

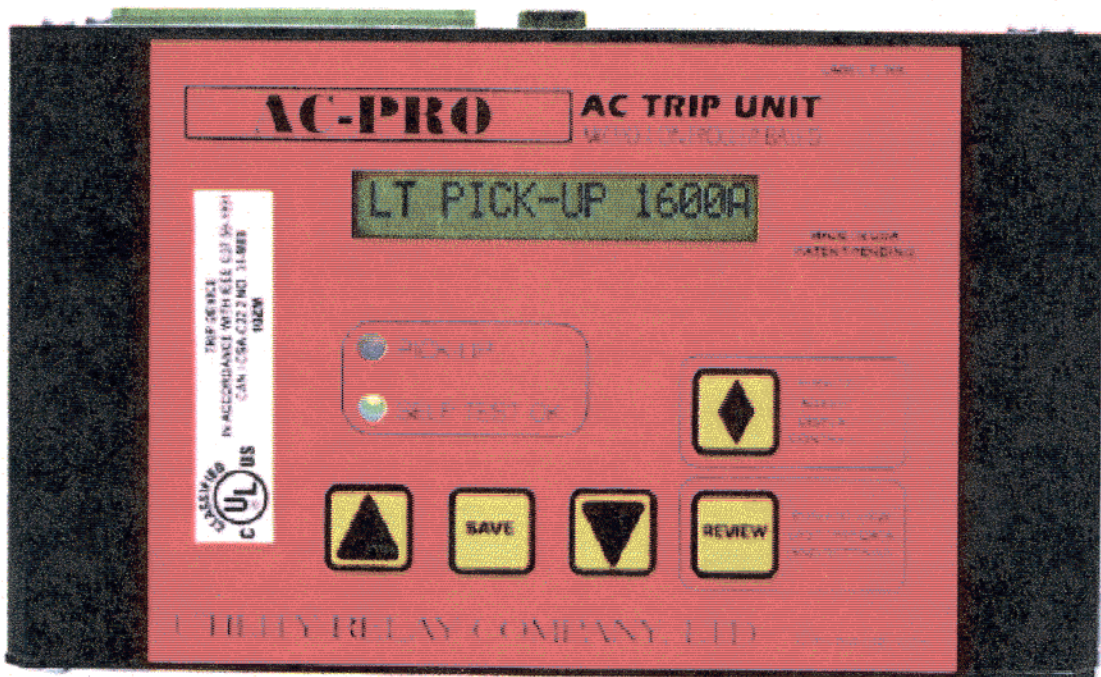
# AC-PRO

**AC TRIP UNIT**  
MICRO-CONTROLLER BASED

# Instruction Manual

## I-AC-PRO

Revision: May, 2000



**State of the art technology for low  
voltage circuit breaker retrofitting.**

**URC**

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## 1. Introduction

The AC-PRO is a state of the art, micro-controller based trip unit for use on three phase, 600 Volt class, AC circuit breakers.

The AC-PRO is a digital trip unit that uses a Motorola 8-bit micro-controller and a 16 character liquid crystal display (LCD).

The AC-PRO measures the true RMS current through each of the breaker's three poles. The trip unit also does a vector sum of the three phase currents (and neutral current if applicable) and determines the 60 Hz component of any ground fault current. For the 50 Hz, 40 Hz, and 25 Hz versions of the AC-PRO, the appropriate fundamental frequency is determined.

The trip unit provides over-current, as well as short-time and instantaneous fault protection. The trip unit also offers ground fault and phase unbalance (U/B) tripping functions as user selectable options.

The trip unit stores trip data in a non-volatile memory for later recall.

The trip unit does not require external power to operate. Power is derived from the current transformers (Cts). An internal battery provides power to review and change protection settings when CT power is unavailable.

All settings are made directly in amps or in seconds. A security system reduces the risk of unauthorized tampering with the trip unit settings.

## 2. UL/ULC Classification

AC-PRO is UL and ULC classified for use on the following low voltage AC power circuit breakers:

Westinghouse DB-50

UL and ULC classification is in accordance with UL1066, CSA C22.2, IEEE C37.59-1991 as well as appropriate sections of ANSI C37.17-1979 and C37.50-1989.

AC-PRO was tested by an independent laboratory and found in compliance with the following tests:

RF Susceptibility  
Surge Withstand  
15KV Electro-Static Discharge  
Accuracy @ -20°C & +65°C

## 3. Unit Power

The AC-PRO can be powered in 3 different ways: Cts, battery, or auxiliary power pack.

### 3.1 Current Transformer (CT) Power

The AC-PRO derives both signal and power from the phase Cts. The trip unit will power-up with less than 10% of the rated CT tap current through a single CT (20% for the 1/2 Amp version). This current is below the lowest pick-up setting.

While on CT power, the battery is float charging.

### 3.2 Battery Power

A 9 volt style, Nickel Metal Hydride battery is incorporated in the trip unit. The battery is under a 5mA trickle charge whenever the trip unit is powered from the Cts or the auxiliary power pack.

The trip unit periodically checks the battery charge. The state of the battery charge (OK, LOW or DEAD) is displayed in the settings review mode. If the battery is "dead", the Self Test OK LED will go out.

The battery is designed to provide two functions:

- 1) Allow the user to commission (program) the trip unit without using the auxiliary power pack.
- 2) Recall the last trip data even if the breaker is open and without using the auxiliary power pack.

Press the "REVIEW" push button to turn on the trip unit under Battery power. The unit also enters battery power mode after control power is removed.

When on battery power, the trip unit will automatically turn off after 60 seconds to conserve battery energy.

#### \*\*\*\* NOTE \*\*\*\*

The battery is NOT involved in the protective functions of the trip unit. The trip unit will provide protection even if the battery is removed.

The battery is NOT required for the trip unit to maintain any of its memory including the user programmed pick-up and delay settings.

The battery will slowly self discharge if the breaker is not in service for an extended period of time. The battery will begin recharging immediately after the trip unit is returned to service and the breaker is carrying more than 10% current (20% for the 1/2 Amp version).

The battery can be accessed by removing the four screws securing the top cover plate on the trip unit.

#### \*\*\*\* IMPORTANT \*\*\*\*

It is important that the battery be replaced only with one of the following type of 9.0 volt style battery.

Plainview No. PBNH-1605 Ni Metal Hydride  
Eveready No. CH22 Ni-Cad  
Panasonic P-9SPA Ni-Cad

***Installing an alkaline type battery will cause severe damage to the trip unit.***

The breaker must be removed from service before removing the top cover on the trip unit.

### 3.3 Auxiliary Power

Auxiliary power is optional. It can be used to recharge the trip unit's internal battery (if the breaker is not in service or carrying very low current) and to change or review trip unit settings under low battery charge conditions.

Connect the 24 Vac auxiliary power pack into the auxiliary power jack on the top of the trip unit.

The power pack is available from Utility Relay Company as part number T-390.

## 4. External Connections

Figure 4.1 shows the external connections to the AC-PRO trip unit.

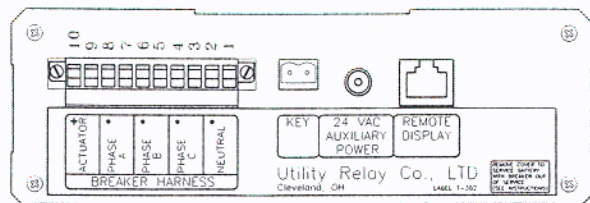


Figure 4.1 AC-PRO Top View.

### 4.1 Breaker Wiring Harness

The breaker wiring harness connects the trip unit to the Cts and actuator. The wiring harness plugs into the 10 pin connector on the top of the trip unit and is retained with two screws.

Table 4.1 shows the breaker wiring harness pin-outs.

Terminal	Function	Color Code
1	Neutral CT	White
2	Neutral CT	Green
3	Phase C	White
4	Phase C	Brown
5	Phase B	White
6	Phase B	Yellow
7	Phase A	White
8	Phase A	Blue
9	Actuator (-)	Black
10	Actuator (+)	Red

Table 4.1 Breaker Wiring Harness

The neutral CT wiring is part of the neutral CT installation kit and is only required with ground fault on a 4-wire system. The ground fault function on a 3-wire system does not require a neutral CT.

The CT side of the breaker wiring harness connects either to the CT lugs using ring tongue terminals or to the CT wires using butt splice connectors. The wiring harness should be shortened as required to suite the application.

### 4.2 Remote Display

A panel mount remote display is available as an option for the AC-PRO. It is mounted on the front of the cubicle door. It provides the capability of viewing the breaker currents and reviewing the settings and the last trip data **without opening the breaker cubicle door**.

**For security reasons, it is not possible to change any settings from the remote display.**

A shielded cable with modular type connectors is provided to connect the trip unit to the remote display. See the Remote Display manual for more details.

### 4.3 Security Key

The AC-PRO trip unit contains a security feature that only allows someone familiar with the operation of the trip unit to commission the trip unit or make changes to the settings. A security key is required to change any settings.

The "Key" is simply a short jumper wire that is connected between the two terminals marked "KEY" on the top of the trip unit.

Refer to Figure 4.1 AC-PRO Top View.

To turn the security Key "ON":  
Jumper the two terminals labeled "KEY" on the top of the trip unit.

To turn the security Key "OFF":  
Remove the jumper wire.

The key allows the user to commission the trip unit or to change the settings on a trip unit by performing the steps as outlined in sections 6.0 and 7.0.

## 5. Front Panel

The front panel is shown in Figure 5.1.

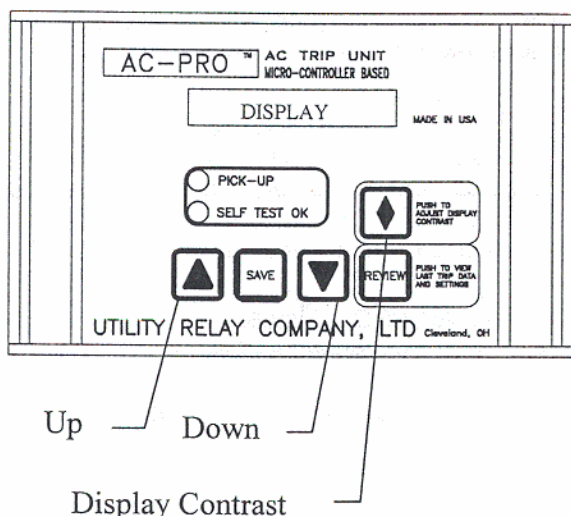


Figure 5.1 AC-PRO Front Panel

### 5.1 16 Character Display

A 16 character dot matrix liquid crystal display (LCD) provides information to the user.

The LCD is used for the following purposes:

- 1) Entering the CT rating and making the pick-up and time delay settings with prompts from the display.
- 2) Displaying on demand, the CT rating and the various pick-up and delay settings.
- 3) Displaying on demand, the reason for the last trip and the currents at the time of trip.
- 4) Continuously monitoring the actual AC currents on the circuit.

### 5.2 Pick-Up LED

The Pick-up LED is normally off. It will turn on whenever the breaker current is above the LT Pick-up setting.

### 5.3 Self Test LED

The Self Test LED is normally on. It will turn off under the following conditions:

- 1) The actuator is not connected. The LCD will also display an error message.
- 2) There is a checksum error in the micro-controller. The LCD will also display an error message.
- 3) The battery is dead. No LCD error message will appear.

### 5.4 Display Contrast

The contrast level of the LCD can be adjusted by pressing this push button

When the contrast push button is pressed and held, the display will begin to get either darker or lighter. To change direction, release the push button for more than 1 second, then press and hold the push button until the desired contrast is achieved.

## 5.5 Up

Use this push button to increase the setting values during commissioning. When the push button is held longer than 1 second, the settings are increased in fast mode.

When the maximum setting value is reached, the increase key will have no further effect on the setting value.

## 5.6 Down

Use this push button to decrease the setting values during commissioning. When the push button is held longer than 1 second, the settings are decreased in fast mode.

When the minimum setting value is reached, the decrease key will have no further effect on the setting value.

## 5.7 Save

Use this push button to step through the settings in commissioning mode.

Holding this push button has no effect.

## 5.8 Review

Use this push button to step through the settings in settings review mode. Also use this push button to turn on the trip unit using battery power.

Hold this push button down to review trip counts during settings review.

## 6. Commissioning

Before the AC-PRO trip unit is put into service, it must first be commissioned so it will function. This requires the user to enter all of the pick-up and delay settings into the unit.

The commissioning process normally takes less than a few minutes to complete.

### \*\*\*\* IMPORTANT \*\*\*\*

The trip unit will NOT FUNCTION as it is shipped from the factory. The user must first COMMISSION the unit as outlined in this Section to make it functional.

After the AC-PRO is installed on the breaker, it must be commissioned as follows:

- 1) Close the security key (see Section 4.4)
- 2) Power-up the trip unit (see Section 6.1)
  - a.) If the trip unit has not yet been commissioned, the trip unit will alternately display the following when powered up:

ENTER DATA

SERIAL # XXXXXXXX

Press the "SAVE" push button to begin the commissioning process.

- b.) If the trip unit has already been commissioned and you simply want to change the settings, the trip unit will display the following when powered up:

LOW CURRENT

Pressing the "REVIEW" push button with the security key closed will now cause the display to alternate the following:

ENTER DATA

SERIAL # XXXXXXXX

Press the "SAVE" push button to begin the commissioning process.

- 3) Enter the appropriate CT tap, pick-up and delay settings (see Sections 6.3 thru 6.15).
- 4) Open the security key (see Section 4.3).

## 6.1 Powering-Up The Trip Unit

For commissioning, the AC-PRO trip unit can be powered-up in either of the following two ways.

### 1) Internal Battery

Press the "REVIEW" button to power-up the trip unit using the internal battery.

The trip unit is designed to shut off automatically if none of the 4 lower push buttons on the face of the unit are pressed for 30 seconds. It is, therefore, best to have all the desired setting readily available before commissioning the unit when using the battery.

If the unit shuts down before the commissioning process is completed, the process must be started again from the beginning.

If the battery charge is low, it is best to power the trip unit by providing it with external power as described below.

### 2) External Power

Apply 24 VAC to the "auxiliary power" jack located on the top of the trip unit using the Utility Relay auxiliary power pack, part T-390.

By applying external power, the unit will stay energized as long as necessary to complete the commissioning process.

When the trip unit is powered, the following will alternate on the display if the trip unit has not already been commissioned:

ENTER DATA

SERIAL # XXXXXXXX

Press the "SAVE" push button to continue.

## 6.2 Security Key During Commissioning

The following will be displayed if the security key is not already installed:

SECURITY KEY OFF

Install the security key to continue the commissioning process. See Section 4.3.

## 6.3 CT Rating

After the security key is closed, the following will be displayed:

CT RATING      XXXXA

Where "XXXX" represents the CT Rating in amps. The CT rating can range from 50 amps to 4,000 amps in 25 amp steps.

Press and hold the "UP" or "DOWN" push button as required until the correct CT rating is displayed.

Press the "SAVE" push button to continue.

## 6.4 Long Time (LT) Pick-Up Setting

The following will be displayed:

LT PICK-UP      XXXXA

Where "XXXX" represents the LT Pick-Up setting in amps. The LT Pick-Up setting ranges from 20% to 100% of the CT rating. This setting is adjustable in 5 amp steps.

Press and hold the "UP" or "DOWN" push button as required until the correct LT Pick-Up setting is displayed.

Press the "SAVE" push button to continue.

## 6.5 Long Time (LT) Delay Setting

The following will be displayed:

LT DELAY XX.XSEC

Where "XX.X" represents the LT Delay band. The LT Delay band is labeled by the number of seconds to trip at 6 times the LT Pick-Up setting.

The LT Delay setting ranges from 2.5 to 30 seconds in steps of 0.5 seconds. This provides 56 LT Delay bands.

Please note that the LT Trip Time is not a constant value, but is a function of breaker current. For low currents the trip time is longer, and for higher currents the trip time is shorter. The trip time is only equal to the LT Delay setting when a current 6 times the LT Pick-Up setting is applied. See the time-current curves in Section 15.

Press and hold the "UP" or "DOWN" push button as required until the correct LT Delay setting is displayed.

Press the "SAVE" push button to continue.

## 6.6 Short Time (ST) Pick-Up Setting

The following will be displayed:

ST PICK-UP OFF

If the ST function is **not** desired, press the "SAVE" push button and go to Step 6.9.

If the ST function **is** desired, press the "UP" push button and the following will be displayed:

ST PICK-UP XXXXA

Where "XXXX" represents the ST Pick-Up in amps.

The ST Pick-Up setting ranges from 150% to 1200% of the LT Pick-Up setting in 100 amp steps. Press and hold the "UP" or "DOWN" push button as required until the correct ST Pick-Up setting is displayed.

Press the "SAVE" push button to continue.

\*\*\*\* CAUTION \*\*\*\*

DO NOT set the ST Pick-Up above the breaker ST interrupting rating

## 6.7 Short Time (ST) Delay Setting

If the ST function is not off, then the following will be displayed:

ST DELAY .XXSEC

Where ".XX" represents the ST Delay.

The ST Delay settings are .07, .10, .15, .20 and .30 seconds.

Press and hold the "UP" or "DOWN" push button as required until the correct ST Delay setting is displayed.

Press the "SAVE" push button to continue.

## 6.8 Short Time (ST) I<sup>2</sup>T

If the ST function is not off, then the following will be displayed:

ST I SQ T OFF

If the I<sup>2</sup>T ramp is **not** desired, press the "SAVE" push button to move to the next setting.

If the ST I<sup>2</sup>T ramp **is** desired, press the "UP" push button. The following will be displayed:

ST I SQ T ON

Pushing the "DOWN" push button will turn the ST I<sup>2</sup>T ramp off again.

Press the "SAVE" push button to continue.

## 6.9 Instantaneous (I) Pick-Up Setting

The following will be displayed:

I PICK-UP	XXXXXA
-----------	--------

Where "XXXXX" represents the I Pick-Up in amps.

The I Pick-Up setting ranges from 150% to 1200% of the LT Pick-Up setting in steps of 100 amps.

Press and hold the "UP" or "DOWN" push button as required until the correct I Pick-Up setting is displayed.

If the I function is **not** desired and the ST function is **not** off, press the "DOWN" push button until the following is displayed:

I PICK-UP	OFF
-----------	-----

### \*\*\*\* NOTE \*\*\*\*

Having both the ST and the I functions off at the same time is not allowed by the trip unit.

Press the "SAVE" push button to continue.

## 6.10 Ground Fault (GF) Pick-Up Setting

The following will be displayed:

GF PICK-UP	OFF
------------	-----

If the GF function is **not** desired, press the "SAVE" push button and go to Step 6.13.

If the GF function is desired, press the "UP" push button and the following will be displayed:

GF PICK-UP	XXXXA
------------	-------

Where "XXXX" represents the GF Pick-Up setting in amps.

The minimum GF Pick-Up setting is 20% of the CT rating. Steps are in 10 amp increments. The maximum value is 200% of CT rating or 1200 amps, whatever is lower.

Press and hold the "UP" or "DOWN" push button as required until the correct GF Pick-Up setting is displayed.

Press the "SAVE" push button to continue.

## 6.11 Ground Fault (GF) Delay Setting

If the GF function is not off, then the following will be displayed:

GF DELAY	.XXSEC
----------	--------

Where ".XX" represents the GF Delay.

The GF Delay settings are .10, .20, .30, .40 and .50 seconds.

Press and hold the "UP" or "DOWN" push button as required until the correct GF Delay setting is displayed.

Press the "SAVE" push button to continue.

## 6.12 Ground Fault (GF) I<sup>2</sup>T

If the GF function is not off, then the following will be displayed:

GF I <sup>2</sup> T	OFF
---------------------	-----

If the I<sup>2</sup>T ramp is **not** desired, press the "SAVE" push button to move to the next step.

If the GF I<sup>2</sup>T ramp is desired, press the "UP" push button. The following will be displayed:

GF I <sup>2</sup> T	ON
---------------------	----

Pushing the "DOWN" push button will turn the GF I<sup>2</sup>T ramp off again.

Press the "SAVE" push button to continue.

### 6.13 Phase Unbalance (U/B) Pick-up Setting

The following will be displayed:

U/B PICK-UP      OFF

If the U/B function is **not** desired, press the "SAVE" push button and go to Step 6.15.

If the U/B function **is** desired, press the "UP" push button and the following will be displayed:

UB PICK-UP      XX%

Where "XX" represents the U/B Pick-Up setting in percentage of largest phase current.

The minimum UB Pick-Up setting is 20%. Steps are in 5% increments. The maximum value is 50%.

Press and hold the "UP" or "DOWN" push button as required until the correct U/B Pick-Up setting is displayed.

Press the "SAVE" push button to continue.

### 6.14 Phase Unbalance (U/B) Delay Setting

If the U/B function is not off, then the following will be displayed:

UB DELAY      XXSEC

Where "XX" represents the U/B Delay.

The U/B Delay setting ranges from 1 to 60 seconds in steps of 1 second.

Press and hold the "UP" or "DOWN" push button as required until the correct U/B Delay setting is displayed.

Press the "SAVE" push button to continue.

### 6.15 Exit Procedure

The following will be displayed:

SAVE IF DONE

REVIEW TO REVIEW

If it is desired to review the setting, push the "REVIEW" push button. Make any changes necessary using the "UP" or "DOWN" push buttons. As before, use the "SAVE" push button to move to each new setting.

If the settings are as desired, push the "SAVE" push button.

The following will be displayed:

REMOVE KEY TO

COMMISSION UNIT

Remove the "key". See section 4.3 and the settings will be saved in the non-volatile EEPROM memory.

If the commissioning process was performed using the internal battery, the unit will turn itself off.

If the commissioning process was performed by supplying external power to the trip unit, the following will be displayed:

LOW CURRENT

**The commissioning process is complete.**

## 7. Changing Settings

### \*\*\*\* IMPORTANT \*\*\*\*

While it is possible to make changes to the settings with the breaker in service, it is strongly recommended that **THE BREAKER BE REMOVED FROM SERVICE** while making these changes since the trip unit will not provide protection during this process.

After the trip unit is commissioned, settings can easily be changed in the following manner.

Close the security key. See Section 4.3.

Power up the trip unit by pressing "REVIEW" or by applying external power as described in Section 6.1.

Press the "REVIEW" push button. The following will be displayed:

ENTER DATA

SERIAL # XXXXXXXX

Press the "SAVE" push button.

Make any necessary changes using the "UP" or "DOWN" push buttons. Use the "SAVE" push button to move to each new setting.

After going through all the settings, the following will be displayed.

SAVE IF DONE

REVIEW TO REVIEW

If it is desired to review the setting, push the "REVIEW" push button. Make any changes necessary using the "UP" or "DOWN" push buttons. As before, use the "SAVE" push button to move to each new setting.

If the settings are as desired, push the "SAVE" push button. The following will be displayed:

REMOVE KEY TO

COMMISSION UNIT

Remove the security key. See Section 4.4. The settings will be saved in the non-volatile EEPROM memory.

**The Settings have been changed.**

Remember, if power is lost by the trip unit during this process, the old settings will be retained and the process must be repeated.

## 8. Target Recall of Last Trip Data

The AC-PRO has an especially useful "target recall" system.

After a breaker trip, the trip unit will display the type of trip (i.e. LT, ST, I, GF, or U/B as applicable) and the currents at the time of trip followed by the settings. This information is saved in the non-volatile EEPROM memory and is available immediately after a trip or anytime thereafter.

### \*\*\*\* NOTE \*\*\*\*

Only the data from the last trip is saved. The second time the breaker trips, the new trip data is written over the first trip data.

- a) Push the "Review" push button to recall the Last Trip Data and settings. The following will be displayed if there was **no** last trip:

NO LAST TRIP

If there was a last trip, the following messages will alternately display showing the cause of the trip and the currents at the time of trip. The messages alternate at a 1.0 second interval rate:

LAST TRIP	XX
PHASE A	XXXXXA
PHASE B	XXXXXA
PHASE C	XXXXXA
GF	XXXXXA

If GF current is greater than 2 times the CT Rating, the following will be displayed for GF:

GF>2XCT RATING
----------------

Currents will be displayed only if greater than 10% of the CT Rating.

U/B	YY%
-----	-----

The U/B percentage will only be displayed if greater than 4%.

The text "XX" is the type of tripping event (i.e. LT, ST, I, GF, or U/B as applicable) and "XXXXXA" is the magnitude of the current at the time of trip for each phase. The text "YY" is the percentage of unbalance at trip.

- b) Press the "REVIEW" push button again to view the following message:

HOLD <REVIEW> TO
VIEW TRIP COUNTS

- c) If the "REVIEW" key is pushed again and held down for longer than 2 seconds, each type of trip is displayed along with the number of times that trip has occurred. If the "REVIEW" is pressed, but not held for 2 seconds, the trip count is skipped and the battery status is displayed.

INST TRIPS:	XX
LT TRIPS:	XX
ST TRIPS:	XX
GF TRIPS:	XX
U/B TRIPS:	XX

The text "XX" is the number of trips since last commissioned or reset.

- d) Pressing the "REVIEW" push button again will display the state of the unit's battery. The battery state will be one of the following:

BATTERY	????
---------	------

The battery has not been tested yet to determine its condition.

BATTERY	DEAD
---------	------

The battery has barely enough energy to operate the display.

BATTERY	LOW
---------	-----

The battery has enough energy to operate the display for a short time only.

BATTERY	OK
---------	----

The battery is fully charged.

- e) By pressing the "REVIEW" push button the present settings programmed in the trip unit can be stepped through in sequence.

**\*\*\*\* NOTE \*\*\*\***

Pushing the "SAVE", "UP" or "DOWN" push buttons during "target recall" has no effect because the key is not installed.

When pushing "REVIEW" after the last setting, the trip unit will turn itself off. If the "REVIEW" push button is not pressed for about 60 seconds, the trip unit will also turn off.

## 9. Normal Operation

### Breaker Current Less than 20% of CT Rating:

With the breaker in service, and the current is less than 20% of the CT rating, the display will show the following:

LOW CURRENT

### Breaker Current Greater than 20% of CT Rating:

If the breaker current is greater than 20% of the CT rating but less than the LT pick-up value, the following will be shown on the display:

PHASE X      XXXXA

Where X is the phase and XXXX is the current in amps for that phase.

When the trip unit detects a phase overload situation, the "PICK-UP" light on the front of the trip unit will illuminate, and the following will alternately be shown on the display at 1 second intervals:

PHASE X      XXXXA

OVERLOAD

## 10. Testing

A "primary injection" test is recommended as the final test of the AC-PRO retrofit.

It is not necessary to turn off the Unbalance (U/B) function when doing a single phase primary injection test.

If used, GF must be temporarily turned OFF when testing the other trip functions.

### 10.1 Commission the Trip Unit

Before proceeding with the normal primary injection tests, the trip unit must be commissioned to make it functional. See Section 6.0 for the commissioning procedure.

It is best to use the final pick-up and time delay settings if they are known. If not, use typical settings for the primary injection test.

Make sure GF is temporarily set to "OFF". U/B can be left "ON".

### 10.2 LT Trip Test

To test the LT Pick-Up, increase the current until the "Pick-Up" LED illuminates.

The injected current should correspond to the programmed LT Pick-Up setting.

To test the LT trip time, first determine the trip time based on the value of the test current that will be applied. Use the formula in Section 13.1.

***A simple shortcut is to note that the trip time (center of the curve) at 3 times the LT pick-Up current is 4 times the LT Delay setting.***

For example:

If the LT Pick-Up is 1600 amp and the LT Delay setting is 10 sec.; the trip time at 4800 amp (3 times 1600 amp) is 40 sec. (4 times 10 sec.).

### 10.3 ST Trip Test

Make sure GF is temporarily set to "OFF". U/B can be left "ON".

To test the ST Pick-Up, apply a short pulse of current that is 10% or 20% less than the ST Pick-Up setting. Continue applying short pulses of current while increasing the current for each pulse until a ST trip occurs. The first current where a ST trip occurred is the ST Pick-Up.

To test the ST Delay, apply a current that is at least 10% greater than the ST Pick-Up current.

The trip time should fall within the time band shown on the Time-Current curves.

### 10.4 I Trip Test

Make sure GF is temporarily set to "OFF". U/B can be left "ON".

Test the Instantaneous Pick-Up and trip time in the same manner as ST.

### 10.5 GF Trip Test

With GF Pick-Up and Delay set to the required values, testing any one of the three poles will provide a GF trip.

Test the GF Pick-Up and trip time in the same manner as ST.

### 10.6 U/B Trip Test

The U/B trip function is not easy to test with a single phase, high current test set.

Figure 10.1 illustrates a method to test the U/B trip function. It requires using cable or bus to jumper the breaker poles as shown. This generates an unbalanced current of 50% or slightly more depending on how equally the current is split between the two poles.

It is only necessary to inject a current equal to 20% or 30% of the CT rating for this test. It is only possible to test the U/B trip time and not the U/B Pick-Up with this method.

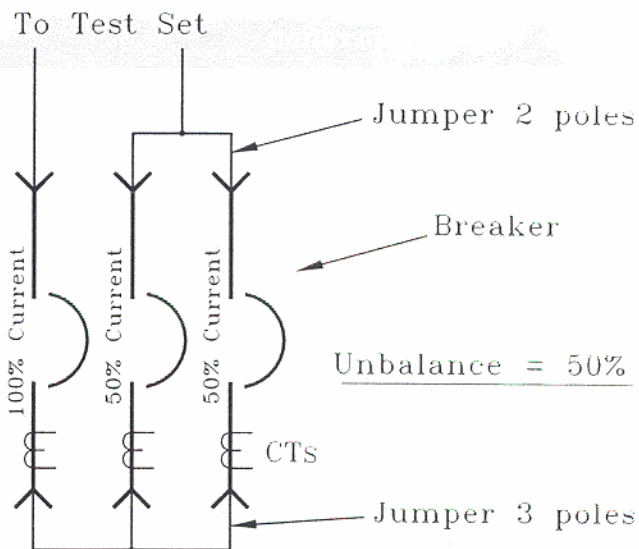


Figure 10.1, U/B Test

## 10.7 Erase Last Trip Data

*After completing the primary injection test, it is important to erase the last trip data from the memory of the trip unit. Note that the trip counter is also erased using the procedures below.*

To erase the last trip data from memory in the trip unit after completing the primary injection tests, use one of the following methods:

### Method 1:

- 1) The trip unit should not be powered-up (i.e. the display should be OFF).
- 2) Press the **REVIEW** push button once. This will activate the LCD and display the Last Trip Data.
- 2) Press and hold in both the ▲ and ▼ push buttons simultaneously.
- 3) While continuing to depress the ▲ and ▼ push buttons, press the **SAVE** push button.
- 4) Release all push buttons. The following will be displayed:

NO LAST TRIP

The trip counter data is also erased and set to 0.

### Method 2:

- 1) The trip unit should not be powered-up (i.e. the display should be OFF).
- 2) Close the security key. See section 4.3.
- 3) Press and hold in both the ▲ and ▼ push buttons simultaneously.
- 4) While continuing to depress the ▲ and ▼ push buttons, press the **REVIEW** push button.
- 5) Release all push buttons. The following will be displayed:

ERASE COM FLAG?

- 5) Pressing the ▲ push button will **ERASE** the current pick-up and delay settings. Press the ▼ push button if you **DO NOT** want to erase the current pick-up and delay settings.  
NOTE: If the COM FLAG is erased, the trip unit will need to be recommissioned.

- 6) The following will be displayed next:

ERASE LAST TRIP?

- 7) If the last trip data is to be erased, press the ▲ push button. If the data is **not** to be erased, push the ▼ push button.
- 8) Remove the security key. Press the **REVIEW** push button to confirm any changes.

### \*\*\*\* IMPORTANT \*\*\*\*

If the last trip data is not erased after the primary injection test, the operating personnel may later assume that the breaker interrupted a fault at some time in the past when they use the "TARGET RECALL" feature. The trip counter will also have misleading data.

## 11. Ratings

Ambient Temperature:

Trip Unit:

-4°F (-20°C) to 150°F (65°C)

LCD Display:

Standard Temp, Super Twist  
32°F (0°C) to 122°F (50°C)

Humidity:

95% non-condensing

Conformal Coating:

Acrylic conformal coating  
HumiSeal type 1B15H  
or Konform type AR2000

Enclosure:

Extruded aluminum housing  
6.76" X 3.84" X 2.28" nominal overall  
dimensions.

## 12. Warranty

A conditional 2-year warranty is offered with each AC-PRO trip unit.

Contact Utility Relay Company, LTD for full details.

## 13. Time-Current Curves

The Time-Current curves are shown in Section 15.

The curves are shown on a 4 X 5 log-log graph with seconds in the vertical direction and normalized current or percentage in the horizontal direction.

Overload and fault currents are shown as multiples of the LT pick-up setting. Ground current is shown as a percentage of the CT rating.

Tolerances for the Pick-Up bands are  $\pm 10\%$  in the current direction. Tolerance for LT, ST  $I^2 T$  and GF  $I^2 T$  trip times are  $\pm 23\%$  in the time direction.

The curves for the following time bands:

LT  
ST  $I^2 T$   
GF  $I^2 T$

are based on the following equation:

$$I^2 T = \text{Constant}$$

Where: I is current in amps

T is time to trip in seconds (center of the band)

When performing trip timing tests using a primary injection test set, the trip time at various test currents can be determined by calculation as follows:

## 13.1 LT Trip Time

For overload currents, the above equation can be restated as follows:

$$T = TBC_{LT} \text{ divided by } X^2$$

Where: T = time to trip in seconds (center of the band)

X = current in multiples of the LT pick-up setting

$TBC_{LT}$  = the LT Time Band Constant  
= 36 X LT time band setting

Test Current = Test set current

### \*\*\*\* NOTE \*\*\*\*

The LT Time Band Constant ( $TBC_{LT}$ ) = 36 X  
The LT Time Band Setting in seconds.

### EXAMPLE #1:

CT Rating	1600A	
LT pick-up	1200A	350
LT time band	20S	30S
Test Current	3600A	900

$$\begin{aligned} TBC_{LT} &= 36 \times \text{LT Time Band Setting} \\ &= 36 \times 20 \\ &= 720 \end{aligned}$$

$$\begin{aligned} \text{and } X &= 3600A / 1200A \\ &= 3 \end{aligned}$$

therefore:

$$\begin{aligned} \text{trip time} &= T = TBC_{LT} / X^2 \text{ or } 720/3^2 \\ &= 720/9 \\ &= 80 \text{ seconds} \end{aligned}$$

### \*\*\*\* NOTE \*\*\*\*

To determine the LT trip time by calculation:

- 1) Calculate the LT Time Band Constant ( $TBC_{LT}$ )
- 2) Calculate "X" where  
 $X = \frac{\text{(test current)}}{\text{(LT Pick-Up Setting)}}$
- 3) Solve the equation:  
 $\text{trip time(sec)} = TBC_{LT} \text{ divided by } X^2$

## 13.2 ST Trip Time

With  $I^2T$  off or for currents greater than 10 X LT Pick-Up Setting, the ST trip time is a constant equal to the ST Time Band setting.

With  $I^2T$  on and for currents less than 10 X LT Pick-Up Setting, the ST trip time is determined by the following equation:

$$T = TBC_{ST} \text{ divided by } X^2$$

Where: T = time to trip in seconds (center of the band)

X = current in multiples of the LT pick-up

$TBC_{ST}$  = the ST Time Band Constant

Test Current = Test set current

### \*\*\*\* NOTE \*\*\*\*

The ST Time Band Constant ( $TBC_{LT}$ ) =  
 30 for the .30S Time Band  
 20 for the .20S Time Band  
 15 for the .15S Time Band  
 10 for the .10S Time Band  
 7 for the .07S Time Band

### EXAMPLE #2:

CT Rating	1600A
LT pick-up	1200A
ST pick-up	6000A
ST time band	.20S $I^2T$ ON
Test Current	7200A

$$TBC_{ST} = 20$$

$$\text{and } X = 7200A/1200A = 6$$

therefore:

$$\begin{aligned} \text{trip time} &= T = TBC_{ST} / X^2 \text{ or } 20/6^2 \\ &= 20/36 \\ &= .556 \text{ seconds} \end{aligned}$$

### \*\*\*\* NOTE \*\*\*\*

To determine the ST  $I^2T$  trip time by calculation:

- 1) Determine the ST Time Band Constant ( $TBC_{ST}$ )
- 2) Calculate "X" where  $X = (\text{test current})/(\text{LT Pick-Up Setting})$
- 3) Solve the equation:  
 $\text{trip time(sec)} = TBC_{ST} \text{ divided by } X^2$

## 13.3 GF Trip Time

With  $I^2T$  off or for currents greater than 2 times the CT rating, the GF trip time is a constant equal to the GF Time Band setting.

With  $I^2T$  on and for currents less than 2 times the CT rating, the GF trip time is determined by the following equation:

$$T = TBC_{GF} \text{ divided by } X_{GF}^2$$

Where: T = time to trip in seconds (center of the band)

$X_{GF}$  = current/ CT rating

$TBC_{GF}$  = the GF Time Band Constant

Test Current = Test set current

### \*\*\*\* NOTE \*\*\*\*

The GF Time Band Constant ( $TBC_{GF}$ ) =  
 2.0 for the .50S Time Band  
 1.6 for the .40S Time Band  
 1.2 for the .30S Time Band  
 0.8 for the .20S Time Band  
 0.4 for the .10S Time Band

### EXAMPLE #3:

CT Rating	1600A
LT pick-up	1200A
GF pick-up	640A
GF time band	.20S $I^2T$ ON
Test Current	800A

$$TBC_{GF} = .80$$

$$\text{and } X_{GF} = 800A/1600A = .50$$

therefore:

$$\begin{aligned} \text{trip time} &= T = TBC_{GF} / X^2 \text{ or } .80/ (.50)^2 \\ &= .80/.25 \\ &= 3.20 \text{ sec} \end{aligned}$$

### \*\*\*\* NOTE \*\*\*\*

To determine the GF  $I^2T$  trip time by calculation:

- 1) Determine the GF Time Band Constant ( $TBC_{GF}$ )
- 2) Calculate " $X_{GF}$ " where  $X_{GF} = (\text{test current})/(\text{CT Rating})$
- 3) Solve the equation:  
 $\text{trip time(sec)} = TBC_{GF} \text{ divided by } X_{GF}^2$

### 13.4 U/B Trip Time

U/B is calculated as follows:

$$U/B = \frac{(I_{NL} - I_{NS})}{I_{NL}} \times 100\%$$

Where:

$I_{NL}$  = Largest Phase current

$I_{NS}$  = Smallest Phase current

The U/B function is defeated if any two phase currents are less than 10% of the CT rating.

The U/B trip time is a definite time as shown on the U/B TCC in Section 15.

### 14. Error Message Summary

The following is a summary of the possible error messages and what action to take to correct the problem.

#### 14.1 Actuator Not Connected

When the actuator is not connected or is open circuited, the following message will be displayed:

NO ACTUATOR

All push buttons are disabled. To return to normal operation, a functioning actuator must be connected.

#### 14.2 Memory Error

The micro-controller continuously monitors its memory. When a discrepancy occurs, the following message will be displayed:

MEMORY ERROR

All push buttons are disabled. The micro-controller must be replaced. Contact Utility Relay Company for more information.

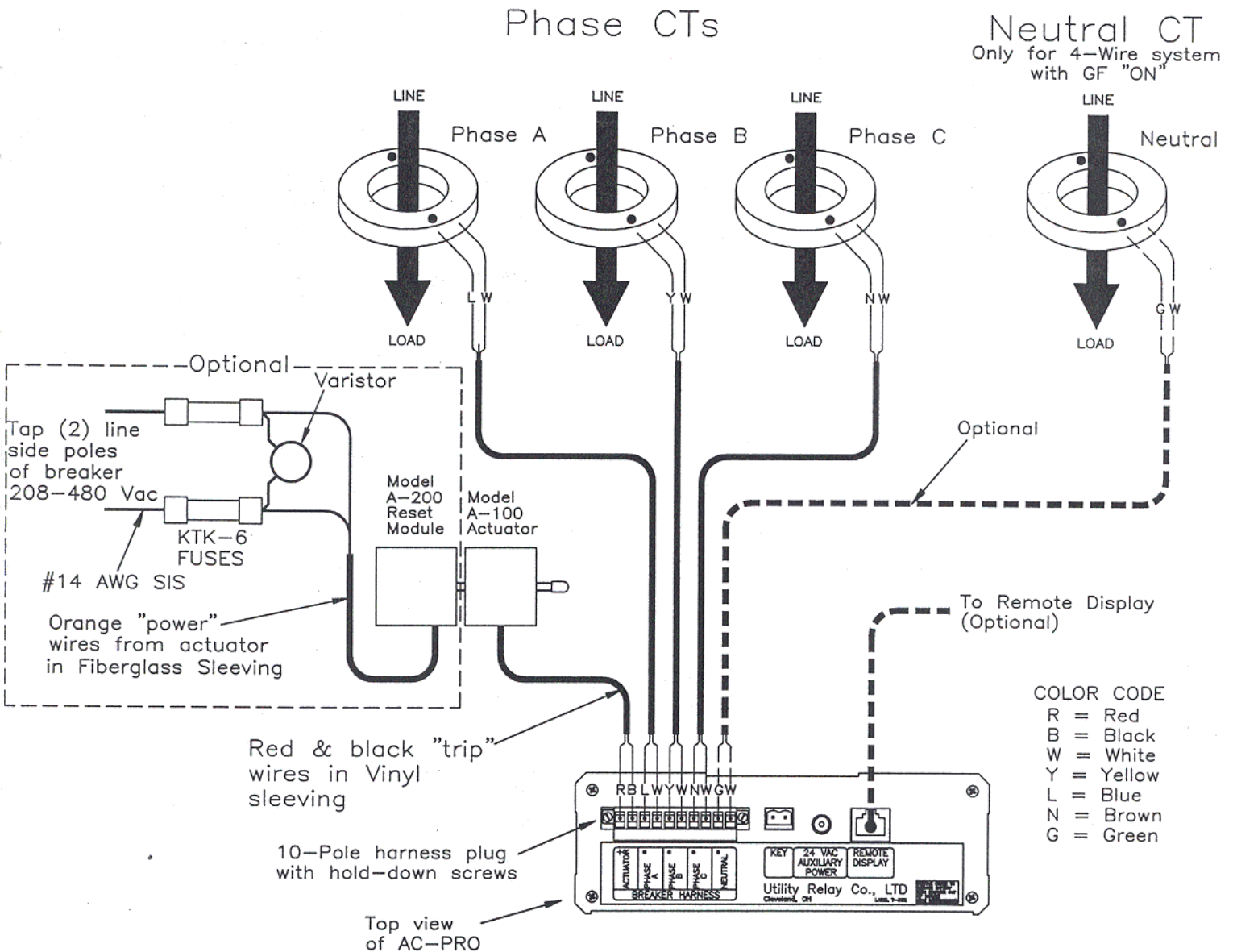


Figure 15.1, Wiring Diagram

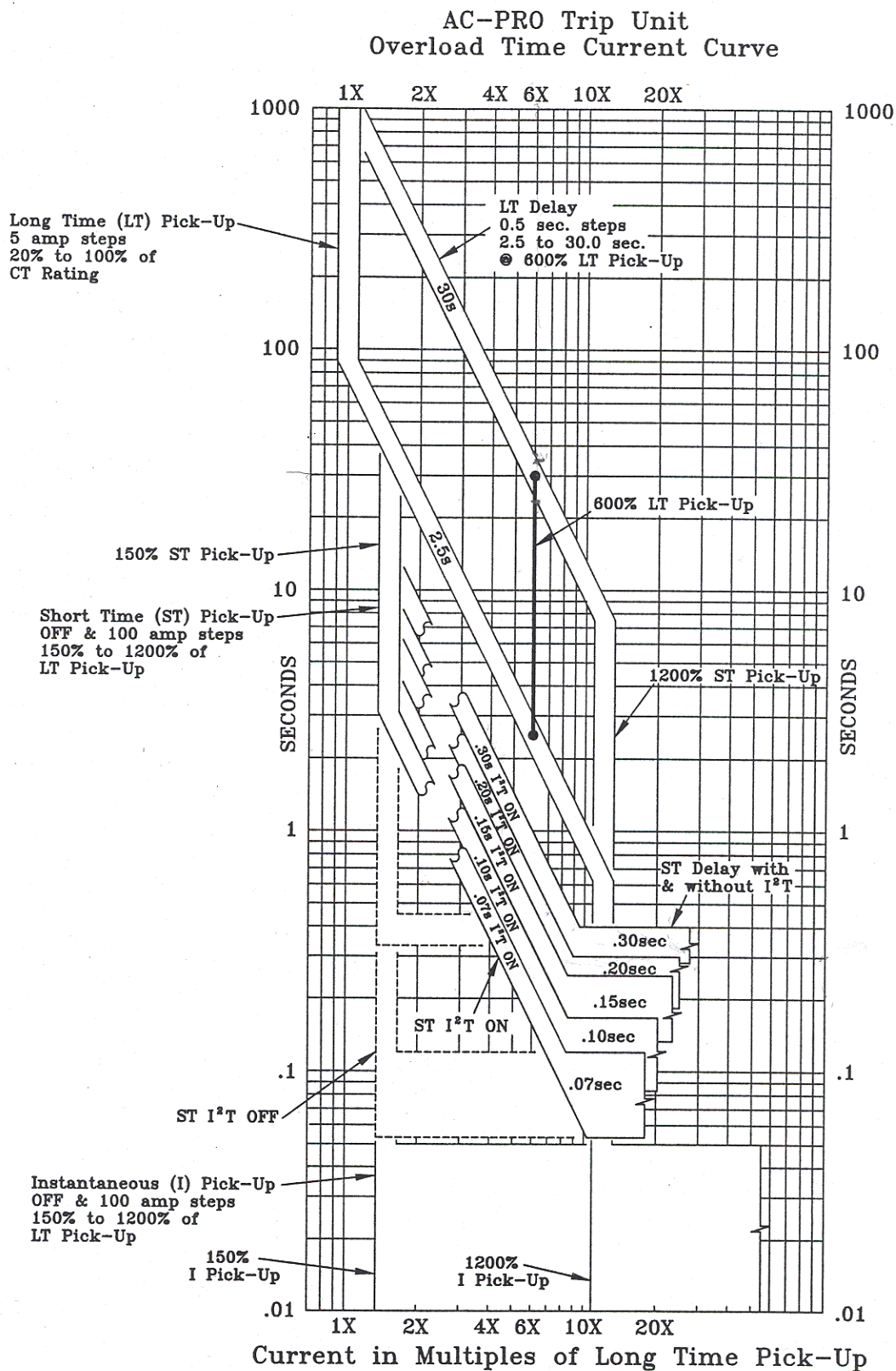


Figure 15.2 Overload TCC

# AC-PRO Trip Unit

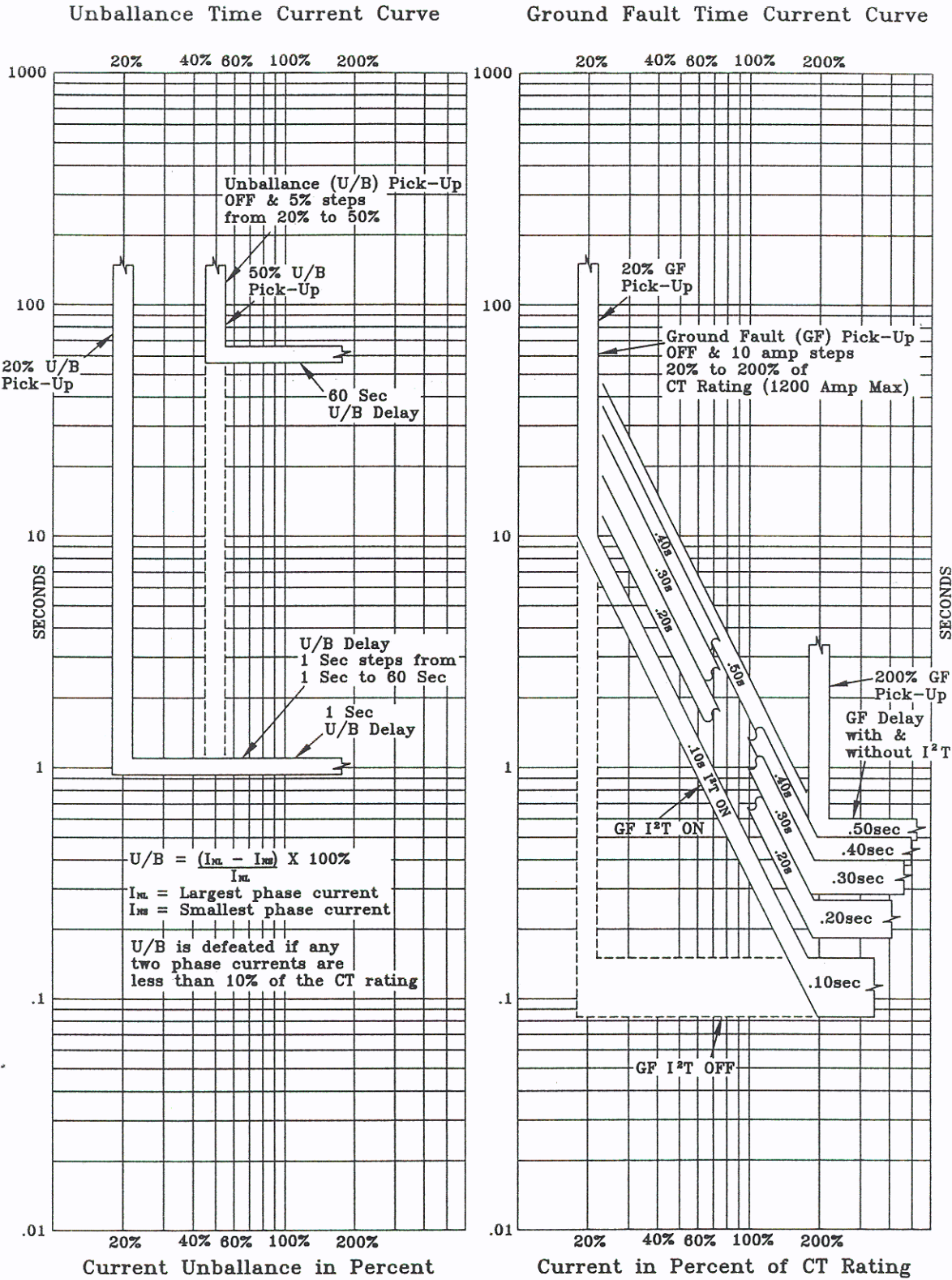


Figure 15.3, U/B & GF TCC