Dielectric strength in Production tests
5.8.7	5.8.7	Updated the Device 43/10: Select to Trip Control Switch section

Table 8–7: Major Updates for GEK-106471R

SECT (AG)	SECT (AH)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AH
Cover	Cover	Added 10 year warranty logo
4.3.3	4.3.3	Note added, for self-tests that do not de-energize the relay: Clock not set, Internal RS485, Internal temp, and IRIG-B failure
4.3.3	4.3.3	Updated Table 4-2, removed RTC Crystal
6.5.1	6.5.1	Updated Table 6-6, removed RTC Crystal
8.4.1	8.4.1	Updated warranty information

Table 8–8: Major Updates for GEK-106471Q (Sheet 1 of 2)

SECT (AF)	SECT (AG)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AG
Cover	Cover	Web address corrected
2.3.1	2.3.1	Order code updated. Discontinued: Basic Display

**Table 8-8: Major Updates for GEK-106471Q (Sheet 2 of 2)**

SECT (AF)	SECT (AG)	DESCRIPTION
3.2	3.2	Typical Wiring Diagram updated
3.2.12	3.2.12	RS485 Wiring Diagram updated RS422 Wiring Diagram updated

**Table 8-9: Major Updates for GEK-106471P**

SECT (AE)	SECT (AF)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AF
Cover	Cover	Address/Telno changes
5.6.1	5.6.1	Added setpoint group change examples

**Table 8-10: Major Updates for GEK-106471N**

SECT (AD)	SECT (AE)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AE
2.4.9	2.4.9	Revision: Supercap-backed internal clock information
5.2.3	5.2.3	Revision: Supercap-backed internal clock information

**Table 8-11: Major Updates for GEK-106471M**

SECT (AC)	SECT (AD)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AD
5.5.3	5.5.3	Revised Output Relay Close Logic drawing to 818772AS.
5.8.2	5.8.2	Revised Synchrocheck Logic drawing to 818008BU.
5.8.7	5.8.7	Add "Bus Transfer Logic" setting to Settings table.
N/A	5.8.7	Add Transfer Scheme 2 text (p 5-150).
N/A	5.8.7	New drawings added as follows: Transfer Scheme 2 Incomer No. 1 Logic 818740.DWG (p 5-151) Transfer Scheme 2 Incomer No. 2 Logic 818741.DWG (p 5-152) Transfer Scheme 2 Bus Tie Breaker Logic 818746.DWG (p 5-153)

Table 8-12: Major Updates for GEK-106471L

SECT (AB)	SECT (AC)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AC
2.4.2	2.4.2	Add CT Burden table
2.4.6	2.4.6	Add "Operate Time" to Synchrocheck section
2.4.4 2.4.5	2.4.4 2.4.5	Change Timing Accuracy in "Underfrequency" and "Overfrequency"
5.7.8	5.7.8	Add note to "Coil Monitor" section
5.7.8	5.7.8	Change "breaker operation function" and "coil monitor function" ranges

Table 8-13: Major Updates for GEK-106471K

SECT (AA)	SECT (AB)	DESCRIPTION
Title	Title	Manual part number to 1601-0120-AB.
2.2.5	2.2.5	Text added
2.2.6	2.2.6	Text added
2.4.4	2.4.4	Phase / Ground / Neutral / Negative Sequence IOC changes
2.4.8	2.4.4	Trip Contact and Service Contact changes
4.7.1	4.7.1	Warning added
---	Gen	Loop wire added between case GND and safety GND, on several wiring diagrams.

Table 8-14: Major Updates for GEK-106471H

PAGE (A8)	SECT (A9)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0120-A9.
2.3.1 2.4.2	2.3.1 2.4.2		Change to DC power supply range

**Table 8–15: Major Updates for GEK-106471G**

PAGE (A7)	SECT (A8)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0120-A8.
2-14	2.4.11	Update	Electrostatic Discharge
2-6	2.3.1	Update	Order Codes (LO voltage)
2-3	2.2.1	Update	Processor type change
2-12	2.4.9	Update	CPU - 4 Ethernet sessions
3-10	3.2.5	Update	Drawing 996630 updated to version A5
4-16	4.5.3	Update	Add: Supports a maximum of 4 TCP/IP sessions
5-31	5.5.4	Update	Pulsed Output Dwell Time clarified
5-10	5.2.3 5.2.2	Update Update	Clock (Date) Add: Supports a maximum of 4 TCP/IP sessions (Network Configuration section)
6-31	6.3.4	Update	Frequency Decay Rate
6-6	6.2.3	Update	Last Trip Data

**Table 8–16: Major Updates for GEK-106471F**

PAGE (A6)	PAGE (A7)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0120-A7.
2-21	2-21		Changes to ELECTROSTATIC DISCHARGE value

**Table 8–17: Major Updates for GEK-106471D**

PAGE (A4)	PAGE (A5)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0120-A5.
--	--		Formatting changes only; no changes to content in this revision

Table 8–18: Major Updates for GEK-106471C

PAGE (A3)	PAGE (A4)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0120-A4.
2-6	2-6	Update	Update Order Codes to indicate Ethernet option
2-11	2-11	Update	Updated specifications for Event Recorder and Waveform Capture
2-13	2-13	Update	Updated Type Testing specifications
---	3-4	Add	Added Ethernet Connection section
---	4-16	Add	Added Configuring Ethernet Communications section
---	5-10	Add	Added Network Configuration sub-section

Table 8–19: Major Updates for GEK-106471B

PAGE (A2)	PAGE (A3)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0120-A3
--	--		Formatting changes only; no changes to content in this revision

Table 8–20: Major Updates for GEK-106471A

PAGE (A1)	PAGE (A2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0120-A2
7-	--	Remove	Removed communications chapter. This will now be available as a separate publication, GEK-106473: 750/760 Communications Guide

---

## 8.3 GE Multilin Device Warranty

### 8.3.1 Warranty Statement

For products shipped as of 1 October 2013, GE warrants most of its GE manufactured products for 10 years. For warranty details including any limitations and disclaimers, see our Terms and Conditions at <https://www.gegridsolutions.com/multilin/warranty.htm>

For products shipped before 1 October 2013, the standard 24-month warranty applies.

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