

**Manual Revision #0302**

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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 of ground fault current 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 EEPROM 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. Trip 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 breaker 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 trickle charged.

#### 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 three 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.
- 3) Provide power to the micro-controller for about 1/2 second after a trip event to allow the micro-controller to save the last trip data in non-volatile EEPROM memory.

Press the "REVIEW" push button to turn on the trip unit under Battery power.

When on battery power, the trip unit will automatically turn off after 30 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.

For the last trip data to be saved after a trip event, the battery must have sufficient charge to power the micro-controller for about 1/2 second.

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).

Removing the four screws securing the top cover plate on the trip unit can access the battery.

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

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

Gold Peak 15F8H 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.

Plug 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.

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. External Connections

The external connections are made to the top of the AC-PRO trip unit (or the left side for the vertical version).

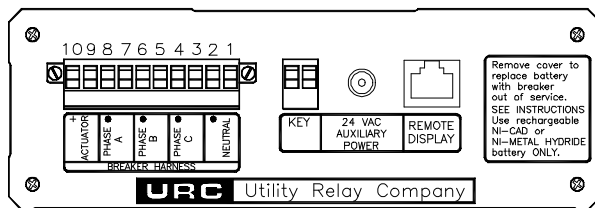


Figure 4.1 AC-PRO Top View

### 4.2 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.

### 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.

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 Pin-Out

### 4.3 Remote Display

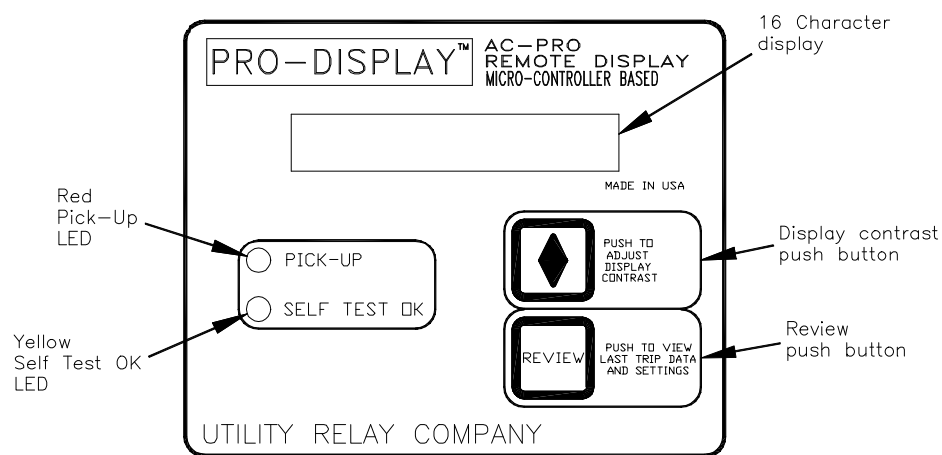


Figure 4.2 PRO-DISPLAY Front View

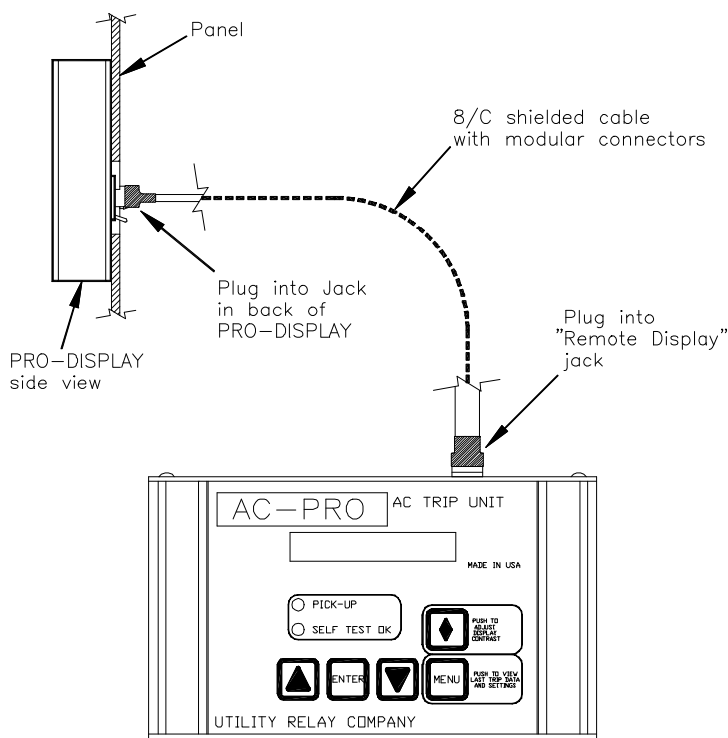


Figure 4.3 PRO-DISPLAY Connection

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.

## 5. Front Panel

The front panel of the horizontal version of the AC-PRO trip unit is shown in Figure 5.1. The front panel of the vertical version of the AC-PRO is shown in Figure 5.2.

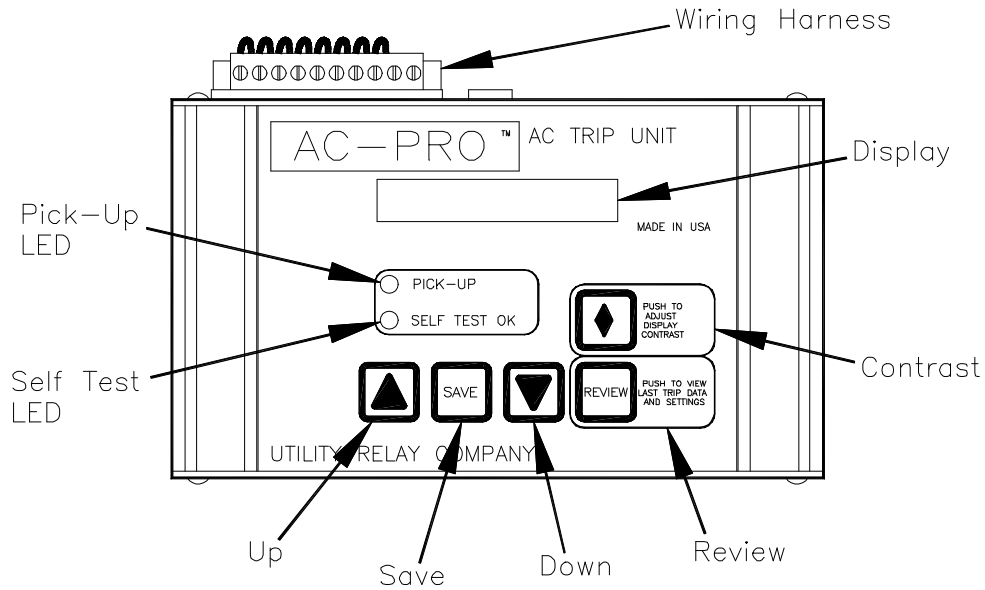


Figure 5.1 AC-PRO Horizontal Front Panel

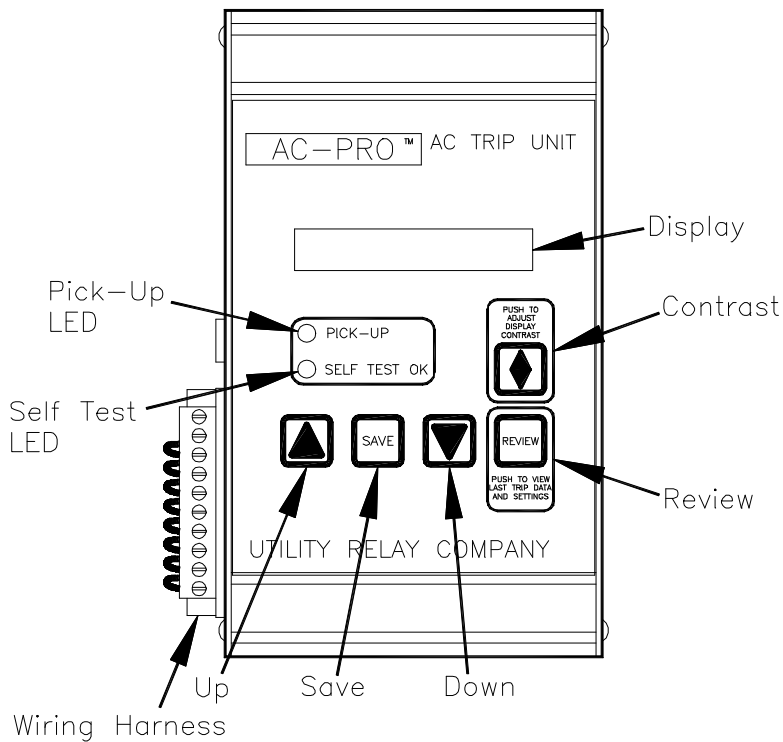


Figure 5.2 AC-PRO Vertical Front Panel

## 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 displaying the actual 3-phase 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 push button 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 push button will have no further effect on the setting value.

## 5.7 Save

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

Holding this push button has no effect.

## 5.8 Review

Use this push button to step through the settings in the 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 the 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) Connect the security key (see Section 4.2)
- 2) Push the "REVIEW" push button to power-up the trip unit. The trip unit will alternately display 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 using the "UP", "DOWN" and "SAVE" push buttons.
- 4) Remove the security key (see Section 4.2).

Sections 6.1 through 6.15 go over the commissioning process in greater detail.

## 6.1 Powering-Up The Trip Unit

In normal service, the AC-PRO trip unit is powered directly from the breaker mounted CTs.

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, therefore, is best to have all the desired settings 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.

## 6.2 Security Key During Commissioning

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

SECURITY KEY OFF

Connect the security key to continue the commissioning process. See Section 4.2.



### 6.3 CT Rating

After the security key is connected, 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 5,000 amps in 25 amp steps and 5250 amps to 6000 amps in 250 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 (50 amp steps for 5250 amp to 6000 amp CTs).

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.XS
----------	-------

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 2.0 to 30 seconds in steps of 0.5 seconds. This provides 57 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 (1000 amp steps for 5250 to 6000 amp CTs). 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	.XXS
----------	------

Where ".XX" represents the ST Delay.

The ST Delay settings are .07, .10, .15, .20, .30 and .40 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**

The I<sup>2</sup>T function adds a ramp to the ST delay if required for coordination purposes as shown in the Overload TCC in Figure 15.2.

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

ST I SQ T	XXX
-----------	-----

Where "XXX" represents ON or OFF.

If the ST I<sup>2</sup>T ramp **is** desired, press the "UP" push button. If the ST I<sup>2</sup>T ramp **is not** desired, press the "DOWN" push button.

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 100 amp steps (1000 amp steps for 5250 to 6000 amp CTs).

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 \*\*\*\*

The trip unit does not allow setting both the ST and the I functions off at the same time.

Press the "SAVE" push button to continue.

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

If the GF function is **not** desired, then press the "DOWN" push button until the following is displayed:

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

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 with 10 amp steps. The maximum value is 200% of the 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	.XXS
----------	------

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

The I<sup>2</sup>T function adds a ramp to the GF delay if required for coordination purposes as shown in the Ground Fault TCC in Figure 15.3.

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

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

Where "XXX" represents ON or OFF.

If the GF I<sup>2</sup>T ramp **is** desired, press the "UP" push button. If the GF I<sup>2</sup>T ramp **is not** desired, press the "DOWN" push button.

Press the "SAVE" push button to continue.

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

On a 4-wire system, a neutral CT must be installed to avoid nuisance GF trips.

**6.13 Phase Unbalance (U/B) Pick-Up**

The following will be displayed:

U/B PICK-UP	OFF
-------------	-----

If the U/B function is **not** desired, then 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. The minimum and maximum UB Pick-Up setting is 20% and 50% in steps of 5 percentage points.

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.

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

The U/B function should not be confused with the GF function.

The U/B function is a motor protection function and should **ONLY** be used on breakers feeding a large 3-phase motor where unbalanced currents are not normal.

**6.14 Phase Unbalance (U/B) Delay**

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

UB DELAY	XXS
----------	-----

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 4.2). 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 external power was used to power the trip unit during the commissioning process, 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 part of this process.

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

Connect the security key. See Section 4.2.

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 4.2). The settings will be saved in the non-volatile EEPROM memory.

### The Settings have been changed.

Remember, if the trip unit loses power 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 and trip counter system.

After a breaker trip, the trip unit will be able to display the type of trip (i.e. LT, ST, I, GF, or U/B as applicable) and the currents at the time of trip. 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. The trip counter is also updated at this time.

The battery must be able to power the micro-controller for about 1/2 second after a trip event to allow time for it to save the last trip data in the non-volatile EEPROM memory.

- 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
----------------

Only those phase currents greater than 10% of the CT Rating will be displayed.

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 "XXXXX" 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 30 seconds, the trip unit will also turn off.

## 9. Normal Operation

### Breaker Current Less than about 8% of CT Rating:

With all phase currents less than about 8%, the trip unit is not receiving enough energy from the CTs to operate and the display will be blank.

### Breaker Current Less than 12.5% of CT Rating:

When the currents are greater than 8% but less than 12.5% of the CT rating, the display will show the following:

LOW CURRENT

### Breaker Current Greater than 12.5% of CT Rating:

If the breaker current is greater than 12.5% of the CT rating but less than the LT pick-up value, the following will be alternately displayed on the LCD at 1-second intervals:

PHASE A XXXXA

PHASE B XXXXA

PHASE C XXXXA

GF XXXXA

Where "XXXX" is the current in amps for that phase or ground fault current.

Only those currents above 12.5% will be displayed. The GF current will only be displayed if the GF function is on.

### Breaker Current Greater than the LT pick-up:

When the trip unit detects a phase overload situation, the "PICK-UP" LED on the front of the trip unit will go on, and the following will alternately be displayed on the LCD at 1-second intervals:

OVERLOAD

PHASE A XXXXA

PHASE B XXXXA

PHASE C XXXXA

GF XXXXA

Where "XXXX" is the current in amps for that phase or ground fault current.

Only those currents above 12.5% will be displayed. The GF current will only be displayed if the GF function is on.

## 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

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

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. Verify that the correct phase is indicated on the LCD display.

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

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

***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 LT Pick-Up is 1600A and Delay is 10.0S, then the trip time at 4800A (3 times 1600A) is 40 sec. (4 times 10 sec).

### 10.3 ST Trip Test

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

To test the ST Pick-Up, temporarily set ST I<sup>2</sup>T to OFF and 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, turn ST I<sup>2</sup>T on again (if applicable) and 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". The U/B function 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.

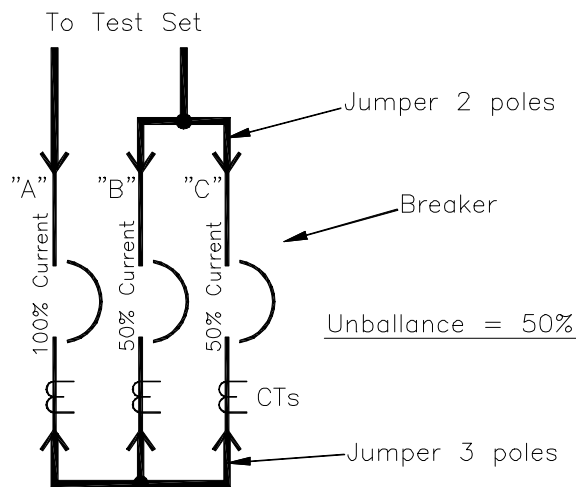


Figure 10.1 U/B Test

## 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.

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

Erase the last trip data from the memory of the trip unit after completing the primary injection tests.

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

### Method 1:

- 1) The trip unit can be either off or powered-up.
- 2) Push the "REVIEW" button to display the last trip data.
- 3) While the last trip data is flashing, push and hold both the "UP" and "DOWN" push buttons.
- 4) Continue to hold the "UP" and "DOWN" buttons and push the "SAVE" button. Release all buttons. The following will be displayed:

NO LAST TRIP

### Method 2:

- 1) The trip unit should not be powered-up (i.e. the display should be OFF).
- 2) Connect the security key. See section 4.2.
- 3) Press and hold in both the "UP" and "DOWN" push buttons simultaneously.
- 4) While continuing to depress the "UP" and "DOWN" push buttons, press the "REVIEW" push button to turn the trip unit on.
- 2) Release all push buttons. The following will be displayed:

DECOMMISSION?

- 5) Pressing the "UP" push button will **ERASE** the pick-up and delay settings. Pressing the "DOWN" push button will **NOT** erase the pick-up and delay settings.
- 6) The following will be displayed next:

ERASE TRIP DATA?

- 7) If the last trip data is to be erased, press the "UP" push button. If the data is **not** to be erased, push the "DOWN" 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

Nominal overall dimensions:

6.76 X 3.84 X 2.28 inches

172 X 100 X 58 millimeters

## 12. Warranty

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

Contact Utility Relay Company for full details.

### 13. Time-Current Curves

The Time-Current curves are shown in Section 15.

For all the functions except U/B, the curves are shown on log-log graph with seconds in the vertical direction and current in the horizontal direction.

Overload and fault currents are shown as multiples of the LT pick-up setting. Ground fault 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  $+23\%$  and  $-17\%$  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)

The curves for the U/B function are shown on a semi-log graph with seconds in the vertical direction and unbalance in percent in the horizontal direction.

Tolerance for U/B function is given in Section 13.4.

When performing trip-timing tests using a primary injection test set, the trip time at various test currents can be determined by calculation as explained in Sections 13.1, 13.2 and 13.3.

#### 13.1 LT Trip Time

For overload currents, the " $I^2 T = \text{Constant}$ " equation can be restated as follows:

$$T = \frac{TBC_{LT}}{X^2}$$

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

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

The LT Time Band Constant ( $TBC_{LT}$ ) is by definition 36 times the LT Time Band Setting in seconds.

#### EXAMPLE #1:

CT Rating	1600A
LT pick-up	1200A
LT time band	20.0S
Overload Current	3600A

$$\begin{aligned} TBC_{LT} &= 36 \times \text{LT Time Band Setting} \\ &= 36 \times 20.0 \\ &= 720 \end{aligned}$$

$$\text{and } X = \frac{\text{overload current}}{\text{LT Pick-Up}} = \frac{3600A}{1200A} = 3$$

therefore:

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

#### \*\*\*\* IN SUMMARY \*\*\*\*

To calculate the LT trip time:

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

## 13.2 ST Trip Time

With I<sup>2</sup>T **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<sup>2</sup>T **ON** and for currents less than 10 X LT Pick-Up Setting, the ST trip time is determined by the following equation:

$$T = \frac{TBC_{ST}}{X^2}$$

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

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

**TBC<sub>ST</sub>** = the ST Time Band Constant

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

The ST Time Band Constant (TBC<sub>ST</sub>) =  
 40 for the .40S Time Band  
 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 <sup>2</sup> T ON
Overload Current	7200A

$$TBC_{ST} = 20$$

$$\text{and } X = \frac{\text{overload current}}{\text{LT Pick-Up}} = \frac{7200A}{1200A} = 6$$

therefore:

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

\*\*\*\* IN SUMMARY \*\*\*\*

To calculate the ST I<sup>2</sup>T trip time:

- 1) Determine the ST Time Band Constant (TBC<sub>ST</sub>)
- 2) Calculate "X" where  

$$X = \frac{\text{overload current}}{\text{LT Pick-Up}}$$
- 3) Solve the equation:  

$$\text{trip time(sec)} = \frac{TBC_{ST}}{X^2}$$

### 13.3 GF Trip Time

With I<sup>2</sup>T **OFF** or for ground fault currents greater than 2 times the CT rating, the GF trip time is a constant equal to the GF Time Band setting.

With I<sup>2</sup>T **ON** and for currents less than 2 times the CT rating, the GF trip time is determined by the following equation:

$$T = \frac{TBC_{GF}}{X_{GF}^2}$$

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

**X<sub>GF</sub>** =  $\frac{\text{ground fault current}}{\text{CT rating}}$

**TBC<sub>GF</sub>** = the GF Time Band Constant

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

The GF Time Band Constant (TBC<sub>GF</sub>) =  
 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 <sup>2</sup> T ON
Ground Fault Current	800A

$$TBC_{GF} = 0.8$$

$$\text{and } X_{GF} = \frac{\text{ground fault current}}{\text{CT Rating}} = \frac{800A}{1600A} = 0.5$$

therefore:

$$\text{trip time} = T = \frac{TBC_{GF}}{X_{GF}^2} \text{ or } \frac{0.8}{(0.5)^2} = \frac{0.8}{.25} = 3.20 \text{ sec}$$

\*\*\*\* IN SUMMARY \*\*\*\*

To calculate the GF I<sup>2</sup>T trip time:

- 1) Determine the GF Time Band Constant (TBC<sub>GF</sub>)
- 2) Calculate "X<sub>GF</sub>" where  
 $X_{GF} = \frac{\text{ground fault current}}{\text{CT Rating}}$
- 3) Solve the equation:  
 $\text{trip time(sec)} = \frac{TBC_{GF}}{X_{GF}^2}$

### 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<sub>NL</sub> = Largest Phase current

I<sub>NS</sub> = Smallest Phase current

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

The tolerance for the U/B Pick-Up is  $\pm 10$  percentage points. An U/B Pick-Up of 20% would have a tolerance of 10% to 30% unbalance. An U/B Pick-Up of 50% would have a tolerance of 40% to 60% unbalance.

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

The tolerance for the U/B trip time is  $\pm 10\%$  of the setting.

## **14. Error Message Summary**

The following is a summary of the possible error messages and what action is necessary 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.

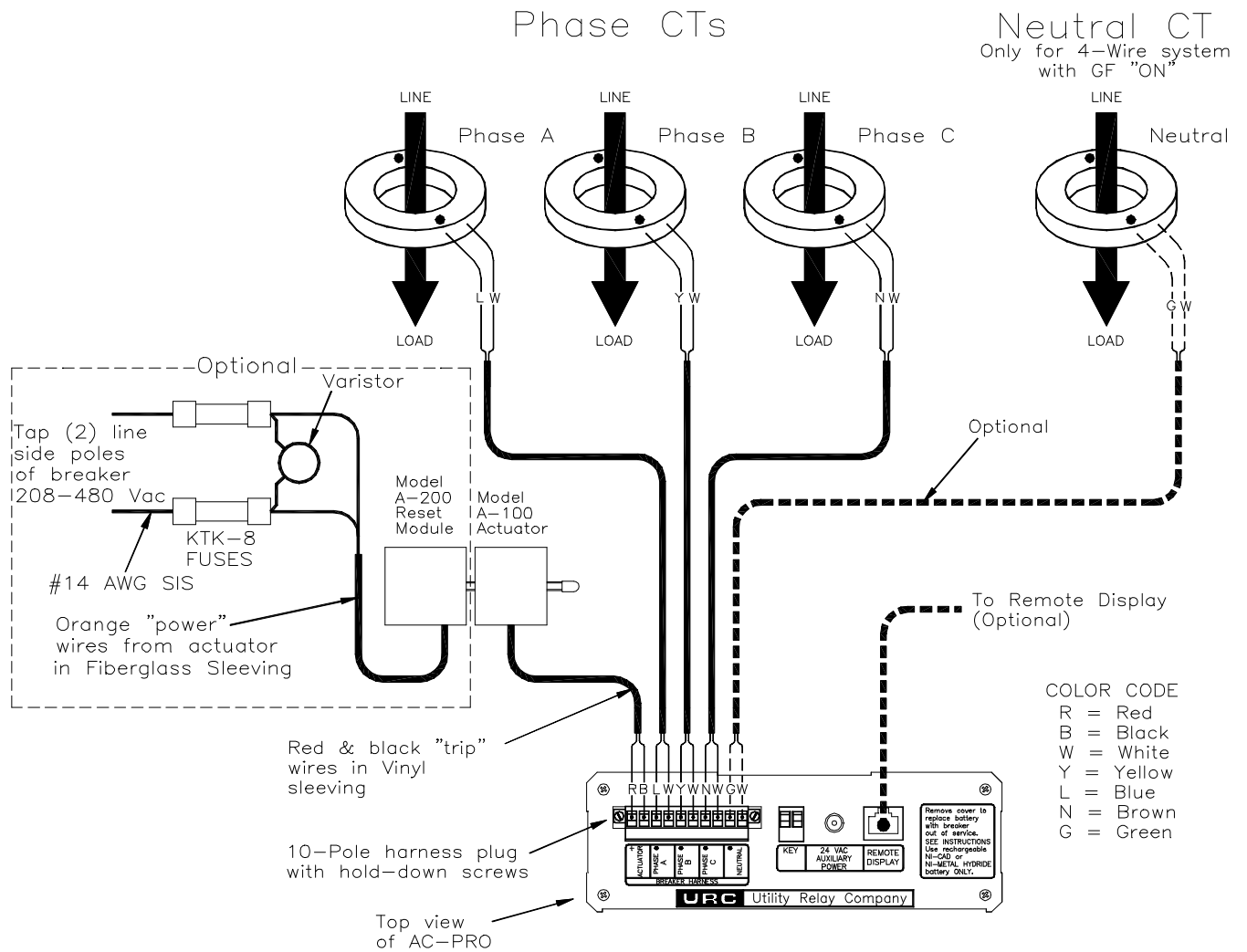
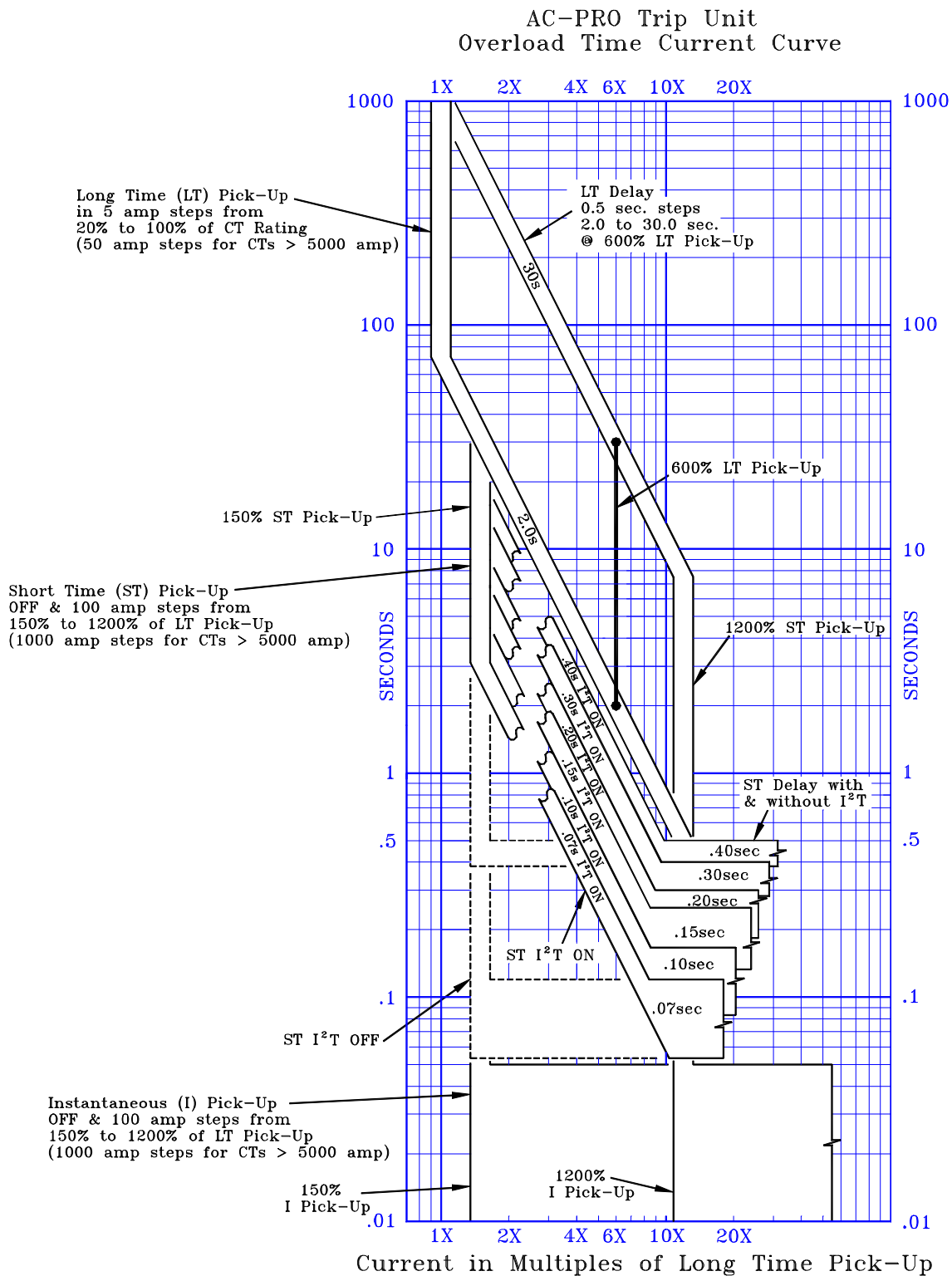


Figure 15.1, Wiring Diagram







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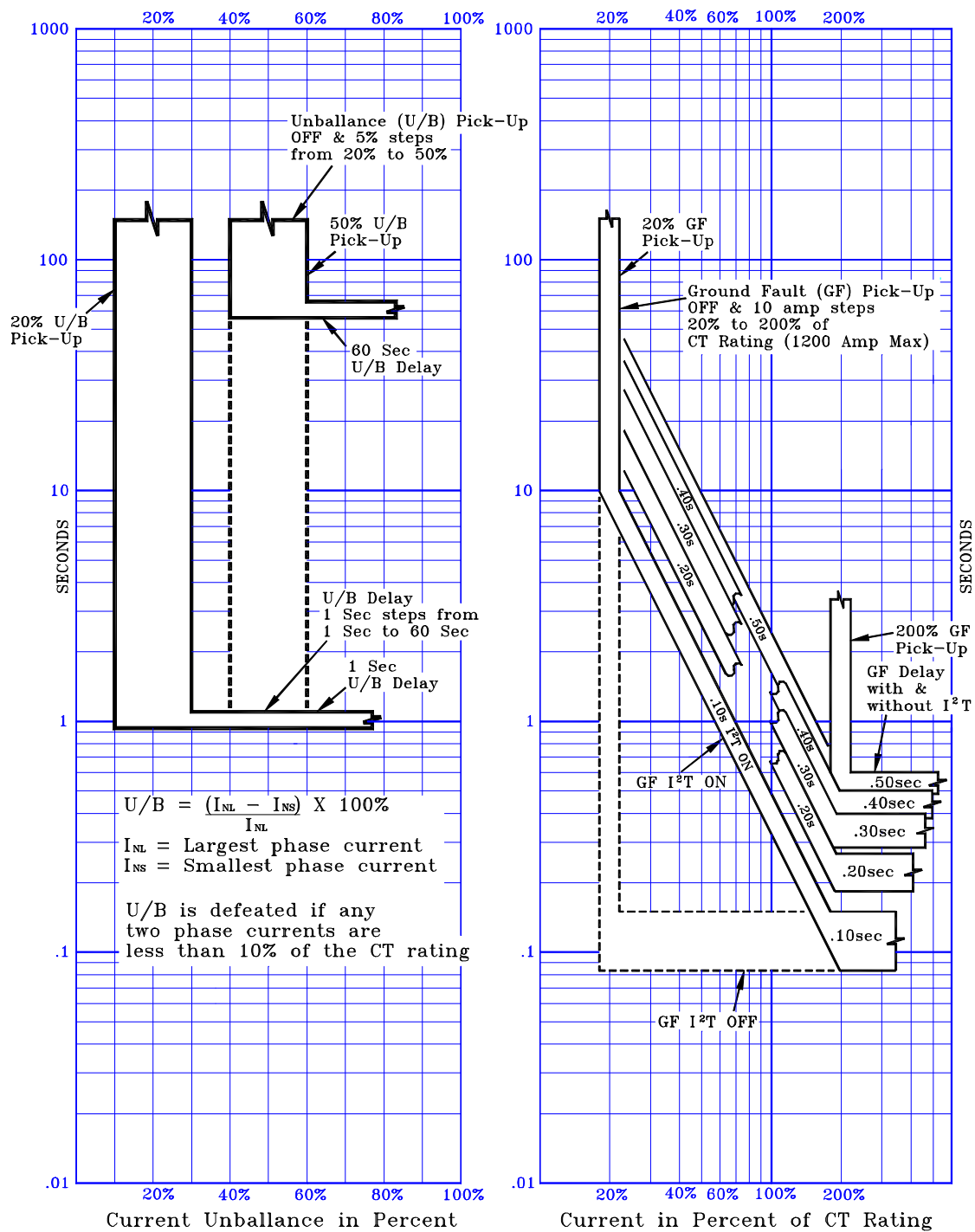
Figure 15.2 Overload TCC



## AC-PRO Trip Unit

Unbalance Time Current Curve

Ground Fault Time Current Curve



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Figure 15.3, U/B &amp; GF TCC