Instructions
REF 550
Advanced Feeder Protection System

ABB Inc.

Instruction Booklet
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Introduction

Precautions

Take the following precautions when using the ABB Advanced Feeder Protection System REF 550:

1. Incorrect wiring may result in damage. Be sure wiring agrees with connection diagram before energizing. See typical connections in Section 9.

2. Apply only the rated control voltage marked on the label located on the rear panel of the unit.

3. **High-potential tests are not recommended.** If a control wire insulation test is required, fully withdraw the REF 550 from its case and perform only a DC high-potential test. **Surge capacitors installed in the unit do not allow AC high-potential testing.**

4. Follow test procedures to verify proper operation. To avoid personal shock, use caution when working with energized equipment. Only competent technicians familiar with good safety practices should service these devices.

5. In the event the self-checking function detects a system failure, the protective functions are disabled and the alarm contact is actuated. Replace the unit as soon as possible. Call the ABB 24/7 Customer Support Line at 1 (800) 534-6005 or 1 (610) 395-7333.

Password

A correct password is required to make changes to the relay settings and to test the output contacts. **The preset factory password is four blank spaces**. Once you have chosen a new password and entered it into the system, access will be denied if the password is forgotten. If you forget the password, contact the factory at 1 (800) 534-6005 or 1 (610) 395-7333.

WARNING: Removal of the relay from the case exposes the user to dangerous voltages. Use extreme care. Do not insert hands or other foreign objects into the case.

This instruction booklet contains the information to properly install, operate and test the REF 550 but does not purport to cover all details or variations in equipment, or to provide for every possible contingency to be met in conjunction with installation, operation or maintenance. Should particular problems arise which are not sufficiently covered for the purchaser's purposes, please contact the local ABB Inc. sales office.

REF 550 Quick Start

The purpose of this document is to provide an engineer or technician with all of the necessary information on how to trip and reclose test a new REF 550 relay. It will answer all of the questions most frequently asked by users who are not familiar with the relay. It is recommended that the initial tests performed be done according to the Acceptance Test procedure in this instruction manual before attempting to test with operational settings. See Section 10 for details.

Initial Tripping

The REF 550 is shipped from the factory with mostly all of the protection functions disabled in the default active settings group Primary. Only the functions 51P (3I>), 50P-1 (3I>>1), 51N (IN>), and 50N-1 (IN>>1) are enabled. The Time Overcurrent elements are set to pick up at 6 amperes and the Instantaneous to trip at 3 times this setting or 18 amperes. Given the default curve Extremely Inverse and time dial 5, 12 Amps rms injected into one or more phase inputs will cause a 51P (3I>) in approximately 16 seconds.

It is not enough that the settings are enabled directly as above, they must also be enabled in the Recloser Select (Trip) Functions settings: 79-1 (O->I1), 79-2 (O->I2), 79-3 (O->I3), 79-4 (O->I4), and 79-5 (O->I5). Only the functions set to “Enable” or “Lockout” are enabled to trip for that step in the reclose sequence. That is, only functions enabled or set to lockout in 79-1 (O->I1)can trip the relay before it’s first reclose, only the functions enabled (or set to lockout) in 79-2 (O->I2) can trip between the first and second reclose, etc. Elements that are set to “Disable” in any reclose step will not operate.

From the factory, only the functions 51P (3I>), 50P-1 (3I>>1), 51N (IN>), and 50N-1 (IN>>1) are enabled in setting 79-1 (O->I1). The 51P (3I>) function is not in the list because it is always enabled. To add to the list in 79-1 (O->I1), a function must first be enabled outside of 79-1 (O->I). The new function will then appear in the 79-1 (O->I1) list as “Disabled” and must be set to “Enable” or “Lockout”. The preceding statements are also applicable to all of the other Recloser Trip step settings, 79-2 (O->I2) through 79-5 (O->I5).

Another way to disable (torque control) protection functions is by mapping that function to one of the programmable inputs in the **Programmable Inputs** screen using WinECP. Mapping a function to an input will disable that function if there is no control voltage detected on that input’s terminals. An will disable the function when control voltage is detected on that input’s terminals.

From the factory, no tripping functions are disabled in this way. The only functions that are mapped to inputs are the 52A, 52B, and 43A (AR) functions which are mapped to IN-1, IN-2, and IN-3 respectively.

Yet another way that a function can be disabled is by deselecting it from the **Master Trip Output** screen. The Master Trip Output allows the user to choose which tripping function will activate the main trip contact and provides a way to separate the different tripping functions among programmable output contacts. From the factory, all tripping functions are mapped to the main trip output.

Reclosing

The REF 550 is shipped with factory settings that include the reclosing function disabled indicated by the “Recloser Out” LED lit. There are a few different ways that reclosing is defeated in the factory settings. Any one of them is capable of disabling the recloser by itself and must each be taken into account. They are listed here:

1. The control point 43A (AR) is mapped to the Operator Control Interface (OCI) button C1 in the Advanced Programmable Logic. See Section 5 for details. Enable this control by toggling C1 until the button is deselected indicated by the “C1 Selected” LED off.

2. The factory settings do not map the CLOSE function to any programmable output. Use the WinECP Advanced Programmable Logic settings to map the status point CLOSE to the desired physical outout, e.g., OUT01, or any other output contact.

3. The **79-1 (O->I1) Open Time** setting is factory set to “Lockout”. Change this open setting to a numeric time interval.

4. The **79V (O->IU<) Voltage Select** setting is enabled and one of the phase voltages is below the **79V (O->IU<) Pickup** setting.

With the “Recloser Out” LED off, the cause of the relay not reclosing during testing could be due to the breaker contacts or test current. When the relay issues a trip, the breaker status 52A and 52B contacts must change state and the fault current must drop to 5% below the lowest overcurrent pickup within the **Trip Failure Time** setting or the relay will go to Lockout and issue a breaker failure alarm.

The breaker status requirement can be bypassed by putting the relay into Functional Test Mode via the OCI Test Menu. In this mode, the relay will ignore the status of the 52A and 52B contacts for 15 minutes. To interrupt the fault current, the current source should be configured to turn off when it senses that the trip contact has closed or the current could be wired through an A-contact controlled by the breaker. If the current is not turned off quickly enough, the **Trip Failure Time** setting (in the Configuration Settings group) can be increased up to one second (60 cycles).

WARNING: This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access.

ABB shall not be responsible for any damage resulting from unauthorized access.

Quick Reference for Protection & Control Functions

Category	Protection Function	Page Reference
High Impedance Ground Fault, Downed Conductor Detection	HIF Detect™	**1-4**
Overcurrents	Phase Time - 51P (3I>)	**1-11**
	Phase Instantaneous, Low Set - 50P-1 (3I>>1)	**1-13**
	Phase Instantaneous, Mid Set - 50P-2 (3I>>2)	**1-13**
	Phase Instantaneous, High Set - 50P-3 (3I>>3)	**1-14**
	Neutral Time - 51N (IN>)	**1-12**
	Neutral Instantaneous, Low Set - 50N-1 (IN>>1)	**1-15**
	Neutral Instantaneous, Mid Set - 50N-2 (IN>>2)	**1-16**
	Sensitive Earth Fault - SEF	**1-16**
	Neutral Instantaneous, High Set - 50N-3 (IN>>3)	**1-17**
	Cold Load	**1-17**
	Phase Current Unbalance 1 - 46-1 (Insc>1)	**1-17**
	Phase Current Unbalance 2 - 46-2 (Insc>2)	**1-19**
Distance Elements	Phase Step Distance - 21P (Z)	**1-39**
Directional Overcurrent	Phase Directional - 67P (3I> —>)	**1-20**
	Neutral Directional - 67N (IN> —>)	**1-22**
Voltage, Frequency, Power	Phase Undervoltage - 27 (U<)	**1-37**
	Phase Power Directional - 32P (I1 —>)	**1-34**
	Neutral Power Directional - 32N (I2 —>)	**1-34**
	Phase Voltage Unbalance - 47 (U2>)	**1-38**
	Phase Overvoltage - 59 (U>)	**1-37**
	Neutral Overvoltage - 59G (U0>)	**1-38**
	Frequency - 81 (f)	**1-35**
Synch Check/Reclose/ Breaker Failure	Synchronism Check - 25 (Sync)	**1-41**
	Breaker Failure - 50/62	**1-51**
	Recloser - 79 (O —> I)	**1-47**

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Feeder Protection & Control Functions

Protective Elements

The REF 550 features a combination of protective elements as typically applied in subtransmission and distribution protection schemes. The following text will describe the various elements, their application, and how to set them.

WARNING: This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. ABB shall not be responsible for any damage resulting from unauthorized access.

Summary of Protection and Control Elements

The following Figure 1-1 summarizes all of the protective elements contained in the REF 550. See the following text for a complete description of each element.

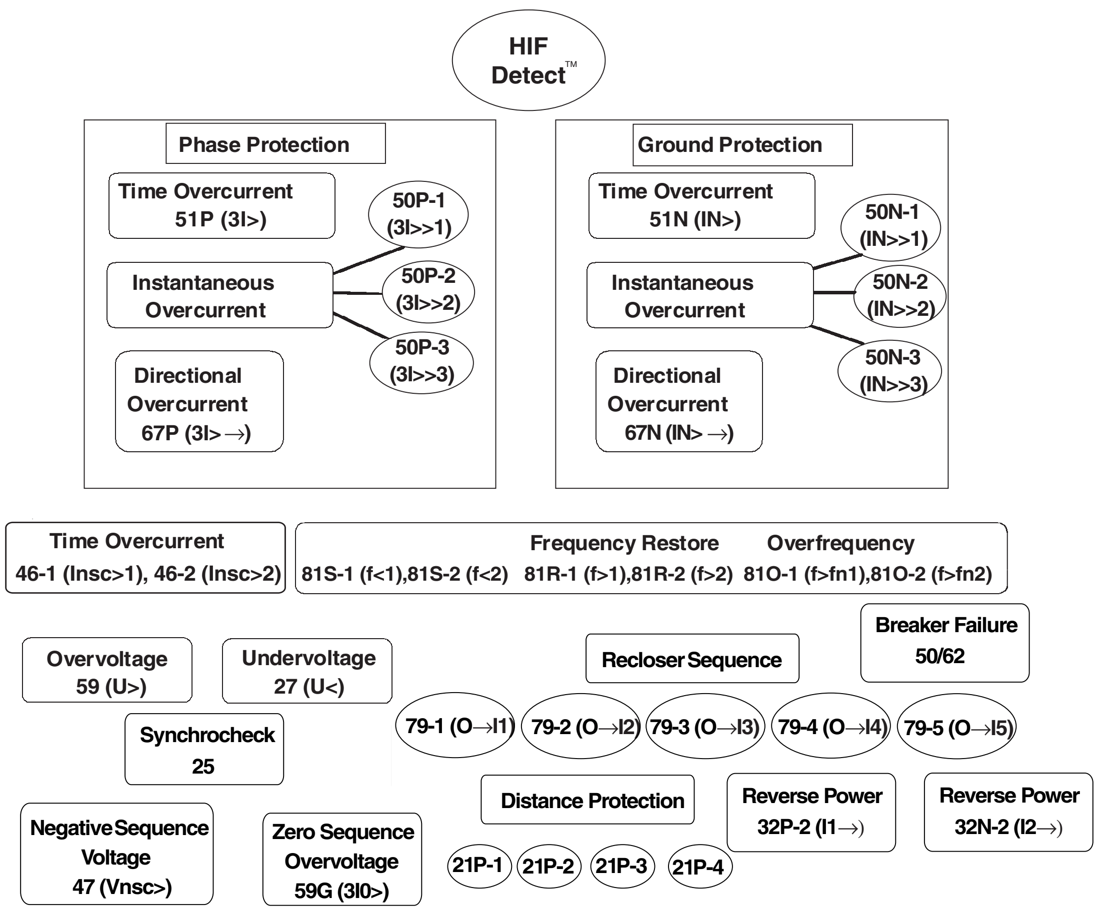


Figure 1-1. REF 550 Protective Functions

HIF Detect™ - High Impedance Ground Fault (HIF) Detection

The HIF Detect™ feature is a high impedance ground fault detection system embedded in the feeder protective relay system. The one-line diagram for the HIF Detect™ feature in Figure 1-2 clearly demonstrates the advantages of this type of downed conductor detection system in efficiency, cost effectiveness of wiring and ease of use. This system utilizes the same set of CT's and VT's installed for feeder protection, HIF Detect™ can also be used without any VT inputs to the relay.

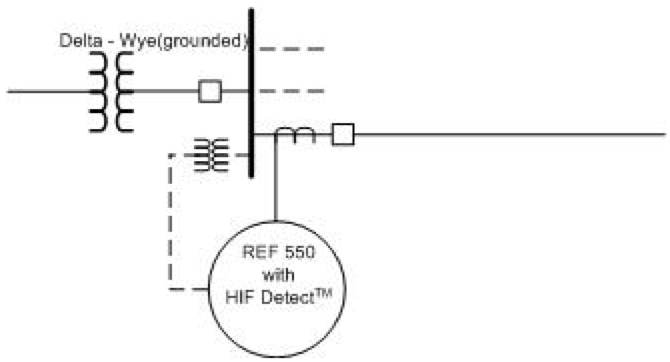


Figure 1-2. One-line diagram of a power system having the HIF Detect™ feature

The HIF Detect™ system is optimized for application in solid wye-grounded sections of the power system for conductors falling on the following type surfaces, wet and dry:

- Concrete
- Grass
- Gravel
- Sand
- Soil

Many field validation tests have been performed on these surfaces with high rate of success.

Flexibility in the settings presents multiple programming solutions in applying the HIF Detect™ feature to improve reliability of service in the power system. Applications can include the following:

- tripping the breaker feeding the downed conductor,
- energizing a physical output contact wired to local annunciation,
- triggering waveform capturing, fault recording and sequence of events, and
- monitoring the status via SCADA and taking appropriate action.

Installing and applying a downed detector detection system for tripping or simple monitoring offers a wealth of information enabling critical decisions to be made realizing a variety of potential benefits system-wide, such as:

- Reduced risk of live conductor exposure to employees and customers
- Reduced risk of live conductor exposure to livestock and other animals
- Reduced risk of the creation of forest fires
- Reduced risk of equipment damage due to potential evolving faults
- Potential future reduction of liability insurance premiums
- Potential reduction of legal liability
- Improved detection of downed live conductors from auto accident and severe weather
- Improved system reliability through outage management notification

Operation

HIF Detect™ executes multiple algorithms to detect a downed conductor in contact with a high impedance ground path, due to surface type or geological characteristics, that reduces the fault current to levels undetectable by conventional ground relaying. Figure 1-3 shows the flowchart of the HIF Detect™ feature. HIF Detect™ algorithms take the measured phase and neutral current inputs and filters the data, processes the signal for detection decision. A detection signal is issued that may be programmed for local alarm/targeting, remote alarming and tripping of the feeder breaker.

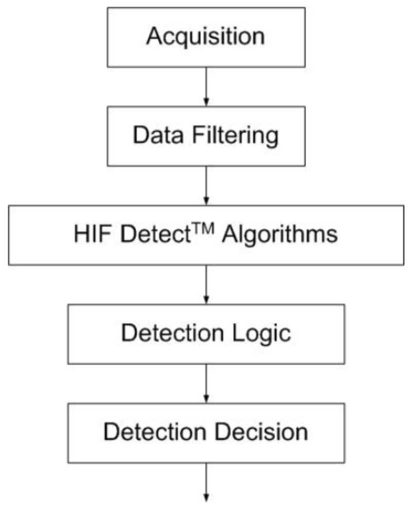


Figure 1-3 HIF Detect™ Feature Flowchart

HIF Detect™ feature is in service when the logical status of 52a and 52b, as defined by the Enhanced Programmable Logic equations, indicate a breaker is closed or in an indeterminate position. With either breaker status, the detection feature continuously adapts to the feeder's load conditions. The feature is designed to insure that no false detections are made for sudden changes in system conditions.

When the logical status of 52a and 52b indicates an open breaker condition, the feature will automatically disable itself and adjust the algorithms' parameters. The adjusted parameters prevent a mis-detection when the breaker is closed. This automatic action can occur during an auto-reclose sequence. Upon breaker closure following an open time, HIF Detect™ will automatically re-enable itself, provided the settings and control logic are true, at the adjusted parameters and automatically adapt to system conditions based on the HIF Detect™ Level setting programmed. The HIF Detect™ functional block diagram in Figure 1-4 reflects this operational logic.

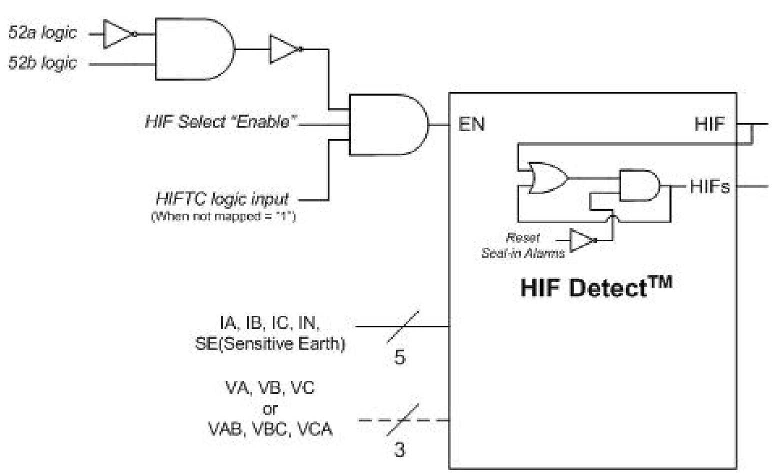


Figure 1-4 HIF Detect™ Functional Block Diagram

Settings

Primary / Alternate 1 / Alternate 2
For the greatest flexibility of application, the HIF Detect™ settings are located in the three settings groups – Primary, Alternate 1 and Alternate 2 – and are password protected requiring the Relay Password to edit. The feature settings' options and ranges are shown in Table 1-1.

Table 1-1 HIF Detect™ settings

HIF Detect™ Setting	Setting Range	Setting Step Size	Setting default
Select	Disable or Enable	Not applicable	Disable
Level	1 - 10	1	5

The HIF Detect™ feature is set by factory default not to operate the "Master Trip" contact. When mapped to the Master Trip and the reclose control point "43A' is enabled, an auto-reclose will be initiated per the recloser settings after the HIF Detect™ element operates.

WinECP Users Tools

Figure 1-5 shows the placement of the HIF Detect™ settings with all the other groups of protective functions in the Users Tool WinECP. Having these settings in the settings groups allows for advanced applications such as fast and secure switching to different HIF Detect™ settings for different system conditions - See Application Example 1-2. This allows for greater programming flexibility during particular weather conditions where the likelihood of a downed conductor is greater.

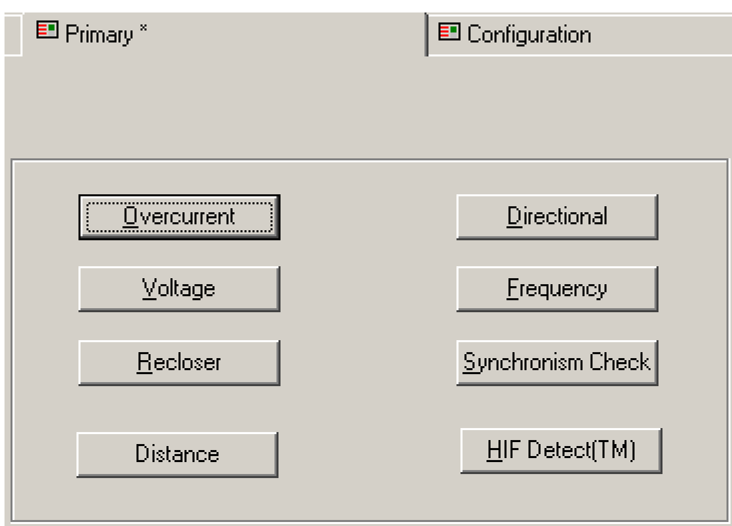
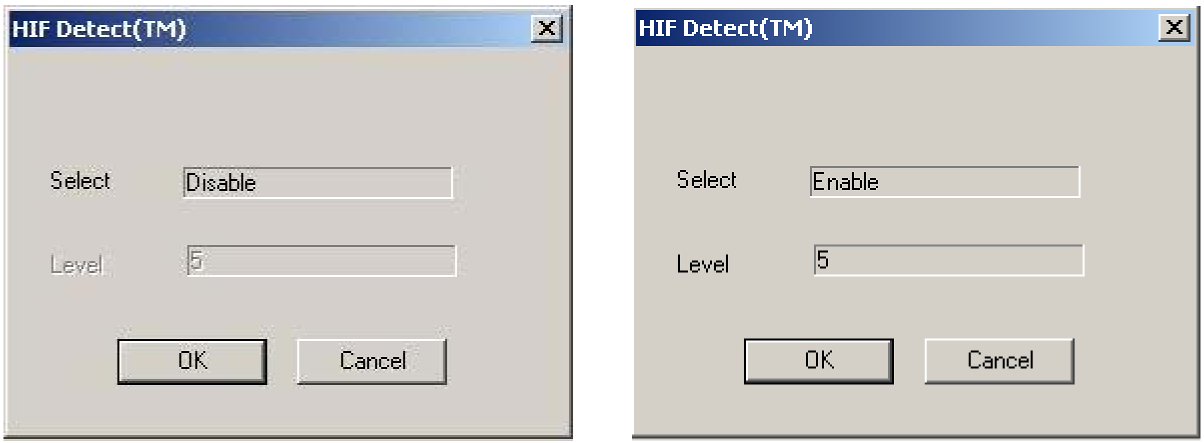


Figure 1-5 HIF Detect™ location in Primary, Alternate 1 and Alternate 2 groups with WinECP

The HIF Detect™ algorithms are novel in approach and sophisticated in their complex mathematics, yet the settings required to activate and operate the function are quite simple. There are only two settings for the HIF Detect™ feature. The first setting, **Select**, activates the function and the second setting, **Level**, enables the function to operate at a desired level of security in a scale 1 to 10, where 10 is more secure than 1. Figure 1-6 shows the actual HIF Detect™ settings as provided in the Users Tools WinECP.



a) b)

Figure 1-6 HIF Detect™ settings in WinECP a) default settings, b) example settings

OCI Front Panel LCD Menu

The HIF Detect™ settings are also editable from the front panel Operator Control Interface's (OCI) LCD screen. The Relay Password is required to change the settings located in the settings groups Primary, Alternate 1 and Alternate 2.

Reliability

Reliability is a delicate balance between securing against mis-operations and depending on correct operations, and it is also true for the reliability of the HIF Detect™ feature. The When mapped to the Master Trip and the reclose control point "43A' is enabled, an auto-reclose will be initiated per the recloser settings after the HIF Detect™ element operates.

Level setting represents a degree of security of the detection indication in a scale of 1 to 10 that is very intuitive – 10 is more secure than 1. **Default or recommended setting of HIF Detect™ Level is 5,** which is at the middle of the minimum value 1 and the maximum value 10. With the Enhanced Programmable Logic, the security (likelihood to not detect) can be decreased or increased based on event changes that would call for it such as weather conditions. HIF Detect™ Level may be decreased from the default setting of 5 during severe weather conditions or may be increased during calm weather conditions.

Enhanced Programmable Logic
The available HIF Detect™ Status Point programmable for status and control are shown Tables 1-2 and 1-3.

Table 1-2 HIF Detect™ Control Points

Control Point	Description	Default Assignment
HIFTC	Torque control logical control point that must be active (-high or -low) for the HIF Detect™ feature to be enabled and running. Example 1: Active-high logic HIFTC = C4 Example 2: Active-low program logic HIFTC = !C4	The control point HIFTC is not mapped in the default Advanced Programmable Logic settings. When not mapped, it is internally enabled and will be activated per the settings programmed in the Primary, Alternate 1 or Alternate 2 active settings group.

Table 1-3 HIF Detect™ Status Points

Status Point	Description	Default Assignment
HIF	Non seal-in logical status point for indication of a high impedance ground fault detection. When detection is no longer present, this point will self-reset.	HIF is not mapped in the default Advanced Programmable Logic. When the status point is mapped to operate the Master Trip and the reclose control point 43A is enabled, an auto-reclose will be initiated per the recloser settings after the HIF Detect element operates.
HIFs	Seal-in logical status point for indication of a high impedance ground fault detection. When detection is no longer present, this point will remain asserted and can only be reset using the Reset Seal-in Alarms command from the OCI LCD menu, WinECP or SCADA command.	HIFs is not mapped in the default Advanced Programmable Logic. When the status point is mapped to operate the Master Trip and the reclose control point 43A is enabled, an auto-reclose will be initiated per the recloser settings after the HIF Detect™ element operates.

Using the Advanced Programmable Logic, see Section 5, the HIF status point may be utilized for local and remote system indication and operation such as the examples given in Table 1-4.

Table 1-4 HIF Detect™ Status and Control Applications

HIF Operation Utilization	**Local**	**Remote**
Status indication	Map HIFs to OCI programmable LED. Reset via OCI front panel's TARGET RESET pushbutton or SCADA command. Map HIFs to physical output that is wired to local annunciation panel. Reset via OCI front panel's TARGET RESET pushbutton or SCADA command.	DNP3.0 Level 2+: Report by Exception of HIF binary output point 44. Modbus: Assign change-of-state register to global registers mapping.
Control	Click checkbox for HIF in the Master Trip settings tab sheet to activate master trip output contact upon detection of a high impedance ground fault. HIFs is not mapped in the default Advanced Programmable Logic. When the status point is mapped to operate the Master Trip and the reclose control point 43A is enabled, an auto-reclose will be initiated per the recloser settings after the HIF Detect element operates. See Master Trip in Enhanced Programmable Logic Section 6. Map HIFs to a physical output wired to breaker trip circuit. Reset via OCI front panel's TARGET RESET pushbutton or SCADA command. Map HIF to a physical output with a dropout-after-operate time set to exceed breaker failure time.	DNP3.0: Level 2+: After receiving asserted HIF binary output, dispatcher can issue trip command. Modbus: After receiving asserted HIF binary output, dispatcher can issue trip command.

Application Example 1-1

Local Annunciation and SCADA Monitoring of HIF Detect™

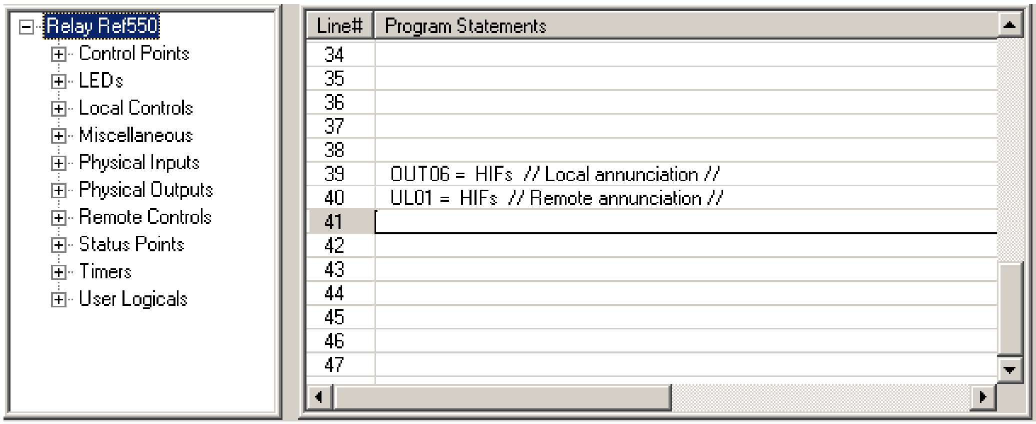
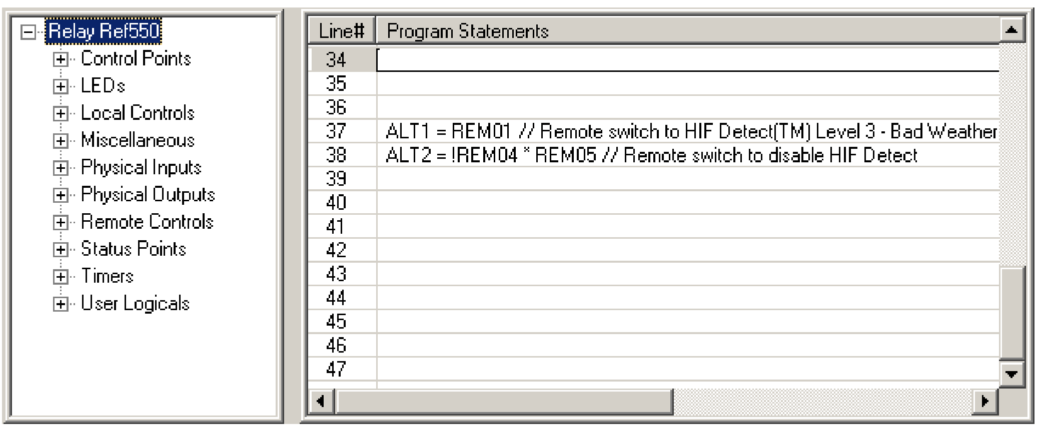


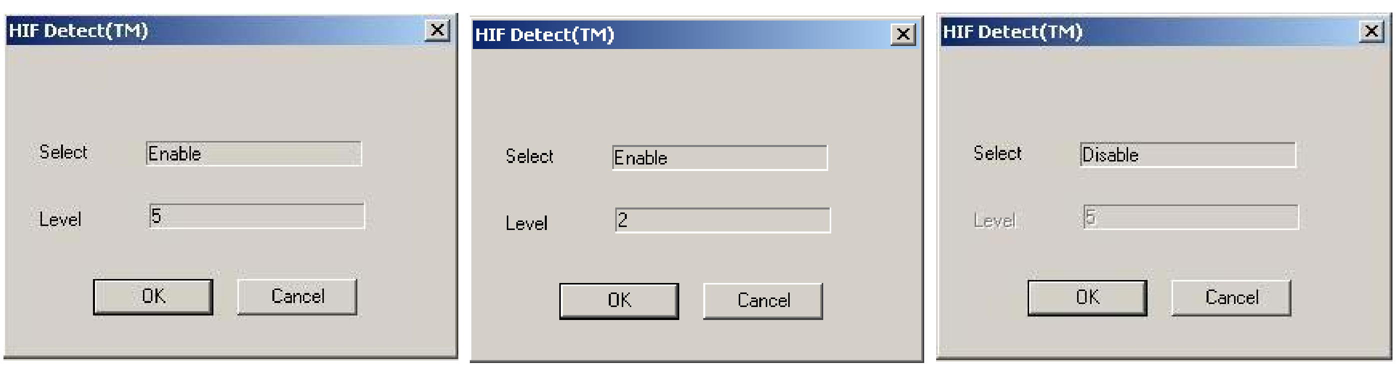
Figure 1-7 Advanced Programmable Logic for Application Example 1-1

Application Example 1-2

Security and Control of HIF Detect™ feature during Severe Weather Conditions



a)



b) c) d)

Figure 1-8 Settings for Application Example 1-2: a) Enhanced Programmable Logic, b) Primary group with standard HIF Detect™ settings, c) Alternate 1 group with less secure HIF Detect™ settings and d) Alternate 2 group with HIF Detect™ disabled

Note: For Application Example 1-2, Alt1 and Alt2 settings must be enabled in Configuration settings. See System Configuration section.

Phase Time Overcurrent Element 51P (3I>)

The phase time overcurrent element, 51P, contained in the REF 550 is set based on CT secondary current as connected to the phase current inputs; terminals 54-53 (Ia), 52-51 (Ib) and 50-49 (Ic). See Section 9 for typical connections. Multiple time curves and time dials are available (see Table 1-5) to closely coordinate with other devices in the system. The IEEE standard, recloser and User Programmable time-current curves included in the REF 550 can be found later this section. See Section 12 for help defining the unit model number. The 51P pickup, curve type, and time dial are all set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 51P element to operate the "Trip" contact, it must be selected in the "Master Trip Output" mapping (see the Advanced Programmable Logic section). **51P is set by factory default to operate the "Master Trip" contact.**

Table 1-5. 51P (3I>) Characteristics

51P Parameter	Range/Curve	Time Dial	Increment
Pickup for 5 ampere model	0.4 to 12 amperes		0.1 ampere
Pickup for 1 ampere model	0.08 to 2.4 amperes		0.02 ampere
ANSI Time Overcurrent Curves			
	Inverse	1 to 10	0.1
	Very Inverse	1 to 10	0.1
	Extremely Inverse	1 to 10	0.1
	Long Time Inverse	1 to 10	0.1
	Long Time Very Inverse	1 to 10	0.1
	Long Time Ext. Inverse	1 to 10	0.1
	Short Time Inverse	1 to 10	0.1
	Definite Time	0 to 10	0.1
	Recloser Curve	1 to 10	0.1
	User Prog. Curve #1	1 to 10	0.1
	User Prog. Curve #2	1 to 10	0.1
	User Prog. Curve #3	1 to 10	0.1

See Table 4-1 for the 51P factory default settings.

The phase time overcurrent element, 51P, can be supervised (torque controlled) by mapping the control point PH3TC to a physical input for local supervision or Remote status point for SCADA supervision. See the Advanced Programmable Logic section for programming instructions.

There are two selectable reset modes available for the 51P element - "instantaneous" and "delayed". The instantaneous mode is used to coordinate with other instantaneous reset devices such as solid state or microprocessor based relays. In the instantaneous mode the 51P will reset when the current drops below the pickup setting for one half cycle.

The delayed mode simulates the reset action of an eletromechanical induction disk relay. In this mode the 51P reset follows a slow reset characteristic that depends upon the duration of the overcurrent condition and the amount of load current flowing after the event. The reset equations are described on page 1-25. When the REF 550 "Multiple Device Trip Mode" (see "Multiple Device Trip Mode" in the System Configuration section) is enabled, the 51P reset characteristic may be set to delayed. The reset mode applies to all time overcurrent elements in the REF 550.

Ground Time Overcurrent Element 51N (IN>)

The ground time overcurrent element, 51N, contained in the REF 550 is based on CT secondary current (I_0) as connected to the ground current input terminals 48-47 (In). See Section 9 for typical external connections. Multiple time curves and time dials are available (see Table 1-6) to closely coordinate with other devices in the system. The IEEE standard, recloser and User Programmable time-current curves for the REF 550 are can be found later in this section. The 51N pickup, curve type, and time dial are all set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 51N element to operate the "Trip" contact, it must be selected in the "Master Trip Output" mapping (see the Advanced Programmable Logic section).

Table 1-6. 51N (IN>) Characteristics

51N Parameter	Range/Curve	Time Dial	Increment
Pickup for 5 ampere model	0.4 to 12 amperes		0.1 ampere
Pickup for 1 ampere model	0.08 to 2.4 amperes		0.02 ampere
ANSI Time Overcurrent Curves			
	Inverse	1 to 10	0.1
	Very Inverse	1 to 10	0.1
	Extremely Inverse	1 to 10	0.1
	Long Time Inverse	1 to 10	0.1
	Long Time Very Inverse	1 to 10	0.1
	Long Time Ext. Inverse	1 to 10	0.1
	Short Time Inverse	1 to 10	0.1
	Definite Time	0 to 10	0.1
	Recloser Curve	1 to 10	0.01
	User Prog. Curve #1	1 to 10	0.1
	User Prog. Curve #2	1 to 10	0.1
	User Prog. Curve #3	1 to 10	0.1

See Table 4-1 for the 51N factory default settings.

The 51N element is set by factory default to operate the "Master Trip" contact.

The 51N element tripping can be enabled or disabled in each step of the reclose sequence. See "Reclosing" later in this section for more details. The 51N element can be supervised ("torque controlled") by mapping the control point "GRDTC" to a physical input for local supervision or Remote status point for SCADA supervision. See the Advanced Programmable Logic section for programming instructions.

There are two selectable reset modes available for the 51N element - "instantaneous" and "delayed". The instantaneous mode is used to coordinate with other instantaneous reset devices such as solid state or microprocessor based relays. In the instantaneous mode the 51N will reset when the current drops below the pickup setting for one half cycle. The delayed mode simulates the reset action of an electromechanical induction disk relay. In this mode the 51N reset follows a slow reset characteristic that depends upon the duration of the overcurrent condition and the amount of load current flowing after the event. The delayed reset equations are described later in this section. When the REF 550 "Multiple Device Trip Mode" (see "Multiple Device Trip Mode" in the System Configuration section) is enabled the 51N reset characteristic may be set to delayed. The reset mode applies to all time overcurrent elements in the REF 550.

Phase Instantaneous Overcurrent Element 50P-1 (3I>>1) - Level 1, Low set

The low set phase instantaneous function, 50P-1, operates when the level of any phase current exceeds the pickup level. It should be enabled where phase instantaneous tripping is desired. It is typically set equal to or higher than the phase time overcurrent pickup. The pickup level of 50P-1 is set as a multiple of the 51P pickup. The timing of the 50P-1 element varies depending upon which curve is selected (see Table 1-7). The curves can be found later in this section. The 50P-1 pickup, curve type, and time dial are all set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 50P-1 element to operate the "Trip" contact, it must be selected in the "Master Trip Output" mapping (see the Advanced Programmable Logic section). **The 50P-1 element is set by factory default to operate the "Master Trip" contact.**

Table 1-7. 50P-1 (3I>>1) Characteristics

50P-1 Parameter	Range/Curve	Time Dial	Increment
Pickup	0.5 to 40 x 51P setting	- - -	0.1x
ANSI Instantaneous Curves			
	Standard	No Intentional Delay	- - -
	Inverse Instantaneous	1 to 10	0.1
	Short Time Inverse	1 to 10	0.1
	Short Time Ext. Inverse	1 to 10	0.1
	Definite Time	0 to 9.99	0.01

See Table 4-1 for the 50P-1 factory default settings.

The 50P-1 element tripping can be enabled or disabled in each step of the reclose sequence. See "Reclosing" later in this section for more details. It can also be supervised (torque controlled) by mapping the control point "50-1TC" to a physical input for local supervision or Remote status point for SCADA supervision. See the Advanced Programmable Logic Section for programming instructions. When the Two Phase 50P tripping function is enabled, the 50P-1 element trips only when two or three phases exceed the pickup setting and does not operate for single phase faults. This is applicable where instantaneous tripping for single phase to ground faults is not desired (see "Two Phase 50P Tripping" later in this section).

When the circuit breaker is closed by an external source such as a control switch or SCADA, the 50P-1 can be disabled from tripping for a "Cold Load Time". See the "Cold Load Time" also in this section.

Phase Instantaneous Overcurrent Element 50P-2 (3I>>2) - Level 2, Mid set

Table 1-8. 50P-2 (3I>>2) Characteristics

50P-2 Parameter	Range/Curve	Increment
Pickup	0.5 to 40 x 51P setting	0.1x
Definite Time	0 to 9.99 seconds	0.01 sec.

See Table 4-1 for 50P-2 factory default settings.

The mid set phase instantaneous function, 50P-2, operates when the level of any phase current exceeds the pickup level. 50P-2 is used to establish an additional layer of instantaneous overcurrent protection. The pickup level of 50P-2 is set as a multiple of the 51P pickup. The timing of the 50P-2 is set strictly as definite time (see Table 1-8). The 50P-2 pickup is often set higher than the 50P-1 and used to trip faster than the 50P-1 or for recloser Lockout. See "Reclosing" later in this section. The 50P-2 pickup and time delay are all set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 50P-2 element to operate the "Trip" contact, it must be selected in the "Master Trip Output" mapping (see the Advanced Programmable Logic section). **The 50P-2 element is set by factory default to operate the "Master Trip" contact.** Note: The 50P-2 element cannot be blocked by the cold load timer.

50P-2 tripping can be enabled or disabled in each step of the reclose sequence. See the "Reclosing" Section for more details. It can also be supervised (torque controlled) by mapping the control point "50-2TC" to a physical input for local supervision or Remote status point for SCADA supervision. See the Advanced Programmable Logic section for programming instructions. When the Two Phase 50P tripping function is enabled, the 50P-2 element trips only when two or three phases exceed the pickup setting and does not operate for single phase faults. See also "Two Phase 50P Tripping" later in this section.

Phase Instantaneous Overcurrent Element 50P-3 (3I>>3) - Level 3, High set

The high set phase instantaneous function, 50P-3, operates when the level of any phase current exceeds the pickup level. 50P-3 is typically used to establish high set instantaneous overcurrent protection. The 50P-3 setting is often used to block reclosing at high levels of fault current, or as a level detector supervised by another function within the relay such as the phase power directional element 32P-2. To operate an output relay with the 50P-3 only, a physical output contact must be programmed to only operate on the 50P-3 element. The 50P-3 element can be supervised by mapping the control point "50-3TC" to a physical input for local supervision or Remote status point for SCADA supervision. See the Advanced Programmable Logic section for more details. The pickup level of 50P-3 is set as a multiple of the 51P pickup (see Table 1-9). The timing of the 50P-3 is not selectable and trips instantaneously with no intentional time delay. The 50P-3 pickup is set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 50P-3 element to operate the "Trip" contact, it must be selected in the "Master Trip Output" mapping (see the Advanced Programmable Logic section). **The 50P-3 element is set by factory default to operate the "Master Trip" contact.**

Table 1-9. 50P-3 (3I>>3) Characteristics

50P-3 Parameter	Range/Curve	Increment
Pickup	0.5 to 40 x 51P setting	0.1x

See Table 4-1 for 50P-3 factory default settings.

50P-3 tripping can be enabled or disabled in each step of the reclose sequence. See "Reclosing" later in this section for more details. When the Two Phase 50P tripping function is enabled, the 50P-3 element trips only when two or three phases exceed the pickup setting and does not operate for single phase faults. This is applicable where instantaneous tripping for ground faults is not desired. Note: The 50P-3 element cannot be blocked by the cold load timer.

Two Phase 50P (3I>>) Tripping

The Two Phase 50P tripping is used to increase sensitivity and improve clearing time for three phase, phase to phase, and two phase to ground faults on the main section of radial distribution lines. The Two Phase 50P tripping mode is not responsive to single phase to ground faults. When the Two Phase 50P mode is enabled in the Primary, Alternate 1, or Alternate 2 settings groups, the 50P-1, 50P-2, and 50P-3 elements will trip only for two or three phase faults. The 50N-1, 50N-2, and 50N-3 ground instantaneous overcurrent elements will still operate for single phase to ground faults where the ground current exceeds the 50N-1, 50N-2, and 50N-3 pickup settings. Two Phase 50P tripping is disabled in the factory default settings. Refer to Application Note AN-24.

Ground Instantaneous Overcurrent Element 50N-1 (IN>>1) - Level 1, Low set

The low set neutral instantaneous function, 50N-1, operates when the level of ground current exceeds the pickup level. It is enabled where ground instantaneous tripping is desired. It is typically set equal to or at a higher pickup level than the ground time over current pickup. The pickup level of 50N-1 is set as a multiple of the 51N pickup. The timing of the 50N-1 element varies depending upon which curve is selected (see Table 1-10). The 50N-1 pickup, curve type, and time dial are all set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 50N-1 element to operate the "Trip" contact, it must be selected in the "Master Trip Output" mapping (see the Advanced Programmable Logic section). **The 50N-1 element is set by factory default to operate the "Master Trip" contact.**

Table 1-10. 50N-1 (IN>>1) Characteristics

50N-1 Parameter	Range/Curve	Time Dial	Increment
Pickup	0.5 to 40 x 51N setting		0.1x
ANSI Instantaneous Curves			
	Standard Instantaneous	No Intentional Delay	
	Inverse Instantaneous	1 to 10	0.1 sec
	Short Time Inverse	1 to 10	0.1 sec
	Short Time Ext. Inverse	1 to 10	0.1 sec
	Definite Time	0 to 9.99	0.01 sec

See Table 4-1 for 50N-1 factory default settings.

50N-1 tripping can be enabled or disabled in each step of the reclose sequence. See "Reclosing" later in this section for more details. It can also be supervised (torque controlled) by mapping the control point "50-1TC" to a physical input for local supervision or Remote status point for SCADA supervision. See the Advanced Programmable Logic section for programming instructions.

When the circuit breaker is closed by an external source such as a control switch or SCADA, the 50N-1 can be disabled from tripping for a "Cold Load Time". See the "Cold Load Time" Section for more details.

Ground Instantaneous Overcurrent Element 50N-2 (IN>>2) - Level 2, Mid set

The mid set neutral instantaneous function, 50N-2, operates when the level of ground current exceeds the pickup level. 50N-2 is used to establish one more layer of instantaneous overcurrent protection such as a high set instantaneous overcurrent element. If the fault current exceeds the 50N-2 setting, a typical scenario would be to trip faster than the 50N-1 setting, lockout reclosing, or operate an external lockout relay. To operate an external lockout relay with the 50N-2 only, a programmable output contact must be mapped to operate on the 50N-2 element only. See the Advanced Programmable Logic section for more details. The pickup level of 50N-2 is set as a multiple of the 51N pickup. The timing of the 50N-2 is set strictly as definite time (see Table 1-11). The 50N-2 pickup and time delay are set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 50N-2 element to operate the “Trip” contact, it must be selected in the “Master Trip Output” mapping (see the Advanced Programmable Logic section). **The 50N-2 element is set by factory default to operate the “Master Trip” contact.** Note: The 50N-2 element cannot be blocked by the cold load timer.

Table 1-11. 50N-2 (IN>>2) Characteristics

50N-2 Parameter	Range/Curve	Increment
Pickup	0.5 to 40 x 51N setting	0.1x
Definite Time	0 to 9.99 seconds	0.01 sec.

See Table 4-1 for 50N-2 factory default settings.

50N-2 tripping can be enabled or disabled in each step of the reclose sequence. See “Reclosing” later in this section for more details. It can also be supervised (torque controlled) by mapping the control point “50-2TC” to a physical input for local supervision or Remote status point for SCADA supervision. See the Advanced Programmable Logic section for programming instructions.

Sensitive Earth Fault (SEF) Option, 50N-2 (IØ>2) - Definite Time

The Sensitive Earth Fault (SEF) is applicable to systems where all loads are connected line to line **and no neutral or earth current flows unless an earth fault occurs**. This feature is included in the standard REF 550 model and is selectable using the 50N-2 element described earlier. A separate SEF current input is provided at terminals 46-45 (I_0SEF). This input **must** be connected in series with the neutral input or to a separate window type CT that encloses all three phase conductors - see typical connections in Section 9. See Table 1-12 for applicable SEF settings.

The analog and digital filtering provide a rejection ratio of third harmonic greater than 50:1 to prevent incorrect operation due to the effects of distribution transformer excitation currents.

Table 1-12. 50N-2 (IN>>2) Sensitive Earth Fault Units

SEF 50N-2 Parameter	Range/Curve	Increment
Pickup	5 mA to 400 mA	0.5mA
Definite Time	0.5 to 180 seconds	0.01 sec.

See Table 4-1 for SEF factory default settings.

The SEF 50N-2 tripping can be enabled or disabled in each step of the reclose sequence. See “Reclosing” later in this section for more details. It can also be supervised (torque controlled) by mapping the control point “SEFTC” to a physical input for local supervision or remote status point for SCADA supervision. See the Advanced Programmable Logic section for programming instructions.

Ground Instantaneous Overcurrent Element 50N-3 (IN>>3) - Level 3, High set

The high set neutral instantaneous function, 50N-3, operates when the level of ground current exceeds the pickup level. 50N-3 is typically used to establish high set instantaneous overcurrent protection. If the fault current exceeds the 50N-3 setting a typical scenario would be to lockout reclosing or operate an external lockout relay. To operate an external lockout relay with the 50N-3 only, a programmable output contact must be mapped to operate on the 50N-3 element only. This function can also be used as a level detector supervised by some other function such as the neutral power directional element 32N-2. See the Advanced Programmable Logic section for more details. The pickup level of 50N-3 is set as a multiple of the 51N pickup (see Table 1-13).

Table 1-13. 50N-3 (IN>>3) Characteristics

50N-3 Parameter	Range/Curve	Increment
Pickup	0.5 to 40 x 51N setting	0.1x

See Table 4-1 for the 50N-3 factory default settings.

The timing of the 50N-3 is not selectable and trips instantaneously with no intentional time delay. The 50N-3 pickup is set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 50N-3 element to operate the "Trip" contact, it must be selected in the "Master Trip Output" mapping (see the Advanced Programmable Logic section). **The 50N-3 element is set by factory default to operate the "Master Trip" contact.** 50N-3 tripping can be enabled or disabled in each step of the reclose sequence. See "Reclosing" later in this section for more details. It can also be supervised (torque controlled) by mapping the control point "50-3TC" to a physical input for local supervision or Remote status point for SCADA supervision. See the Advanced Programmable Logic section for programming instructions. Note: The 50N-3 element cannot be blocked by the cold load timer.

Cold Load Time

The Cold Load timer as set in the Primary, Alternate 1, and Alternate 2 settings groups is used to block unintentional tripping of the 50P-1 and the 50N-1 due to inrush currents seen by the REF 550 after a manual breaker close. The timer is set from 0 to 254 with a resolution of 1. Select "seconds" or "minutes" in the Configuration Settings (see the System Configuration section). During the cold load time delay period, a status point, CLTA, is asserted. This status point can be mapped to a physical output for alarm and control purposes (see the Advanced Programmable Logic section). The cold load timer is operational only after a manual breaker close. It does not operate during a REF 550 reclose sequence.

The Cold Load Time is disabled in the factory default settings.

A separate Neutral Cold Load Time function is supplied in units with the Sensitive Earth Fault feature.

Negative Sequence Time Overcurrent Elements 46-1 (Insc>1) and 46-2 (Insc2>)

Protective Element 46-1 (Insc>1)

The negative sequence overcurrent element is used where increased sensitivity for phase to phase faults is desired. In addition to the typical application of feeder protection, this element can also be applied on REF 550 relays protecting a main bus breaker in medium to large distribution substations. The main REF 550 would typically be set to provide protection for bus faults and backup protection for a failed feeder relay or breaker. In the case of a medium to larger substation the time and instantaneous overcurrent elements 50/51 in the main REF 550 must be set well above the combined full load current of all the individual feeders. This slows the response to bus faults and decreases the sensitivity to faults on a single distribution feeder. Since the negative sequence element only looks at the amount of negative sequence current in the system it can be set just above the maximum negative sequence current level produced by single phase load unbalance. The negative sequence element 46-1 then allows the REF 550 to react more quickly for phase to phase bus faults.

Multiple time curves and time dials are available (see Table 1-14) to coordinate with other devices in the system. The IEEE standard, recloser and User Programmable time-current curves included in the REF 550 are located later in

Section 1. The 46-1 pickup, curve type, and time dial are all set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 46-1 element to operate the "Trip" contact, it must be selected in the "Master Trip Output" mapping (see the Advanced Programmable Logic section). **The 46-1 element is set by factory default to operate the "Master Trip" contact.** The 46-1 element will always initiate reclosing unless the recloser is disabled. See "Reclosing" later in this section for more details.

There are two selectable reset modes available for the 46-1 element - "instantaneous" and "delayed". The instantaneous mode is used to coordinate with other instantaneous reset devices such as solid state or microprocessor based relays. In the instantaneous mode the 46-1 will reset when the current drops below the pickup setting for one half cycle. The delayed mode simulates the reset action of an electromechanical induction disk relay. In this mode the 46-1 reset follows a slow reset characteristic that depends upon the duration of the overcurrent condition and the amount of load current flowing after the event. The reset time equations are available at the end of Section 1. When the REF 550 "Multiple Device Trip Mode" (see "Multiple Device Trip Mode" in the System Configuration section) is enabled the 46-1 reset characteristic may be set to delayed. The reset mode when set applies to all time overcurrent elements in the REF 550.

Table 1-14. 46-1,-2 (Insc>1,2) Characteristics

46-1,-2 Parameter	Range/Curve	Time Dial	Increment
Pickup for 5 ampere model	0.4 to 12 amperes		0.1 ampere
Pickup for 1 ampere model	0.08 to 2.4 amperes		0.02 ampere
ANSI Time Overcurrent Curves			
	Inverse	1 to 10	0.1
	Very Inverse	1 to 10	0.1
	Extremely Inverse	1 to 10	0.1
	Long Time Inverse	1 to 10	0.1
	Long Time Very Inverse	1 to 10	0.1
	Long Time Ext. Inverse	1 to 10	0.1
	Short Time Inverse	1 to 10	0.1
	Definite Time	0 to 10	0.1
	Recloser Curve	1 to 10	0.1
	User Prog. Curve #1	1 to 10	0.1
	User Prog. Curve #2	1 to 10	0.1
	User Prog. Curve #3	1 to 10	0.1

See Table 4-1 for 46-1 and 46-2 factory default settings.

NOTE: For the REF 550 relay with a current pickup range of 0.4 to 12A, the available setting range for the 46 function are as follows:

If the 51P pickup is set from 0.4 to 6.0A, then the 46 function pickup range is settable from 0.4 to 12A.
If the 51P pickup is set from 6.1 to 12A, then the 46 function pickup range is settable from 1 to 12A.

For the REF 550 relay with a current pickup range of 0.08 to 2.4A, the available setting ranges for the 46 function are as follows:

If the 51P pickup is set from 0.08 to 1.20A, then the 46 function pickup range is from 0.08 to 2.4A.
If the 51P pickup is set from 1.21 to 2.4A, then the 46 function pickup range is from 0.20 to 2.4A.

Protective Element 46-2 (Insc->2)

In addition to the negative sequence time overcurrent element 46-1, a second negative sequence overcurrent element 46-2 is also provided. This element is identical in functionality as the 46-1 element - the available IEEE standard, recloser and User Programmable inverse-time curves listed on Table 1-14.

The 46-2 negative sequence overcurrent element is programmed and operates independent of the 46-1 element.

Directional Phase Time Overcurrent Element 67P (3I>-->)

The directional phase time overcurrent element 67P, is used to provide phase time overcurrent protection in one direction of current flow only. This applies to applications of the REF 550 in parallel subtransmission lines or double ended substations with multiple sources. The IEEE standard, recloser and User Programmable time-current curves and time dials are available (see Table 1-15) to closely coordinate with other devices in the system. The time-current curves included in the REF 550 can be found later in Section 1. The 67P pickup, curve type, time dial, and torque angle are all set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 67P element to operate the “Master Trip” contact, it must be selected in the “Master Trip Output” mapping (see the Advanced Programmable Logic section). **The 67P element is set by factory default to operate the “Master Trip” contact.**

The 67P element may be programmed to initiate reclosing at each step of the recloser function via the Select setting “Enable” or drive the recloser to a lockout state via the setting selection “Lockout”. See “Reclosing” later in this section for more details. It can also be controlled by mapping the control point “67PTC” to a physical input for local supervision or Remote status point for SCADA control. See the Advanced Programmable Logic section for programming instructions.

Polarizing of the 67P is provided by the positive sequence voltage (V_1) in the system. It is sensitive down to 1 volt AC line to line. If the polarizing voltage drops below this level, the 67P will lose direction and will not trip. The 67P function is achieved by comparing the positive sequence voltage (V_1) to the direction of the positive sequence current (I_1). The torque angle is set 0 to 355 degrees in 5 degree steps (I_1 leading V_1) with a sector width of 180 degrees. See Figure 1-9 for examples of different torque angle settings. It should be noted that when the voltage seen by the relay is at or near the minimum sensitivity point of 1 volt line to line, the set angle may move $\pm$ 10 degrees.

As noted above, the 67P angle represents the angle by which I_1 *leads* V_1 at maximum torque. For a typical distribution line having a line angle of 75 degrees (arctan {X/R} = 75 degrees), the 67P angle would be typically set at 285 degrees (I_1 *leads* V_1 by 285 degrees) for sensing forward directional phase faults.

Table 1-15. 67P (3I>-->) Characteristics

67P Parameter	Range/Curve	Time Dial	Increment
Pickup for 5 ampere model	0.4 to 12 amperes		0.1 ampere
Pickup for 1 ampere model	0.08 to 2.4 amperes		0.02 ampere
ANSI Time Overcurrent Curves -			
	Inverse	1 to 10	0.1
	Very Inverse	1 to 10	0.1
	Extremely Inverse	1 to 10	0.1
	Long Time Inverse	1 to 10	0.1
	Long Time Very Inverse	1 to 10	0.1
	Long Time Ext. Inverse	1 to 10	0.1
	Short Time Inverse	1 to 10	0.1
	Definite Time	0 to 10	0.1
	Recloser Curve	1 to 10	0.1
	User Prog. Curve #1	1 to 10	0.1
	User Prog. Curve #2	1 to 10	0.1
	User Prog. Curve #3	1 to 10	0.1
Maximum Torque Angle	0 to 355°		5°

NOTE: For the REF 550 relay with a current pickup range of 0.4 to 12A, the available setting range for the 67P function are as follows:

If the 51P pickup is set from 0.4 to 6.0A, then the 67P function pickup range is settable from 0.4 to 12A.
If the 51P pickup is set from 6.1 to 12A, then the 67P function pickup range is settable from 1 to 12A.

For the REF 550 relay with a current pickup range of 0.08 to 2.4A, the available setting ranges for the 67P function are as follows:

If the 51P pickup is set from 0.08 to 1.20A, then the 67P function pickup range is from 0.08 to 2.4A.
If the 51P pickup is set from 1.21 to 2.4A, then the 67P function pickup range is from 0.20 to 2.4A.

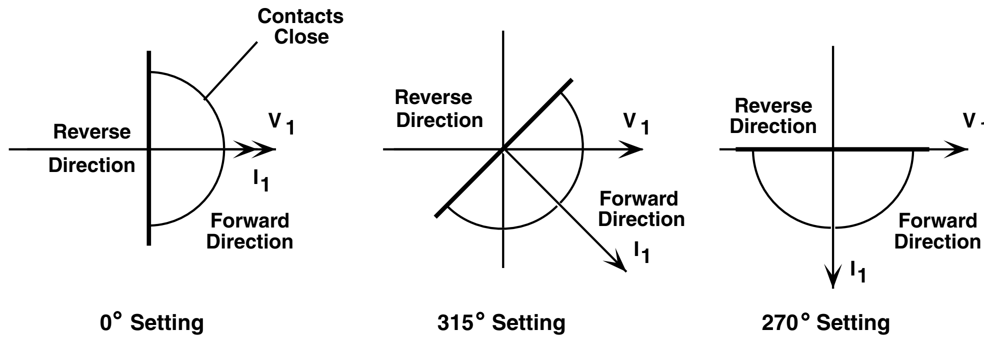


Figure 1-9. 67P Maximum Torque Angles, Example Settings

There are two selectable reset modes available for the 67P element - "instantaneous" and "delayed". The instantaneous mode is used to coordinate with other instantaneous reset devices such as solid state or microprocessor based relays. In the instantaneous mode the 67P will reset when the current drops below the pickup setting for one half cycle. The delayed mode simulates the reset action of an electromechanical induction disk relay. In this mode the 67P reset follows a slow reset characteristic that depends upon the duration of the overcurrent condition and the amount of load current flowing after the event. The reset equations can be fund later in this section. When the REF 550 "Multiple Device Trip" mode (see "Multiple Device Trip Mode" in the System Configuration section) is enabled the 67P reset characteristic may be set to delayed. The reset mode when set applies to all time overcurrent elements in the REF 550.

If the 51P element is not used for phase time overcurrent protection, disable the element in the "Master Trip" mapping (see Programmable Trip Contact Section) and set the pickup level equal to that of the 67P to enhance metering resolution.

Directional Ground Time Overcurrent Element 67N (IN>-->)

The directional ground time overcurrent element 67N, is used to provide ground time overcurrent protection in one direction of current flow only. This applies to applications of the REF 550 in parallel subtransmission lines or double ended substations with multiple sources. Multiple time curves and time dials are available (see Table 1-16) to coordinate with other devices in the system. The IEEE standard, recloser and User Programmable time-current curves included in the REF 550 can be found later in this section. The 67N pickup, curve type, time dial, and torque angle are all set in the Primary, Alternate 1, and Alternate 2 settings groups. For the 67N element to operate the "Master Trip" contact, it must be selected in the "Master Trip Output" mapping (see the Advanced Programmable Logic section). **The 67N element is set by factory default to operate the "Master Trip" contact.** The 67N element may be programmed to initiate reclosing at each step of the recloser function via the Select setting "Enable -" or drive the recloser to a lockout state via the setting selection "Lockout -". See "Reclosing" later in this section for more details. Note in Figure 1-10 that the 67N maximum torque angle settings are 180 degrees opposite the 67P maximum torque angle settings for the same direction.

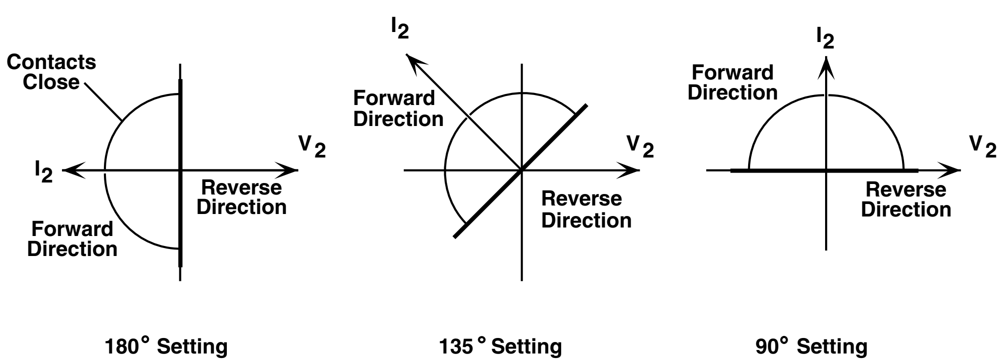


Figure 1-10. 67N Maximum Torque Angles, Negative Sequence Polarization and Operate Quantities, Example Settings

Table 1-16. 67N (IN>-->) Characteristics

67P Parameter	Range/Curve	Time Dial	Increment
Pickup for 5 ampere model	0.4 to 12 amperes		0.1 ampere
Pickup for 1 ampere model	0.08 to 2.4 amperes		0.02 ampere
ANSI Time Overcurrent Curves -			
	Inverse	1 to 10	0.1
	Very Inverse	1 to 10	0.1
	Extremely Inverse	1 to 10	0.1
	Long Time Inverse	1 to 10	0.1
	Long Time Very Inverse	1 to 10	0.1
	Long Time Ext. Inverse	1 to 10	0.1
	Short Time Inverse	1 to 10	0.1
	Definite Time	0 to 10	0.1
	Recloser Curve	1 to 10	0.1
	User Prog. Curve #1	1 to 10	0.1
	User Prog. Curve #2	1 to 10	0.1
	User Prog. Curve #3	1 to 10	0.1
Maximum Torque Angle	0 to 355°		5°

NOTE: For the REF 550 relay with a current pickup range of 0.4 to 12A, the available setting range for the 67N function are as follows:

If the 51P pickup is set from 0.4 to 6.0A, then the 67N function pickup range is settable from 0.4 to 12A.
If the 51P pickup is set from 6.1 to 12A, then the 67N function pickup range is settable from 1 to 12A.

For the REF 550 relay with a current pickup range of 0.08 to 2.4A, the available setting ranges for the 67N function are as follows:

If the 51P pickup is set from 0.08 to 1.20A, then the 67N function pickup range is from 0.08 to 2.4A.
If the 51P pickup is set from 1.21 to 2.4A, then the 67N function pickup range is from 0.20 to 2.4A.

It can also be controlled by mapping the control point “67NTC” to a physical input for local supervision or Remote status point for SCADA control. See the Advanced Programmable Logic section for programming instructions.

Polarizing of the 67N function is provided by the negative sequence voltage (V_2) in the system, or by the zero sequence voltage (V_0) from the WYE connected potential transformers. It is selectable in the relay program. If the REF 550 relay is connected to an open delta or delta voltage source, then the unit cannot use V_0 as it is not generated. In this case, the negative sequence selection must be chosen as the required polarizing quantity for the 67N element.

The directional element 67N function is achieved by comparing the negative sequence or zero sequence voltage to the direction of the negative sequence current (I2) or zero sequence current (I_0), respectively. The torque angle is set 0 to 355 degrees in 5 degree steps (current s leading voltage) with a sector width of 180 degrees. See Figure 1-10 for examples of different angles of maximum reach settings. It should be noted that when the voltage seen by the relay is at or near the minimum sensitivity point of 1 volt line to line, the set angle may move $\pm$ 10 degrees.

As noted above, the 67N element may be set to use either negative sequence voltage (V2) or zero sequence voltage (V0) polarization.

If negative sequence voltage polarization is used, the 67N angle represents the angle by which I_2 *leads* V_2 at maximum torque. For a typical distribution line having a line angle of 75 degrees (arctan {X/R} = 75 degrees), the 67N angle would be typically set at 105 degrees (I_2 *leads* V_2 by 105 degrees) for sensing forward directional ground faults.

If zero sequence voltage polarization is used, the 67N angle represents the angle by which I_0 *leads* V_0 at maximum torque. For a typical distribution line having a line angle of 75 degrees (arctan {X/R} = 75 degrees), the 67N angle would be typically set at 285 degrees (I_0 *leads* V_0 by 285 degrees) for sensing forward directional ground faults.

There are two selectable reset modes available for the 67N element - “instantaneous” and “delayed”. The instantaneous mode is used to coordinate with other instantaneous reset devices such as solid state or microprocessor based relays. In the instantaneous mode the 67N will reset when the current drops below the pickup setting for one half cycle. The delayed mode simulates the reset action of an electromechanical induction disk relay. In this mode the 67N reset follows a slow reset characteristic that depends upon the duration of the overcurrent condition and the amount of load current flowing after the event. The reset curves can be found later in this section. When the REF 550 “Multiple Device Trip” mode (see “Multiple Device Trip Mode” in the System Configuration section) is enabled the 67N reset characteristic may be set to delayed. The reset mode when set applies to all time overcurrent elements in the REF 550.

If the 51N element is not used for ground time overcurrent protection, disable the element in the “Master Trip” mapping (see Programmable Trip Contact Section) and set the pickup level equal to that of the 67N to enhance metering resolution.

Timing Curves

Time Overcurrent Curve Equation

ANSI

$$\text{Trip Time} = \left(\frac{A}{M^p - C} + B\right) \times \left(\frac{14n-5}{9}\right)$$

$$\text{Reset Time} = \left(\frac{D}{|1-EM|}\right) \times \left(\frac{14n-5}{9}\right)$$

M = Multiples of pickup current (I/Ipu)
n = Time Dial setting

Table 1-17. Constants for ANSI Time Overcurrent Characteristics

Curve	A	B	C	P	D	E	K	a
Extremely Inverse	6.407	0.025	1	2.0	3	0.998	80.0	2.0
Very Inverse	2.855	0.0712	1	2.0	1.346	0.998	13.5	1.0
Inverse	0.0086	0.0185	1	0.02	0.46	0.998	0.14	0.02
Short Time Inverse	0.00172	0.0037	1	0.02	0.092	0.998		
Short Time Ext. Inv.	1.281	0.005	1	2.0	0.6	0.998		
Long Time Ext. Inv.	64.07	0.250	1	2.0	30	0.998		
Long Time Very Inv.	28.55	0.712	1	2.0	13.46	0.998		
Long Time Inverse	0.086	0.185	1	0.02	4.6	0.998	120.0	1.0
Recloser Curve #8	4.211	0.013	0.35	1.8	3.29	1.5		

Notes:

- The time in seconds for the **Long Time Extremely Inverse** Curve is 10 times that of the Extremely Inverse Curve.
- The time in seconds for the **Long Time Very Inverse** Curve is 10 times that of the Very Inverse Curve.
- The time in seconds for the **Long Time Inverse** Curve is 10 times that of the Inverse Curve.
- The time in seconds for the **Short Time Inverse** Curve is 1/5 times that of the Inverse Curve.
- The time in seconds for the **Short Time Extremely Inverse** Curve is 1/5 times that of the Extremely Inverse Curve.

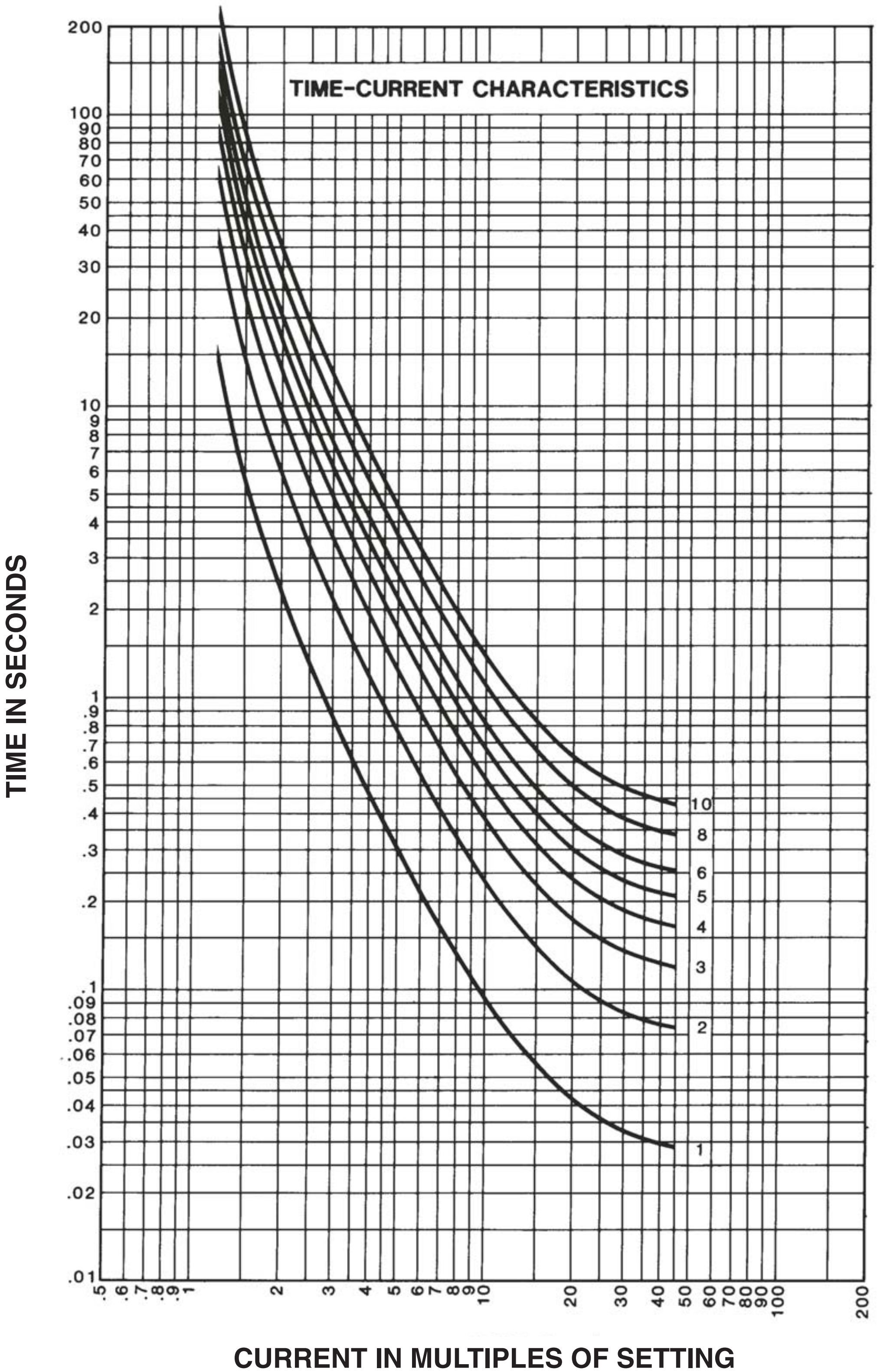


Figure 1-11. Extremely Inverse Curve

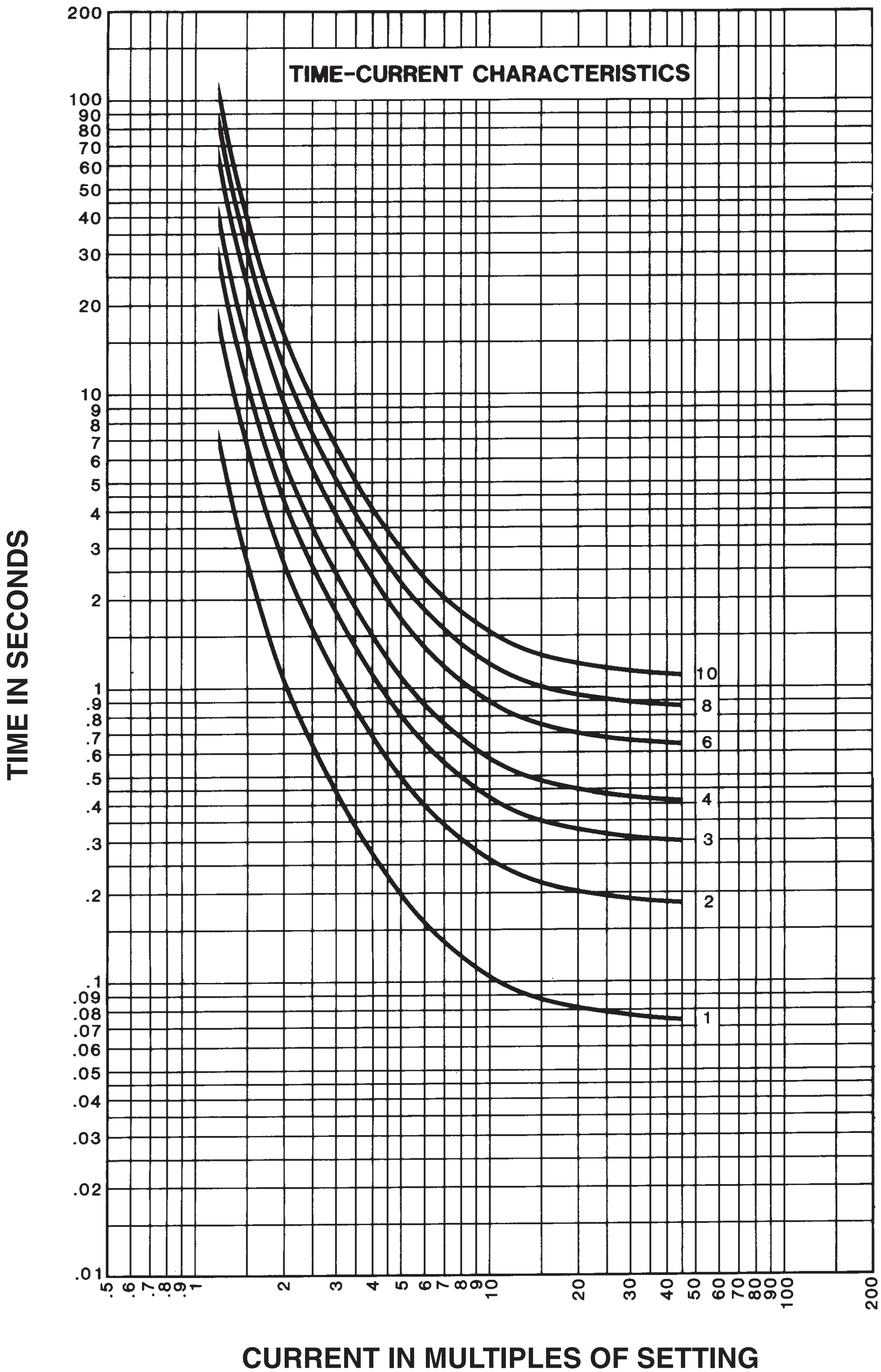


Figure 1-12. Very Inverse Curve

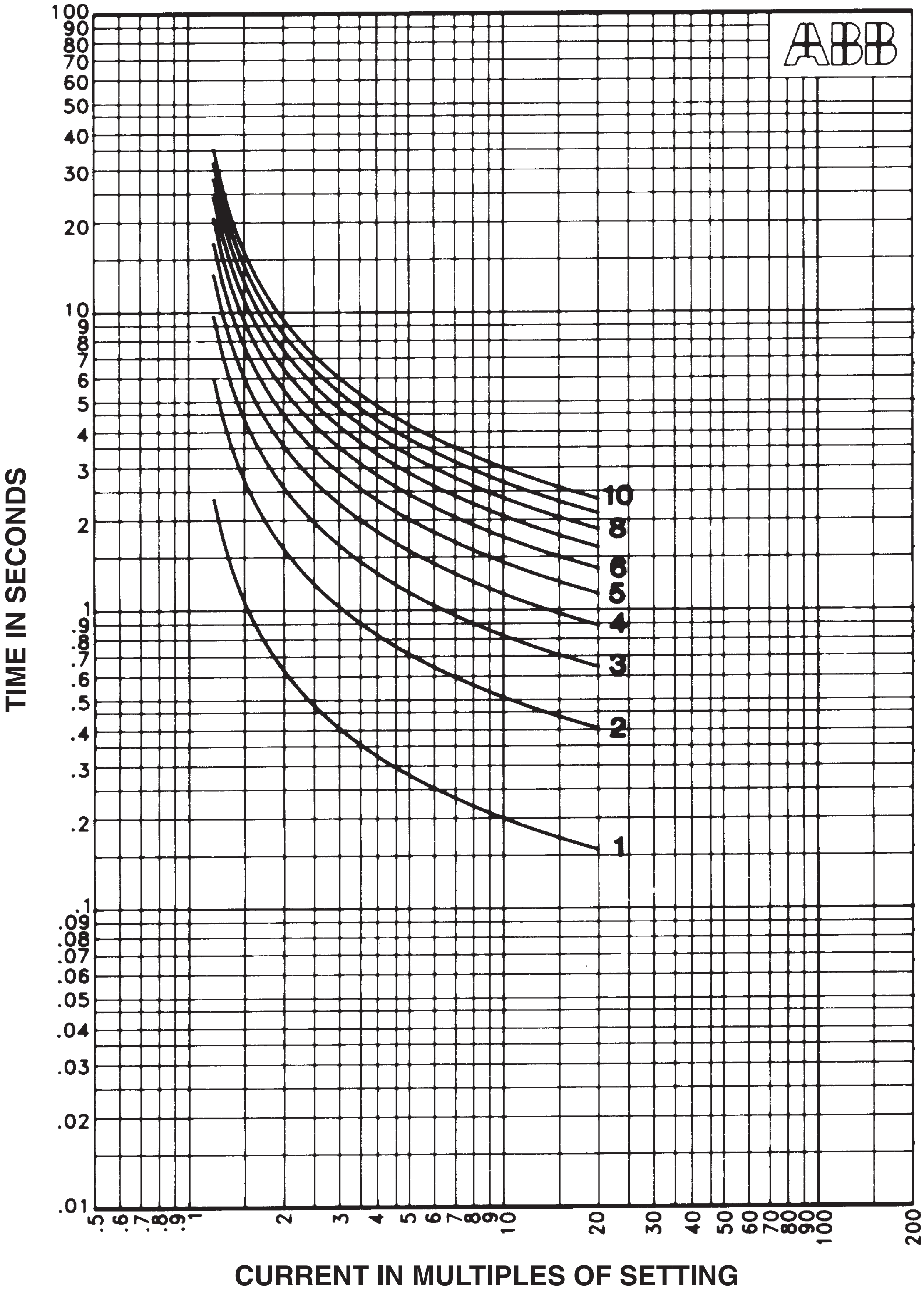


Figure 1-13. Inverse Curve

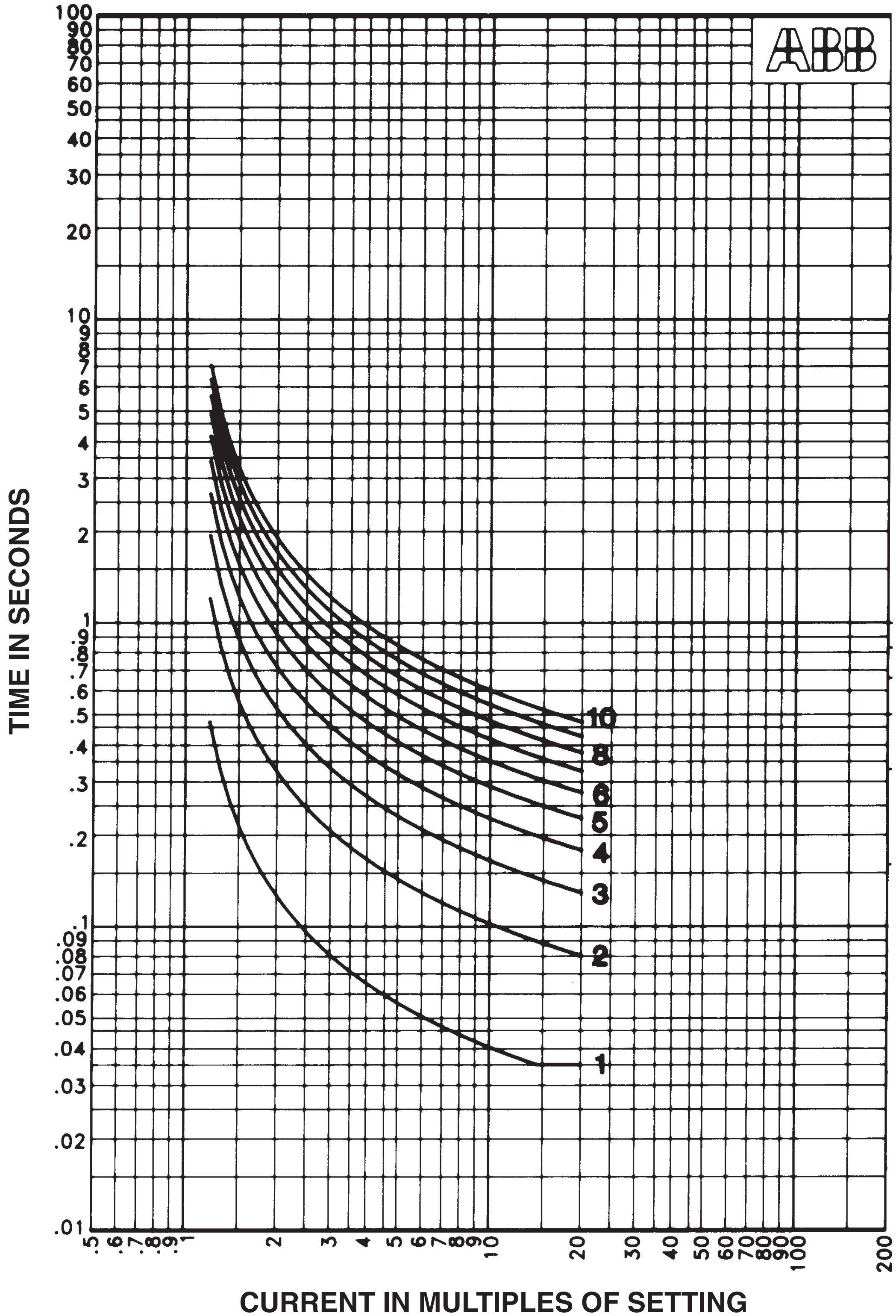


Figure 1-14. Short Time Inverse Curve

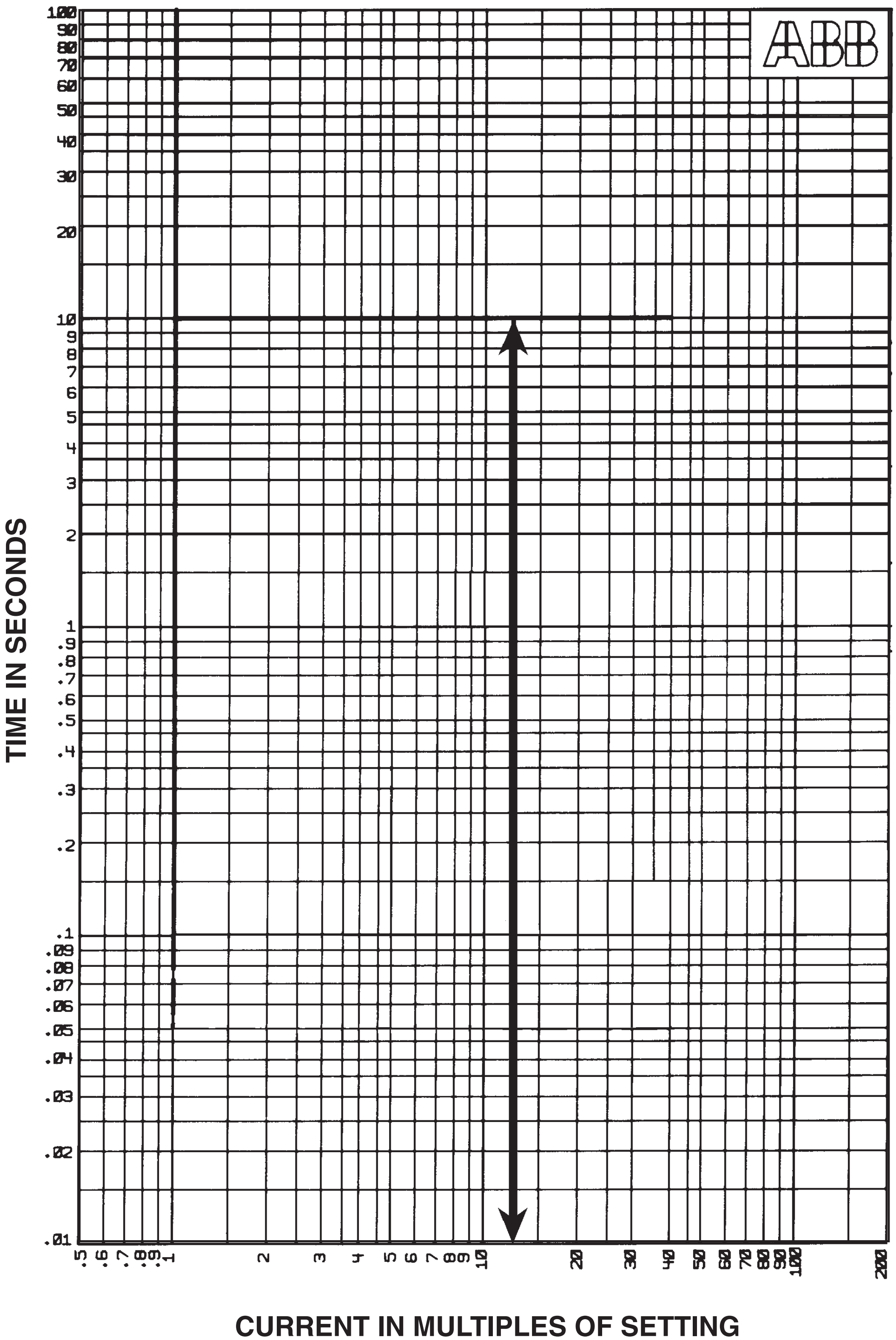


Figure 1-15. Definite Time Curve

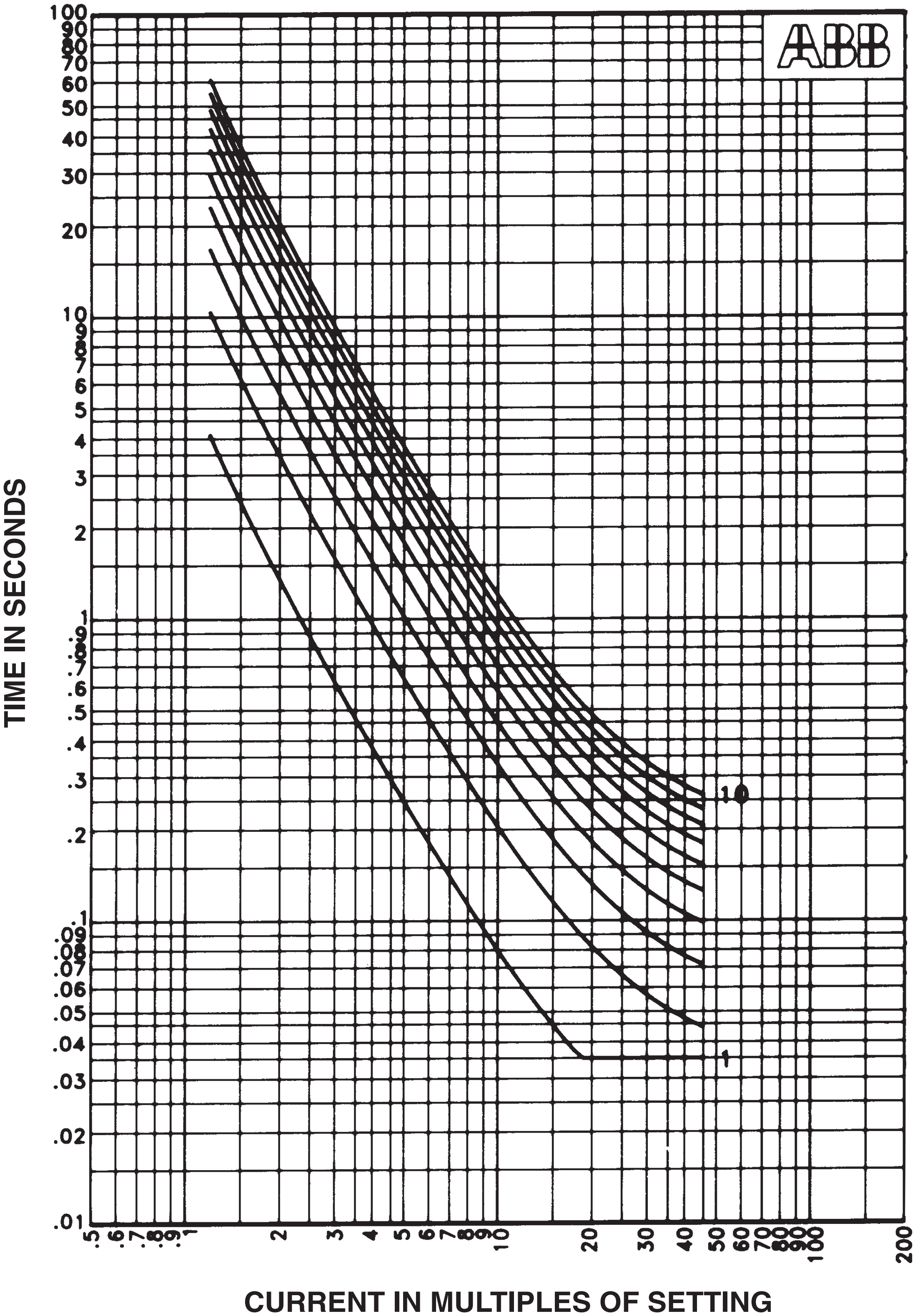


Figure 1-16. Reclosure Curve #8

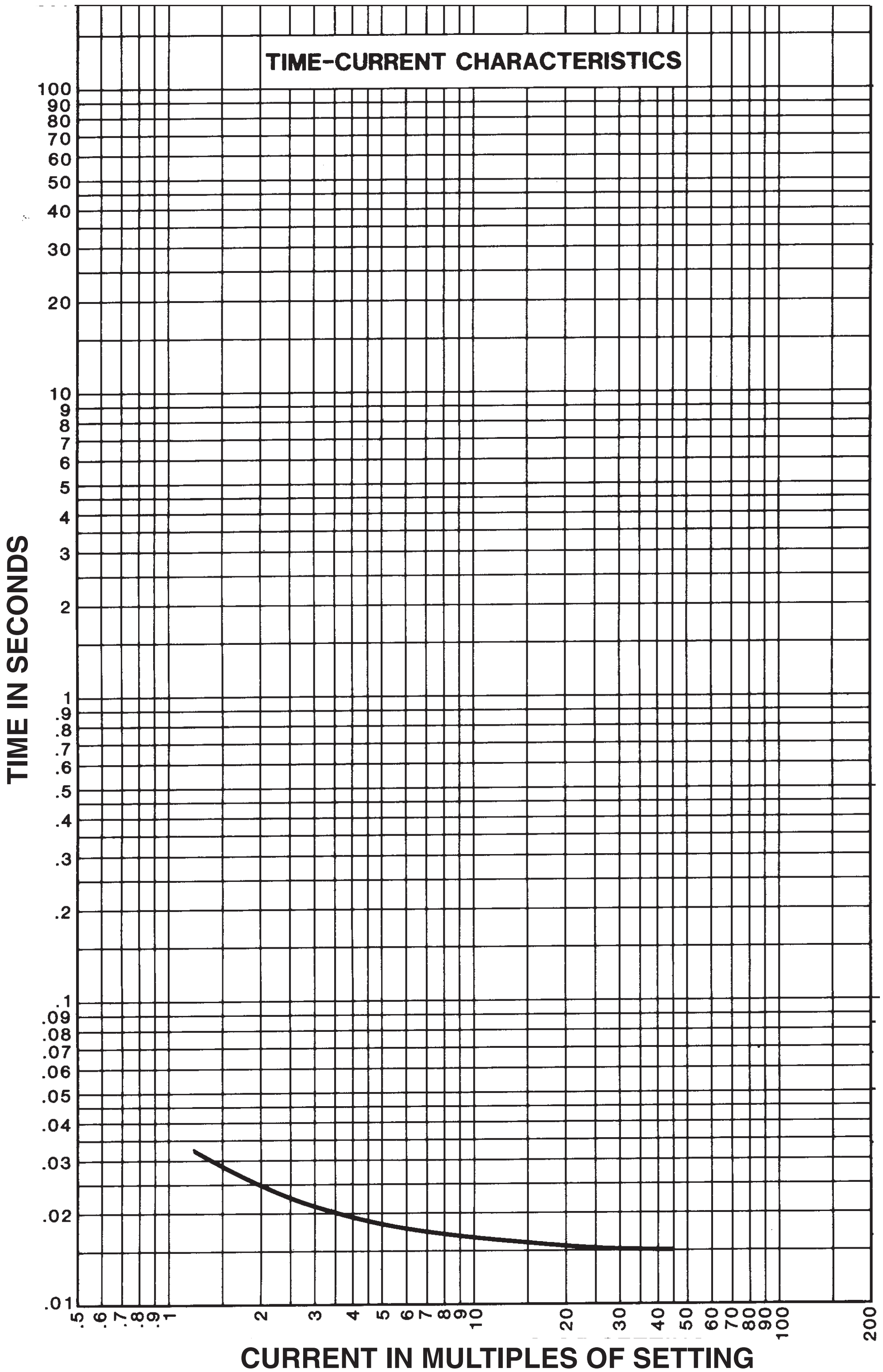


Figure 1-17. Standard Instantaneous Curve

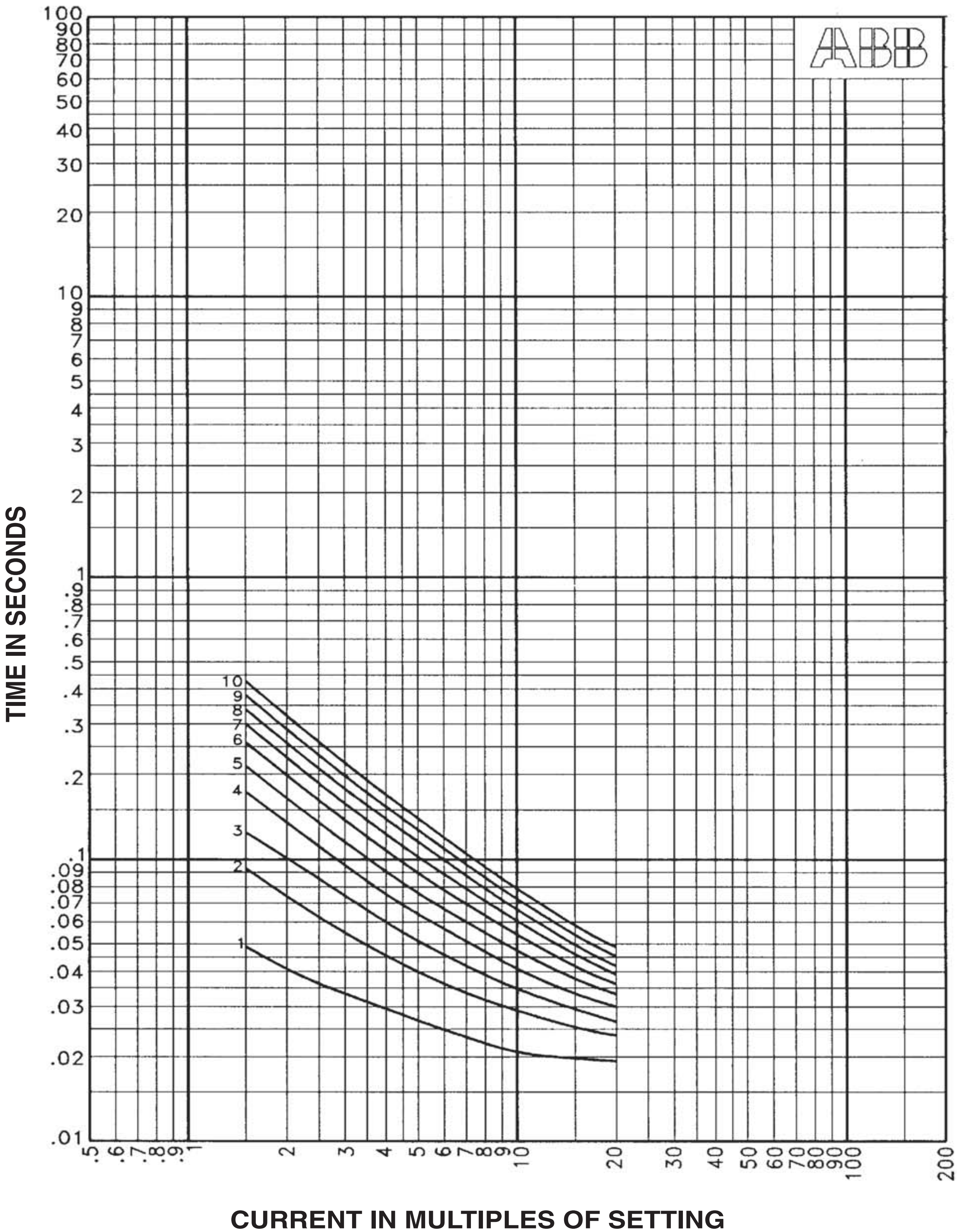


Figure 1-18: Inverse Instantaneous Curve

Phase Directional Power Element 32P-2 (I1>-->)

A phase power directional unit 32P-2 can be used to supervise (torque control) other protective elements within the REF 550. In addition, its status point, 32P-2, can be mapped to a physical output contact (see the Advanced Programmable Logic section) for supervision of external devices. The 32P-2 logical element operation is based upon the torque angle setting defined as the positive sequence current angle compared to the positive sequence voltage angle, respectively - see Figure 1-9. The torque angle is set 0 to 355 degrees in 5 degree steps with a sector width of 180 degrees and is the only setting associated with the 32P-2 element. The 32P-2 unit operates **independently** of the 67P element described earlier. It should be noted that if the 32P-2 is used to supervise the phase instantaneous element(s), 50P, a minimum of 50 milliseconds time delay on the 50P unit is required for coordination. It should also be noted that when the voltage seen by the relay is at or near the minimum sensitivity point of 1 volt line to line, the set angle may move $\pm$ 10 degrees. This power directional element has a current sensitivity of 4% of the phase time overcurrent 51P(3I>) pickup setting. 32P-2 is disabled in the factory default settings.

Although the angle setting for the 32P-2 function is independent of the 67P function, the angle setting is defined the same way (I_1 leading V_1) as the 67P function.

Ground Directional Power Element 32N-2 (I2>-->)

A ground power directional unit 32N-2 can be used to supervise (torque control) other protective elements within the REF 550. In addition, its status point, 32N-2, can be mapped to a physical output contact (see theAdvanced Programmable Logic section) for supervision of external devices. The 32N-2 logical element operation is based upon the torque angle setting defined as the negative or zero sequence current angle compared to the negative or zero sequence voltage angle, respectively - see Figure 1-10. The torque angle is set 0 to 355 degrees in 5 degree steps with a sector width of 180 degrees and is the only setting associated with the 32N-2 element. The 32N-2 unit operates **independently** of the 67N element described earlier. It should be noted that if the 32N-2 is used to supervise the ground instantaneous element(s), 50N, a minimum of 50 milliseconds time delay on the 50N unit is required for coordination. It should also be noted that when the voltage seen by the relay is at or near the minimum sensitivity point of 1 volt, the set angle may move $\pm$ 10 degrees. This power directional element has a current sensitivity of 4% of the neutral time overcurrent 51N(IN>) pickup setting. 32N-2 is disabled in the factory default settings.

Similar to the 67N function, polarizing of the 32N-2 element is provided by the negative sequence voltage (V_2) in the system, or by the zero sequence voltage (V_0) from the WYE connected potential transformers. It is selectable in the relay program. If the REF 550 relay is connected to an open delta or delta voltage source, then the unit cannot use V_0 as it is not generated. In this case, the negative sequence selection must be chosen as the required polarizing quantity for the 32N-2 element.

Although the angle setting for the 32N-2 function is independent of the 67N function, the angle setting is defined the same way (I_2 leading V_2 or I_0 leading V_0) as the 67N function.

Frequency Load Shed and Restoration Functions 81S, 81R, and 81O

Table 1-18. 81 Status Points

Module Number	Load Shed and Underfrequency	Load Resoration	Overfrequency
1	81S-1	81R-1	81O-1
2	81S-2	81R-2	81O-2

The REF 550 provides two independent stages of frequency protection for load shedding and restoration (81S and 81R) or under- and overfrequency (81S and 81O) applications. The status points from these modules can be assigned to physical outputs for tripping and closing of a circuit breaker based on frequency. The 81 function in general is used to shed load on a distribution feeder when the system becomes unstable and the frequency begins to fall. If the stability of the system is sacrificed due to overloading the frequency will generally drop off slowly. The time delay of the under frequency load shed (trip) element can be set to a “toleration” point to allow time for the power system to recover.

The power system frequency is measured from the zero crossing on the Van voltage input for wye connected VT’s and Vab for delta connected VT’s.

The two independent logical under frequency stages are provided with separate status points. The status points for stage 1 are 81S-1, 81R-1 and 81O-1. The status points for stage 2 are 81S-2, 81R-2 and 81O-2. These points become active (logical 1) when the frequency measures below (for 81S-1,2) or above (for 81R/O-1,2) their respective setting for the associated time delay. Both status points will remain active as long as the frequency measures below the settings. The one exception to this is in the case where the system voltage measures below 81V voltage block setting (see 81V description). The frequency shed outputs 81S-1 and 81S-2, can be assigned to the same trip output contact but set at different frequency thresholds and trip time settings. This provides fast tripping response for severe disturbances and slower trip times for more tolerable system disturbances. For example: Set 81S-1 to sense a slight underfrequency condition and assign a longer time period to it. Set 81S-2 to a lower frequency with a shorter time period. This will allow a longer trip time for slight under frequency conditions and shorter trip time for more severe conditions.

Included in the two stages discussed, are the load restoration elements 81R-1 and 81R-2. These two elements can be used to automatically restore load (close the circuit breaker) after their respective frequency load shed element (81S-1 or 81S-2) trips. The REF 550 senses a load shed trip by the operation of 81S-1 or 81S-2 **and** by the change of the 52A and 52B breaker auxiliary inputs. Only at this time are the 81R-1 and 81R-2 status points allowed to operate. The 81R function will activate when the frequency rises above the frequency setting and the associated timer expires. If the power system frequency falls back below the 81R setting before expiration of the load restore timer (81R), the timer will reset and begin again when the frequency returns to above the setting. The 81R status points remain active until a successful breaker close or until the Trip Fail Time expires (see Trip Failure Time in the System Configuration section for more details). The 81R function is not armed again until the next load shed operation.

Two over frequency elements are also included in the two stages discussed. They are 81O-1 and 81O-2. These status points assert when the frequency rises above the 81R setting and the 81R time delay expires. They can be used to trip the circuit breaker but they do not initiate an automatic restoration regardless of a load shed (81S) operation.

To apply the REF 550 to an intertie with local generation, the 81S-1 can be set to provide underfrequency tripping and 81O-2 can be set to provide over frequency protection. These settings provide a “frequency window” when both status points 81S-1 and 81O-2 are assigned to the same output trip contact. The intertie is tripped when the frequency deviates outside the created frequency window.

The hysteresis (or dropout points) for the 81S and 81R status points is 0.02 hertz above the frequency setting. For 81O the hysteresis is 0.02 hertz below the frequency setting.

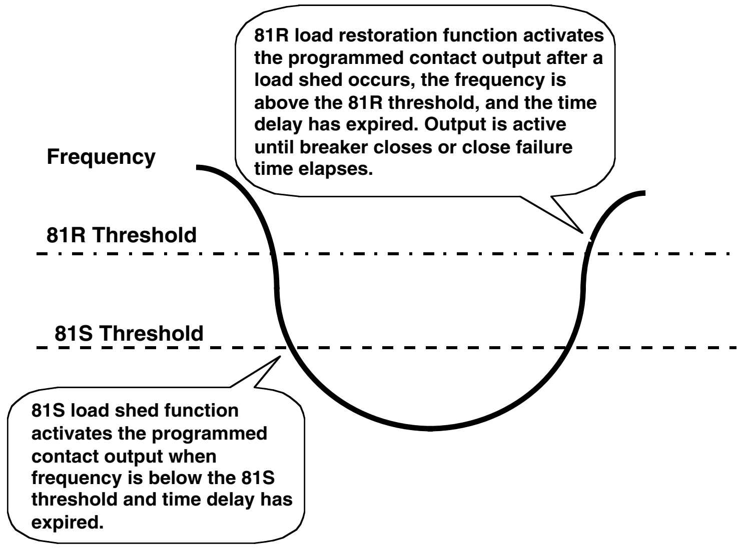


Figure 1-19. 81S and 81R Functions

Voltage Block Element 81V

This elements blocks operation of the status points 81S-1 and 81S-2 when the power system voltage is below the 81V setting. For wye connected VT's, Van is used. For delta connected VT's, the voltage is taken from Vab. Operation of the status points is restored when the voltage returns to normal. The 81S-1 or 81S-2 elements will deactivate if they are active at the time when the power system voltage falls below the 81V setting. The range for this setting is from 40 - 200 VAC. For wye connected VT's in an ungrounded system, it is recommended that the frequency functions be torque controlled by the ground overvoltage function (59G) in addition to using the 81V feature. With presence of significant zero sequence voltage, the frequency functions should be disabled; with no significant presence of zero sequence voltage, the frequency functions can be enabled.

Table 1-19. 81 Characteristics

81 Parameter	Range	Increment
81S-1,2 Pickup - 60 Hz Model	56 to 64 Hz	0.01
81S-1,2 Pickup - 50 Hz Model	46 to 54 Hz	0.01
81S-1,2 Time Delay	0.08 to 60 seconds	0.01
81R/O-1,2 Pickup - 60 Hz Model	56 to 64 Hz	0.01
81R/O-1,2 Pickup - 50 Hz Model	46 to 54 Hz	0.01
81R/O-1,2 Time Delay	0.0 to 7200 seconds	1
81V	40 to 200 volts AC	1

See Table 4-1 for 81 factory default settings.

Undervoltage Element 27 (U<)

The undervoltage element is provided for alarm and control purposes when any one phase voltage drops below a preset threshold. Two status points are provided with the 27 element; one for single phase undervoltage, 27-1P, and one for three phase undervoltage, 27-3P. The 27-1P element will operate when any single phase drops below the undervoltage setting. The 27-3P element will operate only when all three phases drop below the undervoltage setting. Both elements are separate and do not operate the "Master Trip" contact. These status points must be mapped to physical outputs if alarming or tripping is desired (see Advanced Programmable Logic section). The 27 element can also be used to supervise (torque control) other protective elements such as the 51P. Mapping the 27 element to the control point "PH3TC" via the programmable logic, provides a voltage controlled overcurrent protective function. See the Advanced Programmable Logic section for more details.

Table 1-20. 27/59 Characteristics

27/59 Parameter	Range/Curve	Increment
Undervoltage (27)Pickup	10 to 200 VAC	1 volt
Overvoltage (59)Pickup	70 to 250 VAC	1 volt
Time Delay	0 to 60 seconds	1 second

See Table 4-1 for 27/59 factory default settings.

Overvoltage Element 59 (U>)

The overvoltage element, 59, is provided for alarm and control purposes when the system voltage rises above a preset threshold. The overvoltage element 59, is separate from the "Master Trip" contact. The status point, 59, must be connected to a physical output if alarming or tripping is desired (see the Advanced Programmable Logic section).

Three phase overvoltage protection (Device 59-3), is included as a standard REF 550 function. This function requires the voltage of all three phases to be at the pick up setting prior for an output to occur making possible faster identification of system voltage problems and equipment problems compared to the single phase 59-1 function.

The setting for the 59-3 element is the same as the 59 element: namely 70-250 volts in 1.0 volts steps. However, for an output to occur, all three (3) phases must be at or above the setting of the function. The 59-3 threshold and time delay are set in the Primary, Alternate 1, and Alternate 2 settings groups (Table 1-20). Refer to the Advanced Programmable Logic section. The time delay range available for the function is 0 to 60 seconds. If trip times below one second are desired, set the Time Delay to zero and enter the desired trip time in the physical output timers.

The 27/59 threshold and time delay are set in the Primary, Alternate 1, and Alternate 2 settings groups (Table 1-20). The time delay range available for each function is 0 to 60 seconds. If trip times below one second are desired, set the Time Delay to zero and place desired trip time in physical output timers.

Zero Sequence Overvoltage Element 59G

A zero sequence overvoltage protection device 59G is included in the REF 550 relay. This function will detect an overvoltage condition utilizing the V_0 quantity that the relay observes from the potential transformers if they are connected in a WYE configuration. If the relay is contacted to an open delta configuration in which no zero sequence voltage is generated, then the relay forces the zero sequence voltage measured value to zero. This setting is programmable in the Configuration settings and is dependent on the potential transformer configuration.

Table 1-21. 59G Characteristics

59G Parameter	Range	Increment
V_0 Voltage Pickup	1.0 - 50.0 v	0.5 v
Time Delay	0 to 30 seconds	0.1 second

See Table 4-1 for 59G factory default settings.

The 59G function within the relay is normally disabled. Refer to Table 1-21 for the setting parameters for this element. However for an output to occur, the 59G must be enabled with the voltage setting and time delay (if desired) in the Primary, Alternate 1, and Alternate 2 settings groups. The 59G overvoltage element is provided for alarm and control purposes when the zero sequence voltage exceeds the setting level. However, the 59G element is separate from the “Master Trip” contact. The status point 59G must be connected to a physical output if alarming or tripping is desired (see the Advanced Programmable Logic section).

Negative Sequence Voltage Element 47

Negative sequence voltage protection (Device 47) is included in the REF 550 relay. This feature allows the detection of loss of phase or the detection of an unbalanced system without the necessity of current flowing. Benefits include faster identification of blown fuses or an open phase on the primary feeds to a distribution transformer.

Table 1-22. 47 Characteristics

47 Parameter	Range	Increment
V_2 Voltage Pickup	5.0 - 25.0 v	0.5 v
Time Delay	0 to 60 seconds	0.1 second

See Table 4-1 for 47 factory default settings.

The negative sequence voltage unit (Device 47) will have outputs for alarm indication or sealed-in outputs. This function is separate from the “Master Trip” contact. The status point, 47, must be connected (mapped) to a physical output if alarming or tripping is desired (see the Advanced Programmable Logic section). The default position for the 47 element is disabled.

The 47 threshold and time delay are set in the Primary, Alternate 1, and Alternate 2 settings groups (Table 1-22). Refer to the programmable outputs section. The time delay range available for the function is 0 to 60 seconds. If trip times below one second are desired, set the Time Delay to zero and enter the desired trip time in the physical output timers.

Refer to Table 1-22 for the device 47 characteristics.

Phase Step Distance Protection Element 21P

Four zones of phase impedance protection (Device 21P) are included as standard in the REF 550 relay, programmable for forward or reverse operation. With this feature, one style of relay may be used on both the high side and low side of certain distribution substations for the application of sub-transmission and feeder protection. This available application of the REF 550 may also be used for the protection of small and medium size motors where the reverse zones would protect for low excitation.

The four zones of impedance protection are available with a circular characteristic commonly referred to as the MHO circle. In addition, all of the zones have a variable MHO feature insuring protection near the origin of the R-X diagram. Those zones programmed forward will have a maximum reach of 0.1-50.0 ohms. The angle of maximum reach is adjustable from 10.0-90.0 degrees. Time delay is available from 0.0-10 seconds. Those zones programmed reverse will have identical characteristics except the angle of maximum reach will be in the reverse direction with a range of 190.0-270.0 degrees. All zones contain three-phase and phase-to-phase elements and have optional supervision using the positive sequence current I_1 and negative sequence current I_2 level detectors, respectively, each with an adjustable current range of 1.0-10 amperes. Refer to Table 1-23 for the complete zone settings.

All zones of the 21P element have a voltage memory feature for six (6) cycles. This is important in that if the relay were to observe a close in fault where there was insufficient or no voltage for the distance element to operate due to a voltage collapse, the memory of six cycles of voltage will permit the protective unit to operate. Depending on the settings of other protective elements in the REF 550 relay, they may also operate for this condition.

For the 1.0 ampere CT REF 550 relay model, the reaches for all zones are 5 times that of the 5.0 ampere CT model; namely 0.5-250.0 ohms.

All the zone settings are completely independent of each other. The default setting for the 21 element is disabled.

There is a target status point for each zone element mappable to a programmable LED.

Tripping with the 21P Function

To drive the Master Trip contact upon any of the four enabled Phase Step Distance element, use the Advanced Programmable Logic to program the following program statement equation:

OPEN = 21P-1 + 21P-2 + 21P-3 or 21P-4

This mapping will also drive the internal breaker failure feature per the Trip Failure Time Configuration setting. If operating a separate physical output is desired, then use the following program statement equation and program a reasonable dropout time delay on the physical output that exceeds the combined time of the Trip Failure Time and the breaker failure breaker’s maximum operate time:

TM01 = 21P-1 + 21P-2 + 21P-3 + 21P-4
OUT01 = TMO01,

where Timer 1 dropout time equals sum of Trip Failure Time and breaker failure device’s maximum operation time.

Table 1-23. Impedance Characteristics Element 21P

21 Parameter	Range	Increment
Zone 1 Impedance 0.4 - 12.0 Amp model 0.08 - 2.4 Amp model Characteristic Angle Time Delay	 0.1 to 50.0 ohms 0.5 to 250 ohms 10 - 90 or 190 - 270 degrees 0.0 - 10.0 sec.	 0.1 ohm steps 0.5 ohm steps 0.1 degree steps 0.1 sec. steps
Zone 2 Impedance 0.4 - 12.0 Amp model 0.08 - 2.4 Amp model Characteristic Angle Time Delay	 0.1 to 50.0 ohms 0.5 to 250 ohms 10 - 90 or 190 - 270 degrees 0.0 - 10.0 sec.	 0.1 ohm steps 0.5 ohm steps 0.1 degree steps 0.1 sec. steps
Zone 3 Impedance 0.4 - 12.0 Amp model 0.08 - 2.4 Amp model Characteristic Angle Time Delay	 0.1 to 50.0 ohms 0.5 to 250 ohms 10 - 90 or 190.0 - 270.0 degrees 0.0 - 10.0 sec.	 0.1 ohm steps 0.5 ohm steps 0.1 degree steps 0.1 sec. steps
Zone 4 Impedance 0.4 - 12.0 Amp model 0.08 - 2.4 Amp model Characteristic Angle Time Delay	 0.1 to 50.0 ohms 0.5 to 250 ohms 10 - 90 or 190.0 - 270.0 degrees 0.0 - 10.0 sec.	 0.1 ohm steps 0.5 ohm steps 0.1 degree steps 0.1 sec. steps
I_1 Supervision (per Zone) 0.4 - 12.0 Amp model 0.08 - 2.4 Amp model	 1.0 - 10.0 amps 0.2 - 2.0 amps	 0.1 amp steps 0.02 amp steps
I_2 Supervision (per Zone) 0.4 - 12.0 Amp model 0.08 - 2.4 Amp model	 1.0 - 10.0 amps 0.2 - 2.0 amps	 0.1 amp steps 0.02 amp steps

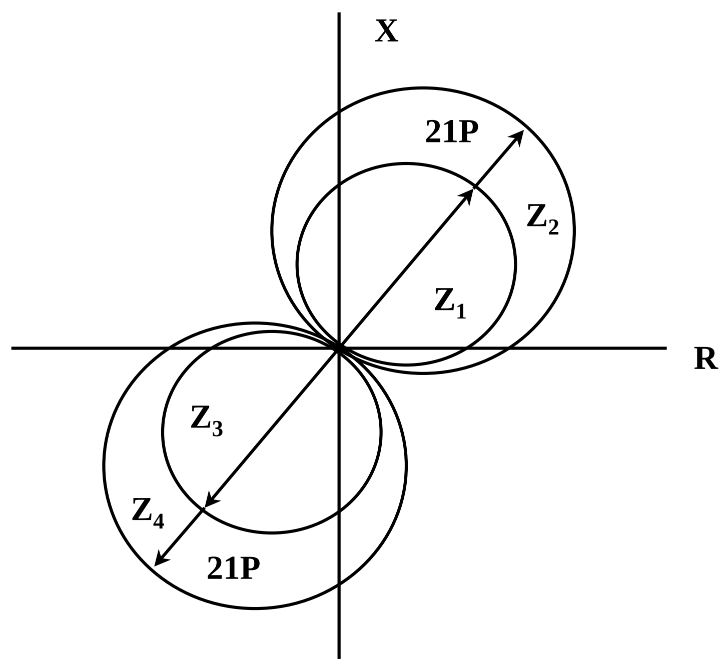


Figure 1-20. Example Characteristics of the Four Zone Distance Elements 21P-1, -2, -3, -4.

Sync Check Function (25)

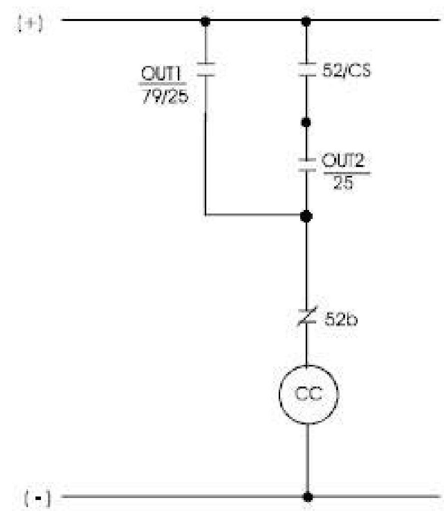
Application

The Sync Check function was developed for application on transmission lines or on distribution lines with a co-generation source. Normally one end of a line would be closed first to energize the line. The sync check dead line setting allows one end to be closed energizing the line. The other end would then require sync check.

The sync check function is intended for application where two parts of a system are to be joined by the closure of a circuit breaker. These lines are interconnected at least at one other point in the system so that even though the voltages on either side of the open circuit breaker are of the same frequency, there may be an angular difference due to load flow throughout the interconnected system. It is usually desirable to close the breaker even though an angular difference exists provided that the difference is not great enough to be detrimental to the system or connected equipment or system stability.

Closing of the breaker is permitted when the phase angle difference, voltage magnitude difference, and slip frequency are within the parameters set by the user.

In conventional sync check relaying, a relatively long time measurement is used to insure that the voltages across the open breaker are in sync. However, this long time delay which may be as long as 10 to 20 seconds, is undesirable if both ends of the line are being reclosed at high speed. If the time delay is shortened, a faster sync check measurement can be made but this may result in reclosing for a non-synchronous condition with slip frequencies that are higher than desired for proper reclosing.



34	
35	OUT01 = CLOSE
36	OUT02 = 25
37	

Figure 1-21. Typical Sync Check Wiring and Mapping

A **slip cut-off** frequency function can allow a high speed sync determination when voltages are in sync without the risk of reclosing if high slip frequencies are actually present. Setting the **slip cutoff frequency** to an acceptable level and the sync time to 0 will assert a synch contact as soon as the line angle reaches the sync window.

The sync check function will not provide an output to permit reclosing if no voltage is present on one or both sides of the open breaker. Therefore for applications where Dead Line and/or Dead Bus operation is required, the undervoltage detection functions can be used. Selection can be for one or more of the following supervision conditions:

1. Live Line - Dead Bus
2. Live Bus - Dead Line
3. Dead Line - Dead Bus

Other selections provide for:

Ability to sync to any phase via setting.
Disabling of sync check from the recloser via setting or user input (manual override permission via control point)
Requiring sync check for manual closing via programmable logic mapping.
Status Point “25” provided. Asserted when synchronism is achieved.

Synchronism Check Settings

The synchronism check element, 25, is set based on a secondary voltage and phase angle comparison between the standard connected LINE voltages (terminals 31-34) and the BUS voltage input, (terminals 35 and 36). The element can be used to supervise closing in the reclose sequence and/or supervise a manual close by a control switch. See Figure 1-21.

By setting the Reclose Sync Supervision, to Enable during a reclose sequence, the status point CLOSE will not become asserted until the conditions of the 25 element are met. After the open interval timer times out during a reclose sequence, the relay will start a Sync Fail Timer. This timer will continue to decrement until the 25 condition is met. When the 25 condition is met, the relay will issue the CLOSE signal. If the condition is not met within the Sync Fail Time setting, the relay will go to lockout.

To supervise a manual Close operation, the 25 status point should be mapped to a separate output contact wired in series with the Control Switch contact. See Figure 1-21.

The following conditions must be met in order to issue the 25 signal - see Figure 1-23.

1) The phase angle difference between the BUS Voltage and the selected Line Voltage (Va, Vb, Vc, Vab, Vbc, and Vca) must be less than or equal to the Synchronism Angle setting, **Angle Diff**.

2) The magnitude difference between the Line Voltage and the selected Bus Voltage must be less than or equal to the Voltage Difference setting, **Volt Diff**.(±)

3) Conditions 1 and 2 must be met continuously for a time equal to or greater than the **Synch** setting.

4) The actual slip frequency must be less than the **slip frequency setting**, **Fs**.

5) The 25 status point will be asserted when the 4 conditions above are true.

Other Conditions that could cause the status point 25 to become asserted are:

1) If the Dead Bus - Live Line (DBLL) setting is set to Enable, and the Line Voltage is “Live” based on the live voltage setting, and the selected Bus Voltage is “Dead” based on the dead voltage setting, then the 25 status point will become asserted after the Dead Time timer has timed out.

2) If the Live Bus - Dead Line (LBDL) setting is set to Enable, and the selected Bus Voltage is “Live” based on the live voltage setting, and the Line Voltage is “Dead” based on the dead voltage setting, then the 25 status point will become asserted after the Dead Time timer has timed out.

3) If the Dead Bus- Dead Line (DBDL) setting is set to Enable, and both the Line and Bus Voltages are “Dead” based on the dead voltage setting, then the 25 status point will become asserted after the Dead Time timer has timed out.

4) If the sync - check bypass Control point, **25BYP**, is mapped to the programmable input table and is true (see Programmable I/O Section), the status point 25 will become asserted regardless of the system conditions.

A status point is available for each of these four conditions programmable for monitoring and control.
The settings in Table 1-24 can be found in the Primary, Alt1 and Alt2 settings tables.

Table 1-24. Synchronism Check Characteristics

Setting		*Range*	*Increments*	*Default*
Sync Check Enable	***(Sync Check)***	Enable, Disable		Disable
Dead Bus - Live Line	***(DBLL)***	Enable, Disable		-
Live Bus - Dead Line	***(LBDL)***	Enable, Disable		-
Dead Bus - Dead Line	***(DBDL)***	Enable, Disable		-
Voltage Difference	***(Volt Diff)***	5 to 80 volts	5 volts	-
Angle Difference	***(Angle Diff)***	1 - 90 Degrees	1 degree	-
Synch Time	***(Synch Time)***	0 to 60 sec	.1 sec	-
Slip Cutoff Frequency	***(Slip Freq)***	.005 to 1.000 Hz	.005 Hz	-
Phase Select	***(Phase Select)***	Van Vbn Vcn Vab, Vbc, Vca	-	-
Line/Bus Voltage Dead	***(Dead Volt)***	10 to 150 volt	1 volt	-
Line/Bus Voltage Live	***(Live Volt)***	10 to 150 volt	1 volt	-
Dead Time	***(Dead Time)***	0 to 120 sec	.1 sec	-
Recloser Sync Supervision	***(Reclose)***	Enable, Disable	-	-
Sync Fail Timer	***(Fail Time)***	Disable, 0 - 600 sec	1 sec	-
Breaker Close Time	***(BCT)***	2.0 - 15.0 cyc, Disable	.5 cyc	

Note: The Sync Fail Timer will appear if the ***25/79sup*** setting is set to enable.

The gray area in Figure 1-22 shows the area that synchronism will occur. The user must be sure to coordinate the slip frequency setting with the sync time setting and the phase angle setting per the formula that follows. If the sync timer is set too high and the slip frequency is set too high, it is possible to never achieve synchronism. The following equation should be used as a check:

$$\frac{\textbf{Sync Ang}}{\textbf{Sync Time} \times 180} = \text{Max Fs Setting (See Figure 1-25)}$$

NOTE: Do not use zero (0) for the sync time for this equation. This would be an undefined value.

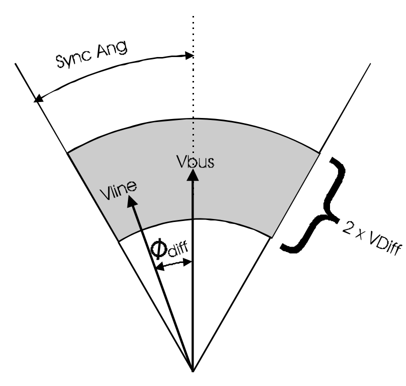


Figure 1-22. Synchronism Area

Another setting in the sync check logic is the **Dead Time**. After the REF 550 senses a Breaker Open Condition, the Dead Time timer will start. The relay will not check for a sync condition until the **Dead Time** timer has expired.

The Sync Check function, 25, can be supervised via the Advanced Programmable Logic by mapping the control point 25TC to a physical input contact. See the Advanced Programmable Logic section for details.

Figure 1-24 shows the logic diagram for the synchronism check function.

Description of Operation

Refer to Figure 1-23. Although the sync check measurement function is constantly running, the sync check logic is activated whenever the REF 550 determines a circuit breaker open state. There are two paths the logic can take depending on what caused the breaker to open.

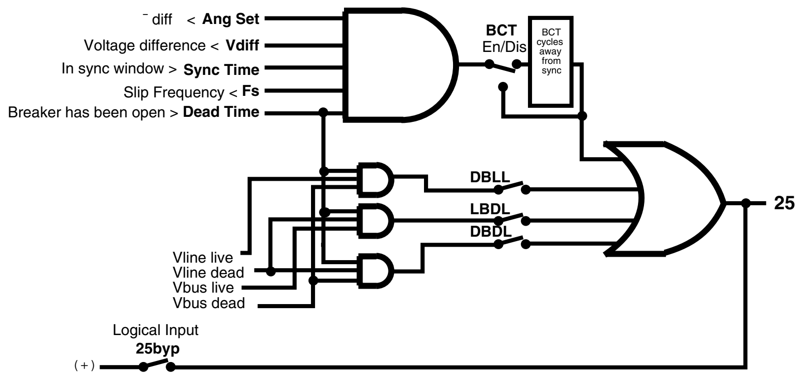


Figure 1-23. Sync Check Logic

Manual Trip

If the breaker was opened but the REF 550 did not cause it to occur via overcurrent trip, the logical path will follow the manual trip path. In this case the logic checks to see if the “25 Select” setting is enabled. If it is not the logic halts and the REF 550 MMI display will read “Breaker Opened”. If the “25 Select” setting is enabled, the logic will start a “Dead Timer”. This timer inhibits the assertion of the “25” status point until the Dead Timer expires. The dead timer can be used when it is not desired to allow reclosing for a period of time even if the system is in sync. Once the dead timer has expired, the “25” status point is allowed to operate if sync has been achieved. If a no-sync condition exists at this time, the REF 550 will wait for sync indefinitely. If the circuit breaker is manually closed the logic starts over again. A “Sync Bypass” control point is provided to override a no-sync condition. This could be used in a SCADA environment where the voltage difference and angular difference are polled by a master operations station and it is determined that a close could be performed safely even though the angle difference or voltage difference is outside the set windows.

Overcurrent Trip Condition

If an overcurrent trip occurs, the REF 550 recloser will function normally if the “25 Select” setting is disabled or the “Recloser Sync Supervision” setting is disabled. When both of these settings are enabled, the REF 550 will check for sync before a close is permitted. After the 79-x open time expires the sync check is performed. If a sync condition exists, a close is asserted immediately. If a no-sync condition exists, the REF 550 will start a “Sync Fail Timer”. If sync is achieved before expiration of this timer, a close is asserted. If sync is not achieved the REF 550 will switch to lockout upon expiration of the Sync Fail Timer. As described above, a “Sync Bypass” control point is provided to override a no-sync condition.

Synchronism Check and External Reclose Initiates 79M / 79S

It is possible to initiate automatic reclosing when the REF 550 detects an external trip as described later in this section. The external multi- and single-shot reclose control points 79M and 79S, respectively, can be activated only after the dead timer expires and 79 is enabled via the “79 Select” setting and the 43A control point. If an external reclose is initiated, the logic will shift to that of an internal trip condition. A synchronism condition must occur first, within the Sync Fail Time, and remain during the reclose open time countdown. If the breaker opens again via external trip before the 79 reset time expires, the dead timer will run but will not inhibit the 79M and 79S control points. What this basically means is that the dead timer will inhibit the 79M and 79S points for reclose step 79-1 only. Any concurrent reclose steps will not be inhibited.

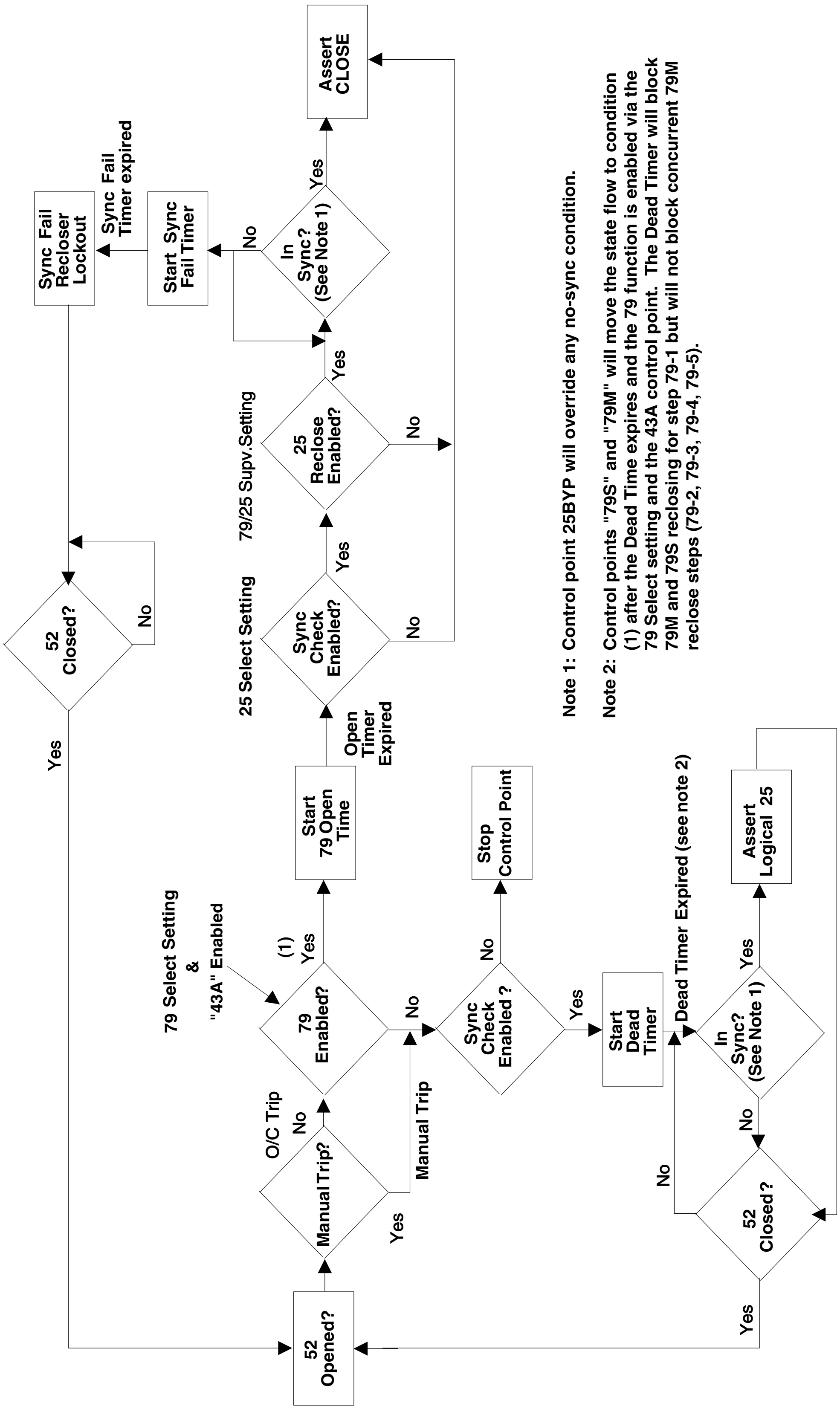


Figure 1-24. Logic Diagram for Synchronism Check Feature

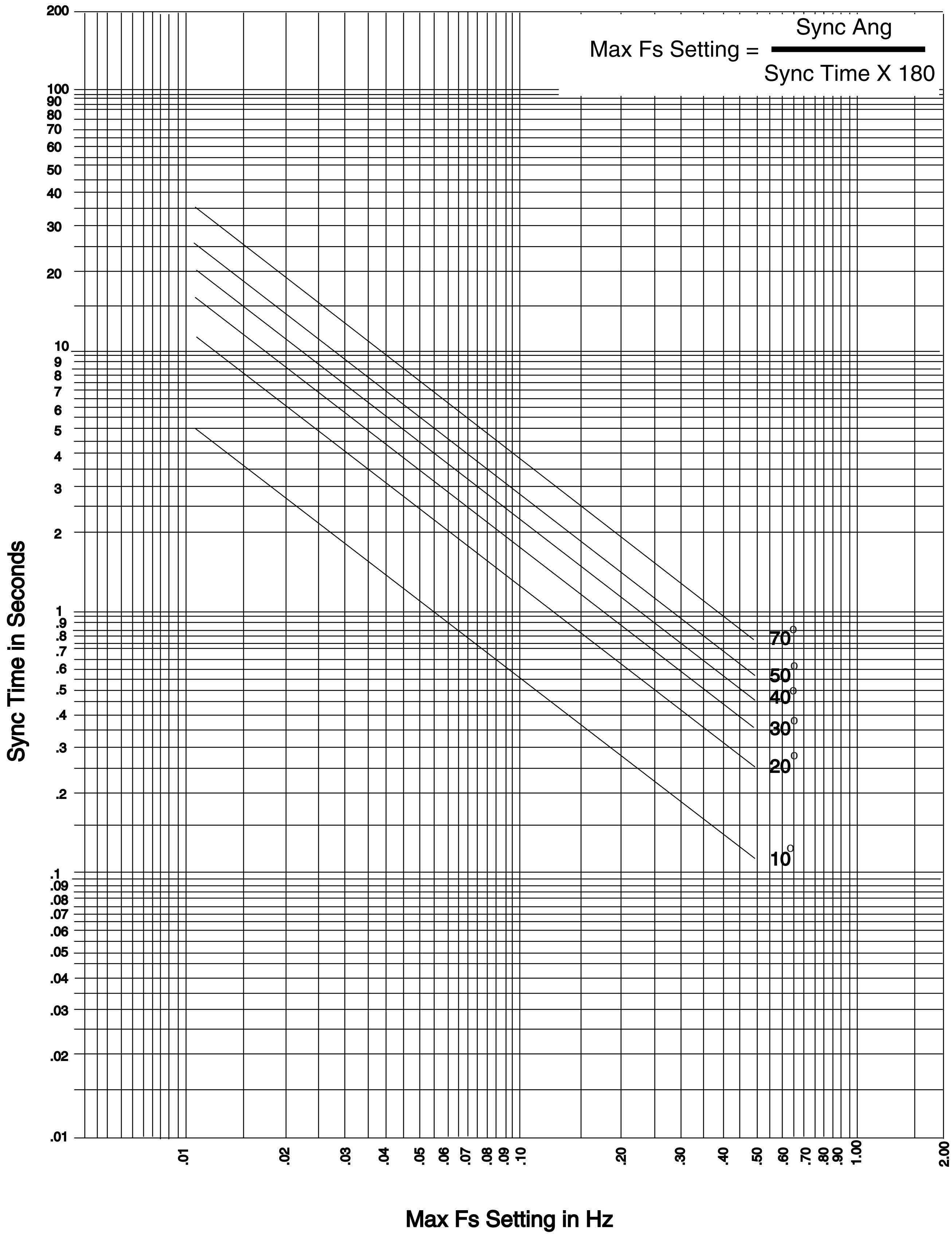


Figure 1-25. Sync Check Maximum Slip Frequency Characteristic

Recloser Function 79 (O->I)

This recloser function, 79, provides automatic reclosing of the circuit breaker after the REF 550 has tripped due to a fault. The circuit breaker will close after a preprogrammed time delay called “Open Time”. Zero to five recloser steps can be selected and each has its own separate “Open Time” and selection of protective elements, except for 79-5 (step 5). The steps as labeled in the REF 550 are 79-1 (step 1), 79-2 (step 2), 79-3, (step 3), 79-4 (step 4) and 79-5 (step 5). If the fault persists after the fifth attempt at reclosing, the 79-5 (step 5) will automatically go to lockout. There is no time delay provision for 79-5 as the REF 550 has completed the complete reclosing operation. During each reclose step the protective elements 50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, and 50N-3 can be enabled or disabled from tripping. Each protective element can also be set such that if the element operates, the reclose sequence will be halted and “locked out”. (See Figure 1-26.) Lockout is a point at which the circuit breaker will remain open after a fault and must be manually closed. These steps can be used to provide high speed reclosing for the first trip and delayed reclosing thereafter. A reset timer runs after a successful circuit breaker reclose (whether automatic or manual) and is used to reset the reclose sequence to 79-1 after its time period expires. If the REF 550 trips the circuit breaker again before the expiration of the reset time, the reclose sequence will increment one step; I.E. 79-1 to 79-2. The settings as programmed in the 79-2 step will then become active. This incremental stepping occurs until the recloser locks out or successfully recloses. If the reclosing function proceeds to lockout, the circuit breaker must be manually closed.

An amber “Reclose Out” LED contained on the front panel of the REF 550 indicates that the recloser function is disabled. The control point, 43A is used to remotely enable or disable the recloser (I.E. via control switch). If this control point is not mapped to a physical input (see the Advanced Programmable Logic section), the recloser is defaulted to enabled. If the recloser is in the middle of a sequence and the 43A control point is made inactive the recloser will stop operation. When 43A is returned to the active state, the recloser will be reset to step 79-1. The recloser function can also be disabled by setting 79-1 to lockout.

See Table 4-1 for the 79 factory default settings.

If the single shot recloser is in the middle of the open time or reset time and the recloser is disabled via the 43A control point, the recloser will stop operation. When 43A is returned to the active state the recloser will be reset.

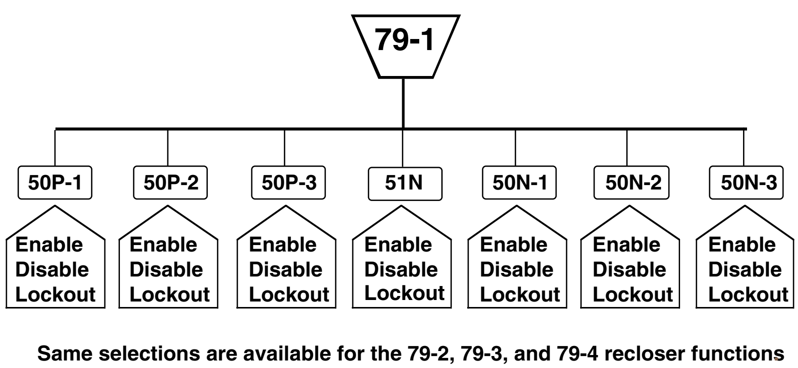


Figure 1-26. Recloser Sequence

Lockout

The REF 550 will lockout reclosing if any one of the following conditions are true:

- A fault persists for the entire reclose sequence.
- The breaker is manually closed and a fault occurs before the reset time expires.
- A Trip output occurs and the fault current is not removed and/or the 52a/52b contacts did not change state before expiration of the Trip Fail Timer (5 to 60 cycles).
- A Close output occurs and the 52a/52b contacts do not change state before the expiration of the Close Fail Timer. If the Circuit Breaker subsequenty closes and trips within the reset time, the recloser will lock out.
- The reclose function is set to lockout after a 50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, or 50N-3 overcurrent trip.
- The voltage block function, 79V, is enabled, the bus voltage is below the 79V setting, and the 79V time delay has expired.

A lockout condition is displayed on the LCD display as "Recloser Lockout". A status point, 79LOA is also asserted for a lockout condition. The lockout state is cleared when the REF 550 senses a manual breaker close by the state of the 52a and 52b contacts and the reset timer expires.

Cutout Timer (O->I-CO)

The 79 Cutout Time (79-CO) function allows for the detection of low-level or intermittent faults prior to the resetting of the reclose sequence. At the end of the selected cutout time period, all overcurrent functions are re-enabled based on the 79-1 settings. (See Figure 1-27.) For example, if the 79 Reset Time is set for ten seconds and the 79 Cutout Time is set for five seconds, the first five seconds after reclosing, the REF 550 follows the overcurrent function settings for the reclose sequence, but the second five seconds (after the cutout time has expired) it follows the 79-1 settings. The 79-CO setting (in Primary, Alternate 1 or Alternate 2 settings) is enabled by programming a time period from 1 to 200 seconds. When enabled, the 79-CO setting must be less than the 79 Reset Time.

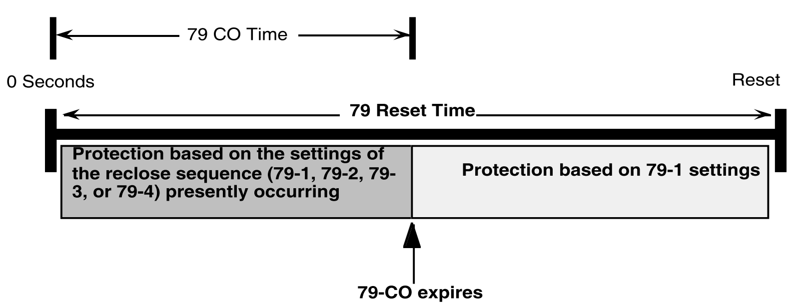


Figure 1-27. 79 Cutout Time

In fuse-saving applications involving large downstream fuses, the 50P and 50N instantaneous functions are set below the fuse curve to detect faults on tapped laterals. These functions are blocked after the first trip in the reclose sequence. The 51P and 51N time overcurrent functions are set above the fuse curve. This results in the upstream protection being less sensitive to an intermittent or low-level fault during the subsequent reclose operations.

If the reset time is too short, the reclosing relay may reset before the fault is detected again. If the reset time is too long, the intermittent or low-level fault is not cleared fast enough by the upstream protective device. In schemes using discrete reclosing relays, blocked instantaneous overcurrent functions are placed back in service only after the reclosing relay has reset. However, the 79-CO function in the REF 550 re-enables the instantaneous functions at the end of the selected cutout period. Set the time for the 79-CO function according to how long it takes a downstream fuse or other protective device to clear downstream faults. The typical time setting is between 10 and 15 seconds. If an intermittent or low-level fault exists, it will be detected at the end of the 79 CO cutout time period, and the REF 550 will trip and continue through the reclose sequence until the fault is permanently cleared or lockout is reached. The 79-CO function allows the reset time to be set beyond 60 seconds without jeopardizing sensitivity to intermittent or low-level faults.

Single Shot Reclose Control Point 79S (O->I1)

The 79S control point is used to initiate a single shot of reclosing when the circuit breaker is opened by an external source. Control point 79S must be mapped to a physical input contact for activation by an external device (see Programmable I/O Section). The 43A (recloser enable) control point must also be active for the 79S function to operate. If 43A is not mapped to a physical input it defaults to enable. The 79S operates as follows:

If the breaker is opened by an external source and the 79S control point is active, the circuit breaker will close in the 79-1 open time.

If the breaker is opened by an external source and the 79S control point is not active but is made active after the circuit breaker is opened, the circuit breaker will close in the 79-1 open time.

If the circuit breaker is opened before the reset time expires, 79S will not operate again until the breaker is manually closed back in and the reset time expires.

> The 79S function can be made active or inactive by the mapping FALSE logic to the 79S control point (see the Advanced Programmable Logic section).
>
> The internal REF 550 logic only checks the status of the 79S control point when it detects that the circuit breaker has opened. Once it has determined that the 79S is active, it will initiate the single shot reclose. It doesn't matter if the 79S is toggled or held active.
>
> If the single shot recloser is in the middle of the open time or reset time and the recloser is dissabled via the 43A control point, the recloser will stop operation. When 43A is returned to the active state the recloser will be reset.

Multi-Shot Reclose Control Point 79M (O->I)

The 79M control point is used to initiate multiple shots of reclosing when the circuit breaker is opened by an external source. Control point 79M must be mapped to a physical input contact for activation by an external device (see the Advanced Programmable Logic section). The 43A (recloser enable) control point must also be active for the 79M function to operate. If 43A is not mapped to a physical input it defaults to enable. The 79M operates as follows:

If the breaker is opened by an external source and the 79M control point is active, the circuit breaker will close in the 79-1 open time. If the circuit breaker is opened again by an external source and the reset time has not expired, the recloser will step to 79-2 and the circuit breaker will close (or lockout depending upon the 79-2 programming) in 79-2 time. If the breaker continues to open before the reset time expires, the recloser will continue to increment steps until it reaches the step that locks out. At this point no further reclosing will take place and the circuit breaker must be closed manually.

If the breaker is opened by an external source and the 79M control point is not active but is made active after the circuit breaker is opened, the circuit breaker will close in the 79-1 open time. If the circuit breaker is opened again by an external source and the reset time has not expired, the recloser will step to 79-2 and the circuit breaker will close (or lockout depending upon the 79-2 programming) in 79-2 time. If the breaker continues to open before the reset time expires, the recloser will continue to increment steps until it reaches the step that locks out. At this point no further reclosing will take place and the circuit breaker must be closed manually.

The 79M function can be made active or inactive by the mapping FALSE logic to the 79M control point (see the Advanced Programmable Logic section).

The internal REF 550 logic only checks the status of the 79M control point when it detects that the circuit breaker has opened. Once it has determined that the 79M is active, it will initiate the reclose. It doesn't matter if the 79M is toggled or held active.

If the multi-shot recloser is in the middle of a sequence and the 43A control point is made inactive, the recloser will stop operation. When 43A is returned to the active state the recloser will be reset and at step 79-1.

Voltage Block 79V (O->IU<)

The 79V Voltage Block function blocks reclosing when one or more of the input voltages is below the 79V voltage setting. When the input voltage is restored within the 79V time delay setting, the recloser operation is unblocked and the "open time" will begin. If the voltage is not restored within the 79V time delay setting, the recloser will proceed to lockout. The 79V time delay can be set to count in seconds or minutes. The setting, "79V Time Mode", is made in the Configurations settings (see Section 2). This function is useful in preventing a feeder breaker closure when the bus voltage is lost or below normal. This reduces inrush currents when the voltage to the bus is eventually restored. The settings for the 79V function are listed in Table 1-25. The 79V element is disabled in the factory default settings.

Table 1-25. 79V Characteristics

79V Parameter	Range/Curve	Increment
Voltage	10 to 200 VAC	1 volt
Time Delay	4.0 to 240 seconds	1 sec. (79V time mode: seconds)
Time Delay	4.0 to 240 minutes	1 min. (79V time mode: minutes)

Note: If the voltage is lost or falls below the 79V voltage setting during the open time interval, the open timer will halt. If the voltage is restored before the 79V time delay expires, the open timer will again run. If the voltage is not restored and the 79V time delay expires, the recloser will proceed to lockout.

Recloser Control Points

Table 1-26. The following are the programmable control points associated with the recloser.

TARC:	Initiate Trip and Auto Reclose. This input is used to issue a circuit breaker trip and reclose. It is useful in the testing of the circuit breaker trip and close circuits as well as the recloser logic and timing settings. When TARC is a logical 1, a trip and automatic reclose sequence is initiated. If the input is held at a logical 1, the REF 550 will continue to trip and reclose through the recloser steps (79-1, 79-2, 79-3, etc., see Recloser section for reclosing details). If TARC is pulsed at a logical 1, the trip and auto reclose will only occur once unless TARC is pulsed again. TARC defaults to a logical 0 when not programmed.
ARCI:	Automatic Reclose Inhibit. This control point stops the recloser open timer for the time in which it is a logical 1. When ARCI is returned to a logical 0 the open timer will continue where it was stopped. ARCI does not affect the recloser reset timer. ARCI defaults to a logical 0 when not programmed.
43A: (AR)	Recloser Enable. This input is used to supervise the REF 550 reclosing function. When the 43A control point is a logical 1, the REF 550 recloser is enabled. When 43A is a logical 0, the recloser is disabled. If the recloser is disabled, a red “Recloser Out” target will illuminate on the front of the REF 550. 43A defaults to a logical 1 (reclosing enabled) when not programmed.
79S: (O->I1)	Single Shot Reclosing. Enables a single shot of reclosing when the REF 550 determines that an external device has opened the circuit breaker. When 79S is a logical 1, single shot reclosing is enabled. 79S defaults to a logical 0 when not programmed.
79M: (O->I)	Multi-Shot Reclosing. Enables a multi shot of reclosing when the REF 550 determines that an external device has opened the circuit breaker. When 79M is a logical 1, multi-shot reclosing is enabled. 79M defaults to a logical 0 when not programmed.
ZSC:	Enables Zone Sequence Coordination scheme. Allows external supervision of the Zone Sequence scheme. When the ZSC input is a logical 1 and the Zone Sequence Configuration setting is enabled, zone sequence is enabled. ZSC defaults to a logical 1 if not programmed. See the Zone Sequence section for more details.
SCC:	Spring Charging Contact. Connect SCC to a physical input to monitor a recloser spring. If the SCC input is a logical 1, a “Spring Charging” event is logged in the operations record. SCC defaults to a logical 0 when not programmed. SCC only functions when the REF 550 determines a breaker open state.

Breaker Failure

A stand alone breaker failure trip (BFT) function is provided in the REF 550. This allows the REF 550 to function as a stand alone breaker failure relay or provide internal breaker failure tripping protection. The REF 550 contains one BFT and one Re-Trip status point and is designed for application in single breaker schemes. Multiple REF 550 relays can be used to provide protection on ring bus or breaker-and-a-half arrangements. Figure 1-28 outlines the REF 550 logic associated with the breaker failure trip function. Both BFT and Re-Trip outputs share the same logic. Both require a Breaker Fail Initiate (BFI) input and a “starter” input. The starter input can be from an internal REF 550 phase and ground level detector, 52a contact, or a combination of both. The BFT and Re-Trip status points must be mapped to physical outputs for operation (see the Advanced Programmable Logic section). The BFI and Starter inputs must be mapped to physical inputs for operation (see the Advanced Programmable Logic section). The Breaker Failure Trip settings can only be made by the Windows External Communication Program (WinECP) included with the REF 550. The settings screen is shown in Figure 1-29.

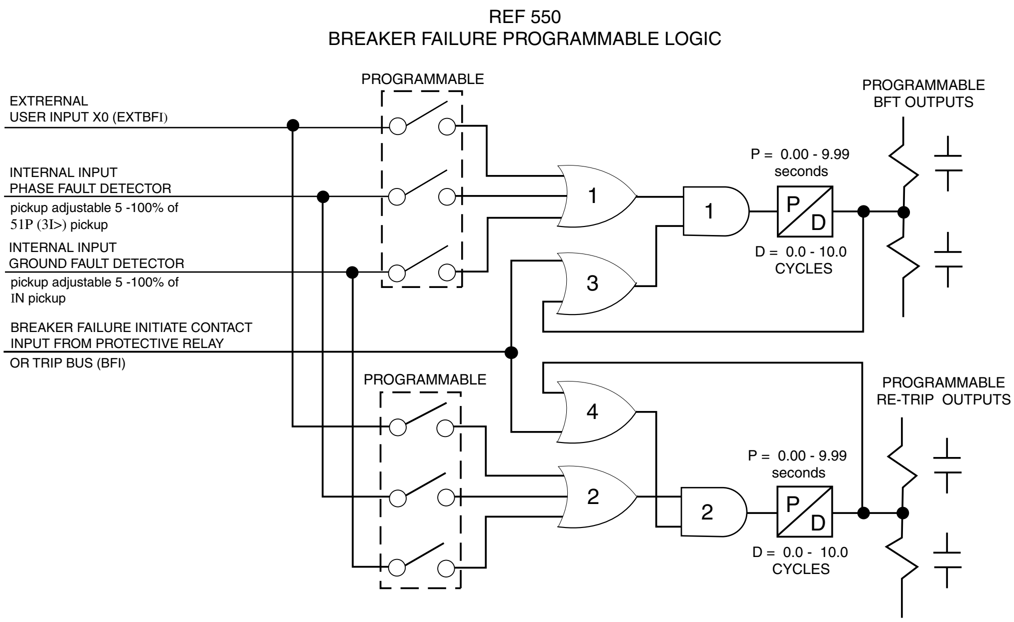


Figure 1-28. Breaker Failure Tripping Logic

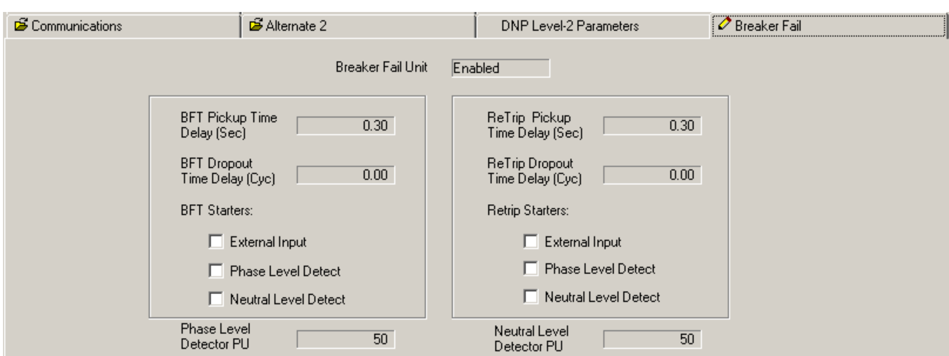


Figure 1-29. Breaker Failure Settings Screen

Alternate Settings Groups

The REF 550 has three separate and identical selectable settings groups for protective relay functions. These groups are labeled Primary, Alternate 1 and Alternate 2. Use of the three groups provides flexibility to quickly change parameters according to some external conditions. For example, Alternate 1 settings might be used during a High load time while Alternate 2 settings might be used when a storm is pending (and modified instantaneous settings are desired). Other uses might be winter/summer settings or line maintenance settings.

In order to activate these alternate settings groups locally and remotely, they must be individually set to “Enable” in Configuration settings and then activated by their respective control point.The control points ALT1 and ALT2 may be assigned (in the Advanced Programmable Logic of WinECP) to programmable input contacts such as IN1 and IN2 respectively. Once the logic functions are assigned to IN1 and IN2, they can be wired to electronically controlled switches which can be actuated through SCADA. (Note: The programmable input contacts can also be actuated through one of our various protocol options by simply issuing the proper commands). The ALT1 and ALT2 are set to “Enable” in factory default settings. The assertion of a alternate settings control point will not affect its activation where the alternate group is disabled in Configuration settings.

The internal logic of REF 550 will only allow one settings group to be active at a time. When ALT2 is active and an ALT1 input is asserted, ALT2 stays active until the ALT2 input is de-asserted. Only then will the ALT1 settings group become active. Note: A settings group switch occurs in two cycles during which time protection is temporarily disabled.

As an example, assign the ALT1 logic function to programmable input IN04 with enabled when closed logic and the ALT2 logic function to programmable inputs IN04 and IN05 with active-low and active-high logic, respectively. Externally wire IN04 to a control switch to be used for Cold Load control and wire IN05 to a control switch to be used for storm settings. Here the Cold Load settings (IN04) has priority over primary settings as well as storm settings (IN05) so the ALT2 logic function is also mapped to programmable input IN04 with active-low logic (see Figure 1-30). The logic will force ALT2 to be disabled whenever ALT1 is enabled. Substation Automation logic is available through the control point SWSET that switches from one settings group to another group more easily in an orderly fashion. See the System Configuration section for details.

All of the protective elements outlined in the “Protective Elements” Section are available in the Primary, Alternate 1, and Alternate 2 settings groups. All other settings in the relay such as the Configuration settings, Advanced Programmable Logic, etc. are fixed at one group and follow the three protective settings groups. These other settings typically do not change once the relay is set and commissioned.

34	
35	ALT1 = IN04
36	ALT2 = !IN04 * IN05
37	

Figure 1-30. Sample Alternate Settings Programmable Logic Assignments

Substation Battery Monitoring and Control

Substation battery monitoring is a standard feature in the REF 550 and can be applied to detect battery anomalies involving high and low voltage levels. The feature measures the substation battery voltage wired to the REF 550 control power terminals 1 and 2 and provides two level detectors: High battery voltage and Low battery voltage. The battery level detectors are available for programming in the Alarm Thresholds settings tab. Each detector can be set from 20 to 300 volts dc which adds flexibility in applying the feature – see Application Example 1-3. Both static and seal-in status points are available for each level detector. To avoid nuisance battery detections, each detector contains an internal 5 seconds pickup-before-operate timer. Where a longer duration battery condition is desired, use the programmable timers to gain the additional time. The feature settings are located in the Alarm Thresholds settings group - see Figure 1-31.

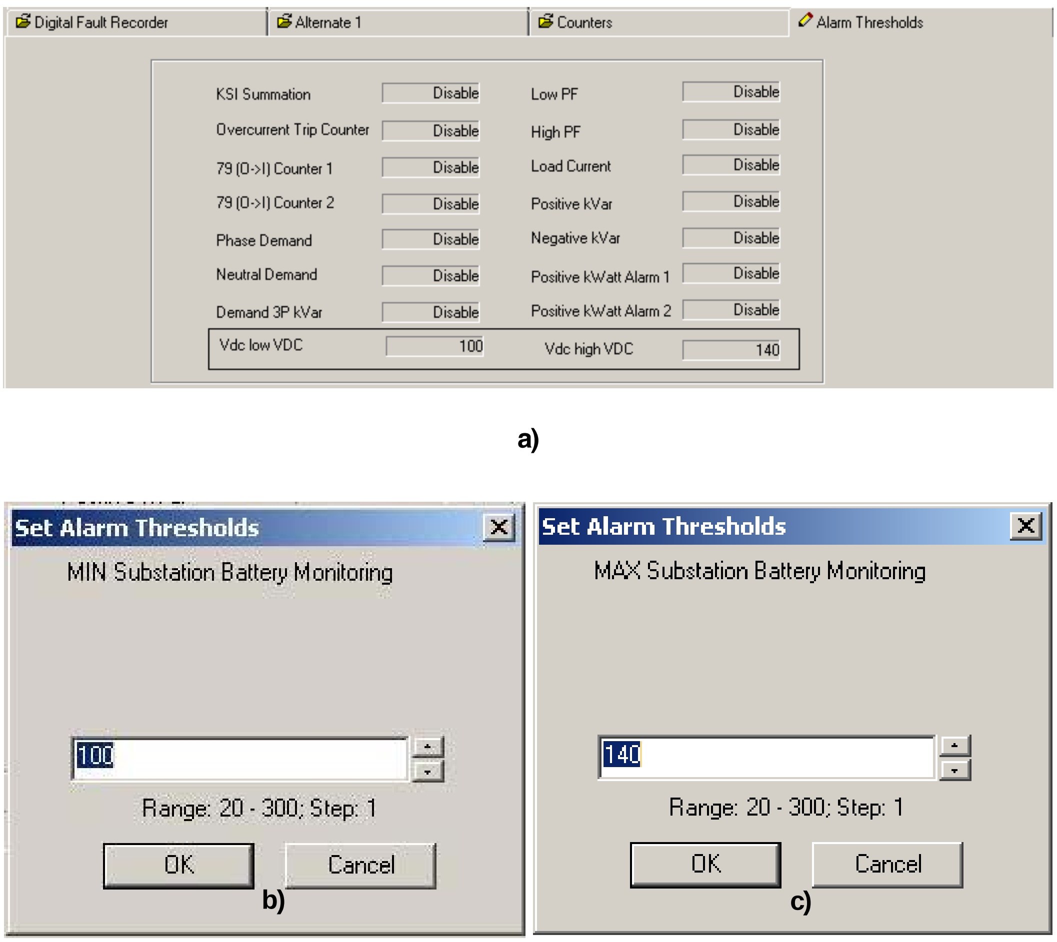


Figure 1-31 Substation Battery Monitoring settings: a) location in Alarm Thresholds tab, b) low battery detector and c) high level detector

In addition to the programmable settings, the battery voltage level is available in real-time within the Load Metering screen, see Figure 1-32, and as a dc waveform displayed, when selected, with the current and voltage ac waveforms in the Digital Fault Recorder (DFR) feature. With the battery voltage level monitored and stored in each DFR file, transient dips during the operation of multiple breakers and surges during battery charging can be viewed and assist in explaining the failure of a breaker or device. The detection of a high or low battery level may also be programmed to trigger a DFR recording.

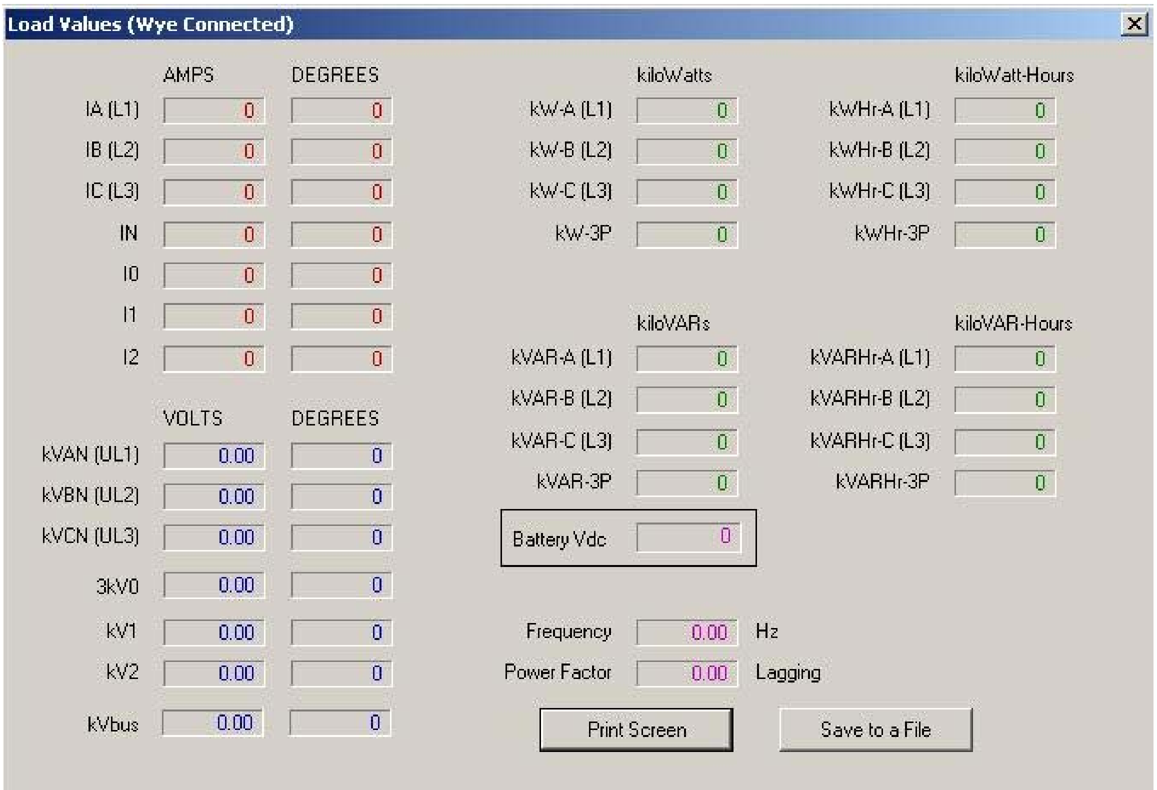


Figure 1-32 Substation battery metering

Application Example 1-3

With the settings shown in Figure 1-30, multiple status points can be programmed to indicate locally and remotely the exact condition of the battery such as “good”, “low” and “high”. See Figure 1-33 for example Advanced Programmable Logic to achieve these indications. See the Advanced Programmable Logic section for details on the available substation battery monitoring Status Points and programming instructions.

```

UL01 = BATT_LOs // Indicates battery low condition.
UL02 = BATT_HIs // Indicates battery high condition.
// Use Reset Seal-in Alarms command to reset battery seal-in alarms.
LED11 = !(BATT_LO + BATT_HI) // Battery OK LED lights with no detects.

```

Figure 1-33 Advanced Programmable Logic for Application Example 1-3

Customer-Programmable Curves

An external PC-based program, CurveGen, is used to create and program time-current curves for the REF 550. With CurveGen you can program time-overcurrent curves other than the ones currently provided in the REF 550 (see Tables 1-5 and 1-6). You can manipulate the curves in the time and current domains just like any other curve currently programmed into the REF 550. CurveGen generates all of the necessary variables for the user-defined curves to be stored in the REF 550 (i.e. the alpha's, beta's and pointers to the curve table). The method of accomplishing this task is curve definition.

The standard curve entered into the REF 550 has the form of:

$$t = \left[\left(\frac{A}{M^p - C}\right) + B\right]\left[\,(14n - 5)/9\,\right]$$

M is the per-unit current above the pickup value
t is total trip time at
M, A, p, C and B are variables to be defined.

To define the curve, you must define the variables in this equation. There are two ways to do this:

- Enter variables by hand: With the CurveGen program you can define all four variables by hand. This is designed for users who do not want curves based on already established functions but instead are ready to define curves through mathematical manipulation.
- Determine variables via curve fitting: Define a series of time versus current points and fit them to the standard equation listed above.

With the CurveGen program you can enter these series of time/current points from an already defined curve. CurveGen then fits the four variables to these points. There are two ways to enter these points into the CurveGen program:

- Enter all sampled points by hand. The ability to remove, sort, plot, edit and view points gives you total power over the curve to be generated.
- File entry: CurveGen can also read files with points defined in them. The ability to remove, sort, plot, edit and view points gives you total power over the curve to be generated.

Once all the points are entered, the CurveGen program is cued to fit a standard curve. After A, p, C and B have been determined, you can plot the curve against the points given as well as determine the overall error of the curve versus the plotted points.

After all four variables have been determined, you can generate a linear approximation of the curve. A maximum error criteria must be satisfied before CurveGen can determine the coefficients needed for the REF 550. Errors and warnings indicate whether or not the error criteria can be met or if the number of entries in the curve table is above the maximum value allowed.

When the curve tables have been defined by CurveGen, download them into the REF 550. When you want a customer-defined curve, select "Export Option" from the File Menu in WinECP.

CurveGen Software Release 1.0

PC Requirements

386 processor or higher

Disk Space:

200K in specified Directory
6 MB in Windows/System Directory

Memory:

480K RAM in the lower 640K for setup

Installation

CurveGen is installed as part of the WinECP Tools Suite installation process. See WinECP Interface section for installation details.

If you encounter errors during the installation, go into your windows/system directory and delete the following files:

0C25.DLL	COMDLG16.DLL	TABCTL.OCX
THREED.OCX	VCFI16.OCX	

Repeat installation.

Using CurveGen

Click on the CurveGen 1.0 icon to run CurveGen. At this point, the user has two options. Curve coefficients can be calculated by the software by manually entering data points.

The standard equations for timing curves are shown below:

Trip Time (ANSI) = $(A/(M^{p}-C)+B) \times ((14n-5)/9)$

Where A, B, C and P are the coefficients to be computed and/or entered

n = time dial

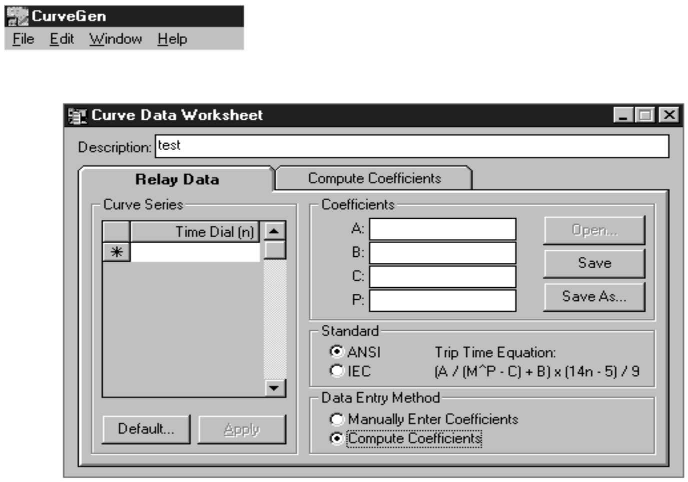
M = Relay current in multiples of tap setting

Computing Coefficients

Step 1: If desired, the user may enter a description in the **Description** field.

Step 2: Under **Standard**, the user should select either **ANSI** curves.

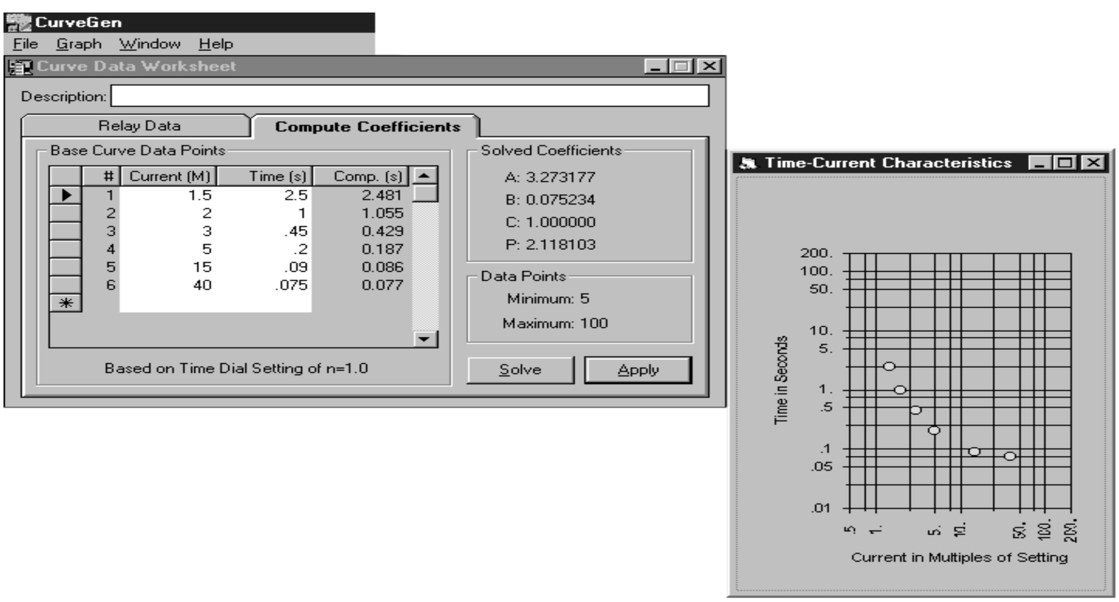
Step 3: Under the **data entry method,** the user should select **Compute Coefficients.** At this point, the **Compute Coefficients Tab** towards the top of the screen should appear. Click this tab.



Step 4: Using the mouse, place the cursor on Row 1, Column 1 (Current M)

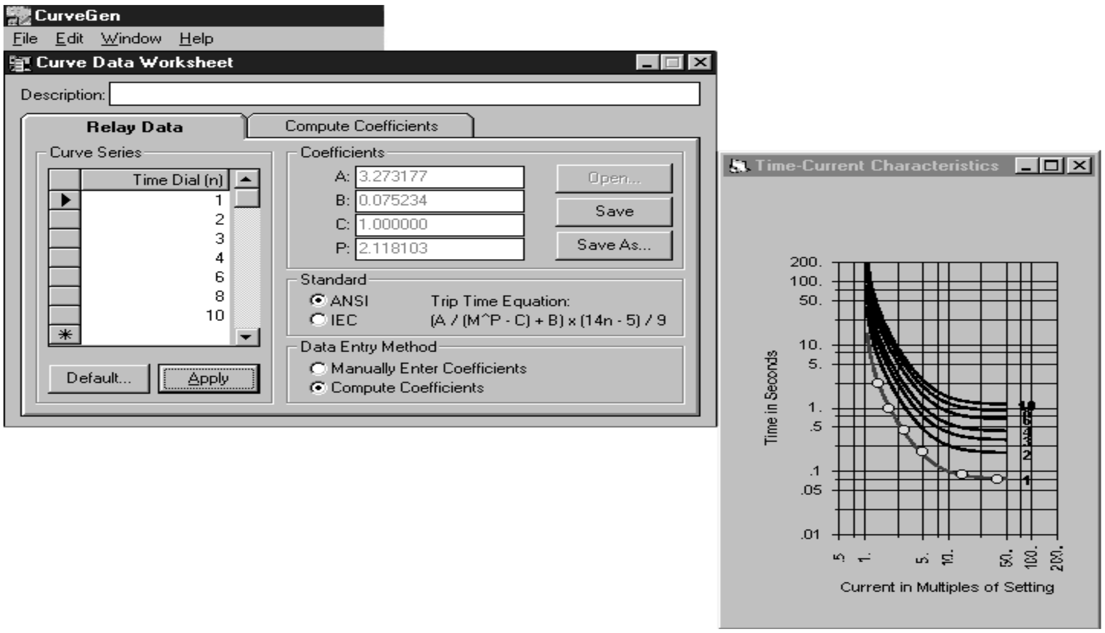
Step 5: Type the desired multiple of tap, M, and press the TAB key. Now type the corresponding time. Press the TAB key again to enter a second point. Continue until at least 5 data points are keyed in (100 points max). Please note that whether you are using ANSI or IEC type curves, the points you enter are equivalent to a time dial of 1.

Step 6: After all points are entered, click on **solve**. The computed coefficients will appear on the screen. In order to see these points on a graph, hit the **Apply** button.



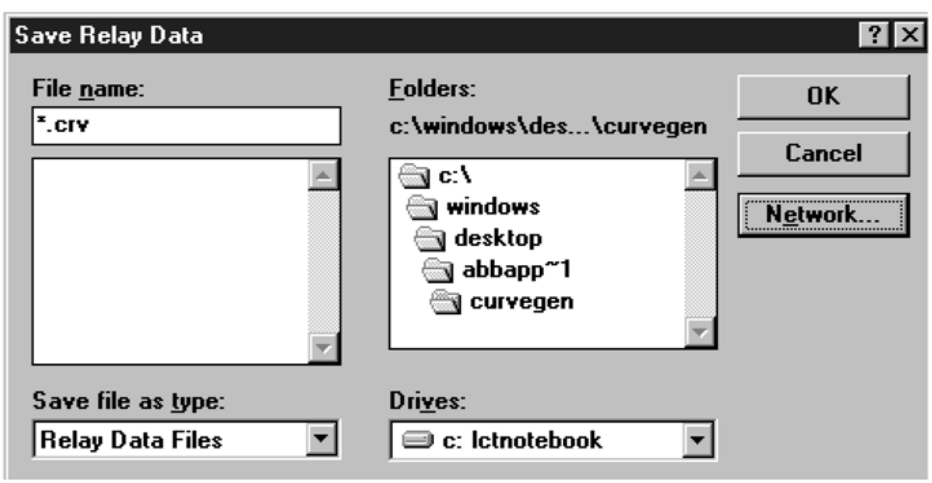
Step 7: Click on the **Relay Data** tab. At this point, you'll see that the coefficients previously calculated appear under **Coefficients**. Under **Curve Series**, select default. Time dial 1 through 10 should appear on the screen for **ANSI**. Any combination of valid time dials can be used.

Step 8: Select **Apply**. At this point, a graph will appear on the screen. The graph format can be changed by selecting different options under the **Graph** Menu at the top of the screen. The Curves can also be printed for a clearer view.



Step 9: If you are satisfied with the results, select **Save As** under **File** and Type in a filename with a .crv extension. This is the file to be used when downloading curves to your REF 550 relay.

Step 10: The user also has the ability to save the worksheet. To do this, select **Save Worksheet As** under **File** and type in a filename with a .wrk extension.



Manually Entering Coefficients

Step 1: If desired, the user may enter a description in the **Description** field.

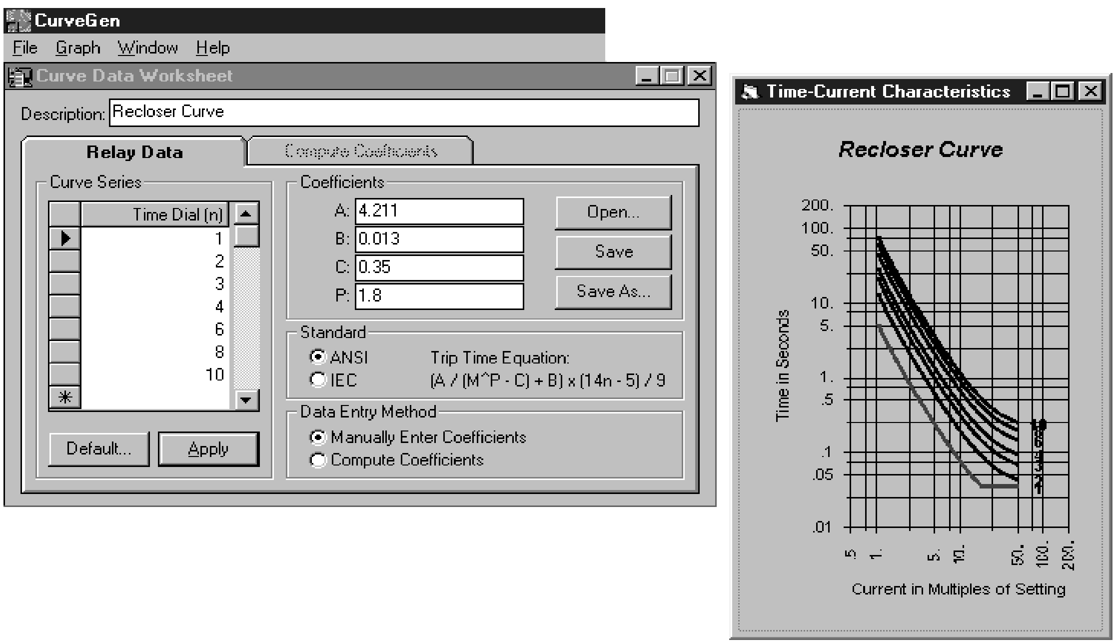
Step 2: Under **Standard,** select **ANSI**.

Step 3: Under **Data Entry Method** select **Manually Enter Coefficients**.

Step 4: The user can now enter the known coefficients **A, B, C** and **P**.

Step 5: Under **Curve Series,** select **Default**. Time dial 1 through 10 should appear on the screen for **ANSI**. Any combination of valid time dials can be used.

Step 6: Select **Apply**. At this point, a graph will appear on the screen. The graph format can be changed by selecting different options under the **Graph** Menu at the top of the screen. The Curves can also be printed for a clearer view.



Step 7: If you are satisfied with the results, select **Save As** under **File** and type in a filename with a .crv extension. This is the file to be used when downloading curves to your REF 550 relay.

Step 8: the user also has the ability to save the worksheet. To do this select **Save Worksheet As** under **File** and type in a filename with a .wrk extension.

Downloading Curves

By using the File Export, you can send (transmit) curve data that you have created via the CurveGen program from your computer to the REF 550. You can also download (receive) curve data from the REF 550 into your computer for storage and for modification through the CurveGen program.

To transmit or receive curve data, highlight the selection you want and press Enter. Type in the curve's filename (including all directories) and press Enter again. The curve data is sent or retrieved as you selected.

System Configuration

Phase CT Ratio

Phase current transformer turns ratio. The ratio range is from 1 - 2000.

Neutral CT Ratio

Neutral current transformer turns ratio. The ratio range is 1 - 2000.

VT Ratio

Voltage transformer turns ratio. The ratio range is from 1 - 2000.

VT Connection

Must be entered for proper REF 550 metering and protection.

Options are: 69V Wye
120V Wye
120V Open Delta
208V Open Delta

With wye connected VT's, the zero sequence voltage, $3V_0$ is calculated and displayed real-time in the Load Metering screen viewable from the LCD menu and WinECP's Monitoring main menu option. This configuration setting enables the application of the ground overvoltage (59G) element and the zero sequence polarization option of the ground directional overcurrent (67N) and the ground power directional elements. If bus voltage transformers are wired to the REF 550 as delta or open delta and can not be rewired as wye, then choose the appropriate VT Connection setting, "120 Delta" or "208 Delta". With delta connected VT's the 59G and the zero sequence polarizing option of the 67N and 32N-2 elements should not be applied.

Important Note: It is imperative that the bus voltage transformers are connected in a wye configuration if deriving 3V0 is desired. See Section 9 for typical VT connections.

Table 2-1. 3V0 Derivation and Metering per VT Connection Setting

VT Connection Option	3V0 Calculation for REF 550	3V0 Metering for REF 550.
69 Wye	Derived	Derived
120 Wye	Derived	Derived
120 Delta	Fixed at 0 /0°	Fixed at 0 /0°
208 Delta	Fixed at 0 /0°	Fixed at 0 /0°

Line Impedances

The line impedances are used for fault location purposes. **The settings are positive and zero sequence reactance, and positive and zero sequence resistance in primary ohms per mile.** The ranges for both resistance and reactance are .001 to 4.00 primary ohms/mi. See the section on "Fault Locator" in Section 7.

Line Length

The line length is used for fault location purposes. The range is from 0.1 to 125 miles. See the section on "Fault Location" in Section 7.

SWSET

Enable this feature where switching from settings group to settings group is to be accomplished via a momentary control signal, e.g., OCI control pushbutton or SCADA pulse command. This logic allows for a smooth transition from one group to another group in the order of Primary, Alternate 1 and Alternate 2, provided the alternate settings are enabled in Configuration settings, whenever the control point SWSET logic is true. Only one transition will occur for each assertion of the control point. Each settings group has a status point that may be read by SCADA or local LED for verification that transition to desired settings group has been achieved. When this feature is enabled, the control points ALT1 and ALT2 are ignored. See Substation Automation Logic in the Advanced Programmable Logic section for more details.

Trip Failure Time

The REF 550 determines a successful trip by the state of the 52a and 52b breaker contacts and the level of input current. The 52a and 52b contacts must indicate an open breaker and the current must have dropped to below 5 percent of the 51P pickup setting. At the time that the REF 550 issues a trip, it also starts a "Trip Fail Timer". This timer is used to determine a failed or slow breaker. It is set in the Configuration Setting and is selectable for 5 to 60 cycles in 1 cycle steps. If the timer expires before the REF 550 determines an open breaker (both conditions stated above are met), a Breaker Failure Alarm, BFA, status point is asserted and the recloser will lockout. If the REF 550 determines an open breaker within the Trip Fail Time setting, it will reset and re-enable when the breaker is reclosed. The Trip Fail Timer is set by factory default to 18 cycles. The Master Trip physical output and status point TRIP will remain energized or latched until the conditions are met or the control power is cycled. A mode setting, Multiple Device Trip, is available that eliminates the 52a and 52b status as a "successful trip" requirement. See MDT Mode in this section for more details.

Close Failure Time

The REF 550 determines a successful close by the state of the 52a and 52b breaker contacts. The 52a and 52b contacts must indicate a closed breaker. At the time that the REF 550 issues a close, it also starts a "Close Fail Timer". This timer is used to determine a failed or slow breaker. It is set in the Configuration Setting and is selectable for 18 to 16000 cycles, in 1 cycle steps, and "Disable". If the timer expires before the REF 550 determines a closed breaker (condition stated above is met), the REF 550 will halt its automatic reclose or manual close operation and wait for the proper state to appear. If the close failure occurred while the recloser was at a certain reclose step, I.E. 79-3, the REF 550 will stay at that step until the breaker is finally closed back in. When this occurs, the reset timer will run and the reclose sequence will pickup where it left off. If a subsequent trip occurs before the reset timer expires, the relay will lock out. If the REF 550 determines a closed breaker within the Close Fail Time setting, it will reset and re-enable when the breaker is opened. The Close Fail Timer is factory default to 18 cycles. A setting of "Disabled" will invoke the same operating principle of the Trip Failure Time for failed conditions; i.e., the CLOSE status point will remain energized or latched until the 52a and 52b status indicates a closed breaker or the control power is cycled.

IMPORTANT NOTE: When a CLOSE command is issued to the REF 550 in a "Circuit Breaker Status Indeterminate" state (that is the 52A and 52B contacts inputs read the same value), the REF 550 will hold the command in memory. This CLOSE command <u>will be</u> executed if the status of the 52A/52B contact inputs become determinate and indicates a "Breaker Open" State. The CLOSE command <u>will not be</u> executed if the status of the 52A/52B contact inputs become determinate and indicates a "Breaker Close" state, or if the REF 550 is reset, or if control power to the REF 550 is cycled.

Phase Rotation

Must be selected for proper sequence calculations for the metering. Options are ABC or ACB phase sequence. This setting directly affects all directional elements in the relay.

Protection Mode

Select “Fund” if the desired operating quantity for overcurrent protection is the 50 or 60 Hz fundamental current.

Select “RMS” if the desired operating quantity is the unfiltered RMS current which includes the fundamental and all harmonics up to and including 11th harmonic.

Reset Mode

Select “Instant” if the desired overcurrent reset mode is instantaneous.

Select “Delayed” if the desired overcurrent reset mode is delayed as with electromechanical relays. The reset characteristic equations are listed in Section 1.

ALT1, ALT2 Setting Enable

The ability to activate the Alternate 1 or Alternate 2 settings tables can be enabled or disabled with these settings. If enabled, the ALT settings will only be active if the control point ALT1 or ALT2 is mapped via the Advanced Programmable Logic and the logic is “true.” Each alternate setting control point can only be asserted when the other control point is disabled. If the first ALT control point remains asserted when the second one is asserted, the first asserted control point has precedence and remains active. Only after the first control point becomes “false” can the other control point assert and activate that alternate settings group. Each settings group, Primary, Alternate 1 and Alternate 2, has a dedicated status point that asserts when that particular settings group is active. See the Advanced Programmable Logic section for programming instructions.

IMPORTANT NOTE: Regardless of the ALT1 Setting Enable and ALT2 Setting Enable settings, the control points ALT1 and ALT2 will be automatically disabled as long as the SWSET feature is enabled. See SWSET in this section for details.

MDT Mode

When the Multiple Device Trip Mode is enabled in the Configuration Settings Table, the REF 550’s TRIP and CLOSE Output Contacts and Breaker Failure Alarm do not depend on the 52A and 52B contact input status. With this mode enabled, the TRIP output is removed 3 cycles after the fault current drops below 90% of the lowest pickup setting. In the reclose sequence, the open interval timer and subsequent CLOSE output are initiated only if an Overcurrent TRIP Output has occurred and the current has dropped below 90% of the lowest pickup setting within the Trip Failure Time setting.

When the MDT mode is enabled, the lockout state is cleared when either of the following occurs:

1) The 52b contact input is open **and** currents in all three phases are greater than 5% of the 51P pickup setting **and** the reset time has expired.

OR

2) The 52b contact input is open **and** the Targets are reset **and** the reset time has expired.

The 52b contact input is required for the 79S contact input (Single Shot Recloser Input) and the 79M contact input (Multi-Shot Recloser Input) functions to initiate a reclosure when the MDT Mode is enabled.

The MDT mode is disabled in the factory default settings.

Cold Load Timer

The cold load time unit can be set to either seconds or minutes. The time itself is set in the primary settings menu. See Section 1 for details on this function.

Barrel Shifters A, B

Two shift registers, A and B, are provided for convenient user-defined state transitions such as Test, No Test and Permissive states for operations. The two registers are independent and can be set from 2 to 4 states. The default setting for each register is 3 and the default state position is 1. Transitioning from one state to the next is accomplished through its specific shift control point, “SHIFT_A” or “SHIFT_B”. Only one transition will occur for each assertion of the control point. A status point exists for each Shift Register’s state useful, for example, for SCADA status information and further control operations through, for example, an automation device such as a PLC. See the Advanced Programmable Logic section for details on this substation automation feature.

79V (O->IU<) Time Mode

The 79V time unit can be set to either seconds or minutes. The time itself is set in the primary settings menu. See Section 1 for more details on this function.

Voltage Display Mode

Select “Line-Line” for voltages to be displayed Line to Line.

Select “Line-Neutral” for voltages to be displayed Line to Neutral.

NOTE: All voltages are displayed in kV (Volts X 1000).

Zone Sequence

The zone sequence coordination function coordinates the instantaneous functions within the reclosing sequence of the upstream and downstream reclosing devices. Applications include fuse-saving schemes for faults that occur beyond the downstream reclosers.

Enable the ZSC function by enabling it in the System Configuration and control it by mapping the ZSC logic function to a contact input in the Advanced Programmable Logic settings in WinECP. The control point “ZSCTC” logic is “true” when not mapped in the Advanced Programmable Logic. The 50P-1/50N-1 or 50P-2/50N-2 and 50P-3/50N-3 instantaneous functions in the upstream REF 550 must be set for a time delay that is equal to or greater than the clearing time of the downstream device plus a margin factor. The Reset Time setting of the upstream REF 550 must also be longer than the longest open interval time of the downstream device.

When the ZSC function is enabled and the REF 550 senses a fault downstream, the relay increments through its reclose sequence. For example, if the downstream device is activated by a phase to ground fault, the REF 550 must see a fault current greater in value than the lowest pickup setting of any of the phase overcurrent protective functions.

The zone sequence step occurs when the fault current exceeds the enabled lowest pickup setting and then decreases to less than 90 percent of the setting value before its time delay setting is exceeded. The recloser reset time is displayed when a zone sequence step occurs. All zone sequence coordination steps that occur are logged in the Fault Summary and Fault Record.

Target Display Mode

Select “Last” if the only target(s) desired on the front panel of the relay is the most recent target(s). If “All” is selected, then all targets will remain displayed since the last target reset.

Local Edit

"Enable" allows settings to be changed via the OCI LCD menu system.

"Disable" disallows setting changes via the OCI LCD menu system.

This setting can only be edited remotely via a communications port interface.

Remote Edit

"Enable" allows setting changes via the communication ports.

"Disable" disallows setting changes via the communication ports.

This setting can only be changed locally through the OCI.

Meter Mode

Select kWHr or MWHr for kilowatt/kilovar or Megawatt/Megavar energy metering.

LCD Light

The REF 550 Operator Control Interface (OCI) LCD backlight utilizes a highly reliable LED that allows it to be energized continuously. Therefore no setting is required.

Unit Name/ID

Type a 15 character alphanumeric description of the relay.

Demand Meter Constant

Select 5, 15, 30 or 60 minute time constant. Demand currents replicate thermal demand meters. The demand kilowatts and kiloVArs are averaged values that are calculated by using the kilowatt-hours, kiloVArs-hours and the selected time constant.

This setting establishes the standard Load Profile feature's storage rate and capacity. See Load Profile in the Historical Records section for more details.

LCD Contrast

A standard LCD contrast design feature of the REF 550 LCD incorporates a sensor that automatically adjusts the viewing contrast over the entire operating temperature range of -40 to +85 degrees C. This feature eliminates the need to change contrast settings in locations where temperature variations are extreme between seasons. This setting allows for a one-time contrast adjustment for optimal legibility for the viewing angle created by its mounting position in the panel. Adjust the contrast setting down for REF 550 units mounted below standing eye level and up for REF 550 units mounted above standing eye level. Adjustable from 0-63 steps of 1 unit.

Change Test Password

The test password allows access to the actions in the Test Menu and the Operations Menu, see Section 3. The user **cannot** make setting changes with the test password. The Test Password has restricted access only to password protected controls. This setting should be changed from the default value and issued only to those persons with breaker control authority for security purposes.

SE (I_0) CT Ratio

Where a dedicated window-type CT is used for the sensitive earth fault current input on terminals 46 and 45, its CT ratio is programmed using this setting. This ensures the proper primary amperes are reflected in the Load Metering and Fault Records. The CT turns ratio range is 1 - 2000.

Vbus Ratio

This setting applies to the VT secondary voltage connected to terminals 35 and 36 for the Sync Check feature. The Vbus VT turns ratio range is 1 - 2000.

Slow Trip Time

At the time the REF 550 issues a trip, the “Slow Trip Time” timer starts. This timer is used to determine a “sluggish” breaker. This setting is adjustable from 5 to 60 cycles in 1-cycle steps. A setting equal to or greater than the Trip Failure Time setting effectively disables this feature. If the timer expires before the REF 550 determines an open breaker, a status point “SBA” is asserted. If the REF 550 determines an open breaker within the “Slow Trip Time” setting, it will reset and re-enable when the breaker is reclosed. The Slow Trip Time is set by factory default to 18 cycles. This breaker health feature is very useful in establishing and maintaining a high reliability of service. A slow breaker detection can drive a maintenance task preventing a future breaker failure operation that trips the entire bus, rendering more customers than necessary without power.

OCI Front Panel Select

The REF 550 Operator Control Interface (OCI) integrates popular protection and breaker controls into the front panel eliminating the costly wiring and auxiliary panel switches that accompanied protection panels in the past. The protective function and feature controls are operated through the six control pushbutton switches C1 to C6. These switches are independent of one another and their operation programmed to disabled, a maintained switch or momentary switch. When set to “Disable”, these switches can still be operated remotely via the integration of the specific SCADA protocol commands. Blocking remote control locally can be achieved through a second control pushbutton, assertion of the control point “LOCAL” or instead integrating one of the SCADA remote control points. See the Advanced Programmable Logic section for programming details. A switch setting of “Maintained” emulates a toggle switch alternating on and off with each button pressing. Default settings contain status points mapped to the programmable LED’s that indicate the present switch status of on or off. A setting of “Momentary” emulates a momentary switch issuing a pulse of required duration for detection by the Advanced Programmable Logic system. The switch status points are not as useful with momentary switch emulation though they will light the programmed LED temporarily reflecting the pulse was issued.

The Breaker Control pushbutton switches and LED’s allow for local breaker control and indication. The available settings are Disable, Enable and LEDs Only. When set to “Disable” neither the control buttons nor LED’s will operate. With a setting of “Enable”, the breaker control buttons can be used to OPEN and CLOSE the breaker and are NOT password protected. These switches emulate the same functionality of a 101 panel switch eliminating the costs of the switch and its wiring. If a separate panel switch is still desired, then set the feature to “LEDs Only” where the LED’s will indicate the breaker position status per the control points 52a and 52b. A breaker indeterminate state is indicated through the alternate lighting of the two LED’s. See the Operator Control Interface section for more details.

Vcn Mode

This special feature is accessible only via the OCI LCD menu system under "Configure Settings". When enabled, this feature causes the measured phase-C-to-neutral voltage, Vcn, to be displayed as its complex conjugate or Vnc. Where open delta or delta connected VT's are applied, this setting has no affect on the displayed voltages.

Change Relay Password

The relay password can be changed via the OCI in the configuration settings menu. Using WinECP, the user can change the relay password when exiting out of the configuration settings menu, selecting "DOWNLOAD to Relay", and a pop-up window will appear requesting the old password for authorization and the new password to set, and checking "Yes" to change relay password. The Relay Password has complete access to all password protected settings and controls. This setting should be changed from the default value and issued only to those persons with complete setting and control authority for security purposes.

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Operator Control Interface

Introduction

The REF 550 Operator Control Interface (OCI) is designed to give the user greater flexibility to access information from the system than available with the standard operator control interface. The OCI provides the following features:

- Control buttons with access to the REF 550 control points
- Breaker control buttons
- 24 target indications for the REF 550 status points: 22 programmable
- Larger LCD with eight lines to display the REF 550 menu system
- A top level menu of Hot Keys for popularly accessed information
- LCD default display of popularly accessed information
- Hot Line Tag control buttons are available as an optional feature in the REF 550 OCI panel

The OCI panel options provided are represented in the catalog number of the REF 550 relay. The seventh position of the relay catalog number indicates the front panel option.

The two (2) front panel options available are as follows:

Catalog Option	Operator Control Interface Description
0	Horizontal enhanced OCI panel
1	Horizontal enhanced OCI with Hot Line Tag

Shown in Figure 3-1 is the front view of the OCI panel with the Hot Line Tag (HLT) option. The HLT option is selectable in the REF 550 relay Order Selection sheet - see Section 12 for ordering information.

Figure 3-1. Front View of the OCI Panel with the Hot Line Tag Feature

A. Pushbutton controls for the breaker
B. Optional "Hot Line Tag" pushbutton control switch
C. Six Control Push Buttons to select/de-select relay functions
D. Expanded Target Information
E. New larger Liquid Crystal Display (LCD) of 8 rows and 21 columns with standard self-compensating contrast over operating temperature range of the REF 550. See the User Interfaces section for details on the information and access available through the LCD menu system and menu navigation instructions.
F. Six Menu Push Buttons serve as hot keys for single-button navigation

Control Buttons

The control buttons are intended to replace the relay's panel buttons. These control buttons give the operator access to the REF 550's control points.

Pressing a control button is analogous to asserting a binary input to the REF 550 unit via a panel mounted switch.

There are six (6) control buttons labeled C1, C2, C3, C4, C5, and C6. In order to activate the designated function of one of the buttons, it must be held depressed for a minimum of 500 ms. The control button action can be enabled or disabled using the "OCI Control Buttons" settings found in the Configuration settings. The default parameter is disabled. The control button operation can be maintained or momentary with the default parameter set to maintained. The control button is externally accessible via communications, and it will assert on activation of its access poiint. When the LOCAL control point is enabled, the control buttons are not accessible via communications.

As previously stated, the six (6) control buttons are analogous to panel switches wired to the REF 550's physical inputs. As such, the control buttons shall be programmable in the REF 550's Advanced Programmable Logic. The control buttons follow the present close enabled and open enabled logic.

The factory default assignments for the OCI without the Hot Line Tag (HLT) option are shipped as follows with the mylar label inserted:

Control Button	Enhanced OCI Label
C1	Block Reclose
C2	Block Ground
C3	Block Inst
C4	Block Remote
C5	Enable Alt 1
C6	Enable Alt 2

The factory default assignments for the OCI with the Hot Line Tag (HLT) option are shipped as follows with the mylar label inserted:

Control Button	Enhanced OCI Label
C1	User Display* (see description below)
C2	Block Ground
C3	Block Inst
C4	Block Remote
C5	Enable Alt 1
C6	Enable Alt 2

***** For OCI with the Hot Line Tag option, C1 will initiate the display of a user-defined message on the LCD panel. This is because the "BLOCK RECLOSE" function is provided as part of the "Hot Line Tag" functionality.

Mode of operation: For "Maintained" operation, press and release toggles the present state, e.g., if previously "De-selected", factory default condition, then pressing and selecting C1 – 6 will toggle state to "Selected". For "Momentary" operation, press and release of the control button generates a pulse of required duration for the Advanced Programmable Logic system to detect and apply.

The control buttons can be programmed to any of the control inputs. A new mylar insert can be easily created using word processing or CAD tools, and then inserted behind the front panel. The REF 550 must be de-energized and the inner chassis removed to access the labels on the backside of the front panel. Blank mylars are included with the REF 550 relay with the enhanced OCI panel. The Word document for typing and printing the customer oriented label identification is available from the website, or by contacting ABB Allentown for a copy of the program. Instructions are as follows for creating the new mylar inserts:

1) Type in the desired name using the same type style as used in the default
2) Print on a standard overhead transparency (or print on paper and then create a standard transparency)
3) Cut on the solid lines
4) Slide into the front panel slots

If necessary, re-map to any REF 550 control point using WinECP. Refer to the Advanced Programmable Logic section for details.

Programming of the control buttons to a different function than the default setting can easily be accomplished by using the WinECP communication software tool. After establishing communication with the relay or working offline, go to “Settings” , Advanced Programmable Logic, and identify the desired control point in the Program Statement window or select it from the Control Points directory in the menu tree and then select the appropriate control button status from the Status Points directory in the menu tree to program C1 through C6. The complete library is available for selection. A listing of all of the functions available can be found in this selection. For a complete discussion on the method of programming the control buttons and other functions of the relay, refer to the Advanced Programmable Logic section of this instruction book.

Circuit Breaker Control Buttons

The Breaker Control section of the REF 550 OCI provides for breaker operation and status indication. Flexible settings located in System Configuration settings are “Disable” for disabling both the breaker control buttons and LED’s indication, “Enable” for breaker control and LED status indication and “LEDs Only” for disabling the breaker control buttons but enabling the LED breaker status. The LED status is displayed per the status of the 52a and 52b logic. A breaker indeterminate state will light the LED’s alternately.

The circuit breaker control buttons on the enhanced OCI panel are designed to replace the panel mounted rotary breaker control switch. There are two buttons provided for breaker control: open or close. This feature may be disabled if the user wishes to delete the function. The REF 550 Configuration settings has the parameter to enable or disable the breaker control buttons. The setting is labeled “OCI Front Panel Select”. The default parameter is disabled. These control buttons are operative when they are enabled per their Configuration settings and the REF 550 Status LED indicates a Normal state.

There are two LED’s on the REF 550 OCI panel to indicate the circuit breaker status. The green LED indicates that the circuit breaker is open, and the red LED indicates that the circuit breaker is closed. If the circuit breaker is in a failed state, and there is no receipt of the 52 “a” or “b” switch contacts, the LED’s will blink on and off alternately.

Note: No password is required to operate the circuit breaker, as this feature of the REF 550 relay is analogous to the standard breaker control switch. Pressing either of the buttons to change the state of the circuit breaker will only require a confirmation query of the F2 function key. If the Hot Line Tag is selected in the ‘tagged position”, the breaker cannotbe closed by the relay. However, if the “tagged position” is selected prior to the breaker being opened, then by depressing the green control button with confirmation of function key F2, the circuit breaker will open but cannot be reclosed.

Programmable LED's

The programmable LED's are designed to replace costly and unreliable annuciator panels. As such, the user may customize the function of the panel indications. The LED programmability allows the user to select the function of a particular LED indicator. There are 24 LED's; 22 are programmable for customization by the user. All of the LED's are yellow except that LED1 is green for "Normal" and LED13 is red for "Trip".

The REF 550 relay with the OCI panel is shipped from the factory with the following default LED programming (provided as a Mylar insert in a sleeve, to the left and right of the actual LED light):

LED1	Normal (green)	LED13	Trip (red)
LED2*	Pickup	LED14	Phase A
LED3	C1 Selected	LED15	Phase B
LED4	C2 Selected	LED16	Phase C
LED5	C3 Selected	LED17	Neutral
LED6	C4 Selected	LED18	Time
LED7	C5 Selected	LED19	Instantaneous
LED8	C6 Selected	LED20	Neg. Seq.
LED9	Recloser Out	LED21	Frequency
LED10	Ground Out	LED22	Directional
LED11	Inst. Out	LED23	Voltage
LED12	HIF Detect™	LED24	Distance

All the LED's are programmed in the Advanced Programmable Logic settings group of WinECP. Target status points can be mapped to a LED for standard targeting. See the Advanced Programmable Logic section for programming instructions.

Inputs: Physical and Control Points
Mode of Operation: When input is enabled, the LED is on. When input is disabled, the LED is off.
Outputs: Physical and Status Points
Mode of Operation: When output is energized (or asserted), the LED is on. When output is de-energized (or de-asserted), the LED is off.

The "C1 Selected" through "C6 Selected" LED's are provided to let operators know that control button "selections" or "de-selections" have been recognized by the relay.

A new, customized Mylar insert can be created easily by customers using the ABB-provided Word .doc template. This template will be shipped with all enhanced OCI relays. Steps to follow:

1) Type in the desired name using the same type style as used in the default
2) Print on a standard overhead transparency (or print on paper and then create a standard transparency)
3) Cut on the solid lines
4) Slide into the front panel slots.

If necessary, re-map the LED's to other REF 550 control and status points that match the desired design. Details of available control and status points are available in the Advanced Programmable Logic section.

Programming a LED to a different function than the default setting can easily be accomplished by using the WinECP communication software. After establishing communication with the relay or working offline, the heading under "Settings", then Advanced Programmable Logic, locate or create the desired Program Statement line and change or add the new LED logic equation using the control and status points listed in the menu tree window located to the left of the Program Statement window. For a complete discussion on the method of programming the LED targets and other functions of the relay, refer to the Advanced Programmable Logic section of this instruction book.

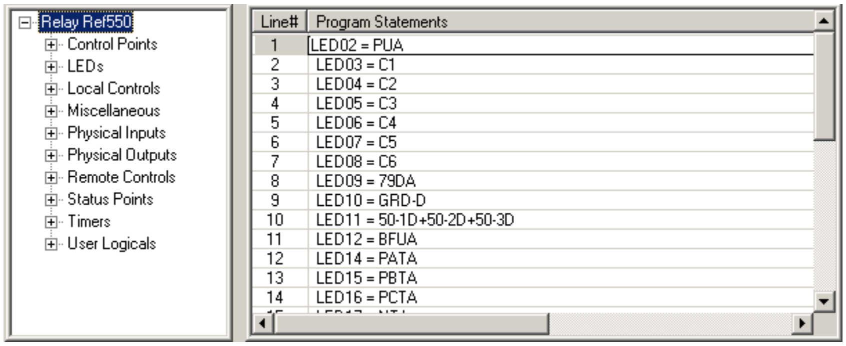

Figure 3-2. Portion of LED Programming

Table 5-1 lists all available status points that may be mapped to the programmable LED's. Figure 3-2 shows an example of the LED mapping.

Hot Line Tag

For the REF 550 OCI with the Hot Line Tag (HLT) option, the user has access to the Hot Line Tag control buttons on the OCI panel. This replaces the costly and conventional 31TR control switch. There are two Hot Line Tag control buttons: left arrow that internally drives the HLT control point "TR_RST" and the and right arrow that internally drives the HLT control point "TR_SET". These arrows will assert their respective HLT control point provided any additional logic mapped to that point is also true. The button de-bounce and recognition are identical and the same as the six control buttons C1 – C6. The **on**, **off,** and **tag** panel indication follow the status of the hot-line-tag status points "TR_ON", "TR_OFF", and "TR_TAG" in the conventional REF 550. If the catalog number is without the HLT option, the operation of the HLT control points is achieved through the Advanced Programmable Logic.

The HLT status indicators are located on the OCI front panel. The Hot Line Tag optional feature has ON or OFF position red LED's, and a magnetic indicator of orange color for the TAGGED position. When the HLT state is in TAG and control power is lost, the magnetic indicator will maintain its tagged condition. The HLT state is saved in non-volatile memory and the REF 550 will power up to its last state. The arrow keys move the status from one state to another state. There are three HLT indicators: on, off, and tag. The HLT indicators assert per the HLT's status.

The operation of the circuit breaker is restricted as follows per the postiions of the Hot Line Tag assertion and are indicated by the respective LED's:

- ON - Circuit breaker may be closed via the auto-reclose function and manual control means through the REF 550.
- OFF - Circuit Breaker may only be operated closed manually through the REF 550. Auto-reclose is disabled.
- TAGGED - Circuit Breaker cannot be closed by auto-reclose or manual control through the REF 550 and is locked in the open position. Operating the left arrow key to either the ON or OFF position will exit the REF 550 from the tagged state. The state transition diagram in Figure 3-3 demonstrates the three HLT states and the control action required to transition to each state. Notice that the OFF state must be passed through in moving between ON and TAG states. One transition occurs for a single press of the arrow key provided a transition is possible. See Substation Automation Logic in the Advanced Programmable Logic section for details.

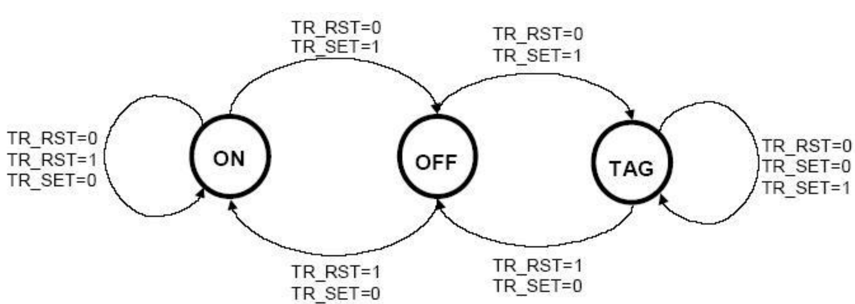

Figure 3-3 HLT State Transition Diagram

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User Interfaces

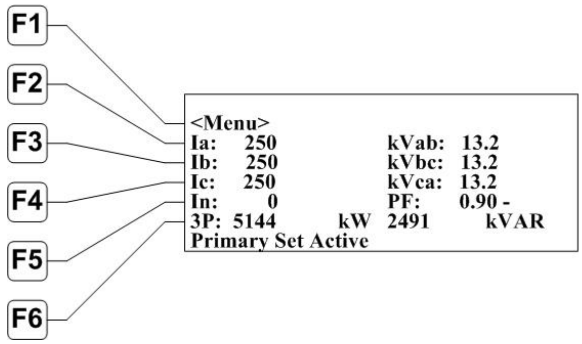


Figure 4-1. OCI Access Panel

Operator Control Interface (OCI) LCD Menu System

The operator control interface (OCI) liquid crystal display (LCD) interface on the front panel consists of an auto temperature compensating graphics LCD and six (6) push-button function keys. The large LCD window comprising of eight (8) lines by 20 characters affords easy viewing with data retrieval and menu navigation for setting changes. Figure 4-1 shows the convenience the default LCD screen provides to easy menu access, real-time power system metering and active settings group indication.

The metered values are updated every second. The last line of the default screen is reserved for identifying the present state of the system.

Examples of immediate condition status that are displayed include:

- Breaker failure (trip or close)
- Recloser Lockout
- Recloser reset and open time countdowns
- Trip circuit status

With the Control Point UDI enabled, see the Advanced Programmable Logic section, the display will alternate between the default information and the User Display Input message programmed in Miscellaneous settings. Each screen is displayed for approximately five seconds before switching to the other display. Figure 4-2 shows an example User Display message.

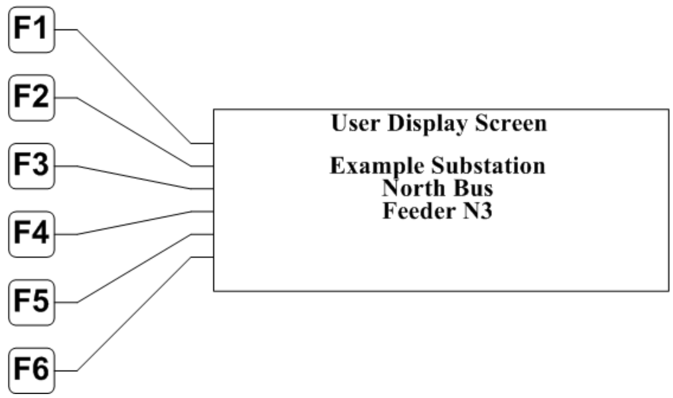


Figure 4-2 OCI. User Display Interface screen example

Hot Keys

The OCI LCD menu system offers quick and easy access to data through Hot Keys. Figure 4-3 shows the Hot Keys available in the REF 550. This eliminates the time and effort drilling down through the menu. A reset of Sealed-in Alarms may also be performed using the OCI TARGET RESET push-button. No password is required to operate any of the Hot Keys.

Main Menu

Multiple tasks can be performed using the OCI LCD menu system without the aid of a personal computer. The categories of tasks include:

- View Metering (Load, Demand, Max/Min Demand)
- Verify Settings
- Change Settings (Password Protected)
- Review Historical Records
- Controls (Password Protected)
- Test and Monitoring (Password Protected)
- Validate REF 550 Unit Information

The specific tasks available within each category are shown in Figure 4-3. Those submenus with an asterisk require the Relay Password to access. Those submenus with a “#” symbol require the Test or Relay Password.

Menu Navigation

Navigating through the menu tree is made easier with the <Esc>, <PgDn> and <PgUp> keys. The <Esc> special key allows easy transition to a higher level in the menu system while <PgDn> and <PgUp> keys provide navigation within a submenu screen when the number of submenu options exceeds the number of LCD rows.

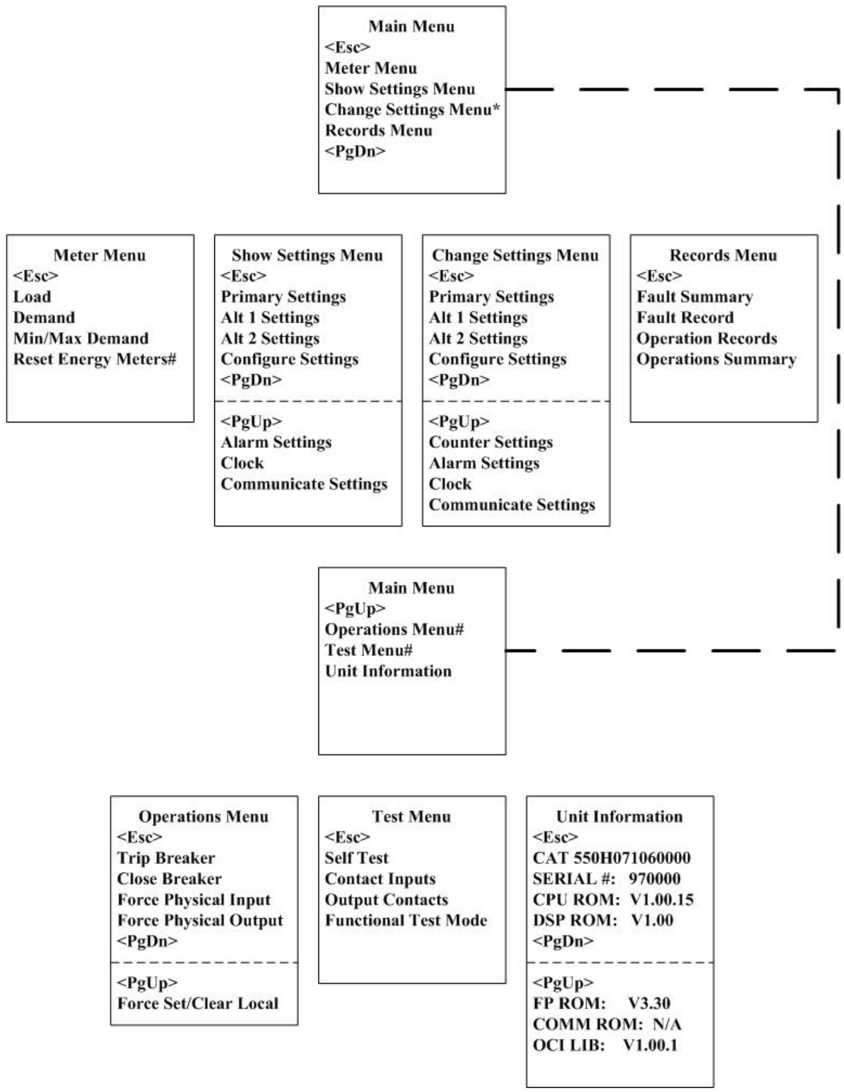


Figure 4-3. Operator Control Interface LCD Menu Tree

Tables 4-1 to 4-5 illustrate the settings accessible through the OCI LCD menu system.

Communications Interface via WinECP Tools Suite

WinECP is a free suite of tools for interfacing with the REF 550 system. **WinECP Version 4.50 or higher must be used when communicating with a REF 550 unit.** WinECP is available on the web at www.abb.com/substationautomation as follows:

- In Distribution Products, select REF 550,
- Click on Downloads
- Scroll to WinECP executable and download to hard drive
- Launch WinECP executable

The software tools available for installation in the WinECP Tools suite include:

WinECP - for REF 550 monitoring, metering, controlling, programming and data retrieving,

WaveWin - for viewing COMTRADE waveform files retrieved by WinECP, (See Section 7 for details.)

CurveGen - for programming and reviewing specially designed inverse-time curves, (See Section 1 for details.)

WinFPI - for flash upgrading a REF 550 to the latest CPU firmware. (See Section 10 for details.)

Use a straight-through 9-pin RS-232 cable when you connect a PC directly to the REF 550 OCI front port for interfacing with the user tool WinECP. When connecting to a modem, simply use a 25-pin to 9-pin RS-232 cable.

The WinECP suite of application programs have been carefully tested on IBM-compatible personal computers running the latest operating systems. If you experience difficulty in using WinECP, use its online Help menu or contact ABB Customer Support at (800) 634-6005 or 1 610 395-7333. WinECP Tools have been tested on the following Windows operating systems:

- Windows 98
- Windows NT4.0
- Windows 2000
- Windows XP

WinECP

Below is an outline of all the menus available through the Windows External Communications Program. Many of these menus are the same as those in the man-machine interface (OCI), but some are unique to the WinECP. Tables 4–1 through 4-5 and the following figures show the specific REF 550 settings programmable in WinECP.

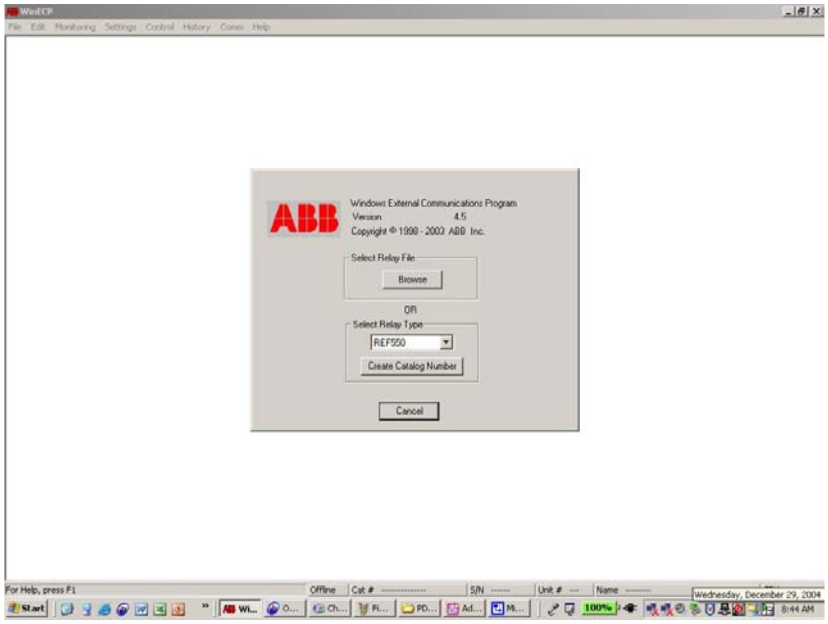


Figure 4-4. WinECP Startup Screen

WHAT IS WINECP?

WinECP is an interface program to ABB protective relays. WinECP resides on a PC and communicates to the relay via one of the PC's serial communication ports.

WinECP operates either "on-line" (i.e., communicating with a relay) or "Offline". In the Offline mode, WinECP is not communicating with a relay but with data files which may have been saved from a relay or from a previous WinECP session. WinECP also acts as a "communication bridge" to other software programs and features such as WaveWin, CurveGen and WinFPI.

System Requirements

To use WinECP you must have:

- Pentium class or better PC
- Windows 98, Windows NT4.0, Windows 2000 or Windows XP Professional
- Minimum screen resolution setting of 800x600

This User Guide is intended for use by power utility technicians and engineers and sales persons familiar with ABB protective relays. These users should also be familiar with the PC and use of Windows programs.

INSTALLATION

To install WinECP on your computer's hard drive, follow these steps:
1. Place the WinECP installation CD in the CD drive or locate the hard drive directory where the WinECP installation files reside.
2. Press the Start key and select Run.
3. Type the CD drive letter and colon followed by “setup” or Browse the hard drive where the WinECP “setup.exe” file is located.

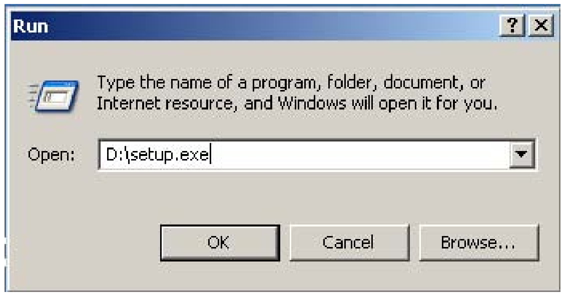


Figure 4-5. WinECP Installation Startup

4. Click OK.
5. Follow the instructions on your computer screen to complete the installation.

The installation program copies the selected application files (WinECP, CurveGen, WinFPi and WaveWin onto your hard drive. Typical and Custom installations are offered. Typical installs all the WinECP Tools application programs and Custom installs selected application programs. A Typical installation is recommended for every WinECP Tools installation. The default sub-directory for installation is \ABB Applications placed in the Program Files directory.

The installation also creates a Windows Start Programs Menu group called ABB Applications, which contains shortcuts to the applications installed by the WinECP installation program.

STARTING WINECP

To start WinECP, follow these steps:

1. Click Start, Programs.
2. From the list of Programs, highlight ABB Applications, then WinECP, then click on "WinECP".
(WinECP installation places a shortcut icon on the computer desktop screen for easy access, avoiding these steps.)

SELECT OPERATING MODE

The "Select Operating Mode" window is the first screen that appears when you start the WinECP program. From this window, you can choose to work Offline, via Direct Access (the PC is directly connected to the Relay), via Remote Access (connected through a modem using a dial-up connection) or via Ethernet network.

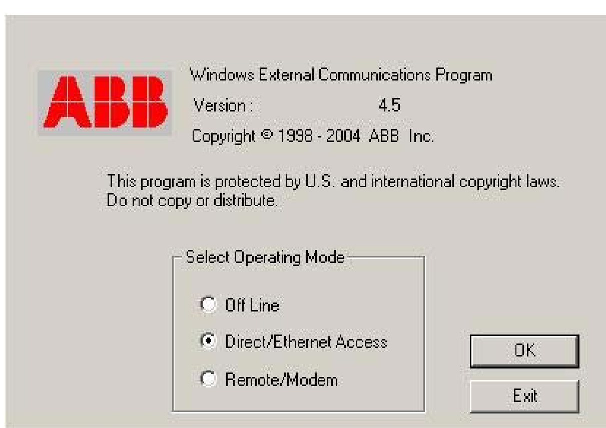


Figure 4-6. WinECP Operating Sessions

Off Line

Selecting Offline displays a window, Figure 4-7, prompting to either Browse a previously saved session (settings file) or start a new session by creating a new Catalog Number. Before making a selection, change the Relay Type to REF 550.

Browse

Selecting Browse will display the computer's directory tree from which the previously saved settings file (session) is to be opened. This is quite convenient when commissioning a substation where all the REF 550 units have the same Catalog Number. For installations where the REF 550 Catalog Numbers are different, a new session for each should be started using Create Catalog Number.

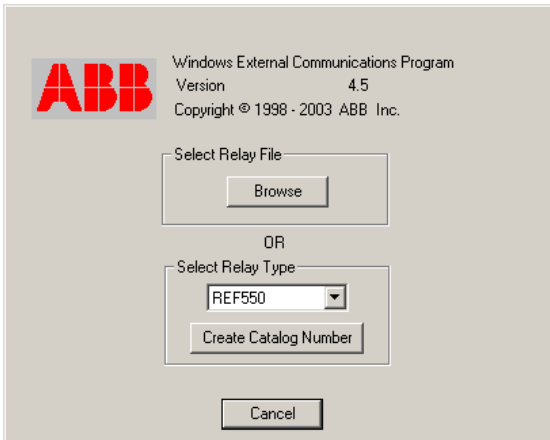


Figure 4-7 Offline Start Window

Create Catalog Number

After selecting a relay type and choosing "Create Catalog Number", the following screen appears: (Figure 4-8) From this screen, you can build the product's catalog number via the editable fields. (NOTE: For additional information regarding catalog numbers, refer to the Ordering Information section in the Instruction Manual or the REF 550 Descriptive Bulletin.) The Catalog Number can be changed by manually inputting the individual numbers, or by using the drop-down arrow in each field and making the desired selection.

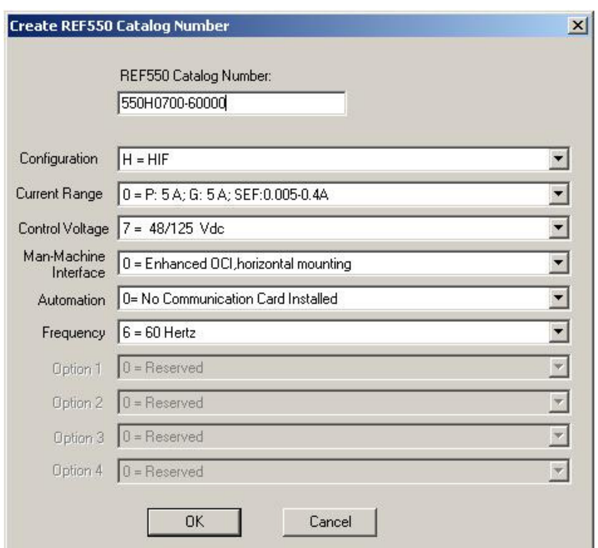


Figure 4-8 Create Catalog Number window

Advanced (Version Number)

By clicking the Advanced button in the Create Catalog Number screen, you can select the firmware version number of the relay. Use the drop down arrow that appears in the "Version" window (Figure 4-9) to choose from a list of Firmware Version Numbers available for the relay type that you have selected. When you have finished making your selection, click OK.

NOTE: This option will not be available in WinECP with REF 550 units running CPU firmware version V1.00.

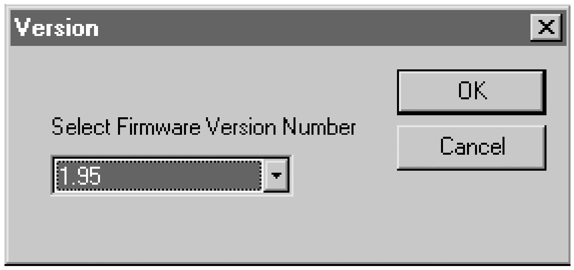


Figure 4-9 Advanced Firmware Version window

Direct Access

If you wish to connect directly to the relay, select “Direct Access” at the Select Operating Mode dialog (See Figure 4-10). Make the appropriate selections from the Comm Port Setup dialog that is displayed and then click Connect.

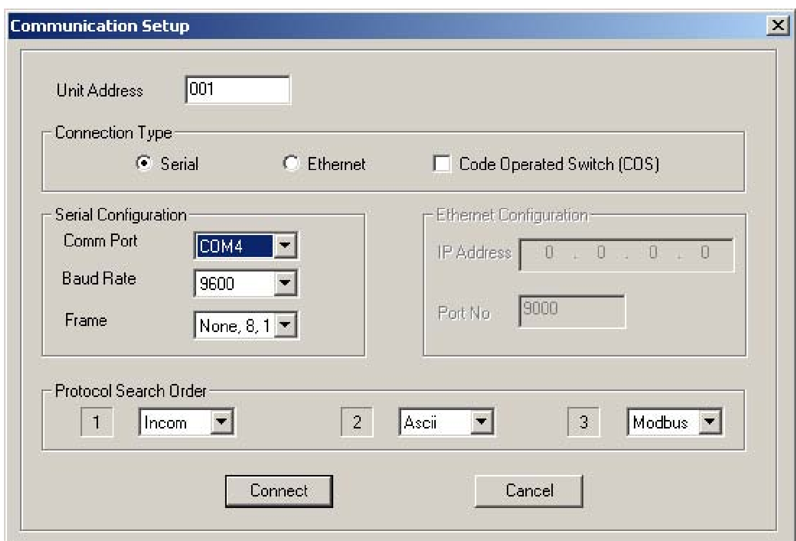


Figure 4-10 Direct Access window

Unit Address

Enter the three hexadecimal unit address of the REF 550 unit for direct communications. It is imperative that in a network of REF 550 units, each has its own Unit Address. Since the recommended number of units connected to any communications network is 32, three characters provides more than enough possible addresses.

Connection Type

Three connection types are available that define the existing communications connection: Serial, Ethernet and Code Operated Switch.

Serial

Use “Serial” where the direct connection is made to any of the available REF 550 serial RS-232 and RS-485 communication ports.

Ethernet

Use “Ethernet” where local and remote communications is available through an Ethernet network. The REF 550 must have the Ethernet communications card installed which is signified by it having an “E” in the eighth character of the REF 550 Catalog Number - see OCI LCD menus in this section for information on reviewing Unit Information. For available Ethernet features, see Internet Connectivity in this section.

Code Operated Switch

This option is only available with a “Serial” connection type selection. Check this box if a Code Operated Switch (COS) is wired into a serial communications network. Checking this option will display a telnet window for communicating to the COS to enable a particular port before communications is attempted with the unit. This is useful where a local COS port is available that can be accessed in the substation to communicate to the star network of units.

Serial Configuration

With serial communications selected, the communication port and settings need to be entered. Comm Port selections number 1 to 255. Where the newest laptop computers no longer provide a DB-9 RS-232 port, without the docking station, use the USB port and a USB-to-DB9 cable. The USB Comm Port assignment will most likely be COM4 or higher. NOTE: The setting “Comm Port” refers to the personal computer communication port and not the REF 550 port. The default communications settings for the REF 550 serial ports are:

Baud Rate: 9600
Frame: None, 8, 1

Ethernet Configuration

With an Ethernet connection, enter the REF 550 Internet Protocol (IP) address. Each unit can be programmed to a unique IP address, similar to Unit Address, for communications over the internet, see Ethernet Connectivity in this section. The IP address is programmed in Communications settings.

Protocol Search Order

As WinECP is the user interface tool for many distribution devices that have differing standard communication protocols, the ability to arrange the order of the protocols WinECP uses to learn the connected device is available. For REF 550 units, the standard communications protocol is “INCOM” so keep the default order.

Remote Access

If you wish to connect to a relay remotely via a dial-up modem (e.g., a relay that is off-site), select "Remote Access" at the Select Operating Mode dialog (See Figure 4-6). When the Remote Access dialog appears (See Figure 4-11), enter the dialing information (phone number) that will enable the modem to dial into the remote relay.

The Comm Port settings can be configured from within the Remote Access dialog by selecting the drop down arrows next to each item included in "Comm Port Setup". This is the comm port on your computer.

Be sure to select the correct "Dial Mode" for your telephone line, either Tone Dial or Pulse Dial, by clicking once on the button located next to your selection.

You must specify the Unit Address of the remote site relay to which you wish to connect.

If you are connecting to a unit with Code Operated Switch capability, place a checkmark in the box next to "Code Operated Switch (COS)" by clicking once on the box. This will cause a telnet window to appear for direct communications with the COS to enable the correct port prior to WinECP establishing communications.

When you have completed entering the phone number information (the dialing string), click Dial.

A database is available for entering all the important substation modem phone numbers for quick and easy access and selection. Use the description field to identify the substation name and the particulars to which that phone number applies.

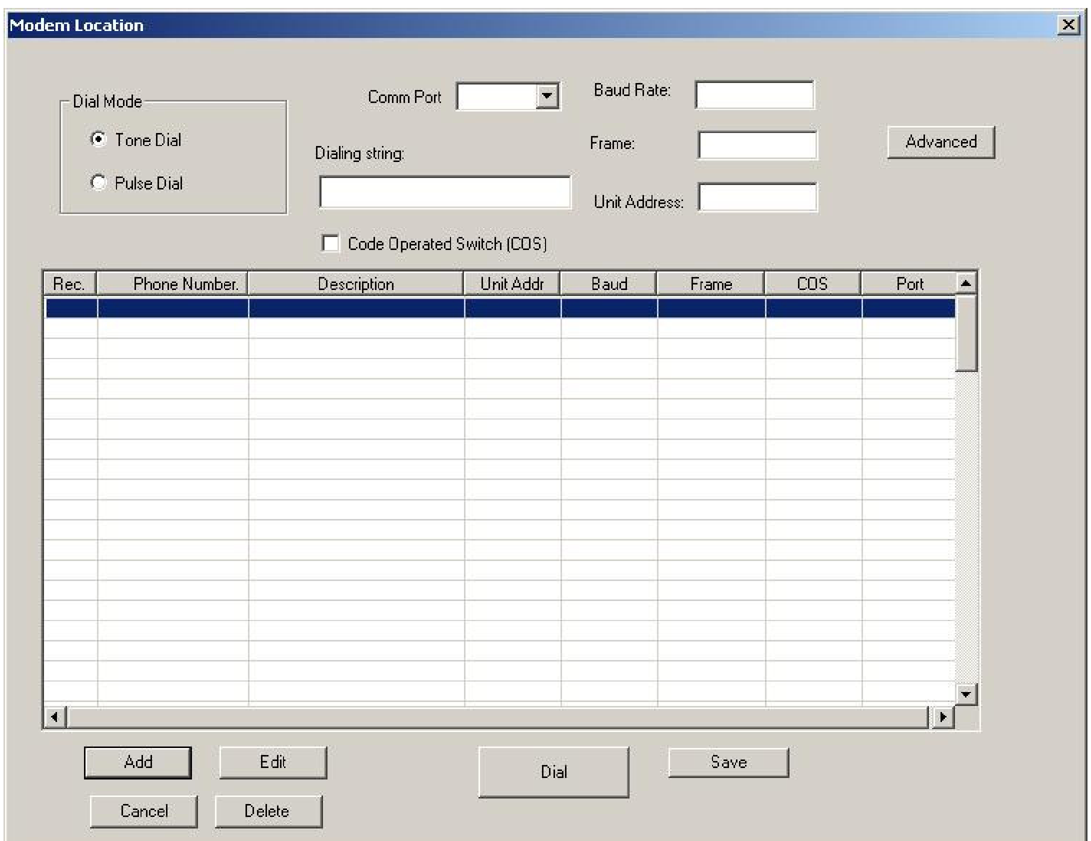


Figure 4-11 Remote/Modem Access window

Advanced (Modem Initialization String)

The Modem initialization string has been written to correctly initialize almost all modems. If your modem fails to work and you need to change the modem initialization string, click the Advanced button and enter the appropriate information. (Figure 4-12) Click OK to return to the Remote Access dialog and initiate the call.

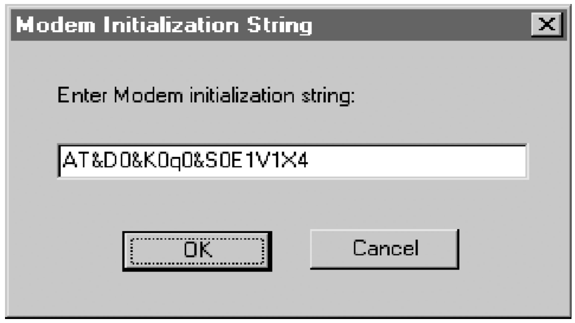


Figure 4-12 Advanced Modem option

Ethernet Connectivity

Those REF 550 units with the Ethernet communications option, the eighth character of the Catalog Number is an “E”, allows for local or remote ethernet connectivity. Use the Direct Access operating mode and click “Ethernet” as the connection type and enter the Internet Protocol (IP) address to communicate via an Ethernet network, see Figure 4-10. The REF 550 IP address is programmed in the Communication settings.

File Transfer Protocol (FTP) Operation

With the Ethernet communications card, FTP capability is supported in the REF 550. Large databases of information can be quickly and easily retrieved from the REF 550 using FTP and Windows Internet Explorer. The databases retrievable include:

- Digital Fault Recorder (DFR) waveforms
- Fault Records
- Operation Records

Figure 4-10 shows the Ethernet Configuration settings required to use Internet Explorer to access a REF 550 with Ethernet communications.

WinECP Main Window

After successful communications has been established with the REF 550 via Direct or Remote Access, a main window will appear as in Figure 4-13. Note that the center of the window is normally blank as menu items have not yet been selected. The main menu consists of the main menu bar located at the top of the window, the status bar located at the bottom of the window and the standard Windows Minimize, Maximize and Close symbols located at the top-right corner of the window.

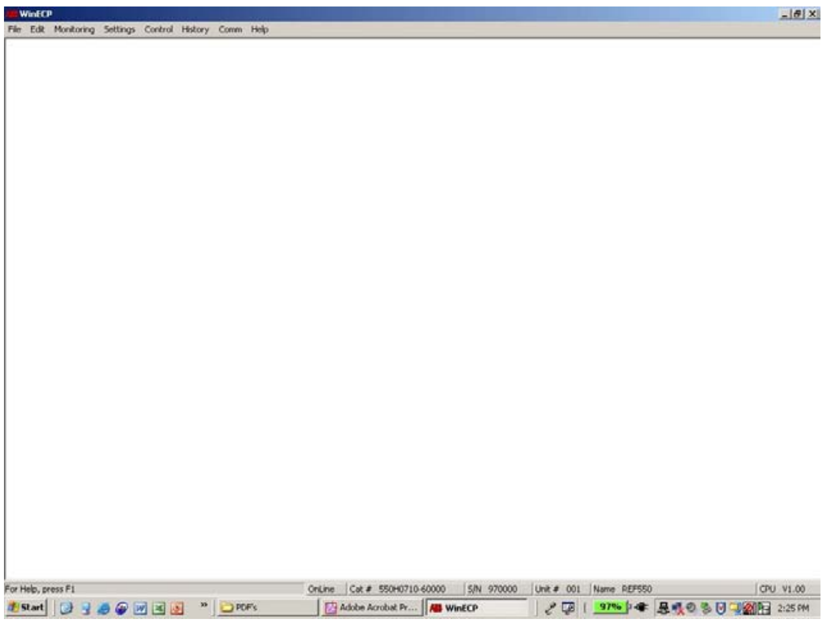


Figure 4-13 WinECP main window

Main Menu Items

The main WinECP window contains the following menu items:

- File
- Edit
- Monitoring
- Settings
- Control
- History
- Comm
- Help

File

From the File menu, you can choose to start a New Session, Import or Export data, open other ABB applications (WaveWin, CurveGen or WinFPI) or Exit the WinECP application.

New Session

1. Click File, New Session.
2. At the prompt, choose Yes to save your current settings to a file on your hard drive, or click No to continue to a new session without saving your current settings. Choose Cancel if you wish to cancel beginning a new session.

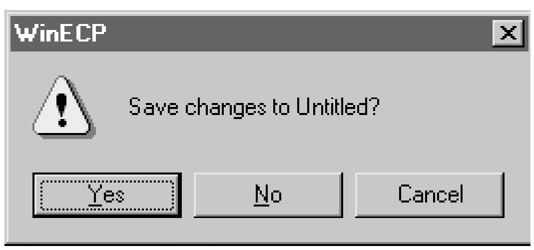


Figure 4-14 Save settings prompt

Export

1. Select File, Export.

2. Select the data you wish to export from the REF 550 and save to a file.

a. Load Profile - When the Save As dialog appears, choose the location where you would like to have the file stored. Assign a name to the file and click Save.

b. Load Profile All - When the Save As dialog appears, choose the location where you would like to save the file on the computer. Assign a name to the file and click Save.

c. Digital Fault Recorder (DFR)- When the Digital Fault Records dialog appears, select the record number you wish to save and click Save to File. When the Save As dialog appears, choose the location where you like to have the file stored.

NOTE: When exporting DFR waveform data, the file name is untitled. You can change the default file name by typing in a new name.

When you have verified that the location and file name are correct, click Save.
When the file save has finished, you may either choose another record to save (repeat the above steps) or click Cancel to end the Export Oscillographics process.

d. Program Curves - When the Save As dialog appears, choose the location where you would like to have the file stored. Assign a name to the file and click Save.

When the User dialog appears, select either User1, User2 or User3 and click OK.

Import

1. Select File, Import.
2. Select Program Curves.
3. When the Open dialog appears, select the file you wish to import to the relay and click Open.
4. When the User dialog appears, select either User1, User2, or User3 and click OK.
5. When the Password dialog appears, enter the correct password and click OK.

WaveWin

To run the waveform viewing program, click File and then WaveWin.

NOTE: If you chose not to install WaveWin at the time of the initial WinECP installation, you will not be able to access the software tool.

CurveGen

Run CurveGen to create unique inverse-time curves for special coordination needs.

To run CurveGen, select File and then CurveGen.

WinFPI

When a newer version of CPU firmware is available that contains enhancements or corrections, it can be flashed into the REF 550 using the Windows-based tool WinFPI.

To run the WinFPI program, select File and then WinFPI.

NOTE: If you chose not to install WinFPI at the time of the initial WinECP installation, you will not be able to access the software tool.

CAUTION!! Flashing upgrading to a new CPU firmware version causes default settings to be installed and all historical data cleared. It is recommended that prior to running WinFPI, all settings and historical data be saved to a hard drive.

Exit

To quit the WinECP application, click Exit.

EDIT

The "Edit" Menu item allows you to copy and paste settings from the Alternate 1, Alternate 2, and Primary settings screens. The copy and paste functions work only with these settings screens, permitting you to copy settings from one screen to another (e.g., from Primary to Alternate 1 or Alternate 2).

NOTE: The copy and paste functions are only enabled when working in the Alternate 1, Alternate 2, and Primary settings screens. They are disabled when you are working on any other settings screen. The "paste" function is enabled only if you have previously selected to "copy" settings from one of these three settings screens.

MONITORING

The monitoring screens periodically poll the relay for data. Select the Monitoring screen whose data you wish to view. Each menu item presents a separate window from which you can view the data as it updates.

To differentiate groups of data, numeric values are shown in differing colors.

To close a Monitoring window, click the "X" in the upper right corner of that window.

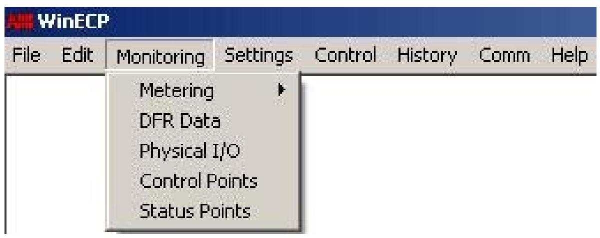


Figure 4-15 WinECP Monitoring menu options

NOTE: You must be online with the relay (either via Direct Access or Remote Access) in order to monitor data "live" from the relay. When in an Offline session, the monitoring windows can be opened, but will show zero values for all displayed quantities.

SETTINGS

From the Settings Menu, you can perform the following functions on one or more tabbed sheets: (Figure 4-16)

1. DOWNLOAD to Relay - load data into the relay from the WinECP program.
2. Upload from Relay - load data from the relay to the WinECP program.
3. Save File - save existing data in the WinECP program to a file on your hard drive.
4. Read File - read data into the current Settings sheets from a file on your hard drive.
5. Print - print selected Settings sheets.
6. Close - close the settings windows.

NOTE: The settings stored in the WinECP window prior to its closure are not lost, but saved in computer memory until the window is reopened for the same session. Should a New Session be started or WinECP exited, the data will be lost. Prompts to save settings data prior to starting a New Session or exiting are provided if they have changed.

Select All/Remove All

From the Settings tab sheet, you can choose to Select All settings if you wish to perform any of the above functions on all or several tabbed sheets.

From the Settings tab sheet, click the Select All button. Note that a checkmark is placed in each box on the Tab Select boxes. This indicates which data settings you wish to manipulate.

To clear all the checkmarks from the Settings tab sheet, click Remove All. Note that all checkmarks are cleared.

You can select or deselect individual settings by clicking once on the checkbox next to the specific setting you wish to change.

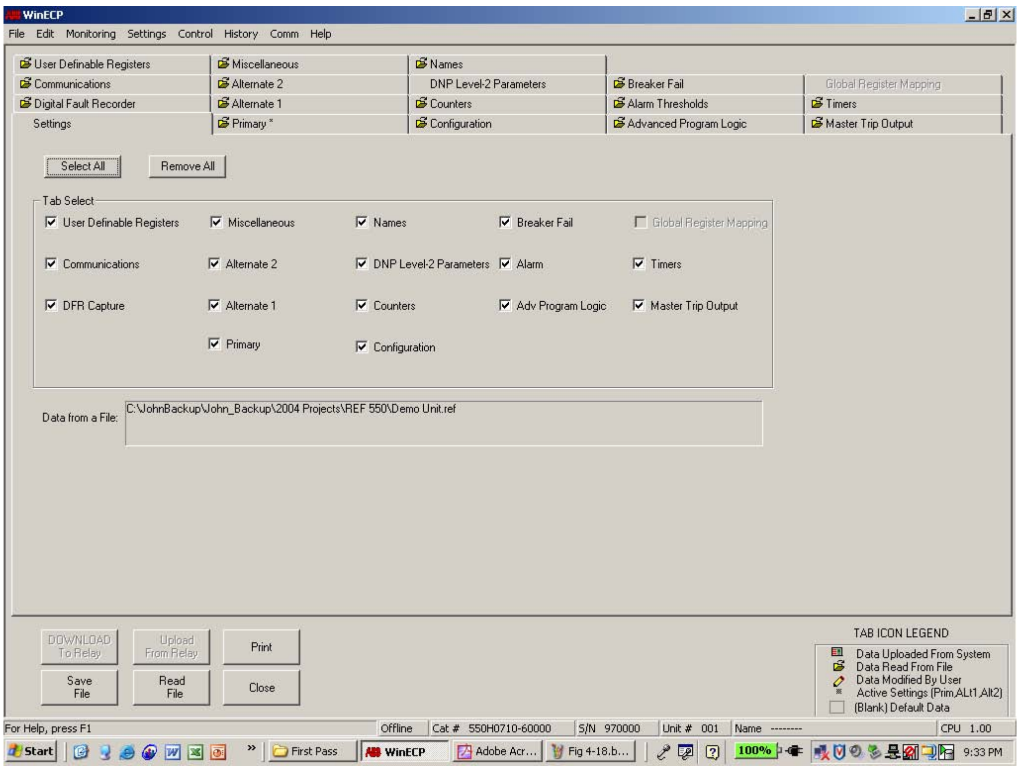


Figure 4-16 WinECP Settings screen

DOWNLOAD to Relay

To Download data to the relay (must be online), click the Select All button from the main Settings tab sheet or select only the Tab Select boxes of those settings you wish to download to the relay.

After selecting the Tab Select boxes you wish to download, click Download to Relay. Enter the correct password and click OK. Note: Checking the “Remember Password” box will save time for all future downloads while in the session.

Upload from Relay

To Upload data from the relay (must be online), click the Select All button from the main Settings tab sheet or select only the Tab Select boxes of those settings you wish to upload from the relay. Click Upload from Relay.

Save File

To Save data to a file on your hard drive, (online or offline), click the Select All button from the main Settings tab sheet or select only the Tab Select boxes of those settings you wish to save to a file.

Click Save File. When the Save As dialog window appears, select a name for the file and the location where the file is to be saved and click Save.

The saved REF 550 settings file will have the extension “ref” appended to the filename provided. This distinguishes it as a REF 550 settings file for WinECP. After the settings are saved in “ref” binary format, a prompt will appear asking if it is desired to save the settings in a text form with a “txt” extension. This is quite useful where settings are stored in a text database for reporting and archiving purposes. Since the extension is different, the same filename can be used as the one for the “ref” binary format.

Read File

To Read data from an existing file on your hard drive, (online or offline), click the Select All button from the main Settings tab sheet or select only the Tab Select boxes of those settings you wish to read in from a file.

Click Read File. When the Select Relay File window appears, select the relay file you wish to read in and click Open.

Print

To Print data, click Select All from the main Settings tab sheet or select only the Tab Select boxes of those settings you wish to print.

Click Print and follow the instructions in the Print dialog window to select your printer, number of copies, etc.

NOTE: You can choose to Download, Upload, Save, Read or Print directly from a Settings tab sheet in which you are currently working, in which case only that sheet will be affected.

View/Make Changes to Individual Settings Sheets

1. Click Settings on the main menu bar.
2. When the Settings screen appears, click the Primary (or other) tabbed sheet.
3. Note that the Primary sheet now opens and from there you can select from the categories contained on that sheet:

a. Overcurrent
b. Voltage
c. Recloser
d. Distance
e. Directional
f. Frequency
g. Synch Check
h. HIF Detect™

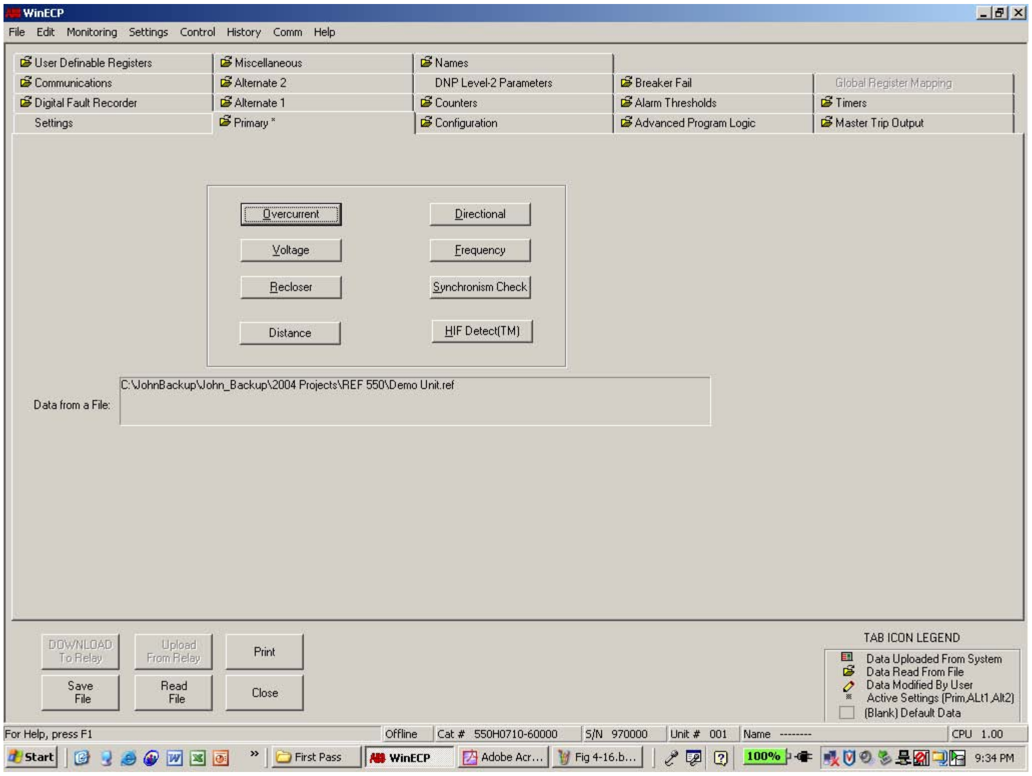


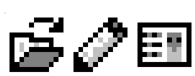
Figure 4-17 WinECP Primary Settings screen

Follow the same guidelines for each tabbed sheet you wish to view, clicking on the appropriate "tab" to bring that sheet to the forefront of the window.

To change data within each tabbed sheet settings category, click on the field whose data you wish to change. When the pop-up window appears, click the arrow to either display a list of items or to change the numeric range of that particular setting.

If the setting you wish to change is a numeric value, you can also enter the desired number by using the numeric keypad on your keyboard.

NOTE: The numeric value you enter manually must fall within the allowable range for that setting. If you enter a value that is outside of the specified range, you will receive a warning to that effect and will need to correct the value.
As data is manipulated in the tabbed sheets, one of the following icons will appear in the left corner of each tabbed sheet whose data has changed.



= Data has been read in from an existing file
= Data has changed in the tabbed sheet
= Data was successfully downloaded or uploaded to/from the relay

NOTE: If you are in a tabbed sheet and select to Download/Upload, Read/Save or Print, only that particular tabbed sheet will be affected.

Table 4-1. Primary, Alternate 1 and Alternate 2 Settings (Password Protected)

Function	Setting	Range for 5A model (1A model)	Step Size	Default
2-Phase 50P (3I>>)	2Phase 50P Trip	Disable or Enable		Disable
21P-1 (Ph Dist-1)	Select	Disable, Enable-Forward, Enable-Reverse	-	Disable
	Phase Reach	0.1 - 50.0 (0.5 - 250.0) ohms	.1 (0.5) ohms	45 (225)
	Char Angle	10 - 90 (Forward) or 190 - 270 (Reverse)	0.1°	45° (225°)
	Time Delay (shed)	0.0 to 10 seconds	0.10	0.0
	I1 Supervision	1.0 to 10.0 (0.2 - 2.0) amps	0.1 (0.02)	1.0 (0.2)
	I2 Supervision	1.0 - 10.0 (0.2 - 2.0) amps	0.1 (0.02)	1.0 (0.2)
21P-2 (Ph Dist-2)	Select	Disable, Enable-Forward, Enable-Reverse	-	Disable
	Phase Reach	0.1 - 50.0 (0.5 - 250.0) ohms	.1 (0.5) ohms	45 (225)
	Char Angle	10 - 90 (Forward) or 190 - 270 (Reverse)	0.1°	45° (225°)
	Time Delay (shed)	0.0 to 10 seconds	0.10	0.0
	I1 Supervision	1.0 to 10.0 (0.2 - 2.0) amps	0.1 (0.02)	1.0 (0.2)
	I2 Supervision	1.0 to 10.0 (0.2 - 2.0) amps	0.1 (0.02)	1.0 (0.2)
21P-3 (Ph Dist-3)	Select	Disable, Enable-Forward, Enable-Reverse	-	Disable
	Phase Reach	0.1 - 50.0 (0.5 - 250.0) ohms	.1 (0.5) ohms	45 (225)
	Char Angle	10 - 90 (Forward) or 190 - 270 (Reverse)	0.1°	45° (225°)
	Time Delay (shed)	0.0 to 10 seconds	0.10	0.0
	I1 Supervision	1.0 to 10.0 (0.2 - 2.0) amps	0.1 (0.02)	1.0 (0.2)
	I2 Supervision	1.0 to 10.0 (0.2 - 2.0) amps	0.1 (0.02)	1.0 (0.2)
21P-4 (Ph Dist-4)	Select	Disable, Enable-Forward, Enable-Reverse	-	Disable
	Phase Reach	0.1 - 50.0 (0.5 - 250.0) ohms	.1 (0.5) ohms	45 (225)
	Char Angle	10 - 90 (Forward) or 190 - 270 (Reverse)	0.1°	45° (225°)
	Time Delay	0.0 to 10 seconds	0.10	0.0
	I1 Supervision	1.0 to 10.0 (0.2 - 2.0) amps	0.1 (0.02)	1.0 (0.2)
	I2 Supervision	1.0 to 10.0 (0.2 - 2.0) amps	0.1 (0.02)	1.0 (0.2)
25 (SYNC)	Select	Enable, Disable	-	Disable
	DBLL	Enable, Disable	-	Disable
	LBDL	Enable, Disable	-	Disable
	DBDL	Enable, Disable	-	Disable
	Voltage Difference	5 to 80 volts	1	10
	Angle Difference	1 to 90 Degrees	1	35
	Sync. Time	0.00 to 60.0 sec.	.1	5.0
	Breaker Close Time	Disable, 2.0 to 15.0 cycles	0.5	Disable
	Slip Frequency	.005 to 0.500 Hz	.005	0.100
	Phase Select	Va-n, Vb-n, Vc-n, Va-b, Vb-c, Vc-a		Va-n

Table 4-1. Primary, Alternate 1 and Alternate 2 Settings (Password Protected) (Continued)

25 (SYNC)	Dead Voltage	10 to 150 volt	1	20
	Live Voltage	10 to 150 volt	1	60
	Dead Time	0.0 to 120.0 seconds	.1	0.00
	Reclose (79/25) Supervision	Enable, Disable	-	Disable
	Sync. Fail Time	0 to 600 seconds	1	20
27 (U<)	Select	Disable or Enable		Disable
	Pickup Volts	10 to 200 volts	1	100
	Time Delay	0 to 60 seconds	1	10
32N-2 (I2->)	Select	Disable, Enable-Neg Seq, Enable-Zero Seq		Disable
	Max. Torque Angle	0 to 355 degrees	5	180
32P-2 (I1->)	Select	Disable, Enable		Disable
	Torque Angle	0 to 355 degrees	5	0
46-1 (Insc>1)	Curve Selection	See Table 1-14 or Disable		Disable
	Pickup Amps	0.4 to 12 A or 0.08 to 2.4 A	0.1 or 0.02	6
	Time Dial/Delay	See Table 1-14	0.1/0.1	5/5
46-2 (Insc>2)	Curve Selection	See Table 1-14 or Disable		Disable
	Pickup Amps	0.4 to 12 A or 0.08 to 2.4 A	0.1 or 0.02	6
	Time Dial/Delay	See Table 1-14	0.1/0.1	5/5
47 (U2>)	Select	Disable or Enable		Disable
	V_2 Pickup Volts	5.0 to 25 volts	0.5	10.0
	Time Delay	0 to 60 seconds	0.1	10.0
50N-1 (IN>>1)	Curve Selection	See Table 1-10 or Disable		Standard
	Pickup X 51N	0.5 to 40 times 51N pickup setting	0.1	3.0
	Time Dial/Delay	See Table 1-6	0.1/0.1	1.0/0.1
50N-2 (IN>>2)	Select	Disable, Standard, SEF		Disable
	Pickup X 51N	0.5 to 40 times 51N pickup setting	0.1	3.0
	Time Delay	0 to 9.99 seconds	0.01	0.10
	SEF Pickup Amps Time Delay	5 mA to 400 mA 0.5 to 180.0 seconds	0.5 mA 0.1	15 0.5

Table 4-1. Primary, Alternate 1 and Alternate 2 Settings (Password Protected) (Continued)

50N-3 (IN>>3)	Selection	Disable or Enable		Disable
	Pickup X 51N	0.5 to 40 times 51N pickup setting	0.1	3.0
50P-1 (3I>>1)	Curve Selection	See Table 1-7 or Disable		Standard
	Pickup X 51P	0.5 to 40 times 51P pickup setting	0.1	3.0
	Time Dial/Delay	See Table 1-7	0.1/0.01	1.0/0.1
50P-2 (3I>>2)	Selection	Disable or Enable		Disable
	Pickup X 51P	0.5 to 40 times 51P pickup setting	0.1	3.0
	Time Delay	0 to 9.99 seconds	0.01	0.1
50P-3 (3I>>3)	Selection	Disable or Enable		Disable
	Pickup X 51P	0.5 to 40 times 51P pickup setting	0.1	10.0
51N (IN>)	Curve Selection	See Table 1-6 or Disable		Extremely Inverse
	Pickup Amps	0.4 to 12 A (0.08 to 2.4 A)	0.1 (0.02)	6.0 (1.2)
	Time Dial/Delay	See Table 1-6	0.1/0.1	5.00/5.00
51P (3I>)	Curve Selection	See Table 1-5		Extremely Inverse
	Pickup Amps	0.4 to 12 A (0.08 to 2.4 A)	0.1 (0.02)	6.0 (1.2)
	Time Dial/Delay	See Table 1-5	0.1/0.1	5.00/5.00
59 (U>)	Select	Disable or Enable		Disable
	Pickup Volts	70 to 250 volts	1	140
	Time Delay	0 to 60 seconds	1	10
59G (U0>)	Select	Disable or Enable		Disable
	Pickup Volts	1 to 50 volts -	0.5	40.0
	Time Delay	.0 to .0 seconds	.1	1.0
67N (IN>->)	Select	Disable, Enable-Zero Seq, Lockout-Zero Seq, Enable-Neg Seq, Lockout-Neg Seq		Disable
	Curve Selection	See Table 1-16		Extremely Inverse
	Pickup Amps	0.4 to 12 A (0.08 to 2.4 A)	0.1 (0.02)	1.0 (0.2)
	Time Dial/Delay	See Table 1-16	0.1/0.1	1.0/1.0
	Torque Angle	0 to 355 degrees	5	180
67P (3I>->)	Select	Disable, Enable or Lockout		Disable
	Curve Selection	See Table 1-15		Extremely Inverse
	Pickup Amps	0.4 to 12 A (0.08 to 2.4 A)	0.1 (0.02)	1.0 (0.2)
	Time Dial/Delay	See Table 1-15	0.1/0.1	5.00/5.00
	Torque Angle	0 to 355 degrees	5	0

Table 4-1. Primary, Alternate 1 and Alternate 2 Settings (Password Protected) (Continued)

79-CO (O->1-CO)	Cutout Time	1 to 200 seconds or Disable	1	Disable
79 (O->I)	Reset Time	3 to 200 seconds	1	10.00
79-1 (O->I1)	Select	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		50P-1 Enable 51N Enable 50N-1 Enable
	Open Time	0.1 to 1800 seconds or Lockout	0.1	Lockout
79-2 (O->I2)	Select	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		50P-1 Enable 51N Enable 50N-1 Enable
	Open Time	0.1 to 1800 seconds or Lockout	0.1	Lockout
79-3 (O->I3)	Select	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		50P-1 Enable 51N Enable 50N-1 Enable
	Open Time	0.1 to 1800 seconds or Lockout	0.1	Lockout
79-4 (O->I4)	Select	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		50P-1 Enable 51N Enable 50N-1 Enable
	Open Time	0.1 to 1800 seconds or Lockout	0.1	Lockout
79-5 (O->I5)	Select	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		50P-1 Enable 51N Enable 50N-1 Enable
	Open Time	Lockout		Lockout
79V (O->IU<)	Voltage Select	Disable or Enable		Disable
	Pickup Volts	10 to 200 volts	1	40
	Time Delay	4 to 240 seconds	1	10
81 (f)	Select	Disable, Enable 81-1, Enable 81-1 & 81-2		Disable
81R-1 (f>1)	Pickup Hz (load restore)	Disable, 56 to 64 Hz, or 46 to 54 Hz	0.01	Disable
	Time Delay (restore)	0 to 7200 seconds	1	10
81R-2 (f>2)	Pickup Hz (load restore)	Disable, 56 to 64 Hz or 46 to 54 Hz	0.01	Disable
	Time Delay (restore)	0 to 7200 seconds	1	10
81S-1 (f<2)	Pickup Hz (load shed)	56 to 64 Hz or 46 to 54 Hz	0.01	56 or 46
	Time Delay (shed)	0.08 to 60 seconds	0.01	0.10
81S-2 (f<1)	Pickup Hz (load shed)	56 to 64 Hz or 46 to 54 Hz	0.01	56 or 46
	Time Delay (shed)	0.08 to 60 seconds	0.01	0.10
81V (fU<)	Voltage Block	40 to 200 volts	1	40
Cold Load Time	Activation Time	0 to 254 seconds/minutes or Disable	1	Disable
HIF Detect™	Select	Disable or Enable		Disable
	Level	1 to 10	1	5
Neutral Cold Load	Activation Time	0 to 254 seconds/minutes or Disable	1	Disable

Table 4-2. Configuration Settings (Password Protected)

Setting	Range	Step Size	Default
79V (O->IU<)Timer Mode	Seconds or Minutes	-	Seconds
Alt 1 Setting Enable	Enable or Disable	-	Enable
Alt 2 Setting Enable	Enable or Disable	-	Enable
Barrel Shifter A	2, 3 or 4	1	3
Barrel Shifter B	2, 3 or 4	1	3
Breaker Control Buttons (OCI Front Panel Select)	Disable, LEDs Only or Enable	-	Disable
C1 Operation (OCI Front Panel Select)	Maintained or Momentary	-	Maintained
C1 Select (OCI Front Panel Select)	Disable or Enable	-	Disable
C2 Operation (OCI Front Panel Select)	Maintained or Momentary	-	Maintained
C2 Select (OCI Front Panel Select)	Disable or Enable	-	Disable
C3 Operation (OCI Front Panel Select)	Maintained or Momentary	-	Maintained
C3 Select (OCI Front Panel Select)	Disable or Enable	-	Disable
C4 Operation (OCI Front Panel Select)	Maintained or Momentary	-	Maintained
C4 Select (OCI Front Panel Select)	Disable or Enable	-	Disable
C5 Operation (OCI Front Panel Select)	Maintained or Momentary	-	Maintained
C5 Select (OCI Front Panel Select)	Disable or Enable	-	Disable
C6 Operation (OCI Front Panel Select)	Maintained or Momentary	-	Maintained
C6 Select (OCI Front Panel Select)	Disable or Enable	-	Disable
Change Test Password?	4 Alphanumeric characters	-	No
Close Failure Time	Disable, 18 to 16000 cycles	1	18
Cold Load Timer	Seconds or Minutes	-	Seconds
Demand Meter Constant (Demand Minutes)	5, 15, 30, or 60 minutes	-	15
LCD Contrast	0 to 63	1	32
Line Length	0.1 to 125 miles (km)	0.1	0.1
Local Edit ††	Enable or Disable	-	Enable
Meter Mode (WHr Display)	kWHr or MWHr	-	kWHr
Multiple Device Trip	Enable or Disable	-	Disable
Phase CT Ratio	1 - 2000	1	100
Neutral CT Ratio	1 - 2000	1	100
Phase Rotation (Phase Sequence:)	ABC or ACB	-	ABC
Positive Sequence Resistance/Mile (km) (Pos Seq R/M)	0.001 to 4 Primary Ohms/Mile (km)	0.001	0.001
Positive Sequence Reactance/Mile (km) (Pos Seq X/M)	0.001 to 4 Primary Ohms/Mile (km)	0.001	0.001
Protection Mode	Fund. or RMS	-	Fund.
Remote Edit †	Enable or Disable	-	Enable

† Remote Edit is editable only in MMI display.

††Local Edit is editable only in OCI LCD menu display.

Table 4-2. Configuration Settings (Password Protected) (Continued)

Setting	Range	Step Size	Default
Reset Mode	Instant (2 cycles) or Delayed	-	Instant
SE(I0) CT Ratio	1 to 2000	1	100
Slow Trip Time (cycles)	5 - 60	1	12
SWSET	Disable or Enable	-	Disable
Target Display Mode	Last or All (faults)	-	Last
Trip Failure Time	5 to 60 cycles	1	18
Unit Name/ID	(15 alphanumeric characters)	-	REF 550
Vbus Ratio	1 - 2000	1	100
Volt Display Mode	Line-Neutral(Vln) or Line-Line(Vll)	-	Line-Neutral(Vln)
VT Connection (VT Conn:)	69 Wye, 120 Wye, 120 Delta, 208 Delta	-	120 Wye
VT Ratio	1 - 2000	1	100
Zero Sequence Resistance/Mile (km) (Zero Seq R/M)	0.001 to 4 Ohms/Mile (km)	0.001	0.001
Zero Sequence Reactance/Mile (km) (Zero Seq X/M)	0.001 to 4 Ohms/Mile (km)	0.001	0.001
Zone Sequence	Disable or Enable	-	Disable

In the Counter Settings Menu, the user has the option to change the value of the various counters. This is very useful where the operations counters differ between a replaced breaker and the spare breaker. By changing the Breaker Operations Counter from the old breaker's value to the number that matches the replacement breaker, the two counters will be synchronized.

Table 4-3. Counter Settings (Password Protected)

Setting	Range	Step Size	Default
KSI Summation A Phase Setting - KSI Sum A (L1)	0 to 9999 kA	1	0
KSI Summation B Phase Setting - KSI Sum B (L2)	0 to 9999 kA	1	0
KSI Summation C Phase Setting - KSI SumC (L3)	0 to 9999 kA	1	0
Overcurrent Trip Counter	0 to 9999	1	0
Breaker Operations Counter	0 to 9999	1	0
79 (O->I) Counter 1	0 to 9999	1	0
79 (O->i) Counter 2	0 to 9999	1	0
1st Reclose Counter (1st Recl) [successful]	0 to 9999	1	0
2st Reclose Counter (2nd Recl) [successful]	0 to 9999	1	0
3rd Reclose Counter (3rd Recl) [successful]	0 to 9999	1	0
4th Reclose Counter (4th Recl) [successful]	0 to 9999	1	0

In the Alarm Thresholds Menu, the user has the option to set thresholds for various alarms. When the threshold is exceeded, the corresponding status point is asserted. (See the Advanced Programmable Logic section.).

Table 4-4. Alarm Thresholds (Password Protected)

Setting	Range	Step Size	Default	Status Point
KSI Summation	1 to 9999 (kA)	1	Disable	KSI
Over Current Trip Counter	1 to 9999	1	Disable	OCTC
79 (O->I) Counter 1	1 to 9999	1	Disable	79CA1
79 (O->I) Counter 2	1 to 9999	1	Disable	79CA2
Phase Demand	1 to 9999 (A)	1	Disable	PDA
Neutral Demand	1 to 9999 (A)	1	Disable	NDA
Demand 3P-kVar [3-phase kilo VAr alarm] (Dmnd 3P-kVAr)	10 to 99,990 (kVAr)	10	Disable	VarDA
Low Batt Vdc^	Disable, 20 to 300	1	Disable	BATT_LO, BATT_LOs
Low PF [power factor alarm]*	0.5 to 1.0 (lagging)	0.01	Disable	LPFA
High PF [power factor alarm]*	0.5 to 1.0 (lagging)	0.01	Disable	HPFA
Load Current [alarm]*	1 to 9999 (A)	1	Disable	LOADA
Positive kVAr [3-phase kiloVAr alarm]*	10 to 99,990 (kVAr)	10	Disable	PVArA
Negative kVAr [3-phase KiloVAr alarm]*	10 to 99,990 (kVAr)	10	Disable	NVArA
Positive KWatt Alarm 1*	1 to 9999 (kW)	1	Disable	PWatt1
Positive KWatt Alarm 2*	1 to 9999 (kW)	1	Disable	PWatt2
High Batt Vdc^	Disable, 20 to 300	1	Disable	BATT_HI, BATT_HIs

* This feature includes an embedded 60 seconds pickup-before-operate timer.

^ This feature includes an embedded 5 seconds pickup-before-operate timer.

Table 4-5. Communications Settings (Password Protected)

Setting	Range	Default
Unit Address	3 hexadecimal characters (0-9 & A-F)	001
Front Port RS-232:		
Baud Rate	300, 1200, 2400, 4800, 9600	9600
Frame	None-8-1; None-8-2	None-8-1
Rear Port RS-232 :		
Baud Rate*	300, 1200, 2400, 4800, 9600, 19200	9600
Frame	Odd-7-1; Even-7-1; None-8-1; Odd-8-1; Even-8-1; None-7-2; None-8-2	None-8-1
Rear Port RS485 :		
Baud Rate*	300, 1200, 2400, 4800, 9600, 19200	9600
Frame	Odd-7-1; Even-7-1; None-8-1; Odd-8-1; Even-8-1; None-7-2; None-8-2	None-8-1
Network Parameters*	0 to 250, step 1	0
Network Modes*	Disable or Enable	Disable
IP Network Address*		0 . 0 . 0 . 0
External Time Sync. (IRIG-B)	Disable; Enable-cc; Enable-mmm; Enable-mmm for MMI and Comm	Disable
SNTP Server Address*		0 . 0 . 0 . 0
SNTP Request	Listen or Period(64 to 1024, step 1)	Period(300)
SNTP Timeout	50 to 1000, step 1	100
UTC Offset Hours	-13.0 to 12.0, step 0.5	0.0

* Check catalog number for available communications options. For example, Network Parameters and Network Modes are specific settings designed for DNP3.0 Level 2+ protocol.

In addition to the Tables 4-1 through 4-5, under the “Change Settings” menu, the following settings are also available:

Advanced Programmable Logic

This feature allows for programming control schemes, status conditions and output operations. Details are provided in the Advanced Programmable Logic section.

Master Trip Output

The user has the ability to allow only certain protective elements to operate the Master Trip Output Contact (terminals 29 and 30). Figure 4-18 shows the WinECP Master Trip Output screen. See the Advanced Programmable Logic section for details on additional methods of operating the Master Trip Output. This output contact is a dry contact, i.e., there are no internal voltages connected to its output terminals. This affords flexibility in application where, for example, different voltage sources are used for various control circuits.

The Master Trip physical output is configured normally open, i.e., it is open when not energized and closed when energized via a user command or the programming logic is true. This physical output can be reconfigured for normally closed operation. This is accomplished by de-energizing the REF 550, removing the inner chassis, locating the appropriate Jumper Selector Plug(JSP) and changing its position from N.O. to N.C. as labeled on the printed circuit board(PCB) silkscreen. The jumper plug for the Master Trip output is assigned as follows:

Master Trip (Terminals 29, 30): J11-J12 (N.C.) or J12-J13 (N.O.)

See Figure 9-1 for location of the Master Trip jumper plug.

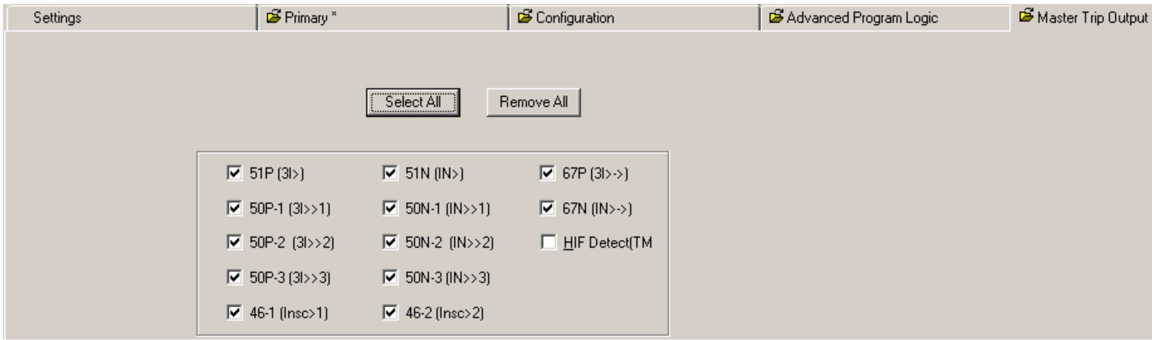


Figure 4-18 Master Trip Output

Digital Fault Recorder

This standard feature stores the analog and digital waveforms during relay operations and various system conditions. Figure 4-19 shows the WinECP settings screen. See the Historical Records section for more details.

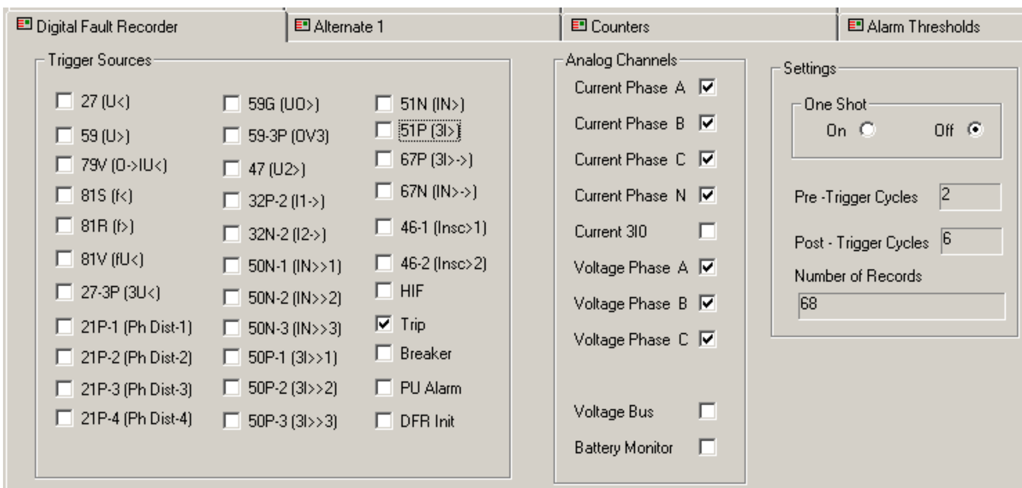


Figure 4-19 DFR settings screen

Timers

Sixteen independent timers are available for use in the Advanced Programmable Logic feature. Each timer has separate pickup-before-operate and dropout-after-operate settings programmable from 0.0 to 250 seconds in 0.01 seconds steps. Figure 4-20 shows the WinECP Timers screen. See the Advanced Programmable Logic section for more details.

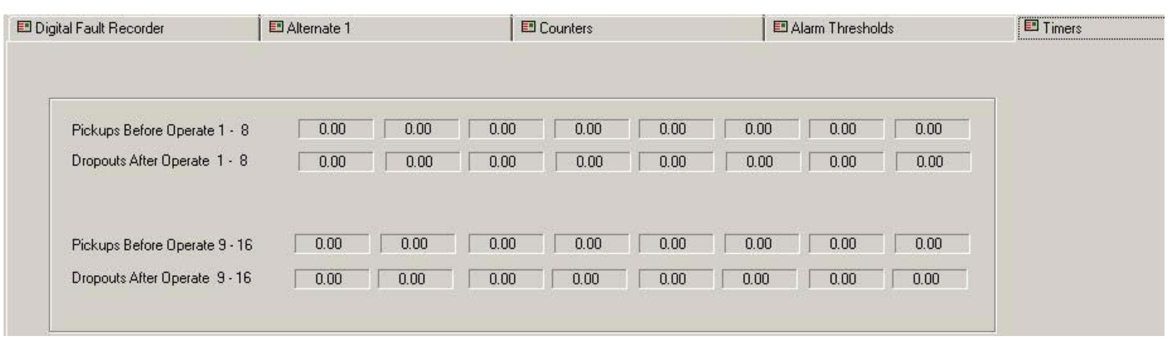


Figure 4-20 Timers settings screen

DNP3.0 Level 2+ Parameters

For communications cards with DNP3.0 Level 2+ protocol, this settings tab is available and provides the ability to program point mappings, analog deadbands, report-by-exception operation and more is available in this settings tab. See the Automation

Breaker Fail

This is where all settings for the independent Breaker Failure Function are done. This feature is available in addition to the embedded breaker failure function described in the System Configuration section. This feature is a stand-alone Breaker Failure relay where external devices may operate the breaker. See Figure 4-21 and the Protective Functions section for more details.

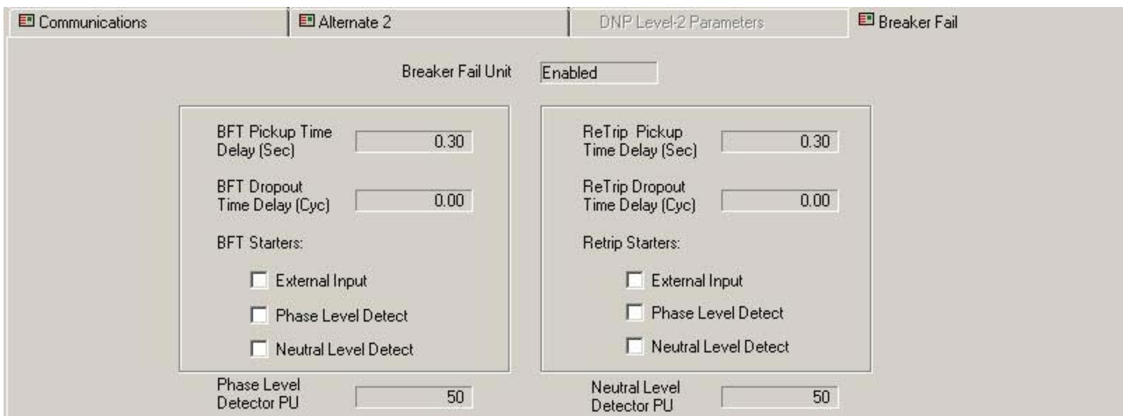


Figure 4-21 Breaker Fail settings screen

Global Register Mapping

This settings tab is available when the Modbus Plus communication cards are installed. For details on these settings, see the Automation & Control section.

User Definable Registers

This feature allows special formatting of data for compliance with unique SCADA systems. See the Automation & Control section for details and these settings.

Miscellaneous Settings

Under the Miscellaneous Settings Menu, see Figure 4-22, you will find the following:

Communications Configurable Settings-	For use with Modbus/Modbus Plus^{TM} Communications. Contact Factory for details.
Security Mask for Writable 4xxxx Control-	For use with Modbus/Modbus Plus^{TM} Communications. Contact Factory for details.
User Display Message-	For use with the User Display Input (UDI) control point. The user can type a 4 line message here. When the Control Point UDI is asserted, this message will be displayed on the OCI LCD alternating with the default display metering information. See Figure 4-27 for an example User Display message.

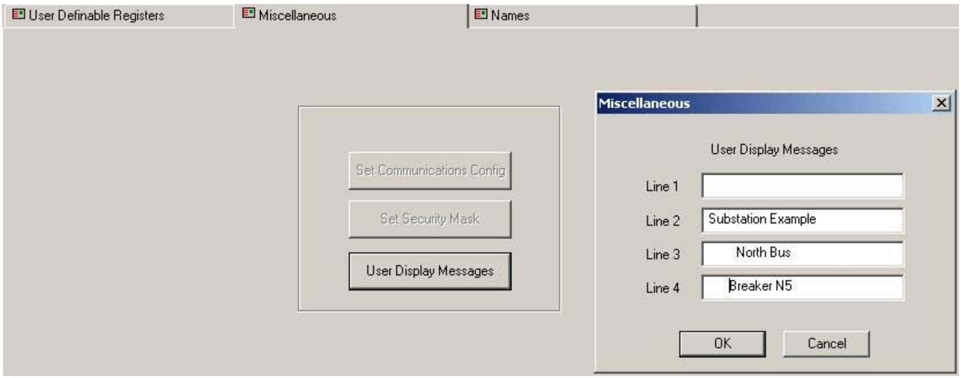


Figure 4-22 Example User Display message.

NAMES

Using the settings folder NAMES, physical and logical components can be assigned tag names that would then appear in the component menu tree located to the left of the equation window. Figure 4-23 shows the components available for naming. Each name may contain up to eight alphanumeric characters as shown in Figure 4-24 for the Physical Inputs.

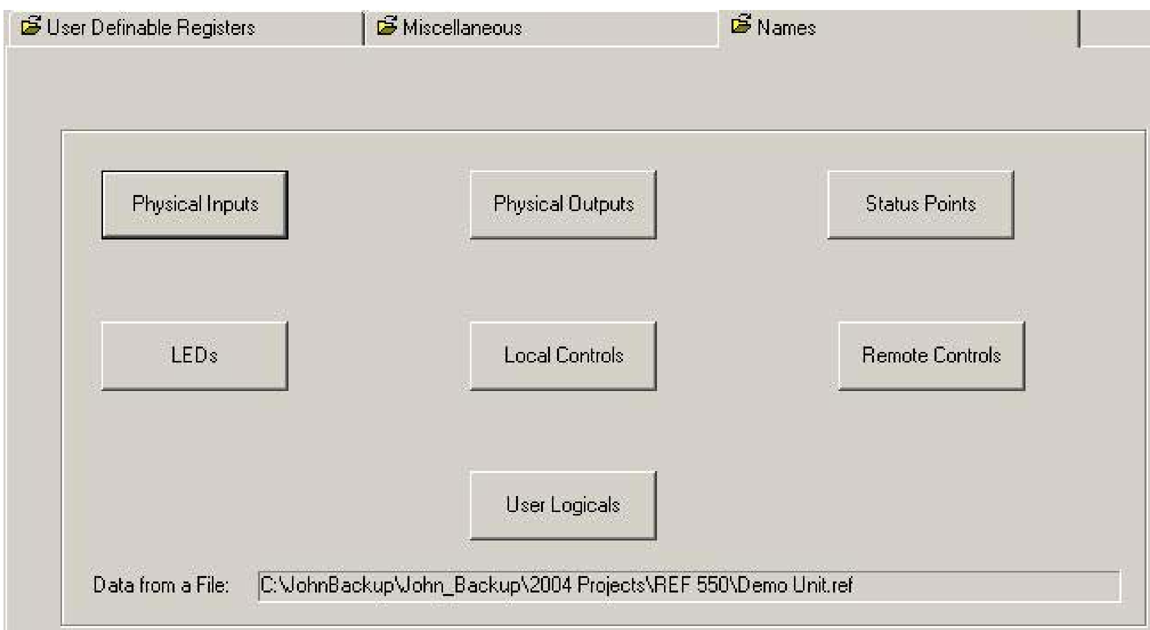


Figure 4-23 Settings folder for naming equation components

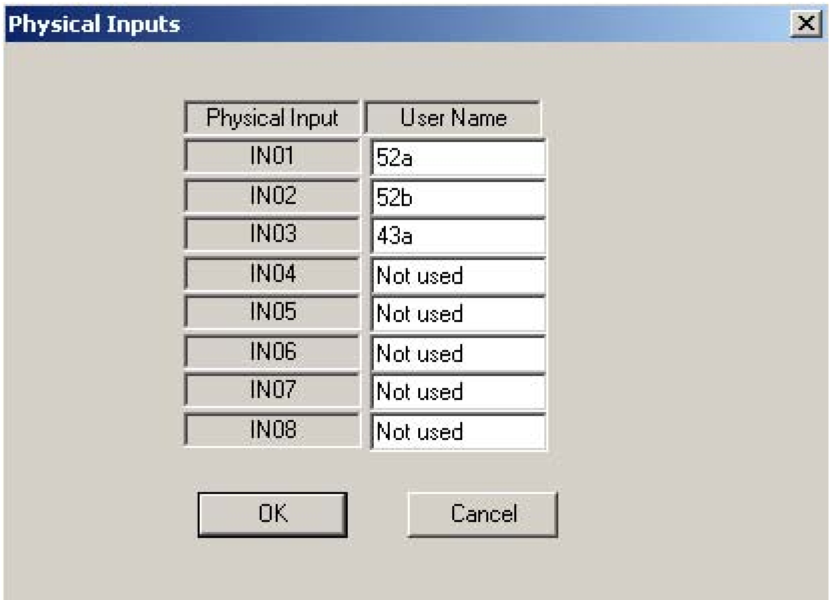


Figure 4-24 Example naming for Physical Inputs

Clock

In WinECP, the user can change the relay date and time to the date and time of the PC. Figure 4-25 shows the Clock settings screen in WinECP.

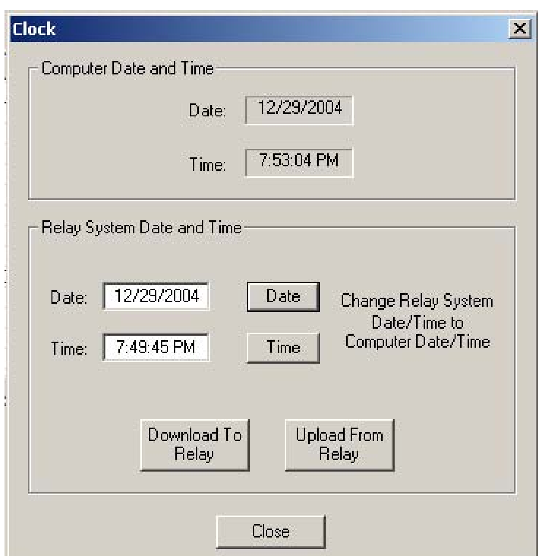


Figure 4-25 WinECP Clock settings screen.

From the MMI, the user can change the relay date and time to the desired setting.

CONTROL

The Control menu provides testing functionality for the relay as shown in Figure 4-26.

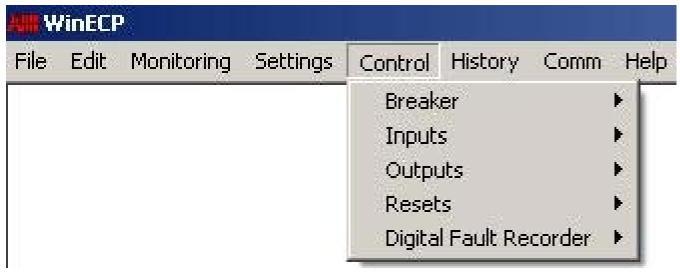


Figure 4-26 WinECP Control menu

NOTE: You must be connected (online) to a relay in order to conduct testing of the relay through the Control Menu.

NOTE: When a CLOSE command is issued to the REF 550 with the breaker status in a "Circuit Breaker Status Indeterminate" state (that is the 52A and 52B contacts inputs read the same value), the REF 550 will hold the command in memory. This CLOSE command will be executed if the status of the 52A/52B contact inputs become determinate and indicates a "Breaker Open" State. The CLOSE command will not be executed if the status of the 52A/52B contact inputs become determinate and indicates a "Breaker Close" state, or if the REF 550 is reset, or if control power to the REF 550 is cycled.

HISTORY

Use the History Menu to view Fault and Operations Records currently stored in the relay. (Figure 4-27) From this screen, you can select and perform the following functions:

1. Upload from Relay
2. Save File
3. Read File
4. Print

Select All/Remove All

You can choose to Select All History records if you wish to perform any of the above functions on all tab sheets.

From the History tabbed sheet, click the Select All button. Note that a checkmark is placed in each Tab Select box. This indicates which data records you wish to manipulate.

To clear all the Tab Select boxes from the History tab sheet, click Remove All. Note that all Tab Select boxes are cleared and you can now select individual records by clicking once on the Tab Select box next to the specific record you wish to use.

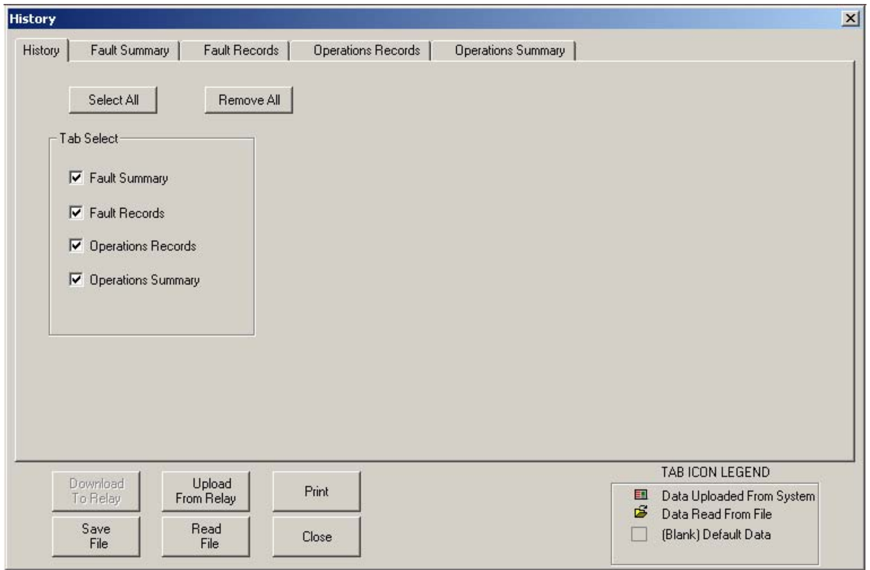


Figure 4-27 WinECP History screen

Upload from Relay

To Upload history data from the relay (must be online), click the Select All button from the History tab sheet or select only the Tab Select boxes of the history records you wish to upload from the relay.

Click Upload from Relay.

Save File

To Save history data to a file on your hard drive after you have Uploaded the data from the relay, click the Select All button from the History tab sheet or select only the Tab Select boxes of the history records you wish to save to a file.

Click Save File. When the Save As dialog window appears, select a name for the file and the location where the file is to be saved and click Save.

Read File

To Read history data from an existing file on your hard drive, (online or offline), click the Select All button from the History tab sheet or select only the Tab Select boxes of the history records you wish to read in from a file.

Click Read File. When the Select Relay File window appears, select the relay file you wish to read in and click Open.

Print

To Print history data, click Select All from the History tab sheet or select only the Tab Select boxes of the history records you wish to print.

Click Print and follow the instructions in the Print dialog window to select your printer, number of copies, etc.

View Individual History Records Sheets

1. Click History on the menu bar.
2. When the History screen appears, click the Fault Summary tab sheet. Note that the Fault Summary sheet now opens. You can now choose to Upload, Save File, Read File, Print or Close (History window) directly from this sheet.

NOTE: Remember that if you choose to Upload, Save, Read or Print directly from a History tab sheet which you are currently viewing, only that tabbed sheet will be affected.

COMM

Dependent upon your current connection to the relay, you can change the type of connection from the Comm Menu. If you are Offline, you can change to either a Direct or Remote Access connection with a relay.

NOTE: When you select to change to either a Direct or Remote Access connection , you will be prompted to save your current settings (see Figure 4-33). Click Yes to save your current settings to a file on your hard drive, or click No to establish a new connection without saving your current settings. Click Cancel if you wish to cancel establishing a new connection.

From the Comm Menu, you can also select to change Comm Port settings, set the Unit Address and open the Terminal application.

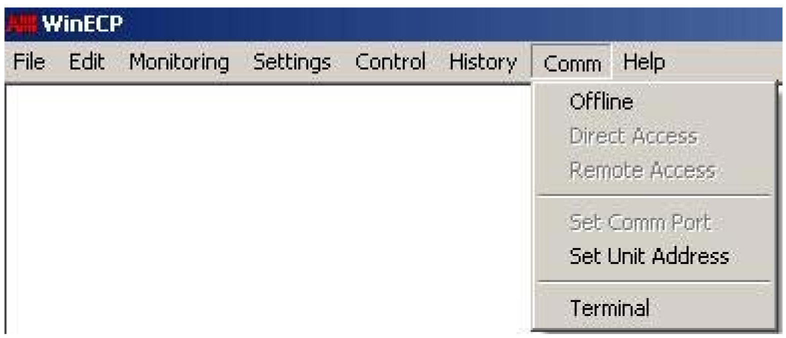


Figure 4-28 WinECP Communications menu

HELP

From the Help Menu item, you can access the Help Topics (currently under development), About WinECP which provides the Version number, License Agreement, Copyright information, and Unit Information (online only).

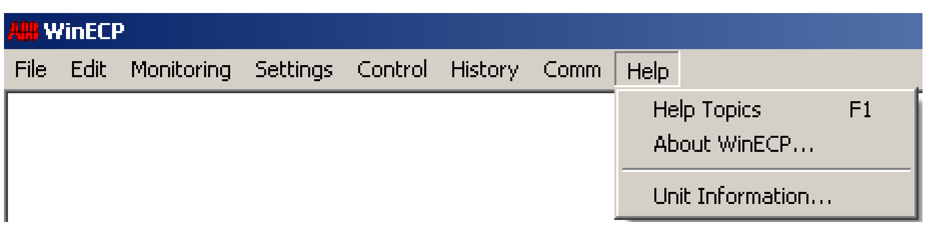


Figure 4-29 WinECP Help menu

Help Topics

For a brief description of the WinECP application, follow these steps:

1. From the menu bar, click Help.
2. Highlight and click Help Topics.
3. Double-click on the "What is WinECP" topic to expand and then double-click on WinECP for a brief description of the application.

About WinECP

About WinECP contains License Agreement information, Copyright information and Version Number. To view the About WinECP information, follow these steps:

1. From the menu bar, click Help.
2. Highlight and click About WinECP.
3. To close the About WinECP window, click OK.

Unit Information

The following unit information is available, during an online session, through the Help Menu item:

- Product ID
- Catalog Number
- CPU Software Version
- DSP Software Version
- Front Panel Software Version
- Rear Comm Software Version
- Serial Number

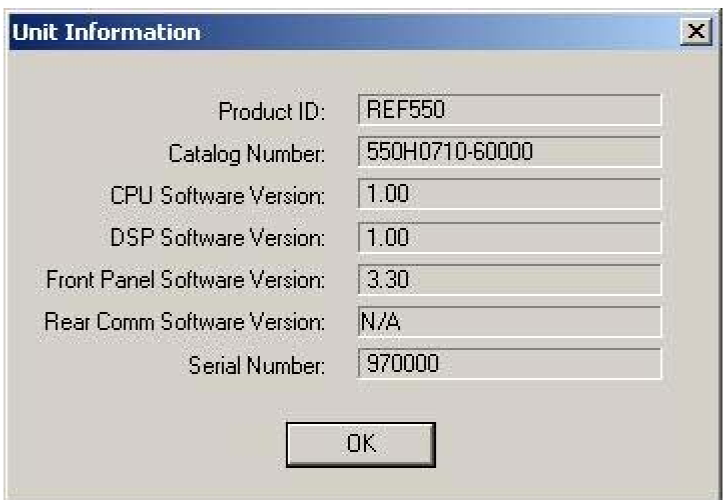


Figure 4-30 WinECP Unit Information window

NOTE: Unit Information is only accessible during an online session with the relay.

To access Unit Information (during an online session), follow these steps:

1. From the menu bar, click Help.
2. Highlight and click Unit Information.
3. To close the Unit Information window, click OK.

NOTE: Having the unit information of the REF 550 available when communicating with ABB Customer Support with regards to application and repair questions is recommended.

Status Bar

The Status Bar appears at the bottom of the main WinECP window. It contains the following information regarding the current connection status to the relay:

• Help
Press F1 to show the embedded Help menu for WinECP. The help menu is a useful tutorial on how to use WinECP.

• Operating Mode
The present operating mode is shown as either Offline or Online depending on the mode selected when WinECP was started. NOTE: When a saved session is browsed into WinECP during an Offline session and that saved session had been Online, this Operating Mode status will be that of the saved session or Online.

• Catalog Number (Cat #)
The unit Catalog Number will be displayed for both Offline and Online operating modes.

• Serial Number (S/N)
The serial number of the unit connected will be displayed. This field will contain dashed lines when a new Offline session has been started and no previously saved session file has been browsed into WinECP.

• Unit Number (#)
This field displays the specific Unit Address of the unit entered in the direct or remote access communications window. This field will contain dashed lines for Offline sessions.

• Firmware Version (CPU)
This field displays the CPU firmware version resident of the online relay unit, the offline relay saved in a previous session or the firmware version selected in the offline Advanced button of Create Catalog Number.

Prolonged Storage of Relay

To preserve the life of the internal battery when the relay is not in service, turn off the clock by entering a “0” for the day.

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Advanced Programmable Logic

The REF 550 incorporates advanced programmable logic for control and status applications utilizing the convenient and familiar Boolean equation format. The advanced logic equations comprise of inputs combined with logic operators such as "AND and "OR" that drive outputs. The inputs and outputs are subdivided into logical groups. The programmable logic is processed by the REF 550 as shown in Figure 5-1. Notice that several logic groups may serve as both an input and output in the logic equation such as Control Points, LED's, Physical Outputs, Timer Inputs and User Logicals. This flexibility will serve well in developing efficient complex combinational logic.

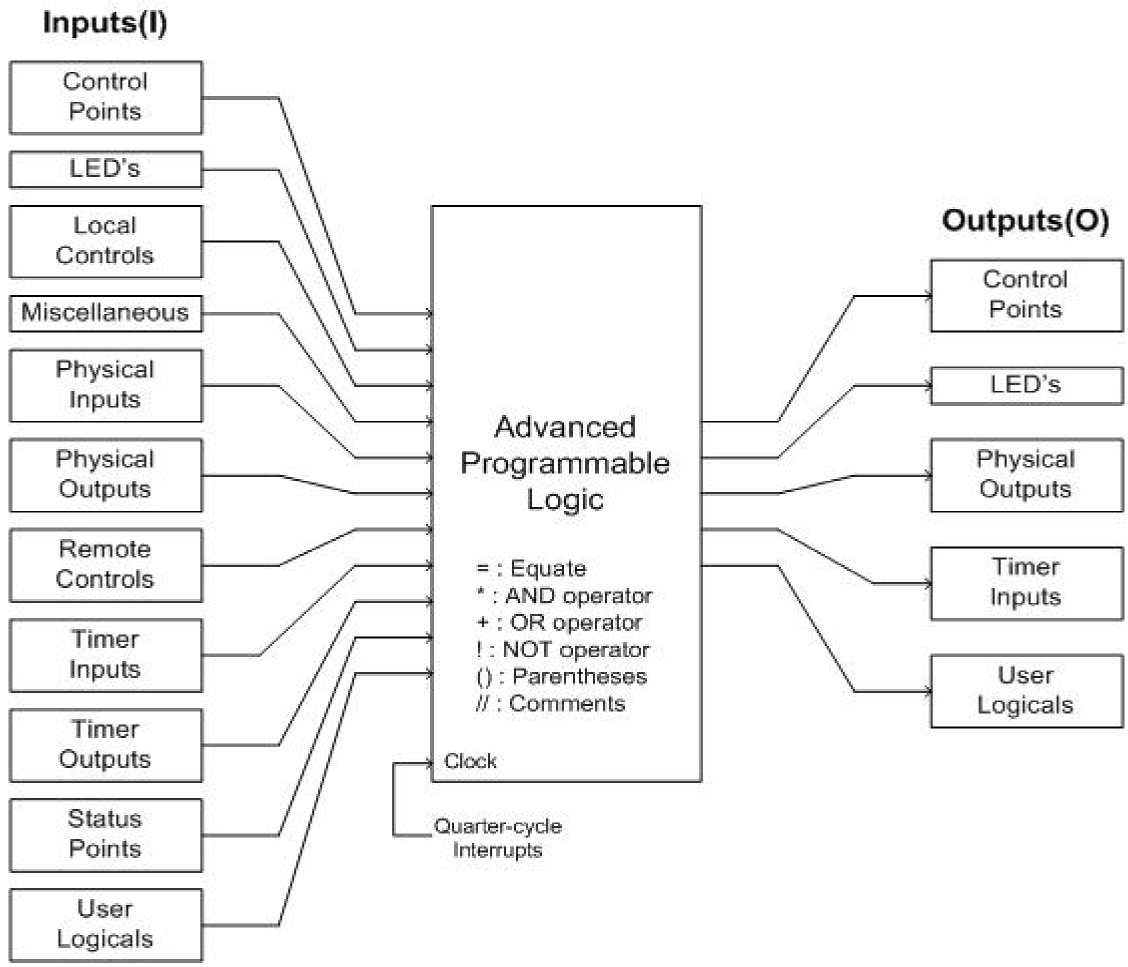


Figure 5-1 REF 550 Advanced Programmable Logic Function Block

The example programmable logic equation or program statement shown in Figure 5-2 demonstrates the use of the function block components and proper syntax required in the REF 550 Advanced Programmable Logic. Each program statement must follow this format though all components need not be used such as inputs, parentheses and comments.

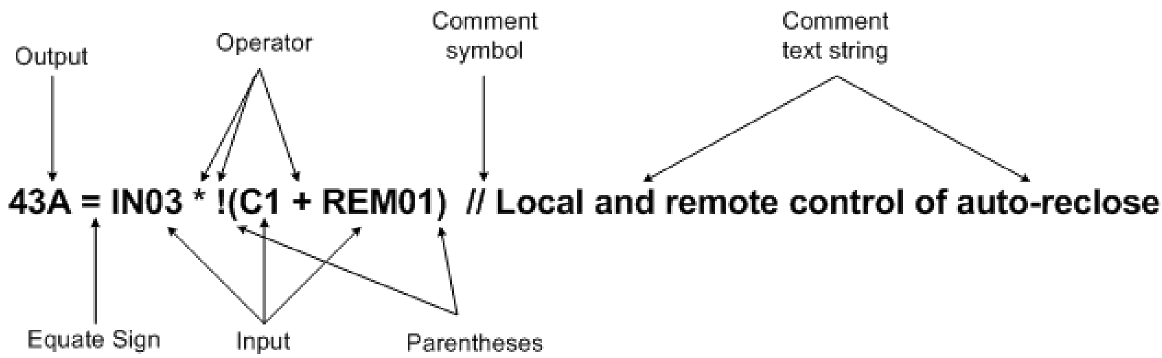


Figure 5-2 REF 550 Advanced Programmable Logic equation structure

The REF 550 program statement is executed in the following order. The order is similar to a math equation where "NOT's" are equivalent to exponents and "AND's" and "OR's" are equivalent to Add and Subtract:

1. Parentheses in order from inside to outside
2. NOT symbols
3. "AND's" and "OR's" in order from left to right

The program statement components – Inputs and Outputs, Equate Signs, Operators, Parentheses and Comments – in the REF 550 Advanced Programmable Logic are defined below in detail with all the available input and output logic components identified and defined in Table 5-1.

Inputs(I) and Outputs(O)

Control Points (IO)

The Control Points are those logical points available for torque controlling a protective function and feature and initiate action such as switching setting groups, recording data, setting and resetting latches and shifting registers.

Default Logical Value
Each control point has a logical value of "0" or disabled when not mapped in the Advanced Programmable Logic. The following points are an exception to the default value rule having a logical value of "1" when not mapped:

46-1TC(Insc>1) – Torque control of 1st negative sequence overcurrent element,
46-2TC(Insc>2) – Torque control of 2nd negative sequence overcurrent element,
50-1TC(I>>1) – Torque control of first set of phase and ground overcurrent elements,
50-2TC(I>>2) – Torque control of second set of phase and ground overcurrent elements,
50-3TC(I>>3) – Torque control of third set of phase and ground overcurrent elements,
GRDTC(IN) – Torque control of 51N(IN>), 50N-1(IN>>1) and 50N-2(IN>>2) elements,
HIFTC – Torque control of HIF Detect™ feature,
PH3TC(3I) – Torque control of 51P(3I>), 50P-1(3I>>1) and 50P-2(3I>>2) elements,
TCM(TCS) – Trip circuit monitor feature
SEFTC(I0>) – Torque control of sensitive earth fault element 50N-2(IN>>2)
ZSCTC – Torque control of Zone Sequence Coordination feature
Note: Though the default logical value of these special control points is "1", each protective function or

feature must be separately enabled in its specific settings tab location.

Programming the Master Trip Output

The Advanced Programmable Logic allows for programming the Master Trip output contact to operate when its logic value is true using the Control Point OPEN in addition to the Master Trip programmable settings - see Master Trip in Section 4. Figure 5-3 shows an example of operating the Master Trip output during a load shedding operation. This flexibility frees a physical output and reduces costs in wiring.

```

OPEN = 81S-1 // Operate Master Trip output for load shedding.

```

Figure 5-3 Master Trip programming example

Table 5-1 includes the identification, description and default mapping of all the Control Points available for programming. Figure 5-5 shows those Control Points that are mapped as default settings.

LED's (IO)

Each of the 22 programmable LED's is available as a resultant in defining the equation that will light the LED when its logical value is true. For more details on the programmable LED's, refer to Section 3.

Naming the LED's

Each of the 22 programmable LED's may have a name assigned using eight alpha-numeric characters as shown in Figure 5-7. To program the LED names, click on the WinECP settings tab NAMES and then LEDs. The programmed name will appear in the Advanced Programmable Logic menu tree to the right of the specific LED.

Application Example 5-1

The illumination of LED's for each auto-reclose status of "Enabled" or "Disabled" using the auto-reclose disabled **Status Point** 79DA is shown in Figure 5-4.

```

LED10 = 79DA // Lights LED when auto-reclose function is disabled.
LED11 = !79DA // Lights LED when auto-reclose function is enabled.

```

Figure 5-4 Programmable logic for Application Example 5-1

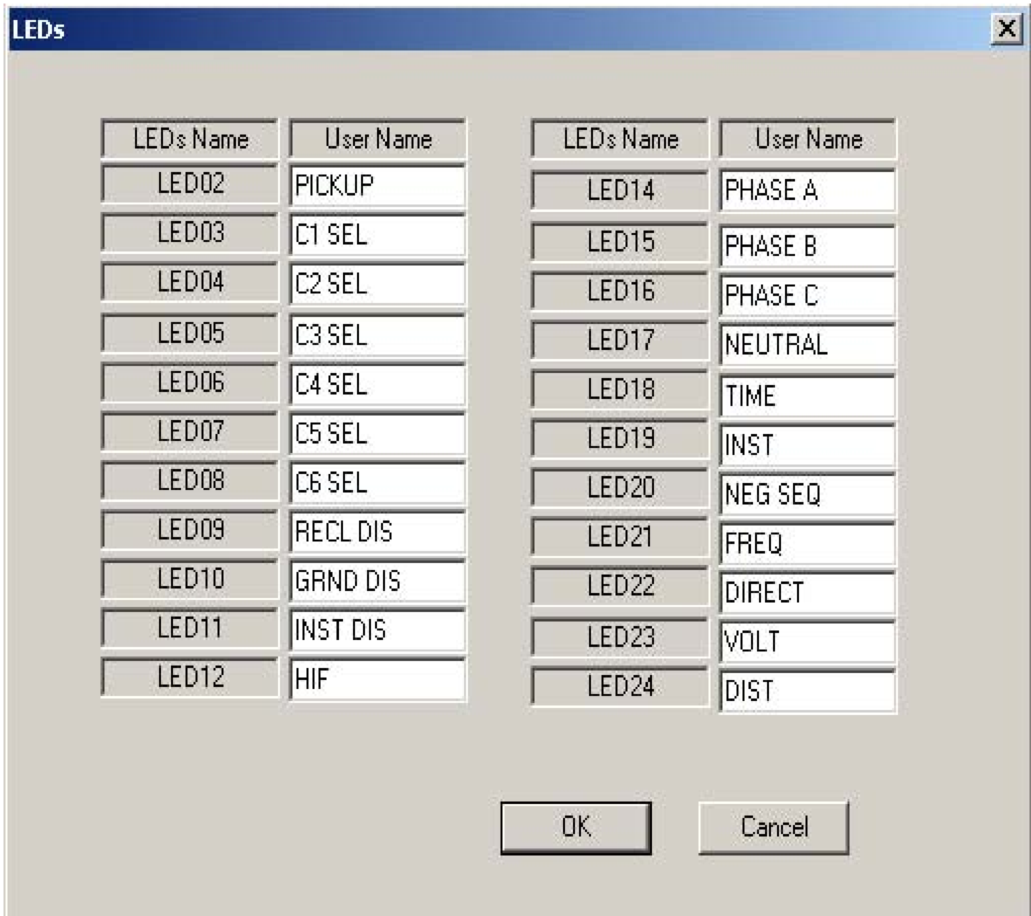


Figure 5-5 WinECP settings window for naming the 22 programmable LED's

Table 5-1 includes the identification, description and default mapping of all the programmable LED's available for programming. Figure 5-5 shows the default programmable logic for all 22 programmable LED's.

Local Controls(I)

The REF 550 supports 16 Local Control points for local control of a protective function or feature or data acquisition. These local points are only accessible locally from the Operator Control Interface (OCI) front panel LCD menu system and are not accessible via WinECP or SCADA protocol commands. These dedicated logicals may be applied to improve the security and safety of control operations such as auto-reclose and switching of settings groups.

Naming the Local Controls

Each of the 16 programmable Local Controls may have a name assigned using eight alpha-numeric characters as shown in Figure 5-6. To program the Local Control names, click on the WinECP settings tab NAMES and then Local Controls. The programmed name will appear in the Advanced Programmable Logic menu tree to the right of the specific Local Control.

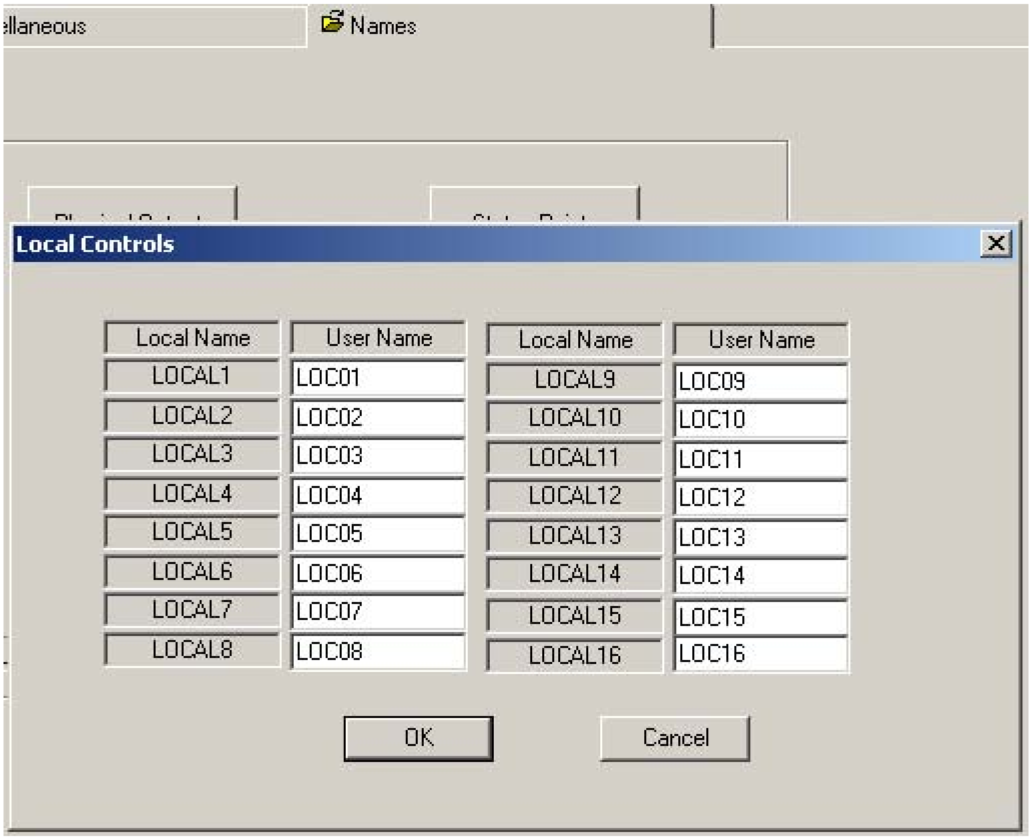


Figure 5-6 WinECP settings window for naming Local Controls

Table 5-1 includes the identification, description and default mapping of all the Local Control points available for programming. **There are no Local Control points mapped in the REF 550 Advanced Programmable Logic default settings.**

Miscellaneous(I)

Two inputs, TRUE and FALSE, are available for debugging purposes as well as defining a permanent logic for specific outputs.

Table 5-1 includes the identification, description and default mapping of all the Miscellaneous inputs available for programming. **There are no Miscellaneous inputs mapped in the default settings of the REF 550 Advanced Programmable Logic.**

Application Example 5-2

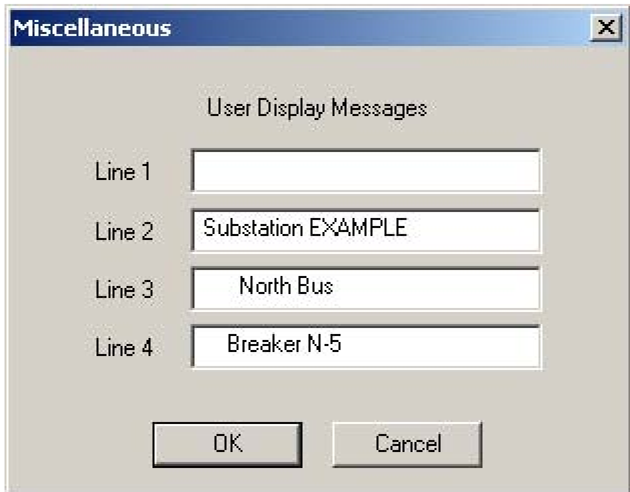
The programmable logic in Figure 5-7a affixes a permanent logical value of “1” or “True” for the User Display screen of the OCI LCD. The User Display message programmed in Figure 5-7b will be displayed on the OCI LCD alternating with the default metering display information.

```

UDI = TRUE // Activate User Display permanently.

```

a)



b)

Figure 5-7 Program Statement logic for Application 5-2

Application Example 5-3

In applications where the auto-reclose function will never be activated, its control logic can be programmed permanently to a disabled state using the miscellaneous component FALSE as shown in Figure 5-8.

```

43A = FALSE // Auto-reclose disabled permanently.

```

Figure 5-8 Programmable logic for Application Example 5-3

Physical Inputs(I)

There are eight programmable inputs, IN01 to IN08, consecutively, in the standard I/O configuration of the REF 550 system. Six of the inputs are single-ended inputs having a single “+” screw terminal and using a common “-” screw terminal. This efficient design eliminates half the wiring normally required with double-ended inputs for control schemes involving only the application of a voltage. The two double-ended inputs, IN07 and IN08, are useful for circuit monitoring where the detection of current flow indicates a healthy circuit. With two such inputs both trip and close circuit monitoring can be monitored. In cases where the breaker contains two trip coils, both can be monitored.

Naming the Physical Inputs

Each of the eight programmable Physical Inputs may have a name assigned using eight alpha-numeric characters as shown in Figure 5-8a. To program the Physical Input names, click on the WinECP settings tab NAMES and then Physical Inputs. The programmed name will appear in the Advanced Programmable Logic menu tree to the right of the specific Physical Input.

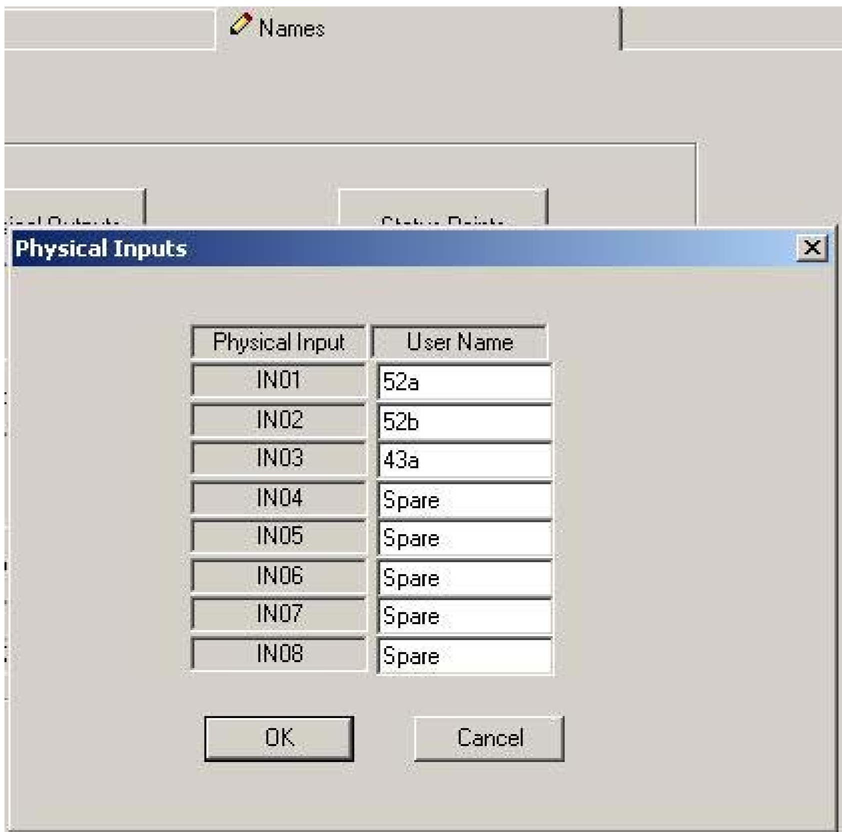
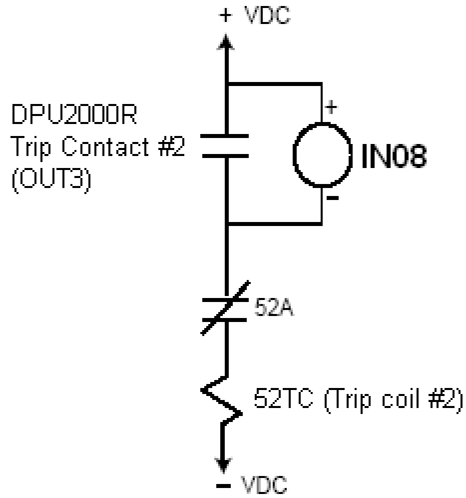


Figure 5-8a WinECP settings window for naming Physical Inputs

The physical input ratings are listed in Section 11 of this manual. Table 5-1 includes the identification, description and default mapping of all the Control Points available for programming. Figure 5-5 shows those physical inputs that are mapped in the default settings of the Advanced Programmable Logic.

Application Example 5-4

Trip circuit monitoring of a second trip circuit of the same breaker or another breaker may be programmed using the physical input wiring and programming shown in Figure 5-9.



a)

```
UL06 = IN02 + !IN08 // Trip circuit monitor #2 using 52b(IN02) and IN08
```

b)

Figure 5-9. Application Example 5-4: a) physical input wiring; b) programming logic

Physical Outputs (IO)

The flexibility of the REF 550 Advanced Programmable Logic allows for the use of the physical output logicals as both outputs to energize the specific output(s) and inputs to energize, control or activate other logic. There are a total of six double-ended physical outputs available for programming in the Advanced Programmable Logic of the REF 550 – OUT01 to OUT06, consecutively. These output contacts are dry contacts, i.e., there are no internal voltages connected to the output terminals. This affords flexibility in application where, for example, different voltage sources are used for various control circuits such as Trip and Close.

All six output contacts are configured for normally open operation, i.e., they are open when not energized and closed when energized via a user command or their programming logic is true. Two physical outputs, OUT1 and OUT2, can be reconfigured for normally closed operation. This is accomplished by de-energizing the REF 550, removing the inner chassis, locating the appropriate Jumper Selector Plug(JSP) and changing its position from N.O. to N.C. as labeled on the printed circuit board(PCB) silkscreen. The jumper plugs for each output are assigned as follows:

OUT1 (Terminals 27, 28): **J14 - J15 for N.C.; J15 - J16 for N.O.**
OUT2 (Terminal 25, 26): **J17 - J18 for N.C.; J18 - J19 for N.O.**

Naming the Physical Outputs

Each of the six programmable physical outputs may have a name assigned using eight alpha-numeric characters as shown in Figure 5-10. To program the Physical Output names, click on the WinECP settings tab NAMES and then Physical Outputs. The programmed name will appear in the Advanced Programmable Logic menu tree to the right of the specific Physical Output.

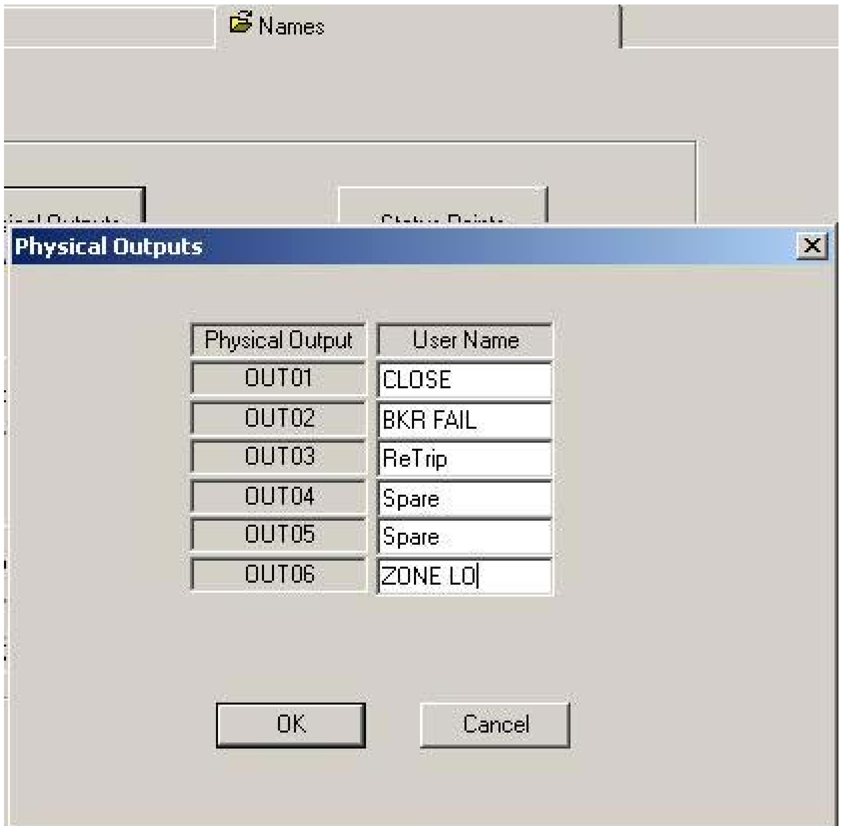


Figure 5-10 WinECP settings window for naming the six Physical Outputs

The physical output ratings are listed in Section 11 of this manual. Table 5-1 includes the identification, description and default mapping of all the physical outputs available for programming. **There are no physical outputs mapped in the Advanced Programmable Logic default settings.**

Remote Controls(I)

The REF 550 supports 16 Remote Control points for remote control of a protective function or feature or data acquisition. Similar to the Local Control points, these remote points have restricted access. They are only accessible through a communications port using WinECP or SCADA protocol commands. These dedicated logicals may be applied to improve the security and safety of control operations such as auto-reclose and switching of settings groups.

Naming the Remote Controls
Each of the 16 programmable Remote Controls may have a name assigned using eight alpha-numeric characters as shown in Figure 5-11. To program the Remote Control names, click on the WinECP settings tab NAMES and then Remote Controls. The programmed name will appear in the Advanced Programmable Logic menu tree to the right of the specific Remote Control.

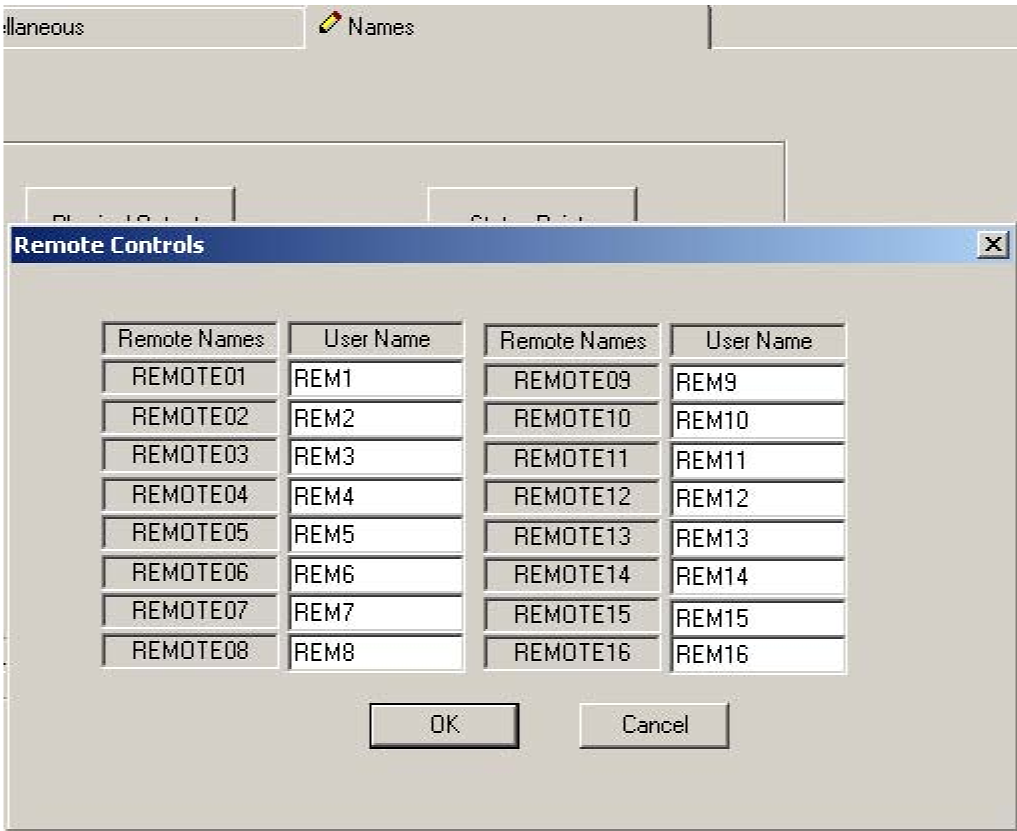


Figure 5-11 WinECP programming window for naming Remote Controls

Table 5-1 includes the identification, description and default mapping of all the Remote Control points available for programming. **There are no Remote Control points mapped in the REF 550 Advanced Programmable Logic default settings.**

Status Points(I)

Over 200 Status Points are available for programming in the Advanced Programmable Logic of the REF 550. These points represent the operation of a protective function or feature within the REF 550. They may be applied in many different manners such as energizing a physical output, starting a timer, torque controlling a protective function or feature and triggering the capture of fault and waveform data.

Figure 5-12 shows an example of using Status Points to operate a physical output.

```
38
39    OPEN = 27-1 + 47 + 59-1 + 59G + 81S-1 //Energize Master Trip on V/f
40
```

Figure 5-12 Program logic to energize Master Trip operation on voltage or frequency operation

Dynamic and Seal-in Alarm Points

For the points related to protective functions such as 51P for phase time overcurrent trip, there are two types of points available for mapping: a dynamic logical point and seal-in alarm logical point. The former point remains asserted as long as the function output remains operated and resets automatically when the function output resets. The seal-in alarm points will also assert when its function output operates, but will remain asserted or sealed-in after the function output has reset. The seal-in alarm status is saved in non-volatile memory and therefore must be reset manually – see *Resetting Seal-in Alarm Points*. A seal-in alarm logical point is identified by a lower-case "s" suffix appended to the same named dynamic logical point.

Resetting Seal-in Alarm Points

Since the status of a seal-in alarm is stored in non-volatile memory and will remain asserted once set, it must be reset manually. There are four methods available to reset seal-in alarm points:

Target Reset pushbutton – located on the front panel of the Operator Control Interface(OCI). See Section 3.
Reset Sealin Alarms LCD command – located in the OCI LCD's Hot Keys menu. See Section 4.
Reset Sealin Alarms via communications – performed using WinECP or SCADA protocol command. See Section 4.
Reset Seal-in Alarms via the control point "SIA". See Section 5.

Naming the Status Points

The six programmable OCI pushbuttons C1 to C6 have the same named status points that may have a name assigned using eight alpha-numeric characters as shown in Figure 5-13. To program the Status Point names, click on the WinECP settings tab NAMES and then Status Points. The programmed name will appear in the Advanced Programmable Logic menu tree to the right of the specific Status Point.

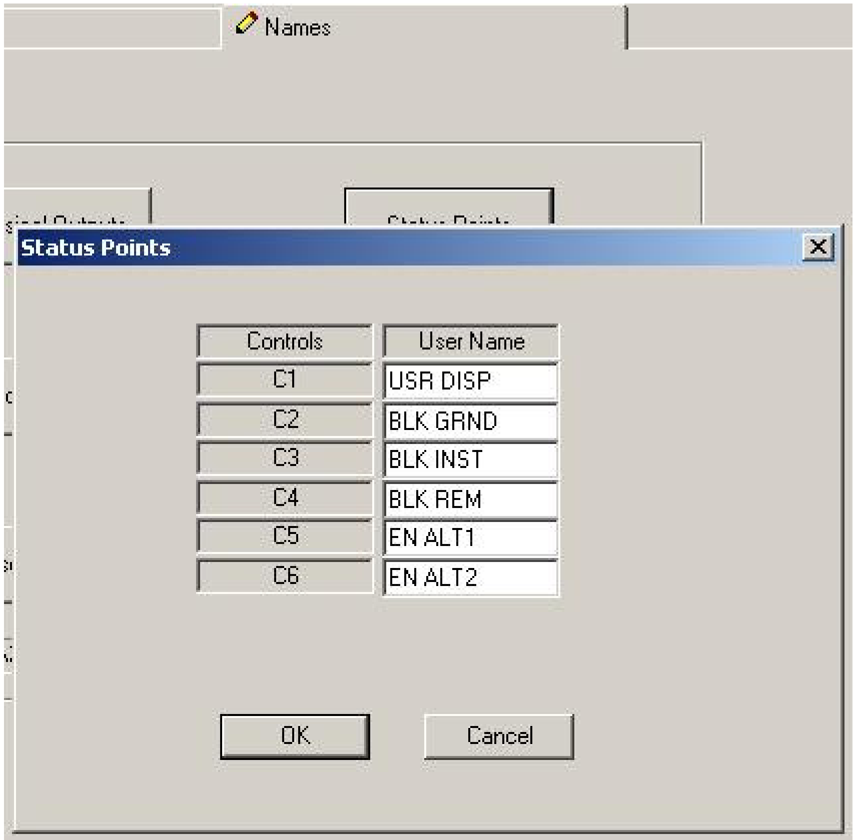


Figure 5-13 WinECP programming window for naming Status Points

Table 5-1 includes the identification, description and default mapping of all the Status Points available for programming. Figure 5-24 shows those Status Points that are mapped as default settings.

Timer Inputs(IO) and Timer Outputs(I)

There are 16 independent timers available for application in the REF 550 Advanced Programmable Logic. Each timer has pickup-before-operate, t_{PU}, and dropout-after-operate, t_{DO}, timers that each has a settings range of 0 to 250 seconds in 0.01 seconds steps. There are two logic components associated with each timer: a Timer Input and Timer Output. Figure 5-14 illustrates the function block of each timer and the Timer Input and Timer Output nomenclature.

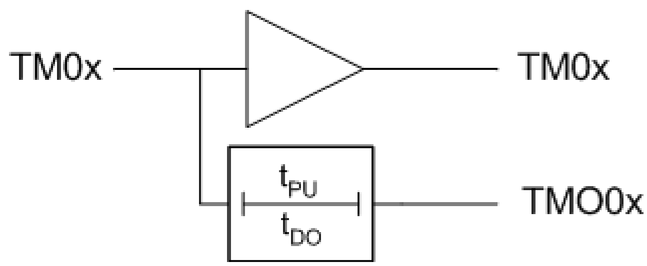


Figure 5-14 Timer Function Block where x = 1 to 16

When the Timer Input is true, then the timer will start. Should that state remain unchanged for the pickup time setting, t_{PU}, then the Timer Output will be asserted. Should the logic status become false any time prior to the expiration of the pickup time setting, then the Timer logic output will not assert and the timer will start from zero the next time the Timer Input becomes true.

The Timer Inputs may be applied as both Inputs and Outputs in a statement equation. The Timer Output may only be applied as an Input in a statement equation.

Figure 5-15 demonstrates the activation of Timer #3 through the status of a physical input and remote control point.

```
TM03 = IN04 * REM05 // Timer #3 starts with voltage on IN04 AND
// a Remote Bit #5 has been set by SCADA.
```

Figure 5-15 Example programming logic for Timer input

Application Example 5-5

The flexibility of applying the timer input logic as an operand in addition to as a resultant allows minimization of the programming equation. If, for example in Figure 5-16, it is desired to start Timer #1 when Timer #3 has started, the ability to use the Timer #3 input as an operand eliminates the effort required to type the logic equation for Timer #3 resultant, reducing the programming time and the equation length.

```
TM01 = IN04 * TM03 * TMO04 // Timer #1 starts with voltage on IN04 AND
// Timer #3 has started timing AND Timer #4 has timed out.
```

Figure 5-16 Programming logic for Application Example 5-5

Table 5-1 includes the identification, description and default mapping of all the Timer logicals available for programming. **There are no timers mapped in the default settings of the REF 550 Advanced Programmable Logic.**

User Logicals (IO)

There are 16 User Logicals (UL's) numbered UL01 to UL16, consecutively. Each UL may serve as both an Input and Output in a statement equation. This flexibility allows multiple programming applications to be designed of unique status indication, control functions and activation of other equations' programming logic. The UL's can be programmed with the Boolean logic and when the logic is true, the UL will assert within one machine cycle.

The logic diagram in Figure 5-17 demonstrates the functional logic of the REF 550 User Logicals and their availability as both an Input and Output for programming logic.

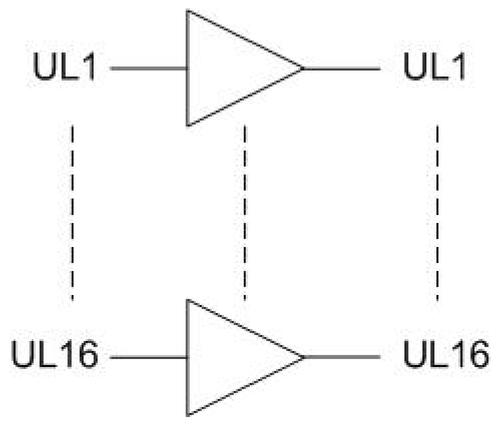


Figure 5-17 REF 550 User Logicals logic diagram

Naming the User Logicals

Each of the 16 programmable User Logicals may have a name assigned using eight alpha-numeric characters as shown in Figure 5-18. To program the User Logical names, click on the WinECP settings tab NAMES and then User Logicals. The programmed name will appear in the Advanced Programmable Logic menu tree to the right of the specific User Logical.

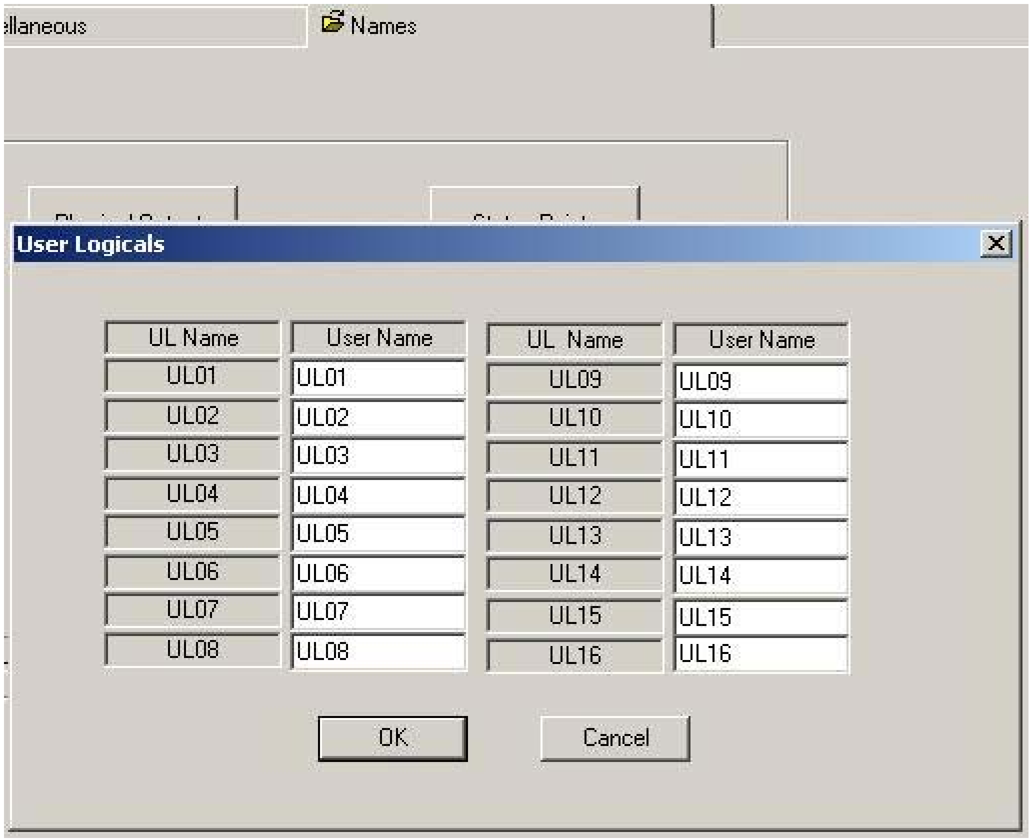


Figure 5-18 WinECP settings window for naming User Logicals

Application Example 5-6

Programmable logic to initiate a signal when a unique combination of two physical input states exists is shown in Figure 19. This eliminates programming this logic, or similar logic, in a Programmable Logic Controller (PLC), Remote Terminal Unit (RTU) or the SCADA master equipment.

Figure 5-19. Logic for Application Example 5-6

Table 5-1 includes the identification, description and default mapping of all the User Logicals available for programming. **There are no User Logicals programmed in the default settings of the REF 550.**

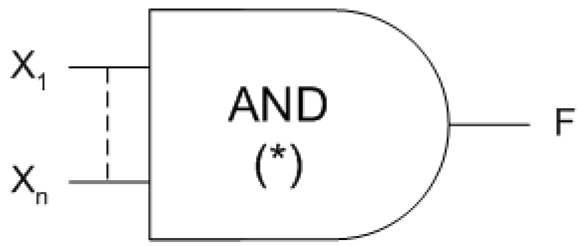
Equate Signs

"="

The REF 550 Advanced Programmable Logic supports the equal sign for all program statement equations. The equal sign must be positioned immediately after a resultant, spaces are allowed, or else a failure will result when the equation is compiled or downloaded to the REF 550.

Operators

AND (*)



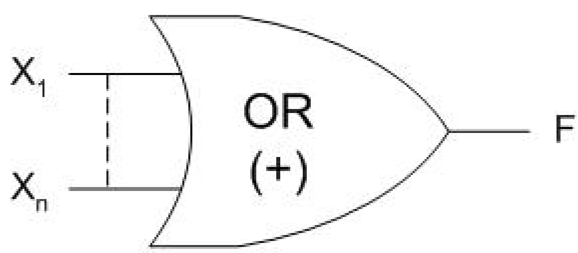
a)

Row #	X_1	- - - -	X_n	F	
1	0	0	0	0	
2	0	0	1	0	All Zeroes
¦	¦	¦	¦	¦	
2^n	1	1	1	1	

b)

Figure 5-20 AND operator Logic Diagram and Truth Table for n $\geq$ 2

OR (+)



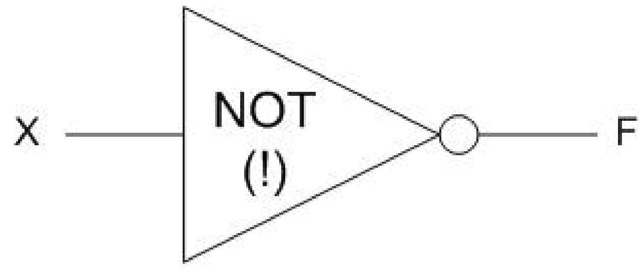
a)

Row #	X_1	- - - -	X_n	F	
1	0	0	0	0	
2	0	0	1	1	
¦	¦	¦	¦	¦	All Ones
2^n	1	1	1	1	

b)

Figure 5-21 OR operator Logic Diagram and Truth Table for n $\geq$ 2

NOT(!)



X	F
0	1
1	0

Figure 5-22 NOT operator Logic Diagram and Truth Table

Parentheses

Parentheses are available for ordering the programmable logic into the required segments for easy viewing or creating complex combinational logic equations such as Minimum Sum of Products(MSOP) and Minimum Product of Sums(MPOS). See ***Using Parentheses*** below in this section for more details.

Comments

Comments may be added to Advanced Programmable Logic equations using double forward slashes “//”. The pair of slashes may be placed at the end of an equation statement or at the beginning of an entire line. All characters written to the right of the paired slashes will be ignored by the Advanced Programmable Logic compiler. When using an entire line for comments, the slashes must be placed in the leftmost position in the program statement line. See ***Adding Comments*** below in this section for more details.

WinECP Graphical User Interface

The Advanced Programmable Logic is programmed through the user tool WinECP. The convenient EZ Use™ feature of WinECP is available for this programmable logic. Direct typing of the programmable logic is also provided. The graphical user interface for the programmable logic is shown in Figure 5-23.

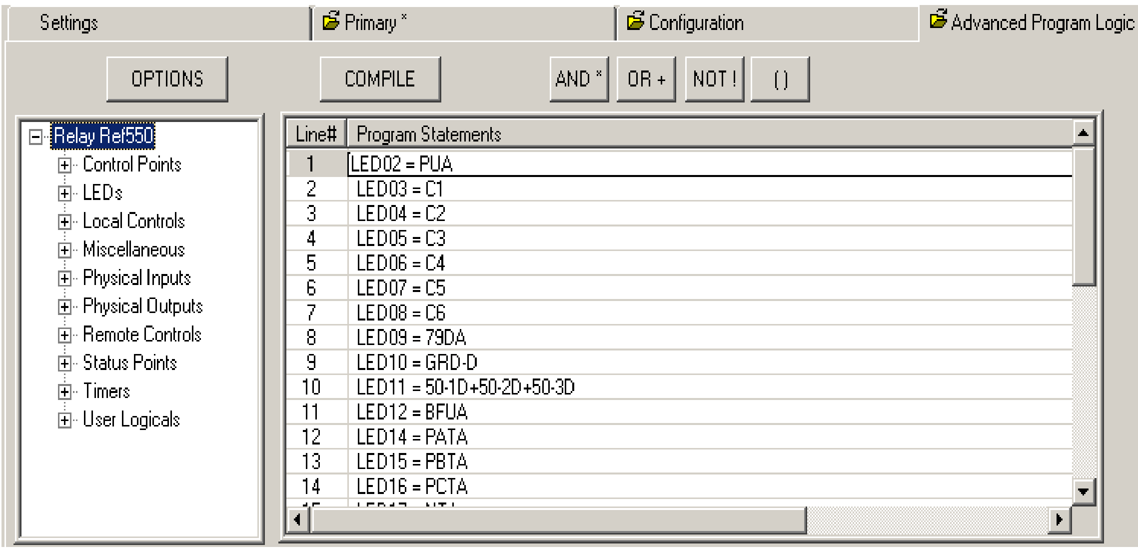


Figure 5-23 Advanced Programmable Logic user interface in WinECP

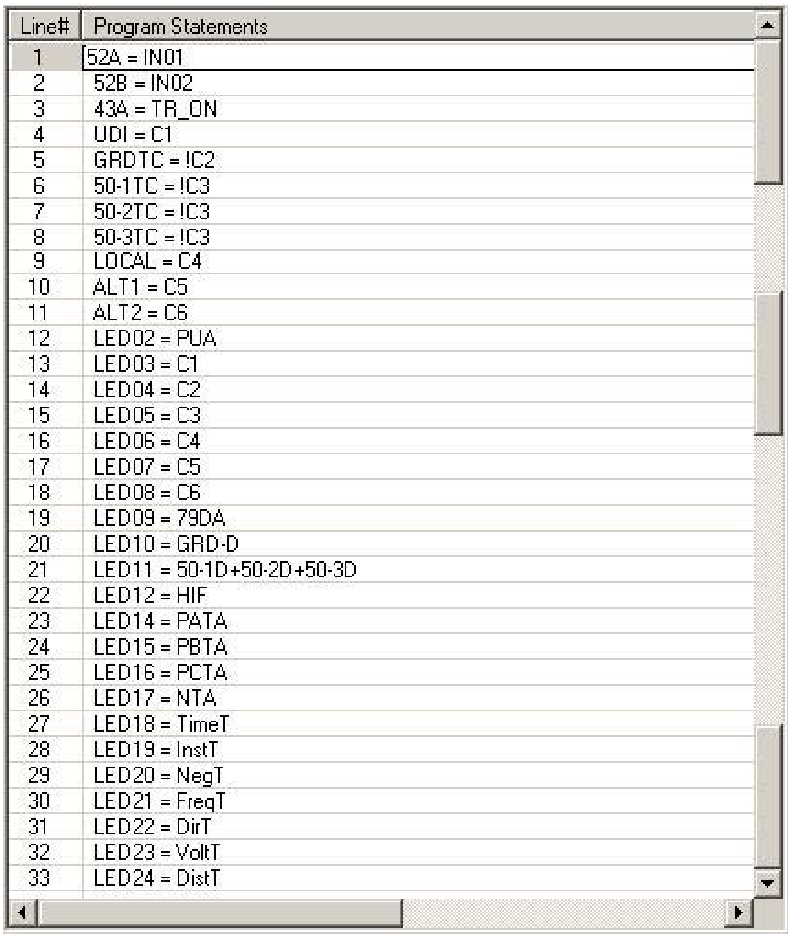
The programmable logic equations displayed will be either a) default settings such as in an offline session or a newly received REF 550 unit, b) file settings in an offline or online session or c) REF 550 settings in an online session.

Default Advanced Programmable Logic Settings

Figure 5-24 shows the Advanced Programmable Logic default settings for the REF 550.

Line#	Program Statements
1	52A = IN01
2	52B = IN02
3	43A = !C1
4	GRDTC = !C2
5	50-1TC = !C3
6	50-2TC = !C3
7	50-3TC = !C3
8	LOCAL = C4
9	ALT1 = C5
10	ALT2 = C6
11	LED02 = PUA
12	LED03 = C1
13	LED04 = C2
14	LED05 = C3
15	LED06 = C4
16	LED07 = C5
17	LED08 = C6
18	LED09 = 79DA
19	LED10 = GRD-D
20	LED11 = 50-1D+50-2D+50-3D
21	LED12 = HIF
22	LED14 = PATA
23	LED15 = PBTA
24	LED16 = PCTA
25	LED17 = NTA
26	LED18 = TimeT
27	LED19 = InstT
28	LED20 = NegT
29	LED21 = FreqT
30	LED22 = DirT
31	LED23 = VoltT
32	LED24 = DistT

a) without HLT option



Line#	Program Statements
1	52A = IN01
2	52B = IN02
3	43A = TR_ON
4	UDI = C1
5	GRDTC = !C2
6	50-1TC = !C3
7	50-2TC = !C3
8	50-3TC = !C3
9	LOCAL = C4
10	ALT1 = C5
11	ALT2 = C6
12	LED02 = PUA
13	LED03 = C1
14	LED04 = C2
15	LED05 = C3
16	LED06 = C4
17	LED07 = C5
18	LED08 = C6
19	LED09 = 79DA
20	LED10 = GRD-D
21	LED11 = 50-1D+50-2D+50-3D
22	LED12 = HIF
23	LED14 = PATA
24	LED15 = PBTA
25	LED16 = PCTA
26	LED17 = NTA
27	LED18 = TimeT
28	LED19 = InstT
29	LED20 = NegT
30	LED21 = FreqT
31	LED22 = DirT
32	LED23 = VoltT
33	LED24 = DistT

b) with HLT option

Figure 5-24 REF 550 Advanced Programmable Logic default settings

With the exception of the Operators and Parentheses defined earlier in this section, details on working the remaining areas of the Advanced Programmable Logic screen follow.

Inserting a new program statement line

Building a new programmable logic equation is achieved quickly and reliably using the convenient EZ Use™ feature available in WinECP. Two types of equations can be added:

- A blank equation
- A copy of an existing equation

Figure 5-25 shows the placement options available from the pop-up menu.

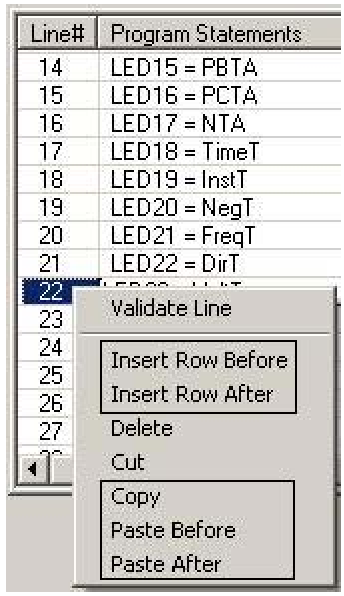


Figure 5-25 Pop-up menu for adding an equation

To add a blank equation, follow these simple steps:

1) Locate the line position in the program window where the new equation is to be added,
2) Place the cursor on the line number so that a hand symbol appears,
3) Right-click the mouse, and
4) Choose the desired placement selection from the pop-up menu to insert the new equation before or after the line selected.

Adding a new equation at the end of all the equations is accomplished by placing the mouse cursor on the line number of the last equation, right-clicking the mouse and selecting **Insert Row After** from the pop-up menu.

To add a copy of an existing equation, follow these simple steps:

1) Locate the line position in the program window of the existing equation,
2) Point the cursor on the line number so that a hand symbol appears,
3) Right-click the mouse and select **Copy** from the pop-up menu,
4) Point the cursor on the line number where the copied equation is to be placed,
5) Right-click the mouse, and
6) Choose the desired placement selection from the pop-up menu of pasting the copied equation before or after the line selected.

The copied equation can then be modified further as required. See ***Editing an Equation*** in this section for details on that pop-up menu. Note that right-clicking on the equation portion of the line instead of the line number will result in the wrong pop-up edit menu being displayed.

Creating an equation

Once the new equation line has been added, building the equation is accomplished through the selection of component groups available in the menu tree located to the left of the equations and shown in Figure 5-26.

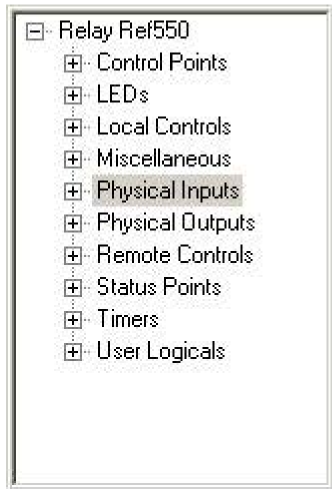


Figure 5-26 Advanced Programmable Logic menu tree

Using the EZ Use™ method, the equation may be formed by selecting the desired components in the following order:

1) Point the cursor to the target resultant group,
2) Double-click the group to expand the view of specific outputs,
3) Double-click the specific desired resultant,
4) Point cursor to the target operand group,
5) Double-click group to expand the view of specific inputs,
6) Double-click specific operand.
7) If applicable, point to and double-click target operator from list of operators located above equation window,
8) Point to and double-click target operand group and double-click specific operand,
9) Repeat steps 7 and 8 until equation is complete.

Note that where the resultant is driven by only a single operand, an operator is not required. Where an operator is used in the equation, it must be followed by an operand. An equation must not end with an operator or an error will result when the settings are compiled or downloaded to the REF 550.

The specific logic available for each of the Resultant, Equate Sign, Operator and Operand component groups identified are described in detail later in this section.

With a studied knowledge of the REF 550 logic names and equation syntax, the logic equations can also be created through direct typing by simply clicking the mouse cursor in the program statement area to the right of the line number. Move the cursor to the desired position and begin typing the equation.

Editing an equation

Editing a programmable logic equation is performed quickly, easily and reliably using both WinECP Point ‘N Click and direct typing methods. Two methods of editing program statement equations are available:

- Edit the entire equation
- Edit components within the equation

Edit the entire equation
To edit the entire equation, point the cursor to the equation line number so that the hand symbol appears and right-click the mouse. The options available when editing an entire equation are shown in Figure 5-27.

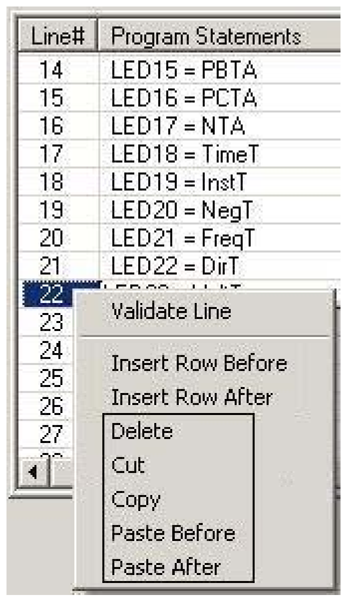


Figure 5-27 Edit options for entire logic equation

<u>Delete</u>
This menu option will remove the entire equation and renumber all the equations positioned below the deleted equation accordingly. A Delete will display an action verification window confirming if the action is actually desired. Select “Yes” to perform the action or “No” to cancel the action. **This function cannot be undone so ensure its deletion is desired.**

<u>Cut</u>
Use the Cut option from the pop-up menu to move an equation from point to another point in the window. After Cut has been selected for the particular line number, the equation line will not immediately disappear. When the cursor is pointed on a new line number, the mouse right-clicked and the desired paste option selected, the equation will move to the new line location in the window.

<u>Copy</u>
The **Copy** function will copy the entire equation for later pasting into another location within the window. This function is useful where the required equations are similar in their format and copying and pasting represents a savings in time compared to creating a new equation from scratch.

<u>Paste Before</u>
The **Paste Before** function is available in the pop-up menu for selection only after a **Cut** or **Copy** function has been selected. Selecting this option pastes the cut or copied equation line before the line number selected.

If a **Cut** or **Copy** has been selected but followed by a **Delete** selection or no **Cut** or **Copy** function has been chosen, then this option will not be selectable.

<u>Paste After</u>
The **Paste After** function is available in the pop-up menu for selection only after a **Cut** or **Copy** function has been selected. Selecting this option pastes the cut or copied equation line after the line number selected.

If a **Cut** or **Copy** has been selected but followed by a **Delete** selection or no **Cut** or **Copy** function has been chosen, then this option will not be selectable.

Edit components within the equation
Pointing the cursor over the equation to be edited and double-clicking will place the cursor inside the equation line. Once the cursor resides within the equation, direct typing can be performed to modify the equation to the desired look. Right-clicking the mouse will display an edit pop-up menu containing familiar edit tools as seen in Figure 5-28.

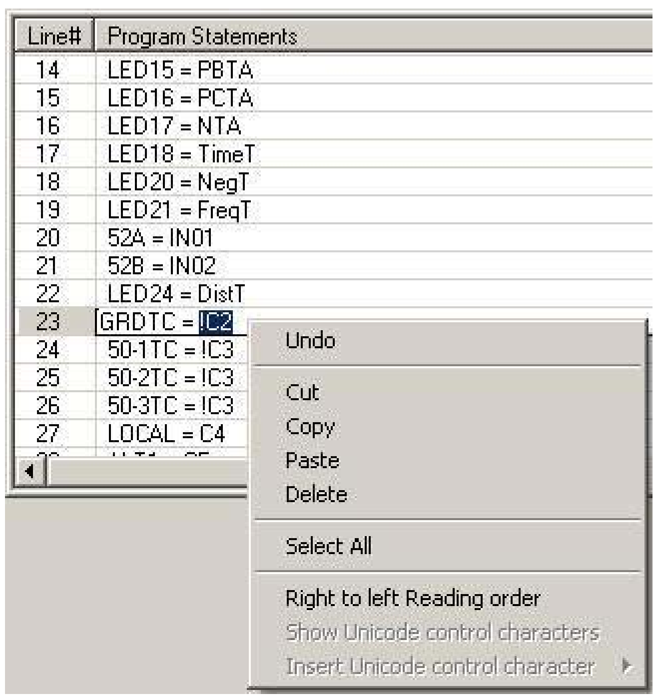


Figure 5-28 Pop-up menu for editing within the equation

<u>Undo</u>
A previous action performed such as cutting a character or string of characters in the equations can be undone by selecting this menu option. **Undo** is only available for selection after an editing function has taken place. When the pop-up menu first appears, this option is not selectable.

Cut
At least one character must be highlighted for this option to become available for selection in the menu. Selecting **Cut** will remove the highlighted characters from the equation. This action can be reversed by selecting the **Undo** command.

Copy
At least one character must be highlighted for this option to become available for selection in the menu. Selecting **Copy** will copy the highlighted section for future paste elsewhere in the equation or other equation. As this is a standard Windows edit function, the paste action may be performed in any Windows software such as Word and Excel.

Paste
After a section of the equation has been cut or copied, it can be pasted to another location within the same equation, into a new equation or any word processing software such as Microsoft Word and Excel.

This option is available for selection from the menu only after a **Cut** or **Copy** command has been selected. If a **Cut** or **Copy** has been selected but followed by a **Delete** selection or no **Cut** or **Copy** function has been chosen, then this option will not be selectable.

Delete
No second chance window. Unlike the **Delete** option in ***Adding an Equation***, this option executes the action immediately without requesting verification window for the chance to cancel the action. Fortunately, the **Undo** option can be selected to reverse if the action was performed by mistake.

Select All
An efficient selection to choose when the entire Program Statement portion of the equation line needs to be removed, but the equation is to remain intact, or copied to another equation line.

Right to left Reading order
This option provides special orientation of equation components.

With a learned knowledge of the REF 550 logic names and equation syntax, the logic equations can also be created through direct typing by simply clicking the mouse cursor in the program statement area to the right of the line number. Move the cursor to the desired position and begin typing the equation.

Using Parentheses

Parentheses are useful in implementing complex combinational logic utilizing Minimum Sum of Products(MSOP) or Minimum Product of Sums(MPOS) format and in increasing the visibility of unique expressions. While building of a new equation with the equation line number highlighted, selecting the parentheses symbol will place a pair of parentheses at the end of the equation. Any further selection of components such as inputs and operators from the menu tree or additional parentheses will be written inside the parentheses. After all the applicable components have been placed inside the parentheses, more components can be added outside the parentheses by highlighting with the mouse the equation line above or below the line being edited and then highlighting the line number that was being edited. Selection of any component will then be placed to the right of the closed parenthesis.

Where the equation editing is perform through direct typing, the pair of parentheses will be placed at the position of the cursor in the equation. In this case, those equation components already written in the equation that need to be positioned inside the parentheses will need to be cut and pasted into the desired position. The new components to be placed inside the parentheses can simply be typed in their proper order. **Direct typing is the recommended equation editing method when using parentheses.**

Parentheses must be placed to the right of the equal sign. Placing any parentheses to the left of the equal sign will result in an error message during the equation compile or download to the REF 550.

Application Example 5-7
To render a portion of the combinational logic active-low, encapsulate the portion in parentheses, see ***Using Parentheses*** in this section for details, and add the NOT logic symbol in front of the open parenthesis. Figure 5- 29 shows examples of the use of the NOT or negation logic.

38	
39	LED10 = !(TM01 + TM02) // Light LED only when both timers are not active.
40	

Figure 5-29. Programmable logic for Application Example 5-7

Adding Comments

Comments offer the ability to describe the purpose of an equation or simply represent the title of the entire advanced programmable logic. To enter comments on an equation line, place two consecutive forward slashes "//" in the equation using the direct typing method within an equation described in ***Editing an equation***. The slashes can be placed at the beginning of an equation line or at the end of an equation. When using an entire equation line, the two slashes must be the first characters in that line or an error will occur when compiling or downloading to the REF 550. All characters placed after the slash marks will be ignored by the compiler and the REF 550 logic processor. The comments will be stored in non-volatile memory along with the logic equations. **It is recommended that comments be used as much as possible; especially where equations are quite complex and the desired control action is not intuitive through inspection of the equation.**

Applications of comments include:

- Establishing a title for the entire program with description, author, date and revision indicated at the top of the window,
- Detailing the purpose of the equation
- Adding initials and new revision number from starting revision in title statement

A sample window in Figure 5-30 contains examples of these applications.

Line#	Program Statements
1	// Example Advanced Programmable Logic //
2	// Created 12/17/04 by John A. Doe //
3	// V1.0 //
4	LED02 = PUA // This LED will light for an overcurrent pickup condition.
5	LED03 = C1
6	LED04 = C2
7	LED05 = C3
8	LED06 = C4
9	LED07 = C5
10	LED08 = C6
11	LED09 = 79DA
12	LED10 = GRD-D
13	LED11 = 50-1D+50-2D+50-3D // This LED will light when any of the phase
14	// or ground instantaneous functions operates.

Figure 5-30 Example uses of comments in the Advanced Programmable Logic

Application Example 5-8
For long text strings or where there is limited viewing space for a comment next to the equation, simply add a new equation line, see ***Adding an Equation***, and dedicate it entirely to comments as shown in Figure 5-31.

38	
39	OPEN = 21P-1 + 21P-2 + 21P-3 + 27-1P + 47 + 59-1P + 59G + 81S-1 // On
40	// any non-overcurrent operation, energize the Master Trip output.
41	

Figure 5-31 Programming logic for Application Example 5-8

OPTIONS

The OPTIONS button displays available editing tools that can be activated to assist the creation of the logic equations. The options supported include the following:

- Insert Spaces

Insert Spaces
This option allows for the insertion of spaces between all items selected in the formation of the Boolean expression and comments. This makes viewing the equation in totality easier; particularly where equations are short and simple. **This checkbox is <u>not</u> selected in default settings as seen in Figure 5-32**.

Figure 5-32. Default setting for Insert Spaces option of Enhanced Programmable Logic

COMPILE

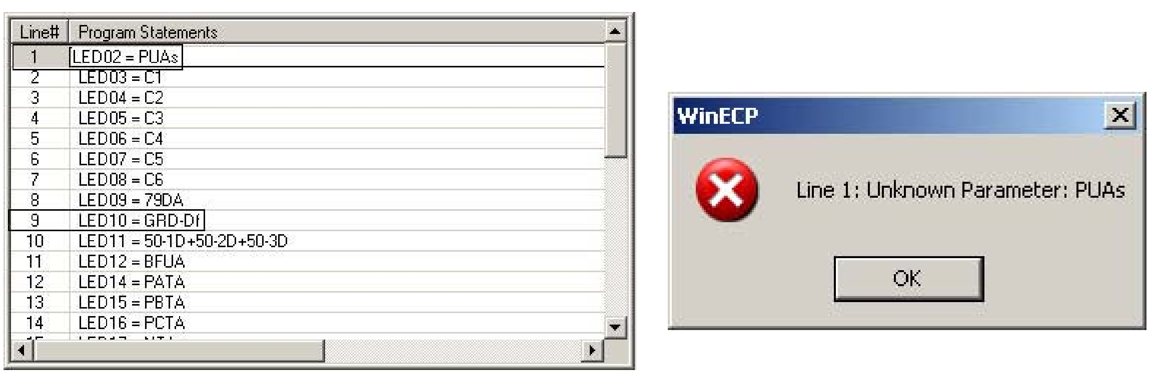
Prior to downloading the REF 550 the programmable logic, verification that the proper formatting has been applied to each Boolean expression can be performed through the selection of the COMPILE button. This proactive command button saves valuable time through immediate notification of proper equation syntax preventing a failed download message that would occur if not performed and an error existed. Selecting this button will automatically initiate a format check on all the lines that contain equations. The compilation will begin with line #1 and end with the last line that contains an equation. A message window will appear indicating whether the compilation was successful or not successful. With indication of a successful compilation such as in Figure 5-33, the programmable logic can then be downloaded to the REF 550 with no interruptions.

a) b)

Figure 5-33 Successful compile messages via a) COMPILE button and b) Validate Line

When the first compilation error is detected, a message window will appear indicating the first program line that contained a format error and a description of the error as in Figure 5-34. In cases where more than one line contains a formatting error, the failure message will indicate the next line after the previous line's formatting has been corrected.

Single equation compiling is available by placing the cursor on the equation line number, right clicking the mouse and selecting **Validate Line**. WinECP will respond with a message regarding the compilation status of only that line. This is useful where the compilation of all the program equations have not yet been performed and immediate feedback on the correct syntax for one particular complex Boolean algebraic expression is desired. Where all the other equations have compiled successfully, then it is recommended that the COMPILE button be selected after creating the additional complex equation as a full compilation requires only a few seconds.



a) b)

Figure 5-34 Failed COMPILE example: a) incorrect syntax in lines #1 and #9, b) unsuccessful compile message with line and error indication

Offline Session

The advantages of the Offline capability of WinECP have been extended to the COMPILE function. Compiling of the Enhanced Programmable Logic may be performed in an offline session insuring that the field personnel will not experience any compile errors during the download of the programmable logic portion of the settings.

Equation Limits and Memory

There are 200 Program Statement equation lines programmable in the Advanced Programmable Logic with a maximum number of components in each equation set to one equal sign, 15 operators (AND or OR), 16 NOT's and 16 inputs. The text string positioned after the comments symbol may be of any length and is only limited by the total memory of the Advanced Programmable Logic. It is recommended that the comments text string not exceed the viewing window. The equation lines fits approximately 60 characters.

There are 64K or 65,536 bytes of memory allocated for the Advanced Programmable Logic. There are 20 overhead bytes reserved for file size, binary program size, text string size and two 32 bit checksums (one checksum for file size and one checksum for diagnostics) leaving 65,516 bytes available for the logic equations and comments.

Each operator (NOT's, AND's and OR's) and the equal sign utilize eight (8) bytes. With a maximum of 200 equation lines and 32 operators per line, including the equal sign, 51200 bytes are used leaving 14,316 bytes available for input, output and comment characters. With each character taking eight bytes, there are over 1789 characters that may be programmed. These numbers are calculated using the maximum number of lines and operators per line. Using quantities less than these maximum quantities, results in more memory available for programmable logic.

Substation Automation Logic

S-R Flip Flops

The REF 550 Advanced Programmable Logic provides eight independent S-R Flip Flops for latching in momentary signals via any of the groups' logic components. Figure 5-35 shows the state transition diagram for each S-R Flip Flop. The state of each flip flop is stored in non-volatile memory and therefore will power-up to its last state.

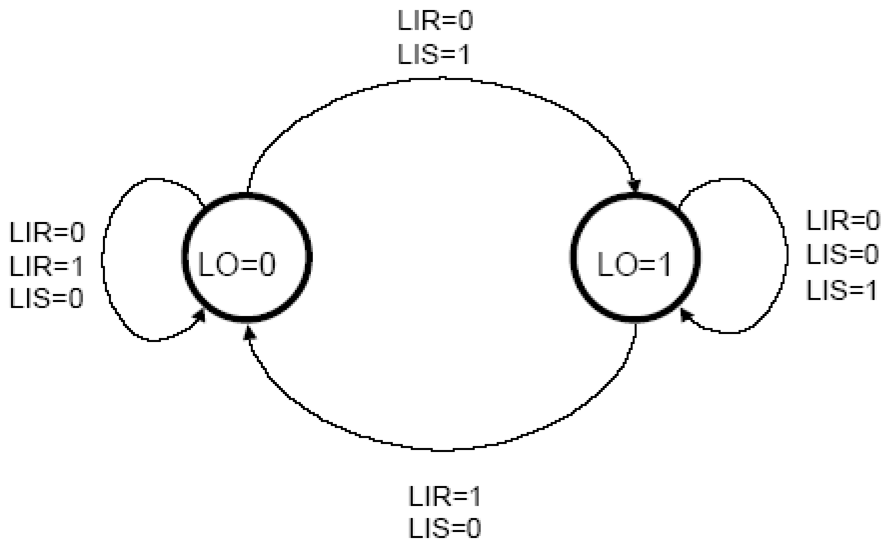


Figure 5-35 S-R Flip Flop State Transition Diagram

Hot-Line-Tag Logic (31TR Emulation)

The REF 550 includes Hot-Line-Tag (HLT) logic for 31TR emulation. This three state logic is applicable to control schemes where both auto-reclose and manual closing through the relay is desired. The three states are defined as follows:

ON: Auto-reclose and manual close through the REF 550 is allowed,
OFF: Auto-reclose is disabled, but manual close through the REF 550 is allowed,
TAG: Both auto-reclose and manual close through the REF 550 are disallowed. The Status Point Close is disabled and assigned a logical state of FALSE.

The HLT state is stored in non-volatile memory and therefore will power-up to last state. The Hot-Line-Tag (HLT) option of the REF 550 Operator Control Interface, see **Ordering Selections** in Section 12, provides for easy access to transition from one state to another state. Only one state transition will occur with one assertion of a HLT Control Point. Transitions between ON and TAG must pass through OFF. Figure 36 shows the state transition diagram for the HLT logic.

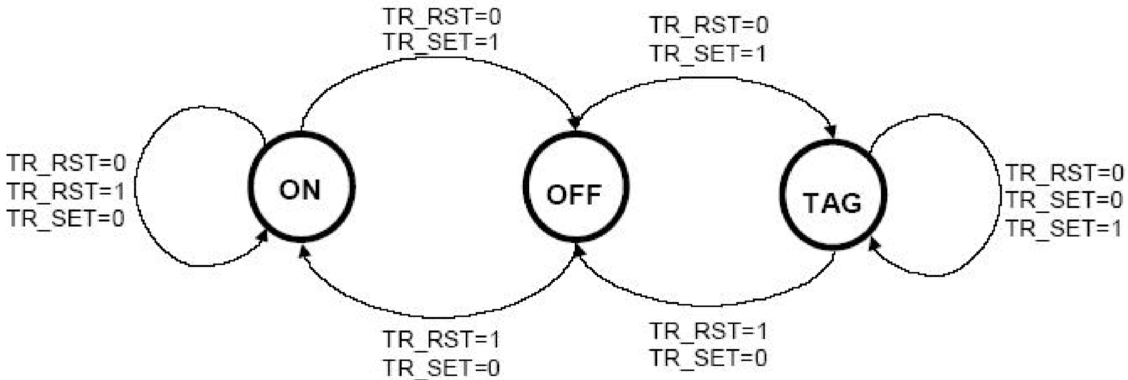


Figure 5-36 Hot-Line-Tag State Transition Diagram

Switch Settings Groups

In the REF 550, the convenience of efficiently transferring from one settings group to another group is available via the control point SWSET. The activation of this control point drives the REF 550 to switch from the present active settings group to the next enabled settings group in the order of Primary, Alternate 1 and Alternate 2. This control point is rising-edge triggered and thus requires only a pulse or momentary input to activate it. The need for external latching relays or internal latching logic mapped to maintain the control points ALT1 and ALT2 is eliminated.

The factory default position is Primary settings active. The active settings group is stored in non-volatile memory so that the cycling of control-power will not change that status. Figure 5-37 shows the functional block diagram and logic flow for SWSET.

NOTE: When enabling this control point in Configuration settings, the control points ALT1 and ALT2 will automatically be disabled regardless of their Configuration settings values or control point status. SWSET takes precedence over the control points ALT1 and ALT2.

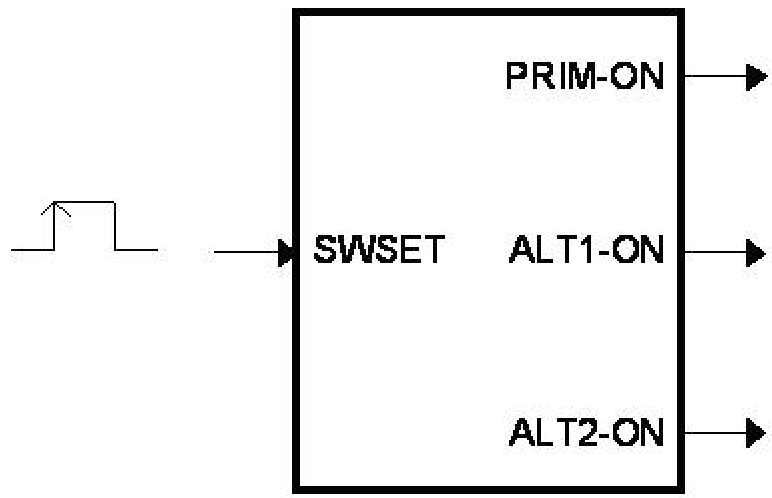
Control Points

Control	PointDescription
SWSET	The assertion of this control point causes the REF 550 to switch from its present active settings group to the next enabled settings group in the order of Primary, Alternate 1 and Alternate 2. This control point is rising-edge triggered; therefore the control signal should be momentary (pulsed). If the control signal is maintained rather than momentary type, e.g., latching relay, then use instead the alternate settings groups' dedicated control points ALT1 and ALT2. Figure 5-37 shows the function block representation and logic flow for SWSET. **NOTE**: When selecting this control point in the programmable logic, the control points ALT1 and ALT2 must be removed. SWSET takes precedence over the control points ALT1 and ALT2.

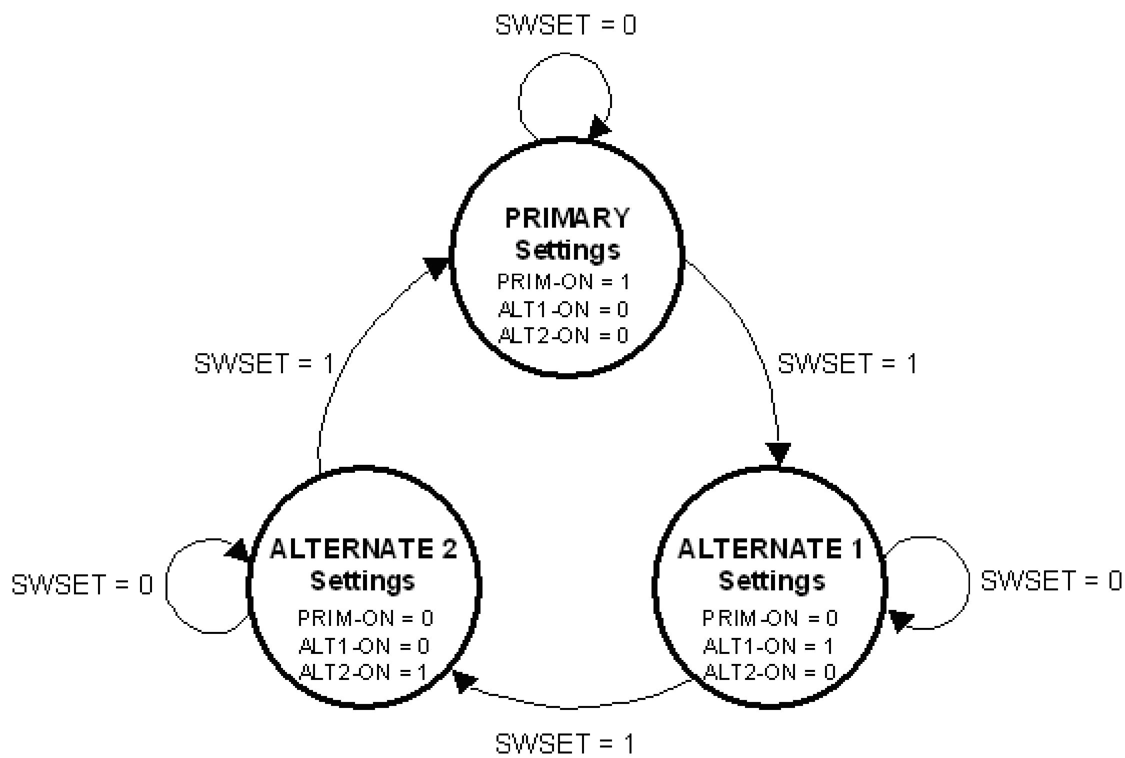
Each of the three settings groups have a dedicated status point that when asserted indicates it is the active settings group. This offers quick and reliable feedback to ensure the proper switch of settings groups has taken place.

Status Points

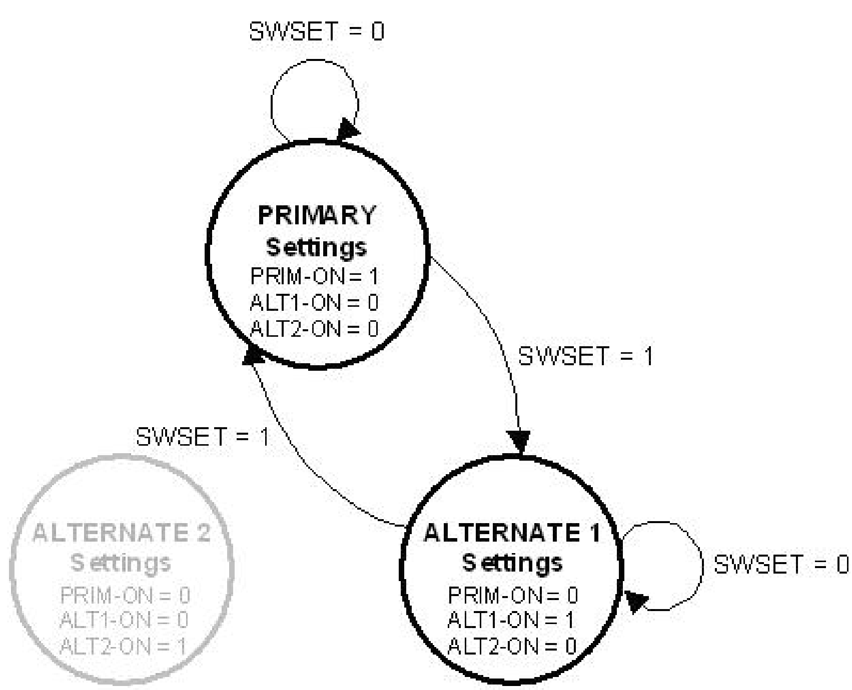
Status Points	Description
PRIM-ON	This status point asserts when Primary settings group becomes active via the assertion of control point SWSET, both control points ALT1 and ALT2 are de-asserted or both alternate settings groups are disabled in Configuration settings.
ALT1-ON	This status point asserts when Alternate 1 settings group becomes active via the assertion of the control point ALT1 or SWSET.
ALT2-ON	This status point asserts when Alternate 2 settings group becomes active via the control point ALT2 or SWSET.



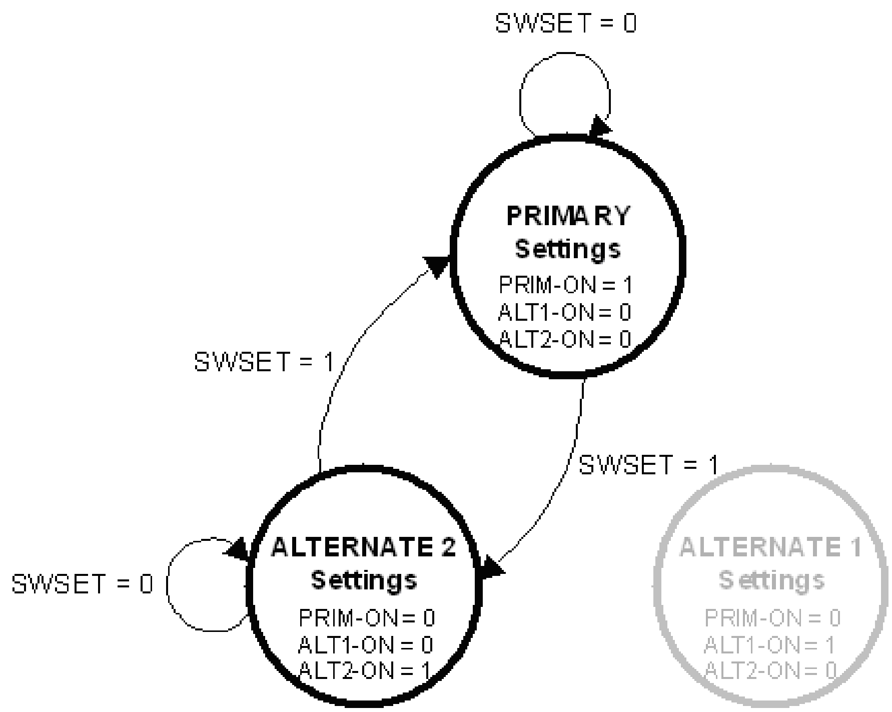
a) SWSET Functional Block



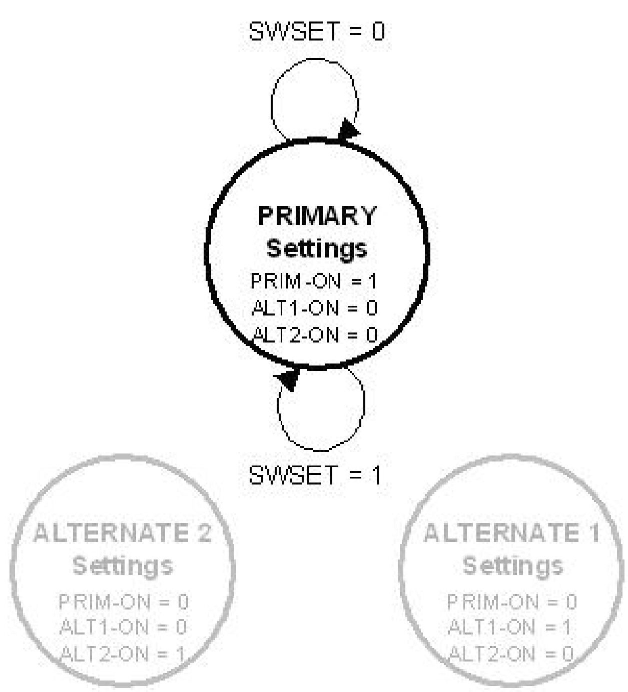
b) SWSET state transition diagram with ALT1 = Enable, ALT2 = Enable



c) SWEST state transition diagram with ALT1 = Enable, ALT2 = Disable



d) SWSET state transition diagram with ALT1 = Disable, ALT2 = Enable



e) SWSET state transition diagram with ALT1 = Disable, ALT2 = Disable

Figure 37 SWSET Function Block and State Transition Diagrams

Application Example 5-9

Using SWSET, operators can easily and confidently switch to the particular settings group for the required maintenance scheduled for that day. The following example shows how this can be accomplished in the REF 550. Figure 5-38 shows the Advanced Programmable Logic settings for this example.

Settings Groups Setup

Primary Group:	Normal feeder application.
Alternate 1 Group:	Hot-line work - reclosing is disabled and sensitive phase and ground instantaneous elements enabled.
Alternate 2 Group:	Adjacent feeder breaker maintenance – time overcurrent settings raised by a predetermined percentage.

Configuration Settings

C5 Select:	Enable
C5 Operation:	Momentary

```

SWSET = C5 // Switch settings groups with pressing of control PB C5.
LED03 = PRIM-ON // Light this LED when Primary group is enabled.
LED04 = ALT1-ON // Light this LED when Alternate 1 group is enabled.
LED05 = ALT2-ON // Light this LED when Alternate 2 group is enabled.

```

Figure 5-38 Programming logic for Application Example 5-9

Operation

When either hot-line work or breaker maintenance is required, the local operator can simply activate the desired settings group by pressing the OCI control pushbutton C5, confirming the activation through the appropriately labeled OCI LED. The remote dispatcher can also “press C5” via SCADA DNP3.0 or Modbus protocol and activate the appropriate output for the local personnel.

Barrel Shift Registers

Two Shift Registers, SHIFT_A and SHIFT_B, are available in the REF 550 Advanced Programmable Logic. Each Shift Register (Barrel Shifter) is composed of a control point and two to four status points, each representing the number of states, selectable in Configuration settings. The number of programmable states is set independently for each Shift Register with the default for each programmed to three. Figure 39 shows the location of the Shift Register settings in WinECP Configuration settings window.

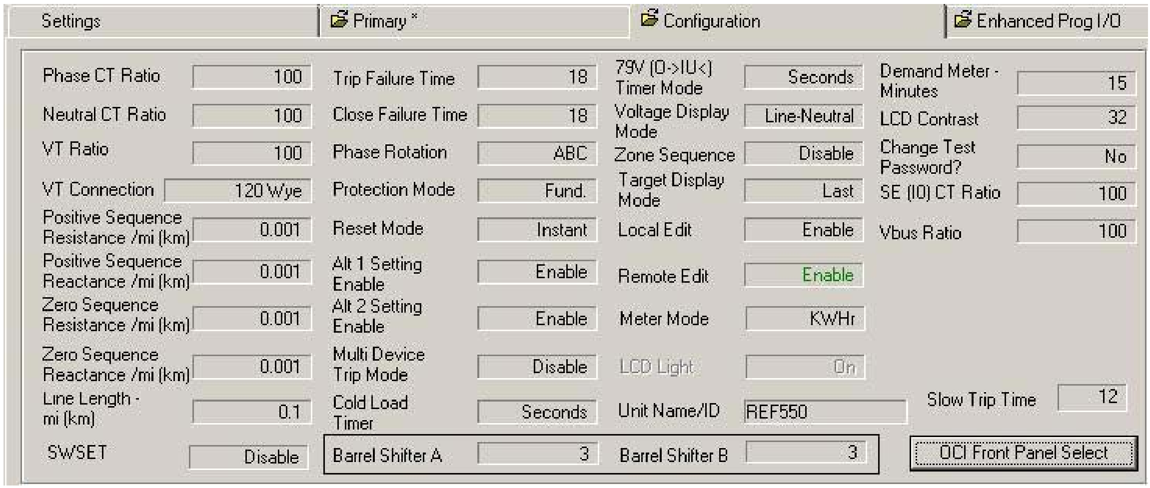


Figure 5-39 WinECP Configuration settings for Shift Registers

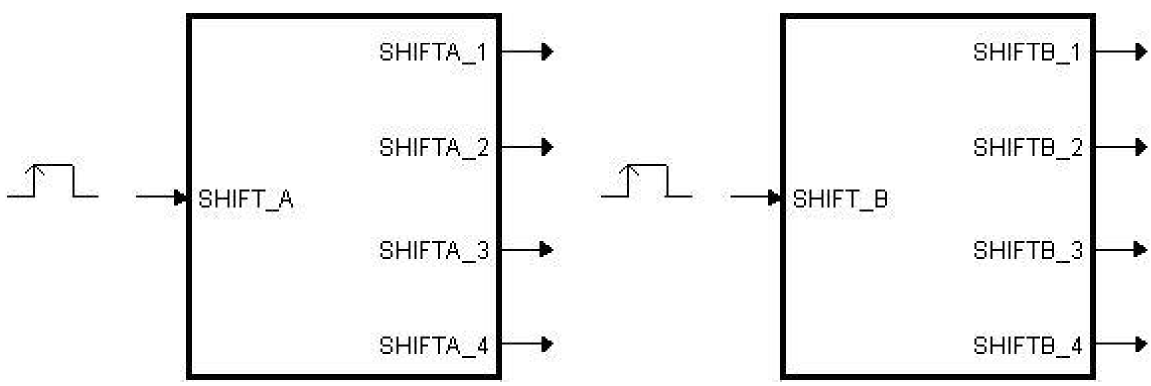
Figure 40 shows the Shift Register functional block representation and logic flow. The factory default settings will assert the first output of each shift register. The active output is stored in non-volatile memory so that the cycling of control-power will not change that status. See Application Example 5-10 for an example of applying this function.

Control Points

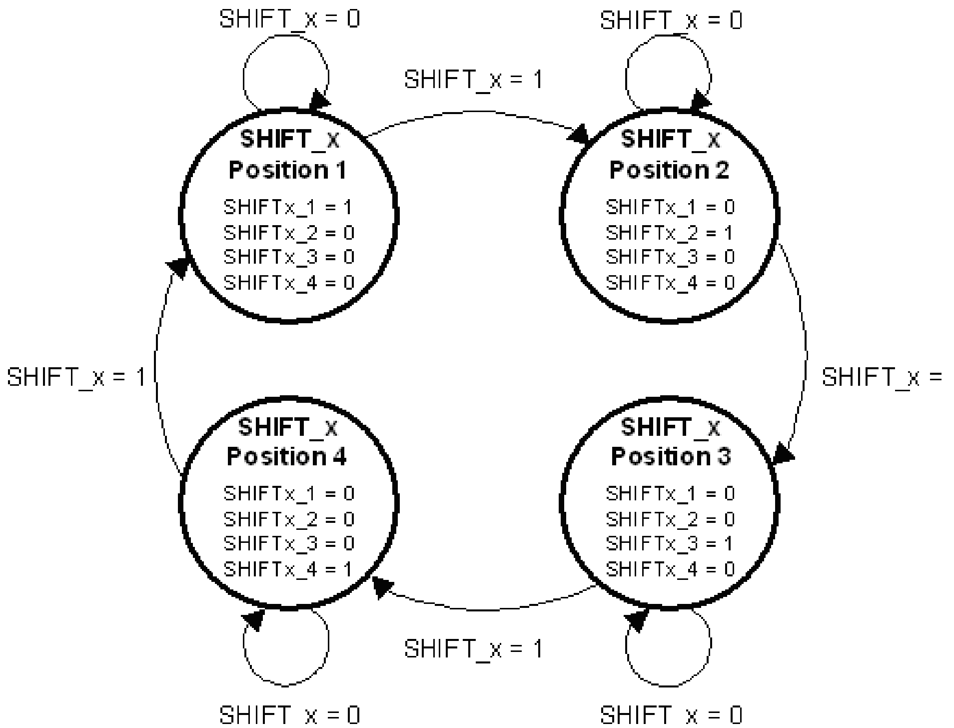
Control Points	Description
SHIFT_A	When asserted, this control point causes the Shift Register A to energize the next enabled status point in the order of 1, 2, 3 and 4. When the last enabled status point is reached, another assertion of this control point causes the register to return to the first status point.
SHIFT_B	When asserted, this control point causes the Shift Register B to energize the next enabled status point in the order of 1, 2, 3 and 4. When the last enabled status point is reached, another assertion of this control point causes the register to return to the first status point.

Status Points

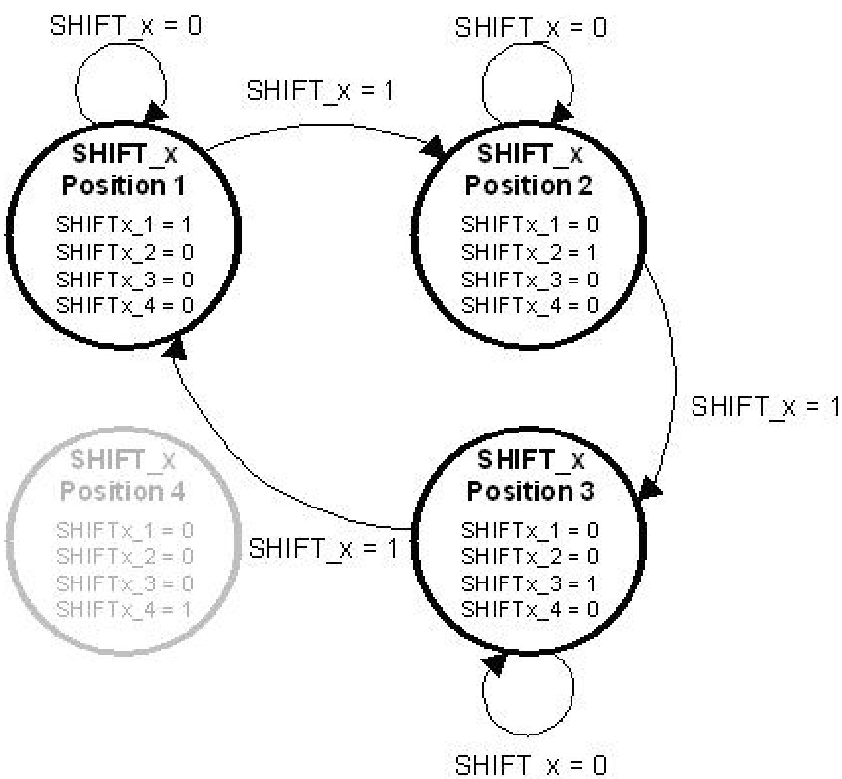
Status Point	Description
SHIFTA_1	This status point asserts when Shift Register A is in the first position. This is the factory default position.
SHIFTA_2	This status point asserts when Shift Register A is in the second position.
SHIFTA_3	This status point asserts when Shift Register A is in the third position when enabled. See Configuration settings.
SHIFTA_4	This status point asserts when Shift Register A is in the fourth position when enabled. See Configuration settings.
SHIFTB_1	This status point asserts when Shift Register B is in the first position. This is the factory default position.
SHIFTB_2	This status point asserts when Shift Register B is in the second position.
SHIFTB_3	This status point asserts when Shift Register B is in the third position when enabled. See Configuration settings.
SHIFTB_4	This status point asserts when Shift Register B is in the fourth position when enabled. See Configuration settings.



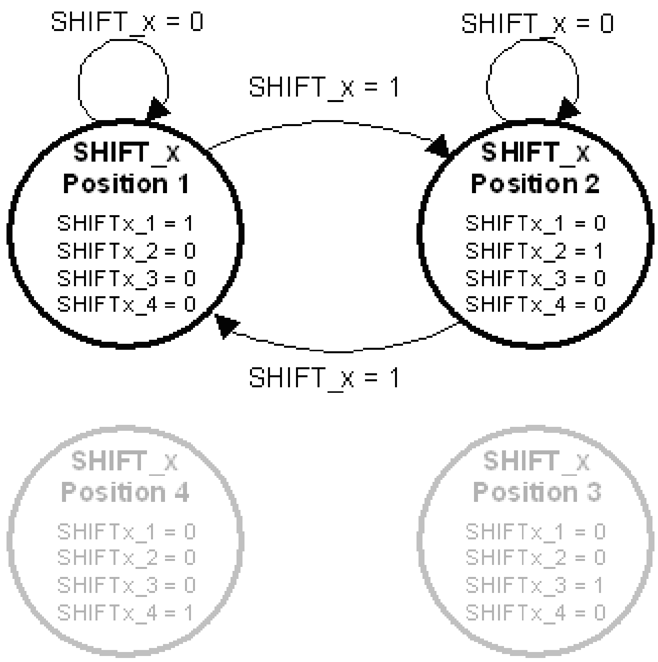
a) Shift Register Function Block



b) Shift Register State Transition Diagram with four states (where x = A or B)



c) Shift Register State Transition Diagram with three states (where X = A or B)



d) Shift Register State Transition D with two states (where x = A or B)
Figure 5-40 Shift Register State Transition Diagram

Application Example 5-10

Changing the entire automation system configuration during testing or other checks can be quickly and easily accomplished using a Shift Register. The following example shows how this can be accomplished in the REF 550. Figure 5-41 shows the Advanced Programmable Logic for the application example.

<u>Configuration Settings</u>

Barrel Shifter A:	3
C6 Select:	Enable
C6 Operation:	Momentary

```

SHIFT_A = C6 // Change Shift Register A state with control PB C6.
LED06 = SHIFT_1 // Light this LED when Shift Register reaches state 1.
LED07 = SHIFTA_2 // Light this LED when Shift Register A reaches state 2.
LED08 = SHIFTA_3 // Light this LED when Shift Register A reaches state 3.

```

Figure 5-41 Programming logic for Application Example 5-10

Operation
With each press of the OCI control pushbutton C6, Shift Register A will energize the next output in the order of 1, 2 and 3. The shift register will, upon the next assertion of its control point, wrap around to its first output when the maximum enabled output is reached. The operator can confirm the output activation by viewing its appropriately labeled OCI LED. The remote dispatcher can also “press C6” via SCADA DNP3.0 or Modbus protocol and activate the appropriate output for the local personnel.

Operator Control Interface (OCI) Breaker Control

The OCI Breaker Control pushbuttons may be programmed to one of three operating positions: Disable, LED’s Only and Enable. Their operating controls are described as follows:

Disable: Neither the Breaker Control pushbuttons or LED’s operate. The LED’s will never light.
LED’s Only: The Breaker Control pushbuttons do not operate, but the LED’s will indicate breaker status per the 52A and 52B control points.
Enable: Both the Breaker Control pushbuttons and the LED’s operate. The LED’s will indicate breaker status per the 52A and 52B control points.

These options are useful in double breaker schemes where the mapped control points 52A and 52B represent a single breaker via the combination of the two. The factory default setting is **Disable**.

Phase Targets Operation on Ground Faults

In the REF 550, the phase current that measures greater than or equal to the 51P or 50P Pickup setting when a ground trip operation occurs will have its phase target illuminated. This will assist Operations personnel in identifying and focusing on the specific line(s) to inspect for the fault location.

Status Points

Status Point	Description
PATA	This status point asserts when the phase A current measures above any phase overcurrent pickup and the REF 550 trips on a phase or ground overcurrent element.
PBTA	This status point asserts when the phase B current measures above any phase overcurrent pickup and the REF 550 trips on a phase or ground overcurrent element.
PCTA	This status point asserts when the phase C current measures above any phase overcurrent pickup and the REF 550 trips on a phase or ground overcurrent element.

Advanced Programmable Logic Components

All of the logical components available for programming in the REF 550 Advanced Programmable Logic are shown in Table 5-1.

Table 5-1 Advanced Programmable Logic Components

Logical	Group Assignment	Input(I) / Output(O)	Description	Default Setting
21P-1	Status Points	I	(Ph Dist-1) Phase Distance Element Zone 1 Alarm	Not mapped.
21P-1s	Status Points	I	(Ph Dist-1s) Phase Distance Element Zone 1 Seal In Alarm	Not mapped.
21P-2	Status Points	I	(Ph Dist-2) Phase Distance Element Zone 2 Alarm	Not mapped.
21P-2s	Status Points	I	(Ph Dist-2s) Phase Distance Element Zone 2 Seal In Alarm	Not mapped.
21P-3	Status Points	I	(Ph Dist-3) Phase Distance Element Zone 3 Alarm	Not mapped.
21P-3s	Status Points	I	(Ph Dist-3s) Phase Distance Element Zone 3 Seal In Alarm	Not mapped.
21P-4	Status Points	I	(Ph Dist-4) Phase Distance Element Zone 4 Alarm	Not mapped.
21P-4s	Status Points	I	(Ph Dist-4s) Phase Distance Element Zone 4 Seal In Alarm	Not mapped.
21PZone1T	Status Points	IO	Phase Step Distance Element Zone 1 Target	Not mapped
21PZone2T	Status Points	IO	Phase Step Distance Element Zone 2 Target	Not mapped
21PZone3T	Status Points	IO	Phase Step Distance Element Zone 3 Target	Not mapped
21PZone4T	Status Points	IO	Phase Step Distance Element Zone 4 Target	Not mapped
25	Status Points	I	(SYNC) Sync Check Condition Alarm	Not mapped.
25BYP	Control Points	IO	(SYNC byp) Sync Check Bypass	Not mapped.
25s	Status Points	I	(SYNCs) Sync Check Condition Seal In Alarm	Not mapped.
25TC	Control Points	IO	(SYNC) Sync Check Enable	Not mapped.
27-1	Status Points	I	(1U<) Single Phase Undervoltage Alarm	Not mapped.
27-1s	Status Points	I	(1U<s) Single Phase Undervoltage Seal In Alarm	Not mapped.
27-3P	Status Points	I	(3U<) Three Phase Undervoltage Alarm	Not mapped.
27-3Ps	Status Points	I	(3U<s) Three Phase Undervoltage Seal In Alarm	Not mapped.
32N-2	Status Points	I	(I2->) Neutral Power Directional Alarm	Not mapped.
32N-2s	Status Points	I	(I2->s) Neutral Power Directional Seal In Alarm	Not mapped.
32NA	Status Points	I	(IN>->Is) 67N Zone Pickup Alarm	Not mapped.
32P-2	Status Points	I	(I1->) Phase Power Directional Alarm	Not mapped.
32P-2s	Status Points	I	(I1->s) Phase Power Directional Seal In Alarm	Not mapped.
32PA	Status Points	I	(3I>->Is) 67 Zone Pickup Alarm	Not mapped.
46-1	Status Points	I	(Insc>1) 46-1 Negative Sequence Time Overcurrent Alarm	Not mapped.
47	Status Points	I	(U2>) Negative Sequence Overvoltage Alarm	Not mapped.

43A	Control Points	IO	(AR) Reclose Function: Enable/Disable	= !C1 (w/o HLT) = TR_ON (w/ HLT)
46-2	Status Points	I	(Insc>2) 46-2 Negative Sequence Time Overcurrent Alarm	Not mapped.
46-2s	Status Points	I	(Insc>2s) 46-2 Negative Sequence Time Overcurrent Seal In Alarm	Not mapped.
46-2TC	Control Points	IO	(Insc>2) Enables the 46-2 Negative Sequence Time Overcurrent Function	Not mapped.
46-1s	Status Points	I	(Insc>1s) 46-1 Negative Sequence Time Overcurrent #1 Seal In Alarm	Not mapped.
46-1TC	Control Points	IO	(Insc>1) Enables the 46-1 Negative Sequence Time Overcurrent Function	Not mapped.
47s	Status Points	I	(U2>s) Negative Sequence Overvoltage Seal In Alarm	Not mapped.
50-1D	Status Points	I	(I>>1D) 50-1 Instantaneous Overcurrent Disabled Alarm	Not mapped.
50-1TC	Control Points	IO	(I>>1) Enables 50P-1 & 50N-1	= !C3
50-2D	Status Points	I	(I>>2D) 50-2 Instantaneous Overcurrent Disabled Alarm	Not mapped.
50-2TC	Control Points	IO	(I>>2) Enables 50P-2 & 50N-2	= !C3
50-3D	Status Points	I	(I>>3D) 50-3 Instantaneous Overcurrent Disabled Alarm	Not mapped.
50-3TC	Control Points	IO	(I>>3) Enables 50P-3 & 50N-3	= !C3
50N1	Status Points	I	(IN>>1) Ground Instantaneous Overcurrent Trip Alarm Level 1	Not mapped.
50N1s	Status Points	I	(IN>>1s) Ground Instantaneous Overcurrent Trip Seal IN Alarm Level 1	Not mapped.
50N2	Status Points	I	(IN>>2) Ground Instantaneous Overcurrent Trip Alarm Level 2	Not mapped.
50N2s	Status Points	I	(IN>>2s) Ground Instantaneous Overcurrent Trip Seal IN Alarm Level 2	Not mapped.
50N3	Status Points	I	(IN>>3) Ground Instantaneous Overcurrent Trip Alarm Level 3	Not mapped.
50N3s	Status Points	I	(IN>>3s) Ground Instantaneous Overcurrent Trip Seal IN Alarm Level 3	Not mapped.
50P1	Status Points	I	(3I>>1) Phase Instantaneous Overcurrent Trip Alarm Level 1	Not mapped.
50P1s	Status Points	I	(3I>>1s) Phase Instantaneous Overcurrent Trip Seal In Alarm Level 1	Not mapped.
50P2	Status Points	I	(3I>>2) Phase Instantaneous Overcurrent Trip Alarm Level 2	Not mapped.
50P2s	Status Points	I	(3I>>2s) Phase Instantaneous Overcurrent Trip Seal In Alarm Level 2	Not mapped.

50P3	Status Points	I	(3I>>3) Phase Instantaneous Overcurrent Trip Alarm Level 3	Not mapped.
50P3s	Status Points	I	(3I>>3s) Phase Instantaneous Overcurrent Trip Seal In Alarm Level 3	Not mapped.
51N	Status Points	I	(IN>) Ground Time Overcurrent Trip Alarm	Not mapped.
51Ns	Status Points	I	(IN>s) Ground Time Overcurrent Trip Seal IN Alarm	Not mapped.
51P	Status Points	I	(3I>) Phase Time Overcurrent Trip Alarm	Not mapped.
51Ps	Status Points	I	(3I>s) Phase Time Overcurrent Trip Seal In Alarm	Not mapped.
51PTC	Control Points	IO	(3I>) Enables the 51P Time Overcurrent Function	Not mapped.
52A	Control Points	IO	Breaker Auxiliary Contact	= IN01
52B	Control Points	IO	Breaker Auxiliary Contact	= IN02
59-1	Status Points	I	(1U>) Single Phase Overvoltage Alarm	Not mapped.
59-1s	Status Points	I	(1U>s) Single Phase Overvoltage Seal In Alarm	Not mapped.
59-3	Status Points	I	(3U>) Three Phase Overvoltage Alarm	Not mapped.
59-3s	Status Points	I	(3U>s) Three Phase Overvoltage Seal In Alarm	Not mapped.
59G	Status Points	I	(U0>) Ground Overvoltage Alarm	Not mapped.
59Gs	Status Points	I	(U0>s) Ground Overvoltage Seal In Alarm	Not mapped.
67N	Status Points	I	(IN>->) Negative Sequence Supervised Ground Directional Time Overcurrent Trip Alarm	Not mapped.
67Ns	Status Points	I	(IN>->s) Negative Sequence Supervised Ground Directional Time Overcurrent Trip Seal In Alarm	Not mapped.
67NTC	Control Points	IO	(IN>->) Enables the Negative Sequence Directionally Controlled Ground Time Overcurrent Function	Not mapped.
67P	Status Points	I	(3I>->) Positive Sequence Supervised Phase Directional Time Overcurrent Trip Alarm	Not mapped.
67Ps	Status Points	I	(3I>->s) Positive Sequence Supervised Phase Directional Time Overcurrent Trip Seal In Alarm	Not mapped.
67PTC	Control Points	IO	(3I>->) Enables the Positive Sequence Directionally Controlled Phase Time Overcurrent Function	Not mapped.
79CA1	Status Points	I	(O->I1) Recloser Counter 1 Alarm	Not mapped.
79CA1s	Status Points	I	(O->I1s) Recloser Counter 1 Seal In Alarm	Not mapped.
79CA2	Status Points	I	(O->I2) Recloser Counter 2 Alarm	Not mapped.
79CA2s	Status Points	I	(O->I2s) Recloser Counter 2 Seal In Alarm	Not mapped.
79DA	Status Points	I	(O->IDA) Recloser Disable Alarm	Not mapped.
79LOA	Status Points	I	(O->ILO) Recloser Lockout Alarm	Not mapped.
79M	Control Points	IO	(O->I) Multi-Shot Reclosing	Not mapped.
79S	Control Points	IO	(O->I1) Single Shot Reclosing	Not mapped.

79V	Status Points	I	Reclose Undervoltage Block	Not mapped.
81O-1	Status Points	I	(f>s1) Overfrequency Alarm Module 1	Not mapped.
81O-1s	Status Points	I	(f>s1s) Overfrequency Seal In Alarm Module 1	Not mapped.
81O-2	Status Points	I	(f>s2) Overfrequency Alarm Module 2	Not mapped.
81O-2s	Status Points	I	(f>s2s) Overfrequency Seal In Alarm Module 2	Not mapped.
81R-1	Status Points	I	(f>1) Frequency Load Restoration Module 1 Alarm	Not mapped.
81R-1s	Status Points	I	(f>1s) Frequency Load Restoration Module 1 Seal In Alarm	Not mapped.
81R-2	Status Points	I	(f>2) Frequency Load Restoration Module 2 Alarm	Not mapped.
81R-2s	Status Points	I	(f>2s) Frequency Load Restoration Module 2 Seal In Alarm	Not mapped.
81S-1	Status Points	I	(f<1) Frequency Load Shed Trip Module 1 Alarm	Not mapped.
81S-1s	Status Points	I	(f<1s) Frequency Load Shed Trip Module 1 Seal In Alarm	Not mapped.
81S-2	Status Points	I	(f<2) Frequency Load Shed Trip Module 2 Alarm	Not mapped.
81S-2s	Status Points	I	(f<2s) Frequency Load Shed Trip Module 2 Seal In Alarm	Not mapped.
ALARM	Status Points	I	(IRF) Self Check Alarm	Not mapped.
ALT1	Control Points	IO	Enables ALT 1 Settings	= C5
ALT1-ON	Status Points	I	Alternate Settings One Active	Not mapped.
ALT2	Control Points	IO	Enables ALT 2 Settings	= C6
ALT2-ON	Status Points	I	Alternate Settings Two Active	Not mapped.
ARCI	Control Points	IO	Automatic Reclose Inhibit	Not mapped.
BATT_HI	Status Points	I	Station Battery High Alarm	Not mapped.
BATT_HIs	Status Points	I	Station Battery High Seal In Alarm	Not mapped.
BATT_LO	Status Points	I	Station Battery Low Alarm	Not mapped.
BATT_LOWs	Status Points	I	Station Battery Low Seal In Alarm	Not mapped.
BFA	Status Points	I	Breaker Failure Alarm	Not mapped.
BFAs	Status Points	I	Breaker Failure Seal In Alarm	Not mapped.
BFI	Control Points	IO	Breaker Fail Initiate	Not mapped.
BFT	Status Points	I	Break Failure Trip Alarm	Not mapped.
BFTs	Status Points	I	Break Failure Trip Seal In Alarm	Not mapped.
BFUA	Status Points	I	Blown Fuse Alarm	Not mapped.
BZA	Status Points	I	Bus Zone Alarm	Not mapped.

C1	Status Points	I	Control Button 1 Selected	Not mapped.
C2	Status Points	I	Control Button 2 Selected	Not mapped.
C3	Status Points	I	Control Button 3 Selected	Not mapped.
C4	Status Points	I	Control Button 4 Selected	Not mapped.
C5	Status Points	I	Control Button 5 Selected	Not mapped.
C6	Status Points	I	Control Button 6 Selected	Not mapped.
CLOSE	Status Points	I	Breaker Close Output	Not mapped.
CLTA	Status Points	I	Cold Load Timer Alarm	Not mapped.
CRI	Control Points	IO	Clear Reclose and Overcurrent Counters	Not mapped.
DBDL	Status Points	I	Dead Bus Dead Line	Not mapped.
DBLL	Status Points	I	Dead Bus Live Line	Not mapped.
DFRI	Control Points	IO	Initiates Digital Fault Recorder capture	Not mapped.
DirT	Status Points	I	Directional Trip Target	Not mapped.
DistT	Status Points	I	Distance Trip Target	Not mapped.
ECI1	Control Points	IO	Event Capture Initiate	Not mapped.
ECI2	Control Points	IO	Event Capture Initiate	Not mapped.
EXTBFI	Control Points	IO	External Starter Input	Not mapped.
FALSE	Miscellaneous	I	Logical 0 for debug or permanent mapping	Not mapped.
FreqT	Status Points	I	Frequency Trip Target	Not mapped.
GRD-D	Status Points	I	(IN>D) Ground Control Disabled Alarm	Not mapped.
GRDTC	Control Points	IO	(IN) Enables 51N/50N-1/50N-2	= !C2
HIF	Status Points	I	HIF Detect™ operation	LED12 = HIF
HIFs	Status Points	I	HIF Detect™ Seal-in Alarm	Not mapped.
HIFTC	Control Points	IO	Enables the HIF Detect™ feature	Not mapped.
HPFA	Status Points	I	High Power Factor Alarm	Not mapped.
IN01	Physical Inputs	I	Physical Input 1	Not mapped.
IN02	Physical Inputs	I	Physical Input 2	Not mapped.
IN03	Physical Inputs	I	Physical Input 3	Not mapped.
IN04	Physical Inputs	I	Physical Input 4	Not mapped.
IN05	Physical Inputs	I	Physical Input 5	Not mapped.
IN06	Physical Inputs	I	Physical Input 6	Not mapped.
IN07	Physical Inputs	I	Physical Input 7	Not mapped.
IN08	Physical Inputs	I	Physical Input 8	Not mapped.
InitCLOSE	Control Points	IO	Initiates Close Output	Not mapped.
InstT	Status Points	I	Instantaneous Trip Target	Not mapped.
KSI	Status Points	I	KSI Summation Alarm	Not mapped.
LBDL	Status Points	I	Live Bus Dead Line	Not mapped.
LBLL	Status Points	I	Live Bus Live Line	Not mapped.

LED02	LEDs	IO	LED 2	= PUA
LED03	LEDs	IO	LED 3	= C1
LED04	LEDs	IO	LED 4	= C2
LED05	LEDs	IO	LED 5	= C3
LED06	LEDs	IO	LED 6	= C4
LED07	LEDs	IO	LED 7	= C5
LED08	LEDs	IO	LED 8	= C6
LED09	LEDs	IO	LED 9	= 79DA
LED10	LEDs	IO	LED 10	= GRD-D
LED11	LEDs	IO	LED 11	=50-1D+50-2D+50-3D
LED12	LEDs	IO	LED 12	= HIF
LED14	LEDs	IO	LED 14	= PATA
LED15	LEDs	IO	LED 15	= PBTA
LED16	LEDs	IO	LED 16	= PCTA
LED17	LEDs	IO	LED 17	= NTA
LED18	LEDs	IO	LED 18	= TimeT
LED19	LEDs	IO	LED 19	= InstT
LED20	LEDs	IO	LED 20	= NegT
LED21	LEDs	IO	LED 21	= FreqT
LED22	LEDs	IO	LED 22	= DirT
LED23	LEDs	IO	LED 23	= VoltT
LED24	LEDs	IO	LED 24	= DistT
LIR01	Control Points	IO	Latching Logical Input 1 Reset	Not mapped.
LIR02	Control Points	IO	Latching Logical Input 2 Reset	Not mapped.
LIR03	Control Points	IO	Latching Logical Input 3 Reset	Not mapped.
LIR04	Control Points	IO	Latching Logical Input 4 Reset	Not mapped.
LIR05	Control Points	IO	Latching Logical Input 5 Reset	Not mapped.
LIR06	Control Points	IO	Latching Logical Input 6 Reset	Not mapped.
LIR07	Control Points	IO	Latching Logical Input 7 Reset	Not mapped.
LIR08	Control Points	IO	Latching Logical Input 8 Reset	Not mapped.
LIS01	Control Points	IO	Latching Logical Input 1 Set	Not mapped.
LIS02	Control Points	IO	Latching Logical Input 2 Set	Not mapped.
LIS03	Control Points	IO	Latching Logical Input 3 Set	Not mapped.
LIS04	Control Points	IO	Latching Logical Input 4 Set	Not mapped.

LIS05	Control Points	IO	Latching Logical Input 5 Set	Not mapped.
LIS06	Control Points	IO	Latching Logical Input 6 Set	Not mapped.
LIS07	Control Points	IO	Latching Logical Input 7 Set	Not mapped.
LIS08	Control Points	IO	Latching Logical Input 8 Set	Not mapped.
LO01	Status Points	I	Latching Output 1	Not mapped.
LO02	Status Points	I	Latching Output 2	Not mapped.
LO03	Status Points	I	Latching Output 3	Not mapped.
LO04	Status Points	I	Latching Output 4	Not mapped.
LO05	Status Points	I	Latching Output 5	Not mapped.
LO06	Status Points	I	Latching Output 6	Not mapped.
LO07	Status Points	I	Latching Output 7	Not mapped.
LO08	Status Points	I	Latching Output 8	Not mapped.
LOADA	Status Points	I	Load Current Alarm	Not mapped.
LOC01	Local Controls	I	Local 1	Not mapped.
LOC02	Local Controls	I	Local 2	Not mapped.
LOC03	Local Controls	I	Local 3	Not mapped.
LOC04	Local Controls	I	Local 4	Not mapped.
LOC05	Local Controls	I	Local 5	Not mapped.
LOC06	Local Controls	I	Local 6	Not mapped.
LOC07	Local Controls	I	Local 7	Not mapped.
LOC08	Local Controls	I	Local 8	Not mapped.
LOC09	Local Controls	I	Local 9	Not mapped.
LOC10	Local Controls	I	Local 10	Not mapped.
LOC11	Local Controls	I	Local 11	Not mapped.
LOC12	Local Controls	I	Local 12	Not mapped.
LOC13	Local Controls	I	Local 13	Not mapped.
LOC14	Local Controls	I	Local 14	Not mapped.
LOC15	Local Controls	I	Local 15	Not mapped.
LOC16	Local Controls	I	Local 16	Not mapped.
LOCAL	Control Points	IO	Local Control Enable/Disabled	= C4
LPFA	Status Points	I	Low Power Factor Alarm	Not mapped.
NDA	Status Points	I	Neutral Current Demand Alarm	Not mapped.
NegT	Status Points	I	Negative Sequence Target	Not mapped.
NTA	Status Points	I	Neutral Trip Target	Not mapped.

NTA	Status Points	I	Neutral Trip Target	Not mapped.
NVArA	Status Points	I	Negative 3 Phase kiloVAr Alarm	Not mapped.
OCTC	Status Points	I	(I>TC) Overcurrent Trip Counter Alarm	Not mapped.
OPEN	Control Points	IO	Initiates Trip Output	Not mapped.
OUT01	Physical Outputs	IO	Physical Output 1	Not mapped.
OUT02	Physical Outputs	IO	Physical Output 2	Not mapped.
OUT03	Physical Outputs	IO	Physical Output 3	Not mapped.
OUT04	Physical Outputs	IO	Physical Output 4	Not mapped.
OUT05	Physical Outputs	IO	Physical Output 5	Not mapped.
OUT06	Physical Outputs	IO	Physical Output 6	Not mapped.
PATA	Status Points	I	(L1TA) Phase A Target	Not mapped.
PBTA	Status Points	I	(L2TA) Phase B Target	Not mapped.
PCTA	Status Points	I	(L3TA) Phase C Target	Not mapped.
PDA	Status Points	I	Phase Current Demand Alarm	Not mapped.
PH3-D	Status Points	I	(3I>D) Phase Control Disabled Alarm	Not mapped.
PH3TC	Control Points	IO	(3I) Enables 51P/50P-1/50P-2	Not mapped.
PRIM-ON	Status Points	I	Primary Settings Active	Not mapped.
PUA	Status Points	I	(I>Is) Overcurrent Pickup Alarm	Not mapped.
PVArA	Status Points	I	Positive 3 Phase kiloVArA Alarm	Not mapped.
Rclin	Status Points	I	Circuit Breaker Close Initiate	Not mapped.
REM01	Remote Controls	I	Remote 1	Not mapped.
REM02	Remote Controls	I	Remote 2	Not mapped.
REM03	Remote Controls	I	Remote 3	Not mapped.
REM04	Remote Controls	I	Remote 4	Not mapped.
REM05	Remote Controls	I	Remote 5	Not mapped.
REM06	Remote Controls	I	Remote 6	Not mapped.
REM07	Remote Controls	I	Remote 7	Not mapped.
REM08	Remote Controls	I	Remote 8	Not mapped.
REM09	Remote Controls	I	Remote 9	Not mapped.
REM10	Remote Controls	I	Remote 10	Not mapped.
REM11	Remote Controls	I	Remote 11	Not mapped.
REM12	Remote Controls	I	Remote 12	Not mapped.
REM13	Remote Controls	I	Remote 13	Not mapped.
REM14	Remote Controls	I	Remote 14	Not mapped.

REM15	Remote Controls	I	Remote 15	Not mapped.
REM16	Remote Controls	I	Remote 16	Not mapped.
ReTrip	Status Points	I	Breaker Failure ReTrip Alarm	Not mapped.
ReTrips	Status Points	I	Breaker Failure ReTrip Seal In Alarm	Not mapped.
SBA	Status Points	I	Slow Breaker Alarm	Not mapped.
SCC	Control Points	IO	Spring Charging Contact	Not mapped.
SEF	Status Points	I	(I0>) Sensitive Earth Fault Trip Alarm	Not mapped.
SEFs	Status Points	I	(I0>s) Sensitive Earth Fault Trip Seal In Alarm	Not mapped.
SEFT	Status Points	I	Sensitive Earth Trip Target	Not mapped.
SEFTC	Control Points	IO	(I0>) Sensitive Earth Fault Enable	Not mapped.
SHIFT_A	Control Points	IO	Barrel Shifter A Input	Not mapped.
SHIFT_B	Control Points	IO	Barrel Shifter B Input	Not mapped.
SHIFTA_1	Status Points	I	Barrel Shifter A Output 1	Not mapped.
SHIFTA_2	Status Points	I	Barrel Shifter A Output 2	Not mapped.
SHIFTA_3	Status Points	I	Barrel Shifter A Output 3	Not mapped.
SHIFTA_4	Status Points	I	Barrel Shifter A Output 4	Not mapped.
SHIFTB_1	Status Points	I	Barrel Shifter B Output 1	Not mapped.
SHIFTB_2	Status Points	I	Barrel Shifter B Output 2	Not mapped.
SHIFTB_3	Status Points	I	Barrel Shifter B Output 3	Not mapped.
SHIFTB_4	Status Points	I	Barrel Shifter B Output 4	Not mapped.
SIA	Control Points	IO	Resets Seal-In Alarms	Not mapped.
STCA	Status Points	I	Settings Table Changed Alarm	Not mapped.
SWSET	Control Points	IO	Switch Active Settings Input	Not mapped.
TARC	Control Points	IO	Initiate Trip and Auto Reclose	Not mapped.
Target_Reset	Status Points	I	Target Reset Pulse	Not mapped.
TCC	Status Points	I	Tap Changer Cutout Contact	Not mapped.
TCFA	Status Points	I	Trip Coil Failure Alarm	Not mapped.
TCM	Control Points	IO	(TCS) Trip Coil Monitoring	Not mapped.
TGT	Control Points	IO	Target Alarms Reset	Not mapped.
TimeT	Status Points	I	Time Trip Target	Not mapped.
TM01	Timers	IO	Timer Input 1	Not mapped.
TM02	Timers	IO	Timer Input 2	Not mapped.
TM03	Timers	IO	Timer Input 3	Not mapped.
TM04	Timers	IO	Timer Input 4	Not mapped.

TM05	Timers	IO	Timer Input 5	Not mapped.
TM06	Timers	IO	Timer Input 6	Not mapped.
TM07	Timers	IO	Timer Input 7	Not mapped.
TM08	Timers	IO	Timer Input 8	Not mapped.
TM09	Timers	IO	Timer Input 9	Not mapped.
TM10	Timers	IO	Timer Input 10	Not mapped.
TM11	Timers	IO	Timer Input 11	Not mapped.
TM12	Timers	IO	Timer Input 12	Not mapped.
TM13	Timers	IO	Timer Input 13	Not mapped.
TM14	Timers	IO	Timer Input 14	Not mapped.
TM15	Timers	IO	Timer Input 15	Not mapped.
TM16	Timers	IO	Timer Input 16	Not mapped.
TMO01	Status Points	I	Timer Output 1	Not mapped.
TMO02	Status Points	I	Timer Output 2	Not mapped.
TMO03	Status Points	I	Timer Output 3	Not mapped.
TMO04	Status Points	I	Timer Output 4	Not mapped.
TMO05	Status Points	I	Timer Output 5	Not mapped.
TMO06	Status Points	I	Timer Output 6	Not mapped.
TMO07	Status Points	I	Timer Output 7	Not mapped.
TMO08	Status Points	I	Timer Output 8	Not mapped.
TMO09	Status Points	I	Timer Output 9	Not mapped.
TMO10	Status Points	I	Timer Output 10	Not mapped.
TMO11	Status Points	I	Timer Output 11	Not mapped.
TMO12	Status Points	I	Timer Output 12	Not mapped.
TMO13	Status Points	I	Timer Output 13	Not mapped.
TMO14	Status Points	I	Timer Output 14	Not mapped.
TMO15	Status Points	I	Timer Output 15	Not mapped.
TMO16	Status Points	I	Timer Output 16	Not mapped.
TR_OFF	Status Points	I	Hot Hold Off	Not mapped.
TR_ON	Status Points	I	Hot Hold On	Not mapped.
TR_RST	Control Points	IO	Hot Hold Tag Reset	Not mapped.
TR_SET	Control Points	IO	Hot Hold Tag Set	Not mapped.
TR_TAG	Status Points	I	Hot Hold Tag	Not mapped.
TRIP	Status Points	I	Breaker Trip Output	Not mapped.
TRIPA	Status Points	I	(TRIPL1) Phase A Trip Alarm	Not mapped.

TRIPAs	Status Points	I	(TRIPL1s) Phase A Trip Seal In Alarm	Not mapped.
TRIPB	Status Points	I	(TRIPL2) Phase B Trip Alarm	Not mapped.
TRIPBs	Status Points	I	(TRIPL2s) Phase B Trip Seal In Alarm	Not mapped.
TRIPC	Status Points	I	(TRIPL3) Phase C Trip Alarm	Not mapped.
TRIPCs	Status Points	I	(TRIPL3s) Phase C Trip Seal In Alarm	Not mapped.
TripT	Status Points	I	Trip Target	Not mapped.
TRUE	Miscellaneous	I	Logical 1 for debug or permanent mapping	Not mapped.
UDI	Control Points	IO	User Display Input	Not mapped.
UL01	User Logicals	IO	User Logical 1	Not mapped.
UL02	User Logicals	IO	User Logical 2	Not mapped.
UL03	User Logicals	IO	User Logical 3	Not mapped.
UL04	User Logicals	IO	User Logical 4	Not mapped.
UL05	User Logicals	IO	User Logical 5	Not mapped.
UL06	User Logicals	IO	User Logical 6	Not mapped.
UL07	User Logicals	IO	User Logical 7	Not mapped.
UL08	User Logicals	IO	User Logical 8	Not mapped.
UL09	User Logicals	IO	User Logical 9	Not mapped.
UL10	User Logicals	IO	User Logical 10	Not mapped.
UL11	User Logicals	IO	User Logical 11	Not mapped.
UL12	User Logicals	IO	User Logical 12	Not mapped.
UL13	User Logicals	IO	User Logical 13	Not mapped.
UL14	User Logicals	IO	User Logical 14	Not mapped.
UL15	User Logicals	IO	User Logical 15	Not mapped.
UL16	User Logicals	IO	User Logical 16	Not mapped.
VArDA	Status Points	I	Three Phase Kilo Var Demand Alarm	Not mapped.
VoltT	Status Points	I	Voltage Target	Not mapped.
Watt1	Status Points	I	Positive Watt 1 Alarm	Not mapped.
Watt2	Status Points	I	Positive Watt 2 Alarm	Not mapped.
ZSC	Status Points	I	Zone Sequence Coordination Enabled Indicator	Not mapped.
ZSCTC	Control Points	IO	Enables Zone Sequence Coordination Scheme	Not mapped.

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Monitoring & Control

The REF 550 contains a unique feature that allows monitoring, metering, control and test of relay functions from the front-panel OCI Liquid Crystal Display (LCD) or WinECP program. It allows monitoring of physical inputs and outputs (I/O) and control and status points, real-time metering, breaker control (open and close), seal-in alarm reset, and forcing of both physical I/O and control points. See the Advanced Programmable Logic section for available I/O and points.–All control actions are password protected requiring the Test password. The Relay password may also be used to perform the control actions.

Monitoring

The ability to monitor real-time values within the REF 550 is available using WinECP. The WinECP monitoring options shown in Figure 6-1 include:

- Metering (Load, Demand, Max/Min Demand)
- DFR Data
- Physical I/O
- Control Points
- Status Points

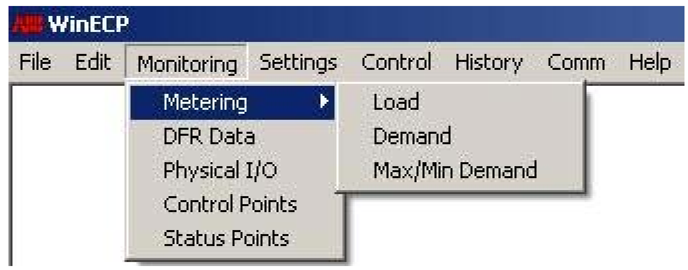


Figure 6-1. REF 550 Monitoring through WinECP

Metering

Load

Steady-state power system load metering is available real-time within the REF 550 viewable via the OCI LCD screen and WinECP. Figure 6-2 shows the load metering screen of WinECP. The energy metering quantities are calculated as long as there is measurable current flow, greater than 1% of the 51P pickup, and can only be reset through the OCI LCD Metering menu system.

In addition to the AC load metering, load metering includes the real-time substation battery voltage. Settings are available for detecting high and low battery voltage levels, see Section 1 for details on the REF 550 Substation Battery Monitoring feature.

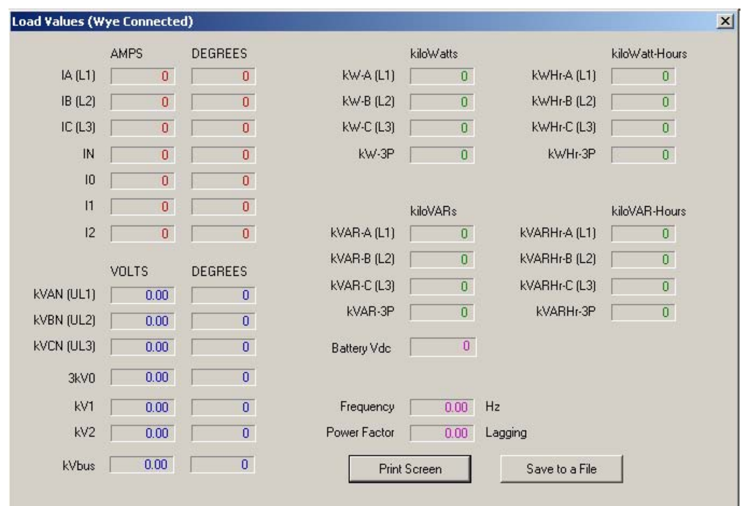


Figure 6-2. REF 550 Metering through WinECP

Demand

Thermal demand metering of the currents, watts and vars is continuously calculated using the Demand Meter Constant programmed in Configuration settings as seen in Figure 6-3, see the System Configuration section. Demand metering runs continuously regardless of the presence of current and voltage signals and the demand values may not be reset.

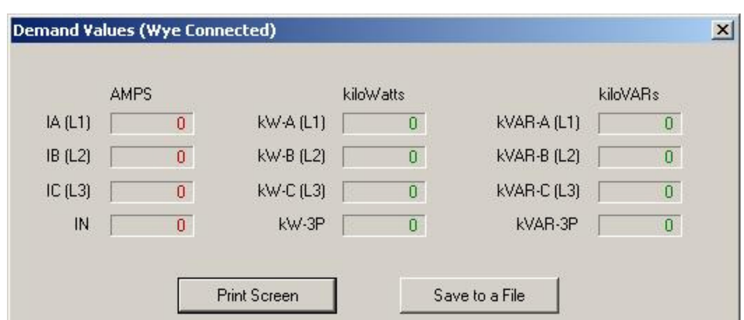


Figure 6-3. REF 550 Metering through WinECP

Max/Min Demand

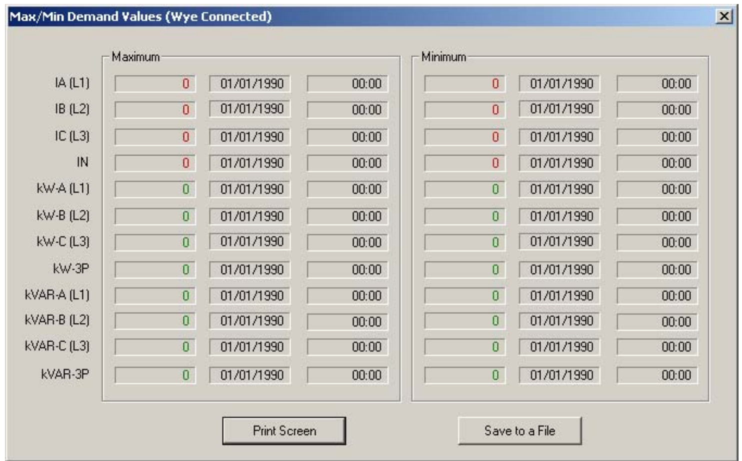


Figure 6-4. REF 550 Metering through WinECP

The maximum and minimum demand values are also calculated and date and time stamped. The data are saved in non-volatile memory so it is recommended that these values be saved to a hard drive before any flash firmware upgrade is performed on the REF 550. The REF 550 continuously determines the maximum and minimum demand values every demand time constant per the demand setting in System Configuration. Figure 6-4 shows the Maximum and Minimum Demand values as seen in WinECP. These maximum and minimum demand values may be reset collectively using the OCI LCD menu system or the WinECP Control option Resets.

DFR Data

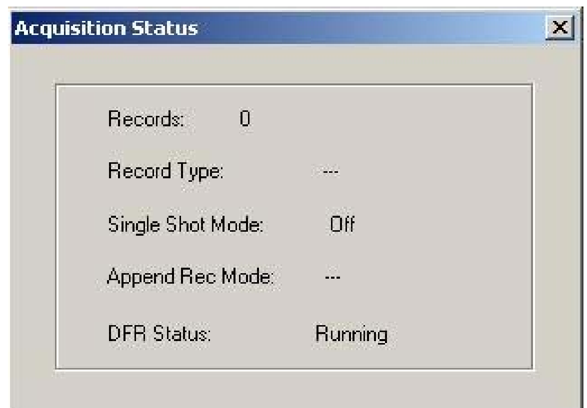


Figure 6-5. DFR Data WinECP screen

The programmed Digital Fault Recorder (DFR) settings and present status of DFR acquisition is available for viewing using WinECP as shown in Figure 6-5. To make changes to the settings or start or stop the DFR data acquisition, use the Settings or Control menu items in WinECP, respectively.

Physical I/O

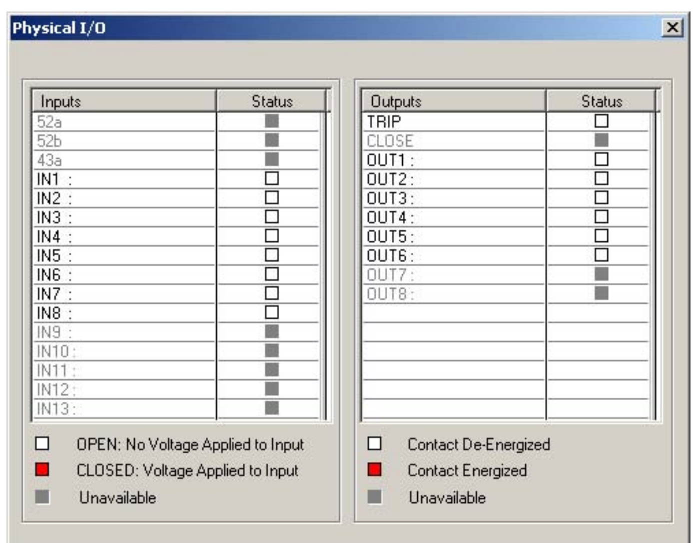


Figure 6-6. Physical I/O WinECP screen

The status of all eight (8) inputs, six (6) outputs, and the Master Trip output is available with WinECP. The Physical I/O Status screen (see Figure 6-6) displays the physical, open/close status of all contact inputs and the energized/de-energized status of all output relays. An "OPEN" status indicates no voltage is present on the physical input terminals. A "CLOSED" status indicates there is voltage present on the physical input terminals. NOTE: The OPEN or CLOSED status does not alone signify the "Disable" or "Enable"status of a particular control point, but depends on how the physical input is mapped. See the Advanced Programmable Logic section for I/O programming details. Use this display to confirm continuity through each optically isolated contact input for both the OPEN (no voltage applied) and CLOSED (voltage applied) states and to confirm the status of each output relay. Input status is also available through the front-panel OCI by accessing the Test Menu. **Output relay status is not available through the front-panel OCI.**

Control Points

The Control Points Status screen (Figure 6-7) displays which functions are enabled or disabled based on the program statement of the Advanced Programmable Logic. Use this screen to verify and validate the Advanced Programmable Logic for the REF 550 and troubleshoot problems.

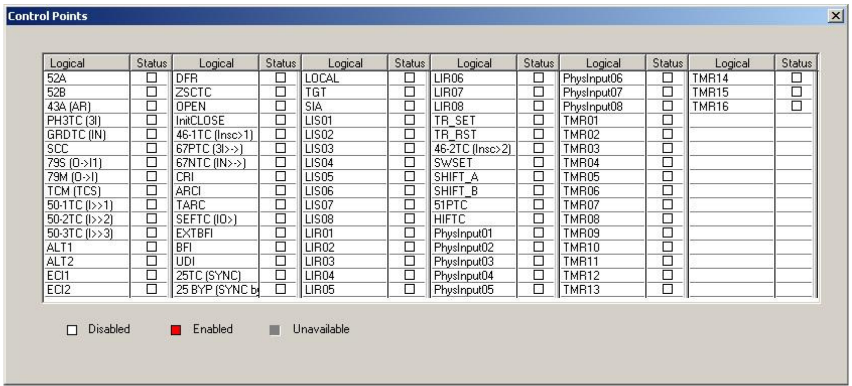


Figure 6-7. Control Points WinECP screen

Each control point has a logical value of "0" or disabled when not mapped in the Advanced Programmable Logic. The following points are an exception to the default value rule having a logical value of "1" when not mapped:

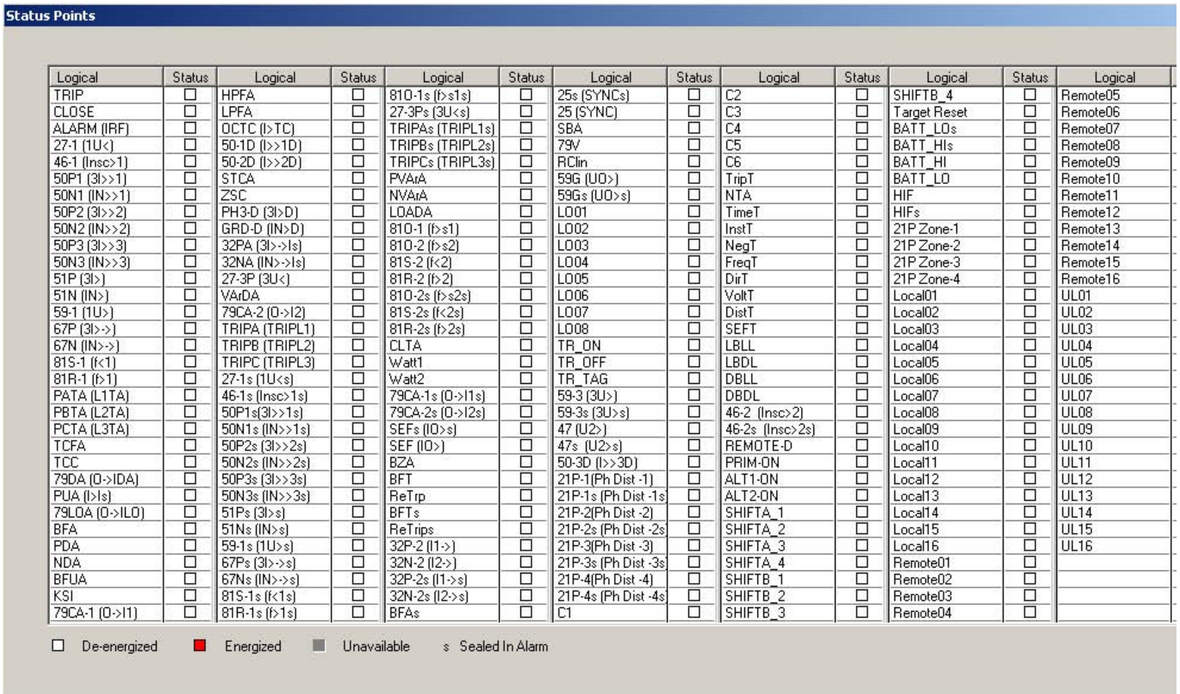
46-1TC(Insc>1) – Torque control of 1st negative sequence overcurrent element,
46-2TC(Insc>2) – Torque control of 2nd negative sequence overcurrent element,
50-1TC(I>>1) – Torque control of first set of phase and ground overcurrent elements,
50-2TC(I>>2) – Torque control of second set of phase and ground overcurrent elements,
50-3TC(I>>3) – Torque control of third set of phase and ground overcurrent elements,
GRDTC(IN) – Torque control of 51N(IN>), 50N-1(IN>>1) and 50N-2(IN>>2) elements,
HIFTC – Torque control of HIF Detect™ feature,
PH3TC(3I) – Torque control of 51P(3I>), 50P-1(3I>>1) and 50P-2(3I>>2) elements,
TCM(TCS) – Trip circuit monitor feature
SEFTC(I0>) – Torque control of sensitive earth fault element 50N-2(IN>>2)
ZSCTC – Torque control of Zone Sequence Coordination feature

Note: Though the default logical value of these special control points is "1", each protective function or feature must be separately enabled in its specific settings tab location.

Therefore, they need not be mapped to physical inputs in the programmable logic (see the Advanced Programmable Logic section) if it is desired they be enabled and no control equation is required. **This feature is not available through the front-panel OCI.**

Status Points

The status of Status points shown in Figure 6-8 displays which logic functions are energized and de-energized. Use this display to confirm whether or not the functions are programmed correctly in the Primary, Alternate 1, Alternate 2, Advanced Programmable Logic and Alarm settings. Also use it to check that the settings provide the desired results. **This feature is not available through the front-panel OCI.**



Status Points

Logical	Status	Logical	Status	Logical	Status	Logical	Status	Logical	Status	Logical	Status	Logical
TRIP	☐	HPFA	☐	81O-1s (f>s1s)	☐	25s (SYNCs)	☐	C2	☐	SHIFTB_4	☐	Remote05
CLOSE	☐	LPFA	☐	27-3Ps (3U<s)	☐	25 (SYNC)	☐	C3	☐	Target Reset	☐	Remote06
ALARM (IRF)	☐	OCTC (I>TC)	☐	TRIPAs (TRIPL1s)	☐	SBA	☐	C4	☐	BATT_LOs	☐	Remote07
27-1 (1U<)	☐	50-1D (I>>1D)	☐	TRIPBs (TRIPL2s)	☐	79V	☐	C5	☐	BATT_HIs	☐	Remote08
46-1 (Insc>1)	☐	50-2D (I>>2D)	☐	TRIPCs (TRIPL3s)	☐	RClin	☐	C6	☐	BATT_HI	☐	Remote09
50P1 (3I>>1)	☐	STCA	☐	PVArA	☐	59G (U0>)	☐	TripT	☐	BATT_LO	☐	Remote10
50N1 (IN>>1)	☐	ZSC	☐	NVArA	☐	59Gs (U0>s)	☐	NTA	☐	HIF	☐	Remote11
50P2 (3I>>2)	☐	PH3-D (3I>D)	☐	LOADA	☐	LO01	☐	TimeT	☐	HIFs	☐	Remote12
50N2 (IN>>2)	☐	GRD-D (IN>D)	☐	81O-1 (f>s1)	☐	LO02	☐	InstT	☐	21P Zone-1	☐	Remote13
50P3 (3I>>3)	☐	32PA (3I>->Is)	☐	81O-2 (f>s2)	☐	LO03	☐	NegT	☐	21P Zone-2	☐	Remote14
50N3 (IN>>3)	☐	32NA (IN>->Is)	☐	81S-2 (f<2)	☐	LO04	☐	FreqT	☐	21P Zone-3	☐	Remote15
51P (3I>)	☐	27-3P (3U<)	☐	81R-2 (f>2)	☐	LO05	☐	DirT	☐	21P Zone-4	☐	Remote16
51N (IN>)	☐	VArDA	☐	81O-2s (f>s2s)	☐	LO06	☐	VoltT	☐	Local01	☐	UL01
59-1 (1U>)	☐	79CA-2 (O->I2)	☐	81S-2s (f<2s)	☐	LO07	☐	DistT	☐	Local02	☐	UL02
67P (3I>->)	☐	TRIPA (TRIPL1)	☐	81R-2s (f>2s)	☐	LO08	☐	SEFT	☐	Local03	☐	UL03
67N (IN>->)	☐	TRIPB (TRIPL2)	☐	CLTA	☐	TR_ON	☐	LBLL	☐	Local04	☐	UL04
81S-1 (f<1)	☐	TRIPC (TRIPL3)	☐	Watt1	☐	TR_OFF	☐	LBDL	☐	Local05	☐	UL05
81R-1 (f>1)	☐	27-1s (1U<s)	☐	Watt2	☐	TR_TAG	☐	DBLL	☐	Local06	☐	UL06
PATA (L1TA)	☐	46-1s (Insc>1s)	☐	79CA-1s (O->I1s)	☐	59-3 (3U>)	☐	DBDL	☐	Local07	☐	UL07
PBTA (L2TA)	☐	50P1s(3I>>1s)	☐	79CA-2s (O->I2s)	☐	59-3s (3U>s)	☐	46-2 (Insc>2)	☐	Local08	☐	UL08
PCTA (L3TA)	☐	50N1s (IN>>1s)	☐	SEFs (IO>s)	☐	47 (U2>)	☐	46-2s (Insc>2s)	☐	Local09	☐	UL09
TCFA	☐	50P2s (3I>>2s)	☐	SEF (IO>)	☐	47s (U2>s)	☐	REMOTE-D	☐	Local10	☐	UL10
TCC	☐	50N2s (IN>>2s)	☐	BZA	☐	50-3D (I>>3D)	☐	PRIM-ON	☐	Local11	☐	UL11
79DA (O->IDA)	☐	50P3s (3I>>3s)	☐	BFT	☐	21P-1(Ph Dist -1)	☐	ALT1-ON	☐	Local12	☐	UL12
PUA (I>Is)	☐	50N3s (IN>>3s)	☐	ReTrp	☐	21P-1s (Ph Dist -1s	☐	ALT2-ON	☐	Local13	☐	UL13
79LOA (O->ILO)	☐	51Ps (3I>s)	☐	BFTs	☐	21P-2(Ph Dist -2)	☐	SHIFTA_1	☐	Local14	☐	UL14
BFA	☐	51Ns (IN>s)	☐	ReTrips	☐	21P-2s (Ph Dist -2s	☐	SHIFTA_2	☐	Local15	☐	UL15
PDA	☐	59-1s (1U>s)	☐	32P-2 (I1->)	☐	21P-3(Ph Dist -3)	☐	SHIFTA_3	☐	Local16	☐	UL16
NDA	☐	67Ps (3I>->s)	☐	32N-2 (I2->)	☐	21P-3s (Ph Dist -3s	☐	SHIFTA_4	☐	Remote01	☐	
BFUA	☐	67Ns (IN>->s)	☐	32P-2s (I1->s)	☐	21P-4(Ph Dist -4)	☐	SHIFTB_1	☐	Remote02	☐	
KSI	☐	81S-1s (f<1s)	☐	32N-2s (I2->s)	☐	21P-4s (Ph Dist -4s	☐	SHIFTB_2	☐	Remote03	☐	
79CA-1 (O->I1)	☐	81R-1s (f>1s)	☐	BFAs	☐	C1	☐	SHIFTB_3	☐	Remote04	☐	

☐ De-energized ■ Energized ■ Unavailable s Sealed In Alarm

Figure 6-8. Status Points WinECP screen

Control

The REF 550 provides the following internal and external control functions through its OCI LCD Test and Operation menus and the WinECP Control selection. These control functions are password protected requiring the Test password though the Relay password may also be used.

Breaker

Trip and Close

The breaker can be tripped and closed using the test password in the REF 550 OCI LCD Operations menu and WinECP Control menu. Breaker operations through these means will activate the respective failure timer programmed in System Configuration. A Breaker Close attempt through WinECP, see Figure 6-9, will be processed immediately. NOTE: If the logic state of Control Point 43A is false, breaker close control will not be processed.

NOTE: When a CLOSE command is issued to the REF 550 with a "Circuit Breaker Status Indeterminate" state (that is the 52A and 52B contacts inputs read the same value), the REF 550 will hold the command in memory. This CLOSE command will be executed if the status of the 52A/52B contact inputs become determinate and indicates a "Breaker Open" State. The CLOSE command will not be executed if the status of the 52A/52B contact inputs become determinate and indicates a "Breaker Close" state, or if the REF 550 is reset, or if control power to the REF 550 is cycled.

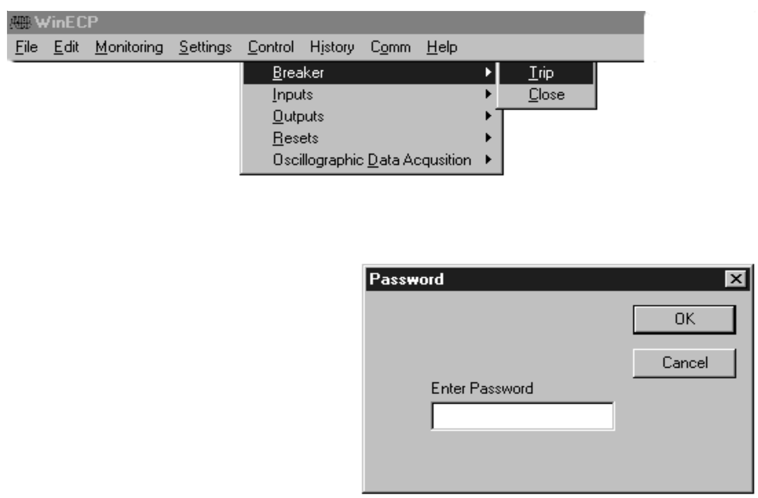


Figure 6-9. Breaker Control via WinECP

Inputs and Outputs

Force Physical Inputs and Outputs

To aid in REF 550 commissioning and testing, the state of all Physical Inputs and Outputs can be forced through WinECP or front-panel OCI. This feature can be accessed in WinECP through the Control Menu, and through front-panel OCI through the Operations Menu. When one or more input/output is in the forced condition the green “Normal” LED on front panel will blink on and off. All forcing of I/O is password protected requiring the Test or Relay password. See Figures 6-10 and 6-11.

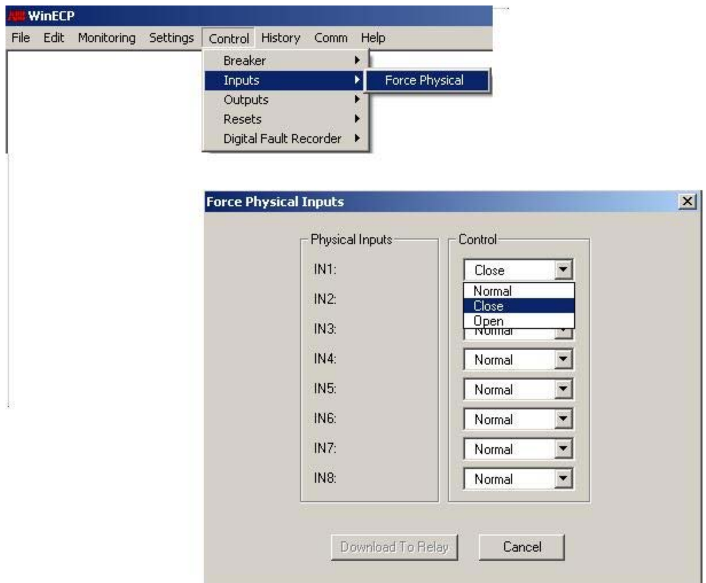


Figure 6-10. Forcing Physical Inputs via WinECP

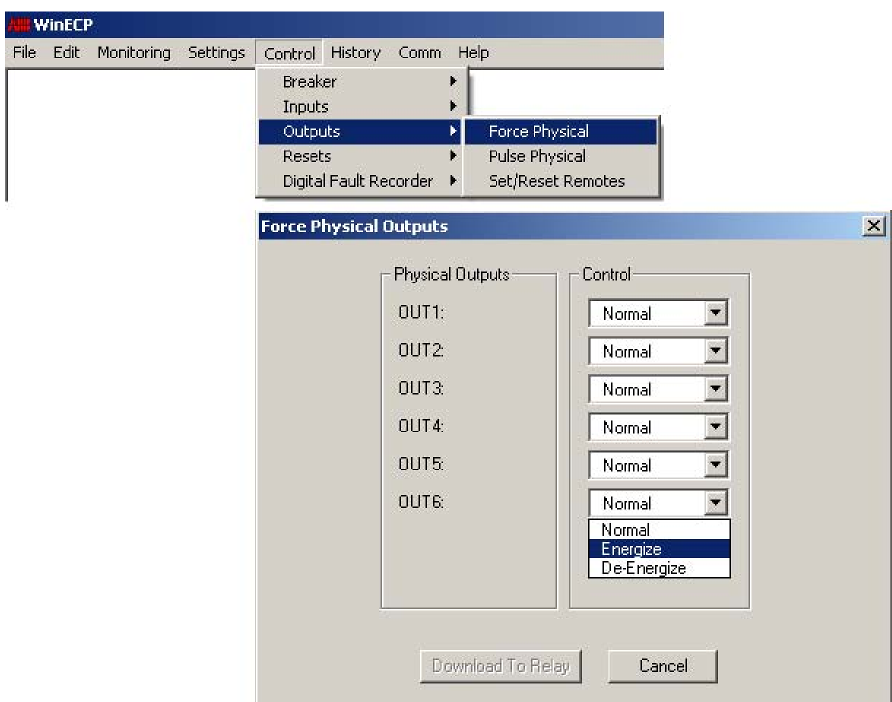


Figure 6-11. Forcing Physical Outputs via WinECP

Pulse Physical Outputs

Sometimes it is desired to pulse an output instead of setting it through the Force Physical Output command. In this case, the Pulse Physical Output command can be used. When the output is pulsed, it will stay asserted for approximately one second. The Pulse Physical Output command is password protected requiring the Test or Relay password, and is available through the Control Menu in WinECP, see Figure 6-12, or the Test Menu through the front-panel OCI.

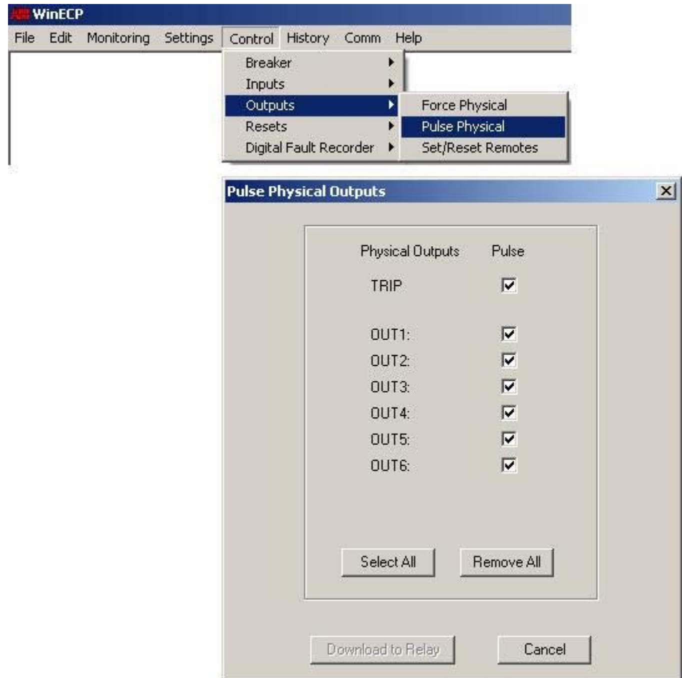


Figure 6-12. Pulse Physical Outputs via WinECP

Set and Clear Remotes

To emulate SCADA remote control for commissioning and testing, WinECP allows for setting and resetting the 16 Remote Controls. Each Remote Control can be individually controlled and the status will remain latched until a command that reverses the present latched state is issued. These controls are only available via WinECP Control menu, as shown in Figure 6-13, and SCADA commands. The WinECP control screen also shows the present state of each remote control for convenience. See the Advanced Programmable Logic section for programming details and examples of the Remote Control outputs.

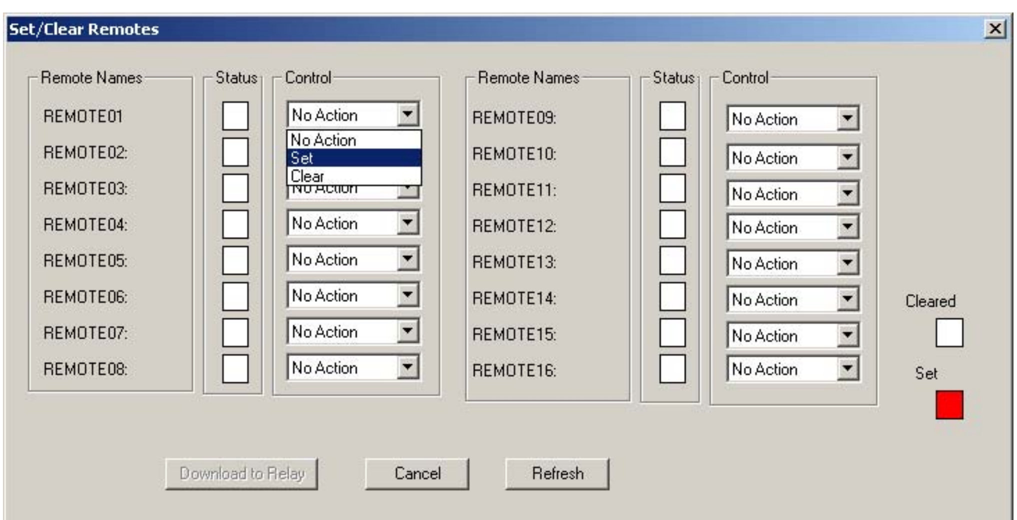


Figure 6-13. Set/Reset Remote Controls via WinECP

Resets

Targets, Alarms, Sealed-in Alarms and Max/Min Demand metering values may be reset via the REF 550 OCI LCD Operations menus and WinECP. Refer to the Operator Control Interface (OCI) section for details on performing resets through the front panel OCI. Figure 6-14 shows the reset options available in WinECP.

Targets

Selecting Reset Targets/Alarms in WinECP, see Figure 6-14, will reset the Status Point targets and alarms. Status point BFUA, blown fuse alarm, is an example of a point reset through this reset control option. Once executed, this operation cannot be reversed.

Sealed In Alarms

Selecting Reset Sealed In Alarms is performed on an individual or collective basis using the WinECP screen shown in Figure 6-15. The present status of each sealed-in alarm is available in the control screen. Once executed, this operation cannot be reversed.

Max/Min Demands

If monthly maximum and minimum demand values are desired, the values can be reset to their default values once the present values are recorded.

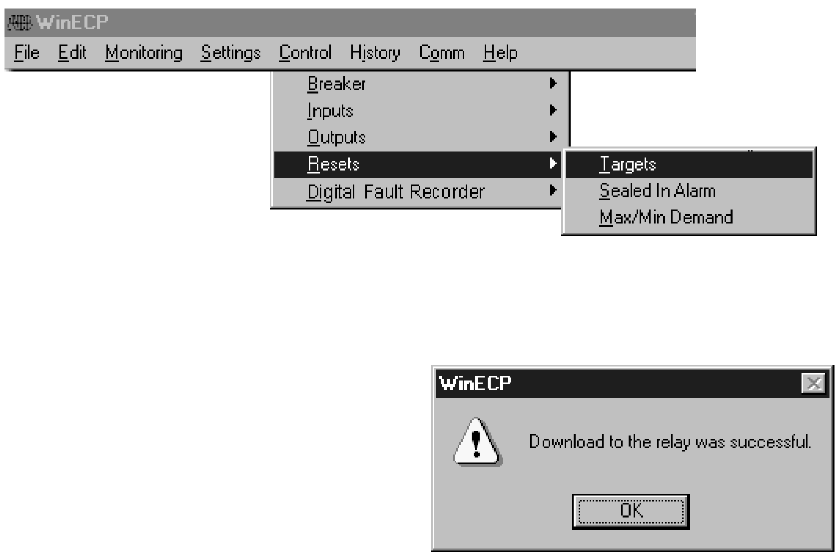


Figure 6-14. Reset Targets and Alarms via WinECP

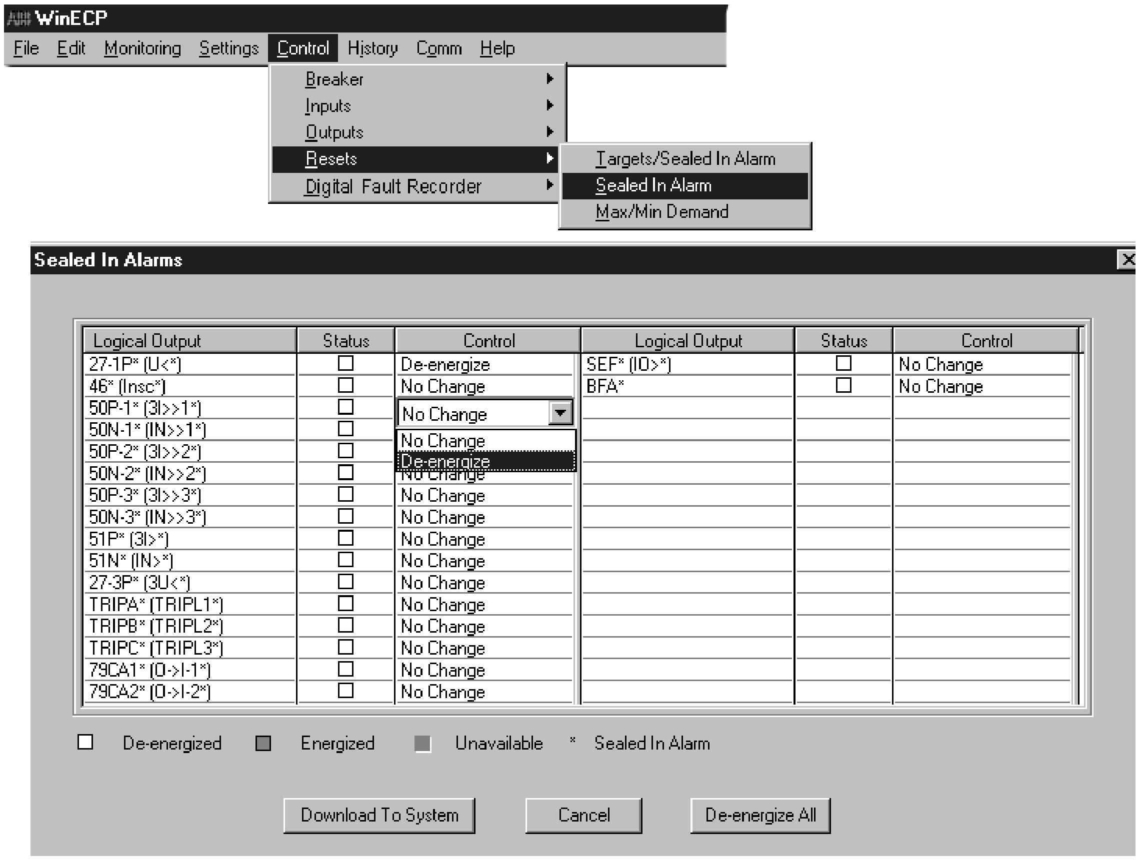


Figure 6-15. Sealed-In Alarm Reset via WinECP

Digital Fault Recorder

The Digital Fault Recorder waveform capture feature can be started and stopped using the WinECP Control menu options shown in Figure 6-16. Once the DFR feature is manually stopped in this fashion, it must be started by the user or no waveform records will be recorded. The WinECP Monitoring menu can be used to verify the DFR status. It is recommended the DFR be started at time of commission and that status verified using the WinECP Monitoring screen.

Digital Fault Recorder data acquisition can be started or stopped with WinECP. Use the Control Menu to start and stop data acquisition (Figure 6-16). The status of the recorder data can be viewed through the Monitoring Menu (Figure 6-5). See the Historical Records section for details on customizing DFR acquisitions and retrieving the DFR data. **This feature is not available through the front-panel OCI.**

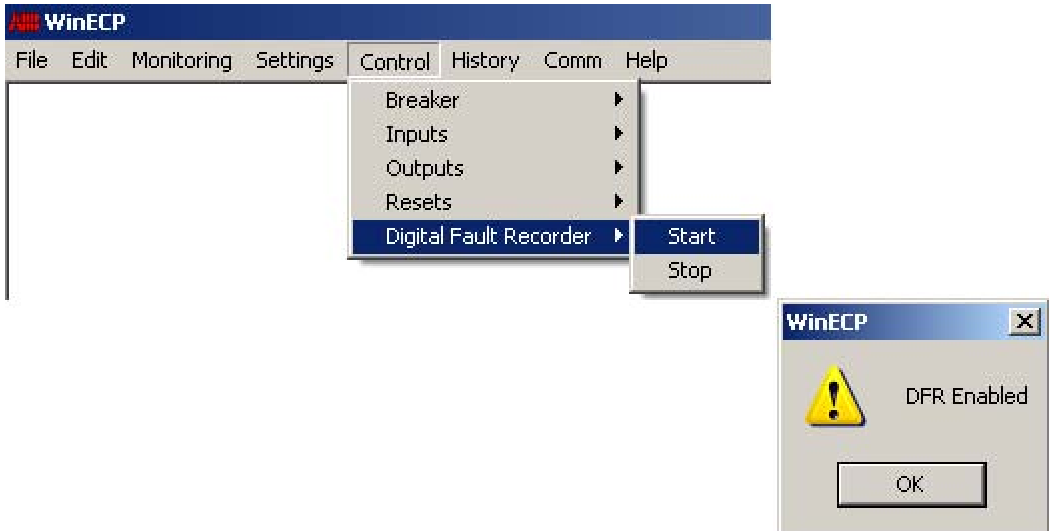


Figure 6-16. Starting the Digital Fault Recorder via WinECP

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Historical Records

The REF 550 provides many recording databases useful in evaluating and analyzing historical events. The historical data includes:

- Fault Summary
- Fault Records
- Sequence of Events (SOE) Operation Records
- Operations Summary
- Digital Fault Recording (DFR)
- Load Profile

The available information each database provides is described in detail in this section. With the exception of the DFR and Load Profile data, all remaining historical data is viewable form the OCI LCD menu system, see the User Interfaces section. All of the data is retrievable from the REF 550 using its user interface tool WinECP.

All the historical data discussed in this section are stored in non-volatile memory and will be retained with a loss of a cycling of control power. It is recommended that these data are saved to a separate memory device, e.g., computer hard drive, before a unit is flash upgraded to the latest CPU firmware.

Fault Summary

The REF 550 provides a summary of the last 32 faults. The Fault Summary data are stored in non-volatile memory and will be retained with a loss of a cycling of control power. It is recommended that these data are saved to a separate memory device, e.g., computer hard drive, before a unit is flash upgraded to the latest CPU firmware. The Fault Summary includes the:

- Record number (most recent listed first as "1")
- Fault number (numbered in order occurred)
- Enabled settings table and recloser sequence number (1, 2, 3, 4 or L for lockout)
- Tripping element
- Date and time
- Phase and neutral currents (magnitude only)

The magnitude of the currents shown in the Fault Summary are the fundamental component of the waveform. After a fault, the OCI continuously displays the apparent distance to the fault in miles and the fault currents (magnitude only) until the targets are reset. Save the Fault Summary as a file via WinECP.

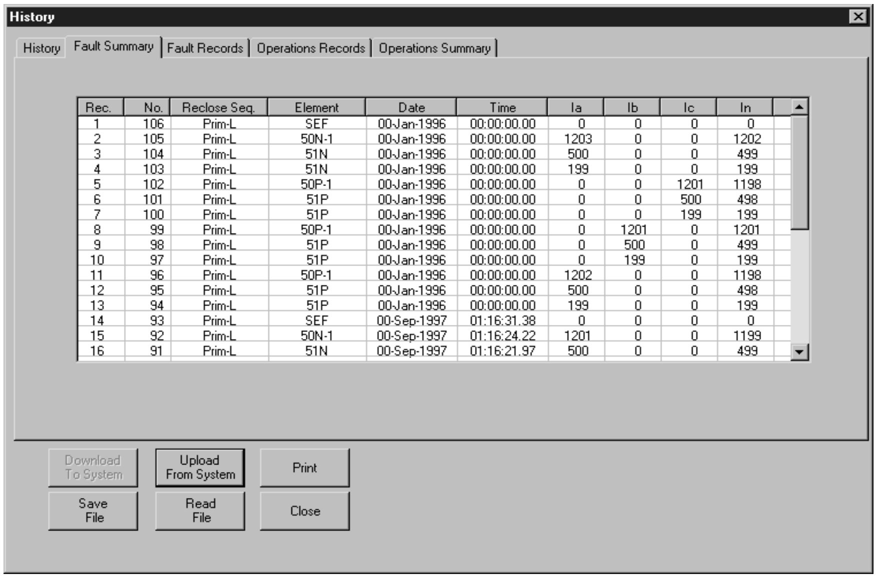

Figure 7-1. Fault Summary Record

Fault Records

The Fault Record contains the last 32 faults. The Fault Records data are stored in non-volatile memory and will be retained with a loss of a cycling of control power. It is recommended that these data are saved to a separate memory device, e.g., computer hard drive, before a unit is flash upgraded to the latest CPU firmware. The Fault Record displays one fault at a time and includes the following information:

- Record number
- Fault number
- Reclose sequence number and enabled settings table
- Date and time
- Tripping element
- Apparent distance to the fault in miles
- Fault resistance
- Relay operate time
- Breaker clearing time
- Phase and neutral currents (magnitude and angle)
- Positive, negative and zero sequence currents (magnitude and angle)
- Phase voltages (magnitude and angle)
- Positive and negative sequence voltages (magnitude and angle)

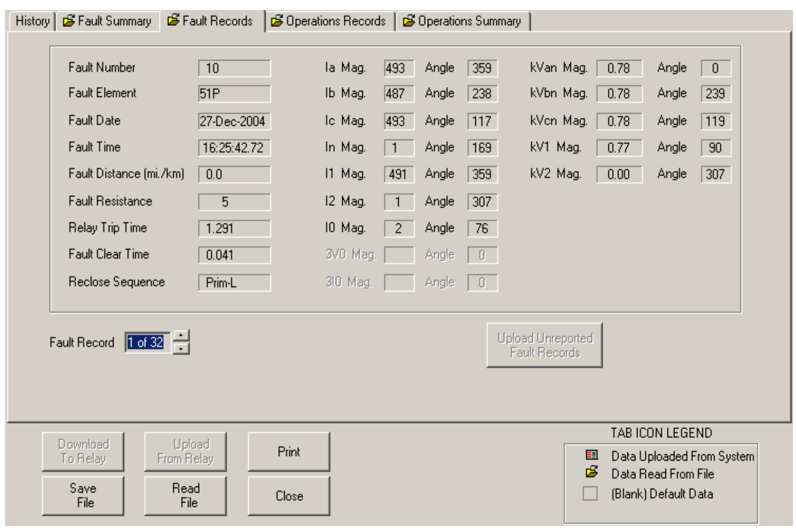

Figure 7-2. Fault Record

The current and voltage magnitudes recorded in each Fault Record is the fundamental component of the waveform.

The Fault Number will increment for each new record stored. When the number reaches 999, the number will reset to 1 for the next fault recorded. Save the Fault Record as a file by using WinECP.

Sequence Of Events (SOE) Recorder - Operation Records

The REF 550 provides an operations log in which any operation within the relay is recorded. This includes internal operations such as logical tripping elements and relay failures. The operations recorder also logs external events such as settings changes, circuit breaker operations, and logical input operations. During a fault the operations recorder does not know or care what element actually tripped and cleared the fault. It only knows that certain logical element became active and logs them with a time stamp. It is very possible that many elements may be logged for a specific fault but only one was responsible for the initiation of the trip signal. See the Fault Records for the element responsible for the trip initiation. A complete listing of all the possible operations logs is listed along with a description in Table 7-2. For detailed definitions to the actual logical elements 51P (3I>), 27-1P (U<), etc., see the Advanced Programmable Logic section. It is important to note that the operations record logs only those elements that change state.

Each event sequence is time and date stamped (see setting the clock in the Testing & Maintenance section) with a time resolution of hundredths of a second. With the REF 550 standard IRIG-B port on the rear panel, one millisecond resolution is achievable for each event sequence. Where multiple events occur within the same machine cycle, they will be stored in the Operation Records in the order in which they occurred and all will be stamped with the same date and time information. The Operation Records data are stored in non-volatile memory and will be retained with a loss of a cycling of control power. It is recommended that these data are saved to a separate memory device, e.g., computer hard drive, before a unit is flash upgraded to the latest CPU firmware.

Three methods are used to obtain operations information from the REF 550.

1. The front panel OCI Main Menu item “Records” is accessed.

2. Operations records can be accessed, viewed, and saved with WinECP. They can be found by in the History Menu by choosing the Operations Records folder.

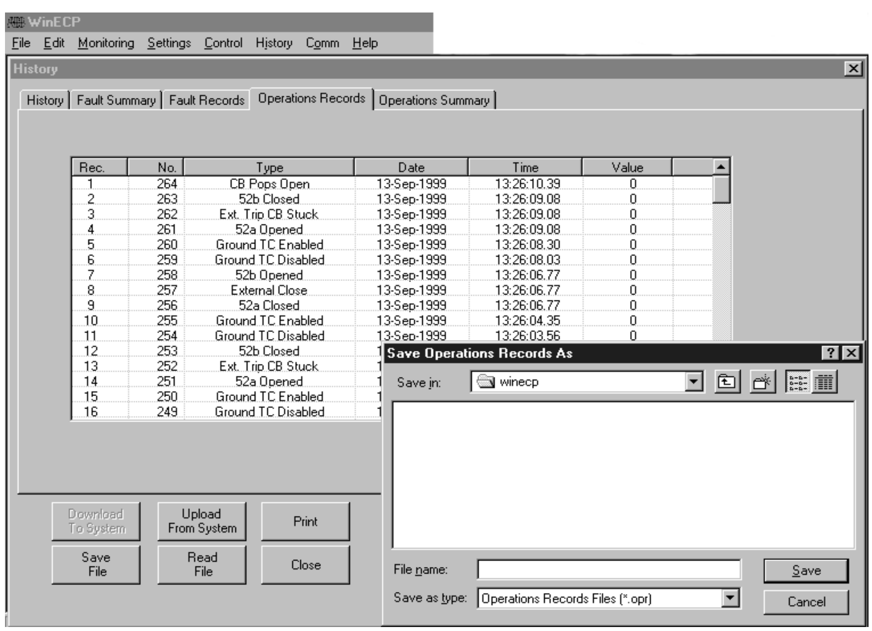

Figure 7-3. Operations Records

3. Depending on the communications protocol contained in the REF 550, a command is issued to send the operations records.

As can be seen in Figure 7-3, the operations records may contain a value associated with them. This value is a decimal number that further defines the occurrence. “Editor Access” and “Self Test Failure” logs will include a value. To interpret this number it must first be converted to binary. The binary bit pattern when compared to Table 7-1 will show what occurred. Notice in Table 7-1 that the values for “Editor Access”. The 1’s in the bit pattern indicate where the edit has occurred. Count from the right of the bit pattern (starting with zero) to the position where a “1” occurs. Compare that bit position with Table 7-1 to reveal the editor access. See the examples on page 7-6 for further explanation.

For example: if the Operations Log records an “Editor Access” with a value of 255 it will not mean the same as a “Self Test Failure” value of 255.

The Operations Record contains the last 255 operations. The Operations Record includes the:

- Record number (most recent listed as "1")
- Operation number (numbered sequentially in order of occurrence)
- Description of the operation
- Date and time of the operation

When the operation number reaches 999, the number resets to 1.

Fault Locator

The REF 550 fault algorithm is used to calculate estimated fault resistance and apparent distance to the fault. This calculation is performed by comparing the prefault current and voltage to the fault current and voltage and by analyzing the positive and zero sequence impedances per mile (kilometer). These impedance parameters are primary quantities and are programmed in the Configuration settings. Where prefault data is not available, e.g., a close into fault scenario, the algorithm will use recently stored prefault data. Three to six cycles of fault current are required to analyze the fault values. The system parameters are used to estimate the source impedance (known impedance) and source voltage. The fault values are used to estimate the load impedance (estimated impedance) and determine fault type. The known impedance and estimated impedance are used to easily calculate the fault impedance. Once the fault impedance is calculated, the distance to fault can be readily calculated using the fault impedance, the line impedance and the line length.

The Fault algorithm was designed to be used on a homogenous radial distribution line. Therefore, the unit is not intended to be used on a distribution line with many different types of conductors because the algorithm will not be as accurate.

Fault data may not be accurate for a close-into-fault condition where there is no prefault power flow. In the case of closing into a fault during a reclose sequence, the apparent distance to the fault in miles for the first fault appears on the first line of the LCD for the entire reclose sequence. The fault records also display the original fault distance in each record of that reclose sequence. The algorithm for the fault locator is most applicable to a radial feeder.

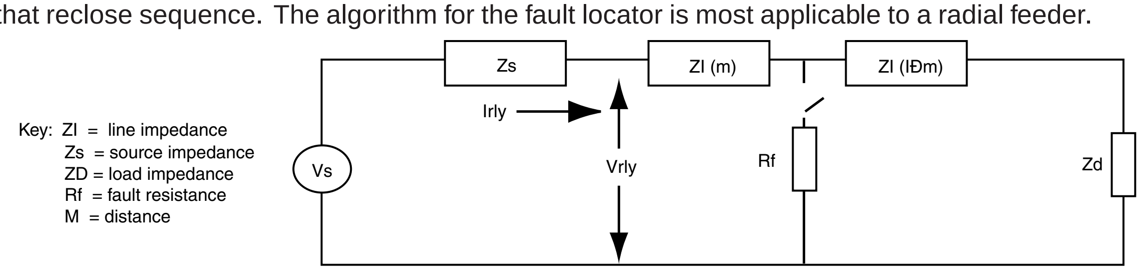

Figure 7-4. Distribution Feeder One-Line for Fault Locator

Self-Test Status

The REF 550 provides continuous self-testing of its power supply voltages, its memory elements and digital signal processor and its program execution. In the event of a system failure, the protective functions are disabled and the Self-Check Alarm contact is actuated. Except for a “processor stalled” condition, review the PASS/FAIL status of these self-test elements by using the Operator Control Interface (OCI) menu system. Press <Menu>, then “Main Menu” and <PgDn> to “Test Menu”. Normal status is indicated by a green NORMAL STATUS light (LED) and system failure is indicated by the green NORMAL STATUS light not being lit, e.g., in the case of a loss of control power.

Self-Test Failures are recorded as a decimal number in the Operations Record. After converting this number to binary, the binary bit pattern indicates the Self-Test Failure. The 1‘s in the bit pattern indicate where a failure has occurred. Count from the right of the bit pattern (starting with zero) to the position where a "1" occurs. Compare that bit position with Table 7-1 to reveal the failure. See the examples on page 7-6 for further explanation.

If the self-test fails, the REF 550 is no longer providing protection. Replace the unit as soon as possible. Contact the ABB Customer Support department at (800) 634-6005 or 1 610 395-7333 to obtain a return authorization number and an emergency replacement unit, if necessary.

Table 7-1. Operations Record Value Information

Bit Position	Self-Test Failure	Editor Access Status	Decimal Value
0	CPU RAM	INTERRUPT LOGGING	1
1	CPU EPROM	REMOTE EDIT DISABLE = 1	2
2	CPU NVRAM	LOCAL EDIT DISABLED = 1	4
3	CPU EEPROM	FRONT MMI EDIT ACTIVE	8
4	MISSING BATTERY	FRONT COMM PORT EDIT ACTIVE	16
5	NOT USED	REAR COMM PORT EDIT ACTIVE	32
6	NOT USED	REAR AUX COMM PORT EDIT ACTIVE	64
7	NOT USED	REAL TIME CLOCK EDITED	128
8	DSP ROM	PROGRAMMABLE I/O EDITED	256
9	DSP INTERNAL RAM	PRIMARY SET EDITED	512
10	DSP EXTERNAL RAM	ALTERNATE1 SETTINGS EDITED	1024
11	DSP ANALOG/DIGITAL CONVERTER	ALTERNATE2 SETTINGS EDITED	2048
12	DSP +/-15 POWER SUPPLIES	CONFIGURATION SETTINGS EDITED	4096
13		COUNTER SETTINGS EDITED	8192
14	DSP STALL or +5 V POWER SUPPLY	ALARM SETTINGS EDITED	16384
15	DSP TO CPU COMMUNICATIONS	COMMUNICATIONS SETTINGS EDITED	32768

Examples of bit interpretation are shown below.

Example of a Self-Test Failure

Value : 256 has a binary bit pattern of 0000000100000000 (bit order 15........0)

The 1 is in bit position 8 as you count from the right. This bit position correlates to DSP ROM failure.

Example of an Editor Access

Value : 145 has a binary bit pattern of 0000000010010001 (bit order 15.........0)

The 1s in this bit pattern have the following bit positions and corresponding Editor Access Status:

Bit 0 : Interrupt logging bit (ignore this bit because it will always be set in this example).

Bit 4 : Front communications port initiated the editor access and change.

Bit 7 : Real-time clock settings were changed.

REF 550 Settings Tables Diagnostics

Three copies of each settings table are stored in a nonvolatile memory device, preventing data loss during control power cycling. When you finish editing any settings table, the changed table's data is transferred from a temporary edit buffer into three separate locations in the nonvolatile memory device.

A background diagnostics task continuously runs a checksum on each copy of the settings tables to verify data consistency. If an invalid copy is detected, the diagnostic task attempts self-correction by transferring a valid copy to the invalid copy location. If this is unsuccessful, the task marks the copy as unusable and switches to the next available copy.

When the REF 550 detects that all three copies of a settings table are not valid, the diagnostic task adds a self-diagnostic error in the Operations Record, drops the self-check alarm and disables all protective functions. In addition, the Self Test display under the OCI Test Menu shows the current status (PASS or FAIL) for all memory devices.

Operations Log Listing

Listed in Table 7-2 are all of the possible operations records and their descriptions.

Table 7-2. Operations Log Listing

Operations Record Log	Definition
21P-1 Zone 1 Trip	Indicates that the phase distance unit zone one 21P-1 element has operated. This indicates only that the programmable status point 21P-1 has operated.
21P-2 Zone 2 Trip	Indicates that the phase distance unit zone two 21P-2 element has operated. This indicates only that the programmable status point 21P-2 has operated.
21P-3 Zone 3 Trip	Indicates that the phase distance unit zone three 21P-3 element has operated. This indicates only that the programmable status point 21P-3 has operated.
21P-4 Zone 4 Trip	Indicates that the phase distance unit zone four 21P-4 element has operated. This indicates only that the programmable status point 21P-4 has operated.
27-1P Alarm	Indicates that the single phase undervoltage element, 27-1P, has operated. This log indicates only that the programmable status point, 27-1P, has operated.
27-3P Alarm	Indicates that the three phase voltage element, 27-3P, has operated. This log indicates only that the programmable status point, 27-3P, has operated.
32N Trip	Indicates that the ground directional power element, 32N, has operated. See Section 5, specifically the “32N-2” output, for more details.
32P Trip	Indicates that the phase directional power element, 32P-2, has operated. See Section 5, specifically the “32P-2” output, for more details.
46-1 Trip	Indicates that the negative sequence time overcurrent element, 46-1, has timed out and operated. It is possible that this may not have been the actual tripping element.
46-1 Unit Disabled	Indicates that the control point, “46-1TC” transitioned from a logical 1 to a logical 0, disabling the negative sequence time overcurrent element if used. This log indicates the state of the “46-1TC” control point only.
46-1 Unit Enabled	Indicates that the control point, “46-1TC” transitioned from a logical 0 to a logical 1, enabling the negative sequence time overcurrent element if used. This log indicates the state of the “46-1TC” control point only.
46-2 Trip	Indicates that the negative sequence time overcurrent alarm element 46-2, has timed out and operated. It is possible that this may not have been the actual tripping element.
46-2 Unit Disabled	Indicates that the control point, “46-2TC” transitioned from a logical 1 to a logical 0, disabling the negative sequence time overcurrent element if used. This log indicates the state of the “46-2TC” control point only.
46-2 Unit Enabled	Indicates that the control point, “46-2TC” transitioned from a logical 0 to a logical 1, enabling the negative sequence time overcurrent element if used. This log indicates the state of the “46-2TC” control point only.
47 Alarm	Indicates the negative sequence voltage element 47 element has operated. This indicates only that the programmable status point 47 has operated.

Table 7-2. Operations Log Listing (cont.)

50N-1 Trip	Indicates that the ground instantaneous overcurrent element, 50N-1 has timed out and operated. It is possible that this may not have been the actual tripping element.
50N-2 Trip	Indicates that the ground instantaneous overcurrent element, 50N-2 has timed out and operated. It is possible that this may not have been the actual tripping element.
50N-3 Trip	Indicates that the ground instantaneous overcurrent element, 50N-3 has operated. It is possible that this may not have been the actual tripping element.
50P/N-1 Disabled	Indicates that the “50-1TC” control point was de-asserted and the active 50P-1 and 50N-1 instantaneous overcurrent elements disabled. The “50-1TC” control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the “50-1TC” control point is forced open in the Operations Menu (see Section 5). This record indicates the state of the “50-1TC” input only. This log will appear even if the 50P-1 and 50N-1 elements are disabled in the active settings group.
50P/N-1 Enabled	Indicates that the “50-1TC” control point was asserted and the active the 50P-1 and 50N-1 instantaneous overcurrent elements enabled. The “50-1TC” control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the “50-1TC” control point is forced open in the Operations Menu (see Section 5). This record indicates the state of the “50-1TC” input only. This log will appear even if the 50P-1 and 50N-1 elements are disabled in the active settings group.
50P/N-2 Disabled	Indicates that the “50-2TC” control point was de-asserted and the active the 50P-2 and 50N-2 instantaneous overcurrent elements disabled. The “50-2TC” control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the “50-2TC” control point is forced open in the Operations Menu (see Section 5). This record indicates the state of the “50-2TC” input only. This log will appear even if the 50P-2 and 50N-2 elements are disabled in the active settings group.
50P/N-2 Enabled	Indicates that the “50-2TC” control point was asserted and the active the 50P-2 and 50N-2 instantaneous overcurrent elements enabled. The “50-2TC” control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the “50-2TC” control point is forced open in the Operations Menu (see Section 5). This record indicates the state of the “50-2TC” input only. This log will appear even if the 50P-2 and 50N-2 elements are disabled in the active settings group.
50P/N-3 Disabled	Indicates that the “50-3TC” control point was de-asserted and the active the 50P-3 and 50N-3 instantaneous overcurrent elements disabled. The “50-3TC” control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the “50-3TC” control point is forced open in the Operations Menu (see Section 5). This record indicates the state of the “50-3TC” input only. This log will appear even if the 50P-3 and 50N-3 elements are disabled in the active settings group.
50P/N-3 Enabled	Indicates that the “50-3TC” control point was asserted and the active the 50P-3 and 50N-3 instantaneous overcurrent elements enabled. The “50-3TC” control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the “50-3TC” control point is forced open in the Operations Menu (see Section 5). This record indicates the state of the “50-3TC” input only. This log will appear even if the 50P-3 and 50N-3 elements are disabled in the active settings group.

Table 7-2. Operations Log Listing (cont.)

50P-1 Trip	Indicates that the phase instantaneous overcurrent element, 50P-1 has timed out and operated. It is possible that this may not have been the actual tripping element.
50P-2 Trip	Indicates that the phase instantaneous overcurrent element, 50P-2 has timed out and operated. It is possible that this may not have been the actual tripping element.
50P-3 Trip	Indicates that the phase instantaneous overcurrent element, 50P-3 has operated. It is possible that this may not have been the actual tripping element.
51N Trip	Indicates that the ground time overcurrent element, 51N has timed out and operated. It is possible that this may not have been the actual tripping element.
51P Trip	Indicates that the phase time overcurrent element, 51P has timed out and operated. It is possible that this may not have been the actual tripping element.
52a Closed	Indicates the state of the programmable logic input “52A”. This record indicates the state of the control point “52A” only. It does not imply an actual breaker state. The “52A Closed” record indicates that the “52A” control point was at a logical 1 at the time of the logging.
52a Opened	Indicates the state of the programmable logic input “52A”. This record indicates the state of the control point “52A” only. It does not imply an actual breaker state. The “52A Opened” record indicates that the “52A” control point was at a logical 0 at the time of the logging.
52b Closed	Indicates the state of the programmable logic input “52B”. This record indicates the state of the control point “52B” only. It does not imply an actual breaker state. The “52B Closed” record indicates that the “52B” control point was at a logical 1 at the time of the logging.
52b Opened	Indicates the state of the programmable logic input “52B”. This record indicates the state of the control point “52B” only. It does not imply an actual breaker state. The “52B Opened” record indicates that the “52B” control point was at a logical 0 at the time of the logging.
59-1	Indicates that the overvoltage element, 59-1, has operated. This log indicates only that the programmable status point, 59-1, has operated.
59-3 P Alarm	Indicates the phase overvoltage element 59-3P element has operated. This indicates only that the programmable status point 59-3P has operated.
67N Trip	Indicates that the directional ground time overcurrent element, 67N has timed out and operated. It is possible that this may not have been the actual tripping element.
67N Unit Disabled	Indicates that the control point, “67NTC” transitioned from a logical 1 to a logical 0, disabling the ground directional time overcurrent element if used. This log indicates the state of the “67NTC” input only.
67N Unit Enabled	Indicates that the control point, “67NTC” transitioned from a logical 0 to a logical 1, enabling the ground directional time overcurrent element if used. This log indicates the state of the “67NTC” input only.
67P Trip	Indicates that the directional phase time overcurrent element, 67P has timed out and operated. It is possible that this may not have been the actual tripping element.
67P Unit Disabled	Indicates that the control point, “67PTC” transitioned from a logical 1 to a logical 0, disabling the phase directional time overcurrent element if used. This log indicates the state of the “67PTC” input only.

Table 7-2. Operations Log Listing (cont.)

67P Unit Enabled	Indicates that the control point, “67PTC” transitioned from a logical 0 to a logical 1, enabling the phase directional time overcurrent element if used. This log indicates the state of the “67PTC” input only.
79 Counter 1 Alarm	Indicates that the number of reclose operations has exceeded the Reclose Counter 1 Alarm setting. See Section 5, specifically the “79CA1” output, for more details.
79 Counter 2 Alarm	Indicates that the number of reclose operations has exceeded the Reclose Counter 2 Alarm setting. See Section 5, specifically the “79CA2” output, for more details.
79M Input Disabled	Indicates the state of the multi shot reclose ,”79M”, control point. This record will appear when the “79M” input transitions from a logical 1 to a logical 0. See Section 1 for more details on the 79M function.
79M Input Enabled	Indicates the state of the multi shot reclose ,”79M”, control point. This record will appear when the “79M” input transitions from a logical 0 to a logical 1. See Section 1 for more details on the 79M function.
79S Input Disabled	Indicates the state of the single shot reclose ,”79S”, control point. This record will appear when the “79S” input transitions from a logical 1 to a logical 0. See Section 1 for more details on the 79S function.
79S Input Enabled	Indicates the state of the single shot reclose ,”79S”, control point. This record will appear when the “79S” input transitions from a logical 0 to a logical 1. See Section 1 for more details on the 79S function.
79V Block	Indicates that one or more phases of voltage fell below the 79V threshold setting. Will log a 79V Block only during a reclose operation.
81O-1 Overfrequency	Indicates that the overfrequency module 1 element, 81O-1, has timed out and operated. This log indicates only that the programmable status point, 81O-1, has operated.
81O-2 Overfrequency	Indicates that the overfrequency module 2 element, 81O-2, has timed out and operated. This log indicates only that the programmable status point, 81O-2, has operated.
81R-1 Restore	Indicates that the frequency restoration module 1 element, 81R-1, has timed out and operated. This log indicates only that the programmable logical output, 81R-1, has operated.
81R-2 Restore	Indicates that the frequency restoration module 1 element, 81R-2, has timed out and operated. This log indicates only that the programmable status point, 81R-2, has operated.
81S-1 Trip	Indicates that the frequency load shed module 1 element, 81S-1, has timed out and operated. This log indicates only that the programmable status point, 81S-1, has operated.
81S-2 Trip	Indicates that the frequency load shed module 2 element, 81S-2, has timed out and operated. This log indicates only that the programmable status point, 81S-2, has operated.
81V Block	
Accumulated KSI	Indicates that the KSI summation has exceeded the KSI Alarm setting. See Section 5, specifically the “KSI” output, for more details.

Table 7-2. Operations Log Listing (cont.)

Alt 1 Set Active	Indicates that a transition from a Alternate 2 or Primary settings group took place and that the Alternate 1 settings are active at this point in the record.
Alt 2 Set Active	Indicates that a transition from a Alternate 1 or Primary settings group took place and that the Alternate 2 settings are active at this point in the record.
ARC Blocked	Indicates that the control point Auto Reclose Inhibit, “ARCI”, transitioned from a logical 0 to a logical 1. See Section 5, specifically the “ARCI” input, for more details on “ARCI” operation.
ARC Enabled	Indicates that the control point Auto Reclose Inhibit, “ARCI”, transitioned from a logical 1 to a logical 0. See Section 5, specifically the “ARCI” input, for more details on “ARCI” operation.
BATRAM Failure	Indicates a failure of the REF 550 Battery Backed-up Random Access Memory. Contact ABB technical support at this time.
BFI Disabled	Indicates that the BFI protection was disabled.
BFI Enabled	Indicates that the BFI protection was enabled.
BFT Operation	Indicates operation of the Breaker Failure Trip (BFT) status point. See Section 1 under “Breaker Failure Logic” for more details.
Blown Fuse Alarm	Indicates that “BFUA” programmable status point has operated. See the Programmable Outputs section specifically the “BFUA” output for more details.
Breaker Closed	Indicates that a “CLOSE BREAKER” command was entered from the Operations Menu
Breaker Opened	Indicates that a “TRIP BREAKER” command was entered from the Operations Menu
CB Failed to Close	Indicates the Close Fail Timer has expired. See Close Fail Timer in the Recloser section for more details.
CB Failed to Trip	Indicates the Trip Fail Timer has expired. See Trip Fail Timer in the Recloser section for more details.
CB Pops Closed	Indicates that the circuit breaker has closed after a CB fail to close state has occurred. This could have only occurred external to the REF 550 or a “Close” command issued via the REF 550 OCI or WinECP program.
CB Pops Open	Indicates that the circuit breaker has opened after a CB fail to trip state has occurred. This open state could have occurred when the breaker finally opened (slow breaker) or when manually opened.
CB Slow to Trip	Indicated that the “Slow Breaker Time” setting in the configuration settings has expired.
CB State Unknown	Indicates that the 52A and 52B circuit breaker auxiliary contact inputs to the REF 550 are in an invalid state. See the Control points section specifically the 52A and 52B control points for valid input states.
CB Stuck Closed	Indicates that the circuit breaker was stuck and failed to open.
Cold Load Alarm	Logs when the cold load timer is counting down. Also see CLTA status point description.

Table 7-2. Operations Log Listing (cont.)

Control Power Fail	Indicates that the control power has dropped below the control power operating threshold as outlined in the Specifications section
CRI Input Closed	Indicates that the control point Clear Reclose and Overcurrent Counters, “CRI”, transitioned from a logical 0 to a logical 1. See Section 5, specifically the “CRI” input, for more details.
CRI Input Opened	Indicates that the control point Clear Reclose and Overcurrent Counters, “CRI”, transitioned from a logical 1 to a logical 0. See Section 5, specifically the “CRI” input, for more details.
DBDL	Dead bus dead line is logged when the 25 function is in the unknown state and transitions to the DBDL state.
DBLL	Dead bus live line is logged when the 25 function is in the unknown state and transitions to the DBLL state.
DSP Failure	Indicates a failure of the REF 550 Digital Signal Processor. Contact ABB technical support at this time.
Editor Access	Indicates that a settings change has been made.
EEPROM Failure	Indicates a failure of the REF 550 Non-Volatile Memory. Contact ABB technical support at this time.
Event Cap 1 Init	Indicates that the control point “ECI1” was asserted and an event capture taken. The data from the event is stored in the Fault Records.
Event Cap 1 Reset	Indicates that the control point “ECI1” was de-asserted.
Event Cap 2 Init	Indicates that the control point “ECI2” was asserted and an event capture taken. The data from the event is stored in the Fault Records.
Event Cap 2 Reset	Indicates that the control point “ECI2” was de-asserted.
Ext Close Disabled	Indicates that the control point “Close” was de-asserted.
Ext Close Enabled	Indicates that the control point “Close” was asserted. This record indicates the state of the control point “Close” only. It does not imply an actual breaker close.
Ext Trip Disabled	Indicates that the control point “Open” was de-asserted.
Ext Trip Enabled	Indicates that the control point “Open” was asserted. This record indicates the state of the control point “Open” only. It does not imply an actual breaker trip.
Ext. BFI Enabled	Indicates that the Ext. BFI protection was enabled.
Ext. BFT Disabled	Indicates that the Ext. BFI protection was disabled.
Ext. Trip & ARC	Indicates that the TARC (Trip and Auto Reclose) control point became a logical 1 and the relay went through the reclose cycle.
Ext. Trip CB Stuck	Indicates that the 52A contact opened and the 52B contact closed but current is still flowing through the relay.
External Close	Indicates that the REF 550 saw the breaker close via the 52A and 52B Programmable Logic inputs, but the relay did not cause the breaker to open.
External Trip	Indicates that the REF 550 saw the breaker open via the 52A and 52B Programmable Logic inputs, but the relay did not cause the breaker to open.

Table 7-2. Operations Log Listing (cont.)

Failed to Sync	Logged after a trip and during a reclose sequence, the Sync Fail Timer times out.TOC Pickup -?No Trip Indicates that a time overcurrent element pickup up but did not result in a trip output.
Grnd.TC Disabled	Indicates that the “GRDTC” control point was de-asserted and the active ground overcurrent elements disabled. The “GRDTC” control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the “GRDTC” control point is forced open in the Operations Menu (see Operations menu section). This record indicates the state of the “GRDTC” input only.
Grnd.TC Enabled	Indicates that the “GRD” control point was asserted and the active ground overcurrent elements enabled. The “GRD” control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the “GRD” control point is forced Closed in the Operations Menu (see Operations menu section). This record indicates the state of the “GRD” input only.
HIF Detect™	The decision logic for the HIF Detect™ feature has detected a high impedance ground fault condition
HIF Unit Disabled	Indicates that the control point “HIFTC” was de-asserted and the HIF Detect™ feature is disabled.
HIF Unit Enabled	Indicates that the control point “HIFTC” was asserted and the HIF Detect™ feature is enabled.
High PF Alarm	Indicates that the power factor has risen above the High Power Factor Alarm setting. See Section 5, specifically the “HPFA” output, for more details.
KVAr Demand Alarm	Indicates that the demand KiloVArs have exceeded the Demand KiloVAr Alarm setting. See Section 5, specifically the “VARDA” output, for more details.
LBDL	Live bus dead line is logged when the 25 function is in the unknown state and transitions to the LBDL state.
LBLL	Live bus live line is logged when the 25 function is in the unknown state and transitions to the LBLL state.
Line Sync Lost	Indicates that the status point “25” has transitioned from a logical 1 to a logical 0.
Lines Synced	Indicates that the status point “25 has transitioned from a logical 0 to a logical 1.
LIRn Asserted	Indicates the control point LIRn has become asserted, where n = 1 to 8.
LIRn Deasserted	Indicates the control point LIRn has become deasserted, where n = 1 to 8.
LISn Asserted	Indicates the control point LISn has become asserted, where n = 1 to 8.
LISn Deasserted	Indicates the control point LISn has become deasserted, where n = 1 to 8.
LO0n Asserted	Indicates the status point LO0n has become asserted, where n = 1 to 8.
LO0n Deasserted	Indicates the status point LO0n has become deasserted, where n = 1 to 8.
Load Alarm	Indicates that the load current has exceeded the Load Current Alarm setting. See Section 5, specifically the “LOADA” output, for more details.
Low PF Alarm	Indicates that the power factor has gone below the Low Power Factor Alarm setting. See the Section 5, specifically the “LPFA” output, for more details.
MDT Close	Indicates that a circuit breaker close was issued by the REF 550 while it was in the MDT mode. See the Multiple Device Trip (MDT) sections for details on MDT tripping.

Table 7-2. Operations Log Listing (cont.)

Neg. KVAr Alarm	Indicates that the negative KiloVArs have exceeded the negative KiloVAr Alarm setting. See Section 5, specifically the "NVArA" output, for more details.
Neutral Demand Alarm	Indicates that the neutral demand current has exceeded the Neutral Demand Current Alarm setting. See Section 5, specifically the "NDA" output, for more details.
OC Trip Counter	Indicates that the Overcurrent Trip Counter has exceeded the Overcurrent Trip Counter Alarm setting. See Section 5, specifically the "OCTC" output, for more details.
Open Trip Contact	Indicates that an open trip contact exists, or open trip circuit.
Phase Demand Alarm	Indicates that the phase demand current has exceeded the Phase Demand Current Alarm setting. See Section 5, specifically the "PDA" output, for more details.
Phase TC Disabled	Indicates that the "PH3" control point was de-asserted and the active phase overcurrent elements disabled. The "PH3" control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the "PH3" control point is forced open in the Operations Menu (see Operations menu section). This record indicates the state of the "PH3" input only.
Phase TC Enabled	Indicates that the "PH3" control point was asserted and the active phase overcurrent elements enabled. The "PH3" control point must be assigned to a physical input or feedback term for this record to appear. It will also appear if the "PH3" control point is forced closed in the Operations Menu (see Operations menu section). This record indicates the state of the "PH3" input only.
Pos Watt Alarm 1	Indicates that the positive kilowatts have exceeded the Positive Kilowatt Alarm 1 setting. See Section 5, specifically the "Pwatt1" output, for more details.
Pos Watt Alarm 2	Indicates that the positive kilowatts have exceeded the Positive Kilowatt Alarm 2 setting. See Section 5, specifically the "Pwatt2" output, for more details.
Pos. KVAr Alarm	Indicates that the positive KiloVArs have exceeded the Positive KiloVAr Alarm setting. See Section 5, specifically the "PVArA" output, for more details.
Primary Set Active	Indicates that a transition from an Alternate settings group took place and that the Primary settings are active at this point in the record.
RAM Failure	Indicates a failure of the REF 550 Random Access Memory. Contact ABB technical support at this time.
Reclose Initiated	Indicates that the REF 550 has entered into the reclose sequence.
Recloser Disabled	Indicates that the 43A control point became de-asserted or was mapped to a non active physical input or feedback term. . This record indicates the state of the "43A" input only. This log will appear even if the Recloser is disabled at 79-1 in the active settings group.
Recloser Enabled	Indicates that the "43A" control point became asserted or was unmapped to a physical input or feedback term. This record indicates the state of the "43A" input only. This log will appear even if the Recloser is disabled at 79-1 in the active settings group.
Recloser Lockout	Indicates a recloser lockout state. See the Recloser section for details on lockout conditions.
ReTrip Operation	Indicates operation of the ReTrip status point. See Section 1 under "Breaker Failure Logic" for more details.

Table 7-2. Operations Log Listing (cont.)

ROM Failure	Indicates a failure of the REF 550 Read Only Memory. Contact ABB technical support at this time.
SEF Disabled	Indicates that the Sensitive Earth Fault programmable logic input, “SEFTC” has transitioned from a logical 1 to a logical 0 disabling the SEF element if used. See the Sensitive Earth Fault section for details on SEF operation.
SEF Enabled	Indicates that the Sensitive Earth Fault programmable logic input, “SEFTC” has transitioned from a logical 0 to a logical 1 enabling the SEF element if used. See the Sensitive Earth Fault section for details on SEF operation.
SEF Trip	Indicates that a Sensitive EarthFault “SEF” has produced an output. See the Sensitive Earth Fault section for details of SEF operation.
Self Test Failed	Indicates a failure of the REF 550 during the self check procedure. See the servicing section for more details.
Shift-A	Indicates the control point “Shift_A” has become asserted.
Shift-B	Indicates the control point “Shift_B” has become asserted
Springs Charged	Indicates the state of the Spring Charging Contact, “SCC”, control point. This record will appear when the “SCC” input transitions from a logical 0 to a logical 1. See Section 5, specifically the “SCC” input, for more details.
Springs Discharged	Indicates the state of the Spring Charging Contact, “SCC”, control point. This record will appear when the “SCC” input transitions from a logical 1 to a logical 0. See Section 5, specifically the “SCC” input, for more details.
St Bat High	Indicates the substation battery is measuring above a programmed time.
St Bat Low	Indicates the substation battery is measuring above a programmed time.
Supervisory Disable	Indicates that the control point “Local/SupV” has transitioned from a logical 1 to a logical 0.
Supervisory Enabled	Indicates that the control point “Local/SupV” has transitioned from a logical 0 to a logical 1.
Sw Set	Indicates the control point “:SWSET” has become asserted.
Sync Bypass Disabled	Indicates that the control point “25BYP” has transitioned from a logical 1 to a logical 0.
Sync Bypass Enabled	Indicates that the control point “25BYP” has transitioned from a logical 0 to a logical 1.
Sync Check Disabled	Indicates that the Sync Check control point “25TC” has transitioned from a logical 1 to a logical 0. See Section 1 for more details on Sync Check.
Sync Check Enabled	Indicates that the Sync Check control point “25TC” has transitioned from a logical 0 to a logical 1. See Section 1 for more details on Sync Check.
System Reboot Init.	Indicates that the relay was rebooted.
TARC Closed	Indicates that the control point Trip and Auto Reclose, “TARC”, transitioned from a logical 0 to a logical 1. See Section 5, specifically the “TARC” input for more details on “TARC” operation. Logs when an External Trip and Auto reclose occurred.

Table 7-2. Operations Log Listing (cont.)

TARC Opened	Indicates that the control point Trip and Auto Reclose, "TARC", transitioned from a logical 1 to a logical 0. See Section 5, specifically the "TARC" input for more details on "TARC" operation.
TCM Input Closed	Indicates the state of the Trip Circuit Monitor,"TCM", control point. This record will appear when the "TCM" input transitions from a logical 0 to a logical 1. See Section 5, specifically the "TCM" input, for more details.
TCM Input Opened	Indicates the state of the Trip Circuit Monitor,"TCM", control point. This record will appear when the "TCM" input transitions from a logical 1 to a logical 0. See Section 5, specifically the "TCM" input, for more details.
Trip Coil Failure	Indicates that the control point "TCM" indicated a trip coil failure. See Section 5, specifically the "TCM" input.
TR_OFF Asserted	Indicates the HLT status point "TR_OFF" has become asserted.
TR_ON Asserted	Indicates the HLT status point "TR_ON" has become asserted.
TR_TAG Asserted	Indicates the HLT status point "TR_TAG" has become asserted.
TR_RST Asserted	Indicates the HLT control point "TR_RST" has become asserted.
TR_RST Deasserted	Indicates the HLT control point "TR_RST" has become deasserted.
TR_SET Asserted	Indicates the HLT control point "TR_SET" has become asserted.
TR_SET Deasserted	Indicates the HLT control point "TR_SET" has become deasserted.
UL1 Input Closed	Indicates that the User Control point, UL1, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL1 Input Opened	Indicates that the User Control point, UL1, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL2 Input Closed	Indicates that the User Control point, UL2, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL2 Input Opened	Indicates that the User Control point, UL2, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL3 Input Closed	Indicates that the User Control point, UL3, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL3 Input Opened	Indicates that the User Control point, UL3, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL4 Input Closed	Indicates that the User Control point, UL4, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL4 Input Opened	Indicates that the User Control point, UL4, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL5 Input Closed	Indicates that the User Control point, UL5, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL5 Input Opened	Indicates that the User Control point, UL5, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL6 Input Closed	Indicates that the User Control point, UL6, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.

Table 7-2. Operations Log Listing (cont.)

UL6 Input Opened	Indicates that the User Control point, UL6, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL7 Input Closed	Indicates that the User Control point, UL7, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL7 Input Opened	Indicates that the User Control point, UL7, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL8 Input Closed	Indicates that the User Control point, UL8, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL8 Input Opened	Indicates that the User Control point, UL8, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL9 Input Closed	Indicates that the User Control point, UL9, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL9 Input Opened	Indicates that the User Control point, UL9, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL10 Input Closed	Indicates that the User Control point, UL10, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL10 Input Opened	Indicates that the User Control point, UL10, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL11 Input Closed	Indicates that the User Control point, UL1, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL11 Input Opened	Indicates that the User Control point, UL1, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL12 Input Closed	Indicates that the User Control point, UL12, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL12 Input Opened	Indicates that the User Control point, UL12, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL13 Input Closed	Indicates that the User Control point, UL13, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL13 Input Opened	Indicates that the User Control point, UL13, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL14 Input Closed	Indicates that the User Control point, UL14, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL14 Input Opened	Indicates that the User Control point, UL14, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL15 Input Closed	Indicates that the User Control point, UL15, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.
UL15 Input Opened	Indicates that the User Control point, UL15, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
UL16 Input Closed	Indicates that the User Control point, UL16, transitioned from a logical 0 to a logical 1. See Section 5 for more details on User Control points.

Table 7-2. Operations Log Listing (cont.)

UL16 Input Opened	Indicates that the User Control point, UL16, transitioned from a logical 1 to a logical 0. See Section 5 for more details on User Control points.
User Displayed On	Indicates that the control point UDI is enabled.
User Displayed Off	Indicates that the control point UDI is disabled.
Wave Cap Init	Indicates that the control point “DFR Init” was asserted and an oscillographic record stored. The data from the event is stored in the Waveform Capture Records.
Wave Cap Reset	Indicates that the control point “DFR Init” was de-asserted.
Waveform Capture	Indicates that the Digital Fault Recorder has been triggered.
Zone Seq. Disabled	Indicates that the control point “ZSCTC” was de-asserted and the Zone Sequence Coordination function was disabled. This record indicates the state of the “ZSCTC” input only. This log will appear even if the Zone Sequence Coordination function is disabled in the Configuration settings.
Zone Seq. Enabled	Indicates that the control point “ZSCTC” was asserted and the Zone Sequence Coordination function was enabled. This record indicates the state of the “ZSCTC” input only. This log will appear even if the Zone Sequence Coordination function is disabled in the Configuration settings.
Zone Step	Indicates that a zone sequence coordination operation occurred. See the Zone Sequence Coordination section for details.

Operations Summary

The Operations Summary includes:

- Summation of breaker interruption duty on a per-phase basis in KSI (thousand symmetrical amperes)
- Number of overcurrent trips
- Total number of reclosures (both counters)
- Number of breaker operations (overcurrent, load current and no load)
- Number of successful reclosings by reclosure sequence number (1st, 2nd, 3rd and 4th)

The Operations Summary data are useful preventive maintenance tools that can improve the reliability of service through tracking of breaker activity. The data are stored in non-volatile memory and will be retained with a loss of a cycling of control power. It is recommended that these data are saved to a separate memory device, e.g., computer hard drive, before a unit is flash upgraded to the latest CPU firmware. Save the Operations Summary as a file using WinECP.

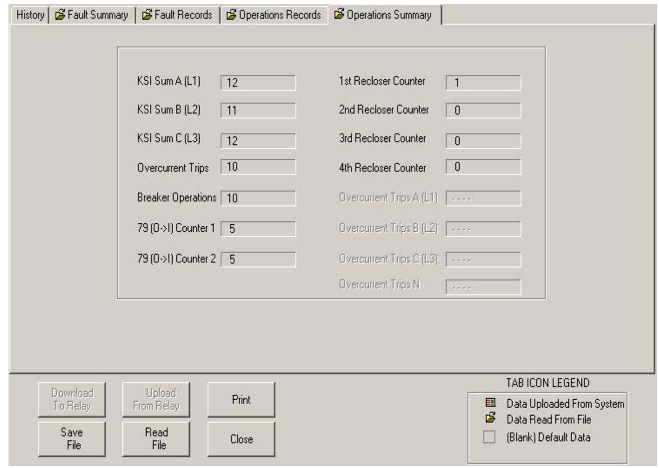

Figure 7-5. Operations Summary

Load Profile

A standard load profile feature records per-phase demand kilowatts, demand kiloVARs and line-to-ground voltages. You can select a 5-, 15-, 30- or 60-minute time interval (Demand Meter Constant) for which the load profile record then contains 13.3, 40, 80 or 160 days of information, respectively (default is 15 minutes and 40 days). The load profile feature requires Wye-connected VTs to accurately measure per-phase kilowatts and kiloVARs for unbalanced loads. For Delta-connected VTs, the load profile feature records three-phase kilowatts and kiloVARs, per-phase and ground demand currents and line-to-line voltages. You can retrieve this load profile data only through the Windows External Communications Program WinECP (see the WinECP Interface section), which stores the load profile and its header in a comma-delimited ASCII file. You can view this file by using any text editor program (word processor or spreadsheet). Figure 7-6 shows the comma delimited format of the Load Profile data stored in the REF 550 that is retrievable using WinECP. The graph in Figure 7-7 is a sample of the type of load profile data analysis that can be performed.

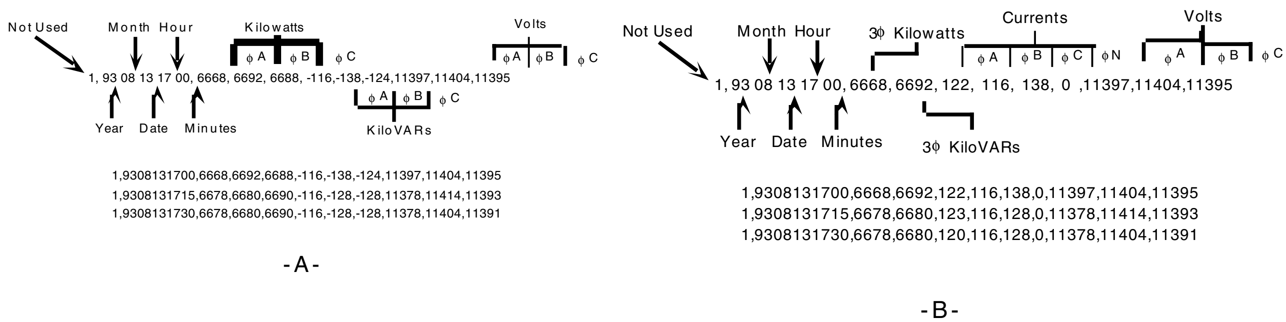

Figure 7-6. Sample Load Profile for (-A-) Wye-Connected VTs and (-B-) Delta-Connected VTs

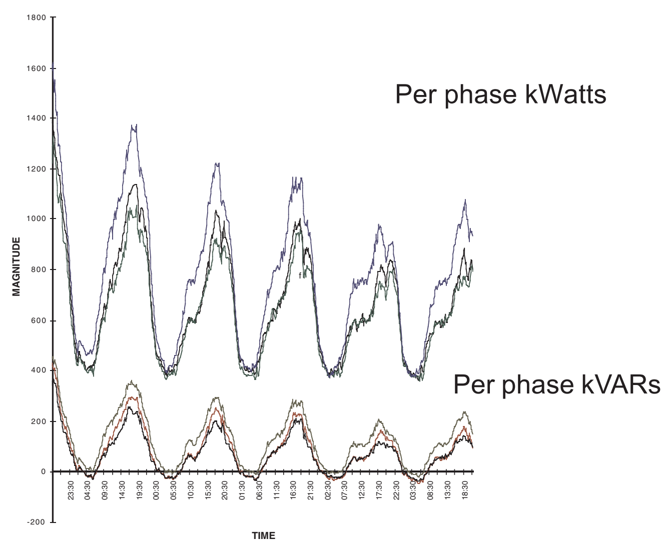

Figure 7-7. Load Profile Analysis

Using the Load Profile Feature

Use WinECP and follow these steps to retrieve and view the optional Load Profile feature information.

1. From the File Menu, choose Export (Figure 7-8). There are two Load Profile options from which to choose. The "Load Profile All " option will upload all the load profile data that is in the buffer. The "Load Profile" option will only upload the data that has been added to the buffer since the last upload. Choosing this option will reduce the transfer time if data was previously exported.

2. Create a file name in the "Save As" dialog box, and click "Save". The file will be saved in comma delimited format (.dla).

3. To view the Load Profile data, open the .dla file with a spreadsheet or word processor program. Follow the program manufacturer's directions for comma delimited data displaying. Many spreadsheet programs, such as Microsoft Excel, have features that allow data to be displayed in graphical form. Consult your spreadsheet's literature for instructions.

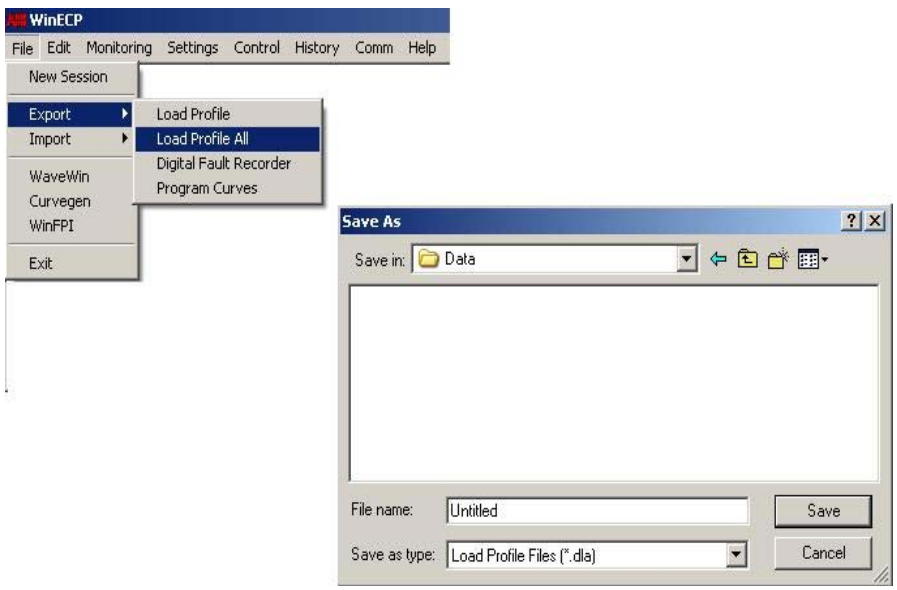

Figure 7-8. Load Profile Data Transfer

Digital Fault Recorder (DFR)

To enhance the ability to analyze fault and disturbance conditions, an advanced digital fault recorder (DFR) is provided as standard in the REF 550. This is referred to in this section of the instruction book as DFR - Digital Fault Recording.

The user can select to record any of the analog waveforms available at the analog inputs to the relay from the connected current and voltage transformers. The user selects the triggering sources and also specifies the number of cycles of pre-trigger and post-trigger data to be captured. Digital signals associated with the operation of the protective functions of the relay are also recorded. The data collected is held within the memory elements of the relay until downloaded to a file on your pc. Then a separate WaveWin Program is used to display the waveforms. This analysis program is supplied when the relay is ordered with the waveform capture feature.

Figure 7-9 shows the screen display when you access the DFR Settings menu item from the WinECP program.

Place an “X” in each box of protective elements that you wish to serve as triggering sources for a waveform recorcer. The operation of any one of these elements will cause a capture. You may also trigger a capture from an external contact closure by assigning a contact input to the control point “DFR Init.” See the Advanced Programmable Logic section.

Place an “X” in each box representing the analog input waveforms that you wish to capture.

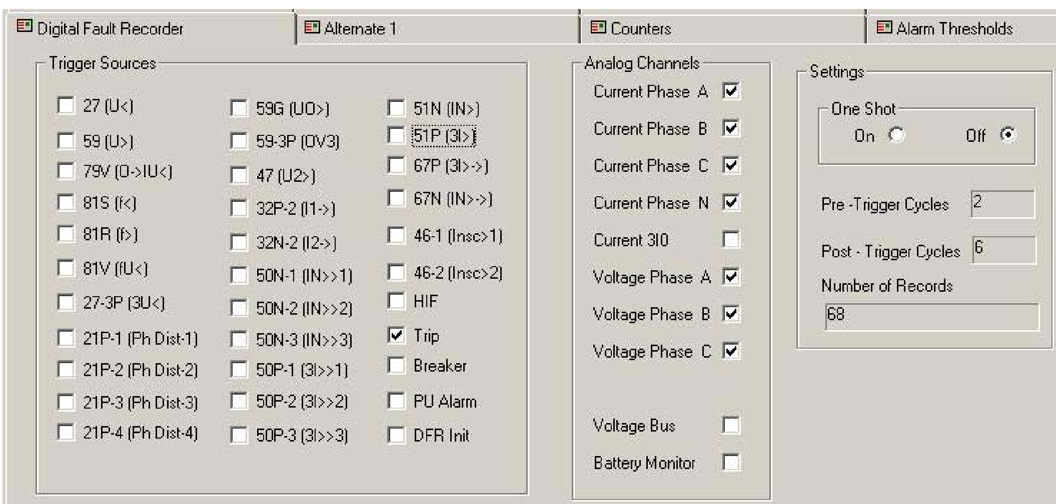

Figure 7-9. Digital Fault Recorder

Record Length and Number of Analog Channels
The installed Digital Fault Recorder comprisesa specific amount of memory within the REF 550 that is available for data storage. The following equation defines the relationship between the number of analog channels that can be recorded, the number of power system cycles that can be recorded per record, and the number of records that can be stored.

Record Size = (1 + CH) * (1 + CY)   Where: CH = number of analog channels selected
CY = number of cycles per record

Maximum Number of Records that can be Stored = 6081 / (Record size)

Record size is allocated equally to each event. As an example, if we choose 9 analog channels, and a record length of 60 cycles, then record size is (10*61) = 610, and we have space for 6081/610 = 9 events. A slightly better allocation would be 66 cycles, (10*67) = 670, 6081/670 = still 9 events, but we gain an additional 6 cycles of record length.

Also in this example, in the waveform capture settings we must allocate the 66 cycles to pre-trigger and post-trigger portions. So we might select 4 cycles pre-trigger, and 62 cycles post-trigger. You must allocate at least one cycle to the pre-trigger storage.

Modes of Operation: One-Shot and Continuous
One-shot recording can be enabled or disabled in the DFR feature. In the One-Shot mode, new events will be recorded until the available memory is filled, then no more events will be recorded even though a selected trigger source is active. So it is not truly a one-shot mode, but rather a “several-shot” mode depending on how you have allocated the available memory.

When in the One-shot mode the relay automatically stops data accumulation when the space available has been filled. Important: After the records are transferred to your pc, you must re-initialize the DFR feature by going to the WinECP Control/Digital Fault Recorder/Start menu.

In a continuous mode where the One-shot is off or disabled, new records are stored as triggering events occur, and when the memory is filled, the oldest event will be lost when the newest record is stored. In the Continuous mode, the storage capability is one less than in the One-shot mode due to the need to record pre-trigger data which is being stored continuously for the “next” record.

Digital Data Captured in Digital Fault Records
The digital data being stored along with the analog data is stored every quarter cycle. The pickup status of each of the protective functions is stored. The operation of any of the protective functions is stored. And the operation of the Master Trip output, the 52a control point, and the Blown Fuse alarm output are recorded.

Triggering Details
Once a trigger is received, further triggers are ignored until the complete record has been stored.

Triggers occuring before the pre-trigger buffer is filled are ignored. Triggers are “edge-triggered”; therefore, any event that causes a trigger must be de-asserted and then re-asserted to obtain a second trigger.

DFR Settings Changes

Use the WinECP Settings menu and the Digital Fault Recorder tab sheet to make DFR settings changes. When the changes have been made, click on “DOWNLOAD to the Relay”. Note: There will be a prompt informing the editor that changing the DFR settings will clear all previous records stored on the current settings and asking if continuation is desired. Continue if the existing DFR data have been transported to a memory storage device or is deemed unimportant. Do not continue if stored records are important and need first to be transferred to a memory device.

When a new set of DFR settings are programmed, the unit takes several seconds to reconfigure the DFR memory allocation, and no records will be recorded during this period. <u>All previous DFR records retained in the memory are lost when the DFR settings are changed, therefore they should be downloaded to files on your pc prior to making any changes.</u>

After the new settings are accepted by the REF 550, the unit will self restart the DFR accumulation. Always verify using the WinECP/Monitoring/DFR Data menu.

Stop/Start Data Digital Fault Recorder

The WinECP/Control/Digital Fault Recorder menu item Start/Stop allows the user to enable or disable the DFR function. When Stop is selected, the records already in the memory are retained and no additional records will be taken until the Start command is initiated.

Important: After making a settings change, or after re-loading your One-shot settings to re-initialize the capture memory, the REF 550 will automatically restart DFR accumulation. Verify this is the case using the WinECP/Monitoring/DFR Data menu.

Transferring a Digital Fault Record to a Memory Device

Use the WinECP File/Export/Digital Fault Recorder menu to view and retrieve stored records. Each DFR includes a number and time stamp. Then, select the menu item Waveform Records. Select the desired record in the listing shown, enter the Relay Password and then save to the desired memory device. You will be prompted to enter the desired filename and path.

Comtrade Format

The DFR data is saved in the COMTRADE standard format, therefore the data files that are downloaded to your pc can be displayed by any analysis program that will accept files in this format.

Automation & Communications

The REF 550 offers the most state-of – the art communications available for any protection device on the market today. The communication port options vary depending upon the REF 550 selected. Several protocols are available including DNP 3.0 and Modbus and the formats of the protocols may vary from serial, protocol specific or Ethernet. With this selection, the interfaces may vary from RS 232, RS 485, fiber, and copper Ethernet.

This section is meant to briefly explain the interface options and provide a points list for each protocol.

Several steps are required to permit successful communication between devices:

1. Identification of the hardware components.
2. Correct physical connection between devices.
3. Correct device configuration of port protocol and operation parameters.
4. Generation and interpretation of the protocol command strings.

Section 8 contains the general procedures to complete steps 1 through 4 when establishing a communication automation system, utilizing the REF 550. Figure 8-1 shows the general look of the units as viewed from the front.

Figure 8-1. REF 550 Protection Relay

The products differentiate themselves as listed in Table 8-1. Table 8-1 lists the available protocols within the relays. Standard Ten Byte is an ABB protocol which is within each of the protective relays. Standard Ten Byte is an asynchronous byte oriented protocol. The programming software (WIN ECP) allows configuration of the relay through a port on the units. Standard Ten Byte is available through an RS 232 or RS 485 port on the REF 550.

Serial Modbus is an industrial de-facto standard protocol, which has been widely embraced by the utility industry. Modbus has two emulation’s, RTU, which is a synchronous protocol and ASCII, which is an asynchronous protocol. Modbus uses only one command set, but two emulation’s. Modbus strengths are that it uses a standard RS 232 or RS 485 interface to interconnect nodes on a network.

TCP/IP Modbus is an evolution of Serial Modbus in that it uses Ethernet as the mechanism to transfer the Modbus Serial packets across an Ethernet LAN. It is gaining in popularity in that several protocols and network transmissions may peaceably coexist on a single network cable. TCP/IP Modbus has its own protocol conventions and is not merely initiation of an Ethernet TELNET session over the Local Area Network (LAN).

Modbus Plus is a hybrid protocol refinement of Modbus. Modbus Plus has a proprietary physical interface which is available to device manufacturers through a connectivity program with Groupe Schneider. The interface offers greater speed and communication features than Modbus.

DNP 3.0 is a protocol, which has its roots deep in the utility industry. It is an asynchronous protocol that allows connectivity through a standard RS 232 or RS 485 port. It includes such defined capabilities as file transfer, and timestamping as part of the protocol, which makes it desirable for a utility implementation. 61850 is a newly emerging protocol based upon an object oriented device structure. Instead of the traditional mindset of data access using address, index terminology, data is retrieved or modified by using predefined “names” to access or modify data. The hardware topology employed for this new protocol is Ethernet (just as that for Network Modbus), however the messaging structure and data access definitions are markedly different. 61850 is not available for the REF 550, but it’s architecture makes it so that an existing unit may be upgraded to the protocol standard once it is available and certified by the standards committee (UCA and IEC).

Table 8-1. Protocol Capabilities Listed by Product Type

Product	Protocol	Notes
REF 550	Standard Ten Byte	RS 232 or RS 485
	Serial Modbus	RS 232 or RS 485
	Modbus Plus	Proprietary Current Injection Physical Interface
	TCP/IP Modbus	Ethernet Interface Copper or Fiber Optic
	DNP 3.0 Level 2+	RS 232 or RS 485

Product Identification

The REF 550 offers interchange-able cards which allow the rear communication ports to function. Table 8-2 lists the REF 550 part number designators for the communication cards and their associated protocols. Please refer to Section 12 and the product ordering table for further information concerning product selection.

Table 8-2. REF 550 Communication Card Matrix for Unit 5 5 0 X X X X Y – X X X X X

“Y” Digit	COM 3	AUX COM
A	Standard 10 Byte or DNP 3.0 **RS 232 Physical Interface**	Standard 10 Byte or DNP 3.0 **RS 485 Physical Interface**
B	Standard 10 Byte or Modbus **RS 232 Physical Interface**	Standard 10 Byte or Modbus **RS 485 Physical Interface**
C	Standard 10 Byte or DNP 3.0 **RS 485 Physical Interface**	Standard 10 Byte or DNP 3.0 **RS 485 Physical Interface**
D	Standard 10 Byte or Modbus **RS 485 Physical Interface**	Standard 10 Byte or Modbus **RS 485 Physical Interface**
E	Not Operable	Modbus TCP/IP , Simple Network Time Protocol (SNTP) Standard 10 Byte TCP/IP **10/100 Base T Copper – 10 FL Fiber Physical Interface**
G	Modbus Plus Protocol **Modbus Plus Physical Interface**	Standard 10 Byte Protocol or Modbus Serial Protocol **RS 485 Physical Interface**
H	Modbus Plus Protocol **Modbus Plus Physical Interface**	Standard 10 Byte Protocol or Modbus Serial Protocol **RS 232 Physical Interface**

The visual identification of a REF 550 communication card is completed through visual inspection of the card component location and of the part number of the base printed circuit board. Product specific protocol documentation is available from the factory on request or via the ABB website: www.abb.com/substationautomation. The documentation numbers are:

DNP 3.0 Protocol – TG 7.11.1.7-70 REF 550 DNP Level 2+ Automation Guide

Modbus Protocol – TG 7.11.1.7-74 REF 550 Modbus Serial/Modbus Plus/ Modbus TCP/IP Automation Guide

For part number 550 X X X X Y- X X X X X , the Y protocol descriptor is further described as follows:

Option 0 – This option provides RS 232 communication via the non-isolated COM 2 port and is suitable only in applications where communication to the unit is through a direct connection to a PC or remote through an external isolating communication device , such as an RS 232 to fiber optic converter which is attached to the relay using a short cable.

Option A or B – These options provide RS 232 communication interfaces via isolated COM 3 port and RS 485 communication via the isolated AUX COM port. The auxiliary port is an isolated RS 485 configuration that supports several communication protocols (as listed in table 8-3). COM 2 is disabled in this configuration.

Option C or D – These options provide dual RS 485 communication via the isolated COM 3 ort (DB 9) and the AUX COM ports. The COM 2 port is disabled in this configuration.

Option E – This option provides Ethernet 10/100 copper interface or Fiber Optic 10 Base F. The COM 3 and COM 2 ports are disabled for this configuration.

Option G- This option provides a Modbus Plus high speed interface via COM 3 port, and an RS 485 interface via the isolated RS 485 port. The AUX COM port is disabled in this configuration. The COM 2 port is disabled in this configuration

Option H – This option provides a Modbus Plus high speed interface via the COM 3 port, and RS 232 physical interface via the COM 3 port. The AUX COM port is disabled in this configuration.

REF 550 Device Connection

Communication between devices is only possible through connectivity of the units through a physical media interface. There are various physical interface types on a REF 550. Table 8-3 lists the characteristics for each of the port types. Those physical interfaces are:

1) RS232 (isolated and non-isolated)

2) RS485 (isolated)

3) Fiber Optic

4) Proprietary (Modbus Plus)

Table 8-3. Physical Interface Options

Port	Configuration	Notes
COM 1	RS232 Non Isolated	Front Port Standard 10 Byte
COM 3	RS232 Isolated/RS485 Isolated or Modbus Plus	REF 550- Communicatioin Option Card Determines Physical Interface
AUX COM	RS485 (Isolated) and/or INCOM or 10/100 Base T/10 Base FL Ethernet	Physical Interface Dependent on Communication Option Card Interface Selected

The connection varies depending upon the product type. A brief explanation of the interfaces and protocols follow in their interconnection.

RS 232 Front Port Connection:

The REF 550 offers a non-isolated RS 232 interface allowing for configuration using the WIN ECP utilities. The cabling connection is illustrated in Figure 8-2.

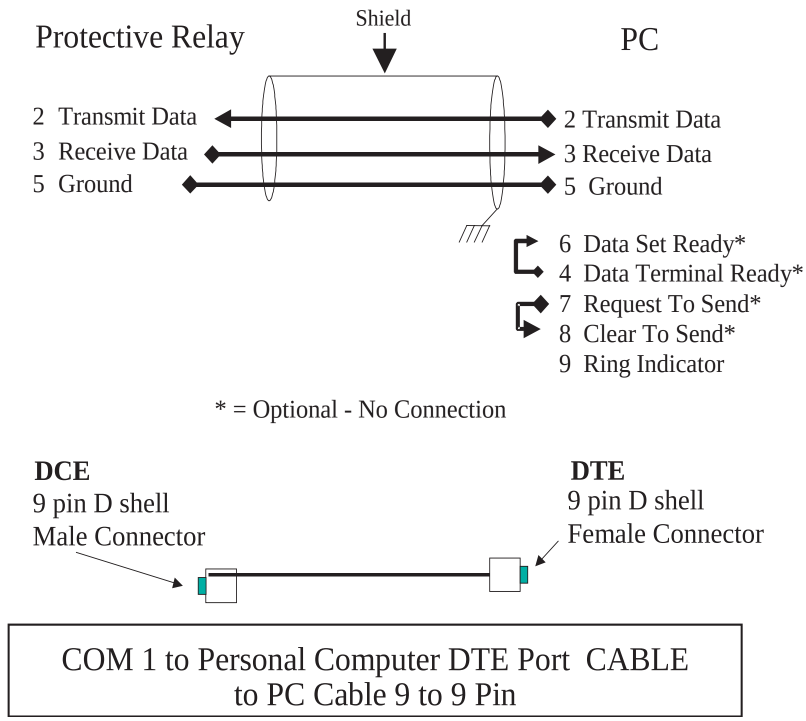

FIGURE 8-2: REF 550 Front Panel Com 1 Connection Cable Diagram

If connectivity is required through the Com 3 communication port located at the rear of the relay as illustrated in Figure 8-3, then the port is a DTE emulation which may require handshaking controls depending upon the relay application. If connectivity is required through the Com 3 communication port located at the rear of the relay as illustrated in Figure 8-2, then the port is a DTE emulation which may require and shaking controls depending upon the relay application. Figure 8-4 illustrates the cable for a null modem connection cable for a DTE to DTE connection.

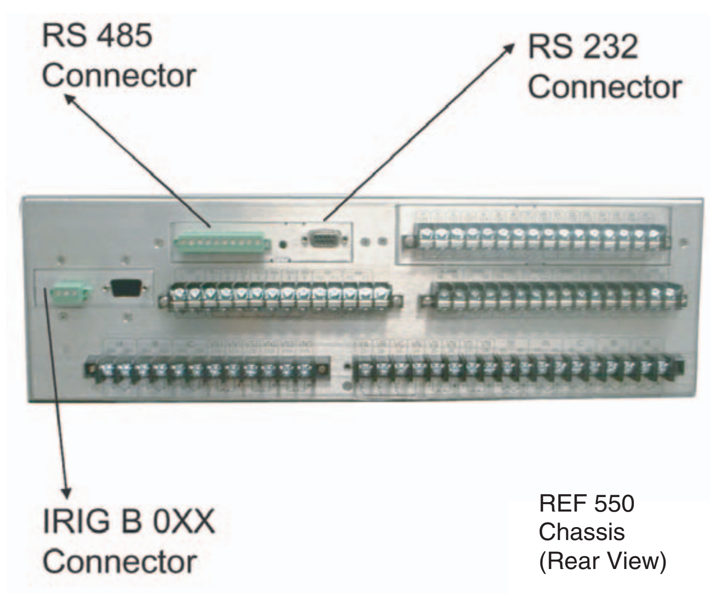

Figure 8-3: Communication Port Location

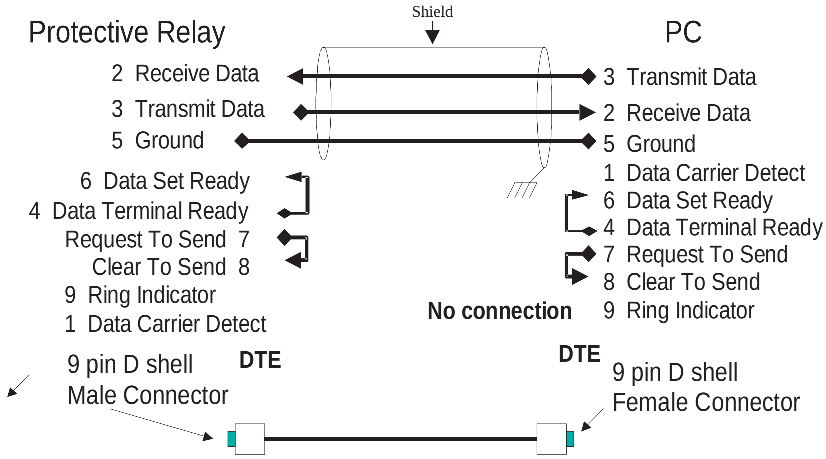

Figure 8-4 RS 232 DTE to DTE NULL Modem Connector

FRONT PORT COM 1 RS 232 Pinout

Pin	Name	
1	N.C.	
2	RxD	Receive Data
3	TxD	Transmit Data
4	N.C.	
5	Common*	
6	N.C.	
7	N.C.	
8	N.C.	
9	N.C.	

*Common is the common return for COM3 Isolated +5V, +7-12V, and RS-232 signals

REAR PORT COM 3 RS 232 Pinout

Pin	Name	
1	N.C.	
2	RxD	Receive Data
3	TxD	Transmit Data
4	7 – 12V DC	
5	Common*	
6	N.C.	
7	RTS**	Request to Send
8	CTS**	Clear to Send
9	Isolated +5V	

*Common is the common return for COM3 Isolated +5V, +7-12V, and RS-232 signals
** Note: Not supported for card options A, C, D, E, F, G

RS 485 Connectivity

The REF 550 also offers RS 485 connectivity. The RS 485 port is isolated to 2.5 kV. The RS 485 port has internal resistors to select 2- Wire or 4- Wire hardware port emulation. Additionally, several jumpers are available for selection of pull-up or pull –down resistors as well as selection of termination resistors.

If the product selection for the protocol is "D" (as per table 8-1), the connectivity hardware pin-out for the port is as follows. Note RS 485 4-wire emulation is not supported on the COM 3 , option D board at this time. Reference Table 8-4 for the RS 485 COM 3 pinout for the REF 550.

Table 8-4: RS 485 COM 3 Port Pin out.

COM 3 RS 485 Pin Number	Description
1	RS 485 + (2 Wire Emulation)
2	RS 485 - (2 Wire Emulation)
3	Reserved
4	Reserved
5	Reserved
6	Reserved
7	RS 485 Common (Isolated)
8	+ 5 VDC at 100 mA

If the AUX COM port is used, the pin out of the communication card listed in Table 8-5.

Figure 8-5 illustrates a 2 Wire connection between a host and REF 550 devices. Note that a separate Ground wire must be added to provide reference to the isolated port. Recommended wire types for 2 Wire RS 485 circuits are Belden 3106A, or Alpha 6222C or Carol CO 271. Please contact the factory for recommended 4 Wire RS 485 wire sets.

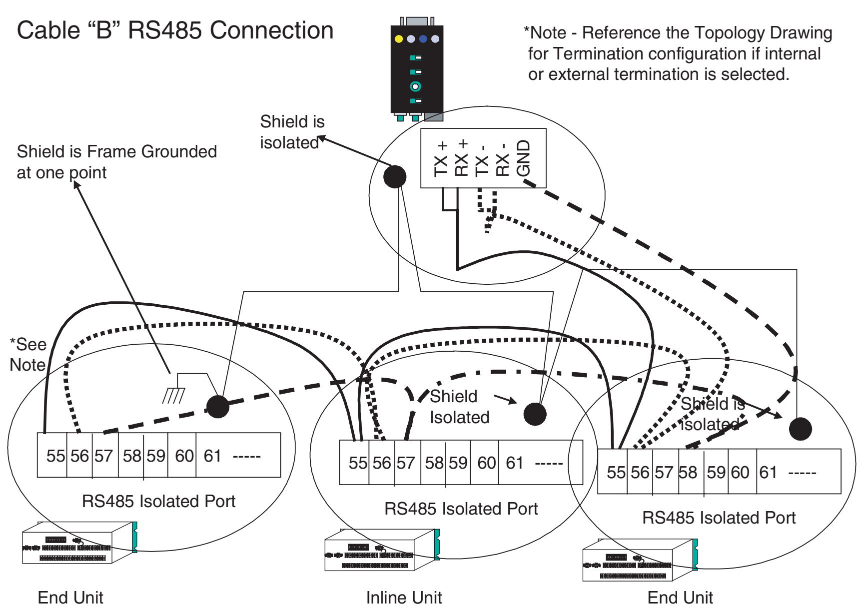

Figure 8-5. RS485 Communication Cabling REF 550 2 Wire Connection

Tables 8-5 list the RS 485 Jumper positions to enable 4 Wire/2 Wire and insert the termination/PULL UP/PULL DOWN resistors. Table 8-6 lists the AUX COM Pinouts for connection of wires.

Table 8-5 : AUX COM Pin Desigations for device interconnection

AUX COM 485 Pin Number	Description If Jumpers J4 and J5 are in the IN position (2 Wire Emulation)	Description If Jumpers J4 and J5 are in the OUT position (4 Wire Emulation)
55	RS 485 + (2 Wire Emulation)	RS 485 TX + (4 Wire Emulation)
56	RS 485 - (2 Wire Emulation)	RS 485 TX - (4 Wire Emulation)
57	Common*	Common*
58	Reserved	RS 485 TX + (4 Wire Emulation)
59	Reserved	RS 485 TX - (4 Wire Emulation)
60	+5 VDC at 100 mA	+5 VDC at 100 mA
61	RS 485 Common (Isolated)	RS 485 Common (Isolated)
62	Incom	Incom
63	Incom	Incom
64	IRIG B+	IRIG B+
65	IRIG B-	IRIG B-

* Common is the common return for all Aux Com RS-485 signals, isolated +5V

The resistor combination for the RS 485 port is as follows:

Table 8-6: RS 485 Card Jumper Position Locations.
(Option A comm. card only)

Jumper Number	JUMPER "IN"	JUMPER "OUT"
Jumper J4	2 Wire RS 485*** (Jumper Position must agree with J5)	4 Wire RS 485
Jumper J5	2 Wire RS 485*** (Jumper Position must agree with J4)	4 Wire RS 485
Jumper J8	Pull Up Resistor 583 Ohms Inserted in Circuit (Pin 55 Pulled up to +5 VDC)	Pull Up Resistor Out of Circuit**
Jumper J7	Pull Up Resistor 583 Ohms Inserted in Circuit (Pin 56 Pulled down to ground)	Pull Down Resistor Out of Circuit**
Jumper J6	Termination Resistor 120 Ohms Inserted in Circuit (Pins 55/56 terminated)	No Termination Rsistor in Circuit**
Jumper J3	Termination Resistor 120 Ohms Inserted in Circuit (Pins 58/59 terminated)	No Termination Resistor in Circuit.
** = Factory Default Settings		

Serial Port Communication Indications

The DNP and Modbus Serial protocol cards have an LED that is visible at the back of the relay. The LED is a BICOLOR LED. The LED will illuminate when the REF 550 receives a communication and answers to the communication. If the LED glows Green, then the REF 550 COM 3 port is responding to the network communication . If the LED glows RED, then the REF 550 AUX COM RS485 port is responding to the network communication.

REF 550 COMMUNICATION PORT CONFIGURATION

Each communication port must be configured for the appropriate communication port parameters. For all protocols the host device and the REF 550 must be configured for the same baud rate, data bits, and stop bits. Serial protocols such as Modbus ASCII, Modbus RTU, or DNP 3.0 require the port to be configured for the proper parameters. Protocols such as Modbus Plus, and Ethernet do not have configurable port parameters for the communication port speeds. Modbus Plus conforms to the packet structure defined by Schneider Electric (www.modicon.com) and Modbus Ethernet conforms to the parameters defined by the Modbus Users Group (www.modbus.org).

If the protocol is serial, then the unit address applies to all the ports. If the protocol is Modbus Plus, then the address of the IED is in the format of “ Unit Address. Path Address.0.0.0”. The Path Address is a number from 1 to 8. If the protocol is Ethernet, then as illustrated in Figure 8-I, the TCP/IP Version 4 address must be entered.

A sample configuration screen for Serial Modbus or DNP is illustrated in Figure 8-6. If an Ethernet TCP/IP card is installed, the grayed sections for TCP/IP addressing will be unlocked and available for IP address configuration by the user.

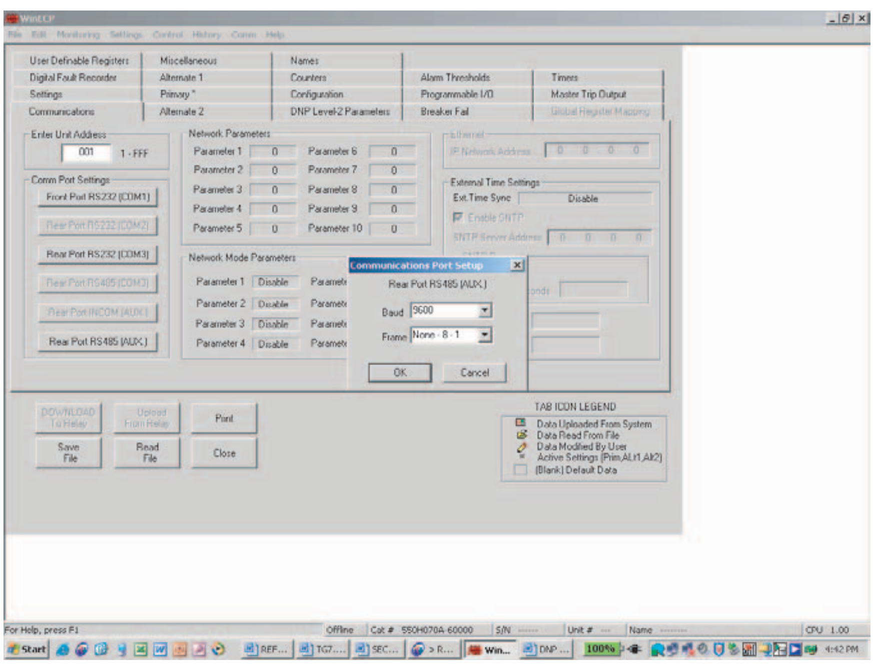

FIGURE 8-6: Modbus Serial or DNP 3.0 Serial Communication Port Configuration Screen

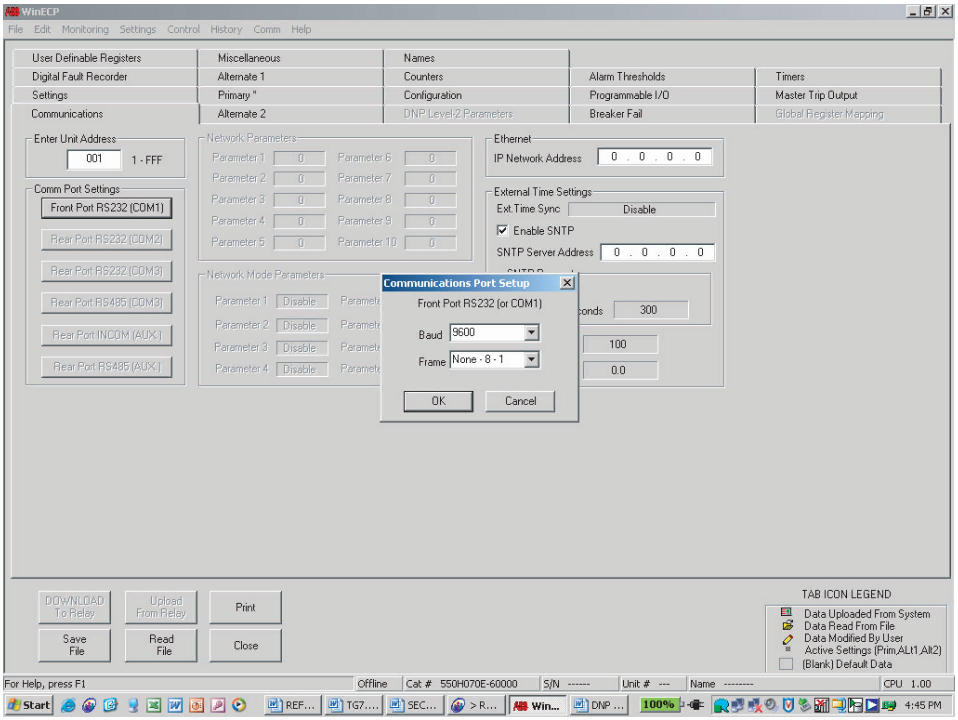

FIGURE 8-7: Modbus TCP/IP Communication Port Configuration Screen

As illustrated in Figures 8-6 and 8-7, several Parameters must be entered to properly configure the card. For Serial Modbus, the parameter selections enable the port and also select the protocol emulation. For DNP 3.0, the parameter selection enables the protocol's options and select the port by which the protocol DNP 3.0 will operate. Please consult the appropriate automation manuals for further information regarding Parameter and Mode Parameter configuration.

Modbus Register Addressing

The memory maps for the Modbus Serial Card (Protocol Options D and E), the Modbus Plus Communication Card (Protocol Option G or H), or the Modbus Ethernet Communication Card, is based upon the same memory map. The following tables list memory maps for 0X, 1X, and 4X

Although 6X memory in the REF 550 is assigned to store the relay configuration parameters, the memory map is not included in this document. Also If further explanation is required, please consult the REF 550 Automation Manual TG7.11.1.7-74 titled REF 550 Serial Modbus, Modbus Plus, and TCP/IP Modbus Automation Manual. Dated January 2005 Version 1.0

The memory map for access of 0X memory is listed in Tables 8-7 and 8-8.

Table 8-7: 0X Memory Register Access

Register	Description
1	TRIP
2	CLOSE
3	ALARM
4	27-1
5	46-1
6	50P1
7	50N1
8	50P2
9	50N2
10	50P3
11	50N3
12	51P
13	51N
14	59
15	67P
16	67N
17	81S-1
18	81R-1
19	PATA
20	PBTA
21	PCTA
22	TCFA
23	TCC
24	79DA
25	PUA
26	79LOA
27	BFA
28	PPDA
29	NPDA
30	BFUA
31	KSI
32	79CA-1
33	HPFA
34	LPFA
35	OCTC
36	50-1D
37	50-2D
38	STC
39	ZSC
40	PH3-D
41	GRD-D
42	32PA
43	32NA
44	27-3P
45	VARDA
46	79CA-2
47	TRIPA
48	TRIPB
49	TRIPC
50	27-1s
51	46-1s

Register	Description
52	50P-1s
53	50N-1s
54	50P-2s
55	50N-2s
56	50P-3s
57	50N-3s
58	51Ps
59	51Ns
60	59s
61	67Ps
62	67Ns
63	81S-1s
64	81R-1s
65	81O-1s
66	27-3Ps
67	TRIPAs
68	TRIPBs
69	TRIPCs
70	SPARE
71	SPARE
72	SPARE
73	SPARE
74	SPARE
75	SPARE
76	SPARE
77	SPARE
78	SPARE
79	PVARA
80	NVARA
81	LOADA
82	81O-1
83	81O-2
84	81S-2
85	81R-2
86	81O-2s
87	81S-2s
88	81R-2s
89	CLPTA
90	Watt1
91	Watt2
92	79CA - 1s
93	79CA - 2s
94	SEFs
95	SEF alarm
96	PUA w/out SEF
97	BF Trip
98	BF ReTrip
99	BF TRIPs
100	BF ReTRIPs
101	32P - 2
102	32N - 2
103	32P ? 2s

Register	Description
104	32N - 2s
105	BFAs
106	25s
107	25
108	SBA
109	79 V Block
110	Reclose Initiated
111	59G
112	59Gs
113	LO1
114	LO2
115	LO3
116	LO4
117	LO5
118	LO6
119	LO7
120	LO8
121	TR_ON
122	TR_OFF
123	TR_TAG
124	3ph_59
125	3ph_59s
126	47
127	47s
128	50-3D
129	21P-1
130	21P-1s
131	21P-2
132	21P-2s
133	21P-3
134	21P-3s
135	21P-4
136	21P-4s
137	C1 (Control Button 1)
138	C2 (Control Button 2)
139	C3 (Control Button 3)
140	C4 (Control Button 4)
141	C5 (Control Button 5)
142	C6 (Control Button 6)
143	TripT
144	NTA
145	TimeT
146	InstT
147	NegSeqT
148	FreqT
149	DirT
150	VoltT
151	DistT
152	SEFT
153	SPARE
154	SPARE
155	SPARE

Table 8-8: 0X Memory Register Access

Register	Description
156	SPARE
157	SPARE
158	SPARE
159	SPARE
160	LBLL
161	LBDL
162	DBLL
163	DBDL
164	46-2
165	46-2s
166	REMOTE - D
167	Prim Sett Active
168	ALT1 Sett Active
169	ALT2 Sett Active
170	SHIFTA-1
171	SHIFTA-2
172	SHIFTA-3
173	SHIFTA-4
174	SHIFTB-1
175	SHIFTB-2
176	SHIFTB-3
177	SHIFTB-4
178	Target Reset
179	BATT LOs
180	BATT His
181	BATT HI
182	BATT LO
183	TRIP - HIF
184	TRIP - HIFs
185	21P Zone - 1 Trip
186	21P Zone - 2 Trip
187	21P Zone - 3 Trip
188	21P Zone - 4 Trip
189	Local01
190	Local02
191	Local03
192	Local04
193	Local05
194	Local06
195	Local07
196	Local08
197	Local09
198	Local10
199	Local11
200	Local12
201	Local13
202	Local14
203	Local15
204	Local16
205	Remote01
206	Remote02
207	Remote03

Register	Description
207	Remote03
208	Remote04
209	Remote05
210	Remote06
211	Remote07
212	Remote08
213	Remote09
214	Remote10
215	Remote11
216	Remote12
217	Remote13
218	Remote14
219	Remote15
220	Remote16
221	UL01
222	UL02
223	UL03
224	UL04
225	UL05
226	UL06
227	UL07
228	UL08
229	UL09
230	UL10
231	UL11
232	UL12
233	UL13
234	UL14
235	UL15
236	UL16
513	Spare
514	Spare
515	Spare
516	Spare
517	Spare
518	Spare
519	(Reserved)
520	(Reserved)
521	OUT 6
522	OUT5
523	OUT4
524	OUT3
525	OUT2
526	OUT1
527	(Reserved)
528	TRIP
1025	TRIP
1026	TRIP Momentary
1027	CLOSE Status
1028	CLOSE Momentary
1029	ALARM Status
1030	ALARM Momentary

Register	Description
1031	27-1 Status
1032	27-1 Momentary
1033	46-1 Status
1034	46-1 Momentary
1035	50P1 Status
1036	50P1 Momentary
1037	50N1 Status
1038	50N1 Momentary
1039	50P2 Status
1040	50P2 Momentary
1041	50N2 Status
1042	50N2 Momentary
1043	50P3 Status
1044	50P3 Momentary
1045	50N3 Status
1046	50N3 Momentary
1047	51P Status
1048	51P Momentary
1049	51N Status
1050	51N Momentary
1051	59 Status
1052	59 Momentary
1053	67P Status
1054	67P Momentary
1055	67N Status
1056	67N Momentary
1057	81S-1 Status
1058	81S-1 Momentary
1059	81R-1 Status
1060	81R-1 Momentary
1061	PATA Status
1062	PATA Momentary
1063	PBTA Status
1064	PBTA Momentary
1065	PCTA Status
1066	PCTA Momentary
1067	TCFA Status
1068	TCFA Momentary
1069	TCC Status
1070	TCC Momentary
1071	79DA Status
1072	79DA Momentary
1073	PUA Status
1074	PUA Momentary
1075	79LOA Status
1076	79LOA Momentary
1077	BFA Status
1078	BFA Momentary
1079	PDA Status
1080	PDA Momentary
1081	NDA Status

Table 8-8: 0X Memory Register Access

Register	Description
1082	NDA Momentary
1083	BFUA Status
1084	BFUA Momentary
1085	KSI Status
1086	KSI Momentary
1087	79CAI Status
1088	79CA1 Momentary
1089	HPFA Status
1090	HPFA Momentary
1091	LPFA Status
1092	LPFA Momentary
1093	OCTC Status
1094	OCTC Momentary
1095	50-1D Status
1096	50-1D Momentary
1097	50-2D Status
1098	50-2D Momentary
1099	STC Status
1100	STC Momentary
1101	ZSC Status
1102	ZSC Momentary
1103	PH3-D Status
1104	PH3-D Momentary
1105	GRD-D Status
1106	GRD-D Momentary
1107	32PA Status
1108	32PA Momentary
1109	32NA Status
1110	32NA Momentary
1111	27-3P Status
1112	27-3P Momentary
1113	VARDA Status
1114	VARDA Momentary
1115	79CA2 Status
1116	79CA2 Momentary
1117	TRIPA Status
1118	TRIPA Momentary
1119	TRIPB Status
1120	TRIPB Momentary
1121	TRIPC Status
1122	TRIPC Momentary
1123	27-1s Status
1124	27-1s Momentary
1125	46-1s Status
1126	46-1s Momentary
1127	50P-1s Status
1128	50P-1s Momentary
1129	50N-1s Status
1130	50N-1s Momentary
1131	50P-2s Status
1132	50P-2s Momentary

Register	Description
1133	50N-2s Status
1134	50N-2s Momentary
1135	50P-3s Status
1136	50P-3s Momentary
1137	50N-3s Status
1138	50N-3s Momentary
1139	51Ps Status
1140	51Ps Momentary
1141	51Ns Status
1142	51Ns Momentary
1143	59s Status
1144	59s Momentary
1145	67Ps Status
1146	67Ps Momentary
1147	67Ns Status
1148	67Ns Momentary
1149	81S-1s Status
1150	81S-1s Momentary
1151	81R-1s Status
1152	81R-1s Momentary
1153	81O-1s Status
1154	81O-1s Momentary
1155	27-3Ps Status
1156	27-3Ps Momentary
1157	TRIPAs Status
1158	TRIPAs Momentary
1159	TRIPBs Status
1160	TRIPBs Momentary
1161	TRIPCs Status
1162	TRIPCs Momentary
1163	SPARE1 Status
1164	SPARE1 Momentary
1165	SPARE2 Status
1166	SPARE2 Momentary
1167	SPARE3 Status
1168	SPARE3 Momentary
1169	SPARE4 Status
1170	SPARE4 Momentary
1171	SPARE5 Status
1172	SPARE5 Momentary
1173	SPARE6 Status
1174	SPARE6 Momentary
1175	SPARE7 Status
1176	SPARE7 Momentary
1177	SPARE8 Status
1178	SPARE8 Momentary
1179	SPARE9 Status
1180	SPARE9 Momentary
1181	PV ARA Status
1182	PVARA Momentary
1183	NVARA Status

Register	Description
1184	NVARA Momentary
1185	LOADA Status
1186	LOADA Momentary
1187	81O-1 Status
1188	81O-1 Momentary
1189	81O-2 Status
1190	81O-2 Momentary
1191	81S-2 Status
1192	81S-2 Momentary
1193	81R-2 Status
1194	81R-2 Momentary
1195	81O-2 Status
1196	81O-2 Momentary
1197	81S-2 Status
1198	81S-2 Momentary
1199	81R-2 Status
1200	81R-2 Momentary
1201	CLTA Status
1202	CLTA Momentary
1203	Watt1 Status
1204	Watt1 Momentary
1205	Watt2 Status
1206	Watt2 Momentary
1207	79CA1s Status
1208	79CA1s Momentary
1209	79CA2s Status
1210	79CA2s Momentary
1211	SEFs Status
1212	SEFs Momentary
1213	SEF alarm Status
1214	SEF alarm
1215	PUA w/out SEF
1216	PUA w/out SEF
1217	BF Trip Status
1218	BF Trip Momentary
1219	BF ReTRIP Status
1220	BF ReTRIP
1221	BF TRIPs Status
1222	BF TRIPs Momentary
1223	BF ReTRIPs Status
1224	BF ReTRIPs
1225	32P Status
1226	32P Momentary
1227	32N Status
1228	32N Momentary
1229	32Ps Status
1230	32Ps Momentary
1231	32Ns Status
1232	32Ns Momentary
1233	BFAs Status

Table 8-8: 0X Memory Register Access

Register	Description
1234	BFAs Momentary
1235	25s Status
1236	25s Momentary
1237	25 Status
1238	25 Momentary
1239	SBA Status
1240	SBA Momentary
1241	79V
1242	79V Momentary
1243	Rclin
1244	Rclin Momentary
1245	59G
1246	59G Momentary
1247	59Gs
1248	59Gs Momentary
1249	LO1
1250	LO1 Momentary
1251	LO2
1252	LO2 Momentary
1253	LO3
1254	LO3 Momentary
1255	LO4
1256	LO4 Momentary
1257	LO5
1258	LO5 Momentary
1259	LO6
1260	LO6 Momentary
1261	LO7
1262	LO7 Momentary
1263	LO8
1264	LO8 Momentary
1265	TR_ON
1266	TR_ON Momentary
1267	TR_OFF
1268	TR_OFF Momentary
1269	TR_TAG
1270	TR_TAG Momentary
1271	3ph_59
1272	3ph_59 Momentary
1273	3ph_59s
1274	3ph_59s Momentary
1275	47 Status
1276	47 Momentary
1277	47s Status
1278	47s Momentary
1279	50-3D Status
1280	50-3D Momentary
1281	21P Zone 1 Status
1282	21P Zone 1 Momentary

Register	Description
1283	21Ps Zone 1 Status
1284	21Ps Zone 1 Momentary
1285	21P Zone 2 Status
1286	21P Zone 2 Momentary
1287	21Ps Zone 2 Status
1288	21Ps Zone 2 Momentary
1289	21P Zone 3 Status
1290	21P Zone 3 Momentary
1291	21Ps Zone 3 Status
1292	21Ps Zone 3 Momentary
1293	21P Zone 4 Status
1294	21P Zone 4 Momentary
1295	21Ps Zone 4 Status
1296	21Ps Zone 4 Momentary
1297	C1 (Control Button 1) Status
1298	C1 (Control Button 1) Mom.
1299	C2 (Control Button 2) Status
1300	C2 (Control Button 2) Mom.
1301	C3 (Control Button 3) Status
1302	C3 (Control Button 3) Mom.
1303	C4 (Control Button 4) Status
1304	C4 (Control Button 4) Mom.
1305	C5 (Control Button 5) Status
1306	C5 (Control Button 5) Mom.
1307	C6 (Control Button 6) Status
1308	C6 (Control Button 6) Mom.
1309	TripT Status
1310	TripT Momentary
1311	NTA Status
1312	NTA Momentary
1313	TimeT Status
1314	TimeT Momentary
1315	InstT Status

Register	Description
1316	InstT Momentary
1317	NegSeqT Status
1318	NegSeqT Momentary
1319	FreqT Status
1320	FreqT Momentary
1321	DirT Status
1322	DirT Momentary
1323	VoltT Status
1324	VoltT Momentary
1325	DistT Status
1326	DistT Momentary
1327	SEFT Status
1328	SEFT Momentary
1329	SPARE10
1330	SPARE10 Momentary
1331	SPARE11
1332	SPARE11 Momentary
1333	SPARE12
1334	SPARE12 Momentary
1335	SPARE13
1336	SPARE13 Momentary
1337	SPARE14
1338	SPARE14 Momentary
1339	SPARE15
1340	SPARE15 Momentary
1341	SPARE16
1342	SPARE16 Momentary
1343	LBLL
1344	LBLL Momentary
1345	LBDL
1346	LBDL Momentary
1347	DBLL
1348	DBLL Momentary
1349	DBDL
1350	DBDL Momentary
1351	46-2
1352	46-2 Momentary
1353	46-2s
1354	46-2s Momentary
1355	REMOTE ? D
1356	REMOTE ? D Momentary
1357	Prim Sett Active
1358	Prim Sett Active Momentary
1359	ALT1 Sett Active
1360	ALT1 Sett Active Momentary

Table 8-7: 0X Memory Register Access

Register	Description
1361	ALT2 Sett Active
1362	ALT2 Sett Active
1363	SHIFTA-1
1364	SHIFTA-1 Momentary
1365	SHIFTA-2
1366	SHIFTA-2 Momentary
1367	SHIFTA-3
1368	SHIFTA-3 Momentary
1369	SHIFTA-4
1370	SHIFTA-4 Momentary
1371	SHIFTB-1
1372	SHIFTB-1 Momentary
1373	SHIFTB-2
1374	SHIFTB-2 Momentary
1375	SHIFTB-3
1376	SHIFTB-3 Momentary
1377	SHIFTB-4
1378	SHIFTB-4 Momentary
1379	Target Reset
1380	Target Reset
1381	BATT LOs
1382	BATT LOs
1383	BATT His
1384	BATT His Momentary
1385	BATT HI
1386	BATT HI Momentary
1387	BATT LO
1388	BATT LO Momentary
1389	TRIP - HIF
1390	TRIP - HIF
1391	TRIP - HIFs
1392	TRIP - HIFs
1393	21P Zone - 1 Trip
1394	21P Zone - 1 Trip
1395	21P Zone - 2 Trip
1396	21P Zone - 2 Trip
1397	21P Zone - 3 Trip
1398	21P Zone - 3 Trip
1399	21P Zone - 4 Trip
1400	21P Zone - 4 Trip
1401	Local01
1402	Local01 Momentary
1403	Local02
1404	Local02 Momentary
1405	Local03
1406	Local03 Momentary
1407	Local04
1408	Local04 Momentary
1409	Local05
1410	Local05 Momentary
1411	Local06
1412	Local06 Momentary
1413	Local07
1414	Local07 Momentary
1415	Local08
1416	Local08 Momentary
1417	Local09
1418	Local09 Momentary
1419	Local10
1420	Local10 Momentary
1421	Local11
1422	Local11 Momentary
1423	Local12
1424	Local12 Momentary
1425	Local13
1426	Local13 Momentary
1427	Local14
1428	Local14 Momentary
1429	Local15
1430	Local15 Momentary
1431	Local16
1432	Local16 Momentary
1433	Remote01
1434	Remote01
1435	Remote02
1436	Remote02
1437	Remote03
1438	Remote03
1439	Remote04
1440	Remote04
1441	Remote05
1442	Remote05
1443	Remote06
1444	Remote06
1445	Remote07
1446	Remote07
1447	Remote08
1448	Remote08
1449	Remote09
1450	Remote09
1451	Remote10
1452	Remote10
1453	Remote11
1454	Remote11
1455	Remote12
1456	Remote12
1457	Remote13
1458	Remote13
1459	Remote14
1460	Remote14
1461	Remote15
1462	Remote15
1463	Remote16
1464	Remote16
1465	UL01
1466	UL01 Momentary
1467	UL02
1468	UL02 Momentary
1469	UL03
1470	UL03 Momentary
1471	UL04
1472	UL04 Momentary
1473	UL05
1474	UL05 Momentary
1475	UL06
1476	UL06 Momentary
1477	UL07
1478	UL07 Momentary
1479	UL08
1480	UL08 Momentary
1481	UL09
1482	UL09 Momentary
1483	UL10
1484	UL10 Momentary
1485	UL11
1486	UL11 Momentary
1487	UL12
1488	UL12 Momentary
1489	UL13
1490	UL13 Momentary
1491	UL14
1492	UL14 Momentary
1493	UL15
1494	UL15 Momentary
1495	UL16
1496	UL16 Momentary

Table 8-7: 0X Memory Register Access

Register	Description
1	TRIP
2	CLOSE
3	ALARM
4	27-1
5	46-1
6	50P1
7	50N1
8	50P2
9	50N2
10	50P3
11	50N3
12	51P
13	51N
14	59
15	67P
16	67N
17	81S-1
18	81R-1
19	PATA
20	PBTA
21	PCTA
22	TCFA
23	TCC
24	79DA
25	PUA
26	79LOA
27	BFA
28	PPDA
29	NPDA
30	BFUA
31	KSI
32	79CA-1
33	HPFA
34	LPFA
35	OCTC
36	50-1D
37	50-2D
38	STC
39	ZSC
40	PH3-D
41	GRD-D
42	32PA
43	32NA
44	27-3P
45	VARDA
46	79CA-2
47	TRIPA
48	TRIPB
49	TRIPC
50	27-1s
51	46-1s
52	50P-1s
53	50N-1s
54	50P-2s
55	50N-2s
56	50P-3s
57	50N-3s
58	51Ps
59	51Ns
60	59s
61	67Ps
62	67Ns
63	81S-1s
64	81R-1s
65	81O-1s
66	27-3Ps
67	TRIPAs
68	TRIPBs
69	TRIPCs
70	SPARE
71	SPARE
72	SPARE
73	SPARE
74	SPARE
75	SPARE
76	SPARE
77	SPARE
78	SPARE
79	PVARA
80	NVARA
81	LOADA
82	81O-1
83	81O-2
84	81S-2
85	81R-2
86	81O-2s
87	81S-2s
88	81R-2s
89	CLPTA
90	Watt1
91	Watt2
92	79CA - 1s
93	79CA - 2s
94	SEFs
95	SEF alarm
96	PUA w/out SEF
97	BF Trip
98	BF ReTrip
99	BF TRIPs
100	BF ReTRIPs
101	32P - 2
102	32N - 2
103	32P ? 2s
104	32N - 2s
105	BFAs
106	25s
107	25
108	SBA
109	79 V Block
110	Reclose Initiated
111	59G
112	59Gs
113	LO1
114	LO2
115	LO3
116	LO4
117	LO5
118	LO6
119	LO7
120	LO8
121	TR_ON
122	TR_OFF
123	TR_TAG
124	3ph_59
125	3ph_59s
126	47
127	47s
128	50-3D
129	21P-1
130	21P-1s
131	21P-2
132	21P-2s
133	21P-3
134	21P-3s
135	21P-4
136	21P-4s
137	C1 (Control Button 1)
138	C2 (Control Button 2)
139	C3 (Control Button 3)
140	C4 (Control Button 4)
141	C5 (Control Button 5)
142	C6 (Control Button 6)
143	TripT
144	NTA
145	TimeT
146	InstT
147	NegSeqT
148	FreqT
149	DirT
150	VoltT
151	DistT
152	SEFT
153	SPARE
154	SPARE
155	SPARE

Table 8-8: 0X Memory Register Access

Register	Description
156	SPARE
157	SPARE
158	SPARE
159	SPARE
160	LBLL
161	LBDL
162	DBLL
163	DBDL
164	46-2
165	46-2s
166	REMOTE - D
167	Prim Sett Active
168	ALT1 Sett Active
169	ALT2 Sett Active
170	SHIFTA-1
171	SHIFTA-2
172	SHIFTA-3
173	SHIFTA-4
174	SHIFTB-1
175	SHIFTB-2
176	SHIFTB-3
177	SHIFTB-4
178	Target Reset
179	BATT LOs
180	BATT His
181	BATT HI
182	BATT LO
183	TRIP - HIF
184	TRIP - HIFs
185	21P Zone - 1 Trip
186	21P Zone - 2 Trip
187	21P Zone - 3 Trip
188	21P Zone - 4 Trip
189	Local01
190	Local02
191	Local03
192	Local04
193	Local05
194	Local06
195	Local07
196	Local08
197	Local09
198	Local10
199	Local11
200	Local12
201	Local13
202	Local14
203	Local15
204	Local16
205	Remote01
206	Remote02
207	Remote03

Register	Description
207	Remote03
208	Remote04
209	Remote05
210	Remote06
211	Remote07
212	Remote08
213	Remote09
214	Remote10
215	Remote11
216	Remote12
217	Remote13
218	Remote14
219	Remote15
220	Remote16
221	UL01
222	UL02
223	UL03
224	UL04
225	UL05
226	UL06
227	UL07
228	UL08
229	UL09
230	UL10
231	UL11
232	UL12
233	UL13
234	UL14
235	UL15
236	UL16
513	Spare
514	Spare
515	Spare
516	Spare
517	Spare
518	Spare
519	(Reserved)
520	(Reserved)
521	OUT 6
522	OUT5
523	OUT4
524	OUT3
525	OUT2
526	OUT1
527	(Reserved)
528	TRIP
1025	TRIP
1026	TRIP Momentary
1027	CLOSE Status
1028	CLOSE Momentary
1029	ALARM Status
1030	ALARM Momentary

Register	Description
1031	27-1 Status
1032	27-1 Momentary
1033	46-1 Status
1034	46-1 Momentary
1035	50P1 Status
1036	50P1 Momentary
1037	50N1 Status
1038	50N1 Momentary
1039	50P2 Status
1040	50P2 Momentary
1041	50N2 Status
1042	50N2 Momentary
1043	50P3 Status
1044	50P3 Momentary
1045	50N3 Status
1046	50N3 Momentary
1047	51P Status
1048	51P Momentary
1049	51N Status
1050	51N Momentary
1051	59 Status
1052	59 Momentary
1053	67P Status
1054	67P Momentary
1055	67N Status
1056	67N Momentary
1057	81S-1 Status
1058	81S-1 Momentary
1059	81R-1 Status
1060	81R-1 Momentary
1061	PATA Status
1062	PATA Momentary
1063	PBTA Status
1064	PBTA Momentary
1065	PCTA Status
1066	PCTA Momentary
1067	TCFA Status
1068	TCFA Momentary
1069	TCC Status
1070	TCC Momentary
1071	79DA Status
1072	79DA Momentary
1073	PUA Status
1074	PUA Momentary
1075	79LOA Status
1076	79LOA Momentary
1077	BFA Status
1078	BFA Momentary
1079	PDA Status
1080	PDA Momentary
1081	NDA Status

Table 8-8: 0X Memory Register Access

Register	Description
1082	NDA Momentary
1083	BFUA Status
1084	BFUA Momentary
1085	KSI Status
1086	KSI Momentary
1087	79CAI Status
1088	79CA1 Momentary
1089	HPFA Status
1090	HPFA Momentary
1091	LPFA Status
1092	LPFA Momentary
1093	OCTC Status
1094	OCTC Momentary
1095	50-1D Status
1096	50-1D Momentary
1097	50-2D Status
1098	50-2D Momentary
1099	STC Status
1100	STC Momentary
1101	ZSC Status
1102	ZSC Momentary
1103	PH3-D Status
1104	PH3-D Momentary
1105	GRD-D Status
1106	GRD-D Momentary
1107	32PA Status
1108	32PA Momentary
1109	32NA Status
1110	32NA Momentary
1111	27-3P Status
1112	27-3P Momentary
1113	VARDA Status
1114	VARDA Momentary
1115	79CA2 Status
1116	79CA2 Momentary
1117	TRIPA Status
1118	TRIPA Momentary
1119	TRIPB Status
1120	TRIPB Momentary
1121	TRIPC Status
1122	TRIPC Momentary
1123	27-1s Status
1124	27-1s Momentary
1125	46-1s Status
1126	46-1s Momentary
1127	50P-1s Status
1128	50P-1s Momentary
1129	50N-1s Status
1130	50N-1s Momentary
1131	50P-2s Status
1132	50P-2s Momentary

Register	Description
1133	50N-2s Status
1134	50N-2s Momentary
1135	50P-3s Status
1136	50P-3s Momentary
1137	50N-3s Status
1138	50N-3s Momentary
1139	51Ps Status
1140	51Ps Momentary
1141	51Ns Status
1142	51Ns Momentary
1143	59s Status
1144	59s Momentary
1145	67Ps Status
1146	67Ps Momentary
1147	67Ns Status
1148	67Ns Momentary
1149	81S-1s Status
1150	81S-1s Momentary
1151	81R-1s Status
1152	81R-1s Momentary
1153	81O-1s Status
1154	81O-1s Momentary
1155	27-3Ps Status
1156	27-3Ps Momentary
1157	TRIPAs Status
1158	TRIPAs Momentary
1159	TRIPBs Status
1160	TRIPBs Momentary
1161	TRIPCs Status
1162	TRIPCs Momentary
1163	SPARE1 Status
1164	SPARE1 Momentary
1165	SPARE2 Status
1166	SPARE2 Momentary
1167	SPARE3 Status
1168	SPARE3 Momentary
1169	SPARE4 Status
1170	SPARE4 Momentary
1171	SPARE5 Status
1172	SPARE5 Momentary
1173	SPARE6 Status
1174	SPARE6 Momentary
1175	SPARE7 Status
1176	SPARE7 Momentary
1177	SPARE8 Status
1178	SPARE8 Momentary
1179	SPARE9 Status
1180	SPARE9 Momentary
1181	PV ARA Status
1182	PVARA Momentary
1183	NVARA Status

Register	Description
1184	NVARA Momentary
1185	LOADA Status
1186	LOADA Momentary
1187	81O-1 Status
1188	81O-1 Momentary
1189	81O-2 Status
1190	81O-2 Momentary
1191	81S-2 Status
1192	81S-2 Momentary
1193	81R-2 Status
1194	81R-2 Momentary
1195	81O-2 Status
1196	81O-2 Momentary
1197	81S-2 Status
1198	81S-2 Momentary
1199	81R-2 Status
1200	81R-2 Momentary
1201	CLTA Status
1202	CLTA Momentary
1203	Watt1 Status
1204	Watt1 Momentary
1205	Watt2 Status
1206	Watt2 Momentary
1207	79CA1s Status
1208	79CA1s Momentary
1209	79CA2s Status
1210	79CA2s Momentary
1211	SEFs Status
1212	SEFs Momentary
1213	SEF alarm Status
1214	SEF alarm
1215	PUA w/out SEF
1216	PUA w/out SEF
1217	BF Trip Status
1218	BF Trip Momentary
1219	BF ReTRIP Status
1220	BF ReTRIP
1221	BF TRIPs Status
1222	BF TRIPs Momentary
1223	BF ReTRIPs Status
1224	BF ReTRIPs
1225	32P Status
1226	32P Momentary
1227	32N Status
1228	32N Momentary
1229	32Ps Status
1230	32Ps Momentary
1231	32Ns Status
1232	32Ns Momentary
1233	BFAs Status

Table 8-8: 0X Memory Register Access

Register	Description
1234	BFAs Momentary
1235	25s Status
1236	25s Momentary
1237	25 Status
1238	25 Momentary
1239	SBA Status
1240	SBA Momentary
1241	79V
1242	79V Momentary
1243	Rclin
1244	Rclin Momentary
1245	59G
1246	59G Momentary
1247	59Gs
1248	59Gs Momentary
1249	LO1
1250	LO1 Momentary
1251	LO2
1252	LO2 Momentary
1253	LO3
1254	LO3 Momentary
1255	LO4
1256	LO4 Momentary
1257	LO5
1258	LO5 Momentary
1259	LO6
1260	LO6 Momentary
1261	LO7
1262	LO7 Momentary
1263	LO8
1264	LO8 Momentary
1265	TR_ON
1266	TR_ON Momentary
1267	TR_OFF
1268	TR_OFF Momentary
1269	TR_TAG
1270	TR_TAG Momentary
1271	3ph_59
1272	3ph_59 Momentary
1273	3ph_59s
1274	3ph_59s Momentary
1275	47 Status
1276	47 Momentary
1277	47s Status
1278	47s Momentary
1279	50-3D Status
1280	50-3D Momentary
1281	21P Zone 1 Status
1282	21P Zone 1 Momentary

Register	Description
1283	21Ps Zone 1 Status
1284	21Ps Zone 1 Momentary
1285	21P Zone 2 Status
1286	21P Zone 2 Momentary
1287	21Ps Zone 2 Status
1288	21Ps Zone 2 Momentary
1289	21P Zone 3 Status
1290	21P Zone 3 Momentary
1291	21Ps Zone 3 Status
1292	21Ps Zone 3 Momentary
1293	21P Zone 4 Status
1294	21P Zone 4 Momentary
1295	21Ps Zone 4 Status
1296	21Ps Zone 4 Momentary
1297	C1 (Control Button 1) Status
1298	C1 (Control Button 1) Mom.
1299	C2 (Control Button 2) Status
1300	C2 (Control Button 2) Mom.
1301	C3 (Control Button 3) Status
1302	C3 (Control Button 3) Mom.
1303	C4 (Control Button 4) Status
1304	C4 (Control Button 4) Mom.
1305	C5 (Control Button 5) Status
1306	C5 (Control Button 5) Mom.
1307	C6 (Control Button 6) Status
1308	C6 (Control Button 6) Mom.
1309	TripT Status
1310	TripT Momentary
1311	NTA Status
1312	NTA Momentary
1313	TimeT Status
1314	TimeT Momentary
1315	InstT Status

Register	Description
1316	InstT Momentary
1317	NegSeqT Status
1318	NegSeqT Momentary
1319	FreqT Status
1320	FreqT Momentary
1321	DirT Status
1322	DirT Momentary
1323	VoltT Status
1324	VoltT Momentary
1325	DistT Status
1326	DistT Momentary
1327	SEFT Status
1328	SEFT Momentary
1329	SPARE10
1330	SPARE10 Momentary
1331	SPARE11
1332	SPARE11 Momentary
1333	SPARE12
1334	SPARE12 Momentary
1335	SPARE13
1336	SPARE13 Momentary
1337	SPARE14
1338	SPARE14 Momentary
1339	SPARE15
1340	SPARE15 Momentary
1341	SPARE16
1342	SPARE16 Momentary
1343	LBLL
1344	LBLL Momentary
1345	LBDL
1346	LBDL Momentary
1347	DBLL
1348	DBLL Momentary
1349	DBDL
1350	DBDL Momentary
1351	46-2
1352	46-2 Momentary
1353	46-2s
1354	46-2s Momentary
1355	REMOTE ? D
1356	REMOTE ? D Momentary
1357	Prim Sett Active
1358	Prim Sett Active Momentary
1359	ALT1 Sett Active
1360	ALT1 Sett Active Momentary

Table 8-9: 1X Memory Data Table

Register	Description
10001	52a
10002	52b
10003	43a
10004	PH3
10005	GRD
10006	SCC
10007	79S
10008	79M
10009	TCM
10010	50-1
10011	50-2
10012	50-3
10013	ALT1
10014	ALT2
10015	ECI1
10016	ECI2
10017	DFRI
10018	ZSC
10019	OPEN
10020	CLOSE
10021	46-1
10022	67P
10023	67N
10024	SPARE1
10025	SPARE2
10026	SPARE3
10027	SPARE4
10028	SPARE5
10029	SPARE6
10030	SPARE7
10031	SPARE8
10032	SPARE9
10033	CRI
10034	ARCI
10035	TARC
10036	SEF TC
10037	ExtBFI
10038	BFI
10039	UDI
10040	25
10041	25 Bypass
10042	Local Enable
10043	TGT
10044	SIA
10045	LIS1
10046	LIS2
10047	LIS3
10048	LIS4
10049	LIS5

Register	Description
10050	LIS6
10051	LIS7
10052	LIS8
10053	LIR1
10054	LIR2
10055	LIR3
10056	LIR4
10057	LIR5
10058	LIR6
10059	LIR7
10060	LIR8
10061	TR_SET
10062	TR_RST
10063	SPARE10
10064	SPARE11
10065	SPARE12
10066	SPARE13
10067	SPARE14
10068	SPARE15
10069	SPARE16
10070	46-2
10071	SWSET
10072	SHIFTA
10073	SHIFTB
10074	51P_tc
10075	HIF_tc
10076	PhyInputOne
10077	PhyInputTwo
10078	PhyInputThree
10079	PhyInputFour
10080	PhyInputFive
10081	PhyInputSix
10082	PhyInputSeven
10083	PhyInputEight
10084	TMR1
10085	TMR2
10086	TMR3
10087	TMR4
10088	TMR5
10089	TMR6
10090	TMR7
10091	TMR8
10092	TMR9
10093	TMR10
10094	TMR11
10095	TMR12
10096	TMR13
10097	TMR14
10098	TMR15

Register	Description
10099	TMR16
10513	Reserved
10514	Reserved
10515	Reserved
10516	Reserved
10517	Reserved
10518	IN8
10519	IN7
10520	IN6
10521	IN5
10522	IN4
10523	IN3
10524	IN2
10525	IN1
10526	Reserved
10527	Reserved
10528	Reserved
11025	52a Status
11026	52a Momentary
11027	52b Status
11028	52b Momentary
11029	43a Status
11030	43a Momentary
11031	PH3 Status
11032	PH3 Momentary
11033	GRD Status
11034	GRD Momentary
11035	SCC Status
11036	SCC Momentary
11037	79S Status
11038	79S Momentary
11039	79M Status
11040	79M Momentary
11041	TCM Status
11042	TCM Momentary
11043	50-1 Status
11044	50-1 Momentary
11045	50-2 Status
11046	50-2 Momentary
11047	50-3 Status
11048	50-3 Momentary
11049	ALT1 Status
11050	ALT1 Momentary
11051	ALT2 Status
11052	ALT2 Momentary
11053	ECI1 Status
11054	ECI1 Momentary
11055	ECI2 Status
11056	ECI2 Momentary

Table 8-9: 1X Memory Data Table

Register	Description
11057	DFRI Status
11058	DFRI Momentary
11059	ZSC Status
11060	ZSC Momentary
11061	OPEN Status
11062	OPEN Momentary
11063	CLOSE Status
11064	CLOSE Momentary
11065	46-1 Status
11066	46-1 Momentary
11067	67P Status
11068	67P Momentary
11069	67N Status
11070	67N Momentary
11071	SPARE1 Status
11072	SPARE1 Momentary
11073	SPARE2 Status
11074	SPARE2 Momentary
11075	SPARE3 Status
11076	SPARE3 Momentary
11077	SPARE4 Status
11078	SPARE4 Momentary
11079	SPARE5 Status
11080	SPARE5 Momentary
11081	SPARE6 Status
11082	SPARE6 Momentary
11083	SPARE7 Status
11084	SPARE7 Momentary
11085	SPARE8 Status
11086	SPARE8 Momentary
11087	SPARE9 Status
11088	SPARE9 Momentary
11089	CRI Status
11090	CRI Momentary
11091	ARCI Status
11092	ARCI Momentary
11093	TARC Status
11094	TARC Momentary
11095	SEF TC Status
11096	SEF TC Momentary
11097	ExtBFI Status
11098	ExtBFI Momentary
11099	BFI Status
11100	BFI Momentary
11101	UDI Status
11102	UDI Momentary
11103	25 Status
11104	25 Momentary
11105	25 Bypass Status

Register	Description
11106	25 Bypass
11107	Local Enable Status
11108	Local Enable
11109	TGT
11110	TGT Momentary
11111	SIA
11112	SIA Momentary
11113	LIS1
11114	LIS1 Momentary
11115	LIS2
11116	LIS2 Momentary
11117	LIS3
11118	LIS3 Momentary
11119	LIS4
11120	LIS4 Momentary
11121	LIS5
11122	LIS5 Momentary
11123	LIS6
11124	LIS6 Momentary
11125	LIS7
11126	LIS7 Momentary
11127	LIS8
11128	LIS8 Momentary
11129	LIR1
11130	LIR1 Momentary
11131	LIR2
11132	LIR2 Momentary
11133	LIR3
11134	LIR3 Momentary
11135	LIR4
11136	LIR4 Momentary
11137	LIR5
11138	LIR5 Momentary
11139	LIR6
11140	LIR6 Momentary
11141	LIR7
11142	LIR7 Momentary
11143	LIR8
11144	LIR8 Momentary
11145	TR_SET
11146	TR_SET Momentary
11147	TR_RST
11148	TR_RST Momentary
11149	SPARE10
11150	SPARE10 Momentary
11151	SPARE11
11152	SPARE11 Momentary
11153	SPARE12
11154	SPARE12 Momentary

Register	Description
11155	SPARE13
11156	SPARE13 Momentary
11157	SPARE14
11158	SPARE14 Momentary
11159	SPARE15
11160	SPARE15 Momentary
11161	SPARE16
11162	SPARE16 Momentary
11163	46-2
11164	46-2 Momentary
11165	SWSET
11166	SWSET Momentary
11167	SHIFTA
11168	SHIFTA Momentary
11169	SHIFTB
11170	SHIFTB Momentary
11171	51P_tc
11172	51P_tc Momentary
11173	HIF_tc
11174	HIF_tc Momentary
11175	PhyInputOne
11176	PhyInputOne
11177	PhyInputTwo
11178	PhyInputTwo
11179	PhyInputThree
11180	PhyInputThree
11181	PhyInputFour
11182	PhyInputFour
11183	PhyInputFive
11184	PhyInputFive
11185	PhyInputSix
11186	PhyInputSix
11187	PhyInputSeven
11188	PhyInputSeven
11189	PhyInputEight
11190	PhyInputEight
11191	TMR1
11192	TMR1 Momentary
11193	TMR2
11194	TMR2 Momentary
11195	TMR3
11196	TMR3 Momentary
11197	TMR4
11198	TMR4 Momentary
11199	TMR5
11200	TMR 5 Momentary
11201	TMR6
11202	TMR6 Momentary
11203	TMR7

Table 8-9: 1X Memory Data Table

Register	Description
11204	TMR7 Momentary
11205	TMR8
11206	TMR8 Momentary
11207	TMR9
11208	TMR9 Momentary
11209	TMR10
11210	TMR10 Momentary
11211	TMR11
11212	TMR11 Momentary
11213	TMR12
11214	TMR 12 Momentary
11215	TMR13
11216	TMR13 Momentary
11217	TMR14
11218	TMR14 Momentary
11219	TMR15
11220	TMR15 Momentary
11221	TMR16
11222	TMR16 Momentary
12049	Reserved
12050	Reserved
12051	Reserved
12052	Reserved
12053	Reserved
12054	Reserved
12055	Reserved
12056	Reserved
12057	Reserved
12058	Reserved
12059	IN8 Status
12060	IN8 Momentary
12061	IN7 Status
12062	IN7 Momentary
12063	IN6 Status
12064	IN6 Momentary
12065	IN5 Status
12066	IN5 Momentary
12067	IN4 Status
12068	IN4 Momentary
12069	IN3 Status
12070	IN3 Momentary
12071	IN2 Status
12072	IN2 Momentary
12073	IN1 Status
12074	IN1 Momentary
12075	Reserved
12076	Reserved
12077	Reserved
12078	Reserved
12079	Reserved
12080	Reserved

Within the REF 550 Word Wide Metering Data is available in the Modbus memory defined areas. Included in Table 8-4 is the 4X memory which can be accessed or written. If additional information is required on the method to write or read the memory, please reference the Modbus Automation Manual TG7.11.1.7-74 titled REF 550 Serial Modbus, Modbus Plus, and TCP/IP Modbus Automation Manual. Dated January 2005 Version 1.0.
The read only registers are listed in Table 8-4.

Table 8-10 4x Read Register Data Map

Register	Data Size	Scale	Description
40129:	Unsigned Short	Relay Status	Bit 15: 12: Spare
			Bit 11: Momentary Change
			Bit 10: New Minimum Demand Value
			Bit 9: New Peak Demand Value
			Bit 8: New Operation Recorded
			Bit 7: Control Power Cycled
			Bit 6: New Fault Recorded
			Bit 5: Alternate 2 Settings Active
			Bit 4: Alternate 1 Settings Active
			Bit 3: Remote Edit Disable
			Bit 2: Local Settings Changed
			Bit 1: Contact Input Changed
			Bit 0: Self-test Status
40130-131:	Unsigned Long	Diagnostic Status Flag	Bit 31: 16: Spare
			Bit 15: DSP COP FAILURE
			Bit 14: DSP +5V FAILURE
			Bit 13: DSP +/-15V FAILURE
			Bit 12: DSP +/-5V FAILURE
			Bit 11: DSP ADC FAILURE
			Bit 10: DSP EXT RAM FAILURE
			Bit 9: DSP INT RAM FAILURE
			Bit 8: DSP ROM FAILURE
			Bit 7: Spare
			Bit 6: Spare
			Bit 5: Spare
			Bit 4: Spare
			Bit 3: CPU EEPROM FAILURE
			Bit 2: CPU NVRAM FAILURE
			Bit 1: CPU EPROM FAILURE
			Bit 0: CPU RAM FAILURE
40132:	Unsigned Short	Relay Configuration	Bit 15: 2: Spare
			Bit 1: 0 = kWhr/kVARhr,1=MWhr/MVARhr
			Bit 0: 0 = Wye PT, 1=Delta PT
40133-142:	20 Char String (NULL Term)		Catalog Number
40143:	Unsigned Short	100	CPU Software Version Number
40144:	Unsigned Short	10	Analog/DSP Software Version Number
40145:	Unsigned Short	10	Front Panel Controller Software Version Number
40146:	Unsigned Short	10	Auxiliary Communication Software Version Number
40147-148:	Unsigned Long	1	Serial Number
40149-157:	18 Char String (NULL Term)		Unit Name
40158:	Unsigned Short		Phase CT Ratio
40159:	Unsigned Short		Neutral CT Ratio

Register	Data Size	Scale	Description
40160:	Unsigned Short		PT Ratio
40161:	Unsigned Short	1	Last Power Fail Timestamp Year
40162:	Unsigned Short	1	Last Power Fail Timestamp Month
40163:	Unsigned Short	1	Last Power Fail Timestamp Day
40164:	Unsigned Short	1	Last Power Fail Timestamp Hours
40165:	Unsigned Short	1	Last Power Fail Timestamp Minutes
40166:	Unsigned Short	1	Last Power Fail Timestamp Seconds
40167:	Unsigned Short	1	Last Power Fail Timestamp Hundredths of Seconds
40168:	Unsigned Short	1	Last Power Fail Type
40169:	Unsigned Short	1	Last Power Fail State Machine Current State
40170-171:	Unsigned Long	1	Fast Status Response Bit 31-24: Heart Beat Counter Bit 23: Spare Bit 22: 1 = One or More Unreported Operations Records Bit 21-16: Division Code = 00101 binary Bit 15-10: Product Code = 001110binary Bit 9-8: Spare Bit 7-6: Reserved for Corporate Status Bit 5: Reserved for Local Operator Action Bit 4-0: Spare
40172	Unsigned Short	1	Last Communications Error Comm Port Type 0=MBP,1=INCOM, 2=RS232,3=RS485,4=Etheret
40173	Unsigned Short	1	Last Communications Error Command (MODBUS Function Code or Standard Protocol command+subcommand)
40174	Unsigned Short	1	Last Communications Error Register
40175	Unsigned Short	1	Last Communications Error Type 1. Invalid password 2. Checksum Error 3. The block/register or range are invalid 4. Block/Register attempted to be accessed invalid 5. Range of data attempted to be accessed invalid 6. Invalid Data 7. Settings being edited elsewhere in unit or remote edit disabled 8. A write to one settings group attempted while actively editing another 9. Breaker state invalid 10. Data entered is below minimum 11. Data entered is above maximum allowed 12. Data entered is out of step 32. Reference Type or File Number invalid 33. Too many registers for Modbus protocol 34. Invalid Function code 35. Invalid Record control
40176-177	Unsigned Long	1	Editor Write Mask 1
40178-179	Unsigned Long	1	Editor Write Mask 2

RMS Load Current/Angular Values Block

Register	Data Size	Scale	Description
40257:	Unsigned Short	1	Load Current-A
40258:	Unsigned Short	1	Load Current-A Angle
40259:	Unsigned Short	1	Load Current-B
40260:	Unsigned Short	1	Load Current-B Angle
40261:	Unsigned Short	1	Load Current-C
40262:	Unsigned Short	1	Load Current-C Angle
40263:	Unsigned Short	1	Load Current-N
40264:	Unsigned Short	1	Load Current-N Angle
40265-266:	Unsigned Long	1	Voltage VAN
40267:	Unsigned Short	1	Voltage VAN Angle
40268-269:	Unsigned Long	1	Voltage VBN
40270:	Unsigned Short	1	Voltage VBN Angle
40271-272:	Unsigned Long	1	Voltage VCN
40273:	Unsigned Short	1	Voltage VCN Angle
40274-275:	Unsigned Long	1	Voltage VAB
40276:	Unsigned Short	1	Voltage VAB Angle
40277-278:	Unsigned Long	1	Voltage VBC
40279:	Unsigned Short	1	Voltage VBC Angle
40280-281:	Unsigned Long	1	Voltage VCA
40282:	Unsigned Short	1	Voltage VCA Angle
40283-284:	Signed Long	1	kWatts A
40285-286:	Signed Long	1	kWatts B
40287-288:	Signed Long	1	kWatts C
40289-290:	Signed Long	1	3 Phase kWatts
40291-292:	Signed Long	1	kVARs A
40293-294:	Signed Long	1	kVARs B
40295-296:	Signed Long	1	kVARs C
40297-298:	Signed Long	1	3 Phase kVARs
40299-300:	Signed Long	1	kWatt Hours A
40301-302:	Signed Long	1	kWatt Hours B
40303-304:	Signed Long	1	kWatt Hours C
40305-306:	Signed Long	1	kWatt Hours 3 Phase
40307-308:	Signed Long	1	kVAR Hours A
40309-310:	Signed Long	1	kVAR Hours B
40311-312:	Signed Long	1	kVAR Hours C
40313-314:	Signed Long	1	kVAR Hours 3 Phase
40315:	Unsigned Short	1	Zero Sequence Current (computed)
40316:	Unsigned Short	1	Zero Sequence Current Angle (computed)
40317:	Unsigned Short	1	Positive Sequence Current
40318:	Unsigned Short	1	Positive Sequence Current Ang1e
40319:	Unsigned Short	1	Negative Sequence Current
40320:	Unsigned Short	1	Negative Sequence Current Angle
40321-322:	Unsigned Long	1	Positive Sequence Voltage Magnitude
40323:	Unsigned Short	1	Positive Sequence Voltage Angle
40324-325:	Unsigned Long	1	Negative Sequence Voltage Magnitude
40326:	Unsigned Short	1	Negative Sequence Voltage Angle
40327:	Unsigned Short	100	System Frequency

Register	Data Size	Scale	Description
40328:	Unsigned Short		Power Factor Bit 15-9: Not used Bit 8: 0=Positive, 1=Negative Bit 7: 0=Leading, 1=Lagging Bit 6-0: Power Factor Value (x100)
40329-330:	Unsigned Long	1	Zero Sequence Current Mag (measured)
40331:	Unsigned Short	1	Zero Sequence Current Angle (measured)
40332-333:	Unsigned Long	1	Zero Sequence Voltage Mag (measured)
40334:	Unsigned Short	1	Zero Sequence Voltage Angle (measured)
40335:	Signed Short	100	Power Factor
40336:	Unsigned Short		Power Factor Status Bit 0: 0=Leading, 1=Lagging
40337:	Unsigned Short	1	Fault Distance
40338-339:	Unsigned long	1	KVA-3
40340-341:	Unsigned Long	1	Vbus Mag
40342:	Unsigned Short	1	Vbus Angle
40343-344:	Unsigned Long	1	Vbus to Vline Voltage Difference
40345:	Unsigned Short	1	Vbus to Vline Angle Difference
40346:	Signed Short	1	Sync Check Slip Frequency
40347-348:	Unsigned Long	1	Zero Sequence Voltage Mag (derived)
40349:	Unsigned Short	1	Zero Sequence Voltage Ang (derived)
40350:	Unsigned Short	1	Substation Battery Voltage Vdc

RMS Demand Current/Real and Reactive Power Values Block

Register	Data Size	Scale	Description
40513:	Unsigned Short	1	Demand Current-A
40514:	Unsigned Short	1	Demand Current-B
40515:	Unsigned Short	1	Demand Current-C
40516:	Unsigned Short	1	Demand Current-N
40517-518:	Signed Long	1	Demand kWatts-A
40519-520:	Signed Long	1	Demand kWatts-B
40521-522:	Signed Long	1	Demand kWatts-C
40523-524:	Signed Long	1	3 Phase Demand kWatts
40525-526:	Signed Long	1	Demand kVARs-A
40527-528:	Signed Long	1	Demand kVARs-B
40529-530:	Signed Long	1	Demand kVARs-C
40531-532:	Signed Long	1	3 Phase Demand kVARs

RMS Peak Demand Current/Real, Reactive Power Values and Time Stamps Block

Register	Data Size	Scale	Description
40641-644:	Unsigned Short	1	Peak Demand Current-A
	Unsigned Byte		Peak Demand Current-AYear
	Unsigned Byte		Peak Demand Current-A Month
	Unsigned Byte		Peak Demand Current-A Day
	Unsigned Byte		Peak Demand Current-A Hour

Register	Data Size	Scale	Description
	Unsigned Byte		Peak Demand Current-A Minute
	Unsigned Byte		Spare
40645-648:	Unsigned Short	1	Peak Demand Current-B
	Unsigned Byte		Peak Demand Current-BYear
	Unsigned Byte		Peak Demand Current-B Month
	Unsigned Byte		Peak Demand Current-B Day
	Unsigned Byte		Peak Demand Current-Hour
	Unsigned Byte		Peak Demand Current-B Minute
	Unsigned Byte		Spare
40649-652:	Unsigned Short	1	Peak Demand Current-C
	Unsigned Byte		Peak Demand Current-C Year
	Unsigned Byte		Peak Demand Current-C Month
	Unsigned Byte		Peak Demand Current-C Day
	Unsigned Byte		Peak Demand Current-C Hour
	Unsigned Byte		Peak Demand Current-C Minute
	Unsigned Byte		Spare
40653-656:	Unsigned Short	1	Peak Demand Current-N
	Unsigned Byte		Peak Demand Current-N Year
	Unsigned Byte		Peak Demand Current-N Month
	Unsigned Byte		Peak Demand Current-N Day
	Unsigned Byte		Peak Demand Current-N Hour
	Unsigned Byte		Peak Demand Current-N Minute
	Unsigned Byte		Spare
40657-661:	Signed Long	1	Peak Demand KWatts-A
	Unsigned Byte		Peak Demand KWatts-A Year
	Unsigned Byte		Peak Demand KWatts-A Month
	Unsigned Byte		Peak Demand KWatts-A Day
	Unsigned Byte		Peak Demand KWatts-A Hour
	Unsigned Byte		Peak Demand KWatts-A Minute
	Unsigned Byte		Spare
40662-666:	Signed Long	1	Peak Demand KWatts-B
	Unsigned Byte		Peak Demand KWatts-B Year
	Unsigned Byte		Peak Demand KWatts-B Month
	Unsigned Byte		Peak Demand KWatts-B Day
	Unsigned Byte		Peak Demand KWatts-B Hour
	Unsigned Byte		Peak Demand KWatts-B Minute
	Unsigned Byte		Spare
40667-671:	Signed Long	1	Peak Demand KWatts-C
	Unsigned Byte		Peak Demand KWatts-C Year
	Unsigned Byte		Peak Demand KWatts-C Month
	Unsigned Byte		Peak Demand KWatts-C Day
	Unsigned Byte		Peak Demand KWatts-C Hour
	Unsigned Byte		Peak Demand KWatts-C Minute
	Unsigned Byte		Spare
40672-676:	Signed Long	1	3 Phase Peak Demand KWatts
	Unsigned Byte		3 Phase Peak Demand KWatts Year
	Unsigned Byte		3 Phase Peak Demand Kwatts Month
	Unsigned Byte		3 Phase Peak Demand KWatts Day
	Unsigned Byte		3 Phase Peak Demand KWatts Hour
	Unsigned Byte		3 Phase Peak Demand Kwatts Minute
	Unsigned Byte		Spare
40677-681:	Signed Long	1	Peak Demand KVARs-A
	Unsigned Byte		Peak Demand KVARs-A Year
	Unsigned Byte		Peak Demand KVARs-A Month

Register	Data Size	Scale	Description
	Unsigned Byte		Peak Demand KVARs-A Day
	Unsigned Byte		Peak Demand KVARs-A Hour
	Unsigned Byte		Peak Demand KVARs-A Minute
	Unsigned Byte		Spare
40682-686:	Signed Long	1	Peak Demand KVARs-B
	Unsigned Byte		Peak Demand KVARs-B Year
	Unsigned Byte		Peak Demand KVARs-B Month
	Unsigned Byte		Peak Demand KVARs-B Day
	Unsigned Byte		Peak Demand KVARs-B Hour
	Unsigned Byte		Peak Demand KVARs-B Minute
	Unsigned Byte		Spare
40687-691:	Signed Long	1	Peak Demand KVARs-C
	Unsigned Byte		Peak Demand KVARs-C Year
	Unsigned Byte		Peak Demand KVARs-C Month
	Unsigned Byte		Peak Demand KVARs-C Day
	Unsigned Byte		Peak Demand KVARs-C Hour
	Unsigned Byte		Peak Demand KVARs-C Minute
	Unsigned Byte		Spare
40692-696:	Signed Long	1	3 Phase Peak Demand KVARs
	Unsigned Byte		3 Phase Peak Demand KVARs Year
	Unsigned Byte		3 Phase Peak Demand KVARs Month
	Unsigned Byte		3 Phase Peak Demand KVARs Day
	Unsigned Byte		3 Phase Peak Demand KVARs Hour
	Unsigned Byte		3 Phase Peak Demand KVARs Minute
	Unsigned Byte		Spare

RMS Minimum Demand Current/Real, Reactive Power Values and Time Stamps Block

Register	Data Size	Scale	Description
40769-772:	Unsigned Short	1	Minimum Demand Current-A
	Unsigned Byte		Minimum Demand Current-A Year
	Unsigned Byte		Minimum Demand Current-A Month
	Unsigned Byte		Minimum Demand Current-A Day
	Unsigned Byte		Minimum Demand Current-A Hour
	Unsigned Byte		Minimum Demand Current-A Minute
	Unsigned Byte		Spare
40773-776:	Unsigned Short	1	Minimum Demand Current-B
	Unsigned Byte		Minimum Demand Current-B Year
	Unsigned Byte		Minimum Demand Current-B Month
	Unsigned Byte		Minimum Demand Current-B Day
	Unsigned Byte		Minimum Demand Current-B Hour
	Unsigned Byte		Minimum Demand Current-B Minute
	Unsigned Byte		Spare
40777-780:	Unsigned Short	1	Minimum Demand Current-C
	Unsigned Byte		Minimum Demand Current-C Year
	Unsigned Byte		Minimum Demand Current-C Month
	Unsigned Byte		Minimum Demand Current-C Day
	Unsigned Byte		Minimum Demand Current-C Hour
	Unsigned Byte		Minimum Demand Current-C Minute
	Unsigned Byte		Spare
40781-784:	Unsigned Short	1	Minimum Demand Current-N
	Unsigned Byte		Minimum Demand Current-N Year

Register	Data Size	Scale	Description
	Unsigned Byte		Minimum Demand Current-N Month
	Unsigned Byte		Minimum Demand Current-N Day
	Unsigned Byte		Minimum Demand Current-N Hour
	Unsigned Byte		Minimum Demand Current-N Minute
	Unsigned Byte		Spare
40785-789:	Signed Long	1	Minimum Demand KWatts-A
	Unsigned Byte		Minimum Demand KWatts-A Year
	Unsigned Byte		Minimum Demand KWatts-A Month
	Unsigned Byte		Minimum Demand KWatts-A Day
	Unsigned Byte		Minimum Demand KWatts-A Hour
	Unsigned Byte		Minimum Demand KWatts-A Minute
	Unsigned Byte		Spare
40790-794:	Signed Long	1	Minimum Demand KWatts-B
	Unsigned Byte		Minimum Demand KWatts-B Year
	Unsigned Byte		Minimum Demand KWatts-B Month
	Unsigned Byte		Minimum Demand KWatts-B Day
	Unsigned Byte		Minimum Demand KWatts-B Hour
	Unsigned Byte		Minimum Demand KWatts-B Minute
	Unsigned Byte		Spare
40795-799:	Signed Long	1	Minimum Demand KWatts-C
	Unsigned Byte		Minimum Demand KWatts-C Year
	Unsigned Byte		Minimum Demand KWatts-C Month
	Unsigned Byte		Minimum Demand KWatts-C Day
	Unsigned Byte		Minimum Demand KWatts-C Hour
	Unsigned Byte		Minimum Demand KWatts-C Minute
	Unsigned Byte		Spare
40800-804:	Signed Long	1	3 Phase Minimum Demand KWatts
	Unsigned Byte		3 Phase Minimum Demand Kwatts Year
	Unsigned Byte		3 Phase Minimum Demand Kwatts Month
	Unsigned Byte		3 Phase Minimum Demand Kwatts Day
	Unsigned Byte		3 Phase Minimum Demand Kwatts Hour
	Unsigned Byte		3 Phase Minimum Demand Kwatts Minute
	Unsigned Byte		Spare
40805-809:	Signed Long	1	Minimum Demand KVARs-A
	Unsigned Byte		Minimum Demand KVARs-A Year
	Unsigned Byte		Minimum Demand KVARs-A Month
	Unsigned Byte		Minimum Demand KVARs-A Day
	Unsigned Byte		Minimum Demand KVARs-A Hour
	Unsigned Byte		Minimum Demand KVARs-A Minute
	Unsigned Byte		Spare
40810-814:	Signed Long	1	Minimum Demand KVARs-B
	Unsigned Byte		Minimum Demand KVARs-B Year
	Unsigned Byte		Minimum Demand KVARs-B Month
	Unsigned Byte		Minimum Demand KVARs-B Day
	Unsigned Byte		Minimum Demand KVARs-B Hour
	Unsigned Byte		Minimum Demand KVARs-B Minute
	Unsigned Byte		Spare
40815-819:	Signed Long	1	Minimum Demand KVARs-C
	Unsigned Byte		Minimum Demand KVARs-C Year
	Unsigned Byte		Minimum Demand KVARs-C Month
	Unsigned Byte		Minimum Demand KVARs-C Day

	Unsigned Byte		Minimum Demand KVARs-C Hour
Register	Data Size	Scale	Description
	Unsigned Byte		Minimum Demand KVARs-C Minute
	Unsigned Byte		Spare
40820-824:	Signed Long	1	3 Phase Minimum Demand KVARs
	Unsigned Byte		3 Phase Minimum Demand KVARs Year
	Unsigned Byte		3 Phase Minimum Demand KVARs Month
	Unsigned Byte		3 Phase Minimum Demand KVA Day
	Unsigned Byte		3 Phase Minimum Demand KVARs Hour
	Unsigned Byte		3 Phase Minimum Demand KVARs Minute
	Unsigned Byte		Spare

Counters Block

Register	Data Size	Scale	Description
40897:	Unsigned Short	1	Unreported Operations Counter
40898:	Unsigned Short	1	Unreported Fault Counter
40899:	Unsigned Short	1	Sum of Fault Currents, A
40900:	Unsigned Short	1	Sum of Fault Currents, B
40901:	Unsigned Short	1	Sum of Fault Currents, C
40902:	Unsigned Short	1	Overcurrent Trip Counter
40903:	Unsigned Short	1	Breaker Operations Counter
40904:	Unsigned Short	1	Recloser Counter 1
40905:	Unsigned Short	1	Recloser Counter 2
40906:	Unsigned Short	1	Stage 1 Reclose Counter
40907:	Unsigned Short	1	Stage 2 Reclose Counter
40908:	Unsigned Short	1	Stage 3 Reclose Counter
40909:	Unsigned Short	1	Stage 4 Reclose Counter

Physical and Control /Status Point State Block

(Note: “s” means Sealed In output)

Register	Data Size	Description
41025-026:	Unsigned Long (out_stat_0)	Status Point 0 – 31

Bit 31:	TRIP	Bit 15:	81S-1
Bit 30:	CLOSE	Bit 14:	81R-1
Bit 29:	ALARM	Bit 13:	PATA
Bit 28:	27-1	Bit 12:	PBTA
Bit 27:	46-1	Bit 11:	PCTA
Bit 26:	50P-1	Bit 10:	TCFA
Bit 25:	50N-1	Bit 9:	TCC
Bit 24:	50P-2	Bit 8:	79DA
Bit 23:	50N-2	Bit 7:	PUA
Bit 22:	50P-3	Bit 6:	79LOA
Bit 21:	50N-3	Bit 5:	BFA
Bit 20:	51P	Bit 4:	PPDA
Bit 19:	51N	Bit 3:	NPDA
Bit 18:	59	Bit 2:	BFUA
Bit 17:	67P	Bit 1:	KSI
Bit 16:	67N	Bit 0:	79CA

Register	Data Size	Description	
41027-028:	Unsigned Long (out_stat_1)	Status Point 32 – 63	
		Bit 31: HPFA	Bit 15: TRIPC
		Bit 30: LPFA	Bit 14: 27-1s
		Bit 29: OCTC	Bit 13: 46-1s
		Bit 28: 50-1D	Bit 12: 50P-1s
		Bit 27: 50-2D	Bit 11: 50N-1s
		Bit 26: STC	Bit 10: 50P-2s
		Bit 25: ZSC	Bit 9: 50N-2s
		Bit 24: PH3-D	Bit 8: 50P-3s
		Bit 23: GRD-D	Bit 7: 50N-3s
		Bit 22: 32PA	Bit 6: 51Ps
		Bit 21: 32NA	Bit 5: 51Ns
		Bit 20: 27-3P	Bit 4: 59s
		Bit 19: VarDA	Bit 3: 67Ps
		Bit 18: 79CA-2	Bit 2: 67Ns
		Bit 17: TRIPA	Bit 1: 81S-1s
		Bit 16: TRIPB	Bit 0: 81R-1s
41029-030:	Unsigned Long (out_stat_2)	Status Point 64 – 95	
		Bit 31: 81O – 1s	Bit 15: LOADA
		Bit 30: 27-3Ps	Bit 14: 81O-1
		Bit 29: TRIPAs	Bit 13: 81O-2
		Bit 28: TRIPBs	Bit 12: 81S-2
		Bit 27: TRIPCs	Bit 11: 81R-2
		Bit 26: SPARE	Bit 10: 81O-2s
		Bit 25: SPARE	Bit 9: 81S-2s
		Bit 24: SPARE	Bit 8: 81R-2s
		Bit 23: SPARE	Bit 7: CLPTA
		Bit 22: SPARE	Bit 6: Watt1
		Bit 21: SPARE	Bit 5: Watt2
		Bit 20: SPARE	Bit 4: 79CA-1s
		Bit 19: SPARE	Bit 3: 79CA-2s
		Bit 18: SPARE	Bit 2: SEFs
		Bit 17: PVArA	Bit 1: SEF
		Bit 16: NVArA	Bit 0: PUA w/out SEF
41031-032:	Unsigned Long (out_stat_3)	Status Point 96 – 127	
		Bit 31: BFT	Bit 15: LO1
		Bit 30: ReTrip	Bit 14: LO2
		Bit 29: BFTs	Bit 13: LO3
		Bit 28: ReTrips	Bit 12: LO4
		Bit 27: 32P – 2	Bit 11: LO5
		Bit 26: 32N – 2	Bit 10: LO6
		Bit 25: 32P – 2s	Bit 9: LO7
		Bit 24: 32N – 2s	Bit 8: LO8
		Bit 23: BFAs	Bit 7: TR_ON
		Bit 22: 25s	Bit 6: TR_OFF
		Bit 21: 25	Bit 5: TR_TAG
		Bit 20: SBA	Bit 4: 3ph_59
		Bit 19: 79V	Bit 3: 3ph_59s
		Bit 18: RClin	Bit 2: 47
		Bit 17: 59G	Bit 1: 47s
		Bit 16: 59Gs	Bit 0: 50-3D

Register	Data Size	Description	
41033-034:	Unsigned Long (out_stat_4)	Status Point 128 – 159	
		Bit 31: 21P – 1	Bit 15: TimeT
		Bit 30: 21P – 1s	Bit 14: InstT
		Bit 29: 21P – 2	Bit 13: NegSeqT
		Bit 28: 21P – 2s	Bit 12: FreqT
		Bit 27: 21P – 3	Bit 11: DirT
		Bit 26: 21P – 3s	Bit 10: VoltT
		Bit 25: 21P – 4	Bit 9: DistT
		Bit 24: 21P – 4s	Bit 8: SEF
		Bit 23: C1	Bit 7: SPARE
		Bit 22: C2	Bit 6: SPARE
		Bit 21: C3	Bit 5: SPARE
		Bit 20: C4	Bit 4: SPARE
		Bit 19: C5	Bit 3: SPARE
		Bit 18: C6	Bit 2: SPARE
		Bit 17: TripT	Bit 1: SPARE
		Bit 16: NTA	Bit 0: LBLL
41035-036:	Unsigned Long (out_stat_5)	Status Point 160 – 191	
		Bit 31: LBDL	Bit 15: SHIFTB
		Bit 30: DBLL	Bit 14: Target Reset
		Bit 29: DBDL	Bit 13: BATT LOs
		Bit 28: 46 – 2	Bit 12: BATT HIs
		Bit 27: 46 – 2s	Bit 11: BATT HI
		Bit 26: REMOTE-D	Bit 10: BATT LO
		Bit 25: Prim Sett Act	Bit 9: TRIP – HIF
		Bit 24: Alt 1 Set Act	Bit 8: TRIP – HIFs
		Bit 23: Alt 2 Set Act	Bit 7: 21P – 1
		Bit 22: SHIFTA – 1	Bit 6: 21P – 2
		Bit 21: SHIFTA – 2	Bit 5: 21P – 3
		Bit 20: SHIFTA – 3	Bit 4: 21P – 4
		Bit 19: SHIFTA – 4	Bit 3: Local01
		Bit 18: SHIFTB – 1	Bit 2: Local02
		Bit 17: SHIFTB – 2	Bit 1: Local03
		Bit 16: SHIFTB – 3	Bit 0: Local04
41037-038:	Unsigned Long (out_stat_6)	Status Point 192 – 223	
		Bit 31: Local05	Bit 15: Remote05
		Bit 30: Local06	Bit 14: Remote06
		Bit 29: Local07	Bit 13: Remote07
		Bit 28: Local08	Bit 12: Remote08
		Bit 27: Local09	Bit 11: Remote09
		Bit 26: Local10	Bit 10: Remote10
		Bit 25: Local11	Bit 9: Remote11
		Bit 24: Local12	Bit 8: Remote12
		Bit 23: Local13	Bit 7: Remote13
		Bit 22: Local14	Bit 6: Remote14
		Bit 21: Local15	Bit 5: Remote15
		Bit 20: Local16	Bit 4: Remote16
		Bit 19: Remote01	Bit 3: UL01
		Bit 18: Remote02	Bit 2: UL02
		Bit 17: Remote03	Bit 1: UL03
		Bit 16: Remote04	Bit 0: UL04

Register	Data Size	Description			
41039-040:	Unsigned Long (out_stat_7)	Status Point 224 – 255			
		Bit 31:	UL05	Bit 15:	SPARE
		Bit 30:	UL06	Bit 14:	SPARE
		Bit 29:	UL07	Bit 13:	SPARE
		Bit 28:	UL08	Bit 12:	SPARE
		Bit 27:	UL09	Bit 11:	SPARE
		Bit 26:	UL10	Bit 10:	SPARE
		Bit 25:	UL11	Bit 9:	SPARE
		Bit 24:	UL12	Bit 8:	SPARE
		Bit 23:	UL13	Bit 7:	SPARE
		Bit 22:	UL14	Bit 6:	SPARE
		Bit 21:	UL15	Bit 5:	SPARE
		Bit 20:	UL16	Bit 4:	SPARE
		Bit 19:	SPARE	Bit 3:	SPARE
		Bit 18:	SPARE	Bit 2:	SPARE
		Bit 17:	SPARE	Bit 1:	SPARE
		Bit 16:	SPARE	Bit 0:	SPARE
41041-042:	Unsigned Long (out_stat_8)	Status Point 256 – 287	All Bits Spare		
41043-044:	Unsigned Long (out_stat_9)	Status Point 288 – 319	All Bits Spare		
41045-046:	Unsigned Long (out_stat_10)	Status Point 320 – 351	All Bits Spare		
41047-048:	Unsigned Long (out_stat_11)	Status Point 352 – 383	All Bits Spare		
41049-050:	Unsigned Long (out_stat_12)	Status Point 384 – 415	All Bits Spare		
41051-052:	Unsigned Long (in_stat_0)	Status Point 0-31			
		Bit 31:	52a	Bit 15:	DFRI
		Bit 30:	52b	Bit 14:	ZSC
		Bit 29:	43a	Bit 13:	OPEN
		Bit 28:	PH3	Bit 12:	CLOSE
		Bit 27:	GRD	Bit 11:	46-1
		Bit 26:	SCC	Bit 10:	67P
		Bit 25:	79s	Bit 9:	67N
		Bit 24:	79M	Bit 8:	SPARE1
		Bit 23:	TCM	Bit 7:	SPARE2
		Bit 22:	50-1	Bit 6:	SPARE3
		Bit 21:	50-2	Bit 5:	SPARE4
		Bit 20:	50-3	Bit 4:	SPARE5
		Bit 19:	ALT1	Bit 3:	SPARE6
		Bit 18:	ALT2	Bit 2:	SPARE7
		Bit 17:	ECI1	Bit 1:	SPARE8
		Bit 16:	ECI2	Bit 0:	SPARE9
41053-054:	Unsigned Long (in_stat_1)	Control Point 32-63			
		Bit 31:	CRI	Bit 15:	LIS5
		Bit 30:	ARCI	Bit 14:	LIS6
		Bit 29:	TARC	Bit 13:	LIS7
		Bit 28:	SEF TC	Bit 12:	LIS8
		Bit 27:	EXTBFI	Bit 11:	LIR1
		Bit 26:	BFI	Bit 10:	LIR2
		Bit 25:	UDI	Bit 9:	LIR3
		Bit 24:	25	Bit 8:	LIR4
		Bit 23:	25By	Bit 7:	LIR5
		Bit 22:	LOCAL	Bit 6:	LIR6
		Bit 21:	TGT	Bit 5:	LIR7
		Bit 20:	SIA	Bit 4:	LIR8
		Bit 19:	LIS1	Bit 3:	TR_SET

Bit 18: LIS2 Bit 2: TR_RST

Register	Data Size	Description	
		Bit 17: LIS3	Bit 1: SPARE10
		Bit 16: LIS4	Bit 0: SPARE11
41055-056:	Unsigned Long (in_stat_2)	Control Point 64-95	
		Bit 31: SPARE12	Bit 15: PhyInput06
		Bit 30: SPARE13	Bit 14: PhyInput07
		Bit 29: SPARE14	Bit 13: PhyInput08
		Bit 28: SPARE15	Bit 12: Timer01
		Bit 27: SPARE16	Bit 11: Timer02
		Bit 26: 46-2	Bit 10: Timer03
		Bit 25: SWSET	Bit 9: Timer04
		Bit 24: SHIFTA	Bit 8: Timer05
		Bit 23: SHIFTB	Bit 7: Timer06
		Bit 22: 51PTC	Bit 6: Timer07
		Bit 21: HIFTC	Bit 5: Timer08
		Bit 20: PhyInput01	Bit 4: Timer09
		Bit 19: PhyInput02	Bit 3: Timer10
		Bit 18: PhyInput03	Bit 2: Timer11
		Bit 17: PhyInput04	Bit 1: Timer12
		Bit 16: PhyInput05	Bit 0: Timer13
41057-058:	Unsigned Long (in_stat_3)	Control Point 96 – 127	
		Bit 31: Timer14	Bit 15: Spare
		Bit 30: Timer15	Bit 14: Spare
		Bit 29: Timer16	Bit 13: Spare
		Bit 28: Spare	Bit 12: Spare
		Bit 27: Spare	Bit 11: Spare
		Bit 26: Spare	Bit 10: Spare
		Bit 25: Spare	Bit 9: Spare
		Bit 24: Spare	Bit 8: Spare
		Bit 23: Spare	Bit 7: Spare
		Bit 22: Spare	Bit 6: Spare
		Bit 21: Spare	Bit 5: Spare
		Bit 20: Spare	Bit 4: Spare
		Bit 19: Spare	Bit 3: Spare
		Bit 18: Spare	Bit 2: Spare
		Bit 17: Spare	Bit 1: Spare
		Bit 16: Spare	Bit 0: Spare
41059-060:	Unsigned Long (in_stat_4)	Control Point 128 – 159	All Bits Spare
41061-062:	Unsigned Long (in_stat_5)	Control Point 160 – 191	All Bits Spare
41063-064:	Unsigned Long (in_stat_6)	Control Point 192 – 223	All Bits Spare
41065-066:	Unsigned Long (in_stat_7)	Control Point 224 – 255	All Bits Spare
41067-068:	Unsigned Long (in_stat_8)	Control Point 256 – 287	All Bits Spare
41069-070:	Unsigned Long (in_stat_9)	Control Point 288 – 319	All Bits Spare
41071-072:	Unsigned Long (in_stat_10)	Control Point 320 – 351	All Bits Spare
41073-074:	Unsigned Long (in_stat_11)	Control Point 352 – 383	All Bits Spare
41075-076:	Unsigned Long (in_stat_12)	Control Point 384 – 415	All Bits Spare

The REF 550 also has the capability to perform Fault Record Access, Event Record Access and Control capabilities using the 4X memory write capability. The memory map registers are listed in Table 8-D. If additional information is required to perform memory control operations in addition to that presented in this table, please reference the Modbus Automation Manual for further information.

Table 8-11: Modbus Write-Able Memory Data Assignments

Register	Data Size	Description
41281	Unsigned Short	Security Mask (read only, See Register 62598 for setup) (bit state:0=Block Password Required,1=Block Unprotected)
		Bit 15: Spare / Bit 7: Spare
		Bit 14: Spare / Bit 6: Initiate Control Button
		Bit 13: Spare / Bit 5: Pulse Outputs
		Bit 12: Spare / Bit 4: Set Reset Outputs
		Bit 11: Spare / Bit 3: Spare
		Bit 10: Spare / Bit 2: Spare
		Bit 9: Spare / Bit 1: Spare
		Bit 8: Spare / Bit 0: Initiate Input
		----- Initiate Input registers ------
41282	Unsigned Short	Execute on Initiate Input Registers (0=No Action, 1=Execute)
41283	high byte	Relay or Test Password Character 1
	low byte	Relay or Test Password Character 2
41284	high byte	Relay or Test Password Character 3
	low byte	Relay or Test Password Character 4
41285	Unsigned Short	Spare
41286	Unsigned Short	Change Initiate Input Mask (change state: No change if bit = 0 & change/initiate action if bit = 1)
41287	Unsigned Short	Confirmation Initiate Input Mask (change state: No change if bit = 0 & change/initiate action if bit = 1)
		Bit 15: Spare / Bit 7: Spare
		Bit 14: Spare / Bit 6: Spare
		Bit 13: Toggle SCADA Redi
		Bit 5: Close Initiate (Independent of 43A)
		Bit 12: Reset Energy Meters / Bit 4: Spare
		Bit 11: Reset Relay Status / Bit 3: Spare
		Bit 10: Reset Min/Max Demands / Bit 2: Spare
		Bit 9: Reset Alarms / Bit 1: Close Initiate (Based on State of 43A)
		Bit 8: Reset LED Targets / Bit 0: Trip Initiate

----- Set/Reset Output registers ----

Register	Data Size	Description
41312	Unsigned Short	Execute on Set/Reset Masks Word 1 and Word 2 Registers
41313	high byte	Relay or Test Password Character 1
	low byte	Relay or Test Password Character 2
41314	high byte	Relay or Test Password Character 3
	low byte	Relay or Test Password Character 4
41315	Unsigned Short	Spare
41316	Unsigned Short	Set/Reset Change Mask Long Word 1(Bit 31-16)
41317	Unsigned Short	Set/Reset Change Mask Long Word 1(Bit 15-0) (bit state:0=No change, 1=Change)
41318	Unsigned Short	Set/Reset Change Mask Long Word 2(Bit 31-16)
41319	Unsigned Short	Set/Reset Change Mask Long Word 2(Bit 15-0) (bit state:0=No change, 1=Change)
41320	Unsigned Short	Set/Reset State Mask Long Word 1(Bit 31-16)
41321	Unsigned Short	Set/Reset State Mask Long Word 1(Bit 15-0)

		(bit state:0=Reset, 1=Set)
41322	Unsigned Short	Set/Reset State Mask Long Word 2(Bit 31-16)
41323	Unsigned Short	Set/Reset State Mask Long Word 2(Bit 15-0) (bit state:0=Reset, 1=Set)

Set/Reset Mask Long Word 1

Bit 31:	27-1s	Bit 15:	27-3Ps
Bit 30:	46-1s	Bit 14:	TRIPAs
Bit 29:	50P1s	Bit 13:	TRIPBs
Bit 28:	50N1s	Bit 12:	TRIPCs
Bit 27:	50P2s	Bit 11:	SPARE1
Bit 26:	50N2s	Bit 10:	SPARE2
Bit 25:	50P3s	Bit 09:	SPARE3
Bit 24:	50N3s	Bit 08:	SPARE4
Bit 23:	51Ps	Bit 07:	SPARE5
Bit 22:	51Ns	Bit 06:	SPARE6
Bit 21:	59s	Bit 05:	SPARE7
Bit 20:	67Ps	Bit 04:	SPARE8
Bit 19:	67Ns	Bit 03:	SPARE9
Bit 18:	81S-1s	Bit 02:	81O-2s
Bit 17:	81R-1s	Bit 01:	81S-2s
Bit 16:	81O-1s	Bit 00:	81R-2s

Set/Reset Mask Long Word 2

Bit 31:	79CA1s	Bit 15:	SPARE10
Bit 30:	79CA2s	Bit 14:	SPARE11
Bit 29:	*SEFs*	Bit 13:	SPARE12

Note: You can only Reset "s" outputs.

Bit 28:	*BF Trips*	Bit 12:	SPARE13

Trying to set these will have no affect on the state of the sealed in alarms

Bit 27:	*BF Retrips*	Bit 11:	SPARE14
Bit 26:	*32Ps*	Bit 10:	SPARE15
Bit 25:	*32Ns*	Bit 09:	SPARE16
Bit 24:	BFAs	Bit 08:	46-2s
Bit 23:	25s	Bit 07:	BATT_Los
Bit 22:	59Gs	Bit 06:	BATT_HIs
Bit 21:	3ph_59s	Bit 05:	Trip_HIFs
Bit 20:	47s	Bit 04:	
Bit 19:	21P-1s	Bit 03:	
Bit 18:	21P-2s	Bit 02:	
Bit 17:	21P-3s	Bit 01:	
Bit 16:	21P-4s	Bit 00:	

----- Pulse Output registers -----

41324	Unsigned Short	Execute on Momentary Output Contact Registers (0=No Action, 1=Execute)
41325	high byte	Relay or Test Password Character 1
	low byte	Relay or Test Password Character 2
41326	high byte	Relay or Test Password Character 3
	low byte	Relay or Test Password Character 4
41327	Unsigned Short	Spare
41328	Unsigned Short	Momentary Output Contact State Mask (bit state:0=No change, 1=Pulse Contact)

41329	Unsigned Short	Confirmation Momentary Output Contact State Mask (bit state:0=No change, 1=Pulse Contact) Momentary Output Contact State Mask Bit 15: Spare Bit 07: OUT6 Bit 14: Spare Bit 06: OUT5 Bit 13: Spare Bit 05: OUT4 Bit 12: Spare Bit 04: OUT3 Bit 11: Spare Bit 03: OUT2 Bit 10: Spare Bit 02: OUT1 Bit 09: Reserved Bit 01: Reserved Bit 08: Reserved Bit 00: TRIP

Note: This register group sets the appropriate physical output contact momentarily for the configured breaker failed to trip time.

----- ***Initiate Control Button registers*** ---

-41330	Unsigned Short	Execute on Initiate Control Button Registers (0=No Action, 1=Execute)
41331	high byte	Relay or Test Password Character 1
	low byte	Relay or Test Password Character 2
41332	high byte	Relay or Test Password Character 3
	low byte	Relay or Test Password Character 4
41333	Unsigned Short	Spare
41334	Unsigned Short	Change Initiate Control Button Mask (No change if bit = 0 & change/initiate action if bit = 1)
41335	Unsigned Short	Confirmation Initiate Control Button Mask (No change if bit = 0 & change/initiate action if bit = 1) Bit 15: HLT's right arrow (set)* Bit 7: Spare Bit 14: HLT's left arrow (reset)* Bit 6: Spare Bit 13: Spare Bit 5: Control Button 6 (C6) Bit 12: Spare Bit 4: Control Button 5 (C5) Bit 11: Spare Bit 3: Control Button 4 (C4) Bit 10: Spare Bit 2: Control Button 3 (C3) Bit 9: Spare Bit 1: Control Button 2 (C2) Bit 8: Spare Bit 0: Control Button 1 (C1)

*Note – The HLT actions are only supported in the HLT option for the OCI model.

----- Remote Control registers -----

41336	Unsigned Short	Execute Remote Control Registers (0=No Action, 1=Execute)
41337	high byte	Relay or Test Password Character 1
	low byte	Relay or Test Password Character 2
41338	high byte	Relay or Test Password Character 3
	low byte	Relay or Test Password Character 4
41339	Unsigned Short	Spare
41400	Unsigned Short	Spare
41401	Unsigned Short	Remotes 1 to 16 Change Mask (LSB = Remote 1) (bit state:0=No change, 1=Change)
41402	Unsigned Short	Spare
41403	Unsigned Short	Remotes 1 to 16 State (LSB = Remote 1) (bit state: 0=Off, 1=On)

FUNCTION CODE 23 (READ/WRITE 4X REGISTERS)

Table 8-12 – Codes for Fault Element Type

Fault Element Type	Message Number
51P	0
51N	1
50P-1	2
50N-1	3
50P-2	4
50N-2	5
50P-3	6
50N-3	7
67P	8
67N	9
46-1	10
81	11
Zone Step	12
ECI-1	13
ECI-2	14
SEF	15
46-2	16
HIF	17

Table 8-13 – Codes for Active Settings and Reclose Sequence

Value	Definition
0x11	Primary-1
0x12	Primary-2
0x13	Primary-3
0x14	Primary-4
0x15	Primary-Lockout
0x21	Alternate 1-1
0x22	Alternate 1-2
0x23	Alternate 1-3
0x24	Alternate 1-4
0x25	Alternate 1-Lockout
0x41	Alternate 2-1
0x42	Alternate 2-2
0x43	Alternate 2-3
0x44	Alternate 2-4
0x45	Alternate 2-Lockout

Fault Record

Register	Data Size	Scale	Description
41409	Unsigned Word	1	Data Control 1=First record 2=Next record 3=Oldest *Unreported* record
41410	Unsigned Word	1	Fault Type Element (Table , p. 1)
41411	Unsigned Word	1	Active Set and Recl Seq (Table , p. 1)
41412	Unsigned Word	1	Fault Number
41413	Unsigned Word	1	Year
41414	Unsigned Word	1	Month
41415	Unsigned Word	1	Day
41416	Unsigned Word	1	Hours
41417	Unsigned Word	1	Minutes
41418	Unsigned Word	1	Seconds
41419	Unsigned Word	1	Hundredths of Seconds
41420	Unsigned Word	x	Ia (Scale at register 41424)
41421	Unsigned Word	x	Ib (Scale at register 41424)
41422	Unsigned Word	x	Ic (Scale at register 41424)
41423	Unsigned Word	x	In (Scale at register 41424)
41424	Unsigned Word	1	Current (I) Scale x
41425	Unsigned Word	1	Ia Angle
41426	Unsigned Word	1	Ib Angle
41427	Unsigned Word	1	Ic Angle
41428	Unsigned Word	1	In Angle
41429	Unsigned Word	1	Zero Seq I (Mag)
41420	Unsigned Word	1	Pos Seq I (Mag)
41431	Unsigned Word	1	Neg Seq I (Mag)
41432	Unsigned Word	1	Zero Seq I (Ang)
41433	Unsigned Word	1	Pos Seq I (Ang)
41434	Unsigned Word	1	Neg Seq I (Ang)
41435	Unsigned Word	100	Kvab/Kvan (Mag)
41436	Unsigned Word	100	KVbc/KVbn (Mag)
41437	Unsigned Word	100	Kvca/KVcn (Mag)
41438	Unsigned Word	1	Vab/Van (Ang)
41439	Unsigned Word	1	Vbc/Vbn (Ang)
41440	Unsigned Word	1	Vca/Vcn (Ang)
41441	Unsigned Word	100	Pos Seq KV (Mag)
41442	Unsigned Word	100	Neg Seq KV (Mag)
41443	Unsigned Word	1	Pos Seq V (Ang)
41444	Unsigned Word	1	Neg Seq V (Ang)
41445	Unsigned Word	10	Fault Location
41446-41447	Unsigned Long	1000	Fault Impedance, Real
41448-41449	Unsigned Long	1000	Breaker Operate Time
41450-41451	Unsigned Long	1000	Relay Operate Time
41452	Unsigned Word	1	Record Status Bit 0: 0=Wye, 1=Delta Bit 1: 0=Fault, 1=Event Capture

Operation Record

Register	Data Size	Scale	Description
41537	Unsigned Word	1	Data Control 1=First record 2=Next record 3=Oldest *Unreported* record
41538	Unsigned Word	1	Year
41539	Unsigned Word	1	Month
41540	Unsigned Word	1	Day
41541	Unsigned Word	1	Hours
41542	Unsigned Word	1	Minutes
41543	Unsigned Word	1	Seconds
41544	Unsigned Word	1	Hundredths of Seconds
41545	Unsigned Word	1	Message # (see Table 1)
41546	Unsigned Word	1	Value
41547	Unsigned Word	1	Operation Number

Table 8-14 8-14 Operation Record Definitions

Operation Number	Operation Record Definitions	Operation Number	Operation Record Definitions
0	51P Trip	33	CB Pops Open
1	51N Trip	34	CB Pops Closed
2	50P-1 Trip	35	CB State Unknown
3	50N-1 Trip	36	CB Stuck Closed
4	50P-2 Trip	37	Ext. Trip CB Stuck
5	50N-2 Trip	38	Springs Discharged
6	50P-3 Trip	39	- Reserved for future use -
7	50N-3 Trip	40	Manual Trip
8	67P Trip	41	Manual Close
9	67N Trip	42	Ground TC Enabled
10	46-1 Trip	43	Ground TC Disabled
11	27-1P Alarm	44	Phase TC Enabled
12	59 Alarm	45	Phase TC Disabled
13	79V Block	46	Primary Set Active
14	81S-1 Trip	47	Alt 1 Set Active
15	81R-1 Restore	48	Alt 2 Set Active
16	81V Block	49	Zone Step
17	TOC Pickup-No Trip	50	Recloser Enabled
18	27-3P Alarm	51	Recloser Disabled
19	SEF Trip	52	Zone Sequence Enabled
20	External Trip	53	Zone Sequence Disabled
21	External Close	54	50P/N-1 Disabled
22	Breaker Opened	55	50P/N-2 Disabled
23	Breaker Closed	56	50P/N-3 Disabled
24	Open Trip Contact	57	50P/N-1 Enabled
25	Recloser Lockout	58	50P/N-2 Enabled
26	Direct Trip	59	50P/N-3 Enabled
27	Direct Close	60	81S-2 Trip
28	MDT Close	61	81R-2 Restore
29	External Trip and ARC	62	81O-1 Overfrequency
30	Reclose Initiated	63	81O-2 Overfrequency
31	CB Failed to Trip	64	Closed Failed No Sync
32	CB Failed to Close	65	Live Bus Live Line

Operation Number	Operation Record Definitions	Operation Number	Operation Record Definitions
66	Live Bus Dead Line	120	Shift-A
67	Dead Bus Live Line	121	Shift-B
68	Dead Bus Dead Line	122	Sw Set
69	Software Error	123	St Bat Low
70	Blown Fuse Alarm	124	St Bat High
71	OC Trip Counter	125	HIF Pickup
72	Accumulated KSI	126	HIF Unit Enabled
73	79 Counter 1 Alarm	127	HIF Unit Disabled
74	Phase Demand Alarm	128	Springs Charged
75	Neutral Demand Alarm	129	Springs Discharged
76	Low PF Alarm	130	79S Input Enabled
77	High PF Alarm	131	79S Input Disabled
78	Trip Coil Failure	132	79M Input Enabled
79	kVAR Demand Alarm	133	79M Input Disabled
80	79 Counter 2 Alarm	134	TCM Input Closed
81	Pos kVAR Alarm	135	TCM Input Opened
82	Neg. kVAR Alarm	136	ALT 1 Input Enabled
83	Load Alarm	137	ALT 1 Input Disabled
84	Cold Load Alarm	138	ALT 2 Input Enabled
85	Pos Watt Alarm 1	139	ALT 2 Input Disabled
86	Pos Watt Alarm 2	140	Ext Trip Enabled
87	32P Trip	141	Ext Trip Disabled
88	32N Trip	142	Event Cap 1 Init
89	- Reserved for future use -	143	Event Cap 1 Reset
90	Event Capture #1	144	Event Cap 2 Init
91	Event Capture #2	145	Event Cap 2 Reset
92	Waveform Capture	146	Wave Cap Init
93	BFT Operation	147	Wave Cap Reset
94	RETRIP Operation	148	Ext Close Enabled
95	Ext. BFI Enabled	149	Ext Close Disabled
96	Ext. BFI Disabled	150	52a Closed
97	BFI Enabled	151	52a Opened
98	BFI Disabled	152	52b Closed
99	- Reserved for future use -	153	52b Opened
100	ROM Failure	154	43a Closed
101	RAM Failure	155	43a Opened
102	Self Test Failed	156	46-1 Unit Enabled
103	EEPROM Failure	157	46-1 Unit Disabled
104	BATRAM Failure	158	67P Unit Enabled
105	DSP Failure	159	67P Unit Disabled
106	Control Power Fail	160	67N Unit Enabled
107	Editor Access	161	67N Unit Disabled
108	System Reboot Init	162	UL01 Input Closed
109	Interrupt Overlap	163	UL01 Input Opened
110	DSP COP Status	164	UL02 Input Closed
111	System Booting	165	UL02 Input Opened
112	I2C_FAILER	166	UL03 Input Closed
113	51P TC Enabled	167	UL03 Input Opened
114	51P TC Disabled	168	UL04 Input Closed
115	Suprvsr Stack Pointer	169	UL04 Input Opened
116	User Stack Pointer	170	UL05 Input Closed
117	Task Control Block	171	UL05 Input Opened
118	Stack Base	172	UL06 Input Closed
119	Task Address	173	UL06 Input Opened

Operation Number	Operation Record Definitions	Operation Number	Operation Record Definitions
174	UL07 Input Closed	228	TR_SET Deasserted
175	UL07 Input Opened	229	TR_RST Deasserted
176	UL08 Input Closed	230	TR_ON Asserted
177	UL08 Input Opened	231	TR_OFF Asserted
178	UL09 Input Closed	232	TR_TAG Asserted
179	UL09 Input Opened	233	59-3P Alarm
180	CRI Input Closed	234	47 Alarm
181	CRI Input Opened	235	21P-1 Zone 1 Trip
182	ARC Blocked	236	21P-2 Zone 2 Trip
183	ARC Enabled	237	21P-3 Zone 3 Trip
184	TARC Input Opened	238	21P-4 Zone 4 Trip
185	SEF Enabled	239	UL010 Input Closed
186	SEF Disabled	240	UL010 Input Opened
187	User Display On	241	UL011 Input Closed
188	User Display Off	242	UL011 Input Opened
189	Sync Check Enabled	243	UL012 Input Closed
190	Sync Check Disabled	244	UL012 Input Opened
191	Lines Synced	245	UL013 Input Closed
192	Line Sync Lost	246	UL013 Input Opened
193	CB Slow To Trip	247	UL014 Input Closed
194	Supervisory Disable	248	UL014 Input Opened
195	Supervisory Enabled	249	UL015 Input Closed
196	25 Bypass Enabled	250	UL015 Input Opened
197	25 Bypass Disabled	251	UL016 Input Closed
198	25 Sync Failed	252	UL016 Input Opened
199	Catalog Number Update	253	46-2 Trip
200	- Reserved for future use -	254	46-2 Unit Enabled
201	- Reserved for future use -	255	46-2 Unit Disabled
202	- Reserved for future use -	256	LIS01 Asserted
203	- Reserved for future use -	257	LIS02 Asserted
204	- Reserved for future use -	258	LIS03 Asserted
205	- Reserved for future use -	259	LIS04 Asserted
206	- Reserved for future use -	260	LIS05 Asserted
207	- Reserved for future use -	261	LIS06 Asserted
208	- Reserved for future use -	262	LIS07 Asserted
209	- Reserved for future use -	263	LIS08 Asserted
210	- Reserved for future use -	264	LIS01 Deasserted
211	- Reserved for future use -	265	LIS02 Deasserted
212	- Reserved for future use -	266	LIS03 Deasserted
213	- Reserved for future use -	267	LIS04 Deasserted
214	- Reserved for future use -	268	LIS05 Deasserted
215	59G Alarm	269	LIS06 Deasserted
216	TGT Enabled	270	LIS07 Deasserted
217	TGT Disabled	271	LIS08 Deasserted
218	SIA Enabled	272	LIR01 Asserted
219	SIA Disabled	273	LIR02 Asserted
220	Shift-A Asserted	274	LIR03 Asserted
221	Shift-B Asserted	275	LIR04 Asserted
222	Sw Set Asserted	276	LIR05 Asserted
223	Shift-A Deasserted	277	LIR06 Asserted
224	Shift-B Deasserted	278	LIR07 Asserted
225	Sw Set Deasserted	279	LIR08 Asserted
226	TR_SET Asserted	280	LIR01 Deasserted
227	TR_RST Asserted	281	LIR02 Deasserted

Operation Number	Operation Record Definitions	Operation Number	Operation Record Definitions
282	LIR03 Deasserted	296	LO01 Dessserted
283	LIR04 Deasserted	297	LO02 Dessserted
284	LIR05 Deasserted	298	LO03 Dessserted
285	LIR06 Deasserted	299	LO04 Dessserted
286	LIR07 Deasserted	300	LO05 Dessserted
287	LIR08 Deasserted	301	LO06 Dessserted
288	LO01 Asserted	302	LO07 Dessserted
289	LO02 Asserted	303	LO08 Dessserted
290	LO03 Asserted	304	- Reserved for future use -
291	LO04 Asserted	305	- Reserved for future use -
292	LO05 Asserted	…	…
293	LO06 Asserted	65535	- Reserved for future use -
294	LO07 Asserted	65536	Not applicable!!
295	LO08 Asserted		

Digital Fault Recorder Configuration

Register	Data size	Scale	Description
41665	Unsigned Word	1	R Number of records stored
41666	Unsigned Word	1	W Record header desired
41667-68	Trigger Flags (63-32)	1	Trigger Flags bits 63-32
41669-70	Trigger Flags (31-0)	1	Trigger Flags bits 31-0
Data/Time stamps of the trigger point			
41671	Unsigned Word	1	yy year
41672	Unsigned Word	1	mm month
41673	Unsigned Word	1	dd day
41674	Unsigned Word	1	hh hour
41675	Unsigned Word	1	mm minutes
41676	Unsigned Word	1	ss seconds (0 to 59.999999)
41677	Unsigned Word	1	hs hundredths of a second
41678	Unsigned Word	1	Quarter cycle trigger point
41679	Unsigned Word	1	TT Total number of channels
41680	Unsigned Word	1	Number of channels of status (digital) data
Line frequency			
41682	Unsigned Word	1	lf Line frequency in Hz (50/60 Hz)
Sample rate information			
41683	Unsigned Word	1	nrates number of different sample
41684	Unsigned Word	1	sssssn sample rate of in Hz
41685	Unsigned Word	1	endsampn last sample at this rate

(** Descriptions of channel numbers, names, phases and units are bottom of this block. ****)**

Register	Data size	Scale	Description
Channel names, units and conversion factors			
41686	Unsigned Word	1	nn Channel number
41687	Unsigned Word	1	id Channel name (two characters)
41688	Unsigned Word	1	p Channel phase identification
41689	Unsigned Word	1	uu Channel units
41690-91	Unsigned Long	1	a Scale factor numerator
41692-93	Unsigned Long	1	a Scale factor denominator
41694	Unsigned Word	1	nn Channel number
41695	Unsigned Word	1	id Channel name
41696	Unsigned Word	1	p Channel phase identification
41697	Unsigned Word	1	uu Channel units
41698-99	Unsigned Long	1	a Scale factor numerator
41700-01	Unsigned Long	1	a Scale factor denominator
41702	Unsigned Word	1	nn Channel number
41703	Unsigned Word	1	id Channel name
41704	Unsigned Word	1	p Channel phase identification
41705	Unsigned Word	1	uu Channel units
41706-07	Unsigned Long	1	a Scale factor numerator
41708-09	Unsigned Long	1	a Scale factor denominator

Register	Data size	Scale	Description
41710	Unsigned Word	1	nn Channel number
41711	Unsigned Word	1	id Channel name
41712	Unsigned Word	1	p Channel phase identification
41713	Unsigned Word	1	uu Channel units
41714-15	Unsigned Long	1	a Scale factor numerator
41716-17	Unsigned Long	1	a Scale factor denominator
41718	Unsigned Word	1	nn Channel number
41719	Unsigned Word	1	id Channel name
41720	Unsigned Word	1	p Channel phase identification
41721	Unsigned Word	1	uu Channel units
41722-23	Unsigned Long	1	a Scale factor numerator
41724-25	Unsigned Long	1	a Scale factor denominator
41726	Unsigned Word	1	nn Channel number
41727	Unsigned Word	1	id Channel name
41728	Unsigned Word	1	p Channel phase identification
41729	Unsigned Word	1	uu Channel units
41730-31	Unsigned Long	1	a Scale factor numerator
41732-33	Unsigned Long	1	a Scale factor denominator
41734	Unsigned Word	1	nn Channel number
41735	Unsigned Word	1	id Channel name
41736	Unsigned Word	1	p Channel phase identification
41737	Unsigned Word	1	uu Channel units
41738-39	Unsigned Long	1	a Scale factor numerator
41740-41	Unsigned Long	1	a Scale factor denominator
41742	Unsigned Word	1	nn Channel number
41743	Unsigned Word	1	id Channel name (two characters)
41744	Unsigned Word	1	p Channel phase identification
41745	Unsigned Word	1	uu Channel units
41746-47	Unsigned Long	1	a Scale factor numerator
41748-49	Unsigned Long	1	a Scale factor denominator
41750	Unsigned Word	1	nn Channel number
41751	Unsigned Word	1	id Channel name
41752	Unsigned Word	1	p Channel phase identification
41753	Unsigned Word	1	uu Channel units
41754-55	Unsigned Long	1	a Scale factor numerator
41756-57	Unsigned Long	1	a Scale factor denominator
41077:	Unsigned Short		Physical Output Bit 15: Spare — Bit 7: OUT 6 Bit 14: Spare — Bit 6: OUT5 Bit 13: Spare — Bit 5: OUT4 Bit 12: Spare — Bit 4: OUT3 Bit 11: Spare — Bit 3: OUT2 Bit 10: Spare — Bit 2: OUT1 Bit 9: Reserved — Bit 1: Reserved Bit 8: Reserved — Bit 0: TRIP
41078:	Unsigned Short		Physical Input Bit 15: Reserved — Bit 7: IN5 Bit 14: Reserved — Bit 6: IN4 Bit 13: Reserved — Bit 5: IN3 Bit 12: Reserved — Bit 4: IN2 Bit 11: Reserved — Bit 3: IN1 Bit 10: IN8 — Bit 2: Reserved Bit 9: IN7 — Bit 1: Reserved Bit 8: IN6 — Bit 0: Reserved

41079	Unsigned Short	InSelectMask			
		Bit 15:	Reserved	Bit 7:	IN5
		Bit 14:	Reserved	Bit 6:	IN4
		Bit 13:	Reserved	Bit 5:	IN3
		Bit 12:	Reserved	Bit 4:	IN2
		Bit 11:	Reserved	Bit 3:	IN1
		Bit 10:	IN8	Bit 2:	Reserved
		Bit 9:	IN7	Bit 1:	Reserved
		Bit 8:	IN6	Bit 0:	Reserved
41080	Unsigned Short	InForceMask			
		Bit 15:	Reserved	Bit 7:	IN5
		Bit 14:	Reserved	Bit 6:	IN4
		Bit 13:	Reserved	Bit 5:	IN3
		Bit 12:	Reserved	Bit 4:	IN2
		Bit 11:	Reserved	Bit 3:	IN1
		Bit 10:	IN8	Bit 2:	Reserved
		Bit 9:	IN7	Bit 1:	Reserved
		Bit 8:	IN6	Bit 0:	Reserved
41081	Unsigned Short	OutSelectMask		Reserved	
		Bit 15:	Spare	Bit 7:	OUT 6
		Bit 14:	Spare	Bit 6:	OUT5
		Bit 13:	Spare	Bit 5:	OUT4
		Bit 12:	Spare	Bit 4:	OUT3
		Bit 11:	Spare	Bit 3:	OUT2
		Bit 10:	Spare	Bit 2:	OUT1
		Bit 9: Reserved		Bit 1:	Reserved
		Bit 8: Reserved		Bit 0:	Reserved
41082	Unsigned Short		OutForceMask		Reserved
		Bit 15:	Spare	Bit 7:	OUT 6
		Bit 14:	Spare	Bit 6:	OUT5
		Bit 13:	Spare	Bit 5:	OUT4
		Bit 12:	Spare	Bit 4:	OUT3
		Bit 11:	Spare	Bit 3:	OUT2
		Bit 10:	Spare	Bit 2:	OUT1
		Bit 9: Reserved		Bit 1:	Reserved
		Bit 8: Reserved		Bit 0:	Reserved
41083 – 84	Unsigned Short	LogSelectMask			Reserved
41085 – 86	Unsigned Short	TimerStatusMask			Reserved

41087 – 41152: Reserved.

DNP 3.0 LEVEL 2+ COMMUNICATION

The REF 550 also allows for DNP attachment conformant to the LEVEL 2 Implementation with options as specified in the BASIC 4 subset documentation. The various objects, and variants may be configured within the REF 550 as per the Device Profile Definition as illustrated in TABLE 8-15 and the Implementation Table as illustrated in TABLE 8-16

Table 8-15. REF 550 Device Profile Definition

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DEVICE PROFILE DOCUMENT

(Also see the Implementation Table section)
Vendor Name: Error! Reference source not found.
Device Name: REF 550

Highest DNP Level Supported:
- For Requests: **Level 2**
- For Responses: **Level 2**

Device Function:
- ☐ Master
- ☒ **Slave**

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported
(the complete list is described in the attached table):

For static (non-change-event) object requests, request qualifier codes 00 and 01 (start-stop), 07 and 08 (limited quantity), and 17 and 28 (index) are supported in addition to request qualifier code 06 (no range – or all points). Static object requests received with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Static object requests received with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event object requests, qualifiers 17 or 28 are always responded.

16-bit and 32-bit Analog Change Events with Time may be requested.

The read function code for Object 50 (Time and Date), variation 1, is supported.

Maximum Data Link Frame Size (octets):
- Transmitted: **292**
- Received **292**

Maximum Application Fragment Size (octets):
- Transmitted: **2048**
- Received: **2048**

Maximum Data Link Re-tries:
- ☐ None
- ☐ Fixed at ____
- ☒ **Configurable (as Network Parameter 3) Number of Data Link Layer Confirm Retries**

Maximum Application Layer Re-tries:
- ☒ **None**
- ☐ Configurable

Requires Data Link Layer Confirmation:
- ☐ Never
- ☐ Always
- ☐ Sometimes
- ☒ **Configurable (as Network Mode Parameter 1) Data Link Layer Confirm Enable or Disable**

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(Also see the Implementation Table section)
Requires Application Layer Confirmation:

- ☐ Never
- ☐ Always
- ☒ **When reporting Event Data**
- ☐ When sending multi-fragment responses
- ☐ Sometimes
- ☐ Configurable
- ☐

Timeouts while waiting for:

Data Link Confirm: ☐ None ☐ Fixed at ____ ☐ Variable ☒ **Configurable (as Network Parameter 2)**

Complete App. Fragment: ☒ **None** ☐ Fixed at ____ ☐ Variable ☐ Configurable

Application Confirm: ☐ None ☐ Fixed at ____ ☐ Variable ☒ **Configurable (as Unsolicited App Layer Retry Timeout)**

Complete App. Response: ☒ **None** ☐ Fixed at ____ ☐ Variable ☐ Configurable

Others:

Transmission Delay: ☐ None ☐ Fixed at 0 ☐ Variable ☒ **Configurable (as Network Parameter 4)**

Inter-character Timeout: ☐ None ☐ Fixed at 50 ☐ Variable ☒ **Configurable (as Network Parameter 1)**

Need Time Delay: ☐ None ☐ Fixed at 30*60*1000 ☐ Variable ☒ **Configurable (as Network Parameter 9)**

Application File Timeout: ☒ **None** ☐ Fixed at 60*60*1000 ☐ Variable ☐ Configurable

Select/Operate Arm Timeout: ☐ None ☒ **Fixed at 10000** ☐ Variable ☐ Configurable

Binary input change scanning period: ☐ None ☒ **Fixed at 1000** ☐ Variable ☐ Configurable

Packed binary change process period: ☐ None ☒ **Fixed at 1000** ☐ Variable ☐ Configurable

Counter change scanning period: ☐ None ☒ **Fixed at 1000** ☐ Variable ☐ Configurable

Frozen Counter Event scanning period: ☒ **None** ☐ Fixed at 5000 ☐ Variable ☐ Configurable

Analog input change scanning period: ☐ None ☒ **Fixed at 2000** ☐ Variable ☐ Configurable

String object change scanning period: ☒ **None** ☒ Fixed at 5000 ☐ Variable ☐ Configurable

Unsolicited offline interval: ☐ None ☒ **Fixed at 1h** ☐ Variable ☐ Configurable

Unsolicited response notification delay: ☐ None ☐ Fixed at 15*1000 ☐ Variable ☒ **Configurable (as Delay 1, Delay 2, Delay 3)**

Unsolicited response retry delay: ☐ None ☐ Fixed ☐ Variable ☒ **Configurable (as Unsolicited App Layer and Retry Timeout)**

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(Also see the Implementation Table section)
Sends/Executes Control Operations:

WRITE Binary Outputs	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
DIRECT OPERATE	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
DIRECT OPERATE – NO ACK	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
Count > 1	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Pulse On	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Pulse Off	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Latch On	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Latch Off	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Queue	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable

Explanation of Sometimes: For each binary output control point, the operations that DPU2000R supports may be different. See the Binary Outputs point List in Section **Error! Reference source not found.** for a description of which control operations are supported for each point.
Reports Binary Input when no specific variation requested:

- ☐ Never
- ☐ Only time-tagged
- ☐ Only non-time-tagged
- ☒ **Configurable (as Default Binary Input Variation)**

Reports Binary Input Change Events when no specific variation requested:

- ☐ Never
- ☐ Only time-tagged
- ☐ Only non-time-tagged
- ☒ **Configurable (as Default Binary Change Variation)**

Reports time-tagged Binary Input Change Events when no specific variation requested:

- ☐ Never
- ☒ **Binary Input Change with Time (Time-tagged binary input change events are reported with absolute time not relative time)**
- ☐ Binary Input Change With Relative Time
- ☐ Configurable (attach explanation)

Default Counter Object/Variation:

- ☐ No Counters Reported
- ☒ **Configurable (as Default Counter Variation)**
- ☐ Default Object:
  Default Variation:
- ☐ Point-by-point list attached

Counters Roll Over at:

- ☐ No Counters Reported
- ☐ Configurable (attach explanation)
- ☐ 16 Bits
- ☐ 32 Bits
- ☒ **Other Value: 9999**
- ☐ Point-by-point list attached

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(Also see the Implementation Table section)

Default Frozen Counter Variation

- ☐ No Frozen Counters Reported
- ☒ **Configurable (as Default Frozen Counter Variation)**
- ☐ Default Object:
  Default Variation:
- ☐ Point-by-point list attached

Default Counter Change Object/Variation:

- ☐ No Counters Reported
- ☒ **Configurable (as Default Counter Change Variation)**
- ☐ Default Object:
  Default Variation:
- ☐ Point-by-point list attached

Default Frozen Counter Change Variation

- ☒ **No Frozen Counters Reported**
- ☐ Configurable
- ☐ Default Object:
  Default Variation:
- ☐ Point-by-point list attached

Default Analog Input Variation

- ☐ No Analog Inputs Reported
- ☒ **Configurable (as Default Analog Input Variation)**
- ☐ Default Object:
  Default Variation:
- ☐ Point-by-point list attached

Default Analog Input Change Variation

- ☐ No Analog Input Change Reported
- ☒ **Configurable (as Default Analog Input Change Variation)**
- ☐ Default Object:
  Default Variation:
- ☐ Point-by-point list attached

Default Binary Output Status Variation

☒ Fixed at 2

Default Deadband Variation

- ☐ No Deadband Reported
- ☒ **Configurable (as Default Deadband Variation)**
- ☐ Default Object:
  Default Variation:
- ☐ Point-by-point list attached

Default Analog Out Status Variation

- ☒ **No Analog Out Status Reported**
- ☐ Configurable
- ☐ Default Object:
  Default Variation:
- ☐ Point-by-point list attached

Deadband (Load Current)

- ☐ Never
- ☒ **Configurable (as Load Current Deadband)**

Deadband (Load Voltage)

- ☐ Never
- ☒ **Configurable (as Load Voltage Deadband)**

Deadband (Sequence Current)

- ☐ Never
- ☒ **Configurable (as Sequence Current Deadband)**

Deadband (Sequence Voltage)

- ☐ Never
- ☒ **Configurable (as Sequence Voltage Deadband)**

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(Also see the Implementation Table section)

Deadband (Watts)

☐ Never
☒ **Configurable (as Watts Deadband)**

Deadband (Vars)

☐ Never
☒ **Configurable (as VARs Deadband)**

Deadband (Power Factor)

☐ Never
☒ **Configurable (as Power Factor Deadband)**

Sends Unsolicited Responses:

☐ Never
☒ **Configurable (as Unsolicited Messages)**
☐ Only certain objects
☐ Sometimes (attach explanation)

Sends Static Data in Unsolicited Responses:

☒ **Never**
☐ When Device Restarts
☐ When Status Flags Change

No other options are permitted.

Unsolicited Response Delay

☐ Never
☒ **Configurable (as Delay 1,2,3)**
☐ Sometimes

Unsolicited Response Address

☐ Fixed
☒ **Configurable (as Unsolicited Messages Address)**

Unsolicited Response Class 1 Events Count

☐ Fixed
☒ **Configurable (as Unsolicited Class 1 Event Count)**

Unsolicited Response Class 1 Event Delay

☐ Fixed
☒ **Configurable (as Unsolicited Class 1 Event Delay)**
☒

Unsolicited Response Class 2 Events Count

☐ Fixed
☒ **Configurable (as Unsolicited Class 2 Event Count)**

Unsolicited Response Class 2 Event Delay

☐ Fixed
☒ **Configurable (as Unsolicited Class 2 Event Delay)**
☒

Unsolicited Response Class 3 Events Count

☐ Fixed
☒ **Configurable (as Unsolicited Class 3 Event Count)**

Unsolicited Response Class 3 Event Delay

☐ Fixed
☒ **Configurable (as Unsolicited Class 3 Event Delay)**
☒

Sends Multi-Fragment Responses:

☒ **Yes**
☐ No

DNP V3.0 Implementation Table

Table 8-7 identifies which object variations, function codes, and qualifiers the REF 550 supports in both request messages and in response messages. Note that while the REF 550 may parse many object variations, it will respond to the request variations identified below with entries in the response column.

The following table identifies the variations, function codes, and qualifiers supported by the REF 550 in both request messages and in response messages.

For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Static object requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event objects, qualifiers 17 or 28 are always responded.

Shading in the table below:

Subset Level 3	Indicates Subset Level 3 functionality (beyond Subset Level 2), and text shaded as
Beyond Subset Level 3	Indicates functionality beyond Subset Level 3.

Table 8-16. DNP 3.0 Object/Variations Supported for the REF 550

OBJECT			REQUEST (REF 550 will parse)		RESPONSE (REF 550 will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
1	0 (see Note 1)	Binary Input (Variation 0 is used to request default variation)\	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)		
1	1 default (see Note 1)	Binary Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
1	2	Binary Input with Status	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
2	0 (see Note 1)	Binary Input Change (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
2	1 default (see Note 1)	Binary Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	2	Binary Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	3 (parse only)	Binary Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
10	0	Binary Output Status (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)		
10	2 default	Binary Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)

OBJECT			REQUEST (REF 550 will parse)		RESPONSE (REF 550 will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
12	1	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	echo of request
12	2	Pattern Control Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	7 (limited quantity)	129 (response)	echo of request
12	3	Pattern Mask	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	00, 01 (start-stop)	129 (response)	echo of request
20	0 (see Note 1)	Binary Counter (Variation 0 is used to request default variation)	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)		
20	1	32-Bit Binary Counter	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
20	2	16-Bit Binary Counter	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
20	5	32-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
20	6 default (see Note 1)	16-Bit Binary Counter without Flag	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
21	0 (see Note 1)	Frozen Counter (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)		
21	1	32-Bit Frozen Counter	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
21	2	16-Bit Frozen Counter	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
21	9	32-Bit Frozen Counter without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
21	10 default (see Note 1)	16-Bit Frozen Counter without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)

OBJECT			REQUEST (REF 550 will parse)		RESPONSE (REF 550 will respond with)	
Object Number	**Variation Number**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
22	0 (see Note 1)	Counter Change Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
22	1	32-Bit Counter Change Event	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	2 default (see Note 1)	16-Bit Counter Change Event	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	5	32-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	6	16-Bit Counter Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
30	0 (see Note 1)	Analog Input (Variation 0 is used to request default variation)	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)		
30	1	32-Bit Analog Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
30	2 default (see Note 1)	16-Bit Analog Input	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
30	3	32-Bit Analog Input without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
30	4	16-Bit Analog Input without Flag	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
32	0 (see Note 1)	Analog Change Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
32	1	32-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	2 default (see Note 1)	16-Bit Analog Change Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	3	32-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	4	16-Bit Analog Change Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
34	0 (see Note 1)	Analog Input Reporting Deadband (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)		
34	1	16-Bit Analog Input Reporting Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)		
34	2 default (see Note 1)	32-Bit Analog Input Reporting Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)		
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)		

OBJECT			REQUEST (REF 550 will parse)		RESPONSE (REF 550 will respond with)	
Object Number	Variation Number	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
50	0	Time and Date	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
50	1 (default – see note 1)	Time and Date	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07 (limited qty=1) 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index – see note 2)
			2 (write)	00, 01 (start-stop) 07 (limited qty=1) 08 (limited qty) 17, 28 (index)		
52	2	Time Delay Fine			129 (response)	07 (limited qty) (qty = 1)
60	0	Class 0, 1, 2, and 3 Data	1 (read) 20 (enbl. unsol.) 21 (dsbl. unsol.)	06 (no range, or all)		
60	1	Class 0 Data	1 (read) 22 (assign class)	06 (no range, or all)		
60	2	Class 1 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dsbl. unsol.) 22 (assign class)	06 (no range, or all)		
60	3	Class 2 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dsbl. unsol.) 22 (assign class)	06 (no range, or all)		
60	4	Class 3 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dsbl. unsol.) 22 (assign class)	06 (no range, or all)		
80	1	Internal Indications	2 (write) (see note 4)	00 (start-stop) 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)		
		No Object (function code only) –See Note 3	13 (cold restart)			
		No Object (function code only)	14 (warm restart)			
		No Object (function code only)	23 (delay meas.)			

(Default variations are responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans.)

Note 1: The default variation can be changed with WinECP. A default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. Default settings for the configuration parameters are indicated in the table above.

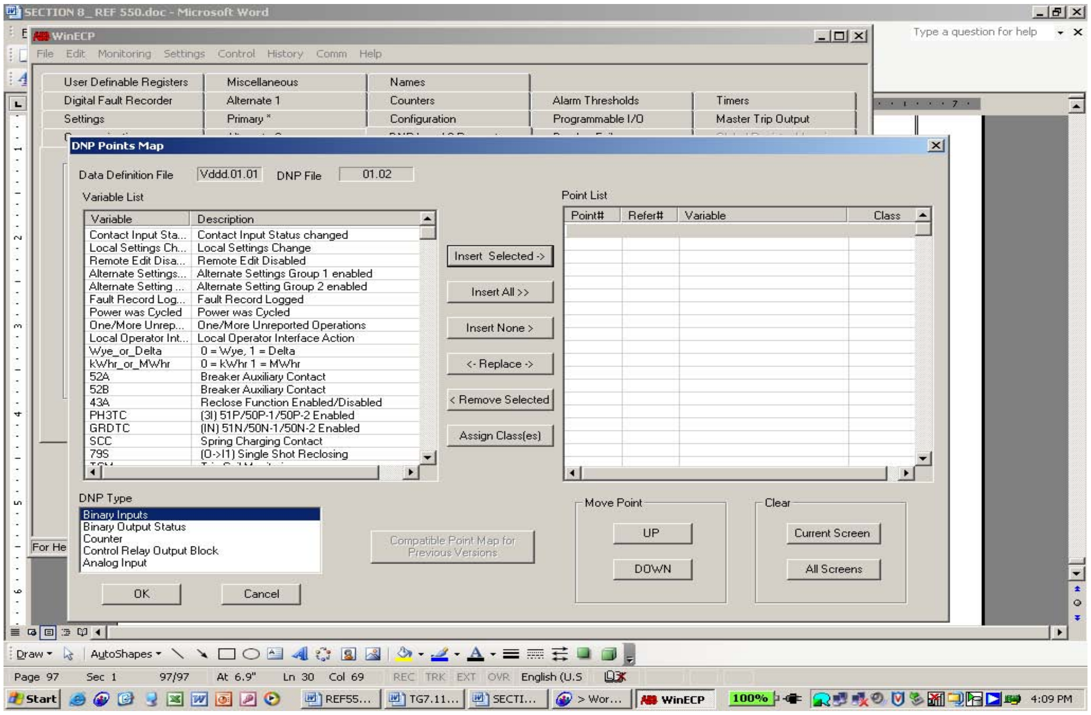
Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. (For change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: For the REF 550, a cold restart is implemented as a warm restart – the unit is not restarted, only the DNP process running on the communication card is restarted.

Note 4: Writes of Internal Indications are only supported for index 7 (Restart IIN1-7). Indices 16 and beyond (user-defined indications) are not supported.

The DNP 3.0 communications point list is configured using the Point Mapping Table feature found within the WIN ECP program Version 4.50 or later. The point mapping table is listed in Tables 8-11 through 8-14. Additional information is contained in the Automation Manual TG7.11.1.7-10 Titled “REF 550 DNP Level 2+ Automation Manual” Version 1.0.

FIGURE 8-8: POINT MAPPING TABLE DNP 3.0 LEVEL 2 + IMPLEMENTATION



The points available for remapping are listed as follows:

Object 1 Through 9 Assignable Points

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read), 22 (assign class)**
Static Variation reported when variation 0 requested: **2 (Binary Input with Status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

Point Index	Name/Description	Default Class and Change Event Assigned Class (1, 2, 3 or none)
0	Contact Input Status changed	none
1	Local Settings Change	none
2	Remote Edit Disabled	none
3	Alternate Settings Group 1 enabled	none
4	Alternate Setting Group 2 enabled	none
5	Fault Record Logged	none
6	Power was Cycled	none
7	One/More Unreported Operations	none
8	Local Operator Interface Action	none
9	Wye_or_Delta, 0 = Wye, 1 = Delta	none
10	kWhr_or_MWhr, 0 = kWhr 1 = MWhr	none
11	52A, Breaker Auxiliary Contact	3
12	52B, Breaker Auxiliary Contact	3
13	43A, Reclose Function Enabled/Disabled	3
14	PH3TC, (3I) 51P/50P-1/50P-2 Enabled	3
15	GRDTC, (IN) 51N/50N-1/50N-2 Enabled	3
16	SCC, Spring Charging Contact	3
17	79S, (O->I1) Single Shot Reclosing	3
18	TCM, Trip Coil Monitoring	3
19	50-1TC, (I>>1) 50P-1 & 50N-1 Enabled	3
20	50-2TC, 50P-2 & 50N-2 Enabled	3
21	50-3TC, 50P-3 & 50N-3 Enabled	3
22	ALT1, ALT 1 Settings Enabled	3
23	ALT2, ALT 2 Settings Enabled	3
24	ECI1, Event Capture Initiate 1	3
25	ECI2, Event Capture Initiate 2	3
26	WCI, WCI Input	3
27	ZSCTC, Zone Sequence Coordination Scheme Enabled	3
28	OPEN, Trip Output Initiated	3
29	InitCLOSE, Close Output Initiated	3
30	46-1TC, (Insc>1) 46-1 Negative Sequence Time Overcurrent Function En	3
31	TRIP, TRIP Output Energized	3
32	CLOSE, CLOSE Output Energized	3
33	ALARM, ALARM Output Energized	3
34	27-1s, (1U<s) Single Phase Undervoltage Seal In Alarm	3

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read), 22 (assign class)**
Static Variation reported when variation 0 requested: **2 (Binary Input with Status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

Point Index	Name/Description	Default Class and Change Event Assigned Class (1, 2, 3 or none)
35	46-1s, (Insc>s) Negative Sequence Time Overcurrent Seal In Alarm	3
36	50P1s, (3I>>1s) Phase Instantaneous Overcurrent Trip Seal In Al	3
37	50N1s, (IN>>1s) Ground Instantaneous Overcurrent Trip Seal In A	3
38	50P2s, (3I>>2s) Phase Instantaneous Overcurrent Trip Seal In Al	3
39	50N2s, (IN>>2s) Ground Instantaneous Overcurrent Trip Seal In A	3
40	50P3s, (3I>>3s) Phase Instantaneous Overcurrent Trip Seal In Al	3
41	50N3s, (IN>>3s) Ground Instantaneous Overcurrent Trip Seal In A	3
42	51Ps, (3I>) Phase Time Overcurrent Trip Alarm	3
43	51Ns, (IN>s) Ground Time Overcurrent Trip Seal In Alarm	3
44	59-1s, (1U>s) Single Phase Overvoltage Seal In Alarm	3
45	67Ps, (3I->) Positive Sequence Supervised Phase Directional Ti	3
46	67Ns, (IN>->s) Negative Sequence Supervised Ground Directional	3
47	81S-1s, (f<1s) Frequency Load Shed Trip Module 1 Seal In Alarm	3
48	81R-1s, (f>1s) Frequency Load Restoration Module 1 Seal In Alar	3
49	PATA, (L1TA) Phase A Target	3
50	PBTA, (L2TA) Phase B Target	3
51	PCTA, (L3TA) Phase C Target	3
52	TCFA, Trip Coil Failure Alarm	3
53	TCC, Tap Changer Cutout Contact	3
54	79DA, (O->IDA) Recloser Disable Alarm	3
55	PUA, PUA Output Energized	3
56	79LOA, (O->ILO) Recloser Lockout Alarm	3
57	BFA*, BFA Output Energized - seal in	3
58	PPDA, PPDA Output Energized	3
59	NPDA, NPDA Output Energized	3
60	BFUA, BFUA Output Energized	3
61	KSI, KSI Summation Alarm	3
62	79CA-1, (O->I1) Recloser Counter 1 Alarm	3
63	HPFA, High Power Factor Alarm	3
64	LPFA, Low Power Factor Alarm	3
65	OCTC, (I>TC) Overcurrent Trip Counter Alarm	3
66	50-1D, (I>>1D) 50-1 Instantaneous Overcurrent Disabled Alarm	3
67	50-2D, (I>>2D) 50-2 Instantaneous Overcurrent Disabled Alarm	3
68	STCA, Settings Table Changed Alarm	3
69	ZSC, Zone Sequence Coordination Enabled Indicator	3
70	PH3-D, (3I>D) Phase Control Disabled Alarm	3
71	GRD-D, (IN>D) Ground Control Disabled Alarm	3
72	32PA, (3I>->Is) 67 Zone Pickup Alarm	3
73	32NA, (IN>->Is) 67N Zone Pickup Alarm	3
74	27-3Ps, (3U<s) Three Phase Undervoltage Seal In Alarm Module 1	3

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read), 22 (assign class)**
Static Variation reported when variation 0 requested: **2 (Binary Input with Status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

Point Index	Name/Description	Default Class and Change Event Assigned Class (1, 2, 3 or none)
75	VarDA, Three Phase Kilo Var Demand Alarm	3
76	79CA-2, (O->I2) Recloser Counter 2 Alarm	3
77	TRIPAs, (TRIPL1s) Phase A Trip Seal In Alarm	3
78	TRIPBs, (TRIPL2s) Phase B Trip Seal In Alarm	3
79	TRIPCs, (TRIPL3s) Phase C Trip Seal In Alarm	3
80	52a Input, 52a Input closed	3
81	52b Input, 52b Input closed	3
82	43a Input, 43a Input closed	3
83	In 1, Input 1 Input closed	3
84	In 2, Input 2 Input closed	3
85	In 3, Input 3 Input closed	3
86	In 4, Input 4 Input closed	3
87	In 5, Input 5 Input closed	3
88	In 6, Input 6 Input closed	3
89	In 7, Input 7 Input closed	3
90	In 8, Input 8 Input closed	3
91	In 9, Input 9 Input closed	3
92	In 10, Input 10 Input closed	3
93	In 11, Input 11 Input closed	3
94	In 12, Input 12 Input closed	3
95	In 13, Input 13 Input closed	3
96	FaultRecStat0, Fault Rec Status (bit 0) 0=Wye, 1=Delta	1
97	FaultRecStat1, Fault Rec Status (bit 1) 0=Fault, 1=Event	1
98	67P, (3I>->) Positive Sequence Supervised Phase Directional Tim	3
99	67N, (IN>->) Negative Sequence Supervised Ground Directional Ti	3
100	CRI, Clear Reclose and Overcurrent Counters	3
101	Target Reset, Target Reset	3
102	BATT_LOWs, Station Battery Low Seal In Alarm	3
13	BATT_HIs, Station Battery High Seal In Alarm	3
104	BATT_HI, Station Battery High Alarm	3
105	BATT_LOW, Station Battery Low Alarm	3
106	HIF, High Impedance Fault Alarm	3
107	HIFs, High Impedance Fault Seal In Alarm	3
108	21P Z1 Enhanced, 21P Zone-1 Enhanced	3
109	21P Z2 Enhanced, 21P Zone-2 Enhanced	3
110	21P Z3 Enhanced, 21P Zone-3 Enhanced	3
111	21P Z4 Enhanced, 21P Zone-4 Enhanced	3
112	LOC01, Local 01	3
113	LOC02, Local 02	3
114	LOC03, Local 03	3

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read), 22 (assign class)**
Static Variation reported when variation 0 requested: **2 (Binary Input with Status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

Point Index	Name/Description	Default Class and Change Event Assigned Class (1, 2, 3 or none)
115	LOC04, Local 04	3
116	LOC05, Local 05	3
117	LOC06, Local 06	3
118	LOC07, Local 07	3
119	LOC08, Local 08	3
120	LOC09, Local 09	3
121	LOC10, Local 10	3
122	LOC11, Local 11	3
123	LOC12, Local 12	3
124	LOC13, Local 13	3
125	LOC14, Local 14	3
126	LOC15, Local 15	3
127	LOC16, Local 16	3
128	REM01, Remote 01	3
129	REM02, Remote 02	3
130	REM03, Remote 03	3
131	REM04, Remote 04	3
132	REM05, Remote 05	3
133	REM06, Remote 06	3
134	REM07, Remote 07	3
135	REM08, Remote 08	3
136	REM09, Remote 09	3
137	REM10, Remote 10	3
138	REM11, Remote 11	3
139	REM12, Remote 12	3
140	REM13, Remote 13	3
141	REM14, Remote 14	3
142	REM15, Remote 15	3
143	REM16, Remote 16	3
144	UL1, User Logical 1	3
145	UL2, User Logical 2	3
146	UL3, User Logical 3	3
147	UL4, User Logical 4	3
148	UL5, User Logical 5	3
149	UL6, User Logical 6	3
150	UL7, User Logical 7	3
151	UL8, User Logical 8	3
152	UL9, User Logical 9	3
153	UL10, User Logical 10	3
154	UL11, User Logical 11	3

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read), 22 (assign class)**
Static Variation reported when variation 0 requested: **2 (Binary Input with Status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

Point Index	Name/Description	Default Class and Change Event Assigned Class (1, 2, 3 or none)
155	UL12, User Logical 12	3
156	UL13, User Logical 13	3
157	UL14, User Logical 14	3
158	UL15, User Logical 15	3
159	UL16, User Logical 16	3
160	PVArA, PVArA Output Energized	3
161	NVArA, NVArA Output Energized	3
162	LOADA, LOADA Output Energized	3
163	81O-1s, (f>s1s) Overfrequency Seal In Alarm Module 1	3
164	81O-2s, (f>s2s) Overfrequency Seal In Alarm Module 2	3
165	81S-2s, (f<2s) Frequency Load Shed Trip Module 2 Seal In Alarm	3
166	81R-2s, (f>2s) Frequency Load Restoration Module 2 Seal In Alarm	3
167	CLTA, Cold Load Timer Alarm	3
168	79M, (O->I) Multi-Shot Reclosing	3
169	LOCAL, Local Control Enable/Disabled	3
170	SBA, Slow Breaker Alarm	3
171	ARCI, Automatic Reclose Inhibit	3
172	TARC, Initiate Trip and Auto Reclose	3
173	SEFTC, (I0>) Sensitive Earth Fault Enable	3
174	EXTBFI, External Starter Input	3
175	BFI, Breaker Fail Initiate	3
176	UDI, User-defined Display Input	3
177	25TC, (SYNC) Sync Check Enable	3
178	25BYP, (SYNC byp) Sync Check Bypass	3
179	TGT, Target Alarms Reset	3
180	SIA, Resets Seal-In Alarms	3
181	PWatt1, Positive Watt Alarm 1	3
182	PWatt2, Positive Watt Alarm 2	3
183	SEFs, (I0>s)Sensitive Earth Fault Trip Seal In Alarm	3
184	BZA, Bus Zone Alarm	3
185	BFTs, Break Failure Trip Seal In Alarm	3
186	BF Retrips, Breaker Failure ReTrip Seal In Alarm	3
187	32P-2s, (I1->s) Phase Power Directional Seal In Alarm	3
188	32N-2s, (I2->s) Neutral Power Directional Seal In Alarm	3
189	25s, (SYNCs) Sync Check Condition Seal In Alarm	3
190	79V, Reclose Undervoltage Block	3
191	RClin, Circuit Breaker Close Initiate	3
192	59Gs, (UO>s) Ground Overvoltage Seal In Alarm	3
193	LO1, Latching output1	3
194	LO2, Latching output2	3

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read), 22 (assign class)**
Static Variation reported when variation 0 requested: **2 (Binary Input with Status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

Point Index	Name/Description	Default Class and Change Event Assigned Class (1, 2, 3 or none)
195	LO3, Latching output3	3
196	LO4, Latching output4	3
197	LO5, Latching output5	3
198	LO6, Latching output6	3
199	LO7, Latching output7	3
200	LO8, Latching output8	3
201	79ON, Hot Hold Tagging On	3
202	79OFF, Hot Hold Tagging Off	3
23	79TAG, Hot Hold Tagging Tagged	3
204	59-3s, (3U>s) Three Phase Overvoltage Seal In Alarm	3
205	47s, (U2>s) Negative Sequence Overvoltage Seal In Alarm	3
206	21P-1s, (Ph Dist-1s) Phase Distance Element Zone 1 Seal In Alarm	3
207	21P-2s, (Ph Dist-2s) Phase Distance Element Zone 2 Seal In Alarm	3
208	21P-3s, (Ph Dist-3s) Phase Distance Element Zone 3 Seal In Alarm	3
209	21P-4s, (Ph Dist-4s) Phase Distance Element Zone 4 Seal In Alarm	3
210	50-3D, Instantaneous Disabled Alarm	3
211	C1, Control Button 1 Selected	3
212	C2, Control Button 2 Selected	3
213	C3, Control Button 3 Selected	3
214	C4, Control Button 4 Selected	3
215	C5, Control Button 5 Selected	3
216	C6, Control Button 6 Selected	3
217	TripT, Trip Target	3
218	NTA, Neutral Trip Target	3
219	TimeT, Time OC Trip Target	3
220	InstT, Instantaneous OC Trip Target	3
221	NegSeqT, Negative Sequence Trip Target	3
222	FreqT, Frequencey Trip Target	3
223	DirT, Directional Trip Target	3
224	VoltT, Voltage Trip Target	3
225	DistT, Distance Trip Target	3
226	SEFT, Sensitive Earth Trip Target	3
227	HBHL, Hot Bus Hot Line	3
228	HBDL, Hot Bus Dead Line	3
229	DBHL, Dead Bus Hot Line	3
230	DBDL, Dead Bus Dead Line	3
231	46-2, Trip 46-2	3
232	46-2s, (Insc>2s) Negative Sequence Time Overcurrent Seal In Alarm	3
233	LIS1, Latch In Set 1	3
234	LIS2, Latch In Set 2	3

Binary Input Points
Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read), 22 (assign class)**
Static Variation reported when variation 0 requested: **2 (Binary Input with Status)**
Change Event Variation reported when variation 0 requested: **2 (Binary Input Change with Time)**

Point Index	Name/Description	Default Class and Change Event Assigned Class (1, 2, 3 or none)
235	LIS3, Latch In Set 3	3
236	LIS4, Latch In Set 4	3
237	LIS5, Latch In Set 5	3
238	LIS6, Latch In Set 6	3
239	LIS7, Latch In Set 7	3
240	LIS8, Latch In Set 8	3
241	LIR1, Latch In Reset 1	3
242	LIR2, Latch In Reset 2	3
243	LIR3, Latch In Reset 3	3
244	LIR4, Latch In Reset 4	3
245	LIR5, Latch In Reset 5	3
246	LIR6, Latch In Reset 6	3
247	LIR7, Latch In Reset 7	3
248	LIR8, Latch In Reset 8	3
249	TR_SET, Set Hot Line Tag function	3
250	TR_RST, Reset Hot Line Tag function	3
251	46-2_TC, 46-2 Torque Control	3
252	51P-TC,Torque Control for 51P	3
253	HIF-TC,Torque Control for HIF	3
254	REMOTE_D, Remote Disable	3
255	SWSET, Switch Settings Group	3
256	SHIFTA, Shifter A	3
257	SHIFTB, Shifter B	3
258	PRIMSETTACTIVE, Primary Settings Active	3
259	ALT1SETTACTIVE, Alt 1 Settings Active	3
260	ALT2SETTACTIVE, Alt 2 Settings Active	3
261	SHIFT_A1, Shift A-1	3
262	SHIFT_A2, Shift A-2	3
263	SHIFT_A3, Shift A-3	3
264	SHIFT_A4, Shift A-4	3
265	SHIFT_B1, Shift B-1	3
266	SHIFT_B2, Shift B-2	3
267	SHIFT_B3, Shift B-3	3
268	SHIFT_B4, Shift B-4	3

OBJECT 10 Through 19 Control Points

Binary Output Status Points
Object Number: **10**
Request Function Codes supported: **1 (read)**
Default Variation reported when variation 0 requested: **2 (Binary Output Status)**
The default Select to Execute timeout is 10000 ms.
A maximum of 20 points may be simultaneously controlled.

Control Relay Output Blocks
Object Number: **12**
Request Function Codes supported: **3 (select), 4 (operate), 5 (direct operate), 6 (direct operate, noack)**

Point Index	Name/Description	Supported Control Relay Output Block Fields
0	TST_TRIP, Trip Contact energized	Trip, Close, Pulse ON, Latch On, Latch Off
1	TST_CLOSE, Close Contact energized	Reserved
2	TST_OUT1, Output 1 Contact energized	Trip, Close, Pulse ON
3	TST_OUT2, Output 2 Contact energized	Trip, Close, Pulse ON
4	TST_OUT3, Output 3 Contact energized	Trip, Close, Pulse ON
5	TST_OUT4, Output 4 Contact energized	Trip, Close, Pulse ON,
6	TST_OUT5, Output 5 Contact energized	Trip, Close, Pulse ON,
7	TST_OUT6, Output 6 Contact energized	Trip, Close, Pulse ON,
8	TST_OUT7, Output 7 Contact energized	Reserved
9	TST_OUT8, Output 8 Contact energized	Reserved
10	TRIP, Trip operate command processed	Trip, Close, Pulse ON, Latch On, Latch Off
11	CLOSE, Close operate command processed	Trip, Close, Pulse ON, Latch On, Latch Off
12	RST_ALMS_LEDS, Reset Alarms/Target LEDs	Trip, Close, Pulse ON, Latch On, Latch Off
13	RST_MINMAX, Reset Peak & Minimum Demand Currents	Trip, Close, Pulse ON, Latch On, Latch Off
14	REM01, Remote 01	Trip, Close, Pulse ON, Latch On, Latch Off
15	REM02, Remote 02	Trip, Close, Pulse ON, Latch On, Latch Off
16	REM03, Remote 03	Trip, Close, Pulse ON, Latch On, Latch Off
17	REM04, Remote 04	Trip, Close, Pulse ON, Latch On, Latch Off
18	REM05, Remote 05	Trip, Close, Pulse ON, Latch On, Latch Off
19	REM06, Remote 06	Trip, Close, Pulse ON, Latch On, Latch Off
20	REM07, Remote 07	Trip, Close, Pulse ON, Latch On, Latch Off
21	REM08, Remote 08	Trip, Close, Pulse ON, Latch On, Latch Off
22	REM09, Remote 09	Trip, Close, Pulse ON, Latch On, Latch Off
23	REM10, Remote 10	Trip, Close, Pulse ON, Latch On, Latch Off
24	REM11, Remote 11	Trip, Close, Pulse ON, Latch On, Latch Off
25	REM12, Remote 12	Trip, Close, Pulse ON, Latch On, Latch Off
26	REM13, Remote 13	Trip, Close, Pulse ON, Latch On, Latch Off
27	REM14, Remote 14	Trip, Close, Pulse ON, Latch On, Latch Off
28	REM15, Remote 15	Trip, Close, Pulse ON, Latch On, Latch Off
29	REM16, Remote 16	Trip, Close, Pulse ON, Latch On, Latch Off

Binary Output Status Points
Object Number: **10**
Request Function Codes supported: **1 (read)**
Default Variation reported when variation 0 requested: **2 (Binary Output Status)**
The default Select to Execute timeout is 10000 ms.
A maximum of 20 points may be simultaneously controlled.

Control Relay Output Blocks
Object Number: **12**
Request Function Codes supported: **3 (select), 4 (operate), 5 (direct operate), 6 (direct operate, noack)**

Point Index	Name/Description	Supported Control Relay Output Block Fields
30	TRIP_DUP, Trip operate command (duplicate of TRIP)	Trip, Close, Pulse ON, Latch On, Latch Off
31	CLOSE_NO_43A, Close operate command, Independent of 43A	None
32	RSI, Reset Sealed-In Points	Trip, Close, Pulse ON, Latch On, Latch Off
33	FPI 1S, Forced Physical Input 1 Value	Trip, Close, Pulse ON, Latch On, Latch Off
34	FPI 1F, Forced Physical Input 1 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
35	FPI 2S, Forced Physical Input 2 Value	Trip, Close, Pulse ON, Latch On, Latch Off
36	FPI 2F, Forced Physical Input 2 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
37	FPI 3S, Forced Physical Input 3 Value	Trip, Close, Pulse ON, Latch On, Latch Off
38	FPI 3F, Forced Physical Input 3 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
39	FPI 4S, Forced Physical Input 4 Value	Trip, Close, Pulse ON, Latch On, Latch Off
40	FPI 4F, Forced Physical Input 4 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
41	FPI 5S, Forced Physical Input 5 Value	Trip, Close, Pulse ON, Latch On, Latch Off
42	FPI 5F, Forced Physical Input 5 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
43	FPI 6S, Forced Physical Input 6 Value	Trip, Close, Pulse ON, Latch On, Latch Off
44	FPI 6F, Forced Physical Input 6 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
45	FPI 7S, Forced Physical Input 7 Value	Trip, Close, Pulse ON, Latch On, Latch Off
46	FPI 7F, Forced Physical Input 7 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
47	FPI 8S, Forced Physical Input 8 Value	Trip, Close, Pulse ON, Latch On, Latch Off
48	FPI 8F, Forced Physical Input 8 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
49	FPI 9S, Forced Physical Input 9 Value	Reserved
50	FPI 9F, Forced Physical Input 9 Flag	Reserved
51	FPI 10S, Forced Physical Input 10 Value	Reserved
52	FPI 10F, Forced Physical Input 10 Flag	Reserved
53	FPI 11S, Forced Physical Input 11 Value	Reserved
54	FPI 11F, Forced Physical Input 11 Flag	Reserved
55	FPI 12S, Forced Physical Input 12 Value	Reserved
56	FPI 12F, Forced Physical Input 12 Flag	Reserved
57	FPI 13S, Forced Physical Input 13 Value	Reserved
58	FPI 13F, Forced Physical Input 13 Flag	Reserved
59	FPO 1S, Force Physical Output 1 Value	Trip, Close, Pulse ON, Latch On, Latch Off
60	FPO 1F, Force Physical Output 1 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
61	FPO 2S, Force Physical Output 2 Value	Trip, Close, Pulse ON, Latch On, Latch Off
62	FPO 2F, Force Physical Output 2 Flag	Trip, Close, Pulse ON, Latch On, Latch Off

Binary Output Status Points
Object Number: **10**
Request Function Codes supported: **1 (read)**
Default Variation reported when variation 0 requested: **2 (Binary Output Status)**
The default Select to Execute timeout is 10000 ms.
A maximum of 20 points may be simultaneously controlled.

Control Relay Output Blocks
Object Number: **12**
Request Function Codes supported: **3 (select), 4 (operate), 5 (direct operate), 6 (direct operate, noack)**

Point Index	Name/Description	Supported Control Relay Output Block Fields
63	FPO 3S, Force Physical Output 3 Value	Trip, Close, Pulse ON, Latch On, Latch Off
64	FPO 3F, Force Physical Output 3 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
65	FPO 4S, Force Physical Output 4 Value	Trip, Close, Pulse ON, Latch On, Latch Off
66	FPO 4F, Force Physical Output 4 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
67	FPO 5S, Force Physical Output 5 Value	Trip, Close, Pulse ON, Latch On, Latch Off
68	FPO 5F, Force Physical Output 5 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
69	FPO 6S, Force Physical Output 6 Value	Trip, Close, Pulse ON, Latch On, Latch Off
70	FPO 6F, Force Physical Output 6 Flag	Trip, Close, Pulse ON, Latch On, Latch Off
71	FPO 7S, Force Physical Output 7 Value	Reserved
72	FPO 7F, Force Physical Output 7 Flag	Reserved
73	FPO 8S, Force Physical Output 8 Value	Reserved
74	FPO 8F, Force Physical Output 8 Flag	Reserved
75	OCI C1, Operator Control Button 1	Trip, Close, Pulse ON, Latch On, Latch Off
76	OCI C2, Operator Control Button 2	Trip, Close, Pulse ON, Latch On, Latch Off
77	OCI C3, Operator Control Button 3	Trip, Close, Pulse ON, Latch On, Latch Off
78	OCI C4, Operator Control Button 4	Trip, Close, Pulse ON, Latch On, Latch Off
79	OCI C5, Operator Control Button 5	Trip, Close, Pulse ON, Latch On, Latch Off
80	OCI C6, Operator Control Button 6	Trip, Close, Pulse ON, Latch On, Latch Off
81	HLT_SET, Set Hot Line Tag function (operates TR_SET)	Trip, Close, Pulse ON, Latch On, Latch Off
82	HLT_RST, Reset Hot Line Tag function (operates TR_RST)	Trip, Close, Pulse ON, Latch On, Latch Off

OBJECT 20 through 29 COUNTER REGITER ASSIGNABLE POINTS

Binary Counters
Static (Steady-State) Object Number: **20**
Change Event Object Number: **22**
Request Function Codes supported: **1 (read), 7 (freeze), 8 (freeze noack) 9 (freeze and clear), 10 (freeze and clear, noack), 22 (assign class)**
Static Variation reported when variation 0 requested: **6 (16-Bit Binary Counter without Flag)**
Change Event Variation reported when variation 0 requested: **2 (16-Bit Counter Change Event)**
Frozen Counters
Static (Steady-State) Object Number: **21**
Request Function Codes supported: **1 (read), 22 (assign class)**
Static Variation reported when variation 0 requested: **10 (16-Bit Frozen Binary without Flag)**

Point Index	Name/Description	Default Change Event Assigned Class (1, 2, 3 or none)
0	KsiSumA Ctr, KSI Sum A Counter	None
1	KsiSumB Ctr, KSI Sum B Counter	None
2	KsiSumC Ctr, KSI Sum C Counter	None
3	OverCurrTrip, Over Current Trip Counter	None
4	Break Ctr, Breaker Operations Counter	None
5	Reclose_1, 79(O->I) Counter 1	None
6	Stage1 Reclose Ctr, 1st Reclose Counter	None
7	Stage2 Reclose Ctr, 2nd Reclose Counter	None
8	Stage3 Reclose Ctr, 3rd Reclose Counter	None
9	Stage4 Reclose Ctr, 4th Reclose Counter	None
10	Reclose_2, 79(O->I) Counter 2	None
11	H_INCOM_TO, Host INCOM timeout Counter	None
12	H_INCOM_NACK, Host INCOM host NACK Counter	None
13	H_INCOM_PROTO, Host INCOM protocol error Counter	None
14	H_INCOM_DATA, Host INCOM corrupt data Counter	None
15	H_INCOM_SYNC, Host INCOM synchronization error Counter	None

OBJECT 30 through 39 Analog Input Assignable Points

Analog Inputs
Static (Steady-State) Object Number: **30**
Change Event Object Number: **32**
Reporting Deadband Object Number: **34**
Request Function Codes supported: **1 (read), 2 (write, deadbands only), 22 (assign class)**
Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input)**
Change Event Variation reported when variation 0 requested: **1 (32 -Bit Analog Change Event w/o Time)**
Reporting Deadband Variation reported when variation 0 requested: **2 (32-Bit Reporting Deadband)**

Point Index	Name/Description	Reporting Deadband	Initial Change Event Class (1, 2, 3 or none)
0	Ia (Load Currents)	82	None
1	Ia Angle	82	None
2	Ib	82	None
3	Ib Angle	82	None
4	Ic	82	None
5	Ic Angle	82	None
6	In	82	None
7	In Angle	82	None
8	Iavg	82	None
9	KVan (Mag) (*1000)	82	None
10	KVan (Ang)	82	None
11	KVbn (Mag) (*1000)	82	None
12	KVbn (Ang)	82	None
13	KVcn (Mag) (*1000)	82	None
14	KVcn (Ang)	82	None
15	KWan	82	None
16	KWbn	82	None
17	KWcn	82	None
18	KW3p	82	None
19	KVARan	82	None
20	KVARbn	82	None
21	KVARcn	82	None
22	KVAR3p	82	None
23	KWHra	None	None
24	KWHrb	None	None
25	KWHrc	None	None
26	KWHr3p	None	None
27	KVARHra	None	None
28	KVARHrb	None	None
29	KVARHrc	None	None
30	KVARHr3p	None	None
31	I0, Current - symmetrical components	82	None
32	I0 Angle	82	None
33	I1, Current - symmetrical components	82	None
34	I1 Angle	82	None
35	I2, Current - symmetrical components	82	None

Analog Inputs
Static (Steady-State) Object Number: **30**
Change Event Object Number: **32**
Reporting Deadband Object Number: **34**
Request Function Codes supported: **1 (read), 2 (write, deadbands only), 22 (assign class)**
Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input)**
Change Event Variation reported when variation 0 requested: **1 (32 -Bit Analog Change Event w/o Time)**
Reporting Deadband Variation reported when variation 0 requested: **2 (32-Bit Reporting Deadband)**

Point Index	Name/Description	Reporting Deadband	Initial Change Event Class (1, 2, 3 or none)
36	I2 Angle	82	None
37	KV1 (*1000)	82	None
38	KV1 Angle	82	None
39	KV2 (*1000)	82	None
40	KV2 Angle	82	None
41	Frequency (*100)	None	None
42	PF, LSB 0-6 Power Factor (*100) MSB=0 Leading, MSB=1 Lagging (IF PF>100, PF=(PF-128)/100, Lagging. ELSE, PF=PF/100, Leading)	82	None
43	Demand Ia	None	None
44	Demand Ib	None	None
45	Demand Ic	None	None
46	Demand In	None	None
47	Demand KWan	None	None
48	Demand KWbn	None	None
49	Demand KWcn	None	None
50	Demand KW3p	None	None
51	Demand KVARan	None	None
52	Demand KVARbn	None	None
53	Demand KVARcn	None	None
54	Demand KVAR3p	None	None
55	Fault Type (element)	None	1
56	Fault Record Active Set (bits 0-3) 1=Primary, 2=Alt 1, 4=Alt 2	None	1
57	Fault Record Reclose Seq (bits 4-7) 1-4 = 1-4, 5=L	None	1
58	Fault Number	None	1
59	Fault Ia, (Fault Currents)	None	1
60	Fault Ib	None	1
61	Fault Ic	None	1
62	Fault In	None	1
63	Fault Ia Angle	None	1
64	Fault Ib Angle	None	1
65	Fault Ic Angle	None	1
66	Fault In Angle	None	1
67	Fault Zero Seq I (Mag)	None	1
68	Fault Pos Seq I (Mag)	None	1
69	Fault Neg Seq I (Mag)	None	1
70	Fault Zero Seq I (Ang)	None	1

Analog Inputs
Static (Steady-State) Object Number: **30**
Change Event Object Number: **32**
Reporting Deadband Object Number: **34**
Request Function Codes supported: **1 (read), 2 (write, deadbands only), 22 (assign class)**
Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input)**
Change Event Variation reported when variation 0 requested: **1 (32 -Bit Analog Change Event w/o Time)**
Reporting Deadband Variation reported when variation 0 requested: **2 (32-Bit Reporting Deadband)**

Point Index	Name/Description	Reporting Deadband	Initial Change Event Class (1, 2, 3 or none)
71	Fault Pos Seq I (Ang)	None	1
72	Fault Neg Seq I (Ang)	None	1
73	Fault KVab/KVan (Mag) (*100)	None	1
74	Fault KVbc/KVbn (Mag) (*100)	None	1
75	Fault KVca/KVcn (Mag) (*100)	None	1
76	Fault Vab/Van (Ang)	None	1
77	Fault Vbc/Vbn (Ang)	None	1
78	Fault Vca/Vcn (Ang)	None	1
79	Fault Pos Seq KV (Mag) (*100)	None	1
80	Fault Neg Seq KV (Mag) (*100)	None	1
81	Fault Pos Seq V (Ang)	None	1
82	Fault Neg Seq V (Ang)	None	1
83	Fault location (*10)	None	1
84	Fault impedance, real part (*1000)	None	1
85	Breaker Operate Time (*1000)	None	1
86	Relay Operate Time (*1000)	None	1
87	OP_ID, Operation Record ID	None	2
88	OP_VAL, Operation Record Value (if any)	None	2
89	OP_SEQ, Operation Record Sequence Number	None	2
90	KVab (Mag) (*1000)	None	None
91	KVab (Ang)	None	None
92	KVbc (Mag) (*1000)	None	None
93	KVbc (Ang)	None	None
94	KVca (Mag) (*1000)	None	None
95	KVca (Ang)	None	None
96	Fault Scale Factor, Current Scale Factor (0 or 1 -> 1, 10 -> 10)	None	1
97	UDR 1, User Definable Register 1	None	3
98	UDR 2, User Definable Register 2	None	3
99	UDR 3, User Definable Register 3	None	3
100	UDR 4, User Definable Register 4	None	3
101	UDR 5, User Definable Register 5	None	3
102	UDR 6, User Definable Register 6	None	3
103	UDR 7, User Definable Register 7	None	3
104	UDR 8, User Definable Register 8	None	3
105	UDR 9, User Definable Register 9	None	3
106	UDR 10, User Definable Register 10	None	3
107	UDR 11, User Definable Register 11	None	3

Analog Inputs
Static (Steady-State) Object Number: **30**
Change Event Object Number: **32**
Reporting Deadband Object Number: **34**
Request Function Codes supported: **1 (read), 2 (write, deadbands only), 22 (assign class)**
Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input)**
Change Event Variation reported when variation 0 requested: **1 (32 -Bit Analog Change Event w/o Time)**
Reporting Deadband Variation reported when variation 0 requested: **2 (32-Bit Reporting Deadband)**

Point Index	Name/Description	Reporting Deadband	Initial Change Event Class (1, 2, 3 or none)
108	UDR 12, User Definable Register 12	None	3
109	UDR 13, User Definable Register 13	None	3
110	UDR 14, User Definable Register 14	None	3
111	UDR 15, User Definable Register 15	None	3
112	UDR 16, User Definable Register 16	None	3
113	UDR 17, User Definable Register 17	None	3
114	UDR 18, User Definable Register 18	None	3
115	UDR 19, User Definable Register 19	None	3
116	UDR 20, User Definable Register 20	None	3
117	UDR 21, User Definable Register 21	None	3
118	UDR 22, User Definable Register 22	None	3
119	UDR 23, User Definable Register 23	None	3
120	UDR 24, User Definable Register 24	None	3
121	UDR 25, User Definable Register 25	None	3
122	UDR 26, User Definable Register 26	None	3
123	UDR 27, User Definable Register 27	None	3
124	UDR 28, User Definable Register 28	None	3
125	UDR 29, User Definable Register 29	None	3
126	UDR 30, User Definable Register 30	None	3
127	UDR 31, User Definable Register 31	None	3
128	UDR 32, User Definable Register 32	None	3
129	kVA3_mag, 3 Phase Volt-Amps (kVA) magnitude	None	None
130	PF, Power Factor (*100) Unsigned	None	None
131	PF_Stat, Power Factor Status - 0=Leading or 1=Lagging	None	None
132	IoSensMag, Io Magnitude - Measured	None	None
133	Io Angle - Measured	None	None
134	VZeroMag, Vo Magnitude - Measured	None	None
135	VZero Angle - Measured	None	None
136	VZeroCalcMag, Vo Magnitude - Calculated	None	None
137	VZeroCalc Angle - Calculated	None	None
138	Vbus-VrefMag, Diff between Vbus, Vref magnitude	None	None
139	Voltage Diff Angle	None	None
140	Synch Check Slip Freq	None	None
141	Fault Distance	None	None
142	Peak Dem Ia	None	3
143	Peak Dem Ib	None	3

Analog Inputs
Static (Steady-State) Object Number: **30**
Change Event Object Number: **32**
Reporting Deadband Object Number: **34**
Request Function Codes supported: **1 (read), 2 (write, deadbands only), 22 (assign class)**
Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input)**
Change Event Variation reported when variation 0 requested: **1 (32 -Bit Analog Change Event w/o Time)**
Reporting Deadband Variation reported when variation 0 requested: **2 (32-Bit Reporting Deadband)**

Point Index	Name/Description	Reporting Deadband	Initial Change Event Class (1, 2, 3 or none)
144	Peak Dem Ic	None	3
145	Peak Dem In	None	3
146	Peak Dem KWan	None	3
147	Peak Dem KWbn	None	3
148	Peak Dem KWcn	None	3
149	Peak Dem KW3p	None	3
150	Peak Dem KVARan	None	3
151	Peak Dem KVARbn	None	3
152	Peak Dem KVARcn	None	3
153	Peak Dem KVAR3p	None	3
154	Min Dem Ia	None	3
155	Min Dem Ib	None	3
156	Min Dem Ic	None	3
157	Min Dem In	None	3
158	Min Dem KWan	None	3
159	Min Dem KWbn	None	3
160	Min Dem KWcn	None	3
161	Min Dem KW3p	None	3
162	Min Dem KVARan	None	3
163	Min Dem KVARbn	None	3
164	Min Dem KVARcn	None	3
165	Min Dem KVAR3p	None	3
166	fault year	None	3
167	fault month	None	3
168	fault day	None	3
169	fault hour	None	3
170	fault minutes	None	3
171	fault seconds	None	3
172	fault hundredths of second	None	3
173	oprec year	None	2
174	oprec month	None	2
175	oprec day	None	2
176	oprec hour	None	2
177	oprec minutes	None	2
178	oprec seconds	None	2
179	oprec hundredths of second	None	2

Installation

The REF 550 unit comes enclosed in a metal case. Follow the instructions and diagrams in this section to install the REF 550.

Receipt of the REF 550

When you receive the REF 550, examine it carefully for shipping damage. If any damage or loss is evident, file a claim at once with the shipping agent and promptly notify the nearest ABB sales office.

Before installing the unit, it is suggested that the following procedures be performed using the OCI:

- Power up the relay. The LEDs should light and a slight clicking sound will be heard.
- Using the function key F1, go to the Main Menu, press <PgDn> to Unit Information and press it's key. Verify the Catalog Number and Serial Number against the rear panel nameplate and Purchase Order information.
- Press <PgUp> until <Esc> appears and then press <Esc> to return to main menu.
- Locate the main menu item "Change Settings Menu" and press its key. Press "<PgDn> to the menu item "Clock" and press its key.
- Enter the Relay password (factory default is four spaces) and then correct time to start the clock. (This can also be performed using WinECP Settings menu item "Clock".) Press <Esc> and <PgUp> to return to Change Setting Menu.
- Set the PASSWORD by selecting Configuration. At the Password prompt, enter the present Relay password (factory default is four spaces). Press <PgDn> to Relay Password and enter a password. This will be the Relay password for changing settings and performing tests. Press <Esc> and locate and press the Test Password key. Select Test Password, and enter a different password. This password allows low level entry to the Test options of the unit.

WARNING: If any of the passwords is misplaced or forgotten, the unit cannot be accessed. If this situation occurs, contact ABB Allentown Technical Support at 1-800-634-6005 or 1 610 395-7333.

Installing the REF 550

The REF 550 is enclosed in a standard 3U (3 rack units), 19 x 5-inch case designed for rack mounting. Figure 9-2 shows the dimensions of the REF 550.

Output Master Trip	N.C. Jumpers	N.O. Jumpers
Trip	J11-J12	J12-J13
OUT1	J14-J15	J15-J16
OUT2	J17-J18	J18-J19
Alarm	J23-J24	J24-J25

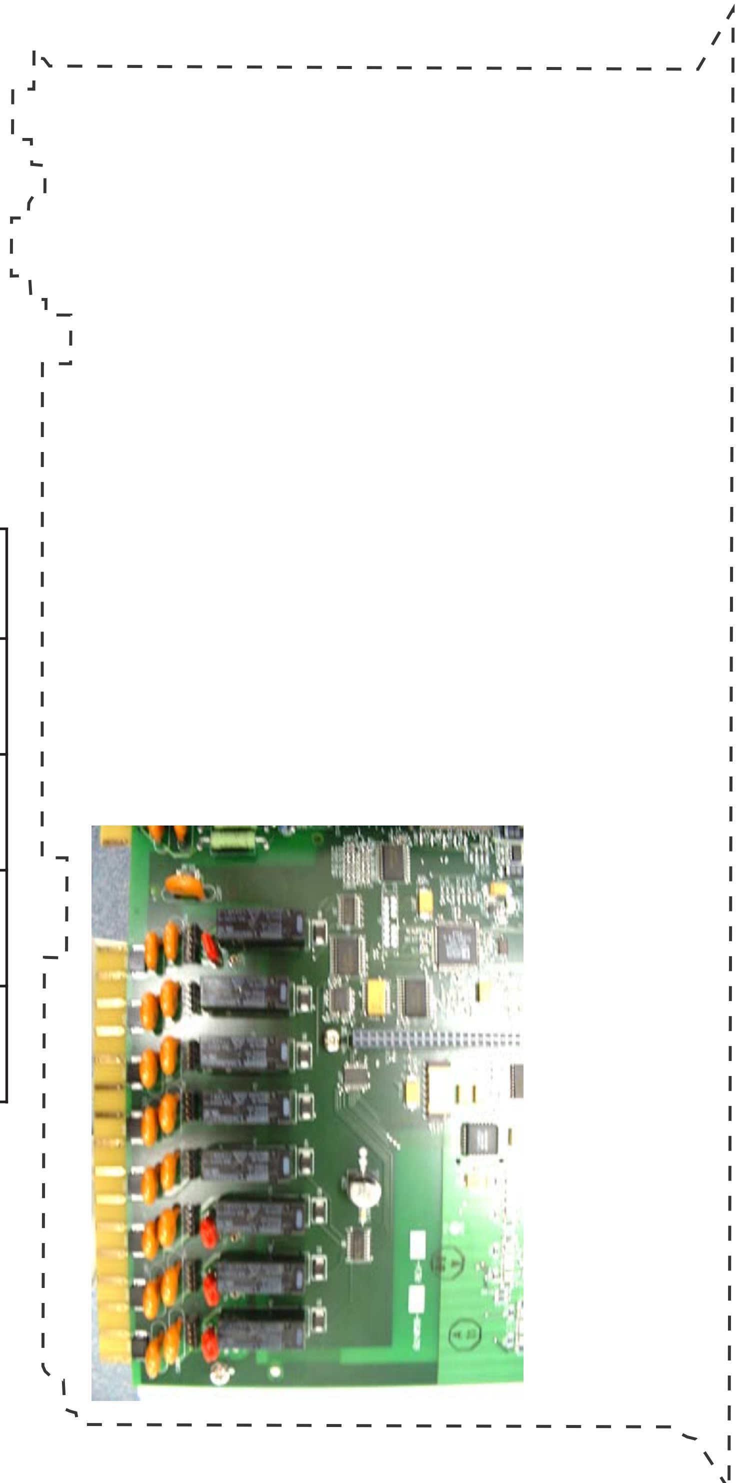


Figure 9-1. Main Circuit Board Jumpers

Case Dimensions (Standard 19" Rack Mount 3 Units High)

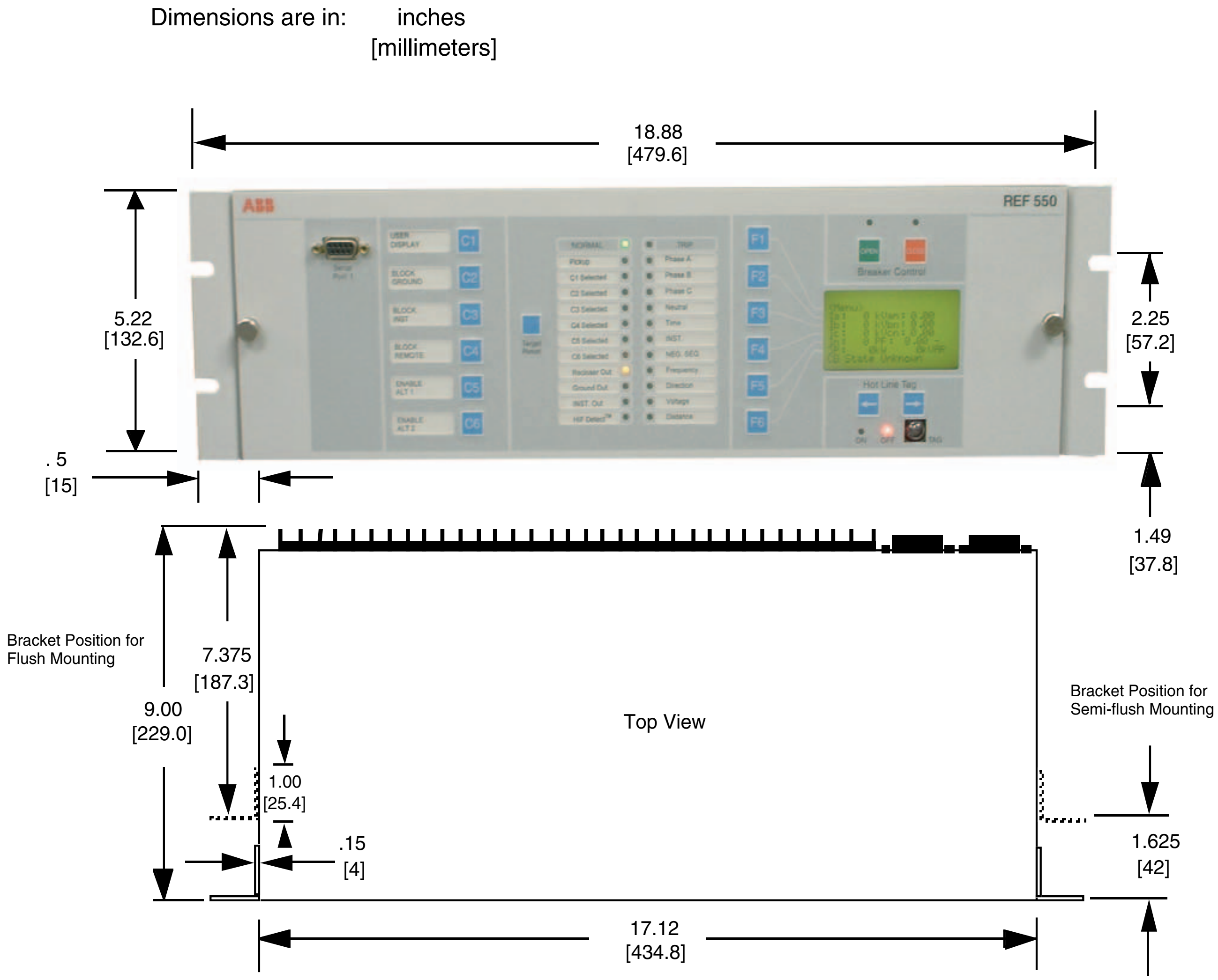


Figure 9-2. Case Dimensions

Panel Mounting Kit

The complete kit will include a bezel, its associated hardware and gasket, as well as a lens cover with its associated hardware. This kit will provide a means for panel mounting and dustproofing.

Ordering Information:

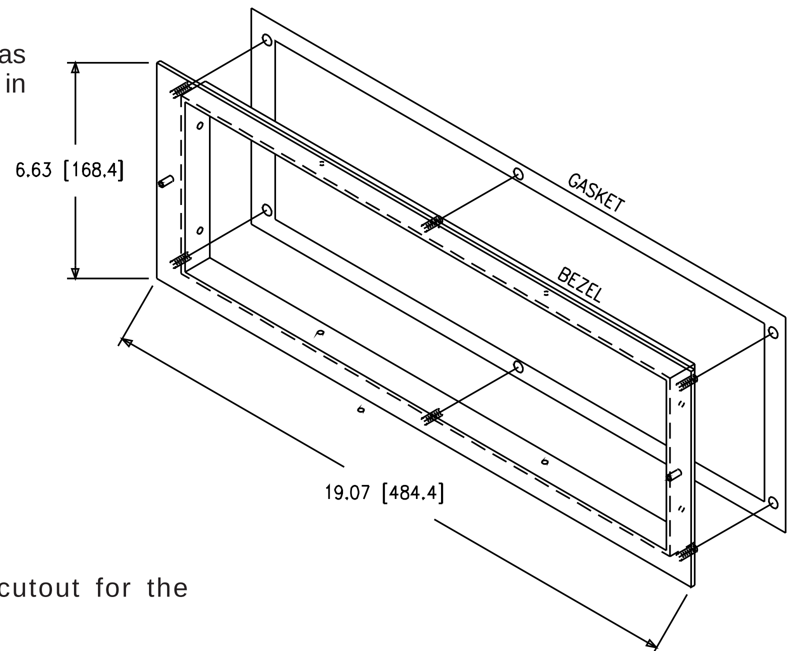
Horizontal Panel Mounting Kit	604513-K1

Spare Parts List:

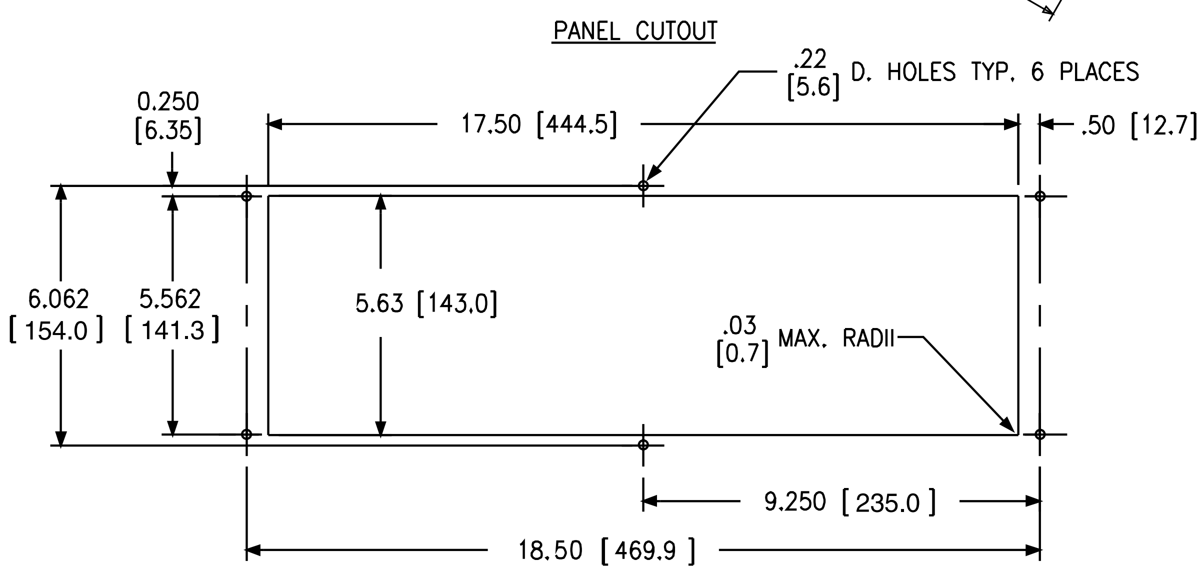
Bezel/gasket assembly only	604513-K3
Horizontal lens cover assembly	613724-K1

Horizontal Mounting

Note: The Bezel Assembly is available as an option for mounting the REF 550 units in a panel application.



Note: Below is the panel drilling cutout for the REF 550 unit and the bezel assembly.



NOTE: DIMENSIONS ARE INCHES [MILLIMETERS]

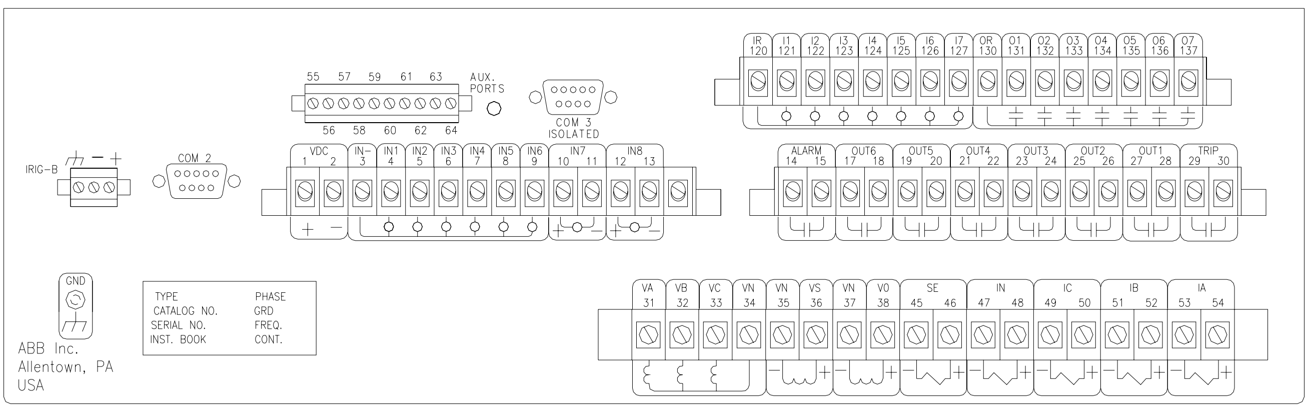
Rear Terminal Block Connections

Apply only rated control voltage marked on the rear panel nameplate of the unit to the positive terminal and the negative terminal. Wire the ground stud on the rear of the case to the equipment ground bus with at least #10 gauge wire. Figure 9-3 shows the rear terminal block layout and numbers.

With exception of the CTs and burden board, you can totally withdraw the REF 550 from its case.

Use input IN7 or IN8 as a Trip Coil Monitor (TCM) input. When the breaker is closed, a small trace current of 6 milliamperes is passed from the positive terminal through the negative terminal and the trip coil circuit. If an open circuit is detected while the breaker is closed, the Trip Circuit Failure Alarm (TCFA) contacts are actuated and a "Trip Coil Failed" message appears on the OCI display.

Note: On older relays, terminals 35-38 do not exist. This should not have any effect on wiring except for SEF and Sync Check units. For SEF and Sync Check units, the V_0 (or Vline) input should be the highest numbered sensor installed in the unit, which will be sensor 8 on older units and sensor 10 in present production.



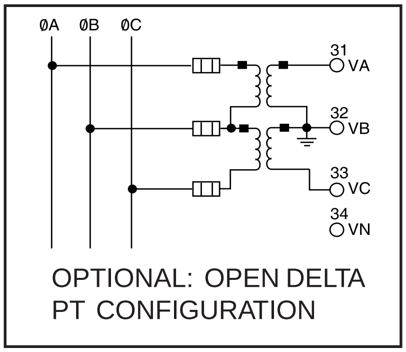
REF550REAR.DWG

Figure 9-3. Rear Terminal Block

Table 9-1. Minimum Connections

Required Connections	Terminals
Control Voltage Inputs	Positive: 1, Negative: 2, Common Negative: 3
Current Inputs	IA: 54 & 53; IB: 52 & 51; IC: 50 & 49; IN: 48 & 47; SE: 46 & 45
52A Contact Input	4(+)
52B Contact Input	5(+)
TRIP Output Contact	29 & 30 (N.O./N.C. Jumper Configurable)
SELF-CHECK ALARM Output Contacts	14 & 15 N.C. (REF550 powered down) NOTE:
Optional Connections	Terminals
Voltage Inputs	VA: 31; VB: 32; VC: 33; VN: 34

Relay External Connections



Note:
In this case, OUT1 is shown programmed as the breaker close contact. Inputs 1 and 2 on terminals 4 and 5 are shown mapped to the 52A and 52B Control Points, respectively. Refer to the Advanced Programmable Logic section for programming details. Auto-reclose control via the Control Point 43A is achieved through the OCI front panel control push-button C1 without the Hot-Line-Tag (HLT) feature or the HLT control push-buttons for an OCI with the Hot-Line-Tag option.

Self check alarm contact is shown in the powered down condition - closed. When control power is applied, contact will change state.

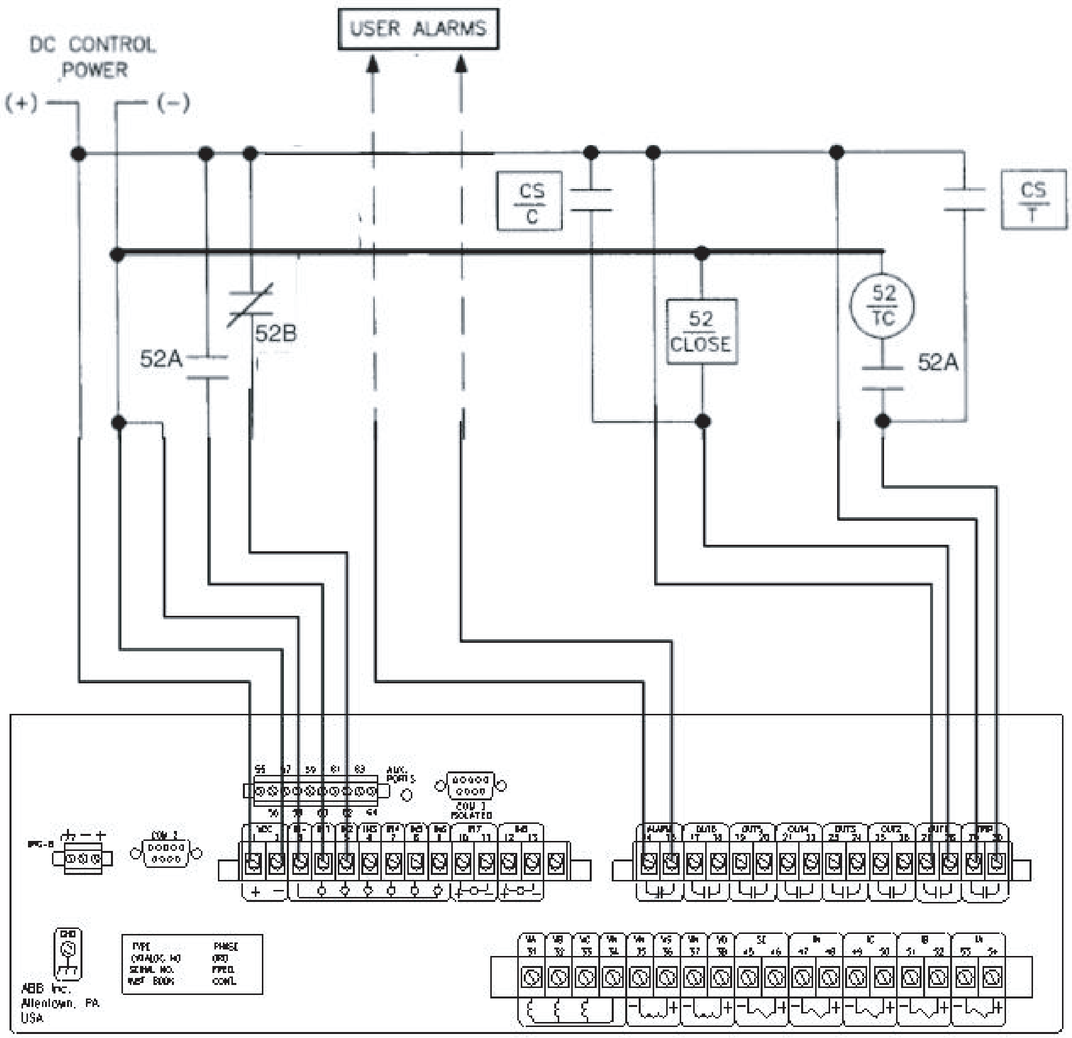


Figure 9-4. Typical DC Connections

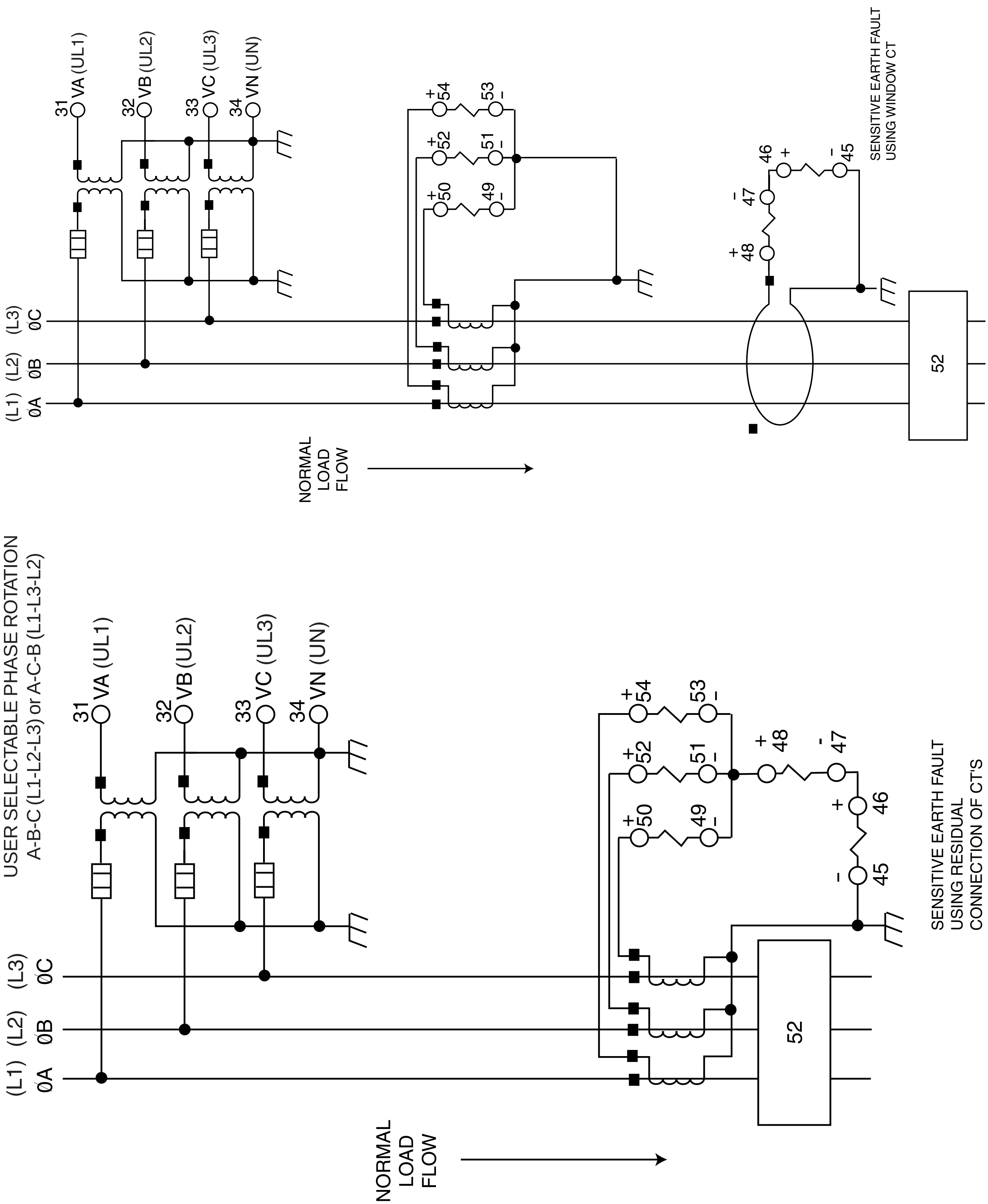
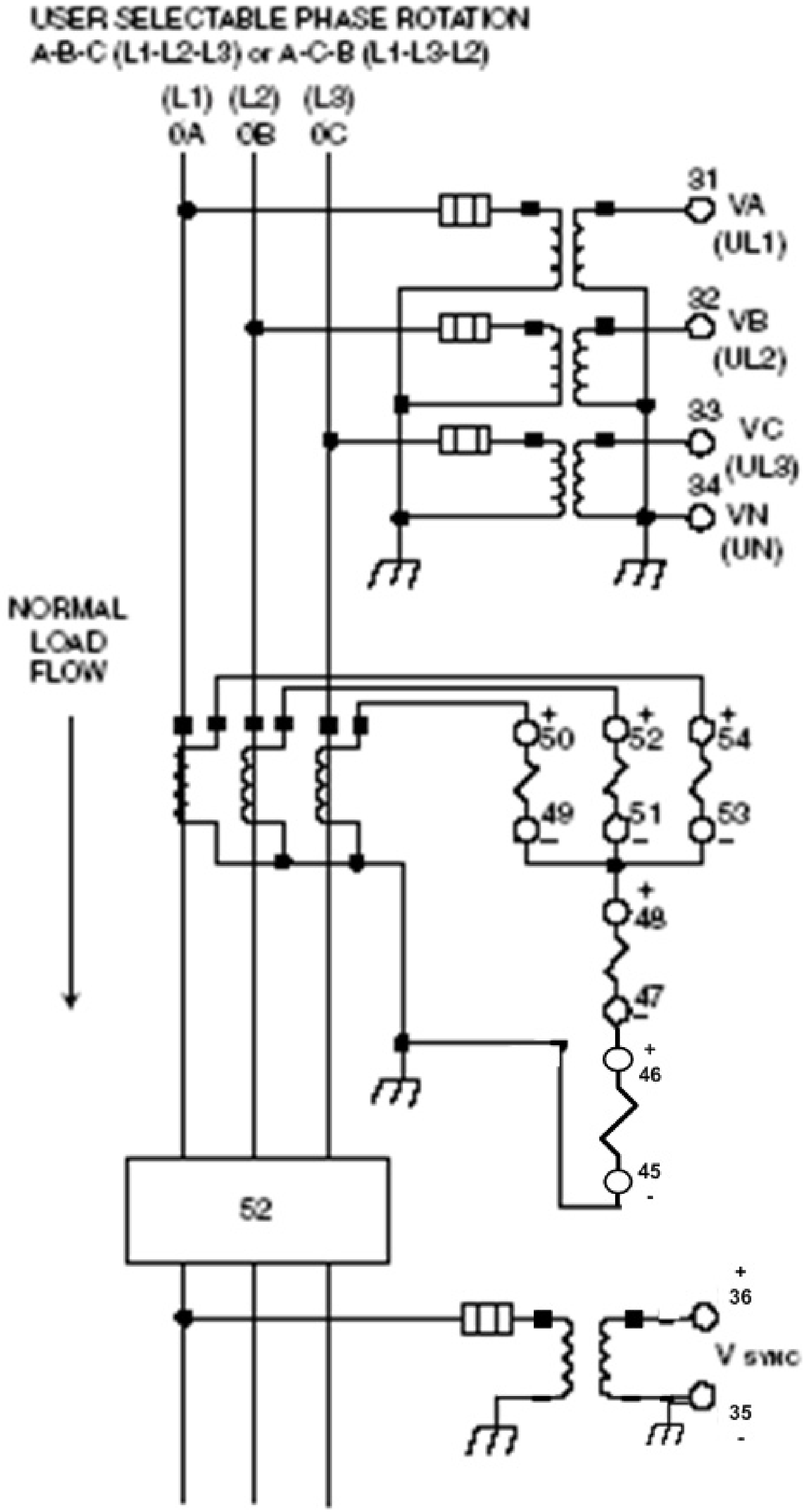


Figure 9-5. Typical AC Connections with Synch Check Select Disabled



IMPORTANT NOTES:

1. Observe the definitions of "Line-Side" and "Bus-Side" as they apply to the relay's VT inputs. This is important when using the DEAD-LINE/ DEADBUS closing functions of the Sync-check element. These relay designations may not match the actual system arrangement, so care must be taken in selecting the relay settings to obtain the desired mode of operation.

2. If the LINE-VT's are connected line-to-neutral, the Sync-check option allows the BUS-VT to be connected either line-to-neutral, or line-to-line, based on the setting "Bus VT Phase." (See Section 1.) If the LINE-VT's are connected line-to-line, then the BUS-VT should also be connected line-to-line.

Figure 9-6. Typical AC Connections with Sync Check Select Enabled

Testing & Maintenance

Because of its continuous self-testing, the REF 550 requires no routine maintenance. However, you can conduct testing to verify proper operation. ABB recommends that an inoperative unit be returned to the factory for repair. If you need to return a unit, contact your local ABB sales office for a return authorization number.

High-Potential Tests

High-potential tests are not recommended. If a control wire insulation test is required, completely withdraw the REF 550 from its case and perform only a DC high-potential test.

Withdrawing the REF 550 from its Case

The REF 550 can be disassembled to install optional equipment or to change jumper settings of the selectable output contacts, between normally open (NO) and normally closed (NC). Disconnect external communication ports before removing the relay from the case. Follow these steps to disassemble the unit:

WARNING: Removal of the relay from the case exposes the user to dangerous voltages. Use extreme care. Do not insert hands or other foreign objects into the case.

1. Loosen the knurled screws on the face of the REF 550 and gently remove the face and attached circuit board by grasping the knurled screws and pulling the unit straight back. Pulling the board out at an angle or otherwise stressing the board on extraction may damage the unit. Once removed from the case, position the unit bottom down on a static secured mat.
2. Install the desired options according to the instructions provided with those options. The output relays are on the top-left-rear section of the board (when viewed from the front) under the metal shield. Movable jumper links alongside the output relays set the selectable output contacts to normally open (NO) or normally closed (NC).
3. To reinstall the unit into the case, carefully align and insert the lips on both sides of the board into the guide rails on the inside walls of the case and gently push the unit straight inward until it fully seats in the case. Secure the knurled screws.

System Verification Tests

Besides continuously monitoring a Self-Check output contact, perform routine hardware tests to verify that the REF 550 is functioning properly. Run these tests via the REF 550 Operator Control Interface (OCI) LCD menu system or the front communications port and the Windows External Communications Program WinECP. The tests are:

1. Confirm pass/fail status of each Self-Check element by using the OCI Test Menu - see Section 4.

2. Confirm continuity of current and voltage through each input sensor by using the default OCI display.

3. Confirm continuity through each optically isolated contact input for both the opened and closed condition by using the OCI Test Menu - see Section 4.

4. Verify operation of each output contact by using the OCI Test Menu.

5. Confirm that all relay settings are correct by using WinECP.

6. Check the Fault and Operation Records for proper sequential operation using the OCI or WinECP.

Testing the REF 550

When the REF 550 is in service, its functions depend on the state of the breaker monitored through the 52a and 52b contacts. Therefore, to fully test the system, apply a test circuit that simulates circuit breaker operation. Figure 10-1 shows a typical test circuit using a latching relay as the simulated breaker.

A **Breaker Simulator Test Accessory** is available from the factory. Instruction Book IB 7.7.1.7-9 applies to this accessory and is available on request. Catalog numbers: 110/125 Vdc = 200S4004; 48 Vdc = 200S4003.

If it is not possible to use a breaker simulator, place the REF 550 in the Functional Test Mode. This mode allows testing of the programmed overcurrent functions and reclose sequence (when the test current is removed) without simulating the operation of the 52a and 52b contacts. The Functional Test Mode is enabled only from the OCI LCD menu system. To enable the Functional Test Mode, apply these simple steps from the OCI display.

1. Select “<Menu>”. (F1)

2. Select “Main Menu”. (F2)

3. Select “<PgDn>”. (F6)

4. Select “Test Menu”. (F3)

5. Select “Functional Test Mode”. (F5)

6. Use Function Keys F2, F3 and F5 to enter Test or Relay Password and then select “<enter>”. (F6)

7. With “< YES >” displayed, select “<Enter>”. (F6)

Use the same procedure to “Disable” the Functional Test Mode.

The REF 550 stays in the Functional Test Mode for fifteen minutes or until you exit whichever occurs first. Use the “TARGET RESET” key on the OCI to reset the recloser when it is in Lockout in the Functional Test Mode. In the Functional Test Mode the fault sequence is written only to the Operation Records. Use this feature to avoid the operation tests from creating Fault Records.

If you do not place the unit in Functional Test Mode and do not connect the 52a and 52b contacts during testing, the REF 550 will go into the Breaker Failure state (and Lockout) on the first trip test.

The tests described below confirm the relay’s protective capabilities and metering accuracy. Test only those functions that will be enabled when the relay is placed into service. Testing the enabled functions ensures that the relay settings are correct for the desired application. Check the Fault and Operations Records after each test to confirm proper sequential operation of the relay logic.

NOTE: The following test procedures are written from the perspective of using the OCI. You can also use the WinECP to change settings and run the test. See Section 4, “User Interfaces”, for basic instructions on using the Windows user software interface tool WinECP.

Use a three-phase current and voltage test set with timer to confirm continuity through the five current input sensors, four voltage input sensors and the proper operation/settings of 51P (3I>) , 51N (IN>) , 50P-1 (3I>>1) , 50N-1 (IN>>1) , 50P-2 (3I>>2) , 50N-2 (IN>>2) , 50P-3 (3I>>3), 50N-3 (IN>>3), 46-1 (Insc>1) and 46-2 (Insc>2) and functions. Test the phase functions by injecting current into the Ia and Ib input sensors. Test the neutral (ground) functions by injecting current into the Ic and In input sensors. Test the 46 functions by injecting current into one phase input sensor (since I_2 = 1/3 Ia when Ib = Ic = 0).

Use the test set to fully test the accuracy of the watts, VARs and power factor metering capabilities. (You must have 3-phase current sources, 3-phase voltage sources and a digital timer.)

Use the voltage sources of the test set to confirm the proper operation/settings of the voltage, recloser and frequency functions.

Properly ground all equipment used in testing.

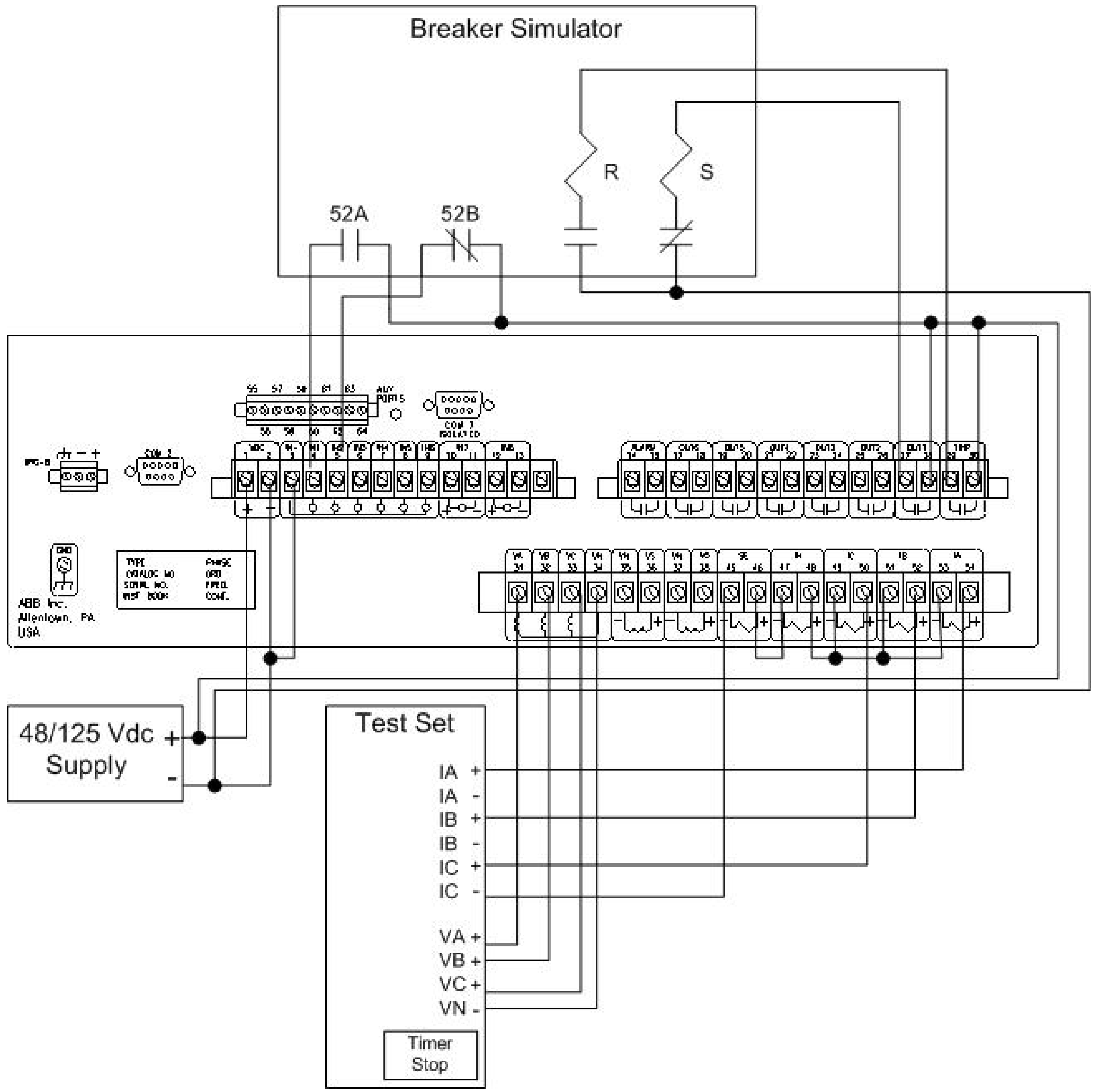
Tables 10-1 and 10-2 show the factory default settings on which the tests are based. These are the same default settings shown in Tables 4-1 and 4-2.

Table 10-1. Factory Defult Primary Settings for Testing

Function	Setting
25 Select	Disable
27 Select	Disable
2Phase 50P	Disable
32N-2 Select	Disable
32P-2 Select	Disable
46-1 Curve	Disable
46-2 Curve	Disable
47 Select	Disable
50N-1 Select	Standard
50N-1 PickupX	3.0
50N-2 Select	Disable
50N-3 Select	Disable
50P-1 Curve	Standard
50P-1 PickupX	3.0
50P-2 Select	Disable
50P-3 Select	Disable
51N Curve	Ext Inv
51N Pickup	6.0
51N Time Dial	5.0
51P Curve	Ext Inv
51P Pickup	6.0
51P Time Dial	5.0
59 Select	Disable
59G Select	Disable
67N Select	Disable
67P Select	Disable
79 Cutout Time	Disable
79 Reset Time	10
79-1 Open Time	LOCK
79-1 Select	Enable: 50P-1, 51N, and 50N-1
79V Select	Disable
81 Select	Disable
Cold Load	Disable
Neutral Cold Load	Disable
HIF Detect(TM)	Disable

Table 10-2. Factory Defult Configuration Settings for Testing

Function	Setting
Phase CT Ratio	100
Grd CT Ratio	100
SE CT Ratio	100
VT Ratio	100
Vbus Ratio	100
VT Connection	120V Wye
Positive Sequence X/mi (km)	.001
Positive Sequence R/mi (km)	.001
Zero Sequence X/mi (km)	.001
Zero Sequence R/mi (km)	.001
Line Length (mi/km)	20
Trip Failure Time	18
Close Failure Time	18
Slow Trip Time	12
Phase Rotation	ABC
Vcn Mode	Normal
Protection Mode	Fund
Reset Mode	Instant
ALT1 Setting Enable	Enable
ALT2 Setting Enable	Enable
MDT Mode	Disable
Cold Load Timer Mode	Seconds
79V Timer Mode	Seconds
Voltage Display Mode	Line-Neutral
Zone Sequence	Disable
Target Mode	Last
Local Edit	Enable
Remote Edit	Enable
Watt-hour Display Mode (WHr Display)	kWHr
Unit ID	REF 550
Demand Meter (Time Constant)	15
LCD Contrast	32
Relay Password	Four (4) spaces
Test Password	Four (4) spaces
Breaker Control Edit	Disable
C1 FP Select	Disable
C1 Mode	Maintained
C2 FP Select	Disable
C2 Mode	Maintained
C3 FP Select	Disable
C3 Mode	Maintained
C4 FP Select	Disable
C4 Mode	Maintained
C5 FP Select	Disable
C5 Mode	Maintained
C6 FP Select	Disable
C6 Mode	Maintained
Shift Register A	3
Shift Register B	3
SWSET	Disable



Programmable inputs IN01 (52a) and IN02 (52b) must be wired to enable their respective functions and programmed in the Input Mapping screen. Progammable output OUT 2 (Close) must be wired to enable the respective function and programmed in the output mapping screen.

Figure 10-1. Typical Test Circuit

Functional Test Mode (Password Protected)

Use the Functional Test Mode to test programmed overcurrent functions and the reclose sequence (upon removal of test current) without simulating operation of the 52a and 52b contact inputs. The REF 550 stays in Functional Test Mode for fifteen minutes or until you exit, whichever occurs first. Use the TARGET RESET pushbutton on the OCI to reset the recloser when it is in Lockout in the Test Mode. The OCI display shows the time remaining in the Functional Test Mode (except when a Trip Circuit Failure has been detected). The test sequences are written only into the Operations Record.

Verify Self-Checking Test Via OCI

Follow these steps to verify the pass/fail status of each self-check element on the REF 550:

1. Connect the proper control power to the unit. Wait for initialization to be complete. The green STATUS LED should be lit and the red RECLOSER OUT LED should also be lit if the recloser is disabled by the active settings table.
2. From the OCI, select <Menu> and then “Main Menu”.
3. Select <PgDn> and then “Test Menu”.
4. Select “Self Test” from the menu. All elements under the “Self Test” should read “pass.”
5. Press <Esc> to return to the default meter display.

Phase Angle Conventions

For tests that follow, refer to Figure 6-1 for phase angle and metering conventions used in the REF 550. In general, all angles are in “degrees leading.”

Metering Test

1. Apply 3-phase voltages and currents as shown in Figure 10-2. The values for these are:
   - Ia (L1) = 3.0 A < 0°
   - Ib(L2) = 3.0 A < 240°
   - Ic (L3) = 3.0 A <120°
   - Van (UL1) = 120.0 V < 0°
   - Vbn (UL2) = 120.0 V < 240°
   - Vcn (UL3) = 120.0 V <120°
2. From the OCI LCD screen, press “<Menu>”, “Main Menu” and then “Meter Menu”.
3. Press the menu item “Load”. The following should be within the ranges listed:
   - Ia (L1) = 300.0 < 0° (±6 A; the ±6A was calculated by taking 1% of the product of the pickup setting [6.0 A] x the Phase CT Ratio [100]: .01 x [6.0 x 100] = 6.)
   - Ib (L2) = 300.0 < 240° (±6 A)

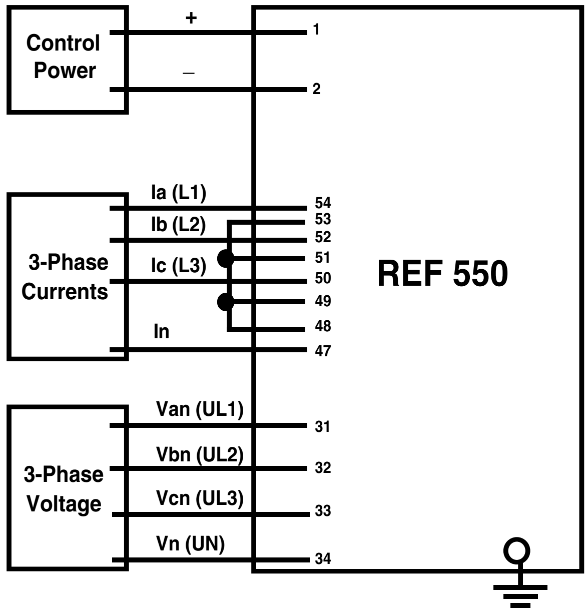


Figure 10-2. Metering Test and Distance Elements

- Ic (L3) = 300.0120° < (±6 A)
- In = 0.0 (±6 A)
- kVan (UL1) = 12.0 < 0° (±0.12 kV)
- kVbn (UL2) = 12.0 < 240° (±0.12 kV)
- kVcn (UL3) = 12.0 < 120° (±0.12 kV)
- kW-A (L1) = 3600 (±144 kW)
- kW-B (L2) = 3600 (±144 kW)
- kW-C (L3) = 3600 (±144 kW)
- kW-3P = 10800 (±432 kW)
- kVAR-A (L1) = 0 (±144 kW)
- kVAR-B (L2) = 0 (±144 kW)
- kVAR-C (L3) = 0 (±144 kW)
- kVAR-3P = 0 (±432 kW)
- I_0 = 0 (±6 A)
- I_1 = 300 < 0° (±6 A)
- I_2 = 0 < 0° (±6 A)
- kV_1 = 12.00 < 0° (±0.12 kV)
- kV_2 = 0 < 0° (±0.12 kV)
- PF = 1.00 Lagging or Leading
- Freq = 60.00 (± 0.01 Hz)

4. Connect the REF 550 as shown in Figure 10-4. Apply 3.0 A to C (L3)-Phase and the Neutral. Read the current from the Metering Menu as above. The currents Ic and In should be 300.0 ±6 A.

Pickup—Time Overcurrent

Follow these steps to check the time overcurrent of the pickup current.

1. Connect there REF 550 as shown in Figure 10-3.
2. Apply 5.5 A, gradually increasing the current until the PICKUP LED just lights. This should be within ±3% of the pickup (see the Specifications and Tolerances section) or ±0.18 A (±18.0 A primary). This confirms the continuity and accuracy of phases A (L1) and B (L2).
3. Decrease the input current to 0 and reset targets, if necessary, by pressing the OCI TARGET RESET push-button.
4. Connect the REF 550 as shown in Figure 10-4. Repeat Step 2 to confirm the continuity and accuracy of phase C (L3) and Neutral.

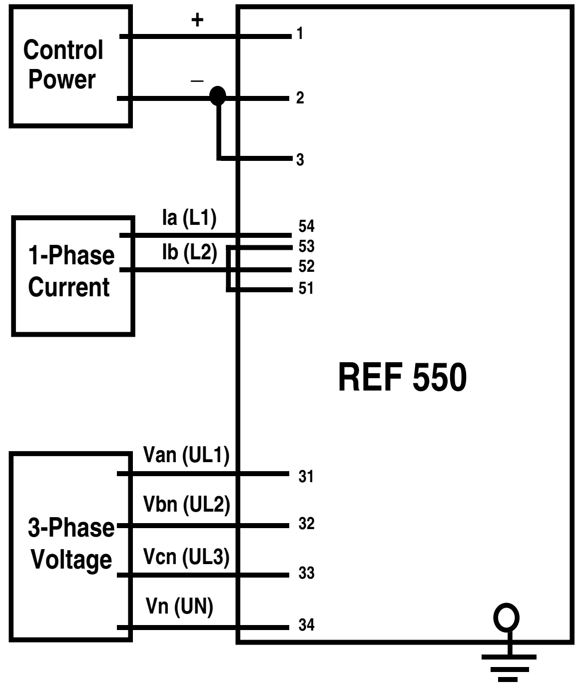


Figure 10-3. Test Circuit for 51P (3I>), 50P-1 (3I>>1), 2-Phase 50P(3I>>) and 46 -1, -2 (Insc>1,2) Functions

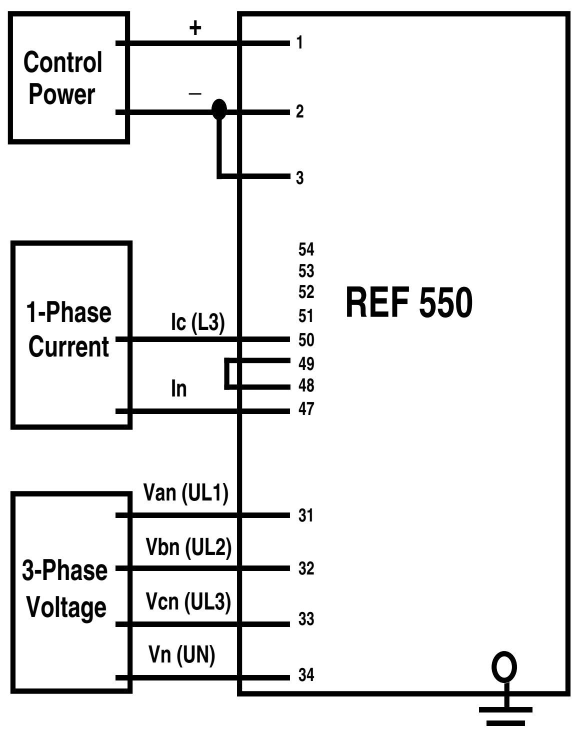


Figure 10-4. Test Circuit for 51N (IN>), 50N-1(IN>>1), 50P-2 (3I>>2), 50N-2 (IN>>2), 50P-3 (3I>>3), 50N-3 (IN>>3) and 2-Phase 50P (3I>>) Functions

5. To confirm the ground pickup, lower the 51N (IN>) setting to 5.0 A. To do this:
   a. Access the settings menu by selecting <Menu> and then “Main Menu” on the OCI LCD screen.
   b. Select “Change Settings Menu”.
   c. Choose “Primary Settings”.
   d. Enter the password (four spaces for factory default) and select <Enter>.
   e. Use <PgDn> to scroll to “51N Pickup A” and select it.
   f. Press the appropriate key until 5.0 is displayed; hit <Enter> to accept this value.
   g. Select <Esc>, <PgUp> to <Esc> and select <Esc> to exit Change Primary Settings menu.
   h. Select “YES” to the “Save Settings” prompt.
   i. Press <Esc> until the default metering screen is displayed.
6. Apply 4.5 A to the REF 550 as shown in Figure 10-4. Gradually increase the current until the PICKUP LED just lights. This should be within ±3% of the pickup (5 A). This confirms the ground pickup.
7. Decrease the input current to 0 and reset targets, if necessary, by pressing the OCI TARGET RESET push-button.
8. Repeat step 5 above to reset the 51N (IN>) pickup to 6.0 amps.

Pickup—Instantaneous Overcurrent

Follow these steps to test the pickup of the instantaneous overcurrent elements:

1. To test the 50P-1 (3I>>1) phase instantaneous unit:
   a. Connect the REF 550 as shown in Figure 10-3.
   b. Apply approximately 85% of the instantaneous pickup current (18 A from Table 10-1) to the relay or 15.3 A.
   c. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% of the setting or ±1.26 A (±126 A primary). This confirms phases A (L1) & B(L2). Targets that should be lit are Phase A, Phase B and INSTANTANEOUS.
   d. Decrease the input current to 0 and reset targets by pressing the OCI TARGET RESET push-button.
2. To test the 50N-1 (IN>>1) ground instantaneous unit:
   a. Disable the 50P-1 (3I>>1) function via the “Change Settings”, “Primary Settings” Menus.
   b. Connect the REF 550 as shown in Figure 10-4.
   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 10-1) to the relay or 15.3 A.
   d. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% (from Table 10-1) of the setting or ±1.26 A (±126 A primary). The Phase C, Neutral and INSTANTANEOUS LED’s should be lit.
   e. Decrease the input current to 0 and reset targets by pressing the TARGET RESET push-button on the OCI.
3. To test the 50P-2 (3I>>2) phase instantaneous unit:
   a. Enable the 50P-2 (3I>>2) function and disable the 50N-1 (IN>>1) function via the “Change Settings”, “Primary Settings” Menus.
   b. Connect the REF 550 as shown in Figure 10-3.
   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 10-1) to the relay or 15.3 A.
   d. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% of the setting or ±1.26 A (±126 A primary). The Phase A, Phase B and INSTANTANEOUS LED’s should be lit.
   e. Decrease the input current to 0 and reset targets by pressing the TARGET RESET push-button on the OCI.

4. To test the 50N-2 (IN>>2) ground instantaneous unit
   a. Enable the 50N-2 (IN>>2) function and disable the 50P-2 (3I>>2) function via the “Change Settings”, “Primary Settings” Menus.
   b. Connect the REF 550 as shown in Figure 10-4.
   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 10-1) to the relay or 15.3 A.
   d. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% of the setting or ±1.26 A (±126 A primary). The Phase C, Neutral and INSTANTANEOUS LED’s should be lit.
   e. Decrease the input current to 0 and reset targets by pressing the TARGET RESET push-button on the OCI.

5. To test the 50P-3 (3I>>3) phase instantaneous unit:
   a. Enable the 50P-3 (3I>>3) function and disable the 50N-2 function via the “Change Settings”, “Primary Settings” Menus.
   b. Connect the REF 550 as shown in Figure 10-3.
   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 10-1) to the relay or 15.3 A.
   d. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% of the setting or ±1.26 A (±126 A primary). The Phase A, Phase B and INSTANTANEOUS LED’s should be lit.
   e. Decrease the input current to 0 and reset targets by pressing the TARGET RESET push-button on the OCI.

6. To test the 50N-3 (IN>>3) ground instantaneous unit:
   a. Enable the 50N-3 (IN>>3) function and disable the 50P-3 (3I>>3) function via the “Change Settings”, “Primary Settings” Menus.
   b. Connect the REF 550 as shown in Figure 10-4.
   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 10-1) to the relay or 15.3 A.
   d. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% of the setting or ±1.26 A (±126 A primary). The Phase C, Neutral and INSTANTANEOUS LED’s should be lit.
   e. Decrease the input current to 0 and reset targets by pressing the TARGET RESET push-button on the OCI.

7. To test the 2-Phase 50P (3I>>) Trip function:
   a. Enable the 50P-2 (3I>>2) and 2-Phase 50P (3I>>) function via the “Change Settings”, “Primary Settings” Menus.
   b. Connect the test set as shown in Figure 10-3.
   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 10-1) to the relay or 15.3 A.
   d. Gradually increase the current until the 50P-2 (3I>>2) relay trips. This should be ±7% of the setting or ±1.26 A (±126 A primary). This confirms phases A (L1) & B (L2). The Phase A, Phase B and INSTANTANEOUS LED’s should be lit.
   e. Decrease the input current to 0 and reset targets by pressing the TARGET RESET push-button on the OCI.
   f. Connect the test set as shown in Figure 10-4, repeat tests c, d and e. This should confirm that the relay does not trip and no LED target lights.

Timing Tests

Follow these steps to test the timing of the REF 550:

1. Connect the REF 550 as shown in Figure 11-5.

2. Apply a fault current of 12 A to the relay. This current is 2x the default pickup current of 6.0 A. The relay should trip between 14.5 and 16.7 seconds (derived from the Extremely Inverse curve, see Section 1, by using the default values in Table 10-1).

3. Apply a fault current of 24 A to the relay (4x the default pickup current). The relay should trip between 3.0 and 3.5 seconds.

4. Apply a fault current of 36 A to the relay (6x the default pickup current). The relay should trip between 1.4 and 1.6 seconds.

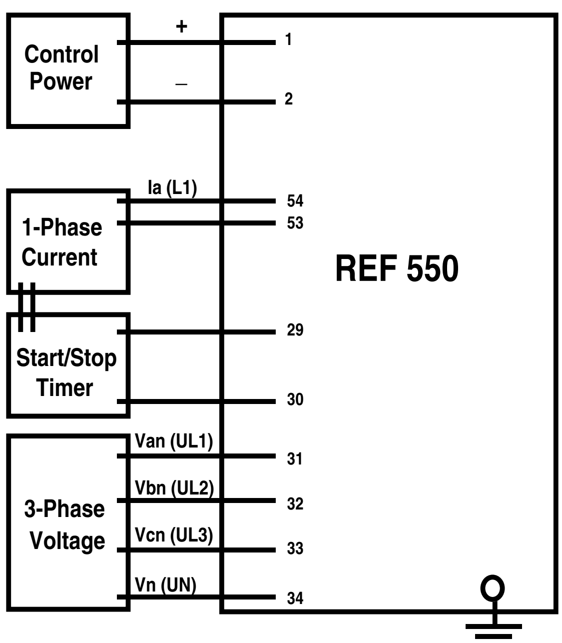


Figure 10-5. Test Circuit for Timing and Recloser Lockout

Directional Testing

Follow these steps to test the directional functions:

1. To test the 67P (3I>->) protective function, enable the directional functions:
   a. Select <Menu>.
   b. Select “Main Menu”.
   c. Locate “Change Settings Menu” and select.
   d. Locate “Primary Settings” and select.
   e. Enter password (four spaces for default) and choose <Enter>.
   f. <PgDn> to “67P Select” and choose.
   g. Change to “Enable”, press <Enter> and then <Esc>.
   h. Select <Esc>, <PgUp> to <Esc> and select <Esc> to exit Change Primary Settings menu.
   i Select “Yes” to save settings.
   j. The factory default settings are as follows:
      - 67P Curve Extremely Inv
      - 67P Pickup 1.0
      - 67P Time Dial 5
      - Torque Angle 0
   k. Apply the following test values to the circuit, as shown in Figure 10-6:
      - Ia = 5 A <0°
      - Ib = 0 A
      - Ic = 0 A
      - In = 5 A <0°
      - Van = 10 V <0°
      - Vbn = 120 V <240°
      - Vcn = 120 V <120°
   l. The relay should trip on 67P directional overcurrent between 2.00 and 2.35 seconds (from the Extremely Inverse curve, see Section 1). The Phase A, Time and Directional LED’s should be lit. Check the fault records to confirm the 67P trip.
   m. Reset the targets by pressing the TARGET RESET push-button on the OCI.
   n. Change the Ia and In test angles to 180° and reapply the current.
   o. The relay should not trip on the phase directional overcurrent.

2. To test the 67N, disable the 67P function and enable the 67N function.
   a. Select <Menu> and “Main Menu”.
   b. Locate “Change Settings Menu” and select.
   c. Locate “Primary Settings Menu” and select.
   d. Enter the password (four spaces for default) and press <Enter>.

f. Scroll down to “67 N Select” and select.

g. Change setting to “Enable - Neg Seq”, select <Enter> and then <Esc>.

h. Choose <Esc>, <PgUp> to <Esc> and select.

i. Set to “Yes” and select to save settings.

j. The factory default settings are as follows:

- 67N Curve Extremely inv
- 67N Pickup 6.0
- 67N Time Dial 1.0
- Torque Angle 180

k. Apply the following test values to the circuit as shown in Figure 10-6:

- Ia = 5 A < 180°
- Ib = 0 A
- Ic = 0 A
- In = 5 A < 180°
- Van = 10 V < 0°
- Vbn = 120 V < 240°
- Vcn = 120 V < 120°

l. The relay should trip on 67N directional overcurrent between 0.28 and 0.32 seconds (from the Extremely Inverse curve, see Section 1). The Neutral, Time and Directional LED’s should be lit. Check the fault records to confirm the 67N trip.

m. Reset the targets by pressing the TARGET RESET push-button on the OCI.

n. Change the Ia and In angles to 0° and reapply the current.

o. The relay should not trip on ground directional overcurrent.

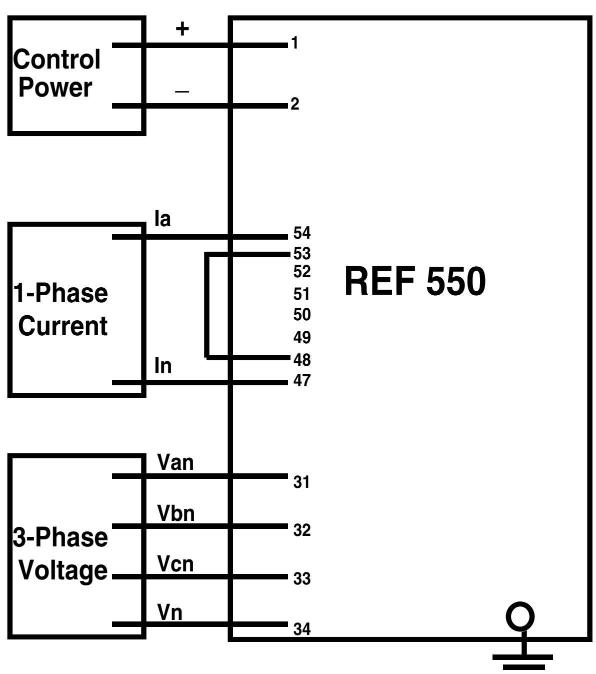


Figure 10-6. Test Circuit for 67P and 67N Functions

Negative Sequence Testing

Follow these steps to test the 46-1 (Insc>1) and 46-2 (Insc>2) functions:

1. Disable all phase instantaneous functions: 50P-1 (3I>>1), 50P-2(3I>>2), 50P-3 (3I>>3).

2. Raise the 51P (3I>) Pickup setting to 12A to prevent a 51P (3I>) operation during this test.

3. Set the 46-1 (Insc>1) function according to the following values:
   - Curve: Extremely Inverse
   - Pickup: 3.5A
   - Time Dial: 5.0

4. Apply the following currents as shown in Figure 10-3:
   - Ia (L1) = 12 A < 0°
   - Ib (L2) = 12 A < 180°
   - Ic (L3) = 0

   This phase-to-phase fault simulation will produce a two per unit negative-sequence current, 6.9A I_2, (12A x 58% = 6.9A), in the REF 550.
   - In = 0

5. In this case, I_2 is determined in the relays as follows:

   $I_2 = 1/3\ (Ia + a^2 I_b + aIc)$

   where:

   $a = 1 \quad < 120$

   $a^2 = 1 \quad < \ -120$

   since Ic = 0, then

   $I_2 = 1/3\ (Ia + (1 < -120)\ Ib)$

   $= 1/3\ (12 < 0 + (1 < -120)\ (12 < 180))$

   $= 1/3\ (12 < 0 + 12 < 60)$

   $= 1/3\ (20.7 < 30°)$

   \ $I_2 = 6.9 < 30°$

   therefore, we are at approximately 2x pickup.

6. The relay should trip between 14.3 and 16.3 seconds (from the Extremely Inverse Curve, see Section 1) and the NEGATIVE SEQUENCE LED should be lit.

Phase Step Distance Testing

1. To enable the 21P-1 function through the OCI LCD menu:

    a. Select <Menu> and "Main Menu".

    b. Locate "Change Settings Menu" and select.

    d. Locate "Primary Settings Menu" and select.

    e. Enter the password (four spaces for default), and choose <Enter>.

    f. <PgDn> to 21P-1 Select and select.

    g. Set the setting to "Enable" and select <Enter> and then <Esc>.

    h. Change the settings to the following values.

· 21P-1 Select	Enable-Forward
· 21P-1 Phase Reach	40.0 ohms
· Characteristic Angle	75 degrees
· Time Delay	0.00 seconds
· I_1 Supervision	Disable or set at 1.0 amp
· I_2 Supervision	Disable or set at 1.0 amp

    i. After changing the values for 21P-1, select <PgUp> to <Esc> and then select.

    j. Select "YES" and press <Enter> to save the new settings.

2. Use WinECP Advanced Programmable Logic settings to map a Physical Output to the Status Point "21P-1" to monitor a 21P-1 operation.

3. Verify the 21P-1 zone condition by applying the following voltages and currents to the relay.

    - Vab = 120 volts < 0 degrees
    - Vbc = 120 volts < 240 degrees
    - Vca = 120 volts < 120 degrees

    - Ia = 2.5 amps < 285 degrees
    - Ib = 2.5 amps < 165 degrees
    - Ic = 2.5 amps < 45 degrees
    - (Phase Angle = 75 degrees current lagging voltage)

4. Lower the voltage to 103 volts, and the 21P-1 unit should not trip.

5. Lower the voltage to 97 volts, and the 2P1-1 unit should trip and the Distance LED should be lit as the impedance reach is inside the circular characteristic.

6. Test the 21P-2, 21P-3 and 21P-4 units in the same manner as described above.

7. To test any of the 21P units in the "Enable-Reverse" selection, add 180 degrees to the angle setting and test current angles.

Negative Sequence Voltage Testing

1. To enable the 47 function through the OCI LCD menu:
   a. Select <Menu>.
   b. Locate “Main Menu” and select.
   c. Locate “Change Settings Menu” and select.
   d. Locate “Primary Settings” and select.
   e. Enter the password (four spaces for default), and select <Enter>.
   f. <PgDn> to 47 Select and select.
   g. Change the setting to “Enable” and select “<Enter> and then <Esc>.
   h. Program the function settings to the following values.
      · 47 Select: Enable
      · 47 Pickup:10.0 volts
      · 47 Time Delay: 0.00 seconds
   i. After changing the values for 47, press <PgUp> to <Esc> and then select <Esc>.
   j. Select “YES” to save the new settings.
2. Use the Advanced Programmable Logic feature, see Section 5, in WinECP to program a Physical Output to the Status Point “47” to verify a phase sequence overvoltage operation.
3. Verify the 47 condition by applying the following voltages and currents to the relay as shown in Figure 10-2.
   · Vab = 120 volts < 0 degrees
   · Vbc = 120 volts < 120 degrees
   · Vca = 120 volts < 240 degrees

   · Ia = 0.0 amps
   · Ib = 0.0 amps
   · Ic = 0.0 amps
4. Lower any two phases to 90 volts, and the 47 device will trip and the Voltage LED will light as V_2 will be 10.0 volts. Raise the voltage slightly, and it should not produce a trip. Press the OCI TARGET RESET push-button to clear all targets displayed.

Undervoltage Testing

1. To enable the 27 function through the menu:
   a. Press the <Menu> key.
   b. Locate “Main Menu” and press key.
   c. Locate “Change Settings Menu” and press its key.
   d. Press “Primary Settings “ key.
   e. Enter the password (four spaces for default), and press the <Enter> Key.
   f. Press <PgDn> to 27 Select and select.
   g. Press the key until “Enable” appears and press <Enter>.
   h. Use the Function Keys to program the following setting.
      · 27 Select: Enable
      · 27 Voltage Pickup: 100 volts
      · 27 Time Delay: 0.00 seconds
   i. After changing the values for 27, press <PgUp> until <Esc> appears and then select <Esc>.
   j. Select “YES” to save the new settings.

2. Program individual Physical Outputs to the voltage Status Points “27-1P” and “27-3P” using the Advanced Programmable Logic feature in WinECP.

3. Verify the 27 condition by applying the following voltages and currents to the relay as shown in Figure 10-2.
   · Vab = 120 volts < 0 degrees
   · Vbc = 120 volts < 120 degrees
   · Vca = 120 volts < 240 degrees

   · Ia = 0.0 amps
   · Ib = 0.0 amps
   · Ic = 0.0 amps

4. Lower any one phase to 100 volts, and the 27-1 device will trip and the Voltage LED will light. For a three phase undervoltage test, lower all three phases to 100 volts, and the 27-3 contact output will trip and the Voltage LED will light. Raise the voltage slightly, and it should not produce a trip. Press the OCI TARGET RESET push-button to reset all displayed targets.

Phase Overvoltage Testing

1. To enable the 59 function through the menu:
   a. Press the <Menu> key.
   b. Locate “Main Menu” and press it’s key.
   c. Locate “Change Settings Menu” and press its key.
   d. Press the “Primary Settings” key.
   e. Enter the password (four spaces for default), and press <Enter>.
   f. Press <PgDn> to 59 Select and press it’s key.
   g. Press the key until 59 Enable appears and press <Enter>.
   h. Use the Function Keys to program the following settings.
      - 59 Select: Enable
      - 59 Pickup: 130 volts
      - 59 Time Delay: 0.00 seconds

   i. After changing the values for 59, press <PgUp> until <Esc> appears and then press <Esc>.
   j. Use the right arrow key to select “YES” to save the new settings.
2. Program individual Physical Outputs to the voltage Status Points “59-1P” and “59-3P” using the Advanced Programmable Logic feature in WinECP.

3. Verify the 59 condition by applying the following voltages and currents to the relay as shown in Figure 10-2.
   - Vab = 120 volts < 0 degrees
   - Vbc = 120 volts < 120 degrees
   - Vca = 120 volts < 240 degrees

   - Ia = 0.0 amps
   - Ib = 0.0 amps
   - Ic = 0.0 amps

4. Raise any one phase to 130 volts, and the 59-1 device will trip and the VOLTAGE LED will light.. For a three phase overvoltage test, raise all three phases to 130 volts, and the 59-3 contact output will trip Reset all targets using the OCI TARGET RESET push-button. Lower the voltage slightly, and it should not produce a trip. Reset all targets using the OCI TARGET RESET push-button.

Ground Overvoltage Testing

1. To enable the 59G function through the menu:

   a. Press the <Menu> key.
   b. Locate “Main Menu” and press its key.
   c. Press the “Change Settings Menu” key.
   d. Press the key for “Primary Settings”.
   e. Enter the password (four spaces for default), and press <Enter>.
   f. Press <PgDn> to 59G Select and press it’s key.
   g. Press the key until 59G Enable appears and press <Enter>.
   h. Program the following settings using the appropriate Function keys.
      · 59G Select: Enable
      · 59G Pickup: 10 volts
      · 59G Time Delay: 0.00 seconds

   i. After changing the values for 59G, press <PgUp> until <Esc> appears and then press <Esc>.
   j. Use the Function key to select “YES” to save the new settings.

2. Program a Physical Output to the voltage Status Point “59G” to detect an operation using the Advanced Programmable Logic feature in WinECP.

3. Verify the 59G condition by applying the following voltage and currents to the relay as shown in Figure 10-2.
   - Van = 10.0 volts
   - Vbc = 0.0 volts
   - Vca = 0.0 volts

   - Ia = 0.0 amps
   - Ib = 0.0 amps
   - Ic = 0.0 amps

4. Raise the phase to 10 volts, and the 59G device will trip and the VOLTAGE LED will light. Lower the voltage slightly, and it should not produce a trip. Reset all targets by pressing the OCI TARGET RESET push-button.

Reclosing Sequence Test

Follow these steps to test the reclosing sequence:

1. Change the Primary Recloser Settings.
   a. Press the <Menu> key.
   b. Locate "Main Menu" and press its key.
   c. Press the "Change Settings Menu" key.
   d. Locate "Primary Settings" and press its key.
   e. Enter the password (four spaces for default) and press <Enter>.
   f. Scroll down to each of the following and change the value as necessary by using the Function Keys. Verify or change the following PRIMARY settings for this test:

50P-1 (3I>>1) Curve	=	Standard
50P-1 (3I>>1) PickupX	=	1.0
2-Phase 50P (3I>>)	=	Disable
79 (O->I) Reset Time	=	10 seconds
79-1 (O->I1) Select	=	50P-1 (3I>>1), 51N (IN>), 50N-1 (IN>>1) enabled
79-1 (O->I1) Open Time	=	0.3 seconds
79-2 (O->I2) Select	=	50P-1 (3I>>1), 51N (IN>), 50N-1 (IN>>1)enabled
79-2 (O->I2) Open Time	=	10 seconds
79-3 (O->I3) Select	=	50P-1 (3I>>1), 51N (IN>), 50N-1 (IN>>1) enabled
79-3 (O->I3) Open Time	=	15 seconds
79-4 (O->I4) Select	=	50P-1 (3I>>1), 51N (IN>), 50N-1 (IN>>1) enabled
79-4 (O->I4) Open Time	=	15 seconds
79-5 (O->I5) Select	=	50P-1 (3I>>1), 51N (IN>), 50N-1 (IN>>1) enabled
79-5 (O->I5) Open Time	=	LOCKOUT
Trip Fail Time	=	18 cycles

   g. Press <Enter> when the value you want is displayed.
   h. Press <PgUp> until <Esc> appears and the press the <Esc> key.
   i. Press the key to "Yes" to save settings.

2. Set the relay to Functional Test Mode. This eliminates the need for a breaker.
   a. Press the "<Menu>" key and then "Main Menu".
   b. Select <PgDn> and then "Test Menu".
   c. <PgDn> to "Func. Test Mode" and select.
   d. Enter the password (four spaces for default) and press <Enter>.
   e. Select "Yes" and press <Enter>.
   f. The REF 550 will remain in the Functional Test Mode for 15 minutes, unless reset.

3. Test the Recloser Lockout function.
   a. Connect the REF 550 as shown in Figure 10-5.
   b. Apply a fault current of 12 A to the relay. Once the relay has tripped, it remains open according to the settings in Step 1f; then the relay should reclose. Be sure the current is removed and the breaker simulator changes state within the "Trip Fail Time" setting in the Configuration settings.
   c. Before the reset time of the relay has expired, apply a subsequent fault current. The relay will trip and reclose.
   d. Continue to apply the fault until Recloser Lockout occurs. This should be on the fourth trip.

NOTE: The OCI LCD screen displays the countdown for both the Open Time and the Reset Time eliminating the need for special timing equipment and connections. Use the Operation Records to verify the accuracy of each Reclose time.

Frequency Tests

1. To enable the 81 function through the menus:
   a. Press the <Menu> key.
   b. Scroll to “Main Menu” and press it’s key.
   c. Press the key for “Change Settings Menu”.
   d. Scroll to “Primary Settings” and press it’s key.
   e. Enter the password (four spaces for default) and press <Enter>.
   f. Press <PgDn> to 81 Select and press it’s key.
   g. Press the key until “81S Enable” appears and press <Enter>.
   h. Press <Esc>.
   i. Press the key for “Change Settings Menu”.
      - 81 Select: 81-1
      - 81S-1 Pickup: 60.02 Hz
      - 81S-1 Time Delay: 0.10 seconds
      - 81V Block: 40 volts
   j. After changing the values for 81, press <PgUp> until <Esc> appears and then press the <Esc> key.
   k. Use the key to select “Yes” to save the new settings.
2. Program a Physical Output to the frequency Status Point “81S-1” to verify operation.
3. Verify the underfrequency condition by applying the following voltage to the relay at 60 Hertz.
   - Van = 120.0 0°
4. The relay should trip for an underfrequency condition and light the FREQUENCY LED on the front panel of the REF 550.
5. Reset the frequency target by pressing the TARGET RESET push-button on the OCI.
6. Change the Frequency settings as follows:
   - 81 Select: 81-1
   - 81S-1 Pickup: 59.95 Hz
   - 81S-1 Time Delay: 0.10 seconds
7. Apply the same voltage as in Step 4. The relay should not trip for an underfrequency condition.

NOTE: For Delta or Open Delta VT connections, use VAB as the test voltage at the same test quantities. When the underfrequency function is enabled, it will operate its Status Point if no VA or VAB voltage is present.

HIF Detect™ Test

1. To enable the HIF Detect™ feature through the menus:
   a. Press the <Menu> key.
   b. Press the “Main Menu” key.
   c. Locate “Change Primary Settings Menu” and press its key.
   d. Press the “Primary Settings” key.
   e. Enter the Relay password (four spaces for default) and press <Enter>.
   f. Press <PgDn> to HIF Detect™ Select and press its key.
   g. Press the key until “Enable” appears and press <Enter>.
   h. Press <Esc>.
   i. Program the following Settings
      - HIF Detect™ Select: Enable
      - HIF Detect™ Level: 5
   j. After changing the values, press <PgUp> until <Esc> appears and then press <Esc>.
   k. Use the key to select “YES” to save the new settings.

2. Program a Physical Output to the seal-in Status Point “HIFs” to verify detection.

3. Verify the HIF Detect™ feature by applying the following voltage and current quantities at the sixth harmonic (360 Hz for a 60 Hz system and 300 Hz for a 50 Hz system).

   - Van = 120.0 < 0
   - Vbn = 120.0 < 240
   - Vcn = 120.0 < 120

   - Ia = 2 < 0

4. The relay should trip for a HIF Detect™ condition and light the HIF Detect™ LED.

5. Reset the LED by pressing the OCI TARGET RESET push-button for resetting Seal-in Alarms.

Loss of Control Power and Self-Check Alarm Contact Test

Follow these steps to test the loss of control power and the self-check alarm contact:

1. With control power applied to the REF 550, check the self-check alarm contact and the STATUS LED. Normal status is indicated by a green LED.
2. Interrupt the control power to the REF 550. The self-check contact should return to it’s normal state.
3. Reapply control power and check the REF 550 to see that all settings were properly retained.

NOTE: The REF 550 self-check alarm contact is a Normally Closed contact that is held open when powered up and the relay is healthy. If there is a requirement that the self-check alarm be Normally Open, then reconfigure its Jumper Plug on the main board - see Section 9.

New Firmware Installation

Introduction

These instructions give guidance for the installation of the REF 550 flash firmware. Specific instructions included with any update kit would supersede the instructions given here.

Precautions

To avoid personal shock, use caution when working with energized devices. Only competent technicians familiar with good safety practices should service the relay.

Before you proceed with the update process, you must identify the construction of your unit in order to select the correct floppy disks from the update kit. Details are given in Step 2 of the procedure.

These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in the installation. If particular problems arise which are not covered sufficiently please contact our Technical Support Group at 800-634-6005, or 610-395-7333, or Fax 610-395-1055.

Should the downloading process be interrupted before completion, a special recovery procedure may be possible. Refer to the procedure “Recovery from Download Failure” given below.

Modification Kit

A Modification Kit exists that contains the latest version of the REF 550 User Interface Tool WinECP, Flash Programming Tool WinFPI (part of the WinECP installation) and the new CPU flash firmware. Contact the Customer Support department at (800) 634-6005 or 1 610 395-7333 to obtain a kit.

Modification Procedure

1. Establish communications via a computer connected to the front port using your WinECP communications program.
2. Record the serial number, catalog number, and existing versions of firmware Installed in the relay by viewing the Unit Information available in the Help main menu item.
3. Select Settings from the main menu and Upload and Save to File all settings. The data will be lost after the flash programming process completes.
4. Select History from the main menu and Upload and Save to File all the History data. These data will be lost after the flash programming process.
5. In order to update the flash memory of the unit, use the front communication port and the pc set to 9600, 8, N, 1. Review, and change your set-up if necessary.
6. Start the WinFPI program from WinECP main menu item File or the Start/Programs/ABB Application button.
7. Browse the directory that contains the flash firmware file. NOTE: WinFPI only uses compressed binary image (*.CBI) files. A CBI file will be provided upon request.
8. When the appropriate CBI file has been located and selected, press the DOWNLOAD button and wait for the software to indicate the flash download has completed. If a download error occurs, contact the Customer Support department at (800) 634-6005 or 1 610 395-7333.
9. When complete, the REF 550 will reset itself. Cycle Control Power once to remove any “Self Test Failure” messages displayed on the default LCD screen.
10. Re-establish communications with WinECP and download all saved settings and verify prior to placing the relay back into service.

Recovery from Download Failure in Surface Mount Units

Should the downloading process fail you will see an error message , contact the ABB Customer Support department at (800) 634-6005 or 1 610 395-7333. Support is available 24 hours a day, seven days a week.

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Specifications & Tolerances

The REF 550 design incorporates multiple 32-bit and 16-bit microprocessors in a multi-tasking environment. This multi-processor design allows for dedicated, unburdened attention to protection and control and independent focus on high-speed communications. The REF 550 meets or exceeds the ANSI and IEC standards required for application in a utility substation environment.

In addition to the typical ANSI and IEC standards, the REF 550 has passed extensive Multi-Environmental Over Stress Tests or MEOST procedure ensuring high design durability and reliability. This guarantees the 12 Year Warranty the REF 550 includes.

Battery Backed-Up Clock

An internal clock time tags the faults in the Fault Record, events in the Operations Record and values in the Load Profile record. In normal operation, this clock is powered by the REF 550. When the REF 550 is withdrawn from its case, a battery powers the clock. As long as you turn off the battery backed-up clock during prolonged storage, the battery should last the life of the unit. Turn off the battery backed-up clock through the front man-machine interface by entering a “0” for the day. Default state of the clock is off.

Ratings and Tolerances

The following are the ratings and tolerances of the REF 550.

Current Input Circuits

- 5A input rating, 16 A continuous and 450 A for 1 second
- 1A input rating, 3 A continuous and 100 A for 1 second
- Input burden at 0.245 VA at 5 A (1 - 12A range)
- Input burden at 0.014 VA at 1 A (0.2 - 2.4A range)
- Frequency 50 or 60 Hz

Voltage Input Circuit

Voltage ratings based on the VT connection setting.

Burden

- 0.04VA for V(A-N) at 120 Vac

Voltage

- **Wye** Connection: 160V continuous and 480V for 10 seconds
- **Delta** Connection: 260V continuous and 480V for 10 seconds

Contact Input Circuits

- 0.52 VA at 125 Vdc and 110 Vdc
- 0.08 VA at 48 Vdc
- Voltage range 38 to 150 Vdc for 48/110/125 Vdc

Control Power Requirements

- 48/110/125 Vdc models, range = 38 to 150 Vdc

Control Power Burden

- 48 Vdc = 0.35A max @ 38 V
- 110/125 Vdc = 0.25A max @ 70 V

Output Contact Ratings

125 Vdc	**220 Vdc**
• 30 A tripping	• 30 A tripping
• 6 A continuous	• 6 A continuous
• 0.25 A break inductive	• 0.1 A break inductive

Operating Temperature

- –40° to + 85° C

Humidity

- Per ANSI 37.90, up to 95% without condensation

Electrical Transient Tests

SURGE WITHSATAND CAPABILITY (SWC)
- Oscillatory SWC
  - ANSI C37.90.1 – 1989 (Section 2.2)
  - IEC 255-22-1 (First Edition, 1988)
- Fast Transient SWC
  - ANSI C37.90.1 – 1989 (Section 2.3)
  - IEC 255-22-4 (First Edition, 1992-03)
- Surge Immunity
  - IEC 1000-4-5 (First Edition, 1995-02)

RADIO FREQUENCY INTERFERENCE (RFI)
- ANSI C37.90.2 – 1995
- IEC 1000-4-3 (First Edition, 1995-02)

Electrostatic Discharge (ESD)
- IEC 255-22-2 (First Edition, 1989-10)

Mechanical Tests

INSERTION/WITHDRAWL OF UNIT

PLUG-IN DURABILITY
- IEC 255-6 (1998)

Dielectric Insulation Rating

STEADY-STATE DIELECTRIC
- ANSI C37.90 – 1989
- IEC 255-5 (First Edition, 1977)

IMPULSE DIELECTRIC
- IEC 255-5 (First Edition, 1977)

Environmental

BUMP
- IEC 255-21-2 (First Edition, 1988)

SEISMIC
- ANSI C37.98

SHOCK
- IEC 255-21-2 (First Edition, 1988)

TEMPERATURE
- –40° to + 85° C operating

DUST PENETRATION
- IEC 529 (Second Edition, 1989-11)

WATER PENETRATION
- IEC 529 (Second Edition, 1989-11)

Functional

CONTROL POWER VARIATION
- ANSI C37.90 (Section 6.4.2)
- IEC 255-6 (Clause 3)

*Tolerances**

Function	Pickup	Dropout	Timing (whichever is greater)
51P/51N	±3% of setting	98% of setting	± 7% or +/-- 16 milliseconds
50P/50N	±7% of setting	98% of setting	± 7% or +/-- 16 milliseconds
46/67P	±3% of 51P setting	98% of setting	± 7% or +/-- 16 milliseconds
67N	±3% of 51N setting	98% of setting	± 7% or +/-- 16 milliseconds
27/59/81V/79V	±3% of 51P setting	98% of setting	± 7% or +/-- 16 milliseconds
59G	±3% of setting	98% of setting	± 7% or +/-- 16 milliseconds
47	±3% of setting	98% of setting	± 7% or +/-- 16 milliseconds
21	±3% of setting	98% of setting	± 7% or +/-- 16 milliseconds
81	± 0.01 Hz	± 0.01 Hz	±1 cycle
Ammeter	± 1% of 51P and 51N time overcurrent pickup setting		
Voltmeter	± 1% of VT Connection setting		
Wattmeter	± 2% of full scale		
VARmeter	± 2% of full scale		
Power Meter	± 2% of I xV, 51P pickup setting x VT Connection setting		
Frequency	± 0.01 Hz from 30-90 Hz, at 120 Vac input on Va.		

Weight

- Unboxed 5.36 kg (11.80lbs)
- Boxed 5.67 kg (12.51 lbs)

***** These accuracies apply to the temperature range of -20° C to +55° C. For temperatures outside this range but within the operating temperature range, the REF 550 will operate.

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Ordering Information

REF 550 Order Selection Sheet

		Options	Cat No. 550 Example: 550	x H	x 0	x 7	x 1	x A	- -	x 6	x 0	x 0	x 0	x 0
Configuration (See Note 1)	Standard (with Sync. Check, HIF Detect™)	Incl.		H	.	.	.	.		.	.	.	.	.
	Power Quality Monitoring	Opt.		*P*	.	.	.	.		.	.	.	.	.
Current Range	**Phase** / **Ground** / **SEF**													
	0.4 – 12 A / 0.4 – 12 A / 0.005 – 0.4A	Incl.			0	.	.	.		.	.	.	.	.
	0.08 – 2.4 A / 0.08 – 2.4 A / 0.005 – 0.4A	Incl.			2	.	.	.		.	.	.	.	.
Control Voltage	*220/250 VDC*	Opt.				*5*	.	.		.	.	.	.	.
	48 VDC	Incl.				3	.	.		.	.	.	.	.
	48/125 VDC	Incl.				7	.	.		.	.	.	.	.
	125 VDC	Incl.				4	.	.		.	.	.	.	.
	24/32 VDC	Opt.				*9*	.	.		.	.		.	.
Operator Control Interface (OCI)	Enhanced OCI, horizontal mounting without Hot Line Tag (HLT)	Incl.					0	.		.	.	.	.	.
	Enhanced OCI, horizontal mounting with Hot Line Tag (HLT)	Opt.					1	.		.	.	.	.	.
Automation Port s	(All units offer front RS-232 port. All ports use standard ABB ten-byte and specific protocol specified.)							.		.	.	.	.	.
	One RS-485 Port & One RS-232 Port with DNP3.0 Level 2+ protocol	Incl.						A		.	.	.	.	.
	One RS-485 Port & One RS-232 Port with Modbus protocol	Incl.						B		.	.	.	.	.
	Dual RS-485 Ports with DNP3.0 Level 2+ protocol	Incl.						C		.	.	.	.	.
	Dual RS-485 Ports with Modbus protocol	Incl.						D		.	.	.	.	.
	Ethernet 10/100 baseT and 10 FL with Modbus/TCP	Opt.						E		.	.	.	.	.
	One Modbus Plus Port & One RS-232 Port with Modbus Plus protocol	Opt.						G						
	One Modbus Plus Port & One RS-485 Port with Modbus protocol	Opt.						H						
Frequency	50 Hertz	Incl.								5	.	.	.	.
	60 Hertz	Incl.								6	.	.	.	.
Options (See Note 2)	Reserved	Incl.									0	.	.	.
	Reserved	Incl.										0	.	.
	Reserved	Incl.											0	.
	Reserved	Incl.												0
Notes	(1) Italicized text indicates availability in future releases. (2) Digital Fault Recorder, Load Profile and User Programmable Curves are included standard.													
Accessories	A panel mounting kit consisting of a bezel and a clear plastic cover is available. For horizontal units order 604513-K1.													

Date Issued: 01/18/05

Spare Parts

Parts and Assemblies

The following table lists the parts and assemblies involved in the REF 550

Table 12-1. REF 550 Parts and Assemblies Table

Part and Assembly Description	Part Number
48/125-Vdc Power Supply Assembly	614040-T2
Isolated RS-232/RS-485 DNP3.0 Level 2+ Comm. card Type A	AUX8XAX
Isolated RS-232/RS-485 Modbus comm. card Type B	AUX8XBX
Isolated Dual RS-485 DNP3.0 Level 2+ comm. card Type C	AUX8XCX
Isolated Dual RS-485 Modbus comm. card Type D	AUX8XDX
Ethernet 10/100 baseT and 10 FL with Modbus/TCP	AUX8EX
Isoated Modbus Plus and RS-232(non-isolated) Modbus comm. card Type G	AUX8GX
Isolated Modbus Plus and RS-485 Modbus comm. card Type H	AUX8HX
Horizontal Panel Mount Kit	604513-K1
Bezel/gasket assembly only	604513-K3
Horizontal lens cover only	613724-K1

Replacing Power Supplies

To replace an existing power supply with a power supply of the same voltage, simply remove the REF 550 relay from its case. The power supply board is located on the underside of the relay. Remove the four (4) mounting screws located near the corners of the printed circuit board (PCB) and gently separate the assembly from the main PCB connector. Install new power supply PCB attaching it at the main board connector and then reinstall the four screws. Insert inner chassis into REF 550 case and secure by tightening front panel thumb screws.

Panel Mounting Kit

The complete kit will include a bezel, its associated hardware and gasket, as well as a lens cover with its associated hardware. This kit will provide a means for panel mounting and dustproofing.

Ordering Information:

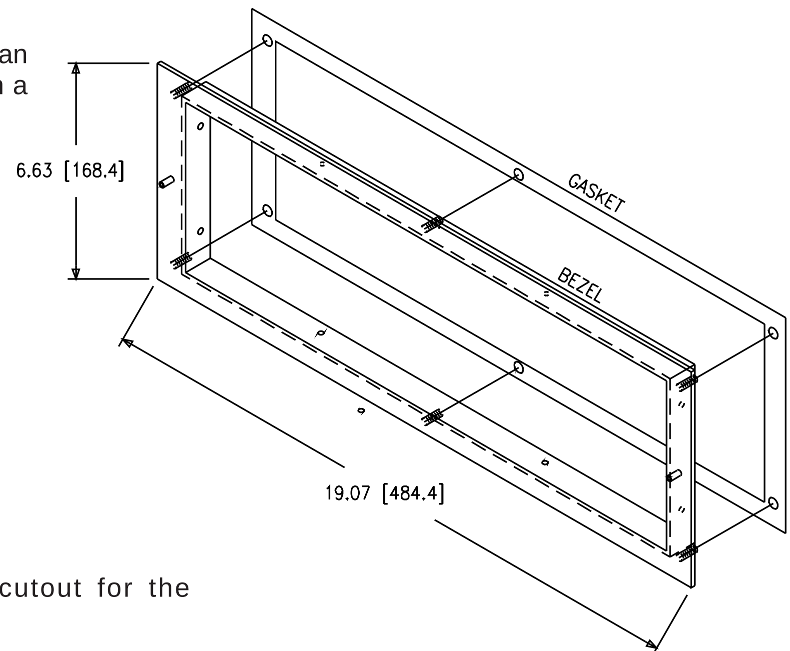
Horizontal Panel Mounting Kit	604513-K1

Spare Parts List:

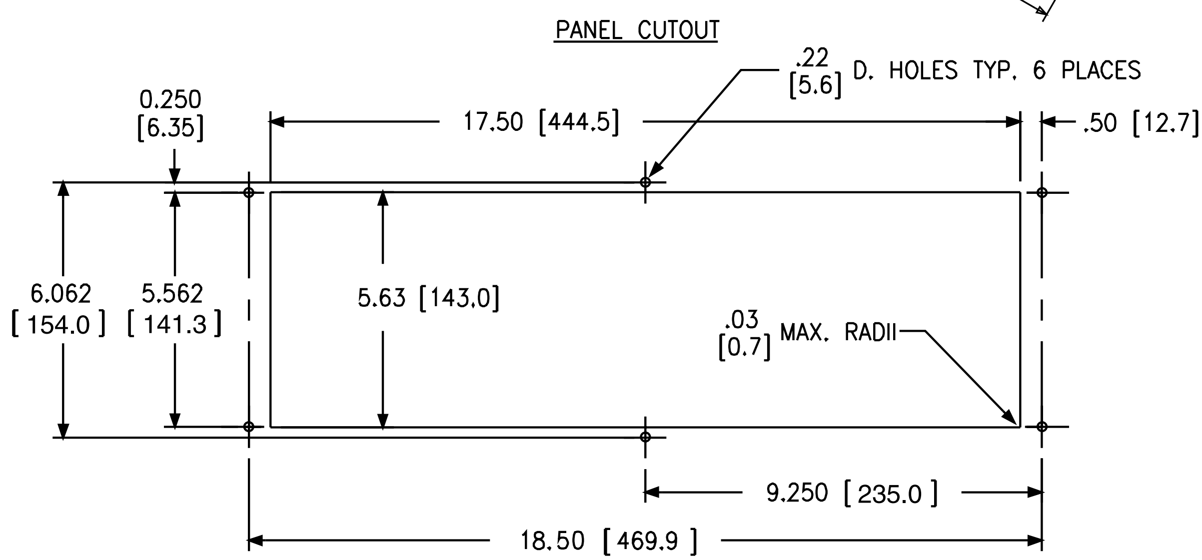
Bezel/gasket assembly only	604513-K3
Horizontal lens cover assembly	613724-K1

Horizontal Mounting

Note: The Bezel Assembly is available as an option for mounting the REF 550 units in a panel application.



Note: Below is the panel drilling cutout for the REF 550 unit and the bezel assembly.



NOTE: DIMENSIONS ARE INCHES [MILLIMETERS]

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