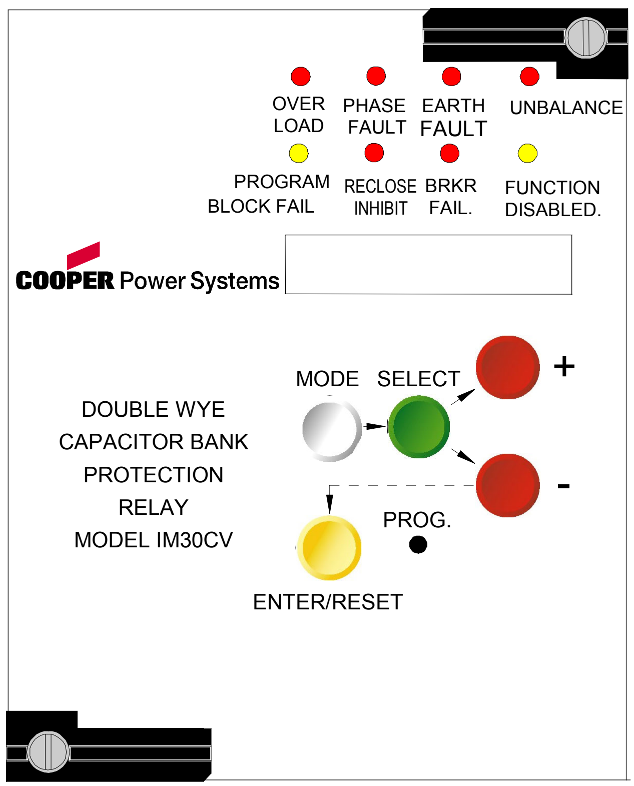
Operations Manual

COOPER Power Systems

Electrical Apparatus

IM30CV Double Wye Capacitor Bank Relay

S150-61-1



Safety for Life

Cooper Power Systems products meet of exceed all applicable industry standards relating to product safety. We actively promote safe practices in the use and maintenance of our products through service literature, instructional training programs and the continuous efforts of all Cooper Power Systems' employees involved in product design, manufacture, marketing and service.

We strongly urge that you always follow all locally approved safety procedures and safety instructions when working around high voltage lines and equipment and support our "Safety for Life" mission.

SAFETY INFORMATION

Following is important safety information. For safe installation and operation of this equipment be sure to read and understand all cautions and warnings.

Hazard Statement Definitions

This manual contains two types of hazard statements:

WARNING: Refers to hazards or unsafe practices which can result in death, severe personal injury and equipment damage.

CAUTION: Refers to hazards or unsafe practices that can result in damage to equipment or in personal injury.

Safety Instructions

The following general caution and warning statements apply to this equipment. Additional statements, relating to specific tasks and procedures, are located throughout the manual.

WARNING: Before installing, operating, maintaining, or testing this equipment, carefully read and understand the contents of this manual. Improper operation handling or maintenance can result in death severe personal injury, and equipment damage.

WARNING: This equipment is not intended to protect human life. Follow all locally approved procedures in safety practices when installing or operating this equipment. Failure to comply can result in death, severe personal injury and equipment damage.

WARNING: Hazardous voltage. Contact with high voltage will cause death or severe personal injury. Follow all locally approved safety procedures working around high voltage lines and equipment.

CAUTION: Equipment mis-operation. Do not connect this relay to an energized circuit breaker until all control settings have been properly programmed and verified. Refer to the programming information for this control. Failure to comply can result in relay and breaker mis-operation, equipment damage, and personal injury.

!	CAUTION:	Hazardous voltage. This device is not a substitute for visible disconnect. Follow all locally approved safety practices. Failure to follow proper safety practices can result in contact with high-voltage, which will cause death or severe personal injury.

!	WARNING:	A relay must be properly selected for the intended application. It must be installed in service by competent personnel who have been trained and understand proper safety procedures. These instructions are written for such personnel and are not a substitute for adequate training and experience in safety procedures. Failure to properly select, install or maintain the relay can result in death, severe personal injury, and equipment damage.

!	CAUTION:	Equipment damage. Always wear grounding wrist strap to control static electricity before handling circuit boards. Failure to use this strap may result in circuit board damage. The relay must be completely de-energized prior to removing, configuring and/or replacing any internal circuit boards.

!	CAUTION:	Equipment damage. Every relay individually undergoes a factory insulation test according to IEC255-5 standard at 2 kV, 50 Hz 1min. Insulation test should not be repeated as it unnecessarily stresses the dielectric system. If such a test must be performed, the terminals relevant to serial output must always be short circuited to ground. When relays are mounted in switchboards or relay boards that will be subjected to insulation tests, the relay modules must be drawn-out of their enclosures and the test must only include the fixed part of the relay with its terminals and the relevant connections. Leaving the draw-out relay module in place can damage.

The Operations Manual is designed to familiarize the reader with how to install, program, and set up the relay for operation. For programming the relay via computer software, consult the appropriate manual. Contact your local Cooper Power Systems representative for ordering information.

CONTENTS

1 INTRODUCTION

The IM30CV relay provides all of the basic functions necessary for the complete protection of a capacitor bank connected in either an ungrounded single wye configuration with a neutral VT, or in an ungrounded double wye[1] configuration where the two wye section neutrals are connected by a VT.

The relay is suitable for protecting externally fused, fuseless, and internally fused capacitor banks. Two digital inputs are provided for selective blocking of various functions. Five output relays are provided, four of which are programmable. Accessing of relay settings and measurements, as well as programming of settings and output relays, can be done through its front panel controls, or by means of a computer connected to the relay's RS485 communications port. The functions provided by the IM30CV are:

- Two levels of capacitor bank unbalance protection (alarm and trip).
- Two levels of phase overcurrent protection. The high-set level is ideal for phase faults and the low-set level is ideal for series reactor current overload protection.
- Two levels of ground overcurrent protection. The high-set level is ideal for tripping and the low-set level is ideal for alarming.
- Undercurrent protection to sense open breaker poles or low line voltage conditions.
- Programmable reclose timer.
- Breaker fail logic.
- Separate unbalance and overcurrent element blocking inputs.

It is possible to disable any of the relay's functions. Independent pickup and time delayed functions are provided which may be assigned to operate any of the four programmable output relays.

2 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 you must handle the exposed (i.e., drawn-out) relay to another person, make sure you are both at the same electrical potential. Shaking hands will achieve equal 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.

3 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 113mm L x 142mm H panel opening. The 19” rack mount case is a standard 3U high 19” cabinet.

[1] Also referred to as a double star, split star, or split wye connection.

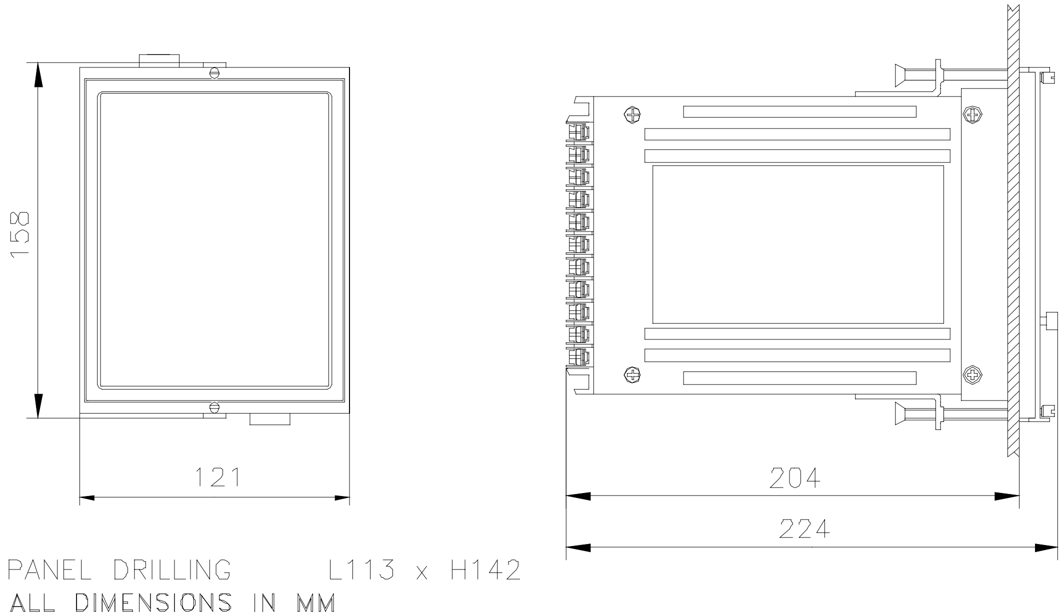


Figure 1: SINGLE MODULE ENCLOSURE MOUNTING

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.

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.

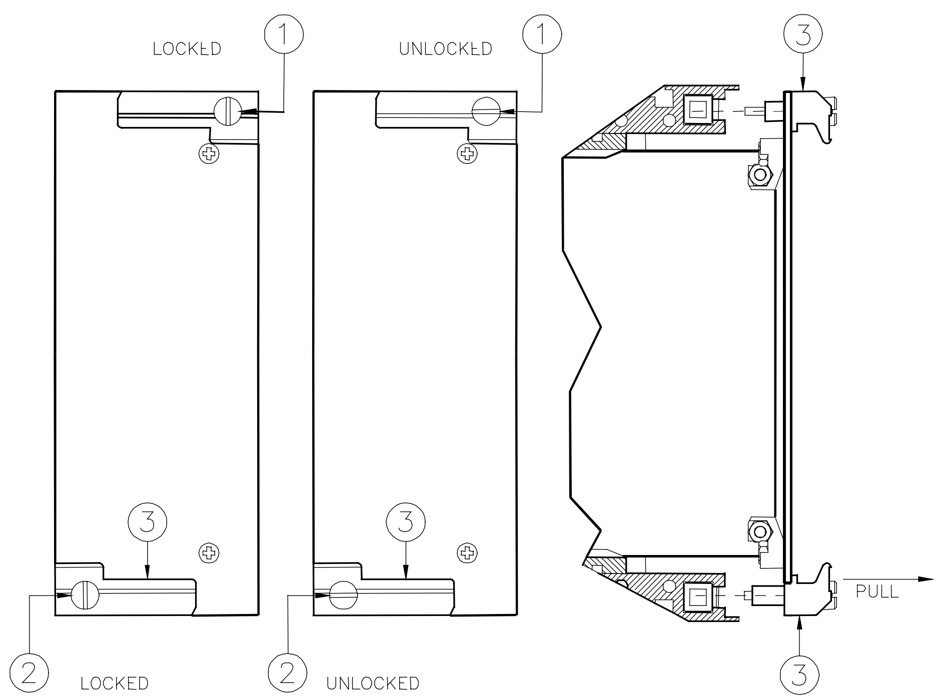


Figure 2: LATCH MECHANISM FOR REMOVAL OF RELAY FROM CASE

4 Electrical Connections

Power is supplied via terminals 12 and 13, with common at terminal 44. Chassis ground is made via the external screw provided on the case. 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.

Table 1: Power Supply Input Ranges

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

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" wide), 12 AWG wire (4 mm²), or FASTON connectors.

Electrical connections must be made in accordance with the relay's wiring diagram found in Figure 4. The numbers next to the circles along the edge of the functional block diagram of the relay indicate the terminal numbers corresponding to the terminal numbers on the back of the relay as shown 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: A 52a contact from the circuit breaker may be connected to terminals 1 and 14 of the IM30CV relay. See Section 12 for more information.

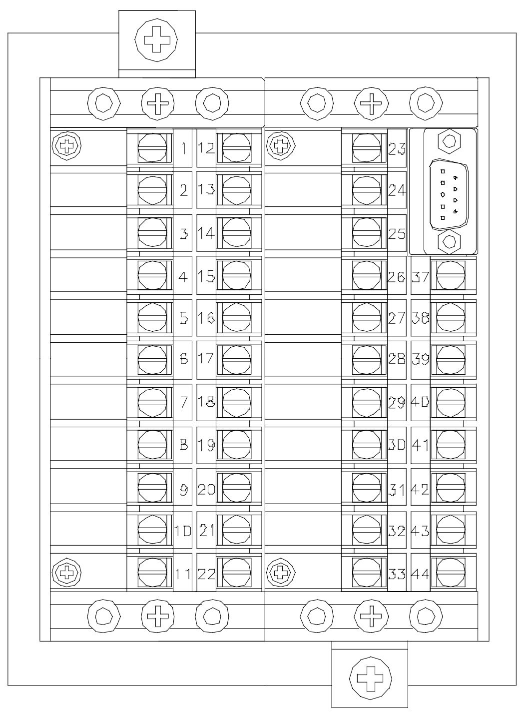


Figure 3: VIEW OF REAR TERMINAL CONNECTIONS

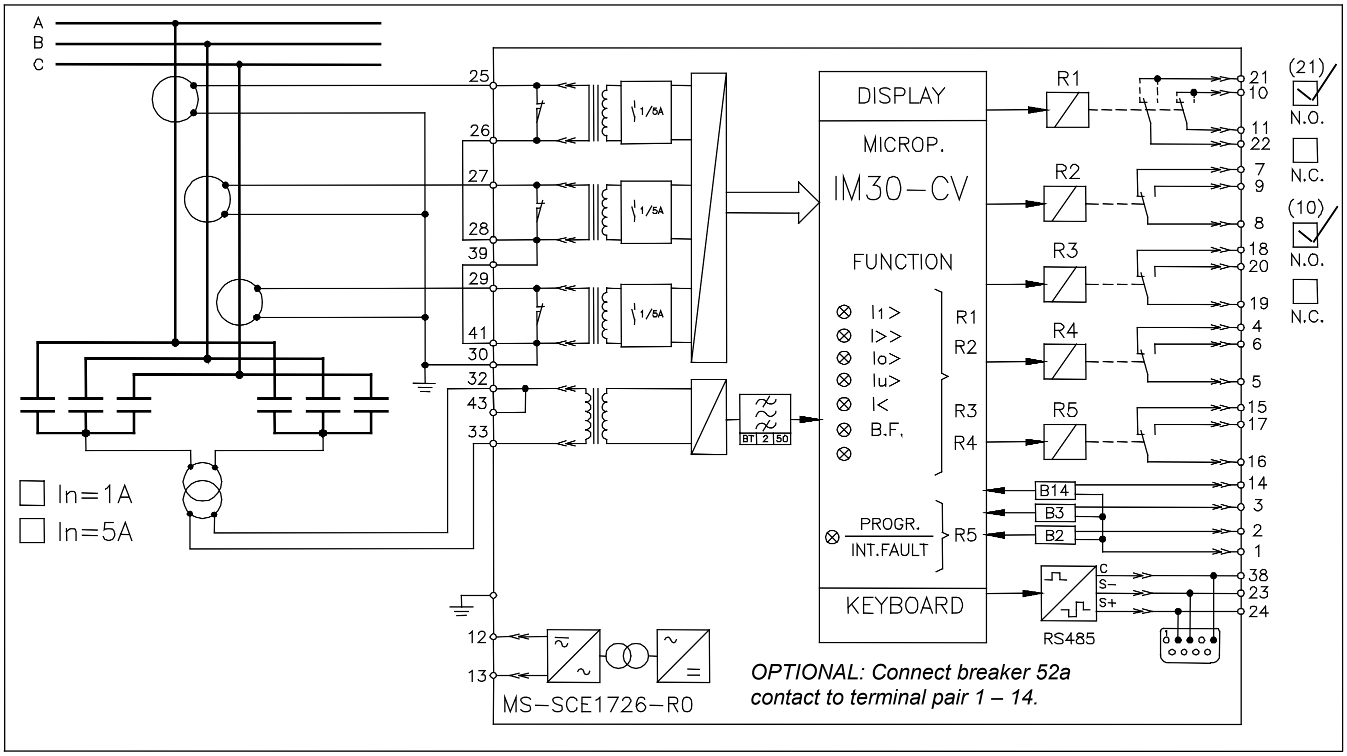


Figure 4: IM30CV WIRING DIAGRAM FOR DOUBLE UNGROUNDED WYE CAPACITOR BANKS

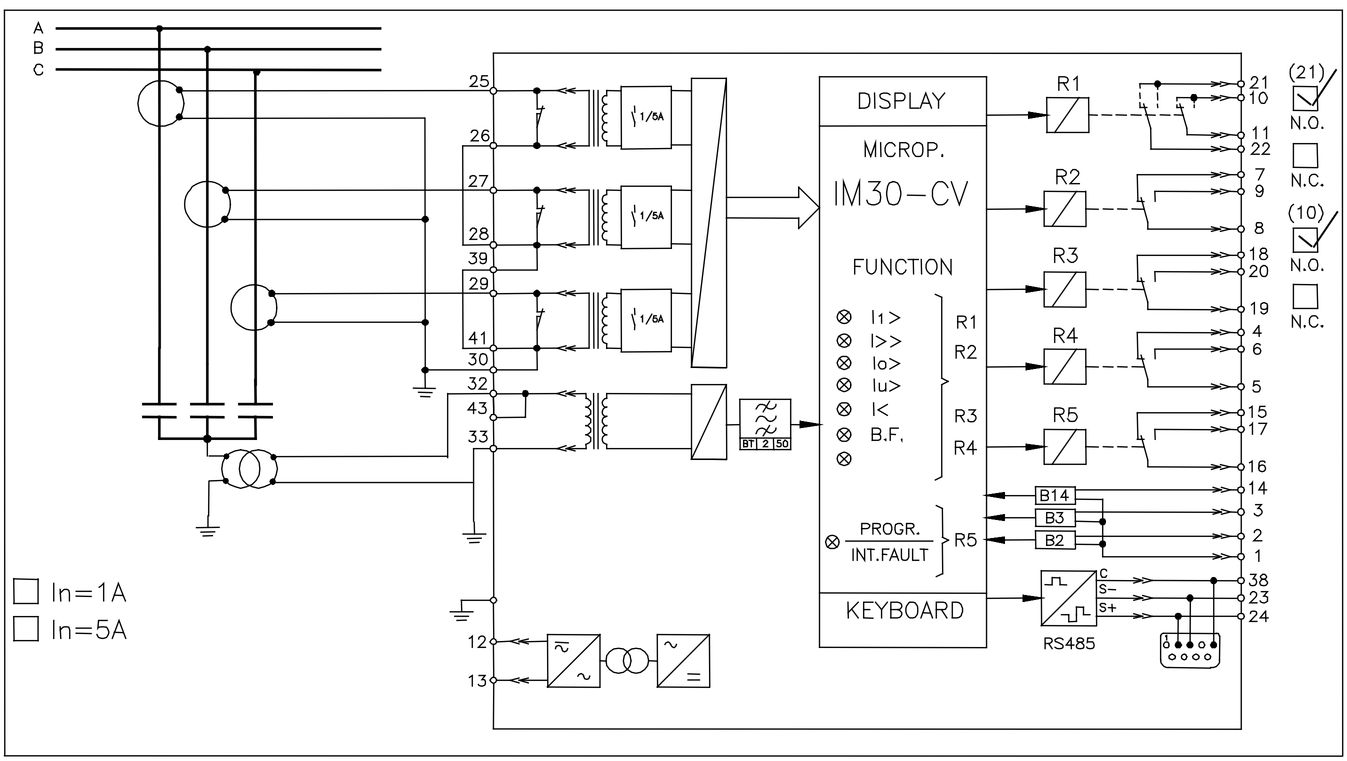


Figure 5: IM30CV WIRING DIAGRAM FOR SINGLE UNGROUNDED WYE CAPACITOR BANKS

5 CHANGE THE CT SECONDARY RATED INPUT, 1 OR 5A

The two possible selections to specify the rated secondary input currents are 1 or 5 Amperes. The jumper placement determines what the secondary rated current values will be. The 5 Amperes rating is selected by either joining the bottom two pins (vertical) or the two leftmost pins (horizontal). The 1 Ampere rating is selected by either joining the top two pins (vertical) or the two rightmost pins (horizontal).

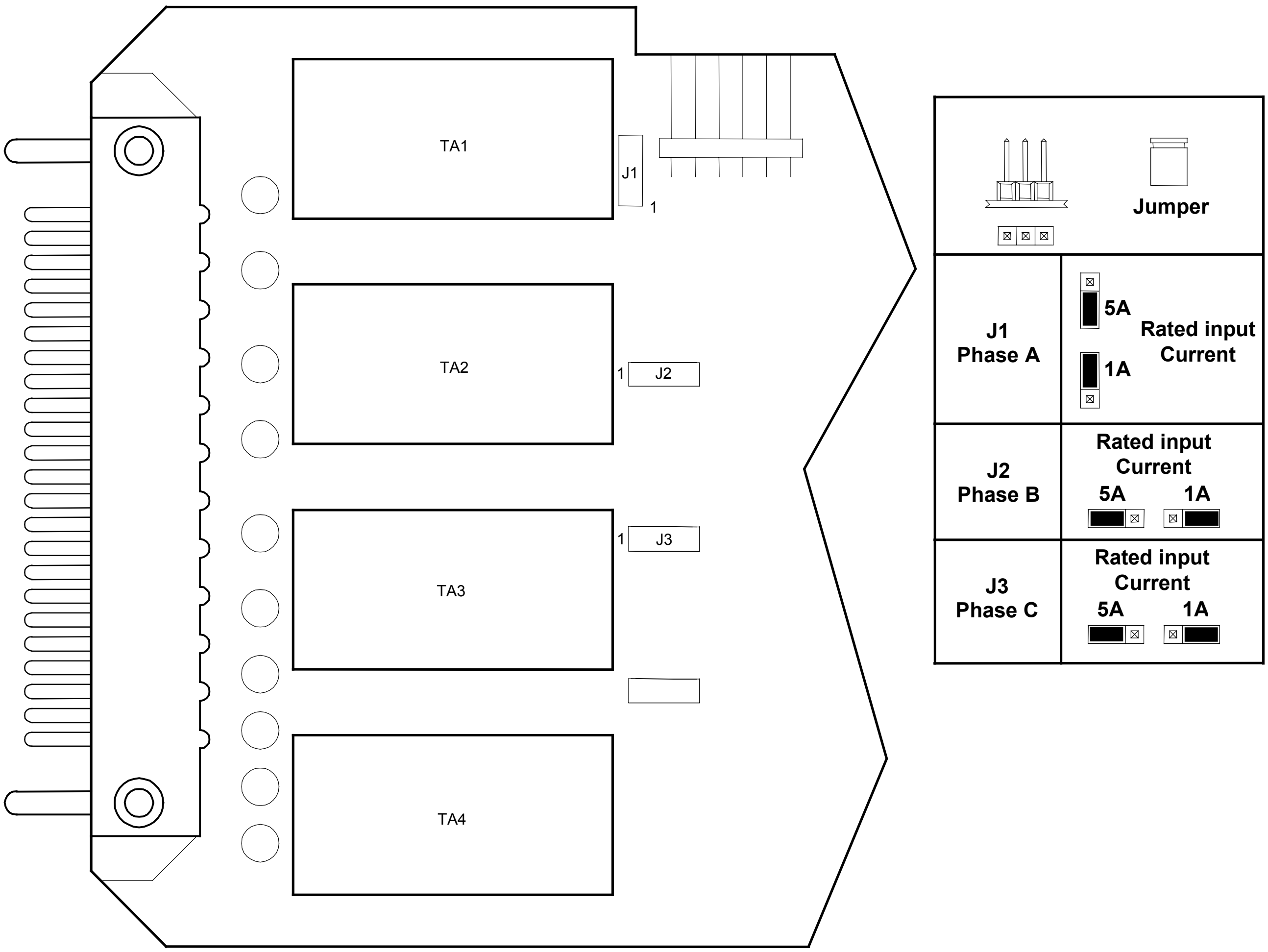


Figure 6: SELECTION OF THE RATED SECONDARY INPUT CURRENTS

5.1 OUTPUT RELAYS

Output relays 1 through 4 are user programmable to operate in conjunction with the activation of any protective element or elements with one exception.

NOTE: Pick-up (IL, IH, OL, OH, UL, and UH) and Time delayed (tIL, tIH, tOL, tOH, tUL, tUH, and tI<) functions may not be assigned to the same output relay(s).

Relay 1 consists of two isolated SPST terminals (one Form A and one Form B). 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 (de-energizes) upon relay power supply failure, on an internal relay fault, and in programming mode.

5.2 BLOCKING INPUTS

The IM30CV has three inputs which perform blocking functions. The open circuit voltage across the terminals of these inputs is 15 VDC. The internal resistance is 2.2 kΩ. When the external resistance across these terminals is less than 2.0kΩ, they are considered to be shorted. These three blocking inputs provide access to setting four variables which determine the controlled protective elements. See Section 8.5 "Programming the Blocking Variables" for more information on the function of these inputs.

6 TARGET DESCRIPTIONS

The front panel of the IM30CV contains eight LEDs which act as the targets for the relay elements. See Figure 7 for identification of the targets.

Figure 7: TARGETS FOR THE IM30CV RELAY

Target a	*Target b*	*Target c*	*Target d*
● OVER LOAD	● PHASE FAULT	● EARTH FAULT	● UNBALANCE
Target e	*Target f*	*Target g*	*Target h*
● PROGRAM/ BLOCK FAIL	● RECLOSE INHIBIT	● BKR FAIL	● FUNCTION DISABLED

a)	RED LED	**OVERLOAD**	❑ Flashing when measured current exceeds the set pick-up level IL. ❑ Illuminated on trip after expiration of the set trip time delay tIL.
b)	Red LED	**PHASE FAULT**	❑ Same as above related to IH and tIH.
c)	Red LED	**EARTH FAULT**	❑ Flashing when Ground Fault current exceeds the pick-up level OL or OH. ❑ Illuminated on trip of the time delayed element tOL or tOH.
d)	Red LED	**UNBALANCE**	❑ Flashing when the UNBALANCE voltage exceeds the pick-up level UL or UH ❑ Illuminated on trip of the time delayed element tUL or tUH.
e)	Yellow LED	**PROGRAM BLOCK FAIL**	❑ Flashing during the programming of the parameters ❑ Illuminated in the event of Internal Relay Fault.
f)	RED LED	**RECLOSE INHIBIT**	❑ Flashing when the current drops below the set level I<. ❑ Illuminated on trip after expiration of the set trip time delay tI<; the LED automatically extinguishes at the end of the set wait time for enabling to reenergize the capacitor bank.
g)	Red LED	**BREAKER FAIL**	❑ Flashing during the reclose inhibition time tRI ❑ Illuminated when the BREAKER FAILURE function is activated.

h) Yellow LED	**FUNCTION DISABLED**	❑ Illuminated when the operation of one or more of the relay functions has been disabled ❑ Flashing when a block signal is present.

The reset of the LEDs takes place as follows

❑ LEDs	a,b,c,d,g	❑ From flashing to off, automatically when the illuminating cause disappears ❑ From ON to OFF, by "ENTER/RESET" push button only if the tripping cause has disappeared.
❑ LEDs	e,f,h	❑ From ON to OFF, automatically when the illuminating cause disappears.

In the case of an auxiliary power supply failure, the status of the targets is recorded to non-volatile memory. The status of the targets is maintained when auxiliary power is restored.

NOTE: The targets will not reset if the cause is still present.

7 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. Figure 8 and Figure 9 give an overview of the keyboard operation.

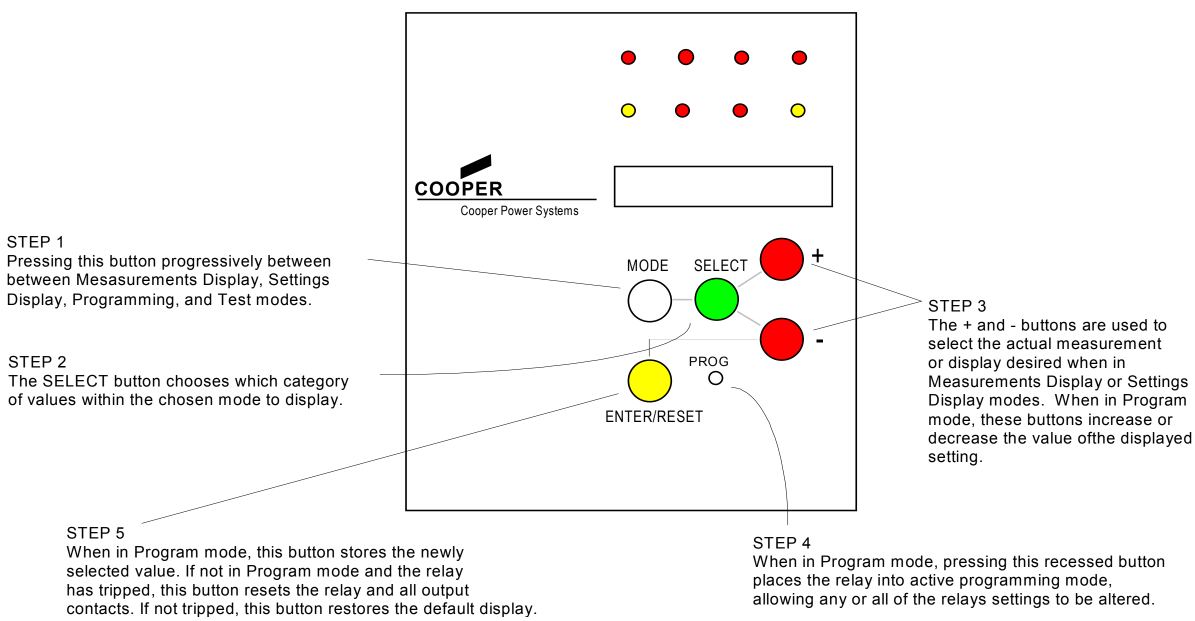


Figure 8: KEYBOARD OPERATION OVERVIEW

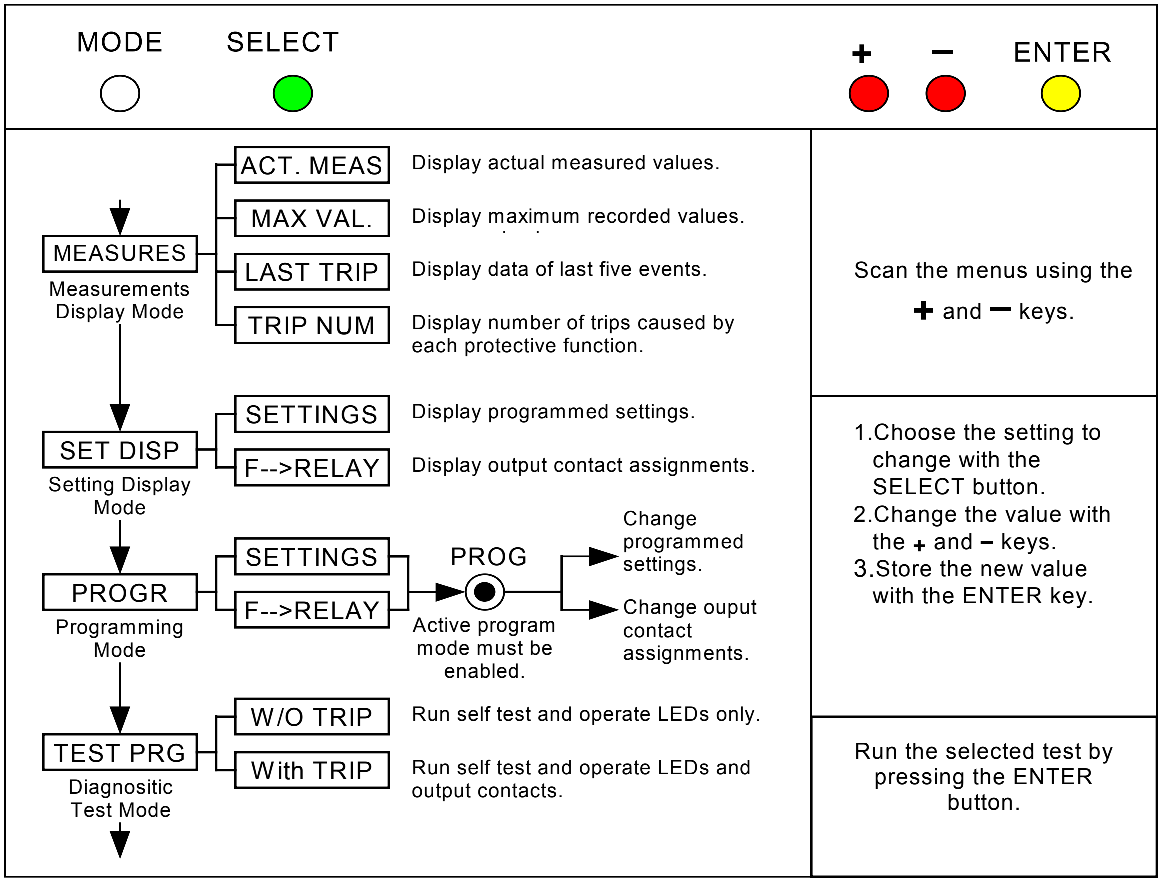


Figure 9: KEYBOARD OPERATION MAP

8 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.

   <u>**NOTE:**</u> The relay will not go into program mode when input quantities are not equal to zero as a security function. This prevents the settings from being altered while the relay is actively protecting the system and preventing any inadvertent trips of the circuit breakers.
2. Press **MODE** 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 or toothpick) press the recessed **PROGRAM ENABLE** button. The **PROGRAM** LED will now be flashing, indicating that **PROGRAM** mode has been successfully entered.

8.1 CHANGING A SETTING

Once in active **PROGRAM SETTINGS** mode, you may now change the relay settings. For instructions on changing the output relay assignments, see Section 8.3 - <u>(Changing Output Relay Assignments)</u>. Change the settings as follows:

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

8.2 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.

For example:

Fn 50**Hz**

Fn is the name of the variable.

Hz is the unit of measure, Hertz.

50 is the setting default.

A value of “Dis” in the Setting range column indicates that when the variable is set to this value, the related function is disabled.

8.3 Changing Output Relay Assignments

Output relays 1 through 4 may be assigned to any protective element, or any combination of elements.

__**NOTE:**__ The only exception is that the relay cannot be assigned to both pick-up 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 to be changed.

For example:

IL - 2 - 4

This is the name of protective element.

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

This dash means that output relay number 1 is <u>not</u> assigned to this element.

This dash means that output relay number 3 is <u>not</u> assigned to this element.

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

TABLE 2 : PROGRAM SETTING Variables

Display	Description	Setting Range
Fn 50**Hz**	System frequency	50 or 60 Hz
In 500**Ap**	Phase CTs rated primary current	1 to 9999 Amps in 1A steps
Un 100**V**	Rated secondary voltage of the P.Ts. supplying the unbalance voltage element .	50 – 125V in 1V steps
F(IL) D	Operating characteristic of the low-set overcurrent element	D Definite time delay SI Inverse time delay
IL 0.3**In**	Pick-up level of the low-set overcurrent element in per unit of the phase CTs rated current (**In**)	0.3 to 1.5 pu of **In** in 0.01 steps, or Disable
tIL 1.0**s**	Time delay of the low-set overcurrent element	1 to 50 seconds in 0.1 second steps
IH 0.6**In**	Pick-up level of the high-set overcurrent element in per unit of the phase CTs rated current (**In**)	0.2 to 2.0 pu of **In** in 0.01 steps, or Disable
tIH 0.1s	Time delay of the high-set overcurrent element	0.1 to 6500 seconds in (0.1 s steps from 0.05 to 9.99 and 1 s steps from 100 to 6500)
F(OL) D	Operating characteristic of the low-set ground (residual) overcurrent element	D Definite time delay SI Inverse time delay
OL 0.1**In**	Pick-up level of the low-set ground (residual) overcurrent element in per unit of the phase CTs rated current (**In**)	0.1 to 1.0 pu of **In** in 0.01 steps, or Disable
tOL 0.05**s**	Time delay of the low-set ground (residual) overcurrent element	0.05 to 30 seconds in 0.01 second steps
OH 0.2**In**	Pick-up level of the high-set ground (residual) overcurrent element in per unit of the phase CTs rated current (**In**)	0.1 to 2.0 pu of **In** in 0.01 steps, or Disable
tOH 0.05s	Time delay of the high-set ground (residual) overcurrent element	0.05 to 9.99 seconds in (0.01 second steps)
F(UL) D	Operating characteristic of the low-set unbalance element	D Definite time delay SI Inverse time delay
UL 0.02**On**	Pick-up level of the low-set unbalance element in per unit of the unbalance CT rated secondary current (**On**)	0.02 to 0.8 pu of **On** in 0.01 steps, or Disable
tUL 1.0**s**	Time delay of the low-set unbalance element	0.05 to 30 seconds in (0.01 second steps from 0.05 to 9.99) and (0.1 second steps from 10.0 to 30.0)
UH 0.04O**n**	Pick-up level of the high-set unbalance element in per unit of the unbalance CT rated current (**On**)	0.01 to 1.0 pu of **On** in 0.01 steps, or Disable
tUH 1**s**	Time delay of the high-set unbalance element	0.1 to 300 seconds in (0.1 second steps from 1.00 to 99.9) and (1 second steps from 100 to 300)

Display	Description	Setting Range
I< 0.10**In**	Pick-up level of the undercurrent element in per unit of the phase CT's rated current (**In**). This element is enabled only when the circuit breaker is closed (see Section 12). The largest among the 3 phase currents (I_{max}) is compared to the set trip level [I<]. If I_{max} < [I<] then the [tI<] timer is started. When such timer expires, a trip occurs.	0.10 to 1.00 pu of **In** in 0.01 steps, or Disable
tI< 1**s**	Time delay of the undercurrent element	1 to 99.9 seconds in 0.1 second steps
tRI 5.0**m**	Wait time for the re-energization of the capacitors	0.5 to 100 minutes in (0.1 minute steps from 0.5 to 9.99 and 1 minute steps from 10 to 100) or Disable
Uc .00**Un**	Unbalance compensation level	0.00 - 0.2Un in 0.01Un steps
α**c** 0°	Inherent compensation angle (angle between the unbalance voltage and the phase A current)	0 to 359 degrees in 1 degree steps (counter-clock wise rotation)
B14 Dis	C/B status monitoring input enabled/disabled. See Section 12.	En - Dis
tBF 0.1**s**	Breaker Fail output relay time delay. After tripping of the output relay R1 the time tBF starts. If at the end of tBF I_{max} is still above the zero current level I_{zero} (equal to 5%In), the output relay associated to the Breaker Failure protection is energized. A breaker failure can be detected also in case the value of I_{max} is not consistent with the status of the B14 digital input (see Section 12).	0.05 to 0.75 seconds in 0.1 second steps
NodAd 1	Modbus communication address	1 to 250 in steps of 1

8.4 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 output relay settings are shown in regular typeface.

TABLE 3 – DEFAULT Output Relay Programming and Display Definitions

Display	Description
IL --3-	Pick-up (or start-time) element associated with the low-set (time) phase over current element.
tIL 12--	Time delayed element associated with the low-set phase overcurrent element.
IH --3-	Start-time element associated with the high-set phase over current element.
tIH 12--	Time delayed element associated with the high-set phase overcurrent element.
OL ----	Pick-up (or start-time) element associated with the low-set (time) ground (residual) overcurrent element.
tOL 12--	Time delayed element associated with the low-set ground (residual) overcurrent element.
OH ----	Start-time element associated with the high-set ground (residual) overcurrent element.
tOH 12--	Time delayed element associated with the high-set ground (residual) overcurrent element.
UL ----	Start-time element associated with the low-set (first level) unbalance element.

Display	Description
tUL -2--	Time delayed element associated with the low-set (first level) unbalance element. This is usually used for the Alarm output.
UH ----	Start-time element associated with the high-set (second level) unbalance element.
tUH -2--	Time delayed element associated with the high-set (second level) unbalance element. This is usually used for the Trip output.
tI< ---4	Time delayed element associated with the undercurrent (undervoltage image) element.
tRI -----	Start of reclose timer tRI
tBF ----	Breaker failure element
tFRes: M	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.

NOTE: Pick-up (IL, IH, OL, OH, UL, UH) and Time delayed functions (tIL, tIH, tOL, tOH, tUL, tUH) may not be assigned to the same output relay(s).

8.5 PROGRAMMING THE BLOCKING VARIABLES

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

TABLE 4: DEFAULT Programming Variables Affecting Blocking Input Behavior and Definitions

Display	Description
Bf - - - i	Operation of the phase element blocking input, Bf. Set the display to show which phase and ground (residual) overcurrent elements are to be blocked when this input is active. **I** and **O** correspond to the high-set, and **i** and **o** correspond to the low-set elements. Bf can be set to any combination and selection of the four elements **O o I i** (16 possible settings).
Bo - u	Operation of the unbalance element blocking input, Bo. Set the display to show which unbalance elements are to be blocked when this input is active. **U** corresponds to the high-set, second level, or trip element, and **u** corresponds to the low-set, first level, or alarm element. Bu can be set to any combination of **U** and **u** (4 possible settings).
tBf 2tBF	Determines if the effect of the phase overcurrent element blocking input lasts as long as the blocking input is active (tBf =OFF), 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 (tBf=2tBF).
tBo 2tBF	Same as for tBf except for the unbalance element blocking input Bu.

8.6 PROGRAMMING VIA SOFTWARE

The IM30CV may also be programmed using the Edison Com Lite or EdisonCom Pro software packages provided by Cooper Power Systems. EdisonCom Lite is available from the Cooper Power Systems website, at http://www.cooperpower.com. Please consult the users manual for the appropriate software.

The IM30CV uses the Modbus© communication protocol. For details on the memory map used in the IM30CV in order to interface it with other Modbus programs or devices, consult the Edison Relay Modbus Reference, bulletin R150-05-3.

9 Overcurrent and Unbalance Element Characteristics

The ground overcurrent protection is derived by summing the three phase currents by the relay algorithm and hence a separate zero sequence CT is not required[2]. The low-set phase and ground overcurrent and low-set (first level) unbalance elements may be selected to exhibit a definite time or a simple inverse characteristic. The high-set phase and ground overcurrent and high-set (second level) unbalance elements exhibit definite time characteristics only. In addition, the IM30CV provides protective elements that operate upon pick-up of any of the above elements independent of the associated time delay. These are referred to as the pick-up elements.

When set for a simple inverse time characteristic, the low-set phase overcurrent and unbalance elements follow a curve based on the following formula:

$$t(I) = \frac{\left(K^{0.02} - 1\right)T_S}{\left(I_{PU}\right)^{0.02} - 1}$$

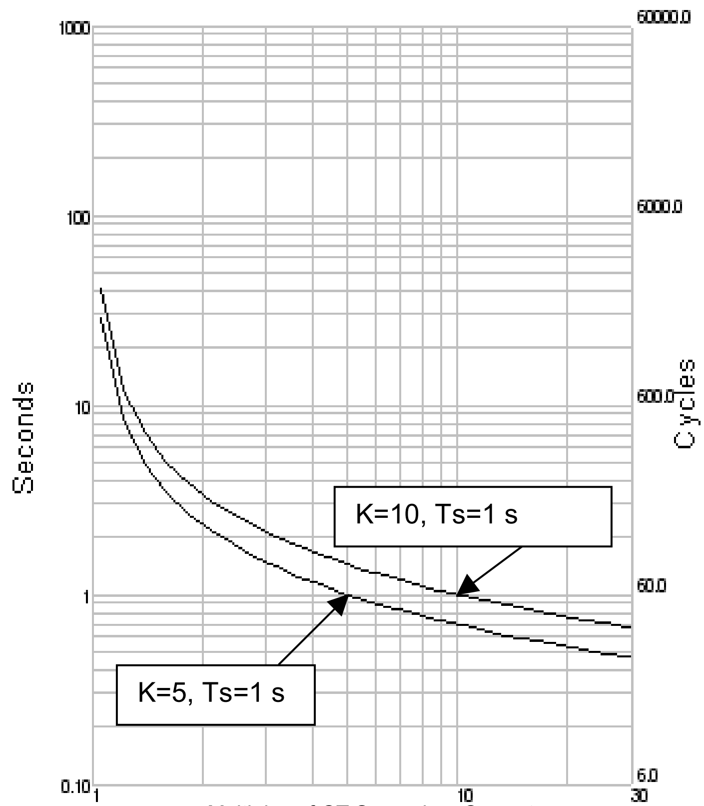
Where: K is a constant - 10 for phase and 5 for unbalance elements

T_S is the set time delay, and;

I_{PU} is the trip level in per unit of rated CT secondary current.

Rather than using a time dial and tap nomenclature, the phase and ground overcurrent and unbalance elements in the IM30CV are set in per unit of CT secondary current. This corresponds to the tap. For adjusting the curve up and down (time dial), an actual time delay in seconds is used. For the phase and ground overcurrent elements K=10, it can be seen that at a current setting of 10pu, the time setting T_S is equal to the actual time delay for the element (due to cancellation of terms). Therefore, selection of the phase and ground overcurrent time setting is performed by reading the time value corresponding to the 10pu current setting for the curve in the proper location. For the unbalance (neutral) overcurrent element, K=5, and the curve produces faster operating times. Similarly, selection of the unbalance overcurrent time setting is performed by reading the time value corresponding to the 5pu current setting for the curve in the proper location.

Figure 8 demonstrates a typical inverse characteristics that can be used with either or both of the low-set phase and ground overcurrent and low-set unbalance elements.



Multiples of CT Secondary Current

Multiples of CT Pickup (Iactual/Is)
Where Is = In * (pick-up level)

Figure 10: TCC Characteristic of the Normal inverse Characteristic Available on the Low-set Phase and Ground Overcurrent (K=10) and Low-set Unbalance Elements (K=5)

[2] The ground fault element measures the fundamental component of the residual current calculated from the vector summation of the 3-phase-currents. The measurement of the fundamental component rejects harmonics up through the 6th Higher triplen harmonics (9th, 12th, 15th , etc) which, in three-phase summation, naturally produce a residual current, can produce some oscillation in the measurement of the fundamental component. This oscillation normally should not produce any spurious tripping unless the trip level is very low, the trip time delay very short or the harmonic content abnormally high.

Figure 8 shows the inverse characteristics that can be used with either or both of the low-set phase and ground overcurrent and low-set unbalance elements.

FOR EXAMPLE:

In = 4000A

IL = 0.50

Pickup level (Is) = 4000 * 0.50 = 2000A

For a fault current of 20000A, the multiple of pick-up is 10pu. Adjust the curve up or down by selecting the appropriate time delay desired at this level of 10pu.

NOTE: The curves shown actually have a minimum pickup of 1.1pu. In the case of the example, the actual minimum pick-up is 2200A primary.

It is important to note that the current waveform from the **unbalance** CT is filtered to remove all harmonics before being processed by the relay. The active filter's specification is 24 dB down at 150 Hz. Thus, the unbalance element setting can be made without any concern of the triple-n harmonics adding in the neutral and causing a false alarm or false trip. Another advantage of filtering is that the setting on harmonic filters can be calculated without any consideration of the harmonic current which can vary over a wide range. Conversely, the current waveform from the **phase** CT is filtered to pass up to the ninth harmonic. The relay calculates the rms current including the ninth harmonic. Thus, the series reactors (if any) are provided with needed overload protection including heating effects from harmonics.

10 USE OF THE I< ELEMENT

A shunt capacitor bank is a constant impedance load to the system and therefore the current drawn by the bank is within the range of voltage variation of the system. The **I<** element is used to indicate a system-wide voltage degradation and trip the bank. The **I<** element is enabled only when the circuit breaker is closed which is determined by the 52a contact input across terminals 1 and 14. The largest amongst the three phase currents currents (Imax) is compared to the set trip level of **I<.** If Imax is less than **I<** then the **tI<** timer is started. When the **tI<** timer expires, the breaker is tripped via any output relays associated to the pick-up element, **tI<.**

11 BREAKER FAILURE PROTECTION (tBF)

The breaker failure protection element **tBF** has a setting range of (0.05-0.75 s) in steps of 0.01s. The **tBF** element is driven via the output relay R1 and therefore it is important to use R1 to trip the breaker if it is desired to use the **tBF** element. After tripping of the output relay R1 the timer **tBF** is initiated and begins to countdown. After the end of **tBF** if the current Imax is still above Izero (equal to 5% of In), then the output relay associated to the Breaker Failure protection is energized. A breaker failure is also detected in case the value of Imax is not consistent with the status of the B14 digital 52a contact input.

12 CIRCUIT BREAKER STATUS DETECTION

A setting is available (B14 En/Dis) to Enable or Disable the B14 digital input. When B14 is enabled the circuit breaker status is computed according to the following truth table:

Status of B14 (52a contact)	Value of Imax	C/B Status
Closed	Imax>Izero	Closed
Open	Imax>Izero	Failure (tBF activated)
Closed	Imax≤Izero	Closed
Open	Imax≤Izero	Open

State transitions are not instantaneous. Signals are validated if and only if no change is detected for at least 50 ms. Furthermore, in case a breaker failure condition is detected (row 2), the breaker failure timer tBF is started. When tBF expires, the I>Izero condition is checked again and the breaker failure function is energized only if current is still above Izero.

When B14 is DISABLED, its status is ignored. Thus, the following truth table applies:

Status of B14 (52a contact)	Value of Imax	C/B Status
Any	Imax>Izero	Closed
Any	Imax≤Izero	Open

13 WAIT TIME FOR THE RE-ENERGIZATION OF THE CAPACITORS

When the relay detects a transition of the circuit breaker status from closed to open, the reclosing inhibition timer tRI is started and the associated (programmed) output relay (R2, R3, or R4) is energized. Typical usage is to put the normally closed tRI contact in the close circuit of the circuit breaker. After the bank is tripped or de-energized the tRI contact opens for the tRI time delay, preventing re-energization before the caps discharge.This condition is indicated by flashing of LED BRKR FAIL. The reset of this function takes place depending upon the reset mode (tFRES=Auto or tFRES=Man).

If tFRES is set to Auto (automatic reset), tRI can be forced to 0 by pressing the yellow ENTER button. This de-energizes the tRI associated output relay and the LED stops flashing. If the ENTER button is not pressed, the element automatically resets itself at the end of tRI.

If tFRES is set to Man (manual reset), the ENTER button must be pressed to reset the element. No command is accepted before tRI has expired.

14 RUNNING THE TEST PROGRAMS

The relay contains a comprehensive program of self-test and self-diagnostic features.

A. Diagnostic and functional tests are performed every time the auxiliary power is turned on to the relay. These tests check the program routines and memory content of the relay.

B. Dynamic functional tests are run every 15 minutes during normal operation (relay's operation is suspended for less than 10ms).

C. 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 **W/O TRIP**, or twice to display **WithTRIP**.
   a. If the **W/O TRIP** 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 **WithTRIP** 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 be operated in addition to the LEDs. The test lasts approximately five seconds. Access to the **WithTRIP** test is enabled only when the current inputs to the relay are zero (breaker open).

⚠ CAUTION

Running the **WithTRIP** 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 generally recommended that this test be run only when all dangerous output connections are removed.

15 REAL TIME MEASUREMENTS

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 5.

Table 5 - Available Metered Values in "ACT. MEAS" Mode

DISPLAY	MEASURED QUANTITY
I/In	Highest phase current (% of rated In)
IA	RMS value of Phase A current
IB	RMS value of Phase B current
IC	RMS value of Phase C current
Io	RMS value of the Ground (residual) Current
Uo	RMS value of the unbalance voltage as per unit of the rated voltage Un.
αu	Compensation angle (angle between Uo and IA in degrees, 0-360° counterclockwise)
Ud	Unbalance compensated voltage in per unit of rated input voltage Un

16 MAXIMUM VALUE DATA

To display the maximum values of the relayed quantities, 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 6.

Table 6 – Available maximum Values in "MAX VAL." Mode

DISPLAY	MAXIMUM VALUE OF THE…
IAxx.x**In**	Maximum Phase A current after the first 100ms from breaker closing
IBxx.x**In**	Maximum Phase B current after the first 100ms from breaker closing
ICxx.x**In**	Maximum Phase C current after the first 100ms from breaker closing
Ioxx.x**In**	Maximum Ground (residual) current (3x zero sequence current)
Udxx.x**Un**	Maximum Unbalance voltage after the first 100ms from breaker closing
SAxx.x**In**	Maximum Phase A current during the first 100ms after breaker closing
SBxx.x**In**	Maximum Phase B current during the first 100ms after breaker closing
SCxx.x**In**	Maximum Maximum Phase C current during the first 100ms after breaker closing
Sdxx.x**In**	Maximum Unbalance current during the first 100ms after breaker closing

17 Last Trip (Event) Data

The relay stores information associated with the last trip event. To access this data, enter the **LASTTRIP** mode of operation as follows:

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

Table 7 - Available Last Event Data in "LASTTRIP" Mode

Display	Historical Quantity
Causexxx	"xxx" is the element which caused the last trip operation as follows: IL Low-set phase overcurrent element IH High-set phase overcurrent element UL Low-set (first level) unbalance element UH High-set (second level) unbalance element
IA	Phase A current at time of trip
IB	Phase B current at time of trip
IC	Phase C current at time of trip
Io	Ground (residual) current at time of trip
Ud	Compensated unbalance voltage at time of trip.

18 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 8.

Table 8 - Cumulative Trip Counter Data in "TRIP NUM" Mode

Display	Number of Trips Due to...
IL	Low-set phase overcurrent element
IH	High-set phase overcurrent element
OL	Low-set ground (residual) overcurrent element
OH	High-set ground (residual) overcurrent element
UL	Low-set unbalance element
UH	High-set unbalance element
I<	Undercurrent element

19 SETTING OF THE CAPACITOR BANK INHERENT UNBALANCE COMPENSATION FUNCTION

STEP 1 - Switch on the capacitor bank and record the values of **Uo**, α_u, and **U**$_d$, located in **MEASURES** mode in the **ACT. MEAS** sub-menu. Note that in the first step **Uo** is approximately equal to **U**$_d$ **.**

STEP 2 - Switch off the capacitor bank and input the settings for **U**$_c$ to be equal to **U**$_o$ and set α_c to be equal to α_u as recorded in STEP 1.

When the capacitor bank is switched on again, **Uo** and α_u should remain practically unchanged, and **U**$_d$ should be approximately zero. Note that Ud is the **magnitude** of the compensated unbalance voltage which is computed from the following vectorial difference equation:

$$V_d = \left| V_u \angle \alpha_u - V_c \angle \alpha_c \right|$$

20 SETTING EXAMPLE

Consider the installation of a 16.8 MVAR fused capacitor bank to provide power factor correction. The bank will be connected split-wye ungrounded to a 69 kV system. Each phase consists of 2 series groups with 7 capacitor units per group. Individual capacitor unit ratings are 200 kVAR at 19.92 kV. Assume the fault level is 500 MVA, phase CT ratio and accuracy are 300:5 A, C200 and the unbalance VT ratio is 39940:240. (If a series reactor is used, the fault level should be calculated downstream of the reactor.)

- Determine the phase and ground overcurrent and instantaneous relay settings.
- Determine what number of units from one series group can be removed without causing an overvoltage of 110% on the remaining units
- Determine what value of unbalance (neutral) current should the relay signal an alarm, and at what value of unbalance (neutral current) should the relay trip the bank

$$V_T = \text{line - to - neutral voltage} = 39.8 \text{ kV}$$

$$V = \text{nameplate capacitor unit rating} = 19.92 \text{ kV}$$

$$S = \text{number of series groups} = 2$$

$$N = \text{number of parallel units per series group per leg} = 7$$

$$I_U = \text{rated current of one unit} = \frac{\text{var}}{V} = \frac{200 \times 10^3}{19.92 \times 10^3} = 10.0 \text{ A}$$

$$I_{load} = \text{rated load current of bank} = \frac{\text{MVAR} \times 10^3}{(\sqrt{3.}) * \text{kV}} = \frac{16.8 \times 10^3}{(\sqrt{3.}) \times 69} = 140.6\text{A}$$

$$I_{fault} = \text{rated fault current at bank} = \frac{\text{MVA} \times 10^3}{(\sqrt{3.}) * \text{kV}} = \frac{500. \times 10^3}{(\sqrt{3.}) \times 69} = 4183.7\text{A}$$

Phase element settings

The phase CTs rated primary current **In** is 300 A. The neutral CTs rated secondary current, **On**, is 5.

The operating characteristic **F(IL)** of the low-set overcurrent relay chosen is SI (Simple Inverse) to allow for coordination with the fuses in the capacitor bank. The pick-up level of the low-set overcurrent element is about 125% of rated load current of bank in per unit of the phase CTs rated current **(In)**.

$$\mathbf{IL} = \frac{1.25 \times 140.6}{300} = 0.59\, p.u.$$

Therefore set **IL**=0.6

The **tIL** or time delay of the low-set overcurrent element is chosen to coordinate with other upstream or downstream devices. The method of selection of the time delay is explained in Section 8.

The pick-up level of the high-set overcurrent element is about 40% of the rated fault current at the bank in per unit of the phase CTs rated current **(In)**

$$\mathbf{IH} = \frac{0.4 \times 4183.7}{300} = 5.58\,pu$$

Set **IH** to 2.0 pu (600 A or 426% of full load current)– the maximum possible setting. Alternatively, a higher ratio CT could be used, 600:5 or 800:5 to obtain a setting closer to the allowable 2.0 pu. However, in this particular case the **IH** setting is 426% of full load current and hence adequate discrimination between load and fault currents exists. The **tIH** or time delay of the high-set overcurrent element is chosen to be 0.1 s for fast clearing of the fault and allow for inrush transients to subside.

Ground (residual) element settings

The pick-up level of the ground (residual) overcurrent **OL** element can be set at 20% of the rated load current of the bank . In this example, 20% of the 140.6 A load current is 28.12 A. The pick-up level of the ground undercurrent element **OL** in per unit of the phase CTs rated current (**In**) is therefore calculated to be 28.12/300 or 0.09 pu. The minimum available setting is 0.1 **In** and therefore **OL** is set at 0.1pu. The operating characteristic **F(OL)** is set to D for definite time delay. The **tOL** setting of 0.2 sec allows for transients to subside and prevents unnecessary alarms or trips.

The pick-up level of the high-set ground (residual) overcurrent **OH** element can be set at 25% of the rated load current of the bank . In this example, 25% of the 140.6 A load current is 35.15 A. The pick-up level of the ground element **OH** in per unit of the phase CTs rated current (**In**) is therefore calculated to be 35.15/300 or 0.12 pu. The **OH** is set at 0.12 pu. The operating characteristic **F(OH)** is set to D for definite time delay. The **tOH** setting of 0.1 sec allows for transients to subside and prevents unnecessary alarms or trips.

Unbalance element settings

The operating characteristic **F(UL)** of the low-set unbalance is set to definite time mode in keeping with common practice, that is, F(UL)=D. The pick-up level of the low-set unbalance element (**UL**) is used for alarming whenever the first fuse operates in an externally fused capacitor bank, or whenever one series pack section is shorted in a fuseless bank. In a properly designed capacitor bank one series element failure will cause a voltage below 110% on the other phases and is calculated below. The pick-up level of the high-set unbalance element (**UH**) is set to detect when a sufficient number of fuse operations or series pack sections have failed and caused a voltage greater than 110% on the other capacitors in the same series group and hence is used for tripping.

The equations used below for calculating unbalance voltages and currents are found in IEEE C37.99, Recommended Practices for the Protection of Shunt Capacitors. For this example, F (i.e., the number of failed capacitors in one series group) is equal to 1.

$$\begin{aligned}\%V_R &= \left[\frac{V_T}{SV}\right]\left[\frac{300SN}{3S(N-F)+2F}\right] \text{ for ungrounded split - wye} \\ &= \left[\frac{39.8\times10^3}{(2)(19.92\times10^3)}\right]\left[\frac{300(2)(7)}{6(2)(7-1)+2(1)}\right] \\ &= 110.5\%\end{aligned}$$

$$\begin{aligned}V_N &= \left[\frac{3FV_N}{3S(N-F)+2F}\right] \text{ for ungrounded wye} \\ &= \left[\frac{3(1)(19920)}{3(2)(7-1)+2(1)}\right] \\ &= 524\text{ V}\end{aligned}$$

For F = 2: (the number of failed capacitors in one series group), the numbers are $\%V_R$=123.5 and V_N=1172 V.

In this example, the loss of the first fuse results in an overvoltage just slightly greater than the 110% continuous rating of the capacitor units. For this example, it will be assumed that the capacitors need not be tripped off-line for this condition.

The failure of two units will cause an overvoltage of 123% on the remaining units. The relay should signal an alarm at V_N = 419V (0.8*524 V), or 2.6Vsec to provide margin for system voltage, relay, and relay setting tolerances. The **UL** setting in per unit of VT rated volts will be set to 2.6/120 = 0.02pu The **tUL** definite time delay of the low-set unbalance element is chosen to coordinate with the protective fuse on the capacitor unit.

The relay should signal a trip condition at V_N = $\frac{524+1172}{2} = 5.1V$, midway between F = 1 and F = 2, where the overvoltage is 123%. The **UH** setting in per unit of unbalance VT secondary rated voltage would be 5.1 / 120 = 0.04 pu. The **tUH** time delay of the high-set unbalance element should be chosen to be equal to the expected fuse operating time of the second fuse. For fuseless banks, the time delay would be set as short as possible.

<u>Undercurrent element settings</u>

The undercurrent element is primarily used to detect when the capacitor bank has been de-energized. This is accomplished by monitoring when the current flowing into the capacitor bank has dropped below some set level. This is an effective means of sensing this condition as capacitor banks are connected shunt to the system, therefore their load current is fixed and varies only with system voltage levels.

The pick-up level of the undercurrent element can be set at 20% of the rated load current of the bank . In this example, 20% of the 140.6 A load current is 28.12 A. The pick-up level of the undercurrent element **I<** in per unit of the phase CTs rated current (**In**) is therefore set at 28.12/300 or 0.09 pu. The time delay of the undercurrent element **tI<** is set at 2.0 s to allow sufficient time for system faults or temporary undervoltages to be cleared. The wait time for the re-energization of the capacitors **tRI** should be 5 minutes (300 sec) to allow the capacitors to adequately discharge before re-energization. Any shorter time delay should be determined in consultation with the capacitor manufacturer.

<u>General settings</u>

The settings for **Ic** and α**c** are determined by actual field tests as described in Section 15, "Setting of the Capacitor Bank Inherent Unbalance Compensation Factor". The **tBF** setting of 0.15 s should be adequate in allowing breaker operation in most cases.

The output relay programming assignments are user specific and hence no overall general example can be considered definitive. It must be noted that the Pick-up and time delayed functions may not be assigned to the same output relay(s). Pick-up functions such as IL, IH, OL, OH, UL, and UH are generally used for alarm purposes. Pick-up of Time-delayed functions such as tIL, tIH, tOL, tOH, tUL, tUH, and tI< are generally used for trip purposes. Hence, for safety reasons, it is **not** possible to assign the pick-up and time-delayed functions to the same output relays.

One example is the use of the **tIL, tIH, tOH,** and **tUH** elements to operate output relays R1 and R2. Note that the **tBF** timer for Breaker Failure relay will be activated by operation of output relay R1. Hence it is usually advisable to use the **tIL, tIH, tOH,** and **tUH** elements to operate output relays R1. The **tI<** function operates R4. See Figure 11. The N.O. R1 contact is connected in series with the breaker trip coil. The N.C. R2 and R4 contacts are connected in series with the breaker close coil. The **tFRes** is set to Manual to ensure either operator intervention either in person or through the RS-485 Modbus communications package. If any of **tIL, tIH, tOH,** or **tUH** elements operate, the N.O. R1 relay contact will close and trip the capacitor bank breaker. The N.C. R2 relay contact will open. The operation of **tI<** will also cause the N.C. R4 relay contact to open. The relay R4 will reset after the wait time for the re-energization of the capacitors **tRI** and the N.C. R4 relay contact in the breaker close coil circuit will close again. The use of **tFRes** Manual requires operator intervention and prevents output relays R1 and R2 from resetting and causing N.C. contact of R2 to complete the breaker close coil circuit.

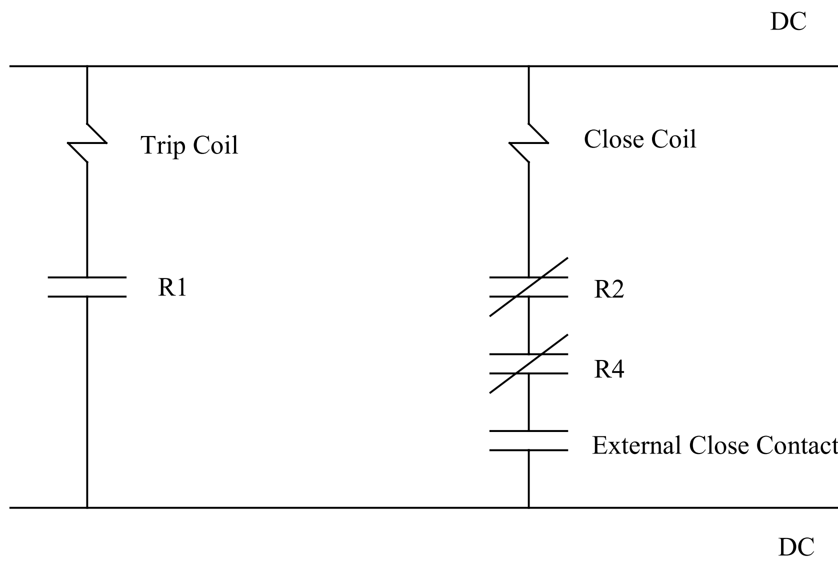


Figure 11: Typical Output Contact Connection for IM30CV

For implementing this example, the output relay assignments for relays R1 through R4 would be as follows:

tIL	1 2 - -
tIH	1 2 - -
tOH	1 2 - -
tUH	1 2 - -
tI<	- - - 4

Verification of Assumed CT Ratings:

1. The phase and unbalance CT assumed ratings are 300:5 A, C200, and 50:5, C50. It is further assumed that the full winding of the CT is employed in this application, i.e., there are no taps in this application that could reduce the CTs' voltage rating in proportion to the number of turns employed. For example, a 600:5 A CT rated C200 being operated on the 300:5 A tap has an effective voltage rating of C100.
2. Assume that the total resistance of the lead wires based on twice the length from the CT to the relay is 0.8 ohms. Also assume the same resistance of lead wires to the unbalance CT.
3. Assume the resistance of the phase CT winding is 0.15 ohms (0.0025 ohm/turn*(300/5) turns) and the resistance of the neutral CT winding is 0.025 ohms (0.0025 ohm/turn*(50/5) turns).
4. The relay resistance is 0.01 ohms for both the phase and neutral windings.
5. Assume the phase CTs are Y connected and allow computing the residual ground current. Delta connected CTs are not preferred, because they would serve as zero sequence filters (including the residual ground current) and it is desirable that the phase overcurrent relay act on all harmonics.
6. The required phase CT secondary voltage = 4183.7 A*(5/300)*(0.8+0.15+0.01) ohms

   = 66.94 V

   Note that the C200 CT's voltage rating is more than twice the required CT secondary voltage (133.88 V) and hence is adequate.
7. The normal current 'seen' by the primary of the unbalance CT is of the order of a few amps which is due to tolerances on the values of individual capacitors. The current 'seen' by the primary of the unbalance CT could be as high as the phase current caused by one open circuited phase.

   The required unbalance CT secondary voltage = 140.6 A*(5/50)*(0.8+0.15+0.01) ohms

   = 13.5 V

Note that the C50 CT's voltage rating is more than twice the required unbalance CT secondary voltage (27.0 V) and hence is adequate. A reasonably conservative voltage rating of the neutral CT is 0.2 times the system line-to-ground voltage, which will protect the CT from surge voltages appearing at the bank neutral.

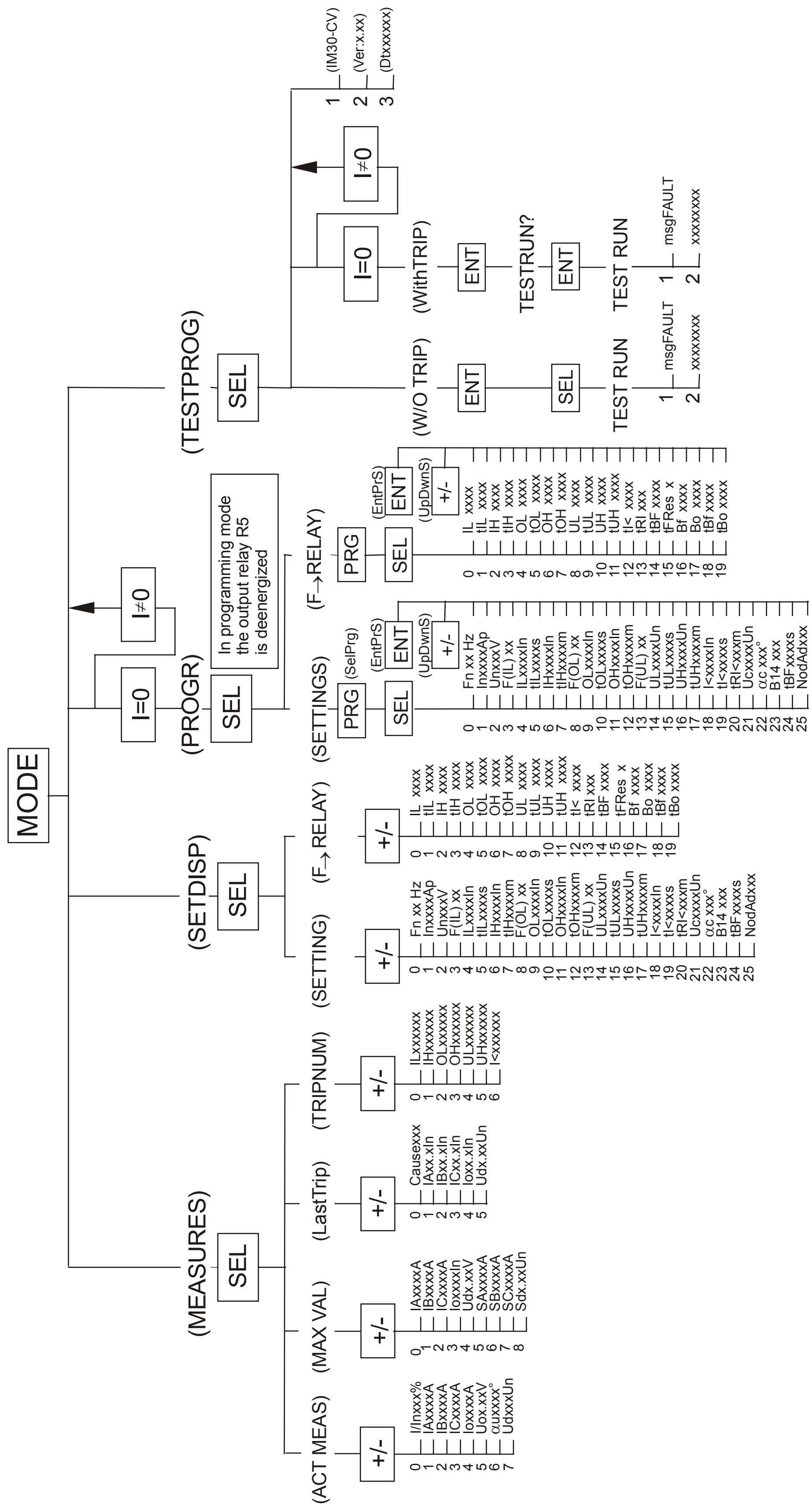
21 TESTING THE IM30CV RELAY FUNCTIONS

This section focuses on testing the IM30CV unbalance functions such as the UL, tUL, UH, and tUH, since the other overcurrent and undercurrent functions are tested with the normal procedure. To test unbalance functions a **minimum** of one current and one voltage sources are needed, although three current sources and one voltage source will provide testing of **all** the functions with one test setup. A minimum of one current source is needed because the reference angle for the unbalance voltage input is the Phase A current. The magnitude of all the phase currents should be near the rated current, with a minimum of 50% of rated for the unbalance function to be activated. If only one current source is being used, it is required that the same phase current be routed through the three phase input CTs.

It is recommended that the default settings of all the output contact relay assignments to output relay 1 be connected back to the test set in order to shut off the test set when the output relay 1 closes its contact.

Assuming only one current source is being used to test the relay, it is required that the phase current source from the test set follow a path from terminal (T) 25, through T26, through T27, through T39, through T29, through T30 back to the test set. Note that external connections to jumper T26 to T27, and jumper T39 to T29 are required. This provides the reference angle for the unbalance voltage and provides a sufficient magnitude to activate the unbalance elements. The unbalance voltage is fed from the test set to terminals 32 and 33. The settings of the unbalance elements UL and UH can be set at 0.5 Un and 1.0 Un respectively, and tUL and tUH can be set at 1 s. The pickup current level of the UL and UH can be verified to be within 0.5% of the setting. Note that at lower settings of UL and UH, for example 0.02 Un and 0.04 Un, the accuracy of the input voltage transformer which now draw a larger percentage of magnetizing current relative to the pickup voltage will result in a lower accuracy of the pickup voltages. Therefore, the accuracy of the pickup level at low settings of UL and UH will be substantially higher than 0.5%.

22 Keyboard Map



23 MAINTENANCE

No maintenance is required. Periodically a functional check-out can be made with the test procedures described under MANUAL TEST chapter. In case of malfunctioning please contact Cooper Power Systems or the local Authorized Dealer mentioning the relay's Serial No reported in the label on the relay's enclosure.

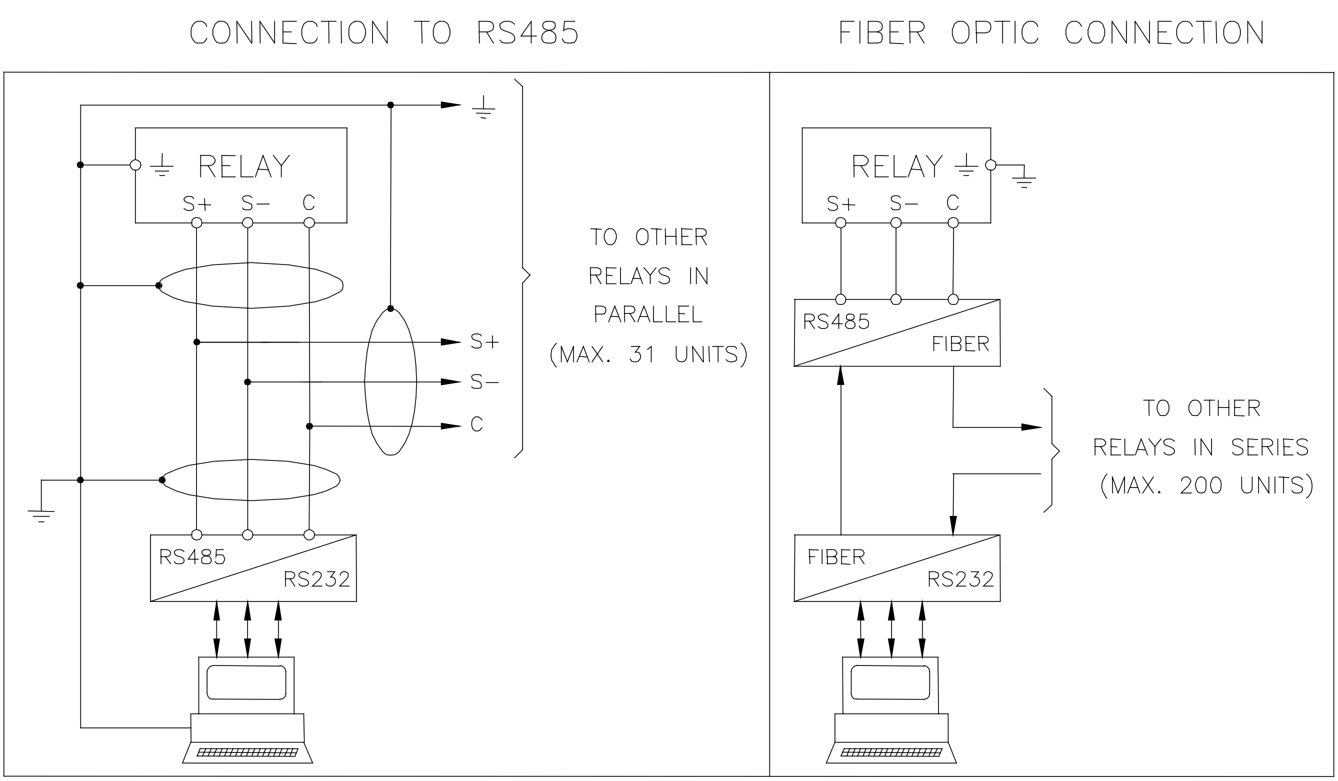
!	WARNING:	Equipment mis-operation. A relay indicating a failure or other problem should be removed from service immediately. Continued operation can result in loss of protection to the capacitor bank and equipment mis-operation.

In case of Internal Relay Fault detection, proceed as here-below indicated :

- If the error message displayed is one of the following "DSP Err", "ALU Err" ,"KBD Err" ,"ADC Err", switch off power supply and switch-on again. If the message does not disappear send the relay to Cooper Power Systems (or its local dealer) for repair.
- If the error message displayed is "E2P Err", try to program any parameter and then run "W/OTRIP".
- If message disappear please check all the parameters.

If message remains send the relay to CPS or its local dealer for repair.

24 SERIAL COMMUNICATION BUS WIRING



25 SPECIFICATIONS

APPROVAL: CE – RINA – UL and CSA approval File : E202083
REFERENCE STANDARDS IEC 60255 - EN50263 - CE Directive - EN/IEC61000 - IEEE C37

❑	Dielectric test voltage	IEC 60255-5	2kV, 50/60Hz, 1 min.
❑	Impulse test voltage	IEC 60255-5	5kV (c.m.), 2kV (d.m.) – 1,2/50µs
❑	Insulation resistance	> 100MΩ	

Environmental Std. Ref. (IEC 68-2-1 - 68-2-2 - 68-2-33)

❑	Operation ambient temperature	-10°C / +55°C
❑	Storage temperature	-25°C / +70°C
❑	Humidity	IEC68-2-3 RH 93% Without Condensing AT 40°C

CE EMC Compatibility (EN50081-2 - EN50082-2 - EN50263)

❑	Electromagnetic emission	EN55022 industrial environment			
❑	Radiated electromagnetic field immunity test	IEC61000-4-3 ENV50204	level 3	80-1000MHz 900MHz/200Hz	10V/m 10V/m
❑	Conducted disturbances immunity test	IEC61000-4-6	level 3	0.15-80MHz	10V
❑	Electrostatic discharge test	IEC61000-4-2	level 4	6kV contact / 8kV air	
❑	Power frequency magnetic test	IEC61000-4-8		1000A/m	50/60Hz
❑	Pulse magnetic field	IEC61000-4-9		1000A/m, 8/20µs	
❑	Damped oscillatory magnetic field	IEC61000-4-10		100A/m, 0.1-1MHz	
❑	Electrical fast transient/burst	IEC61000-4-4	level 3	2kV, 5kHz	
❑	HF disturbance test with damped oscillatory wave (1MHz burst test)	IEC60255-22-1	class 3	400pps, 2,5kV (m.c.), 1kV (d.m.)	
❑	Oscillatory waves (Ring waves)	IEC61000-4-12	level 4	4kV(c.m.), 2kV(d.m.)	
❑	Surge immunity test	IEC61000-4-5	level 4	2kV(c.m.), 1kV(d.m.)	
❑	Voltage interruptions	IEC60255-4-11			
❑	Resistance to vibration and shocks	IEC60255-21-1 - IEC60255-21-2 10-500Hz 1g			

CHARACTERISTICS

❑	Accuracy at reference value of influencing factors	2% Rated Input for trip levels 2% +/- 10ms for times
❑	Rated input Current	In = 1 or 5A ; On = 1 or 5A
❑	Current overload	200 A for 1 sec; 10A continuous
❑	Burden on current inputs	Phase : 0.01VA at In = 1A; 0.2VA at In = 5A Neutral : 0.03VA at In = 1A; 0.2VA at In = 5A
❑	Rated input Voltage	Un = 50 – 125V
❑	Voltage overload	2 Un
❑	Burden on voltage input	0,08 VA at Un
❑	Average power supply consumption	8.5 VA
❑	Output relays	rating 5 A; Vn = 380 V A.C. resistive switching = 1100W (380V max) make = 30 A (peak) 0,5 sec. break = 0.3 A, 110 Vcc, L/R = 40 ms (100.000 op.)

26 SETTINGS SHEET FOR IM30CV RELAY

Relay Type	IM30-CV	Station :		Circuit :	
Date :	/ /			Relay Serial Number :	
Power Supply	☐	24V(-20%) / 110V(+15%) a.c.	24V(-20%) / 125V(+20%) d.c.	Rated Current :	
	☐	80V(-20%) / 220V(+15%) a.c.	90V(-20%) / 250V(+20%) d.c.		

RELAY PROGRAMMING

Variable	Description	Setting Range		Default Setting	Actual Setting	Test Result	
						Pick-up	Reset
Fn	System frequency	50 - 60	**Hz**	50			
In	Rated primary current of the phase C.Ts.	0 - 9999	**Ap**	500			
Un	Rated secondary voltage of the P.Ts.	50 - 125	**V**	100			
F(IL)	Operation characteristic of the low-set overcurrent element	D - SI	-	D			
IL	Trip level of low-set overcurrent element	0.3-1.5-Dis	**In**	0.3			
tIL	Trip time delay of the low-set overcurrent element	1 - 50	**s**	1			
IH	Trip level of high-set overcurrent element	0.2 - 2 - Dis	**In**	0.6			
tIH	Trip time delay of the high-set overcurrent element	0.1 – 6500	**s**	0.1			
F(OL)	Operation characteristic of the low-set earth fault element	D - SI	-	D			
OL	Trip level of low-set earth fault element	0.1-1.0-Dis	**In**	0.1			
tOL	Trip time delay of low-set earth fault element	0.05 – 30	**s**	0.05			
OH	Trip level of high-set earth fault element	0.1-2.0-Dis	**In**	0.2			
tOH	Trip time delay of the high-set earth fault element	0.05 – 9.99	**s**	0.05			
F(UL)	Operation characteristic of the low-set unbalance element	D - SI	-	D			
UL	Trip level of low-set unbalance element	0.02-0.8-Dis	**Un**	0.02			
tUL	Trip time delay of low-set unbalance element	1.0 - 30	**s**	1.0			
UH	Trip level of high-set unbalance element	0.01-1.0-Dis	**Un**	0.04			
tUH	Trip time delay of the high-set unbalance element	0.1 - 300	**s**	1			
I<	Trip level of undercurrent element	Dis-0.10-1.0	**In**	0.1			
tI<	Trip time delay of the undercurrent element	1.0 – 99.9	**s**	1			
tRI<	Wait time for the re-energization of the capacitors	Dis-0.5-100	**m**	5			
Uc	Unbalance compensation level	0.00 - 0.2	**Un**	.00			
αc	Uo Λ IA phase displacement	0 - 359	**°**	0			
B14	C/B STATUS MONITORING INPUT ENABLED/DISABLED	En - Dis	-	Dis			
tBF	Max reset time delay of the instantaneous element	0.1-0.75	**s**	0.1			
NodAd	Identification number for the serial connection	1 - 250	-	1			

CONFIGURATION OF OUTPUT RELAYS											
Default Setting							**Actual Setting**				
Prot Elem.	**Output Relays**				**Description**		**Prot. Elem.**	**Output Relays**			
IL	-	-	3	-	Instantaneous element of low-set overcurrent		**IL**				
tIL	1	2	-	-	As above, time delayed element		**tIL**				
IH	-	-	3	-	Instantaneous element of high-set overcurrent		**IH**				
tIH	1	2	-	-	As above, time delayed element		**tIH**				
OL	-	-	-	-	Instantaneous element of low-set earth fault element		**OL**				
tOL	1	2	-	-	As above, time delayed element		**tOL**				
OH	-	-	-	-	Instantaneous element of high-set earth fault element		**OH**				
tOH	1	2	-	-	**AS ABOVE, TIME DELAYED ELEMENT**		**tOH**				
UL	-	-	-	-	Instantaneous element of low-set unbalance element		**UL**				
tUL	-	2	-	-	As above, time delayed element		**tUL**				
UH	-	-	-	-	Instantaneous element of high-set unbalance element		**UH**				
tUH	-	2	-	-	As above, time delayed element		**tUH**				
tI<	-	-	-	4	**TIME DELAYED ELEMENT MIN. CURRENT**		**tI<**				
tRI	-	-	-	-	**START OF RECLOSE TIMER TRI**		**tRI**				
tBF	-	-	-		**BREAKER FAILURE ELEMENT**		**tBF**				
tFRes:	M				Relay reset mode A = Automatic, M = Manual		**tFRes**:				
Bf	-	-	-	i	The input for blocking the operation of the time delayed elements relevant to phase faults (IL, IH, OL, OH)		**Bf**				
Bo			-	u	The input for blocking the operation of the time delayed elements relevant to unbalance (UH, UL)		**Bo**				
tBf	2tBF				Breaker failure alarm		**tBf**				
tBo	2tBF				As above for the unbalance functions		**tBo**				

Commissioning Engineer : ______________________ **Date :** ____________

MANUAL REVISION HISTORY Initial issue of IM30CV August 2001.

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