Operations Manual

COOPER Power Systems

Electrical Apparatus

IM30AE Non-Directional Overcurrent Relay

S150-10-1

This Operations Manual is designed to familiarize the reader with how to install, program, and set up the **IM30AE relay with Rev 2.00 Firmware** for operation. If using a relay with firmware revisions lower than this, please use the July 1999 issue of this manual. For programming the relay via computer software, consult the appropriate manual. Contact your local Cooper Power Systems representative for ordering information.

CONTENTS

Introduction

The IM30AE relay provides all of the basic functions necessary for the protection of a feeder by providing three phase and ground overcurrent elements. True RMS values of the currents through the 5th harmonic are used, while the ground current and voltage inputs include 3rd harmonic filtering. Two digital inputs are provided to provide selective blocking of various functions. Five output relays are provided, of which four are programmable. All settings, measurements, and programming of the relay is possible through its front panel controls, or by means of a computer connected to the relay's RS485 communications port. The functions provided by the IM30AE are:

- Non-directional time and instantaneous phase overcurrent (50/51).
- Time and instantaneous ground overcurrent (50N/51N).
- Breaker Fail (62 BF).
- Fast Bus Trip (zone inter-locking)
- The IM30AE offers two programmable inputs which can serve to block the operation of the phase or ground overcurrent elements.

It is possible to disable any of the overcurrent elements. Separate pickup functions are also provided which may be used to operate output relays.

HANDLING

As with any piece of electronic equipment, care should be taken when handling the relay, particularly in regards to electrostatic discharge as the damage may not be immediately obvious. All Edison relays are immune to electrostatic discharge when left in their protective case. However, when the relay is removed from its case, the following practices should be observed.

- Touch the case to ensure that your body and the relay are at the same potential.
- Whenever possible, handle the exposed relay by the front panel, the rear connector, or by the edges of the printed circuit boards. Avoid touching the individual electronic components or the embedded traces on the circuit boards.
- If the exposed (i.e., drawn-out) relay must be handed to another person, make sure both persons are at the same electrical potential.
- When setting the drawn-out relay down, make sure the surface is either anti-static or is at the same electrical potential as your body.
- Relays should always be placed in storage in their protective case. If storage of the drawn-out relay outside of its protective case is required, then the exposed relay should be placed in a suitable anti - static plastic or foam container.

INSTALLATION

Edison relays are shipped either in single or double width cabinets, or in standard 19” 3U rack mount enclosures capable of housing up to four Edison relays. Outline dimensions for the single relay housing is shown in Figure 1. For dimensions of other cabinets, see Catalog Section 150-05.

The double case mounting is similar to the single case, but requires a 226mm L x 142mm H panel opening. The 19” rack mount case is a standard 3U high 19” wide cabinet.

To remove the relay from its case, refer to Figure 2. The relay may be removed from its protective case by turning with a flat bladed screwdriver the locking screws ① and ② on the front panel latches ③ so that the slot on the screw is parallel to the ground. The latches may then be pulled from the inside edge to release the relay. Carefully pull on the latches to remove the relay from the housing.

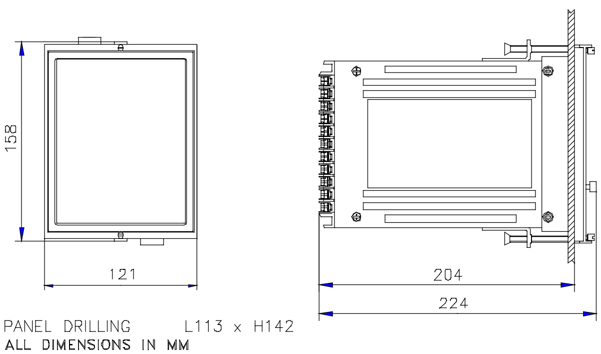

FIGURE 1: SINGLE MODULE ENCLOSURE MOUNTING

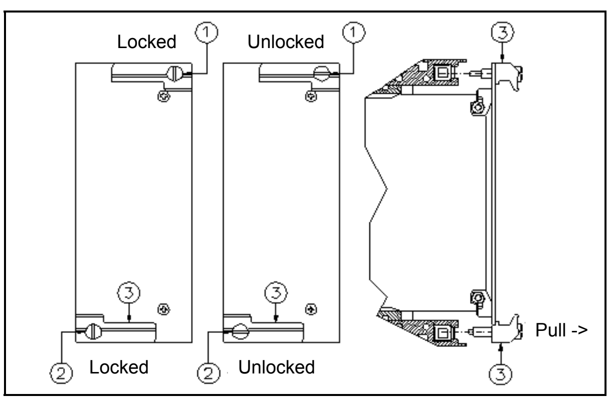

FIGURE 2: LATCH MECHANISM FOR REMOVAL OF RELAY FROM CASE

To re-install the relay in its case, align the printed circuit boards with the guides in the relay case and slide the relay in most of the way. For single and double cases, make sure the locking arm on the back of each of the latches ③ lines up with the locking pins in the case. Then push the latches in, seating the relay. Turn the screws on the latches until the slot is perpendicular to the ground.

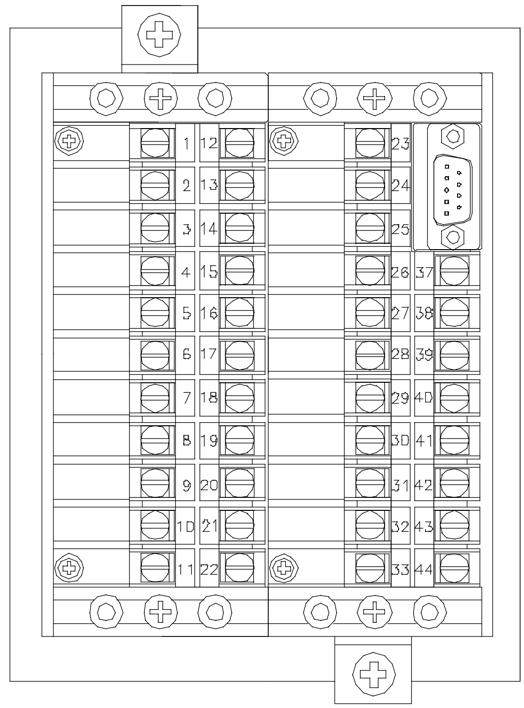

FIGURE 3: VIEW OF REAR TERMINAL CONNECTIONS

ELECTRICAL CONNECTIONS

Power is supplied via terminals 12 and 13, with chassis ground at terminal 44. A case ground is provided by a stud on the side of the relay cabinet. All Edison relays are available with one of two auto-ranging power supplies. Descriptions of the input voltage ranges are given in Table 1. The input supply voltage is noted on the relay case. In the event the relay is fitted with the incorrect power supply, the power supply boards are easily field replaceable. See Bulletin S150-99-1 for instructions and part numbers.

Power Supply	DC Voltage Range	AC Voltage Range
L	24V (-20%) to 125V (+20%)	24V (-20%) to 110V (+15%) 50/60 Hz
H	90V (-20%) to 250V (+20%)	80V (-20%) to 220V (+15%) 50/60 Hz

TABLE 1: POWER SUPPLY INPUT RANGES

All electrical connections, including the RS485 connections, are made on the back of the relay. See Figure 3. All the terminals will accept up to a No. 6 stud size spade connector (or any type of lug up to 0.25” (6.3mm) wide) or 12 AWG wire (4 mm²). Electrical connections must be made in accordance with the relay’s wiring diagram found in Figure 4.

In Figure 4, the numbers next to the circles along the functional diagram of the relay indicate the terminal number on the back of the relay as shown in Figure 3.

Note that three different input configurations are allowed. The two connections shown furthest from the relay (the left connection) utilize window CTs as the source of zero sequence current for the relay. This will provide the most accurate zero sequence input. If this connection is not practical, the connection shown on the right will provide the zero sequence current. The connection furthest to the left will synthesize the missing B phase component from the supplied inputs.

The relay is shipped with the CT inputs set for either 1A or 5A nominal inputs. The 11th character of the relay's part number will either be "1" or "5" indicating the factory set input range. If the input range needs to be changed, for any of the CT inputs, this may be accomplished via jumpers on the relay's main circuit board. Contact Cooper Power Systems for reference material on how to locate and change the jumpers.

Output Relays

Output relays 1 through 4 are user programmable to operate in conjunction with the tripping of any protective element or elements. Relay 1 consists of two isolated SPST terminals which may be selected as being either normally open or normally closed. The other three output relays, 2-4, all have form C (i.e., SPDT) contact arrangements.

Output relay 5 is normally energized (shown de-energized) and operates only upon power supply failure or on an internal relay fault.

Blocking Inputs

The IM30AE has two inputs which perform blocking functions. The open circuit voltage across the terminals of these inputs is 15 VDC. The internal resistance is 2.2kΩ. When the external resistance across these terminals is less than 2.0kΩ, they are considered to be shorted. See Programming the Relay for more information on the function of these inputs.

Clock and Calendar

The unit features a built in clock calendar with Years, Months, Days, Hours, Minutes, Seconds, Tenths of seconds and Hundredths of seconds.

Clock synchronization.

The clock can be synchronised via the serial communication interface.

By programming the variable (T_{syn} = 5', 10', 15', 30', 60', IRGI-B, Dis) Synchronisation can be achieved in several different manners:

T_{syn} = Dis: current date can only be modified manually via the front panel keyboard (SETTING MENU). The relay ignores the serial broadcast signal.

T_{syn} = 5', 10', 15', 30', 60': The date is updated via the serial interface as follows :

The unit expects to receive a sync signal at the beginning of every hour and once every T_{syn} minutes. When a sync signal is received, the clock is automatically set to the nearest expected synchronisation time.

For example: if T_{syn} is 10min and a sync signal is received at 20:03:10 January the 10th, 98, then the clock is set to 20:00:00 January the 10th, 1998. On the other hand, if the same sync signal were received at 20:06:34, the clock would be set to 20:10:00, January the 10th 98.

Note that if a sync signal is received exactly in the middle of a T_{syn} period, the clock is set to the previous expected synchronisation time.

Date and time setting

When the PROG/SETTINGS menu is entered, the current date is displayed with one of the groups of digits (YY, MMM or DD) blinking.

The DOWN key operates as a cursor. It moves through the groups of digits in the sequence

YY => MMM => DD => YY => …

The UP key allows the user to modify the currently blinking group of digits.

If the ENTER button is pressed the currently displayed date is captured.

Pressing the SELECT button leaves the current date unchanged and scrolls the SETTINGS menu. Current time can now be modified using the same procedure described above.

If synchronization is enabled and the date (or time) is modified, the clock is stopped until a sync signal is received (via digital input or the serial port). This allows the user to manually set many units and have them start their clocks in a synchronized fashion.

If synchronization is disabled the clock continues to run.

Note that the setting of a new time always clears 10ths and 100ths of sec.

Time resolution

The clock has a 10ms resolution. This means that any event can be time-stamped with a 10ms resolution, although the information concerning 10ths and 100ths of sec. can be accessed only via the serial communication interface.

Operation during power off

The relay has an on-board Real Time Clock which maintains time information for at least one hour in case of a power supply failure.

Time tolerance

During power on, time tolerance depends on the on-board crystal (±50 ppm typical, ±100 ppm maximum

over the full temperature range)
During power off, time tolerance depends on the real time clock's oscillator (+65 –270 ppm maximum over the full temperature range)

TARGET DESCRIPTION

The front panel of the IM30AE contains eight LEDs which act as the targets for the relay elements. See Figure 5 for identification of the targets. The top row of four targets correspond to the phase and ground overcurrent elements. As soon as the measured current level exceeds the trip level defined by the programming variables I>, I>>, O>, or O>>, the appropriate LED begins to flash. Once the time element associated with that element has expired (tI>, tI>>, IHH, O>, tO>>, and OHH), the relay will have tripped and the LED goes to a constant ON state.

The bottom row of four LEDs indicate the following conditions: Program mode is active, an internal relay failure has occurred, an external blocking input signal is present, a breaker fail condition has occurred.

During auxiliary power supply failure the target status is recorded to non-volatile memory. The status of the targets is maintained when auxiliary power is restored.

KEYBOARD OPERATION

All measurements, programmed settings, and recorded data may be accessed through the front panel. The five buttons are color coded and their sequence of operation is indicated on the front panel by means of arrows directing the user to the next appropriate button to press. Figures 6 and 7 give an overview of the keyboard operation.

PROGRAMMING THE RELAY

Two programming modes are available. The first is the **SETTINGS** mode, where all of the input parameters (e.g., CT ratio, rated frequency) and settings (e.g., time dials, taps) are set. The second is the **F➔Relay** mode where the various output relays are assigned to the various protective elements. To enter program mode, follow these steps:

1. Make sure the input currents are all zero. As a security feature, the relay will not go into program mode when input quantities are not equal to zero. This prevents the settings from being altered while the relay is actively protecting the system.
2. Press the **MODE** button, to get into **PROGRAM** mode.
3. Press the **SELECT** button to obtain either the **SETTINGS** or **F➔Relay** display.
4. Using a thin tool (e.g., a small screwdriver) press the recessed **PROG** button. The **PROGRAM** LED will now be flashing, indicating that **PROGRAM** mode has been successfully entered.

CHANGING A SETTING

Once in active **PROGRAM SETTINGS** mode, you may now change the relay settings. For instruction on changing the output relay assignments see the section titled Changing Output Relay Assignments. Change the settings as follows:

1. Press the **SELECT** button to scroll through the various input parameters available for

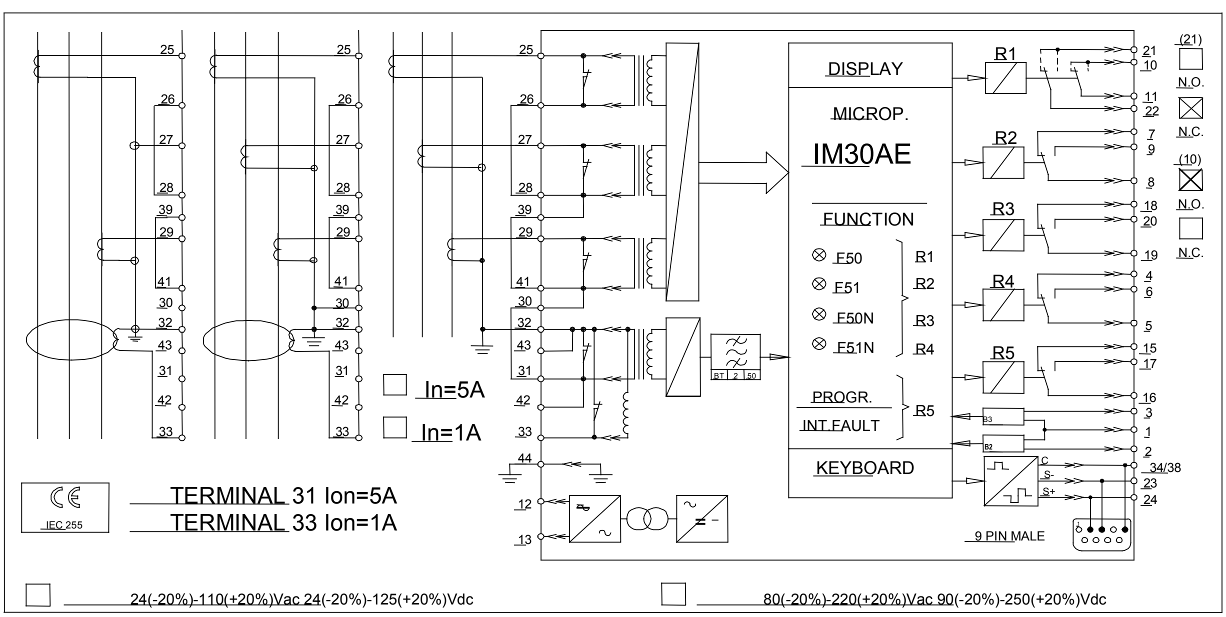

FIGURE 4 - Wiring Diagram for the IM30AE

programming.

2. When the desired parameter to be changed is displayed, press the **+** and **–** buttons to change the displayed value. For numerical values where the range of settings is large, the display may be speeded up by pressing the **SELECT** button at the same time the **+** or **–** is pressed.
3. When the desired value in displayed, press the **ENTER/RESET** button to store the new setting for that parameter.
4. Repeat steps 1-3 for each setting.

When finished, press the **MODE** button to leave programming mode and return the relay to normal operation.

Description of Relay Setting Variables

This section describes each variable in the **PROGRAM SETTINGS** mode. The following conventions are used:

- The name of the variable and any unit of measure displayed (Volts, Hz, etc.) is in bold face type. Some variables do not have a unit of measures displayed. An example of these are variables that define curve shapes.
- The default value is shown in regular typeface.

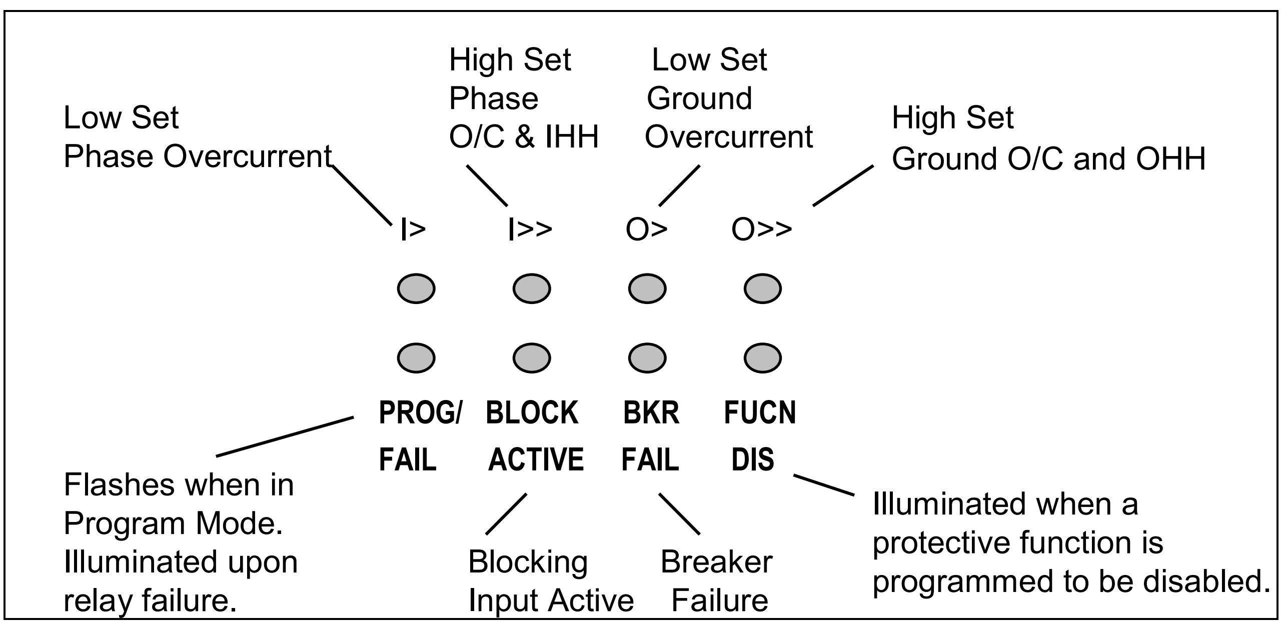

FIGURE 5: Front Panel Targets on IM30AE Relay

For example:

In 500**Ap**

In is the name of the variable.

500 is the setting default.

Ap is the unit of measure, Amps primary.

Table 2 on page 6 details all of the relay setting variables.

CHANGING OUTPUT RELAY ASSIGNMENTS

Output relays 1 through 4 may be assigned to any protective element, or any combination of elements. The only exception is that the relay cannot be assigned to both pick-up (start-time) elements, and time dependent protective elements.

1. First, enter the **F➔Relay** program mode.
2. Press the SELECT button to display the protective element for which the relays assignments are to be made or changed.
3. Press the + key to select the output relay. Each press of the + key selects the next output relay. Once selected, the relay position blinks.
4. Press the - key to toggle whether the element is assigned to the output relay or not. If assigned, the output relay number appears. If not, only a hyphen (-) will be displayed.
5. Press the ENTER/RESET button to store the changes.
6. Repeat steps 1 through 5 for each protective element whose changes you desire to change.

For example:

tI> -2-4

This is the name of protective element.

This dash means that output relay number 1 is not assigned to this element.

The number 2 means that output relay 2 will operate when this element trips.

The number 4 means that output relay 4 will operate when this element trips.

This dash means that output relay number 3 is not assigned to this element.

Display	Description	Setting Range
xxxxxx	Current date	DDMMMYY
xx:xx:xx	Current time	HH:MM:SS
Fn 50**Hz**	System frequency	50 or 60 Hz
In 500**Ap**	Rated primary current of the phase CTs	1 to 9999 in 1A steps
On 500**Ap**	Rated primary current of the CTs or the window CT used for supplying the zero sequence input current	1 to 9999 in 1A steps
F(I>) D	Operating characteristic of the low set (time overcurrent) ground fault element. Note: The US curves follow the formula given in IEEE Standard C37-118. This standard defines three curves, included here as curve names MI, VI and EI. The other curves, I and SI are based on the same formula and represent curve shapes in between the defined standard curves. IEC curves follow the standard curve definitions as given in IEC Standards 255-3 and 255-4.	D Definite time delay A IEC Inverse time (A curve) B IEC Very inverse time (B curve) C IEC Extremely inverse (C curve) MI US Moderate Inverse SI US Short Inverse VI US Very Inverse I US Inverse EI US Extremely Inverse
I> 1.0**In**	Tap (or trip level) of the low set overcurrent element in per unit of the phase CT's rated current	Dis, or 0.5 to 4.0 in 0.01 per unit steps
tI> 1.0	Time delay of the low set phase overcurrent element. See also Time Dial Method Section on page 10.	0.05 - 30.0 in 0.01 second steps
I>> 2.0**In**	Trip level of the high set element in per unit of the phase CT's rated current	Dis, or 0.5 to 40 in 0.1 per unit steps
tI>> 0.1**s**	Time delay in seconds of the high set overcurrent element.	0.05 to 3 seconds in 0.01 second steps
IHH 0.5In	Trip level of instantaneous overcurrent element (I>>>)	Dis, 0.5-40.0, in steps of 0.1 from 0.5 to 10.0, and in steps of 1 from 10-40.

Display	Description	Setting Range
F(O>) D	Operating characteristic of the low set (time overcurrent) ground fault element.	Same curve selections as for F(I>).
O> .1**On**	Tap (trip level) of the low set ground overcurrent element in per unit of the zero sequence sensing CT's rated current	Dis, or 0.02 to 0.4 per unit of On in 0.01 per unit steps
tO> 1.0	Time delay of the low set ground overcurrent element. See also Time Dial Method Section on page 10.	0.05 - 30.00 in 0.01 second steps
O>> .1**On**	Tap (trip level) of the high set ground element in per unit of the zero sequence sensing CT's rated current	Dis, or 0.02 to 1 in 0.01 per unit steps
tO>>0.1**s**	Time delay in seconds of the high set ground overcurrent element.	0.05 to 3 seconds in 0.01 second steps
OHH 0.02**On**	Trip level of instantaneous earth fault element O>>>	Dis, 0.02-4.0, in steps of 0.01 from 0.02 to 1.0, and in steps of 0.1 from 1.0-4.0.
tBF .1**s**	Time delay for Breaker Failure alarm.	0.05 to 0.75 seconds in 0.01 second steps
2I>>OFF	If the setting is selected to be ON, then the element I>> will have an adjusted value of 2I>> only during the first 60ms of energization. This will help to desensitize the I>> element for inrush currents. If during this first 60ms the initial inrush current exceeds 1.5xIn and subsequently declined to 1.25xIn; then the value of I>> will be reduced from 2I>> to I>> for the remaining time of this 60ms window.	ON - OFF
Tsyn Dis **m**	Synchronization Time, expected time interval between synchronizing pulse	Dis, 5, 10, 15, 30, or 60 minutes
NodAd 1	Identification number of relay when connected on a serial communication bus.	1 to 250 in steps of 1

TABLE 2 : PROGRAM SETTING Variables

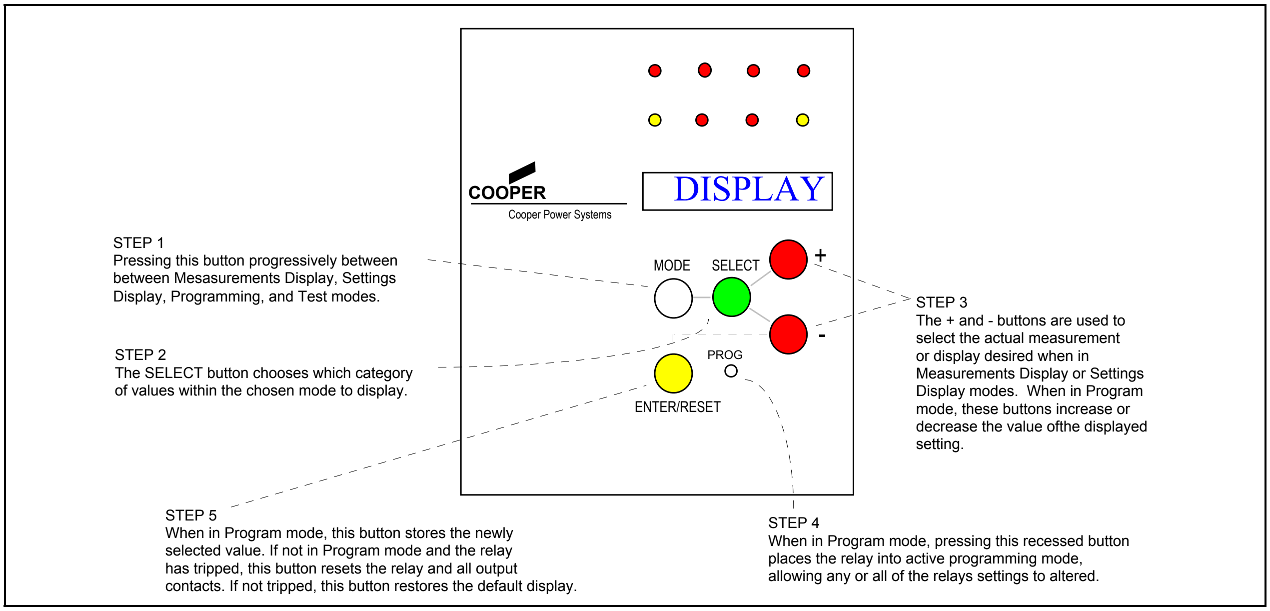

FIGURE 7: KEYBOARD OPERATION OVERVIEW

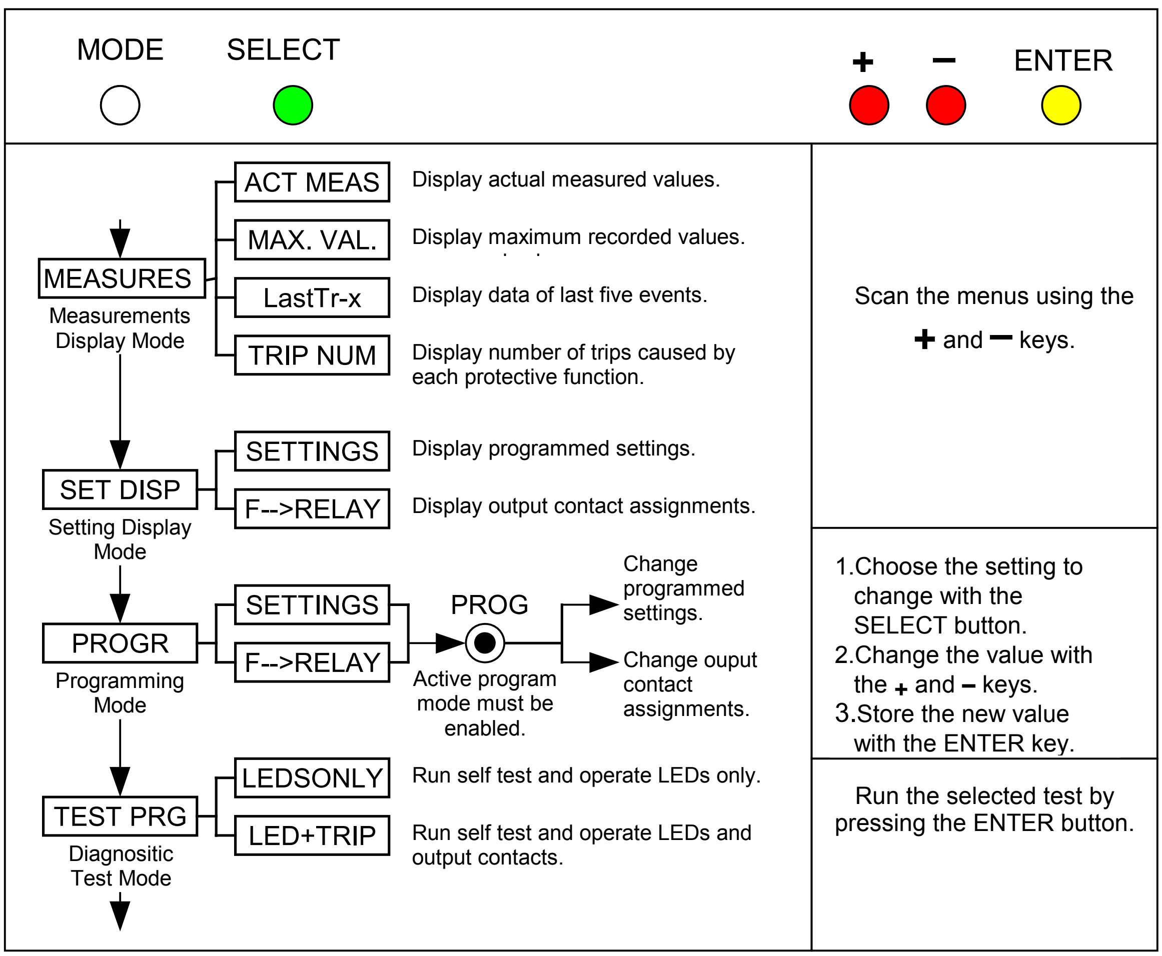

FIGURE 6 - KEYBOARD OPERATION OVERVIEW

Description of Output Relay Variables

This section describes each variable in the **PROGRAM, F➔Relay** mode. The following conventions are used:

- The name of the variable is in bold face type.
- The default settings are in regular typeface.

Display	Description
I> --3-	Pick-up (or start-time) element associated with the low set (time) phase over current element.
tI> 1---	Time delayed element associated with the low set phase overcurrent element.
I>> --3-	Start-time element associated with the high set phase over current element.
tI>> 1---	Time delayed element associated with the high set phase overcurrent element.
IHH ----	Instantaneous overcurrent element
O> ---4	Start-time element associated with the low set ground over current element.
tO> -2--	Time delayed element associated with the low set ground overcurrent element.
O>> ---4	Start-time element associated with the high set ground over current element.
tO>> -2--	Time delayed element associated with the high set ground overcurrent element.
OHH ----	Instantaneous earth fault element
tBF ----	Breaker failure alarm operates
tFRes: A	Reset mode for time delay elements. If “A” then reset takes place automatically when the current drops below the pick-up value. When set to “M”, reset is only possible via the front panel ENTER/RESET key.

TABLE 3 - Output Relay Programming Display Definitions

Programmable Blocking Variables

In addition to the output relay programming, the **PROGRAM F➔Relay** mode also provides access to four variables which determine which protective elements are affected by the various blocking inputs. Descriptions of these variables are found in Table 4.

Display	Description
B2 I>> I>	Operation of the phase element blocking input, B2. Set the display to show which phase overcurrent elements are to be blocked (if any) when this input is active. I>> corresponds to instantaneous, and I> corresponds to time overcurrent (low set).
B3O>>O>	Operation of the ground overcurrent element blocking input, B3. Set the display to show which ground overcurrent elements are to be blocked (if any) when this input is active. O>> corresponds to instantaneous, and O> corresponds to time overcurrent (low set).
tB2 2tBF	Determines if the effect of the phase overcurrent element blocking input lasts as long as the blocking input is active (tBf Dis), or if it lasts only for the set time delay of the function plus an additional time delay equal to twice the time programmed for the variable tBF in the PROGRAM SETTINGS mode. See Breaker Fail
tB3 2tBF	Same as for tBf except for the ground overcurrent blocking input B3.

TABLE 4: Programming Variables Affecting Blocking Input Behavior

Overcurrent Element Characteristics

Both the phase and ground overcurrent elements in the IM30AE consist of a traditional time overcurrent element and an instantaneous element. Figure 7 shows a typical composite relay curve. These are non-directional elements. In addition, the IM30AE provides protective elements that operate upon pick-up of any of the above elements. These are referred to as the pick-up elements.

The time overcurrent elements, being sensitive to lower current levels, are more generically referred to as low set elements.

In Curve Mode the IM30AE may be programmed to mimic one of eight predefined characteristics, including the three standard IEC curve shapes, the three standard IEEE curve shapes, and two other typical US characteristics. The curves are modeled based on the following formula per IEEE Standard C37-112:

$$t(I) = \left(\frac{A}{M^{P} - 1} + B\right) \text{K } (T_s)$$

Where: A, B, and P are constants elected to provide the desired curve characteristics.

M is the ratio (I_{input}/I_{pickup})

T_s is the time setting of the relay and corresponds to either tI> or tO> depending upon whether the phase or ground low set element is being set.

K is a constant which allows for a very simple method of determining the time delay setting for the relay. See the section titled “Easy Set Curve Placement”.

Table 5 Summarizes the values that the variables take for each characteristic.

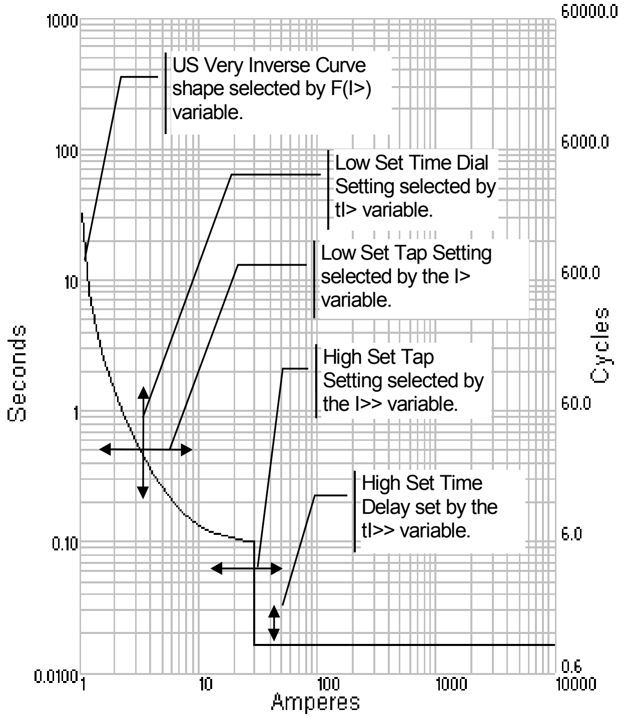

FIGURE 8: EXAMPLE OF COMPOSITE US VERY INVERSE CURVE WITH INSTANTANEOUS (HIGH SET) ELEMENT

Curve Name	Description	A	B	P	K
A	IEC Inverse	0.14	0	0.02	0.3366
B	IEC Very Inverse	13.500	0	1	0.6667
C	IEC Extremely Inverse	80.000	0	2	1.2375
MI	US Moderate Inverse	0.0104	0.0226	0.02	4.1106
SI	US Standard Inverse	0.00342	0.00262	0.02	13.3001
VI	US Very Inverse	3.88	0.0963	2	7.3805
I	US Inverse	5.95	0.18	2	4.1649
EI	US Extremely Inverse	5.67	0.0352	2	10.814
D	Define Time	t=Ts			

Table 5: Variable Values Used for Characteristic Time Overcurrent Characteristics

NOTE: Settings for the time dial (time delay) may be determined using either the time dial or Easy Set[SM] methods.

EASY SET[SM] CURVE PLACEMENT METHOD

Instead of traditional time dial settings, the IM30AE relay uses a time delay setting for moving the TCC curves vertically on the TCC graph. These time delay settings are tI> for the phase element, and tO> for the ground element. The traditional time dial setting may be calculated by multiplying the time setting by the constant K from Table 5 for the appropriate curve shape.

The EASY SET system allows multiple TCC curves to be drawn on a single TCC chart. Figures 9 and 10 show the IEEE and IEC curve families respectively. Note that all of the curves cross at the same point, pickup multiple of 10, and a time of 1x the set time delay.

Once the desired placement of the curve is determined, the time delay setting may be determined by noting the desired actual time delay in seconds at the pickup multiple of 10. That time delay is equal to the time delay setting (tI> or tO>) for the relay.

FOR EXAMPLE, the phase overcurrent element is set up to use the IEEE VI curve. The curve has been determined to be correctly located as shown in Figure 9. The TCC curve crosses the Pickup Multiple=10 line at 2.0 seconds. Therefore the tI> time delay setting (tI>0) is 2.0.

TIME DIAL METHOD

Figures 12 through 19 show a representative sample of the various curve shapes along with their Time Dial settings. The Time Dial settings are converted to the appropriate tI> or tO> settings by dividing the time dial by the value of K (see Table 5) for the appropriate curve shape.

To convert an existing time delay setting (either tI> or tO>) to a time dial value, multiply the time delay by the K factor in Table 5 for the appropriate curve.

Going back to the example shown in Figure 8, the time dial for the curve would be equal to 2.0 seconds multiplied by the constant K for the IEEE Very Inverse curve (7.381). Therefore the time dial would equal 14.8.

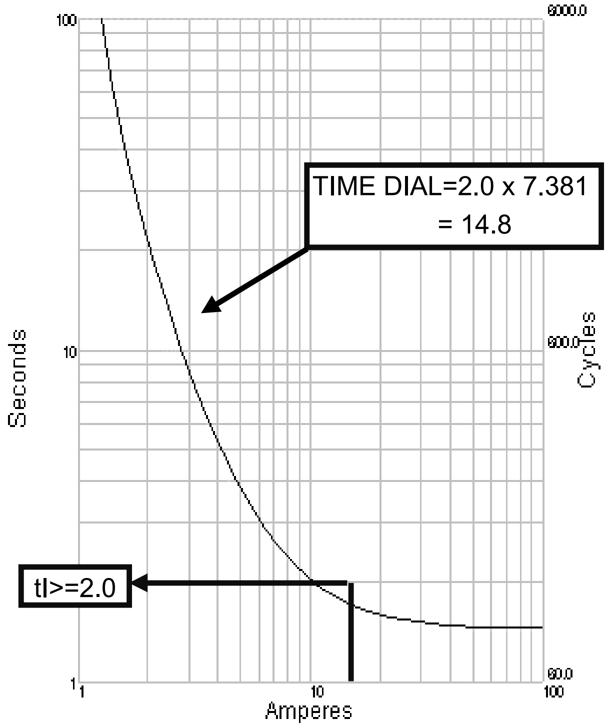

Figure 9: Example of IEEE Very Inverse Curve Time Delay Setting Determination

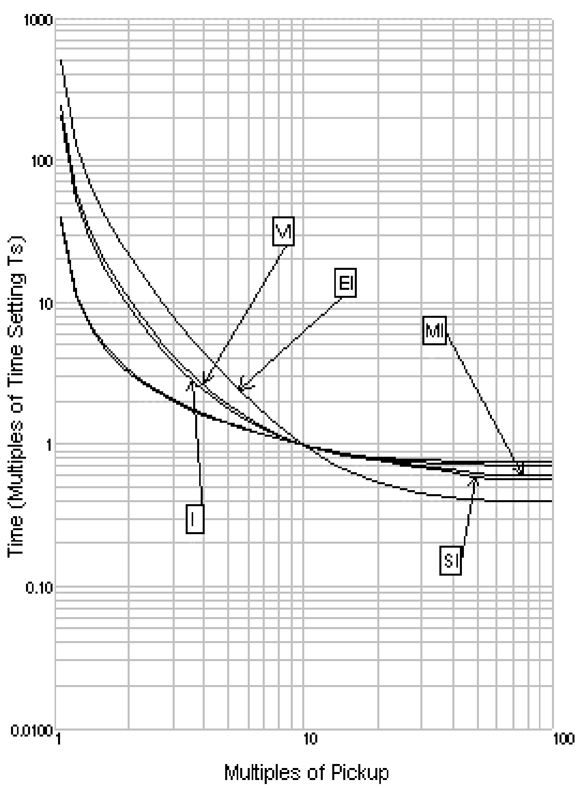

FIGURE 10: Easy Set Curve Set for IEEE TCC Curve Set

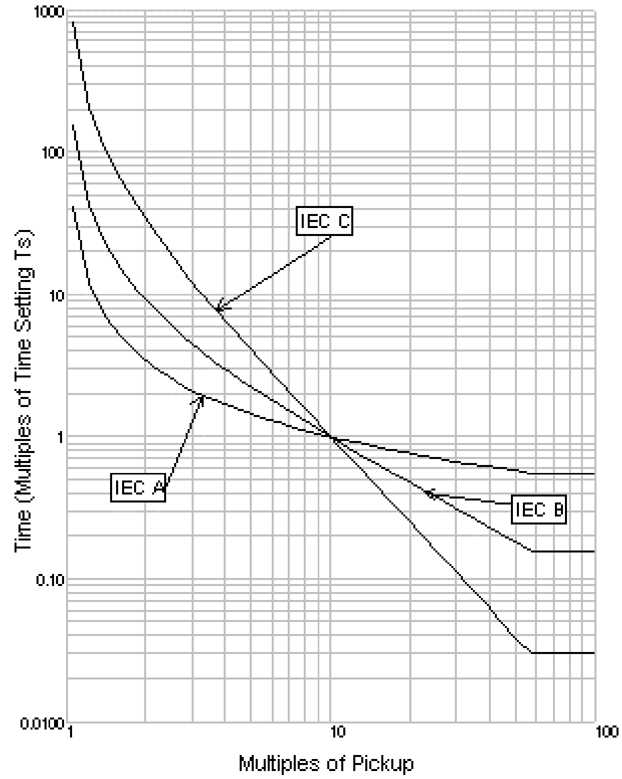

Figure 11: Easy Set Curves for IEC Curve Set

CURVE CHARACTERISTICS

The following figures show the curve shapes available and their setting ranges in terms of time dial settings. The time dial settings must be translated into time delay settings by dividing the time dial setting by the value of K shown on the figures. Note, time dial settings (and corresponding time delays) in between those indicated are possible.

Because of this characteristic, each of the IEEE curves have different absolute time dial ranges. However, the time dial range for any of the relays is much wider than typical, therefore it may be considered that all of the IEEE curves have time dial ranges from 0.7 to 123.0. Table 6 summarizes the actual time dial limits.

Note: Actual time delays will be equal to the shown time delay plus output contact closing time and any algorithm processing time. This additional time delay (pickup time) ranges from 7 to 12 msec.

Curve Name	Curve Characteristic	Minimum Time Dial	Maximum Time Dial
A	IEC A - Normal Inverse	0.017	10.099
B	IEC B - Very Inverse	0.033	20.000
C	IEC C - Extremely Inverse	0.062	37.125
MI	IEEE Moderate Inverse	0.21	123.3
SI	IEEE Standard Inverse	0.67	399.0
VI	IEEE Very Inverse	0.37	221.4
I	IEEE Inverse	0.21	124.9
EI	IEEE Extremely Inverse	0.54	324.4

Table 6: Absolute Time Dial Ranges for TCC Curve Types

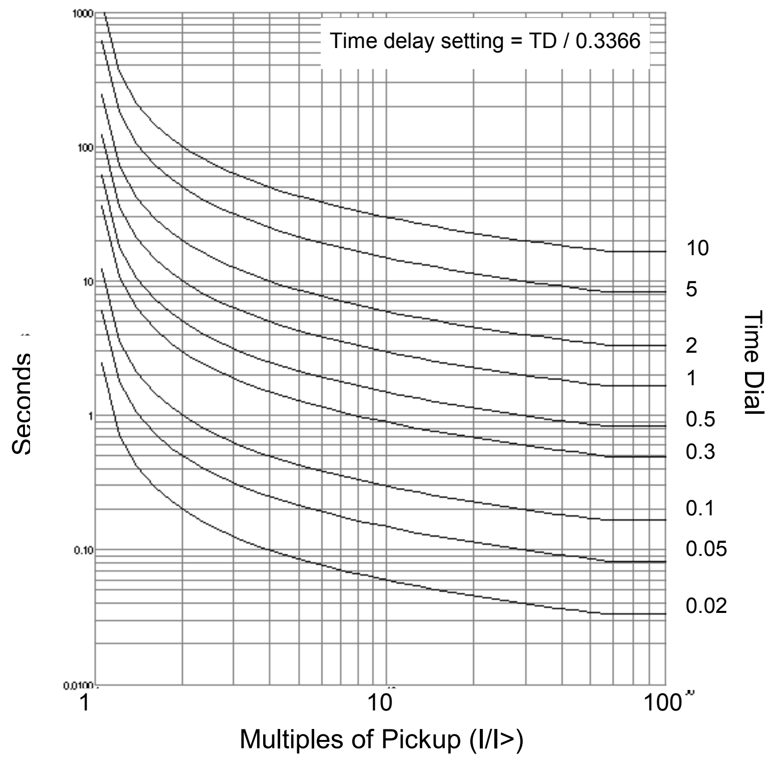

FIGURE 12 - IEC INVERSE CURVE (A)

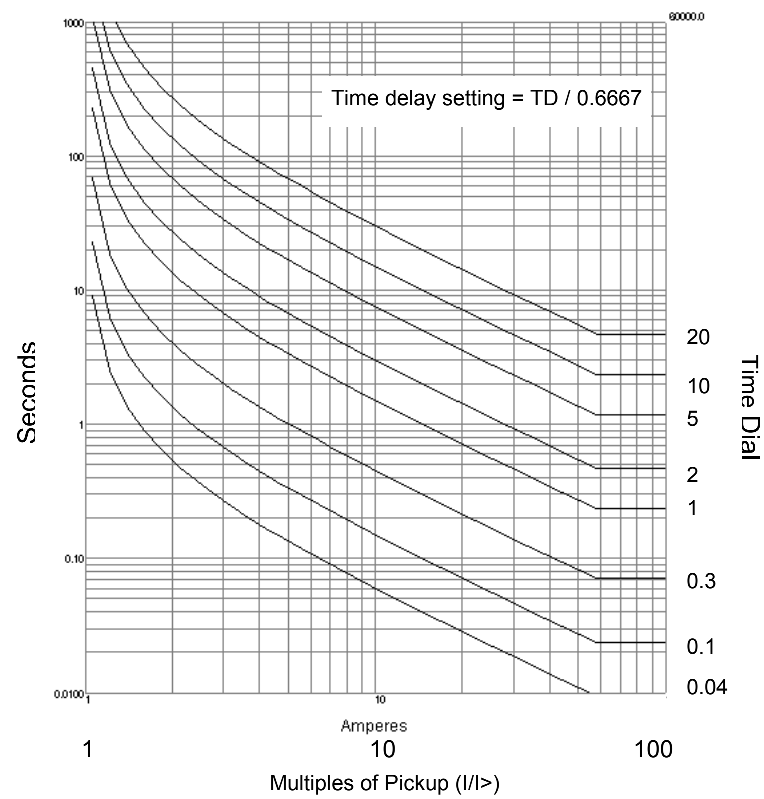

Figure 13 - IEC Very Inverse (B) Curve

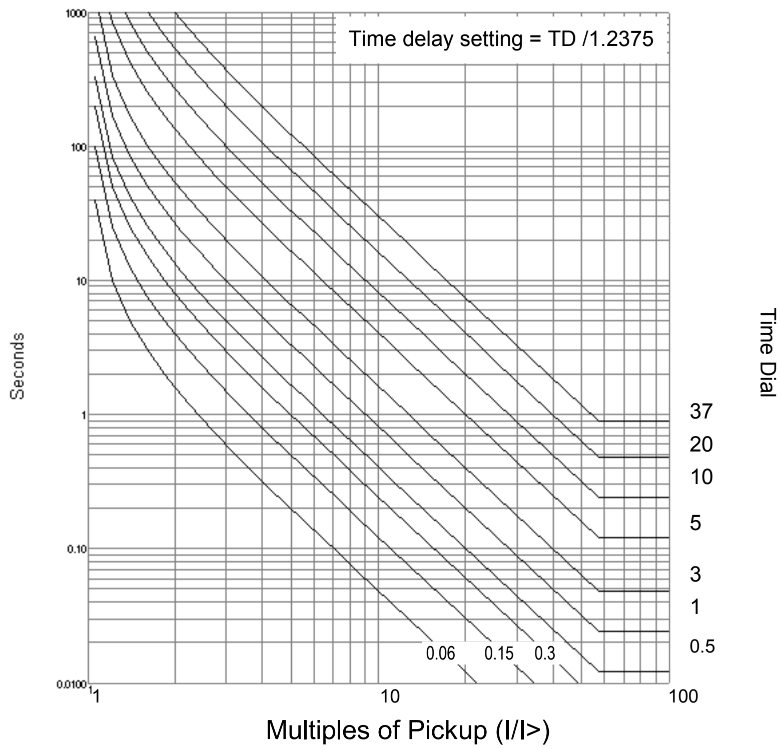

Figure 14 - IEC Extremely Inverse (c) Curve

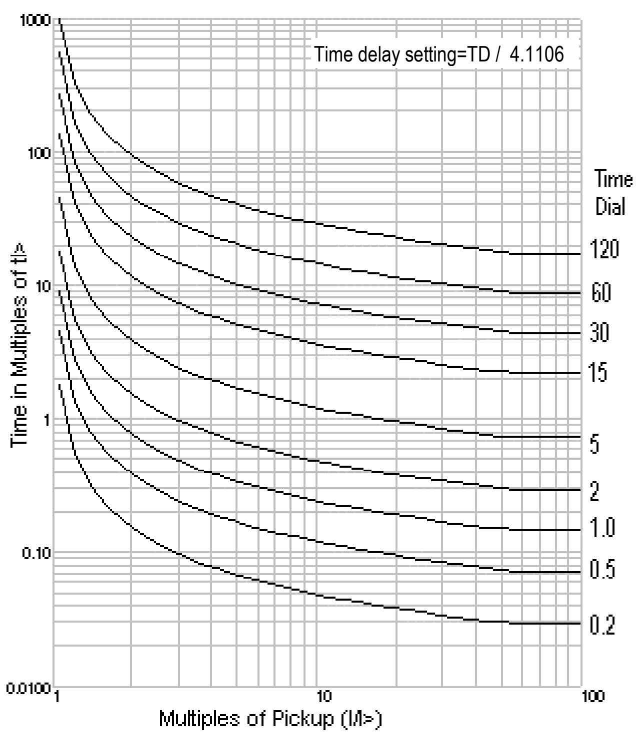

FIGURE 15 - US MODERATELY INVERSE CURVE (MI)

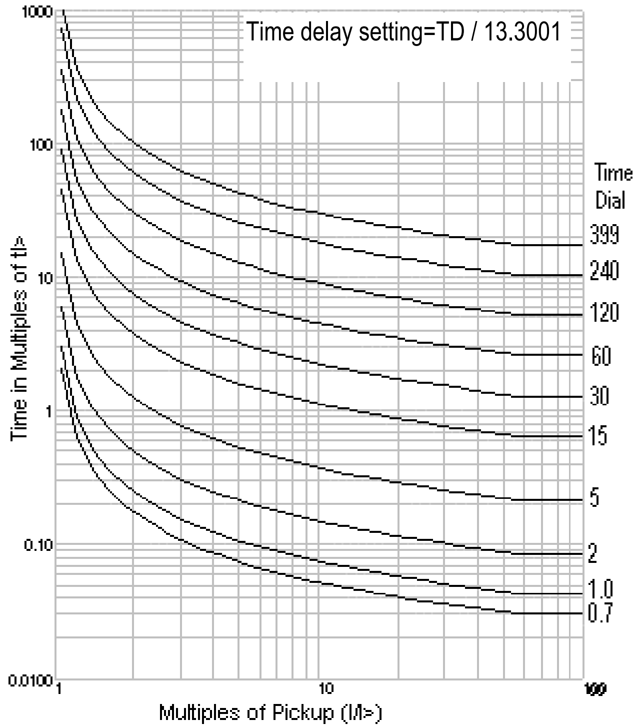

FIGURE 16: US STANDARD INVERSE CURVE (SI)

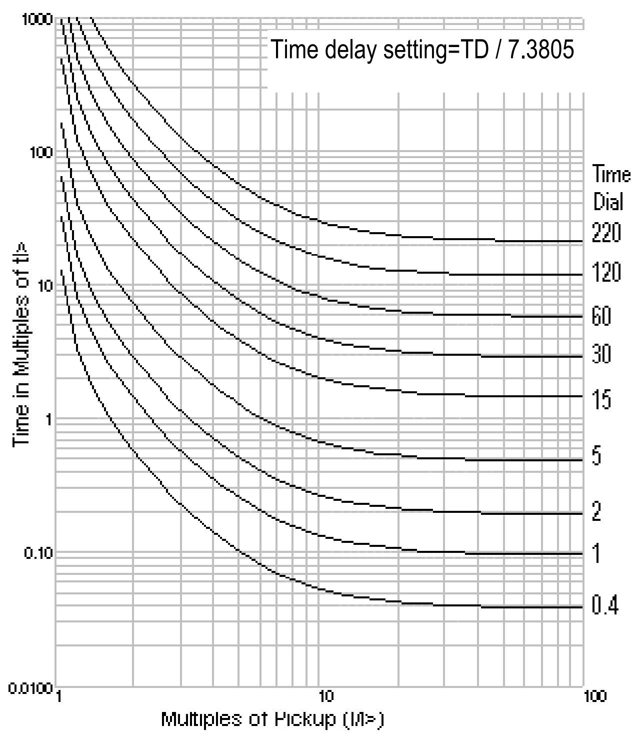

FIGURE 17: US VERY INVERSE CURVES (VI)

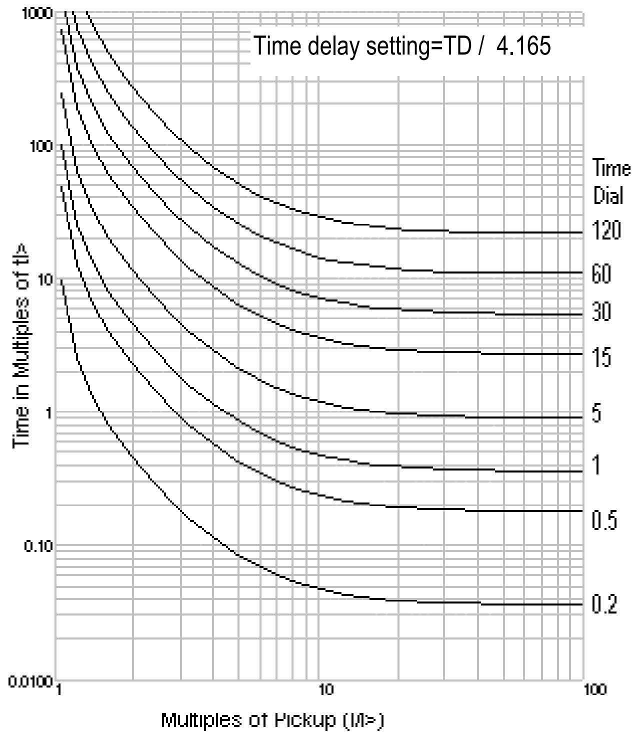

FIGURE 18 - US INVERSE CURVES (I)

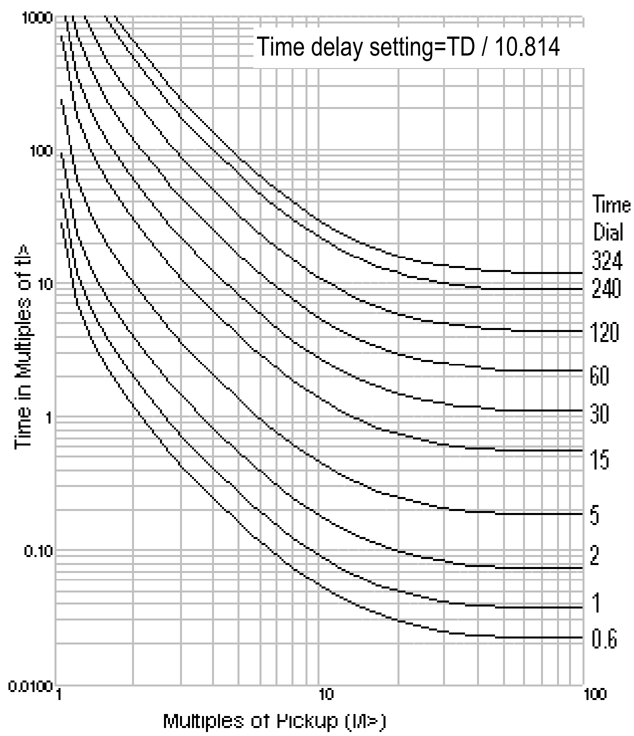

FIGURE 19: US EXTREMELY INVERSE CURVES (EI)

Breaker Failure Logic

The IM30AE may be set to back up a downstream breaker through implementation of its breaker failure logic. This logic is implemented via use of the Program Setting variable tBF (See Table 2), and the Blocking Input Variables tB2 and tB3 (see Table 4).

The breaker fail timer, tBF, is set to a time delay sufficient to allow opening of the circuit breaker after a trip signal is issued by the downstream relay. The downstream relay must be set to block the operation of the IM30AE's phase and/or ground elements via the external blocking contacts B2 and B3 (see Table 4).

When inputs B2 and B3 are shorted, the operation of the output contacts associated with the IM30AE's phase and ground elements are blocked. If the Breaker Failure time delay settings tB2 (phase) or tB3 (ground) are set to "Dis" for "Disable", the blocking action is permanent and will last as long as the blocking signal is present. This effectively disables the Breaker Failure logic.

If tB2 and/or tB3 are set to "2tBF", then the blocking action will last only for twice as long as the time delay set by the variable tBF. If a blocked trip element remains picked up after a time delay equal to twice tBF, the blocking action is ignored, allowing the IM30AE to trip the appropriate output contact(s) and illuminating the BKR FAIL" LED.

Bus Fault Protection

The IM30AE relay contains programmable blocking inputs which may be used to implement a very efficient bus fault and feeder backup mechanism without the need for a separate high impedance bus differential relaying system. Bus trip times of 2.5 to 3.0 cycles are typical. This feature is also shared with the other overcurrent relays in the Edison Line, including the IM30BE, IM30DE, IM30DRE, and DM30E relays. The features used on these relays to implement this protection are:

- Programmable phase and ground blocking inputs, B2, and B3
- Phase and ground fault pick-up protective elements, I>, I>>, I_0>, and I_0>>
- Blocking request timers, tB2, and tB3
- Breaker Fail timer, tBF

Figure 20 indicates typical application. It is assumed that all relays are set for both phase and ground overcurrent protection. In addition, it is assumed that both low and high set protective elements for both phase and ground elements are used. This document should be considered a guide as to the general methodology required to implement the described functions. It is incumbent upon the user to modify the described procedure as required for any given protective application.

The Supply line and both feeders are protected by any combination of IM30AE, IM30BE, IM30DE, IM30DRE or DM30E relays. The Feeder relays are

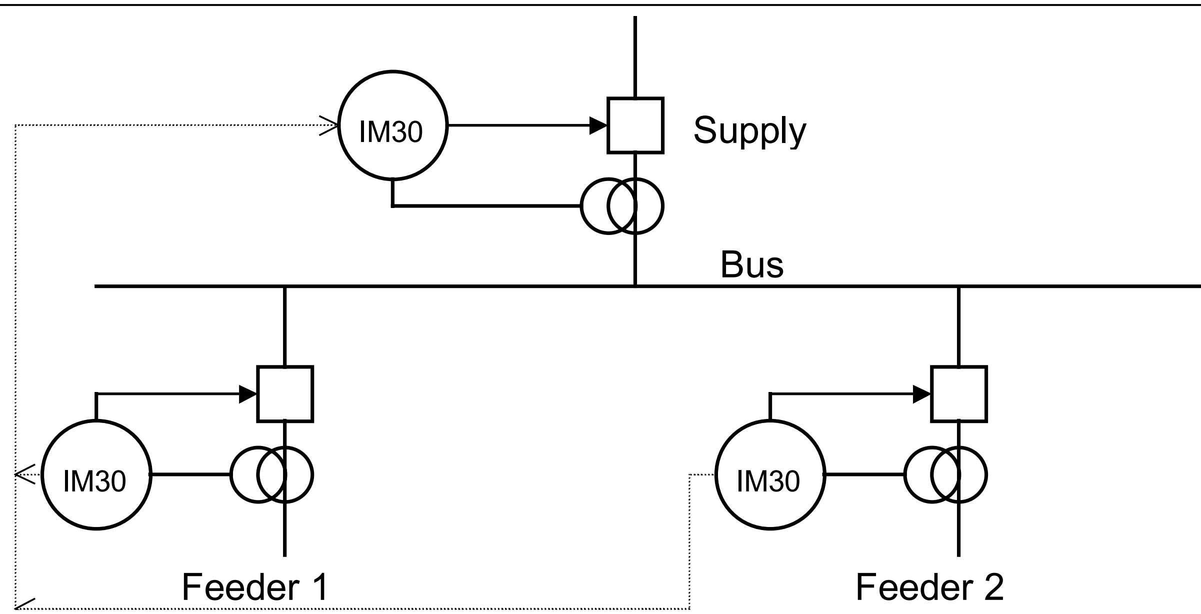

Figure 20: Typical Implementation of the IM30AE's Fast Bus Trip Logic

set so that the phase pick-up elements, I> and I>> are programmed to operate output contact R3. The ground pick-up elements, I_0>, and I_0>> are all assigned to operate contact R4. These contacts will close immediately when the operating quantity exceeds the pick-up value. These are sometimes referred to as start-time elements.

The output of the Feeder's phase pick-up contact, R3, is then connected to the phase blocking input, B2 (terminals 1 and 2) on the Supply relay. The phase blocking input variable B2 should be programmed to display "B2 I>> I>". This ensures that the Supply relay's low and high set phase elements will be prevented from operating as long as the phase block input is active. The ground overcurrent pick-up element contact R4 is similarly wired to the ground blocking input on terminals 1 and 3 of the Supply relay. The ground blocking input on the Supply relay is programmed to display "B3 O>> O>".

The blocking inputs on the Supply relay may be programmed to honor the blocking request for as long as the blocking input is active, or to ignore the blocking request after a certain period of time equal to twice the programming variable tBF (breaker fail timer). The blocking inputs should be set to honor the blocking request for only a fixed time period by setting the tB2 and tB3 variables to "2tBF". The variable tBF on each of the feeder relays should be set to a time delay equal to their breaker's expected operating time after receiving a trip signal.

The Supply relay should be set for very tight coordination with the Feeder relays to ensure rapid bus fault clearing.

With these connections and settings, the following will occur:

1. If a fault occurs on one of the feeders, the feeder relay will pick-up. The pick-up contact will block the operation of the upstream Supply relay, allowing the Feeder relay to clear the fault.
2. If a bus fault occurs, neither of the Feeder relays will pick-up, therefore the Supply relay will not be blocked and the Supply relay will trip, implementing bus fault protection.
3. If the Feeder relay experiences a breaker fail condition – meaning the breaker has not cleared the fault after the time delay tBF, then the pick-up element of the Feeder relay automatically drops out, removing the blocking signal from the Supply relay, allowing it to trip. This implements a breaker fail back-up function.

   Note that the blocking input blocks the pick-up of the time delayed functions on the Supply relay. Therefore the time delay for the Supply can be set for very fast operation, assuming a bus fault, allowing only enough time delay (10ms[1]) for the pick-up element of the Feeder relay to block the operation of the Supply relay in case of a feeder fault.
4. If the breaker fail function does not operate in the Feeder relay, or if the blocking circuit connection is shorted, then after twice the breaker operating time tBF, as set in the Supply relay, the blocking request will be ignored, allowing the Supply relay to trip. This provides an additional level of back-up.

In a similar fashion, the Supply relay may be interconnected with an upstream breaker, effectively implementing fault discrimination and back-up functions for itself.

Running the Test Programs

A. If desired, the start up diagnostic routines may be run at any time by accessing the **TEST PRG** mode. Two tests may be run, both of which are identical except for the effect on the output relays.

1. Press the Mode button until **TEST PRG** is displayed.
2. Select the test to run by pressing the **SELECT** button once to show **LEDSONLY**, or twice to display **LED+TRIP**.
   - A. If the **LEDSONLY** test is selected, pressing the **ENTER/RESET** button will run the test. All the LEDs should illuminate during the duration of the test. If any error is found, an error code will be displayed and the **RELAY FAIL** light will remain illuminated. The test lasts approximately five seconds. No output relays will be operated or will change status.
   - B. If the **LED+TRIP** test is selected, pressing the **ENTER/RESET** button will then display **TestRun?.** To run the test the **ENTER/RESET** button must be pressed again. At this point the test will run and all of the output relays will also be operated. The test lasts approximately five seconds.

[1] The output contact of the feeder relay will close in 7-10 msec after it picks up. This is the inherent time delay of the output contact.

CAUTION

Running the **LED+TRIP** test will operate all of the output relays. Care must be taken to ensure that no unexpected or harmful equipment operations will occur as a result of running this test. It is recommended that this test be run only when all dangerous output connections are removed.

REAL TIME MEASUREMENTS

The normal display of the IM30AE provides automatic scrolling of the three phase and ground currents. Display of any one of these quantities may be selected via the front panel. To display the real-time measured values of the relayed quantities, enter the ACT MEAS mode of operation as follows:

1. Press the **MODE** button, to get into **MEASURES** mode.
2. Press the **SELECT** button to select the ACT MEAS mode.
3. Press the + or – buttons to scroll through the available measurements. The data available is summarized in Table 7.

DISPLAY	MEASURED QUANTITY
xxMAYxx	Current date (month in alphabets)
xx:xx:xx	Current time
I/In	Highest phase current as a percent of the rated line CT primary current
Ia	Phase A RMS current in Amps
Ib	Phase B RMS current in Amps
Ic	Phase C RMS current in Amps
Io	Zero sequence (ground) current in Amps

TABLE 7 - AVAILABLE METERED VALUES IN "ACT MEAS" MODE

MAXIMUM DEMAND MEASUREMENTS

The IM30AE records the maximum measured current both during the first 100 msec after the breaker closes (inrush value) and after the 100 msec energization period (demand value). Display of any one of these quantities may be selected via the front panel. To display the measured maximum demand, enter the MAX VAL mode of operation as follows:

1. Press the **MODE** button, to get into **MEASURES** mode.
2. Press the **SELECT** button to select the MAX VAL mode.
3. Press the + or – buttons to scroll through the available measurements. The data available is summarized in Table 8.

DISPLAY	MEASURED QUANTITY (AMPS RMS[2])
Im/In	Highest phase current as a percent of the rated line CT primary current after first 100msec from energization.
Ia	Maximum phase A RMS current after first 100msec from energization.
Ib	Maximum phase B RMS current after first 100msec from energization.
Ic	Maximum phase C RMS current after first 100msec from energization.
Io	Maximum zero sequence (ground) current after first 100msec from energization.
Sa	Maximum phase A RMS current during first 100msec from energization.
Sb	Maximum phase B RMS current during first 100msec from energization.
Sc	Maximum phase C RMS current during first 100msec from energization.
So	Maximum zero sequence (ground) current during first 100msec from energization.

TABLE 8 - AVAILABLE MAXIMUM DEMAND VALUES IN "MAX VAL" MODE

BASIC EVENT RECORDS

The relay stores all information associated with the last 5 trip events. To access this data, enter the LastTr-x mode of operation as follows:

1. Press the **MODE** button, to get into **MEASURES** mode.
2. Press the **SELECT** button again to select the **LastTr-0** mode. This sets the user up to view the most recent trip event data. Press the **SELECT** button again to view consecutively older data sets. The display will show **LastTr-1**, **LastTr-2**, **LastTr-3**, and **LastTr-4** respectively with each button push. New

[2] Unless noted.

events push out the oldest event in a first-in, first-out (FIFO) process.

3. Once the appropriate basic event record is selected, press the + or – buttons to scroll through the event record. The data available is summarized in Table 9.

DISPLAY	HISTORICAL QUANTITY
Date	Current date
Time	Current time
F:xxxx	"xxxx" is the element which caused the last trip operation as follows: I> ph A A phase low set overcurrent I>>ph A A phase high set overcurrent *Same as above but with "B" or "C" in place of "A" for B or C phase overcurrents.* IHH instantaneous phase O> Low set ground overcurrent O>> High set ground overcurrent OHH instantaneous ground
Ia	Phase A current in Amps at time of trip
Ib	Phase B current in Amps at time of trip
Ic	Phase C current in Amps at time of trip
Io	Zero sequence (ground) current in Amps at time of trip

TABLE 9 - AVAILABLE LAST EVENT DATA IN "LASTTR-X" MODE

CUMULATIVE TRIP COUNTERS

To display how many times the relay has tripped for each of the protective elements, enter the TRIP NUM mode of operation as follows:

1. Press the **MODE** button, to get into **MEASURES** mode.
2. Press the **SELECT** button to select the TRIP NUM mode.
3. Press the + or – buttons to scroll through the available measurements. The data available is summarized in Table 10.

DISPLAY	NUMBER OF TRIPS DUE TO...
I>	Time delayed low set phase overcurrent
I>>	Time delayed high set phase overcurrent
IHH	Instantaneous overcurrent element
O>	Time delayed low set ground overcurrent
O>>	Time delayed high set ground overcurrent
OHH	Instantaneous earth fault element

TABLE 10 - CUMULATIVE TRIP COUNTER DATA IN "TRIP NUM" MODE

SPECIFICATIONS

Operating Temperature Range .... -20 to +60°C at 95% humidity
Storage Temperature .... -30 to +80°C
Dielectric test Voltage .... 2000V, 50/60Hz, 1 minute
Immunity to high frequency burst .... 1 kV common mode, 0.5 kV differential mode at 100 kHz,
.... 2.5 kV common mode, 1 kV differential mode at 1 MHz
Immunity to electrostatic discharge .... 15 kV
Immunity to sinusoidal wave burst .... 100V over 10 - 1000kHz range
Immunity to radiated electromagnetic field .... 10V/m over 20 - 1000MHz range
Immunity to high energy burst .... 4 kV common mode, 2V differential mode
Immunity to 50/60Hz magnetic field .... 1000 A/m
Immunity to magnetic burst .... 100 A/m over 100 - 1000kHz range
Resistance to vibration .... 1g from 10 -500 Hz
Rear Connection Terminals .... Up to 12AWG ($4mm^2$) stranded wire
.... Lugs up to 0.25 inch (6.5mm) wide
Output Contacts .... rated current 5 A, rated voltage 380 V
.... nominal switching power with AC resistive load 1100W(380V max.)
.... breaking capacity at 110 VDC: 0.3A with L/R=40ms for 100,000 operations
.... make and carry capacity for 0.5 sec = 30 A (peak)
Average power supply consumption 8.5VA
Weight (in single relay case) 2.3kg (5.0lbs)

SETTING SHEET FOR IM30AE RELAY

VARIABLE	FACTORY DEFAULT	UNITS	DESCRIPTION	VARIABLE	SETTING	UNITS
Date	Random	xxxxxxx	Current date (month in alphabets)	DDMMMYY	-	-
Time	Random	xx:xx:xx	Current time	HH:MM:SS	-	-
Fn	50	Hz	System Frequency	Fn		Hz
In	500	Primary Amps	Phase CT rated primary current	In		Amps
On	500	Primary Amps	Neutral CT rated primary current	On		Amps
F(I>)	D	None	Curve shape of low set phase overcurrent	F(I>)		None
I>	1.0	PU	Tap of phase low set overcurrent elements	I>		PU
tI>	2.0	None	Time Dial of phase low set overcurrent elements	tI>		Seconds
I>>	2.0	PU	Tap of phase high set element	I>>		PU
tI>>	0.1	seconds	Time delay of high set phase overcurrent element	tI>>		Seconds
IHH	0.5In	PU	Trip level of instantaneous overcurrent element	I>>>		PU
F(O>)	D	None	Curve shape of low set ground overcurrent	F(O>)		None
O>	0.1	PU	Tap of ground overcurrent element	O>		PU
tO>	1.0	None	Time Dial of ground low set overcurrent elements	tO>		Seconds
O>>	0.1	PU	Tap of ground high set element	O>>		PU
tO>>	0.1	seconds	Time delay of high set ground overcurrent element	tO>>		Seconds
OHH	0.02On	PU	Trip level of instantaneous earth fault element	O>>>		PU
tBF	0.10	seconds	Breaker failure time	TBF		Seconds
2I>>	OFF	None	Doubling of the tap value for the phase high set element	2I>>		None
Tsyn	Dis	Minutes	Synchronization time expected time interval between sync. Pulses	Tsyn		minutes
NodAd	1	None	Modbus Communication Address	NodAd		None

Output Relay Programming Assignments (Accessible via the F➔RELAY program mode.)						
I>	- - 3 -	Outputs	Low set phase overcurrent pick-up	I>		Outputs
tI>	1 - - -	Outputs	Time delayed low set phase overcurrent	tI>		Outputs
I>>	- - 3 -	Outputs	High set phase overcurrent pickup	I>>		Outputs
tI>>	1 - - -	Outputs	Time delayed high set phase overcurrent	tI>>		Outputs
IHH	- - - -	Outputs	Instantaneous overcurrent element	IHH		Outputs
O>	- - - 4	Outputs	Low set ground overcurrent pickup	O>		Outputs
tO>	- 2 - -	Outputs	Time Delayed low set ground overcurrent	tO>		Outputs
O>>	- - - 4	Outputs	High set ground overcurrent pickup	O>>		Outputs
tO>>	- 2 - -	Outputs	Time delayed high set ground overcurrent	tO>>		Outputs
OHH	- - - -	Outputs	Instantaneous earth fault element	OHH		Outputs
tBF	- - - -	Outputs	Breaker failure alarm operates relays R1, R2, R3, or R4	tBF		
tFRes	A	None	Relay reset mode	tFRes		None
B2	I>> I>	None	Phase overcurrent blocking input settings	B2		None
B3	O>> O>	None	Ground overcurrent blocking input settings	B3		None
tB2	2tBF	None	Maximum phase overcurrent blocking time	tB2		None
tB3	2tBF	None	Maximum ground overcurrent blocking time	tB3		None

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MANUAL REVISION HISTORY

July 1999 Version Supercedes April 1999 Version: (1) Corrected values in Table 5, (2) Added description of 2I>> in Table 2 and the 2I>> element to the Setting Sheet.

September 2002 Version supercedes July 1999 Version. (1) Added description and settings for IHH and OHH in Tables 2, 3, 5, 7, 9, and 10 and Setting Sheet. (2) Added section on Clock and Calendar. Revised Figures 4, 5, 6, 12, and 13. (3) Revised Sections on Breaker Failure Logic and Bus Fault protection to match nomenclature B2 and B3. This covers the IM30AE firmware version 2.00 (displayed on relay power-up).

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