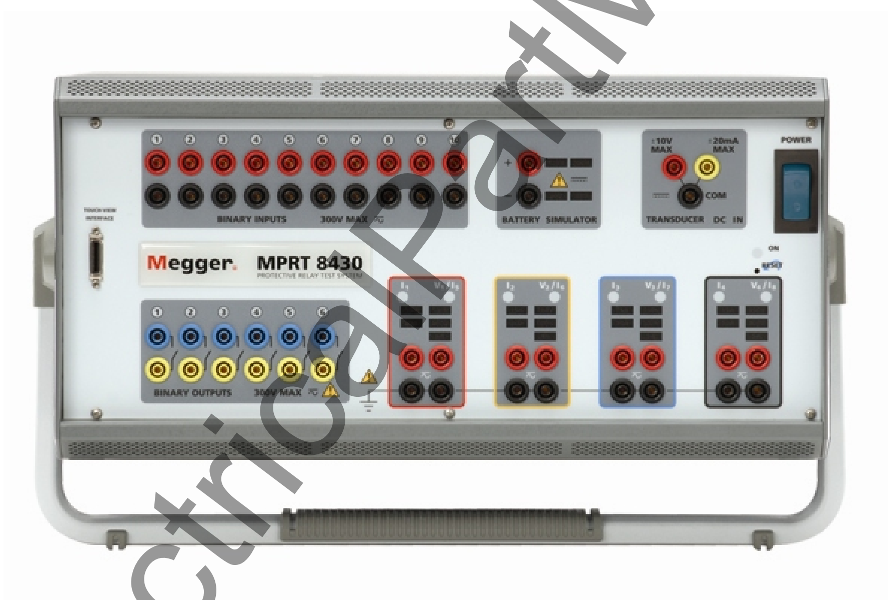
Megger

User Manual



* MPRT shown with optional large carry handle

Model MPRT
Megger Protective Relay Tester

Part 710000
Rev 3 Date 11/15/2005

Revision History

Revision	ECN #	Date
1	Initial Release	12/17/2003
2	30043	3/07/2005
3	30207	11/16/2005

IMPORTANT

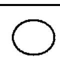
Written and designed at Megger, 4271 Bronze Way, Dallas, Texas 75237.

Printed in the USA.

SAFETY PRECAUTIONS

WARNING:
VOLTAGES GENERATED BY THIS INSTRUMENT CAN BE HAZARDOUS

This instrument has been designed for operator safety; however, no design can completely protect against incorrect use. Electrical circuits are dangerous and can be lethal when lack of caution and poor safety practices are used. There are several standard safety precautions that should be taken by the operator. Where applicable, IEC safety markings have been placed on the instrument to notify the operator to refer to the user manual for instructions on correct use or safety related topics. Refer to the following table of symbols and definitions.

Symbol	Description
	Direct Current
	Alternating Current
	Both direct and alternating current
	Earth (ground) Terminal. There is a common chassis ground terminal located on the back panel (see Back Panel under Description of Controls.
	Protective Conductor Terminal
	Frame or Chassis Terminal
	On (Supply)
	Off (Supply)
	Caution, risk of electric shock
	Caution (refer to accompanying documents)

WARNING: Under no circumstances should the operator or technician attempt to open or service this instrument while connected to a power source. Lethal voltages are present and may cause serious injury or death!

SAFETY PRECAUTIONS (Continued)

The following are some specific safety related items associated with the MPRT test system.

Always start with the power OFF, before connecting the power cord. Make sure outputs are off before attempting to make test connections.

Always use properly insulated test leads. The test leads supplied with the unit are rated for the continuous output ratings of the test system, and should be properly used and cared for. DO NOT use cracked or broken test leads.

Always turn the test system off before disconnecting the power cord or removing / inserting output modules. Turn the power off when removing or inserting the Voltage / Current module(s).

DO NOT power up without the modules secured in their respective slot.

DO NOT attempt to use the unit without a safety ground connected.

DO NOT attempt to use the unit if the power cord ground prong is broken or missing.

Under no circumstances should the operator put their hand or tools inside the test system chassis area with the test system connected to a power source. Lethal voltages are present and may cause serious injury or death!

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1.0 Operation

The unit's design is a "modular" concept. All controls and outputs are clearly marked and logically grouped so continual reference to the instruction manual should not be necessary once the test operator is acquainted with the operation of the test system. The unit's rear panel will appear different among units since each unit may have up to four V/I Generator Modules and may have an optional EPOCH II / EPOCH 20 interface, or other type. However, there must be at least one V/I Generator Module installed for this unit to operate properly.

1.1 Control Description

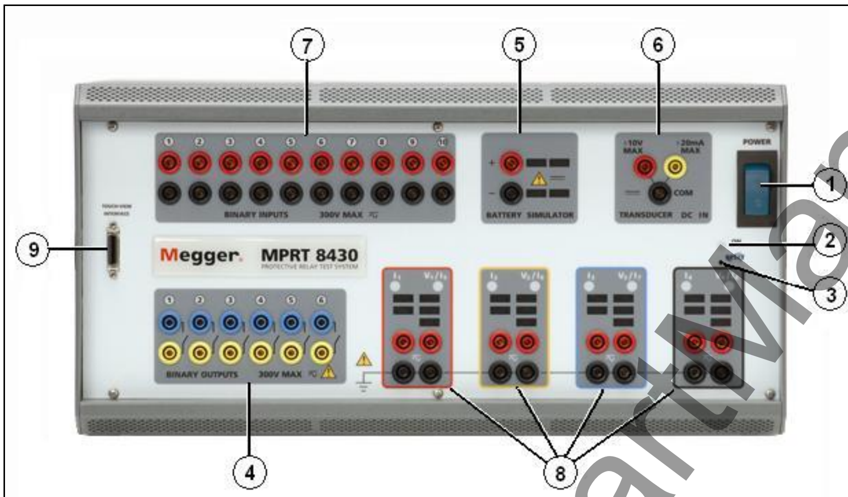


Figure 1 MPRT Front Panel

1.1.1 Front Panel

1. ***POWER ON/OFF Switch*** – used to switch unit on and off.

2. ***ON Light*** – indicates power is on when illuminated.

3. ***Reset Button*** – the reset button provides a soft reboot for the unit and restores the unit to its normal Power-On state. The reset will clear all values entered into various screens. The data should be saved before performing a reset, if possible.

4. ***Binary Outputs*** – there are 6 internal to the MPRT Unit. Each output can be configured as Normally Open or Normally Closed contacts providing logic to the device under test. The output can switch up to 300 VAC or 250 VDC with 1 Amp continuous. The programmable wait duration is from 1 millisecond to 10,000 milliseconds.

5. ***Battery Simulator*** – the output voltages are 24, 48, 125 and 250 Volts DC with current limiting output power protection. If a voltage is powered ON, that respective voltage will have a lighted value.

6. ***Measurement (DC IN)*** – the DC IN will allow measurements up to ± 10 Volts DC or ± 20 milliamps of current.

7. ***Binary Inputs*** – there are 10 internal to the MPRT unit. The input will accept a voltage range of 5 to 300 VAC or 5 to 250 VDC or dry Normally Open / Normally Closed contacts.

8. ***Three Phase Power Indication*** – the three phases are noted by the red, yellow, and blue color boxes surrounding each output. Phase A (V1 & I1) is denoted by the red color;

Phase B (V2 & I2) is denoted by the yellow color; and Phase C (V3 & I3) is denoted by the blue color. An optional fourth output module is denoted by the black color box. With a fourth output module installed, there may be up to four phases of voltage and current, or two three phase open delta voltages, with four currents, or up to eight phases of current. The first four phases are indicated by V1/I1, V2/I2, V3/I3 and V4/I4. Once the voltage generators are converted to current generators, they will change as indicated below:

V1 ⇒ I5
V2 ⇒ I6
V3 ⇒ I7
V4 ⇒ I8

9. ***TVI Connector*** – connects the Touch View Interface to the unit. Used for manual operation, and display outputs when under computer control.

1.1.2 Rear Panel:

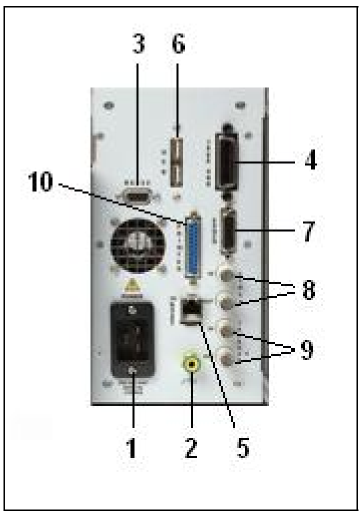


Figure 2 MPRT Rear Panel

1. ***Incoming Power / Line Cord*** – the input line cord, ground terminal, are mounted on the back panel of the test set.

Input Line Cord

The test set is equipped with a line cord; see the accessory kit, which connects to the male plug on the back panel. Verify the input voltage before connecting the line cord to the power source.

NOTE: The unit can be powered from an input source with a rating of 100 VAC to 240 VAC. The unit automatically adjusts to the available power if it is within the specified range.

2. ***Earth Ground Jack*** – use this terminal to connect chassis ground to earth ground.

A chassis ground (earth) point on the back panel is provided as an additional safety ground.

3. ***RS-232C Serial Port -*** The serial port can operate at a maximum baud rate of 115,200 and will send / receive data in a serial fashion. See section 2.2.3.8 for more description.

4. ***IEEE-488 GPIB*** –The IEEE-488 GPIB port enables the unit to function as a talker-listener as well as operate at speeds much faster than the serial bus, which will send / receive data in a parallel fashion. This will allow DFR and EMTP files to be downloaded at a faster rate. See section 2.2.3.9 for more description.

5. ***Ethernet 10BaseT*** – The Ethernet 10BaseT port will typically operate very efficiently and effectively in real time. This port is the fastest communication method within this unit. The setup will be similar to Microsoft® Windows where one may set the protocol. In addition, this port provides the optimal method for downloading EMTP files, DFR streaming, and updating the unit's firmware as required. See sections 2.2.3.7 and 6.2 for more descriptions.

6. ***USB Interface*** – Provides a communication port for connecting external devices, such as the optional external binary input/output box to the unit (when more than 10 binary inputs and/or more than 6 binary outputs are required).

7. ***EPOCH High Current Interface Port*** –The High Current Interface port is provided on the rear panel of the unit. It is designed to interface with the Multi-Amp Models EPOCH-II or EPOCH-20 High-Current Output Units (reference the EPOCH-20 or EPOCH-II Bulletins for output specifications). This port interfaces with the optional interface module box to provide control of up to three EPOCH-20 or EPOCH-II current amplitude, phase angle and frequency outputs. Status of the EPOCH-20/II output can be seen on the TVI display.

8. External Clock –The external clock has separate input and output connections. The ***Clock In*** is used in conjunction with a Clock Out from another unit or other clock source for multiple unit operations or other special test applications. The ***Clock Out*** provides a 24 KHz clock signal to another unit that phase locks these units together.

9. External Trigger –The External Trigger has separate input and output connections. They enable the unit to sync with another unit, or TTL (+ 5Vdc) signal source such as a GPS satellite receiver. The ***Trigger In*** is used in conjunction with another unit to establish a trigger for a special operation or programmed event. Typically the Trigger In synchronizes to the Trigger Out unit and acts as a slave to it. The ***Trigger Out*** provides a TTL digital signal to another unit in order to synchronize a multiple unit operation when it needs to establish a trigger for a special operation or programmed event. The TTL signal and pulse width for the GPS receiver is:

   Voltage Input Signal: 3V peak minimum   Pulse Width: 50μS nominal

10. ***PRINTER Interface Port***– For future use (not used at this time).

Voltage/Current Modules (or V/I Gen). –There are four available slots for the Voltage/Current Amplifier Modules. The slots are numbered from right to left with the back of the unit facing you. Looking at the back of the unit, the rightmost slot equates to Phase A; the second slot from the right equates to Phase B; the third slot from the right equates to Phase C; and left most slot may be used to provide a fourth phase, polarizing voltage and/or current, residual voltage and/or current, or other required sources.

Amplifier EXT Inputs – There can be up to four sets of BNC connectors labeled V1/I5, I1; V2/I6, I2; V3/I7, I3 and V4/I8, I4 on the back panel depending on the number of amplifier modules installed. These connectors are used to amplify an external analog signal using the MPRT amplifiers. Application of ± 10 Volts Peak will provide Full Scale output from the selected output.

Figure 3 MPRT Rear Panel, Analog Input Terminals

CAUTION: DO NOT APPLY MORE THAN ± 10 VOLTS PEAK TO THE EXT INPUT TERMINALS. APPLICATIION OF MORE THAN 10 VOLTS PEAK MAY DAMAGE THE AMPLIFIER.

1.1.3 Touch View Interface

The Touch View Interface is used in manual operation of the unit. The color LCD touch-panel display and control knob are the operator interface for the unit.

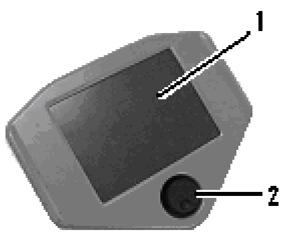


Figure 4 Touch-View Interface

1. ***LCD Color Display*** – this is an 8.5 inch touch panel display.
2. ***Control Knob*** – this knob will adjust values once the cursor is in the box location of the value to be changed.

1.2 Terminology

The acronyms, terms, and definitions used throughout this manual are described below:

1.2.1 Acronyms

AC	Alternating Current
AVTS	Advanced Visual Test Software
CW	Clockwise (rotation)
CCW	Counter Clockwise (rotation)
DC	Direct Current
GPIB	General Purpose Interface Bus (IEEE-488)
GPS	Global Position System
GUI	Graphical User Interface
Hz	Hertz
ID	Identification
I/O	Input/Output
kHz	Kilo Hertz
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MAG	Magnitude
MHz	Megahertz
MTA	Maximum Torque Angle
NVRAM	Non-volatile Random Access Memory
PC	Personal Computer
ROM	Read-Only Memory
RS-232	Serial Communication Interface
RTS	Relay Test System
SRAM	Static Random Access Memory
SSD	Solid State Disk
TCM	Timer Control Module
TVI	Touch View Interface
USB	Universal Serial Bus
VAC	Volts Alternating Current
VDC	Volts Direct Current
V/I Gen	Voltage / Current Generator Module
VRMS	Volts Root Mean Square
UUT	Unit Under Test

1.2.2 Glossary of Terms

The MPRT TVI display screens prompt the user to select, or set, various values. The values vary depending on the relay under test, and the relay setting screen. Many of the terms used are similar in nature and mean virtually the same thing regardless of the type of relay. For example, the term Time Dial is the used to define the time dial setting on the relay under test. The Time Dial could be on an overcurrent relay, or just as easily be on a under voltage relay. Unfortunately, some of the terms described here may apply to different types of relays in different ways, and thus may not cover every possible relay made. However, it is hoped that this glossary will help the user to understand every setting value on every relay setting screen.

1.2.2.1 Tap

A numerical value associated with a tap setting on the relay. Tap is normally associated with a value of current, voltage, frequency or watts. Tap is used to define a setting value, pick up value, or minimum operating point, of the relay under test.

1.2.2.2 Time Dial

A numerical value normally associated with a TIME CURVE, or defines the use of a specific time curve from a family of curves. Used when conducting a timing test. The TIME DIAL number also may be used in a Time-Curve algorithm in calculating the theoretical operating time of the relay under test.

1.2.2.3 Instantaneous (Inst.) Tap

A numerical value associated with a tap setting on the instantaneous element of the relay. Normally associated with a value of current or voltage. Used to define a pick up value, or minimum operating point, of the instantaneous element of the relay under test.

1.2.2.4 Reset Time

Is a numerical value of time in seconds. Normally associated with electromechanical relays, this is the amount of time required for the operating disk to reset. If multiple timing tests are conducted on a relay, the test system will wait the Reset Time value prior to applying the next timing test.

! Note, if the Reset Time is too short, and the disk does not completely reset, then timing error will be introduced to the test. Note that numerical relays also can have reset times to coordinate with electromechanical relays.

1.2.2.5 Target Tap

Is a numerical value of dc current. This value is used when conducting the Target and Seal-in tests on electromechanical relays.

1.2.2.6 Test Multiple

A numerical value normally associated with conducting timing tests. Multiples are normally expressed in terms of 2, 3, 4, etc., times the Relay Tap, or Pickup, value of the relay under test. If only one Test Multiple is entered, then only one timing test point will be conducted. If two or three multiples are entered, then the test system will wait the Reset Time before applying the next Test Multiple.

1.2.2.7 Reach

A numerical value expressed in Ohms. This value is used to determine the “distance”, in Ohms, that the relay under test “sees” either into the transmission line or a generator.

1.2.2.8 Torque

A numerical value expressed in degrees. A value used in impedance relays to define the “maximum torque angle” or “line angle” setting of the relay under test.

1.2.2.9 Operate, (Op) or Trip Time

A numerical value which expresses the operating time of the relay under test. Normally used to specify a definite operating time for a given fault value.

1.2.2.10 Winding (1,2,3,4) Tap

A numerical value associated with the Winding Number i.e. 1, 2, 3, 4, etc., of a transformer differential relay. Used to define the tap setting value and test for each winding.

1.2.2.11 % Slope

A numerical value which establishes the operating characteristic of a differential relay. The operating characteristic of the differential relay is a line, with a slope defined by the ratio of the operating and restraint values.

1.2.2.12 % Harmonic

A numerical value which establishes the percent of harmonic restraint for a harmonic restrained transformer differential relay. This value will be used to determine Pass/Fail during the Harmonic Restraint test.

1.3 **Touch View Interface (TVI)**

The Touch View Interface is the operator's interface for the manual operation of this unit. Variable or value changes are performed by the touch panel keypad or by rotating the control knob after touching the display with your finger where the change is required. See section 2.2 for operational details.

1.4 **Input Power and Control**

1.4.1 Input Power

The input voltage may be from 100 to 240 VAC, 50/60 hertz. Input current required varies with the number of output modules in use and load. The maximum input power is 2100VA. The input is protected by an ON/OFF switch / circuit breaker. Model 84XX-XXXX**A**X comes with a North American power cord (part number 801046).

Model 84XX-XXXX**E**X comes with a Continental Europe power cord (part number 15021).

The 84XX-XXXX**I**X comes with a standard International Color code power cord as shown below. The cord, part number 14525, is ready for wiring to the appropriate plug (depending on country). The following colors apply, Brown = Line, Blue = Neutral and Green/Yellow = Ground.

Figure 5 International Color Coded Power Cord

1.4.2 Control Section

1.4.2.1 V/I Generator Module

The voltage and current ranges may be set to zero for automatic range adjustments or manually set to the number desired in volts or amps as indicated below. The unit will choose the lowest range which contains the desired value.

1.4.2.1.1 Voltage and Current Ranges

1.4.2.1.1.1 Model 8415 (each output module)

Voltage Range	Power / Current (Max)
30.00V	150VA @ 5A
150.00V	150VA @ 1A

Current Range (RMS)	Power / Voltage (Max)
4.0A	200VA @ 50.0 V_{RMS}
7.5A	200VA @ 26.7 V_{RMS}
15.0A	200VA @ 13.4 V_{RMS}

1.4.2.1.1.2 Model 8430 (each output module)

Voltage Range	Power / Current (Max)
30.00V	150VA @ 5.0A
150.00V	150VA @ 1.0A
300.0V	150VA @ 0.5A

Current Range (RMS)	Power / Voltage (Max)
4.0A	200VA@ 50.0 V_{RMS}
7.5A	200VA @ 26.6 V_{RMS}
15.0A	200VA @ 13.4 V_{RMS}
30.0A	200VA @ 6.67 V_{RMS}

1.4.2.1.2 Frequency Ranges

The output module is able to provide a variable frequency output with the following ranges:

DC
00.001 to 99.999
100.01 to 999.99

1.4.2.1.3 Phase Angle

The phase angle may be set from 0° to 359.9° in either lead or lag configuration, clockwise or counterclockwise rotation. In addition, the user may select the angle display configuration of ±180°. See section 2.2.3.11, Phase Angle Setting, for information regarding Factory Default settings.

1.5 **Timer Control**

The Timer can indicate the elapsed time either in seconds or in cycles. The Timer is prearranged in the setup screens of the respective relay types that are to be evaluated. There are factory default settings for the timer inputs.

1.5.1 Binary Inputs – Timer

The Timer is specifically designed to measure high speed operation of electro-mechanical, solid-state and microprocessor-based protection relays. In addition, it will perform timing tests on EHV to low voltage breakers, trip circuits, and contactors. The factory default settings are:

Input 1: Timer start, normally open position, and latched ON
Input 2: Timer stop, normally open position, and latched ON
Input 3: Dry Contact monitor, normally open position, and latched OFF
And Inputs 4 through 16 as dry contact monitor, normally open position, and latched OFF.

It incorporates the banana plug receptacles that may be programmed to be: Start Gates, Stop Gates, and Monitor Gates, all Stop Gates, all Contact Continuity Monitors, or all Voltage Applied/Removed Monitors.

1.5.1.1 Start, Stop, and Monitor Gates

In the TVI there are up to sixteen identical, independent, programmable gate circuits (Start, Stop, and Monitor) that permit simple selection of the desired mode for timing or contact monitoring operation. There are 10 internal inputs and 6 optional external inputs for the unit.

To monitor operation of the contacts or trip SCR in the device under test, an "ACTIVE" light is provided for each gate. The gate circuit is isolated for voltage-sensing and can monitor solid-state logic signals. Each “Active” light will illuminate once contacts close or voltage is applied to the gate. If desired, a tone generator (horn) may provide an audible indication when the contacts close or voltage is applied.

1.5.1.1.1 Dry Contacts Open

Timer starts, stops or a continuity indicator goes out at the opening of normally closed contacts, or when conduction through a semiconductor device, such as a triac or a transistor, is interrupted.

1.5.1.1.2 Dry Contacts Close

Timer starts, stops or a continuity indicator glows at the closing of the normally open contacts, or upon conduction through a semiconductor device such as a triac or a transistor.

1.5.1.1.3 Application or Removal of AC or DC voltage

This will either start the Timer or stop the Timer. The continuity indicator will glow (application) or darkens (removal) upon the application or removal of either an AC or DC voltage. A higher threshold voltage helps to eliminate false triggers due to a noisy source. Lower thresholds allow starting and stopping of timer from TTL voltage signals. The allowable voltage applied is 5 to 300 Volts AC or 5 to 300 Volts DC, current limiting resistors provide protection.

1.5.1.1.4 The Timer can be started when turning on any selected generators.

1.5.1.1.5 The Timer can be started simultaneously with a change in Frequency, Phase Angle, or Amplitude. Also, it can be started simultaneously with a Voltage or Current waveform step.

1.5.1.1.6 The Timer can be stopped upon Phase Synchronization between two voltage channels (normally used to time auto synchronizing relays).

1.5.2 Binary Outputs – Timer

There are 6 internal outputs and 10 optional external outputs for the unit. The contacts can switch up to 300 VAC, 1 Amp or 250 VDC, 1 Amp continuous. The contacts may be to open or closed, thus simulating circuit breaker operation. The programmable wait duration is from 1 millisecond to 10,000 milliseconds.

1.6 Battery Simulator

The receptacles provide 24, 48, 125, or 250 VDC with current limiting protection. The primary application is to provide DC logic voltage to solid-state and microprocessor relays.

CAUTION:

⚠ **NOTE: DC voltage is ON and available when the output is turned on using the LCD touch panel or via software command. Do not plug or insert any test lead into the BATTERY SIMULATOR binding posts without first connecting the test leads to the load!**

1.7 Transducer DC IN Measuring Circuit

The DC measuring circuit's voltage is from 0 ±10VDC and current from either 0±1mADC or 1 to ±20mADC. This circuit is used for testing transducers. See Section 3.8.10.4 for more description.

1.8 Operation of Optional High Current Interface

The High Current Interface may be initiated in the Main Menu Screen. The High Current Interface button is located at the bottom of the TVI. When initiated, the "High I" will change to "Unit I".

When a relay test is completed and the HIGH CURRENT INTERFACE is no longer required, turn OFF the EPOCH-20/II test unit.

2.0 SETUP

2.1 System

Unpack the unit and check for evidence of any shipping damage. If there is any visual damage, notify the freight carrier to make a damage claim and notify Megger of the damage.

⚠ **CAUTION**

Potentially lethal voltages may be present on the output terminals. It is highly recommended the operator read the user manual thoroughly and have an understanding of the test set operation prior to turning power on.

1. Plug the Touch View Interface into the front of the unit. The TVI will be active once the power is turned ON. A personal computer (PC) will take control of the unit if it is connected. The unit power must be OFF before the PC is connected to the unit.

2. Before connecting power to the unit, make sure the POWER ON/OFF Switch is in the OFF position (0). Plug the unit line cord into a power source and turn the POWER ON/OFF Switch to ON (I).

2.2 Touch View Interface Operation

The TVI is the manual control and user interface for the unit. All manual entries will be made through the TVI unless the unit is connected to a personal computer. During the power up sequence the test system automatically does self-test to insure everything is operating properly. Once the system has completed its self checks the Introduction screen will appear.

Figure 6 Introduction Screen

Pressing the Main Menu button will produce the following screen.

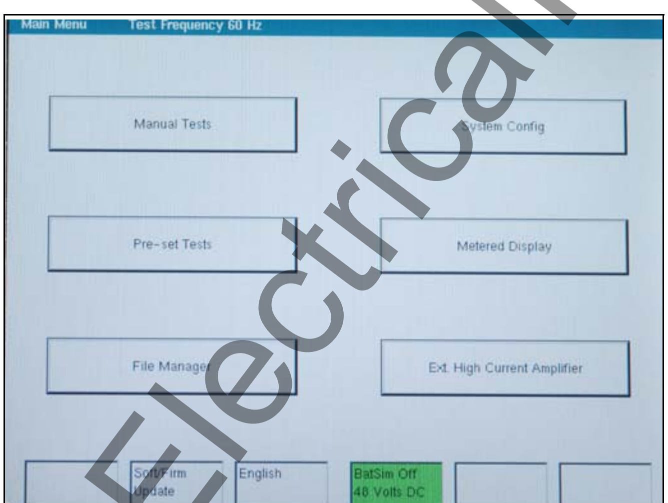


Figure 7 Main Menu Screen

If a PC is connected, the TVI will display the monitored outputs when the PC is in control of the unit. The Timer button will be available to select time ONLY. In addition, the vector graph will be displayed on the TVI.

2.2.1 Touch Panel Display

The TVI Touch Panel Display is the means by which data is entered into the unit, while the unit is in manual control. The TVI will display all active (ON) generators in red and all selected, but inactive (OFF), generators in green. If a generator is not selected it will be grey. If an entered value is out-of-range, an error screen will appear to notify the setting is out-of-range.

2.2.1.1 Keypad Entry

The keypad entry provides an interface to the user when entering a value in the various screens. Touching a data entry window on the TVI will activate the Numeric Keypad. Pressing Enter or Cancel will return the user to the previous screen that is in use. Pressing Ramp will select that value to ramp when using the control knob. Pressing Clear will clear the value you just entered.

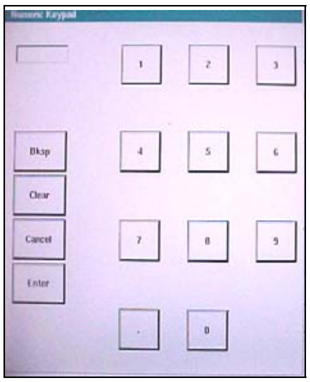


Figure 8 TVI Numeric Keypad

2.2.1.2 Alphanumeric Keypad

The alphanumeric keypad allows the entry of ASCII text into the TVI. This keypad is used to enter file names in length for the primary name, and a 3 character extension in the file management screen. This screen is also used when using the Transducer Test Setting Screen.

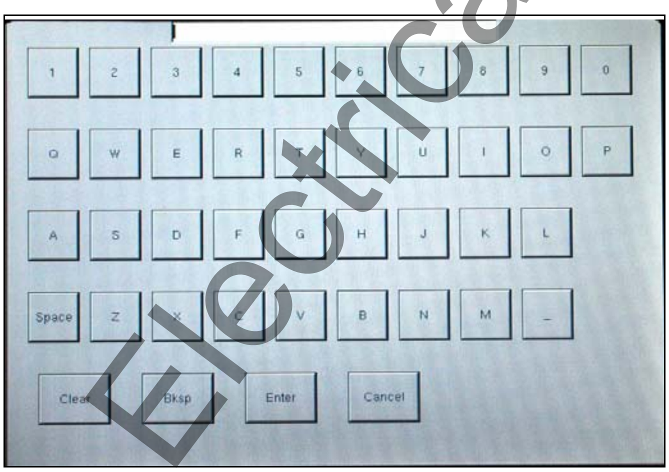


Figure 9 TVI Alphanumeric Keyboard

2.2.2 Control Knob

The control knob will change the values after touching the display to highlight the value that requires ramping. Clockwise rotation increases and counterclockwise decreases. The control knob uses a speed control algorithm to provide fine adjustment, with a slow rotation, and a larger step adjustment with a faster rotation.

2.2.3 Factory Defaults

There are several factory default settings including language, system frequency, phase angle rotation, battery simulator, GPIB address, IP address, brightness and contrast, unit and V/I Gen serial numbers, and the color palette. Pressing the System Config. button on the Main Menu will result in the following,

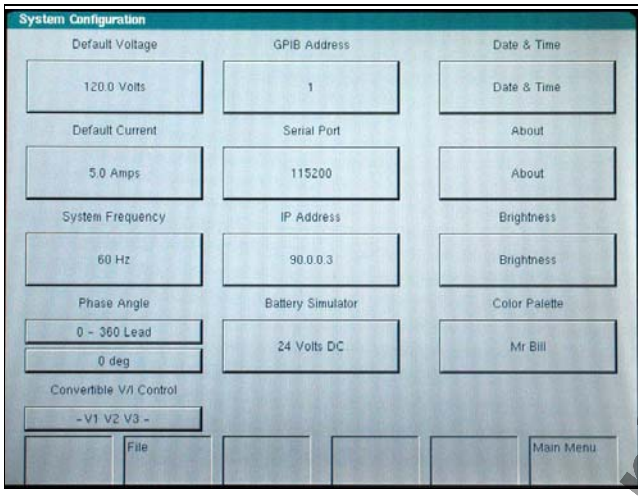


Figure 10 Default System Configuration Screen

2.2.3.1 Language

The factory default is English, but may be changed to French, Spanish, German, Italian, or Portuguese. Other languages will be added to the list at a later date. To change language, press the language select button on the Main Menu Screen, see Figure 7.

2.2.3.2 Color Palette

The background and color scheme is adjustable. Press the button to select from a variety of other color schemes.

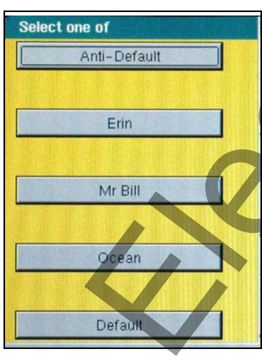


Figure 11 Color Palette Selection Screen

2.2.3.3 Brightness

The brightness is adjustable. The display will always be visible since hardware limits the brightness from becoming too bright or too dark to be seen. Press the brightness + or - buttons to make adjustments.

2.2.3.4 About - Information Screen

The V/I Generators, Timer and Unit Serial Numbers, software/firmware versions and unit configuration will be displayed once the About button is pressed. This information is useful when calling Dallas for service or technical support related issues.

2.2.3.5 Date and Time

Press this button to reset the Date and Time. This information is critical for saving tests and test results in the unit internal file manager.

2.2.3.6 Battery Simulator Setting

The Battery Simulator output voltage can be set to 24, 48, 125, or 250 Volts DC. The Volts DC selection only establishes the voltage values, but does not turn power ON for the Battery Simulator. The various test setup screens will allow the Battery Simulator to be powered ON/OFF as applicable. Pressing the DC Battery Simulator setting button the following selection screen will appear.

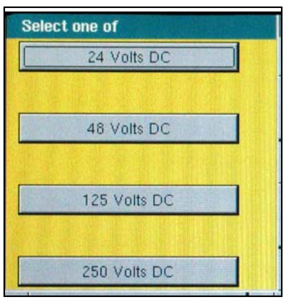


Figure 12 Battery Simulator Voltage Selection Screen

2.2.3.7 IP Address

The IP address allows the unit to be connected and controlled on a local area network. Pressing the IP Address button will produce the IP Address Dialog box. See Section 6.2 MPRT Ethernet Port and IP Networks for details associated with use of the Ethernet port and IP address settings.

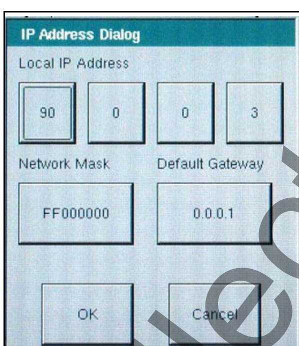


Figure 13 Ethernet IP Address Dialog Box

2.2.3.8 Serial Port

The Serial port will operate at various baud rates. Pressing the Baud Rate button will provide a list of baud rates to choose from. Popular rates are 9600, 19200, 38400, 57600 and 115200. The higher bauds rates provide faster downloads and response to commands.

2.2.3.9 GPIB Address

The GPIB address is selectable from 01 to 15. The factory default is 01. This will permit communication between a personal computer and the unit once the IEEE-488 GPIB driver is set to communicate with the respective address.

2.2.3.10 Convertible V/I Control

Used to change voltage channel to a current channel. Current configuration will be highlighted in red, while the unselected channels will be in green. If the channel is not present, it will be in grey and not available for selection.

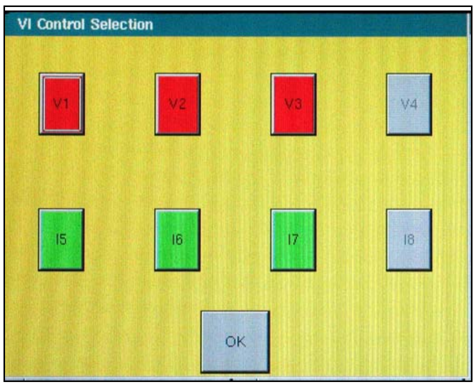


Figure 14 Convertible V/I Selection Screen

Note: If channel is not installed, the channels will be grey (see Figure 15 above).

2.2.3.11 Phase Angle Setting

The Phase Angle Setting has three selections: 0-360° Lead, Lag or ±180°. In addition, the user can set the display for clockwise and counterclockwise rotations. The factory default is 0-360° lagging. Press the Phase Angle select button, and the following screen will appear.

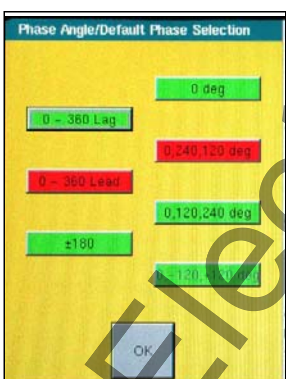


Figure 15 Phase Angle Display Selection Screen

Select either Leading or Lagging and the phase indicators 0 deg., or 0, 240, 120 deg. or 0, 120, 240 deg. or 0, - 120, +120 deg. Selecting 0 -360 Lead and 0, 240, 120 deg. will result with V1 referenced at 0˚, V2 at 240˚ Leading V1 and V3 at 120˚ Leading V1, Counterclockwise rotation. Currents when entered will Lead their respective voltages by the angle entered. Selecting 0 – 360 Lag, and 0, 120, 240 will result with the voltage V2 and V3 lagging V1 by 120 and 240 degrees respectively. Any current values entered will lag their respective voltages by the angle indicated. See section 3.2 for more details on setting phase angle relationships.

2.2.3.12 System Frequency

The system frequency will be set to the typical value of the country, either 50 or 60 hertz. Other fixed frequencies are available. The unit can provide a fixed output frequency of 0 (DC), 25, 50, 60, 100 hertz, or Line Sync 50/60 Hz. To change the default frequency press the System Frequency button and the following selection screen will appear.

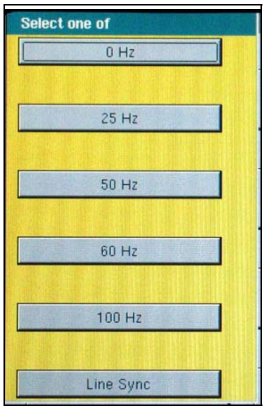


Figure 16 System Default Frequency Select

2.2.3.13 Default Current Output

The Default Current provides a default value (set for 0 Amps) and provides the selectable setup values for the current. The selectable currents are 0, 1, and 5 amps phase-to-neutral. This will also be the value used in the prefault settings screen as well some other preset test screens. These settings will change once the values are changed by the user in the relay settings screen.

2.2.3.14 Default Voltage Output

The Default Voltage output provides a default value (set for 0 volts) and provides the selectable setup values for the voltage. These settings can be changed by the user in the relay settings screen. Press the Default Voltage button and a list of popular phase-to-neutral values will be provided to choose from. This is a big time saver when testing three-phase relays, the user does not have to enter each individual voltage value, they will already be preset ready to use.

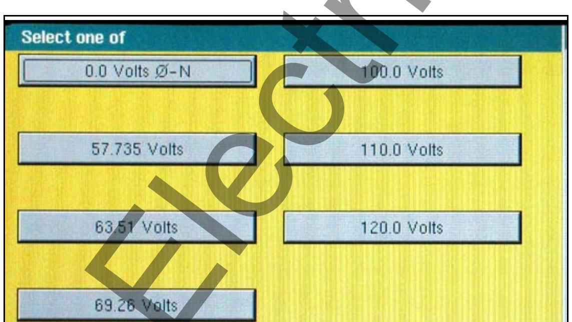


Figure 17 Default Voltage Setting Screen

2.2.4 File Management

The file management display is used by the TVI to access files stored on the unit's internal memory. This display will allow test files to be loaded, make or change directories, rename files and directories, delete files and directories that were created by the customer.

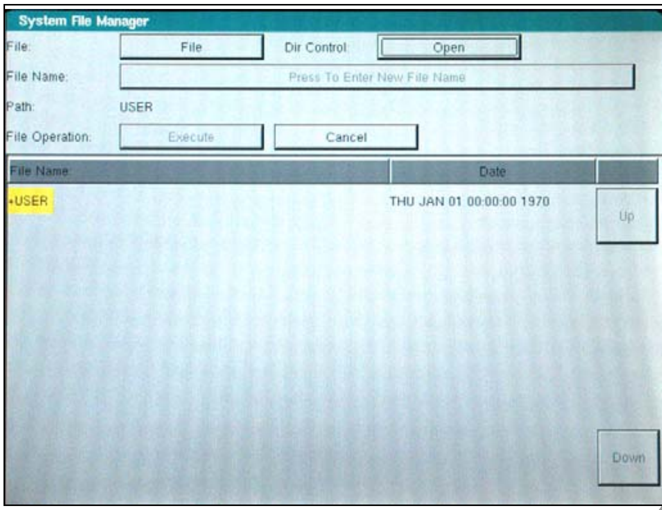


Figure 18 File Manager Screen

The display is divided into two parts: the upper half is used to define the user action; and the lower half displays the files and directories. File names are limited to 99 capital letter characters. The alphanumeric keypad is used to enter file or directory names. In addition, the name of a file or directory will appear in the name area as the cursor moves (using Up and Down buttons) through the list of files or directories.

The following list of actions may be used in this display through pull down menus: Save Data, Read Data, Make Directory, Rename, Delete, Save User Sys Defaults, Read User Sys Defaults, Read Factory Defaults and Delete Factory Defaults. If files are to be deleted or written over, a warning message will alert the operator this action is about to take place. This allows the operator to cancel the action.

2.2.4.1 Test Files

The test files are used to verify the functionality of specific relays. These files typically verify the functionality of the entire relay to ensure the operational readiness of this unit under test (UUT). The test files may be provided by Megger or generated by the customer. Default files may be added to or removed from the database. These files will reside in a specific directory in the MPRT internal memory.

2.2.4.2 Test Results

The test results may be stored in the MPRT internal memory as a soft copy or downloaded into a PC for soft and/or hard copy. The test results file must be saved using the file management display. This is performed using a file naming convention that uniquely identifies the test results.

2.3 **Communication Ports**

There are several different communication ports. These ports are: Serial, USB, GPIB, Parallel, and Ethernet. The function of these ports are similar, but are differentiated by their respective speed at performing a set of operations.

2.3.1 RS-232C Serial Port

The Serial port will operate at various baud rates. The connection to it is limited by this speed. Check baud rate using the System Configuration screen.

2.3.2 IEEE-488 GPIB

The IEEE-488 GPIB port will allow a faster baud rate and connectivity to the Unit. This port is recommended for connection to the unit except when DFR streaming or EMTP files need to be controlled in real-time.

2.3.3 Ethernet 10 BaseT

The Ethernet port will allow the fastest method for DFR playback streaming in real-time.

Firmware updates use this port for downloading purposes, since it is the most effective and efficient communication. Simply connect the port to the networked PC and download accordingly.

2.3.4 USB Port

The USB ports are used for communication to external devices, such as an optional I/O interface box.

2.3.5 Printer Port

The Printer port is for future use and is not available at this time.

2.4 **Error Reporting**

There are over 300 possible error messages that the operator may witness. Some have to do with manual operation, some have to do with automated operation, and some have to do with unit errors or overload situations. For example, errors will be reported when out-of-range values are entered. The error screen will display the range for that value to ensure a value is entered that resides within the tolerance of the range.

2.5 **Advanced Visual Test Software (AVTS)**

AVTS is external software specifically constructed to work with Megger relay test equipment (MPRT and Pulsar). The software contains the necessary steps to perform specific relay tests. It is designed to perform manual or automated relay testing for distance (impedance), over-current, differential, frequency, voltage, synchronous, power and reclose relays. Also, AVTS is specifically designed to perform DFR testing and playback including GPS synchronized end-to-end tests. The MPRT comes with a Basic version of AVTS, while the Advanced and Professional versions are optional.

3.0 **OPERATING PROCEDURES**

This section describes basic operating procedures for using the multiple output modules of the unit for such applications as paralleling current outputs, conducting harmonic restraint tests, series of potential sources to provide higher than rated potential, testing over/under voltage relays and forming three phase voltage outputs.

3.1 **Touch View Interface**

The Touch View Interface (TVI) is used to operate the MPRT manually. It is controlled via a touch screen and a control knob. The touch screen allows the operator to change a parameter by simply touching the location for the value. Then, a keypad can be used to change the value or the operator may use the knob to modify the value.

3.2 Setting Phase Angle Relationships

Think of each V/I Generator module as a vector generator. Each module has an internal zero reference to which it references its phase angle settings as displayed on the TVI. This applies to phase angle settings between the voltage and current outputs. When setting a phase angle between two outputs, it is recommended that one output be set at 0° and the other output be referenced to the 0° . This is for operator convenience only. When setting an angle, the operator has a multiple of choices, depending on the Default Phase Angle setting in the Default Setting Screen, see 2.2.3.9. In the engineering world and in the following figures, the lagging diagram displays negative rotation and will create negative sequence components, while the Lead and +/-180 diagrams display positive rotation which is normal system activity.

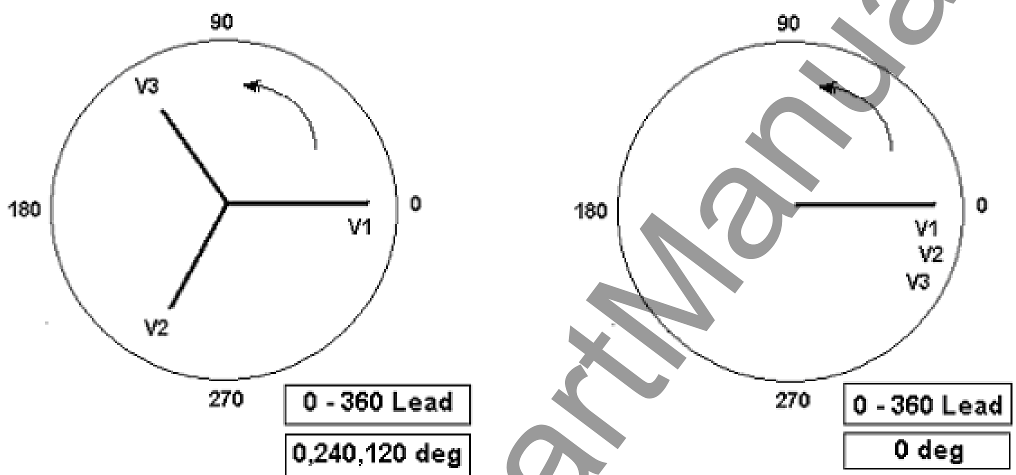


Figure 19 Positive Phase Rotation Diagrams

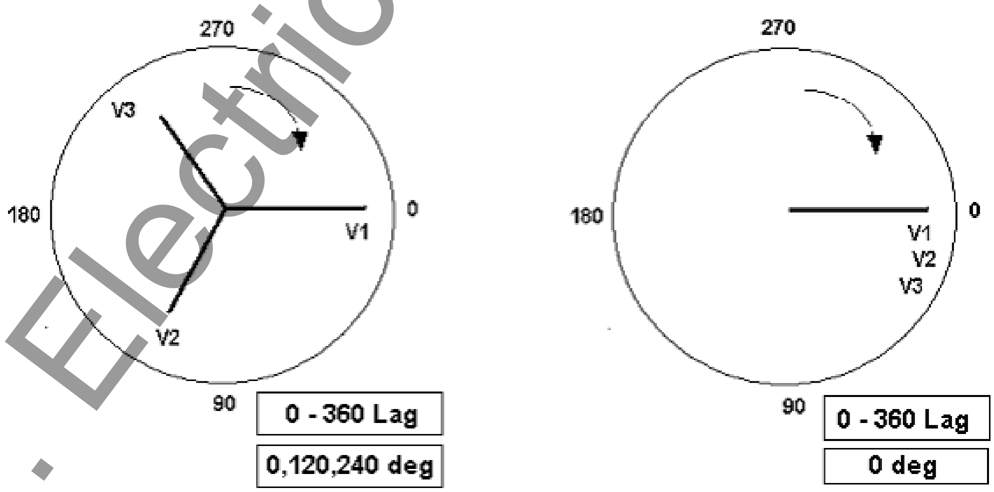


Figure 20 Negative Sequence Phase Rotation Diagrams

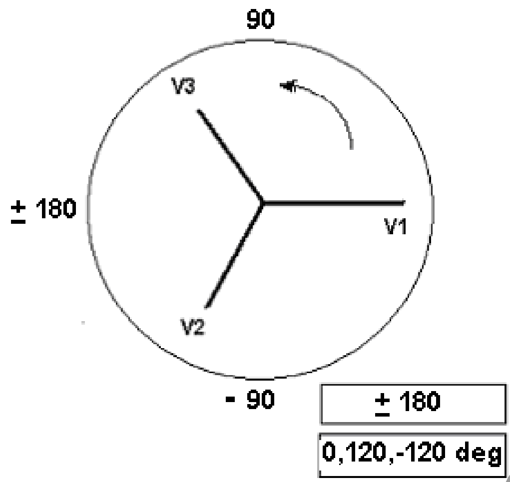
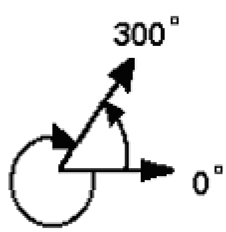


Figure 21 Positive Phase Sequence Rotation Using ± 180˚

For example, using 0-360 Lag (0, 120, 240) setting an angle of 30° between the two outputs would look like:

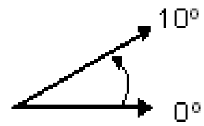
The reference output is 0° and the second output is rotated 30° clockwise. In other words, the angle is lagging the referenced source by 30°.

Conversely, if the angle decreases in the counterclockwise direction from 359.9° toward 0.0°, for a setting angle of 300.0°, the second output would look like:



The reference output is 0° and the second output is rotated to 60° in the counterclockwise direction. In other words, the second output lags the reference output by 300° or leads it by 60°. The user may default to phase angles to ±180° with the - (negative) angles lagging and the +

(positive) angles leading. Therefore, to set an angle of + 10° leading, the vector relationship would be:



3.3 **Current Sources**

3.3.1 Parallel Operation

Two, three or four current channels may be connected in parallel to provide additional current capacity. This is necessary when higher test currents are needed for testing instantaneous trip elements.
To parallel the current channels of the unit, perform the following:

1. Note that all units with a style number **T** in the 7th digit (i.e. 8430L3**T**6A1) the current commons are grounded. Those units with a style number **F** the current commons are floating. Using the current channel test leads, connect each current channel to the relay under test (both red and black terminals to the load). Obviously, for the floating common units you have to connect the black common return to the relay or there would not be any current flow from that channel. By connecting the commons together, all of the current channels would then have a common reference point. For the grounded common return units, there is an internal common ground between the current channels. By not connecting a return lead to all of the current channels in use, part or all of the return current will be forced through the internal ground. That means with a 4 channel unit up to 120 Amperes could be forced through the internal common ground. Because of size and weight restrictions, the unit is protected internally against too high of a current through the common ground using surface mounted fuse type elements. Blowing a ground fuse element will require the unit be returned to the factory for repair! Therefore, it is important that the parallel connections must be made at the relay, not at the source through the common ground return. See the following figure.

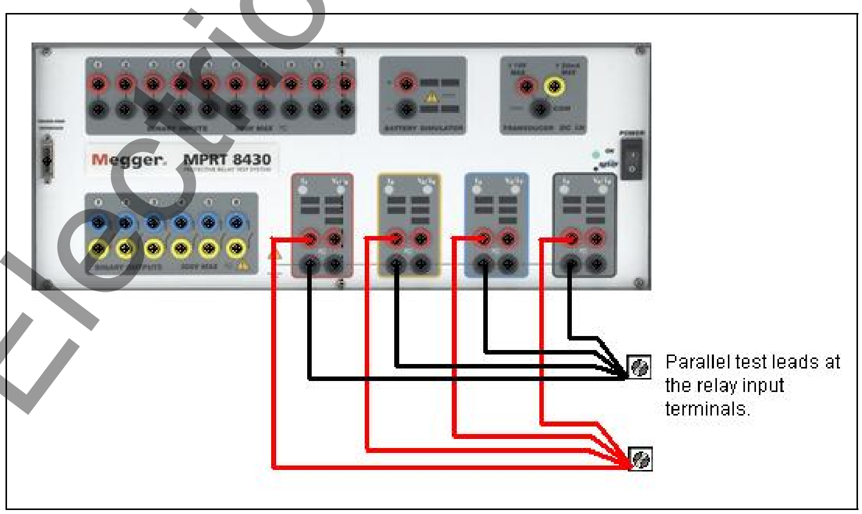


Figure 22 Parallel of All Four Current Outputs

NOTE: All current channels should be set to the same phase angle.

2. If two current channels that are to be used in parallel, set each to one-half of the output requirement. The settings between three current channels will be one-third the output requirement, and four channels would be one-fourth. Initiate all current channels simultaneously by pressing the Start button. All parallel current outputs must be ON to prevent internal shunting of current. Note: If only two currents are to be used, only connect two currents in parallel, etc. for three or four channels. In other words do not parallel a current channel if you do not intend to use it.

3. All current channels have amplitude control now operates simultaneously to provide the desired test current. Selecting Ramp of the current Magnitudes will allow the user to ramp all currents at the same time using the Control Knob. Total output is the sum of the current shown on the individual current channel amplitude displays.

3.3.2 Currents in Series Operation

Two current channels may be connected in series in order to double the available compliance voltage. High impedance electromechanical ground overcurrent relays have always been difficult to test at high multiples of tap due to the winding impedance and saturation characteristics. The peak voltage required can exceed the maximum output voltage of one MPRT current output channel, depending on the required test current. By connecting two current outputs in series, the compliance voltage is doubled, providing higher test currents through the load. To series the current channels of the unit, perform the following:

Using the current channel test leads, connect the Red output terminals of current channel to the relay under test. For “floating” ground units connect the two black return terminals together as shown in the following figure.

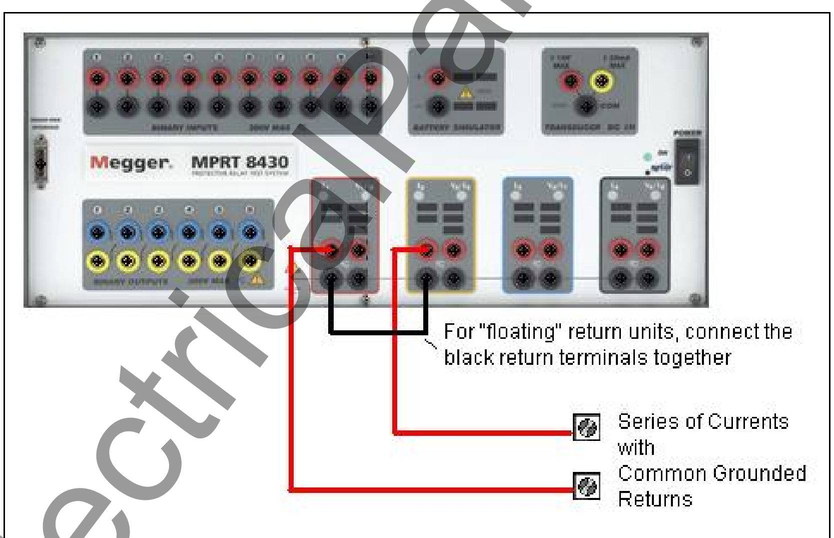


Figure 23 Series of Two Current Channels

NOTE: One current channel should be set to 0 degrees and the other current channel should be set to a phase angle of 180 degrees so that the two compliance voltages add across the load. DO NOT attempt to series more than two currents together.

The two current channels that are to be used in series set each to the same test current magnitude. Initiate the two current channels simultaneously by pressing the Start button.

All current channels have amplitude control now operates simultaneously to provide the desired test current. Selecting Ramp of the two current Magnitudes will allow the user to ramp the two currents at the same time using the Control Knob. The test current is the current shown on either of the current channels amplitude displays.

3.3.3 Harmonic Restraint Test

One V/I Generator could be used to do differential or harmonic restraint tests when the voltage channel is converted to a current source. This is useful when the unit only has one V/I Generator, and if the required operating current doesn't exceed 5 amperes and the restraint current doesn't exceed 15 amperes (Model MPRT 8415) or 30 amperes (Model MPRT 8430).

Two V/I Generator current channels may be used to obtain the desired current output to conduct harmonic restraint tests on differential relays. One of the current channels provides the second or higher harmonic output and the other current channel provides the fundamental current.

There are two methods available to do harmonic restraint tests: the first method uses a pure harmonic (2nd, 3rd, 5th, etc) of the fundamental from one current channel summed with the fundamental current from a second current channel at the relay; The second method uses the unit "HWAVE" feature. The HWAVE simulates the "diode method" recommended in some relay manufacturers instruction literature. When the HWAVE is selected, the output module provides a "half-wave" sinewave (similar to what you would see if using a diode in series with a current source).

! NOTE: Some recommended test procedures prefer using 4 DC amperes of half-wave. Since the unit displays the full RMS sine-wave quantity, it will be necessary to set 8.89 amperes RMS on the selected HWAVE current channel to achieve the desired equivalent of 4 DC amperes half-wave. Use the following formulas to calculate other values of DC half-wave:

$$IDC(halfwave) = \frac{Ipeak}{\pi} \quad \text{and} \quad \mathrm{Ipeak} = \mathrm{Irms} * 1.414$$

Therefore,

$$Idc(halfwave) = \frac{Irms * 1.414}{\pi}$$

Or

$$Irms = \frac{Idc(halfwave)}{0.45}$$

Solving where:

$$Idc = 4$$

$$Irms = \frac{4}{0.45} \quad or \quad Irms = 8.89$$

3.3.3.1 Basic Harmonic Restraint Test Procedure

To set up the unit for harmonic restraint testing use the following procedure:

1. Select a current module to provide the desired harmonic. Set the current channel to the desired harmonic. Use either second, third, or fifth harmonic in conjunction with the selected frequency.

2. Connect the pair of current output leads from two of the unit's current channels to the relay under test so the current from each output is in parallel with one restraint and the operating coil of the relay. Check to ensure both commons (grounds or earths) share the same relay terminal.

3. Initiate the outputs. Increase the output to the appropriate harmonic current. It is recommended that 1.0 ampere of harmonic current be set (it will make the math easier). If using the HWAVE, set the displayed current to 8.89 amperes RMS (this equals 4 amperes DC half-wave).

4. Increase the fundamental current until the relay operates. To calculate the percent of harmonic restraint use the appropriate equation below (if using pure harmonic current). If using the HWAVE refer to the manufacturer's instruction literature for the appropriate % Harmonic Curve.

General Electric Type BDD

$$\%Harmonic = \frac{2nd \text{ Harmonic Current}}{\sqrt{(fundamental)^2 + (2nd \text{ Harmonic})^2}} * 100$$

Westinghouse / ABB Type HU

$$\%Harmonic = \frac{1.2267 * 2nd \text{ Harmonic Current}}{\sqrt{(fundamental)^2 + (2nd \text{ Harmonic})^2}} * 100$$

! NOTE: Restore the HWAVE channel to a sinewave upon test completion if the HWAVE feature was used.

3.4 **Voltage Sources**

3.4.1 Outputs Summed Together

Two voltage channels may be used to sum the voltage outputs to obtain higher than rated voltage provided the load is <u>ungrounded</u>. Connect the load between the voltage channel posts, set V_1 Phase to 0° and set V_2 Phase to 180°. The voltage outputs will add so the total voltage is the sum of the two voltage amplitudes, V_1 and V_2 as can be seen in the picture below.

. Note that all units with a style number **T** in the 7th digit (i.e. 8430L3**T**6A1) the voltage commons are grounded. For the grounded common return units, there is an internal common ground between the voltage channels. Those units with a style number **F** the voltage commons are floating. For the floating common units you have to connect the associated voltage channels black common returns together, when series operation is required. Remove external commons when testing is completed. DO NOT attempt to series more than two voltage channels together.

3.4.2 Dynamic Voltage Relay Test

Over/Under Voltage Relays can be dynamically tested using one voltage channel along with the timer. This procedure applies a "*normal"*" voltage to the relay under test, then automatically adjusts the test voltage to a "*fault*" amplitude that is higher (over voltage) than the pickup voltage. The same is true for testing under voltage relays except the test voltage is dropped below the relay pickup voltage. Additionally, the timer is automatically started with "*fault*" voltage applied to the relay under test.

First, set the "normal" voltage on the relay, then with the relay energized to normal condition, set the desired "fault" voltage and Timer Start (relay trip circuit should be connected to the Timer Stop terminals). If you want to de-energize the voltage to the relay when it trips, use the Auto-Off feature. The Timer starts, the relay trips, and stops the Timer. It then removes power from the outputs. See Voltage Relay in section 3.8.5.

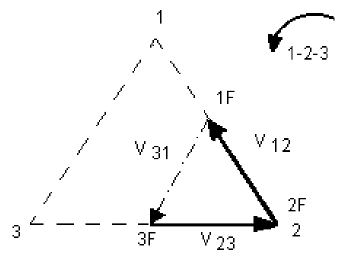
3.4.3 3Ø, 3-Wire, Open-Delta and T-Connection

3.4.3.1 Open Delta

Two methods of obtaining a three-phase, three-wire voltage source are available. The Open-Delta configuration, referenced in the following figure, is the easier to use when a balanced three-phase source and it is required because the amplitude and phase relationship can be set directly. No calculations are necessary.

When using the Open-Delta Configuration to set up a phase-to-phase fault, calculations' using the Law of Cosines is required to calculate amplitude and phase relationships. (See discussion under T-Connection for simulating unbalanced, phase-to-phase faults without need for calculations.)

When using the Open-Delta configuration, it is suggested to use voltage channel #1, designated V_1, and voltage channel #2, designated V_2, while the COMMON binding post is designated V_g. With this arrangement, the magnitude and phase angle of the potentials can be easily calculated and set. For the balanced three-phase condition V_{1g} and V_{2g} are equal in magnitude and separated by an angle of 60^o. This is done by setting the V_1 and V_g potentials equal in magnitude, setting 0° on V_1 and 300^o (60 degrees leading assuming that the default phase rotation is set to 360 Lag) on V_2, (reference following figure).



Balanced 3θ - 3 Wire Fault Open Delta Connection

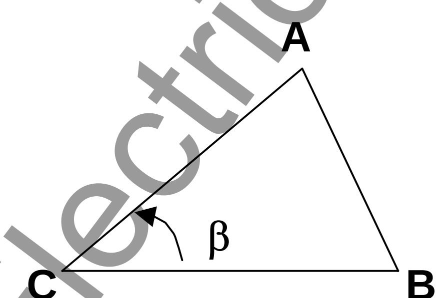
If V_f equals the desired test potential, then:

Set $V_1 = V_f \angle 0^o$

Set $V_2 = V_f \angle 300^o$

3.4.3.1.1 Voltage Output Connections

When setting up an unbalanced Open-Delta configuration, the desired phase-to-phase fault voltage, V_{1f} is set using voltage channel #1 with its phase angle set to 0°. Phase-to-phase voltage V_{2f} and its phase angle relationship for voltage channel #2, must be calculated using the Law of Cosines; where For any triangle the following formula applies:



$$AB^2 = AC^2 + BC^2 - 2 \times AB \times BC \times \cos ß.$$

The next figure shows the phase relationships between voltages and an example of the necessary calculation. For convenience the amplitude and the phase angle settings for the typical V_f fault magnitudes are tabulated.

From the Law of Cosines

$$\theta = \arccos\left(\frac{V_{12}}{2 * V_{23}}\right)$$

$$V_{23}^2 = \left(\frac{V_{12}}{2}\right)^2 + \left(\frac{\sqrt{3}}{2} * 120\right)^2$$

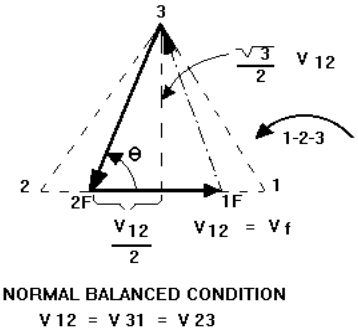


Figure 24 Open-Delta Unbalanced phase-to-phase Fault Voltages

Settings For Typical Phase-to-Phase Fault Voltages

$V_{12} = V_f$

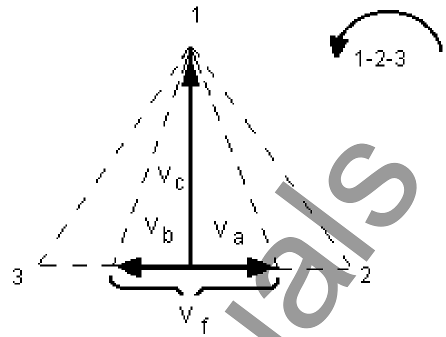
V_{12}	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
V_{23}	104	104	104	104	104	105	105	105	106	106	106	108	108	109	110
At θ° Lag	270	271	273	274	275	277	278	280	281	282	284	285	286	287	289

3.4.3.2 T Connection

The second method of obtaining a three-phase, three-wire voltage source is the so-called T-Connection. The method, shown in the following figure, is easier to use when obtaining an unbalanced, phase-to-phase fault simulation since it eliminates calculations. To reduce confusion when using the T-Connection, the voltage output #1 is designated V_a and its phase angle set at 0°, voltage output #2 is designated V_b and its phase angle set for 180°, and voltage output #3 is designated V_c and its phase angle is set for 270 Any combination of balanced three phase faults or unbalanced phase-to-phase fault conditions can be easily simulated. The following figure indicates these phase relationships.

NOTE: This method should not be used for very low fault voltages (i.e. 5 volts or less, or for testing ABB or Westinghouse type SKD relays).

Balanced or Unbalanced Fault T-Connection



$$V_f = Desired\ Fault\ Voltage$$

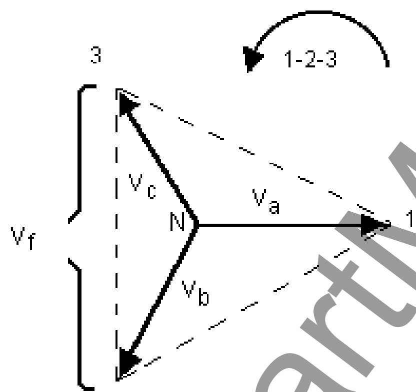
$$V_a = \frac{1}{2} V_f \angle 0^\circ$$

$$V_b = \frac{1}{2} V_f \angle 180^\circ$$

$$V_c = \frac{\sqrt{3}}{2} 120 \text{ or } V_c = 104V \angle 270^\circ$$

3.4.4 3Ø, 4-Wire, Y-Connection

A three-phase, four-wire potential system can be provided using three output modules. The vector relationships are referenced below. This Y-Connection has the advantage of being able to supply a higher line-to-line voltage (1.73 x phase-to-neutral voltage). It is ideally suited for simulating phase-to-ground faults. Voltage channel #1 is designated as V_a with its phase relationship set for 0°. Voltage channel #2 is then designated as V_b and phase angle set for 120°. Finally, voltage channel #3 is designated V_c and phase angle set for 240° (for a 1-2-3 counter clockwise rotation). V_a, V_b and V_c are connected to the voltage potential binding posts on the respective test sets. If a neutral is required, it is connected to a ground post on any voltage output module to ground the load.



$$V_f = \text{Desired Fault Voltage}$$

$$V_a = \frac{\sqrt{3}}{3} V_f \angle 0°$$

$$V_b = \frac{\sqrt{3}}{3} V_f \angle 120°$$

$$V_c = \frac{\sqrt{3}}{3} V_f \angle 240°$$

Balanced 3 θ, 4 Wire Y-Connection

3.5 **Internal Software Test Profiles**

The test profiles are performed on the Relay Under Test to verify the relay is operating correctly. The following describes the procedures to test a unit:

3.5.1 Pulse Ramping

The Pulse Ramping may be used to determine reach values for multi-zone relays, without defeating the zone timer elements. The Pulse Time is set so that the test current is only on long enough for the selected zone to operate. The following figure shows the current pulse generated by the test unit.

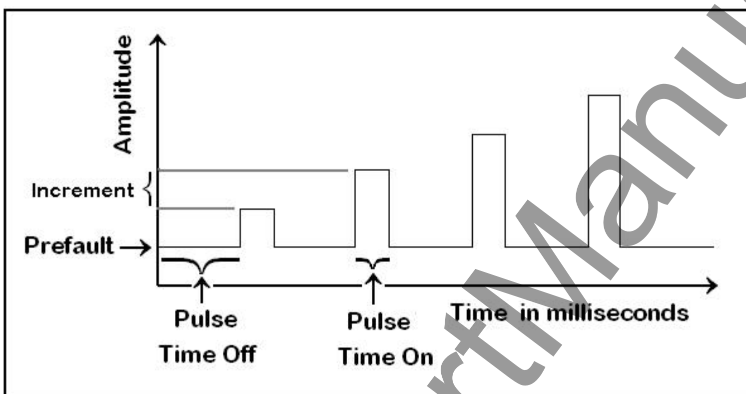
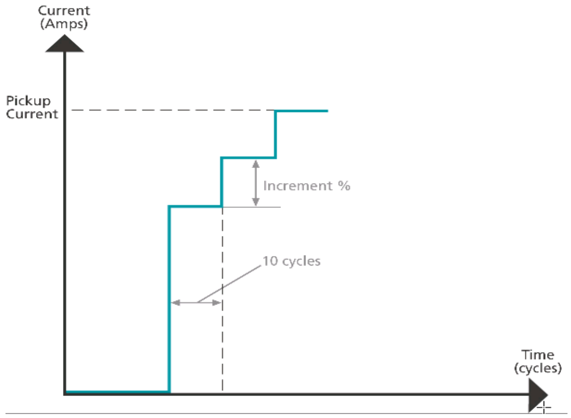


Figure 25 Pulse Ramp

Select the fault type from the several available fault types: phase-to-ground; phase-to-phase; two phases-to-ground; and three phase. Hold the voltage or the current constant. There are different available pre-fault voltages to choose from. The user may enter a different value if desired. The pre-fault current range is from 0 to 9.99 amps. The test starts with a pre-fault current (voltage) for the Pre-fault Time Off delay to ensure the relay energizes (polarize) before starting the test. The Pulse Time Off Delay Time is specified in milliseconds with the factory default value set at 1000 mSec (60 cycles at 60 Hz). The pulse ramping can begin once the relay is energized. The first pulse has a selectable amplitude for the start value. This value is held for the defined Pulse Time (in cycles). The generator output returns to the Pre-fault Value. The time the relay remains at this level is determined by the Delay Time minus the Pulse Time. The next pulse is increased by the increment value specified. The voltage magnitude and angle will be calculated for each of the three phases when the test is complete. The current is calculated for the three phases. The percent error is calculated for the Reach. The resistance is calculated for the final value. A fault calculator, based on symmetrical components, is used to perform the fault calculations.

3.5.2 Ramping

The Ramping test maybe used to determine pickup values, verify single-zone impedance relays or the outer most zone of a multi-zone impedance relays. For example, using the Ramping for finding the reach of an impedance relay, select the fault type from a list. Determine whether the voltage or the current is to be held constant. In the angle of torque calculation both the voltage and current are held constant while the angle is ramping. Start with a pre-fault current (voltage) for the Pre-fault Delay Time to ensure the relay is energized before the test begins. The Pre-fault Delay Time has been specified in milliseconds and the factory default value is 1000 milliseconds (60 cycles at 60 Hz). The ramping starts once the relay energizes. The generator output is set to the start value specified. The generator holds the value for the specified Delay Time by the fault calculator or you may enter a specific value. Once the time has elapsed, the generator output increments by the Increment value specified in the fault calculator or by the entered value. The ramping continues until pickup is detected or the Stop value is reached.

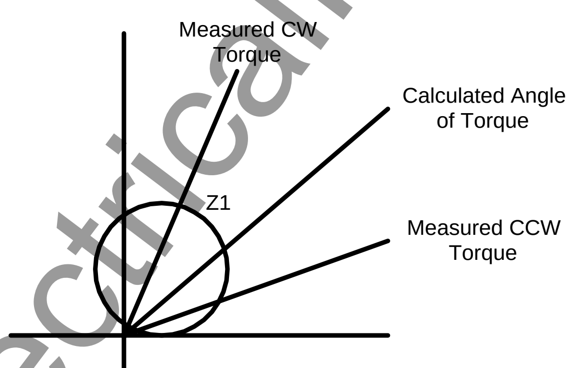


Overcurrent pickup ramp technique

When the test is complete, the voltage magnitude and angle, current, and Reach percent error are calculated for the three phases. One of the inputs is setup to monitor the relay's contacts. When the first fault voltage is applied, the timer starts, and the relay stops when the relay trips.

3.5.3 Angle of Torque

The angle of torque test requires two phase ramps. The first ramp is performed by incrementing the angle CW with the next ramp being incremented CCW. The test will use these two measurements to calculate the angle of torque.



Angle of Torque

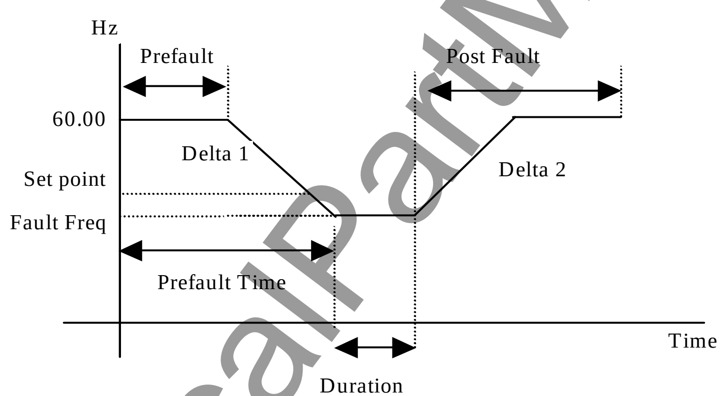
3.5.4 Step

The step test is similar to the pulse ramp except the Step test only uses a single pulse. The test steps from a normal relay setup into the fault condition and waits for the relay to respond. The test energizes the relay with the pre-fault values, sets the output of the generators to the fault values, and then starts the timer. The timer input is used to monitor the relay's trip. The timer stops once the timer detects the relays contacts have operated. This function is normally used when timing under/over voltage or frequency relays.

3.5.5 Dynamic Frequency Hz/S

Some frequency relays require a dual ramp to perform this test. Three sets of data need to be established to perform the test. These sets of data are the pre-fault, fault, and post fault conditions. The dynamic frequency test is executed from the Manual Frequency screen. This test requires a single voltage generator. The change in frequency happens when the frequency passes through the positive going zero-crossing. The rate of change is defined as the delta (Hz/S). The frequency is changed every cycle at the positive going zero crossing. The test limits the delta setting to a maximum value of 10Hz/sec with anything greater being treated as a Step test. The frequency increment is calculated for each cycle prior to starting the dynamic ramp. If we use a delta of 1 Hz/sec and want to ramp from 60 to 50 hertz, then the time would be ten seconds to go from 60 hertz to 50 hertz in increments of 0.01667 hertz steps per cycle.

The first set defines the pre-fault values, which are necessary to energize the relay before the fault condition. The following diagram shows the frequency decreasing. However, the frequency ramp could be increasing as well. The pre-fault and fault values determines the direction of the ramp. If the fault value is less than pre-fault value then the ramp is decreasing. If the fault value is greater than the pre-fault value then the ramp is incremented up from the pre-fault value. There isn't any change to the generator outputs during pre-fault.



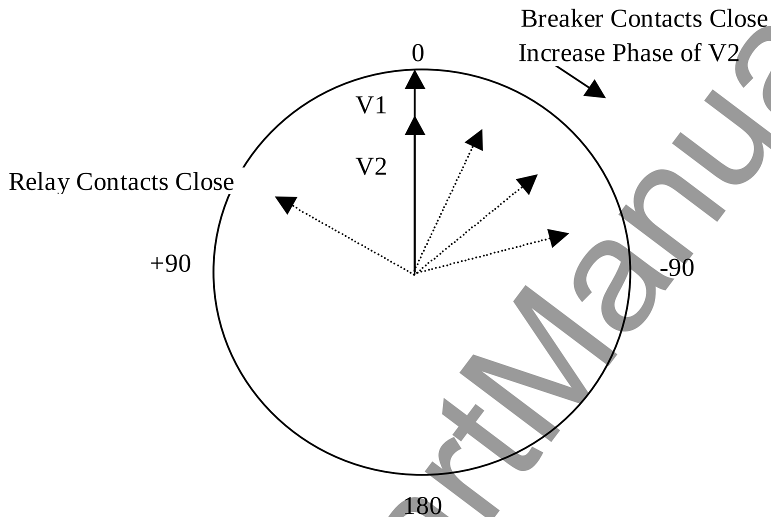
Dynamic Frequency

Duration is the time at the fault frequency. The dynamic fault requires the V/I Generators to ramp to the actual fault value. Delta 1 is the fault ramp and the change in frequency divided by time (Hz/S). The set point indicates the frequency when the relay first detects the fault. Once the set point is reached the relay starts its timer. If the fault is not cleared within the timeout, the relay will trip. The fault frequency is below the set point to ensure the relay trips for a decreasing ramp. The fault value is greater than the set point for the increasing ramp. Once the ramp has reached the set point, the timer is enabled. The fault condition is maintained for the time indicated in the duration.

The post fault requires the V/I Generators to ramp with the generators in the fault condition. This post fault ramp will ramp back to the pre-fault condition. The relay is also in a fault condition and could trip. The post fault will be able to detect the relay trip and record the trip time. The post fault timer will start at the beginning of the ramp and will not wait for the set point. Delta 2 is the post fault ramp and is the change in frequency divided by time (Hz/S).

3.5.6 Auto Synchronizing

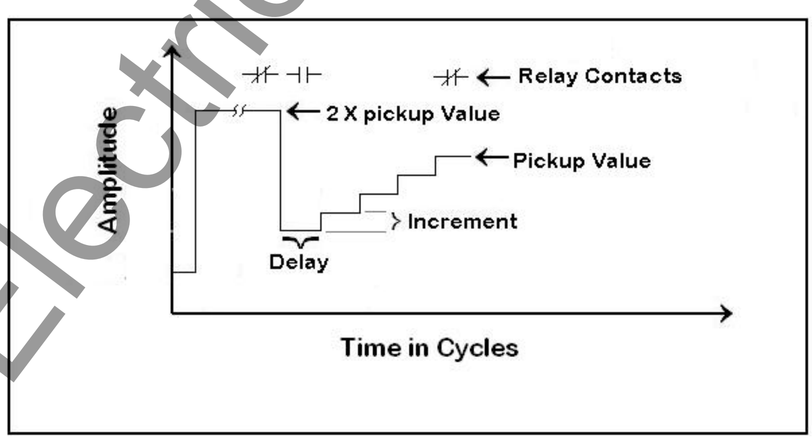
Two voltage output modules are required to perform tests on synchronizing type relays. To perform Pick-Up or Closing Angle tests, voltage channel one, V_1, will be referenced at 0° and allow the second voltage channel, V_2, to provide the variable phase angle adjustment. Remember the phase angle indicated on V_2 will be a lagging angle. If the relay's closing characteristic is 20° leading, set an angle of 340° on voltage channel 2.



Auto Synchronizing Relay

3.5.7 Pickup

The pickup test performs a Ramp or Pulse Ramp (see 3.5.1 for description of Pulse Ramp). Using the Ramp function, the relay is first energized using two times the Tap or Pickup value. After the relay contacts close, the outputs are set to 90% of the Pickup value. The output is increased until the relay trips. Once the relay trips the test stops and the output is recorded.



Pickup Test

3.5.8 Seal-In (Target)

The Seal-In test is performed using DC output current. An AC output current may be applied on over-current relays to close the trip contacts. Some relays require the user to block the trip contacts closed to perform this test. The test ramps the DC output at a pre-selected rate see Test Configuration. The Seal-In test requires the user to press the Stop button, when the Seal-In contact is closed, since these contacts cannot be monitored by the unit.

3.5.9 Timing

The Timing test is similar to the pulse ramp except is uses a single step. The test steps from a normal operating condition into the fault condition and waits for the relay to respond. The test may energize the relay with the normal operating values, then sets the output of the generators to the fault values, and starts the timer. The timer input monitors the relay constants. The fault value is a multiple of relay tap settings. This value could be 70%, 80%, 90%, 200%, 300% or 400% depending on the type of relay being tested (voltage or current). The test has three multiple values and uses each of them until a trip occurs or the last value is used. In some tests, the user may select IEEE / IEC time curves. Trip times are calculated using preprogrammed timing formulas per IEEE or IEC standards. However, if IEEE / IEC times curve are not used, or specific value/trip time tests are to be preformed, the user may manually enter a value(s) and associated trip time(s) in the appropriate value windows.

3.5.10 Harmonic Restraint

This test uses two current generators. The generators are in phase while the current is being ramped. The two currents are set to different frequencies. The starting current is determined by the value entered. With the harmonic current preset (i.e. 1 ampere) the second current channel (fundamental) will be increased at the preset ramp rate, until the relay trips or the max value is reached.

3.5.11 Slope

This test uses two current generators. The starting current is determined by the value entered. The current on one V/I Generator starts at the selected value and is labeled the operate generator. It starts at (I2 x % Slope x 0.9). The restraint current is set as I2. The operate current will be increased at the preset ramp rate, until the relay trips or the max value is reached

3.5.12 Through Fault

This test uses two current generators in parallel. The test is executed and the output current is applied to the relay. The test monitors the relay contact to determine if it is open or closed.

3.5.13 Polarizing

This test uses all three current generators where the output current for each generator is paralleled at the relay. The test is executed and the output current is applied to the relay. This test does not monitor any contacts, but does step the generator outputs to the current value selected. The duration is selected with a maximum time of four cycles to ensure no damage occurs.

3.6 Timer

Due to the timer complexities on the MPRT there are two timer screens. There is a basic timer control screen and the complex timer control screen. When the user presses the Timer Setup button anywhere in the TVI the user will be first presented with the basic timer setup screen. This screen will provide the user with the capability to setup the timer for nearly all relay testing requirements. If the basic timer setup screen does not provide all the capability required the user can press the Complex Timer Setup button. This screen will provide the user the capability of adjusting all the timer input and output setting parameters.

Basic Timer Setup Menu

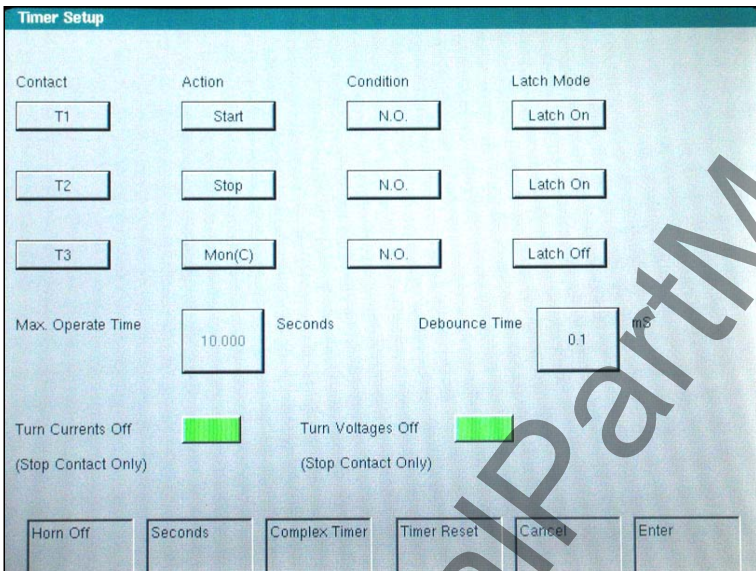


Figure 26 Basic Timer Setup Menu

Description

Controls

Contact: The Contact label identifies which input terminal the associated controls are referring to.

Action The Action control determines the action of the timer. The selections are as follows:
Mon(C) Monitor Contact will light the front panel indicator conditions become true.
Mon(V) Monitor Voltage will light the front panel indicator when the conditions become true.
Start Starts the timer and lights the front panel indicator when the conditions become true.
Stop Stops the timer and lights the front panel indicator when the conditions become true.
CA Starts the timer when current starts to be generated.

Condition	Sets the parameters under which a true or false contact is determined. The selections of condition are as follows: NO Normally Open dry contact. NC Normally Closed dry contact. VA Voltage Applied wet contact. VR Voltage Removed wet contact. N/A Not Applicable.
Latch Mode:	Sets the parameter under which the timer will either stay on after a contact state becomes true or will return to previous state after the contact changes state. Latch On: Will latch the timer in that condition after the timer has reached a true condition. Latch Off: Will allow the timer to return to original condition even after the contact has reached a true condition.
Max Operate Time	Determines the maximum timer the unit will operate before the outputs are turned off. This function is only applicable when the timer is operating.
Debounce Time	Determines how long a contact must be in a true state before the condition is determined to be true.
Turn Currents Off (Stop Contact Only)	When selected will turn all output currents off when the stop contact becomes true.
Turn Voltages Off (Stop Contact Only)	When selected will turn all output voltages off when the stop contact becomes true.
Horn On / Horn Off	This selection will turn the horn on when any contact is determined to be true
Seconds / Cycles	This selection will toggle the timer between measuring in seconds or cycles.
Complex Timer	This selection will display the Complex Timer Setup menu.
Timer Reset	This selection will reset the timer to zero.
Back.	This selection will return the user to the screen previously displayed.

Complex Timer Setup Menu

Description

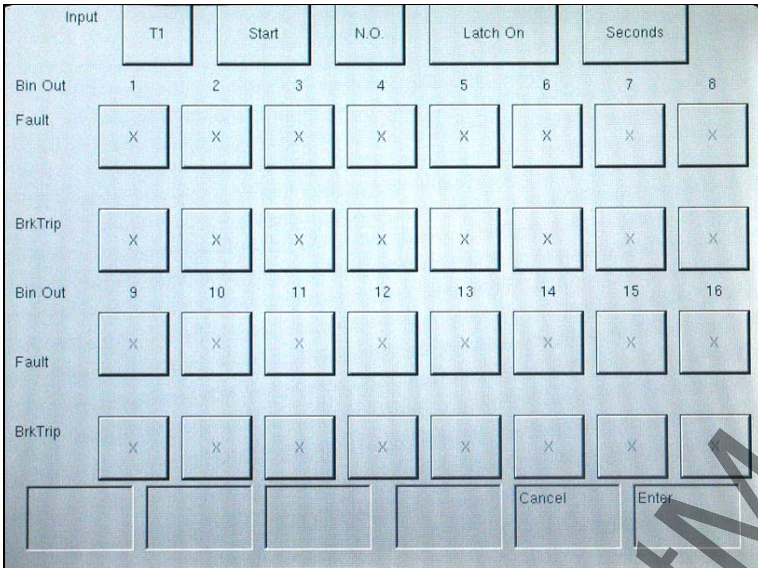


Figure 27 Complex Timer Setup and Binary Output Screen

Up to 16 different timers are available using the button labeled T1. This button will present a pull down menu to select the required timers.

This screen will be used by the default screen to set system defaults. The time selection, when used from the default screen, will set the time base for all screens. If seconds are selected, all screens will set Duration, Op. Time, and Pulse Time to indicate seconds or milliseconds, as applicable. If cycles are selected, the time base will be set to cycles. When this display is called from a setup screen, the time base for the timer in that screen may be changed.

3.7 Battery Simulator

There are two distinct buttons for the Battery Simulator: the Volts DC and value settings. The Battery Simulator output voltage can be set to 24, 48, 125, or 250 volts DC with the factory default set at 125 VDC. This establishes the voltage values, but does not turn the Battery Simulator power ON. The various test setup screens will allow the Battery Simulator to be powered ON, as applicable.

3.8 Relay Testing

The Touch View Interface contains three user interfaces in one unit, a color LCD alphanumeric display panel, a control knob, and a touch panel used to input data into the unit. The TVI will display all active generator settings in red and all inactive, generator OFF, settings in green. If an entered value is out of range, the display will be yellow and an Error Screen will appear. The control knob will change the contents after the value is highlighted by touching the display with your finger.

NOTE: The unit contains factory default values to run a quick test without entering data. However, a one-time warning message will notify the user the test is being conducted with factory default values if the defaults are used.

3.8.1 Touch View Interface Graphical User Interface

3.8.1.1 Main Menu Screen

The main screen is used to access the four normal operating modes and an optional external high current amplifier connection, if this option is purchased.

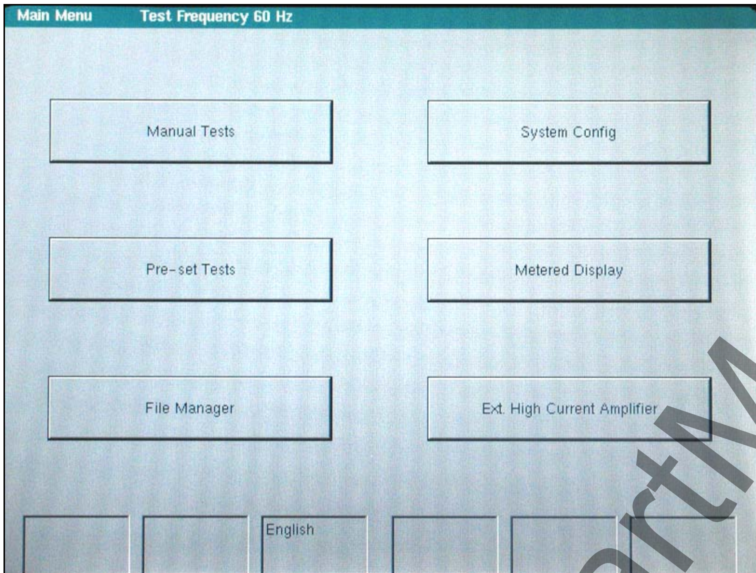


Figure 28 Main Menu Screen

The Manual test screen performs all testing manually.

The Pre-set test screen option provides a variety of preset relay specific test routines.

The File Manager allows access to the stored data files.

The System Config. button allows changes to the system and screen defaults.

The Metered Display allows the viewing of the actual output and input values, as measured by the unit's hardware.

The optional External High Current Amplifier connects to an external source such as an EPOCH II, EPOCH 20, or other system.

3.8.1.2 Pre-Set Test Menu

The Pre-set menu contains all the relay test options.

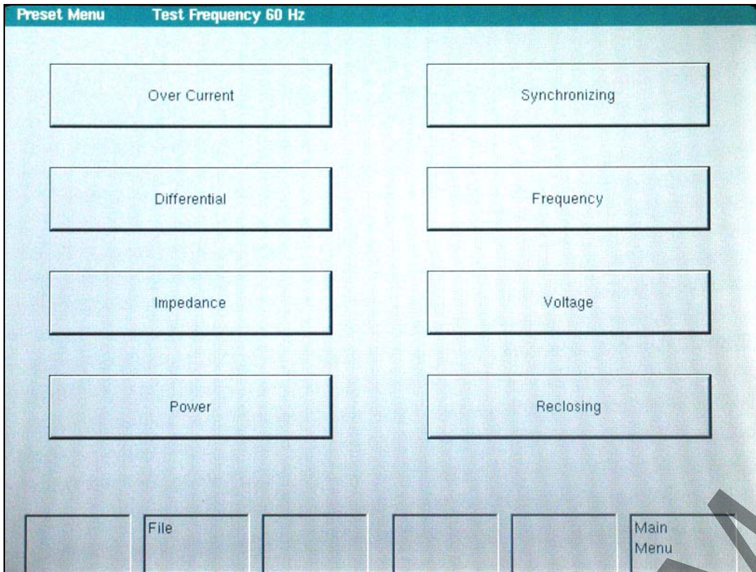


Figure 29 Pre-Set Test Menu

Select the relay type to undergo testing. Once selected, the display will move to that set of relay setting and test screens.

The File button takes the user to the File Management Screen

The Main Menu button will return to the Main Screen.

3.8.2 **Impedance Relay Testing Menu**

The unit contains a set of default values so a test operator interested in running a quick test will not have to enter this data.

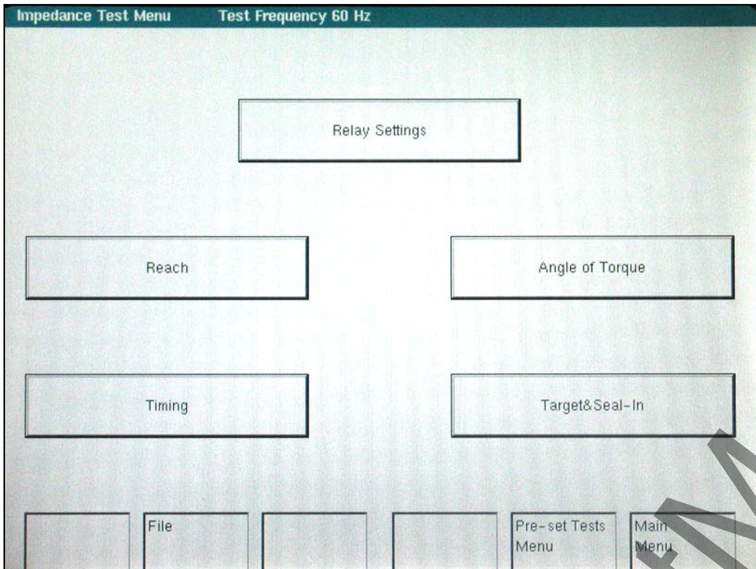


Figure 30 Impedance Relay Menu Screen

This menu permits the setting and testing of an Impedance or Distance relay. These tests should be conducted in accordance with the manufacturers relay specifications.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Pre-set Tests Menu:	This selection will return the controller to the Pre-set Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:

3.8.2.1 Impedance Relay Setting Screen

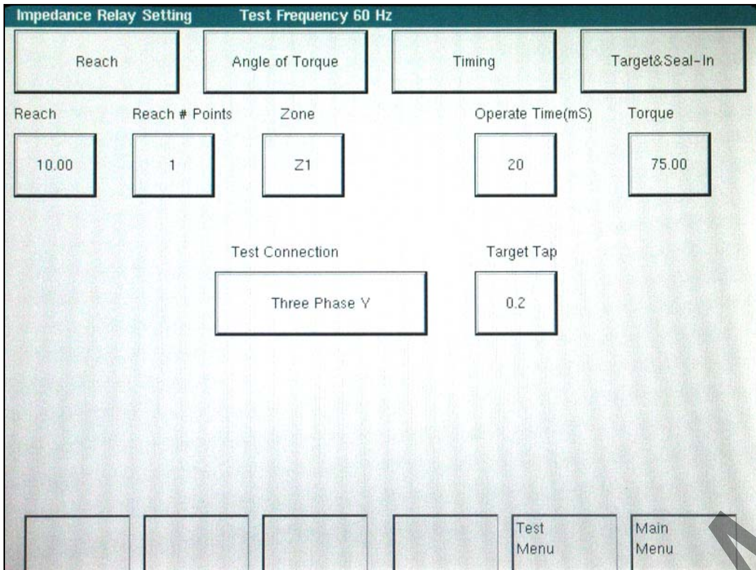


Figure 31 Impedance Relay Setting Screen

The relay setting screen sets the relay values to test the impedance or distance relay. The settings determine if the relay passed or failed when the test completes.

- The Reach setting value is in Ohms with a range of 0.000 to 99.99 ohms. The factory default is 10 ohms.
- There are two parts to defining the torque setting: lag or lead. A lagging torque uses a range of 0-360°, and the lead/lag torque has a range of –180° to +180°. The torque angle value has a range of 0.0 to 999.9. The default value will be set at 75° with current lagging voltage. The user will only be able to enter a value of ± 180° if the ± 180° range is selected.
- The Operating Time is the time in milliseconds with a range of 0 to 9999 milliseconds. The factory default value is 100 milliseconds.
- The Zone button is used to select the test label. The unit tests a single zone at one time and has the information for that zone. The factory default is Zone 1 (Z1). The zone is used during the save operation to separate test data for each zone to save data for all zones in a single file. The Zones are Z1, Z2, Z3, Z4, Z5, Z2R, Z3R, Z4R, and Z5R.
- The Target Tap has selectable values with a factory default of 0.2 DC amperes.
- Select either Single-Phase, Three-Phase Y or Three Phase Open Delta modes with the factory default set to Three-Phase Y. However, selecting the single-phase mode limits the user to one V/I Generator.

The bottom of the screen has common buttons.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

3.8.2.2 The Reach Test Setting Screen

The impedance test settings screen will establish and run a test using factory defaults or manufacturer's recommended values, if entered.

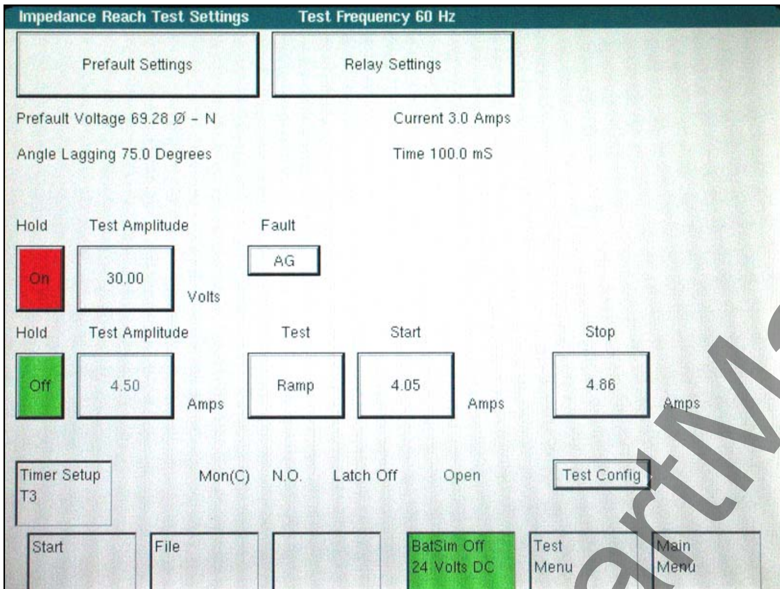


Figure 32 Reach Test Setting Screen

- The Pre-fault Settings button sets the necessary pre-fault conditions for relay testing.
- The Relay Settings button will allow the entry of relay setting values to test and evaluate the relay.
- When the current lags the voltage using 0° to 359.9°, the message "lagging <u>*xxx.x*</u> Degree" is used. Otherwise, no message is required when using ±180°.
- The Fault Type determines the kind of fault tested. The accepted values are AG, BG, CG, AB, BC, CA and ABC (Note: A, B, and C are the phases and G is ground).
- The test entry has two possible selections: Ramp and Pulse Ramp. The selection of the Ramp test will not use all the entries for pulse time. The ramp test changes the V/I Generator output without re-applying the pre-fault conditions. Pulse Ramp uses all screen values.
- The Pulse Time is the length of time the fault value will be applied. The range is from 1to 9999 cycles.
- The Delay Time is the cumulative of fault and fault recovery times with a range of 1 to 9999 cycles. ! Note: The Pulse Time must be less than Delay Time.
- The channel selection default condition enables all Voltage and Current Generators. This is indicated by a check mark in each of the generators selection area.
- The voltage or current may be held. If Voltage is held the Start, Stop, and Increment values will need to be expressed in Amps. If Current is held the Start, Stop and Increment values will need to be expressed in Volts. The Increment value is used to increase the fault values from the start to stop. The Start value is the beginning value for the output ramp. The limit for the MPRT 8415 unit is 15 amps RMS. The limit for the MPRT 8430 unit is 30 amps RMS. The Stop value is the upper limit of the ramp. The two values should be checked to ensure the Stop value is greater than the Start value if ramping current up.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.2.3 Impedance Relay Pre-fault Setting Screen

This screen sets the relay values before fault values are applied to ensure the relay is properly energized.

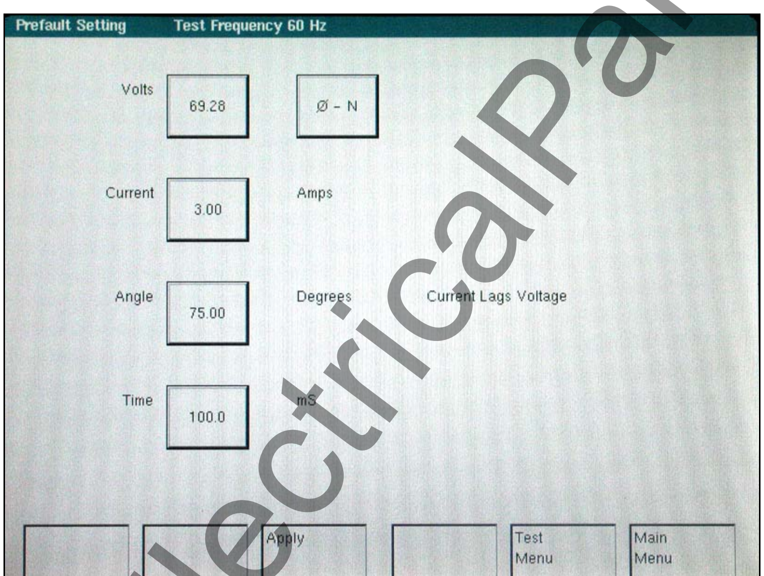


Figure 33 Pre-Fault Setting Screen

- The voltage range is 0.00 to 150.0 volts. This value may be set to two decimal places (i.e. 69.28) with a pull down menu that provide values of 57.735, 63.51, 69.28, 110.0 and 120.0 volts.
- The voltage can be set phase-to-neutral (ϕ-N) or phase-to-phase (ϕ-ϕ) with a factory default voltage of 69.28 ϕ-N.
- The current range is 0.00 to 9.99 amps with the factory default setting of 3.00 amps.
- There are two parts to defining the angle. The first part is set in the System Default Screen where the angle entry is defined as leading or lagging. Lagging value range is 0° to 360°,

and the lead/lag value range is –180° to +180°. The factory default is set to 75° lagging. The second part is the value with a range of 0.0 to 999.9. If the user selects ±180° range the user will only be able to enter a value of ±180°.

- The time entry determines how long the relay will stay in the pre-fault state and the range is 0.0 to 999.9 milliseconds. The factory default is 100.0 milliseconds.

The bottom of the screen has common buttons.

Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Apply: values.	This button will set and apply the pre-fault

3.8.2.4 Impedance Relay Reach Test Result Screen

This screen displays the test results. The Zone and Fault values are copied from the setting screen while all other values are calculated from the test results. The results of the test will be displayed as “Test Passed” or “Test Failed”. No data may be entered in this screen.

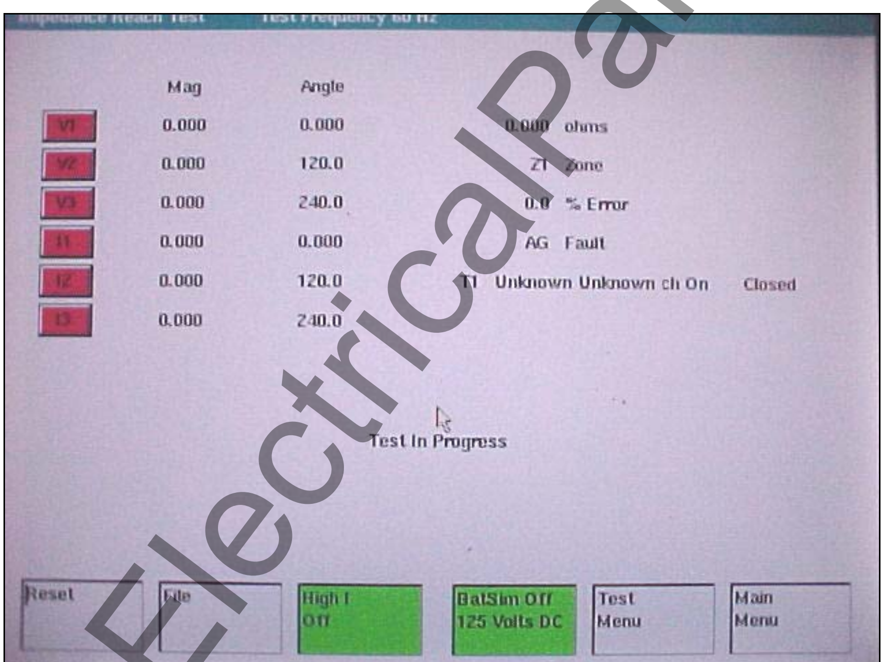


Figure 34 Reach Test Screen

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.2.5 Impedance Relay Test Timing Settings

This screen sets the values to perform the relay timing test.

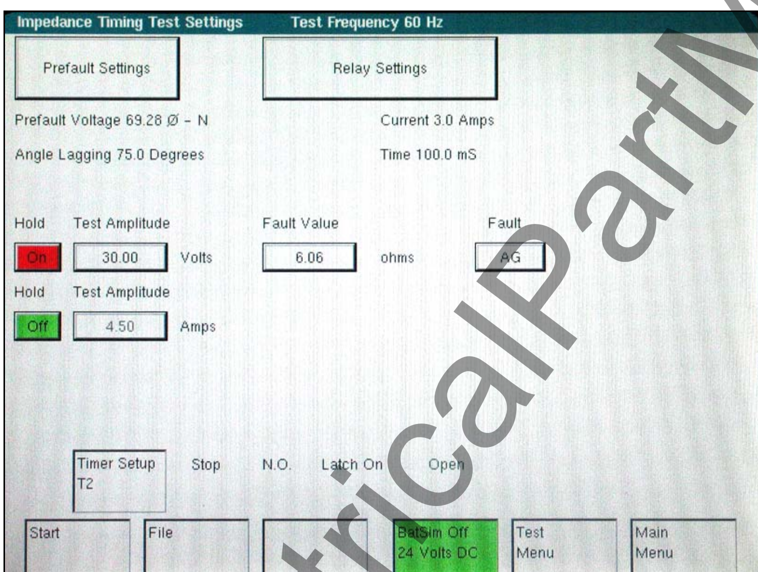


Figure 35 Impedance Timing Test Setting Screen

- The Pre-fault Settings button will move to its screen and will allow changes to the relay specifications. If factory defaults are used, a one-time warning message should be displayed to notify the factory default values are being used.
- The Relay Settings button will move to its screen and allows changes to the relay specifications.
- The Timer Setup screen will define how the timer will be used.
- The Fault type button determines the fault the test will perform. The accepted values are AG, BG, CG, AB, BC, CA and ABC (Note: A, B, and C are the phases and G is ground).
- The voltage and current generators may be enabled or disabled. The default condition has all voltage and current generators enabled. This is indicated by a check mark in the channels selection boxes. If the Voltage is held the Stop value is expressed in Amps. If the Current is held the Stop value is expressed in Volts. The V/I Generators used in the MPRT- 8415 unit have 15 amps / 150 volts RMS limit and the MPRT - 8430 unit have 30 Amps / 300 volts RMS limit. The Stop value is the fault value for the test.

- The timing test jumps from the pre-fault value to the fault value and times how long the relay takes to trip.
- The Run Test button is used to execute the current test setup.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.2.6 Impedance Relay Timing Test Result Screen

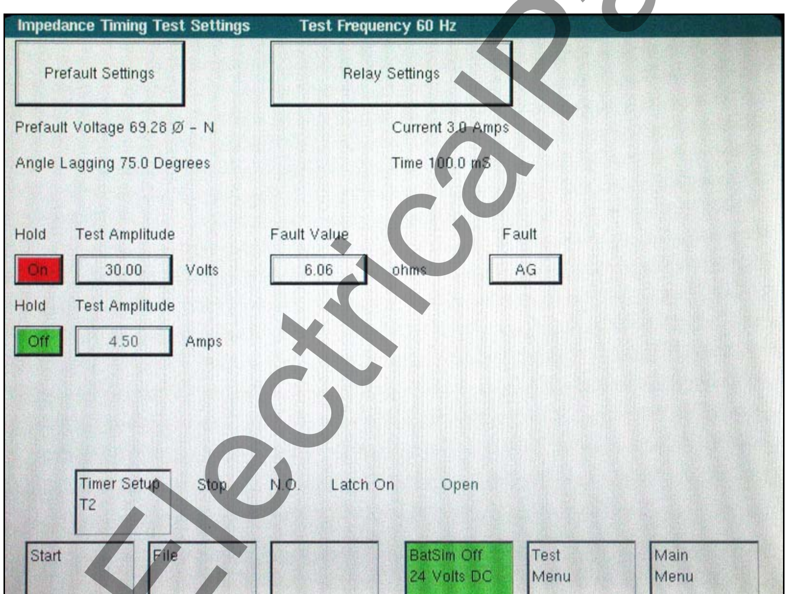


Figure 36 Impedance Timing Test Setting Screen

This screen displays the results upon test completion. The Zone and Fault values are copied from the setting screen while all other values are calculated from the test results.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.2.7 Impedance Relay Angle of Torque Test Settings Screen

The angle of torque settings screen allows the operator to input the values necessary to perform the relay angle of torque test.

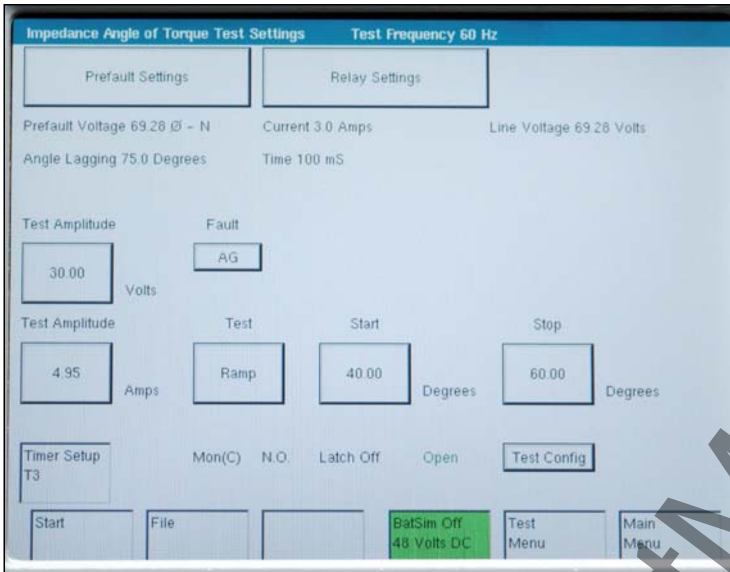


Figure 37 Angle of Torque Setting Screen

- The Pre-fault Settings button will change screens and will allow changes to meet the manufacturer specifications. If the factory defaults are used, a one-time warning message should be displayed to notify default values are being used.
- The Relay Settings button will change screens and will allow changes to meet the manufacturer's specifications.
- The Timer Setup screen allows the user to define how the time will be used.
- The Fault Type determines the fault the test will perform. The accepted values are AG, BG, CG, AB, BC, CA and ABC (Note: A, B, and C are the phases and G is ground).
- The voltage and current generators may be enabled or disabled. The default condition has all voltage and current generators enabled. This is indicated by a check mark in the channels selection boxes. If the Voltage is held constant, the Stop value is expressed in Amps. If the Current is held constant, the Stop value is expressed in Volts. The V/I Generators used in the MPRT-8415 unit have 15 amps / 150 volts RMS limit and the MPRT-8430 unit have 30 Amps / 300 volts RMS limit. The Stop value is the fault value for the test.
- The Start test button is used to execute the current test setup.
- The Start, Stop and Increment values will need to be expressed as an angle in degrees. The Increment value is used to increase the angle values from the start to the stop value. The test needs to be performed in two directions to calculate the torque. During one test the stop value will function as the end point. When the test is performed in the other direction the stop value will be the starting point.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.2.8 Impedance Relay Angle of Torque Test Results Screen

This screen displays the results upon test completion. The Zone and Fault values are copied from the setting screen while all other values are calculated from the test results. The results of the test will be displayed as “Test Passed” or “Test Failed”. No data may be entered in this screen.

Figure 38 Angle of Torque Test Screen

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.2.9 Impedance Relay Target & Seal-In Test and Results

This screen displays the results upon test completion. The results of the test will be displayed as "Test Passed" or "Test Failed". No data may be entered in this screen.

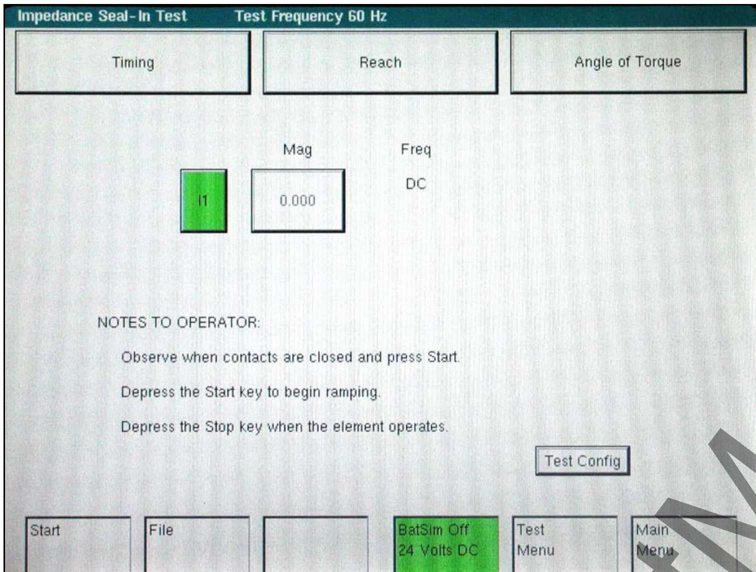


Figure 39 Impedance Target and Seal-in Test Screen

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.3 **Overcurrent Relay Test Menu**

This menu permits the setting and testing of an Overcurrent relay. These tests should be conducted in accordance with the manufacturers relay specifications. There are two different curve types: IEEE/ANSI and IEC which are user selectable on the various screens.

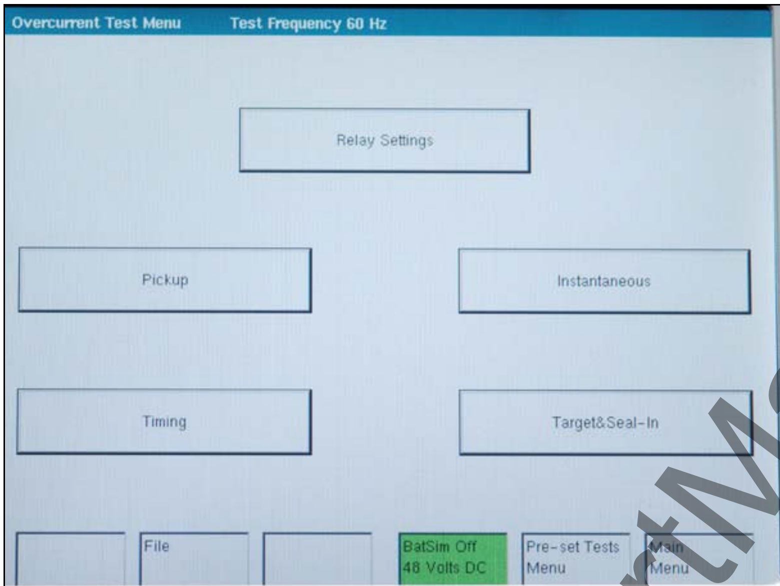


Figure 40 Overcurrent Relay Test Menu Screen

These tests should be conducted in accordance with the manufacturers relay specifications.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Pre-set Test Menu: This selection will return the controller to the Pre-set Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

3.8.3.1 Over-Current Relay Setting Screen

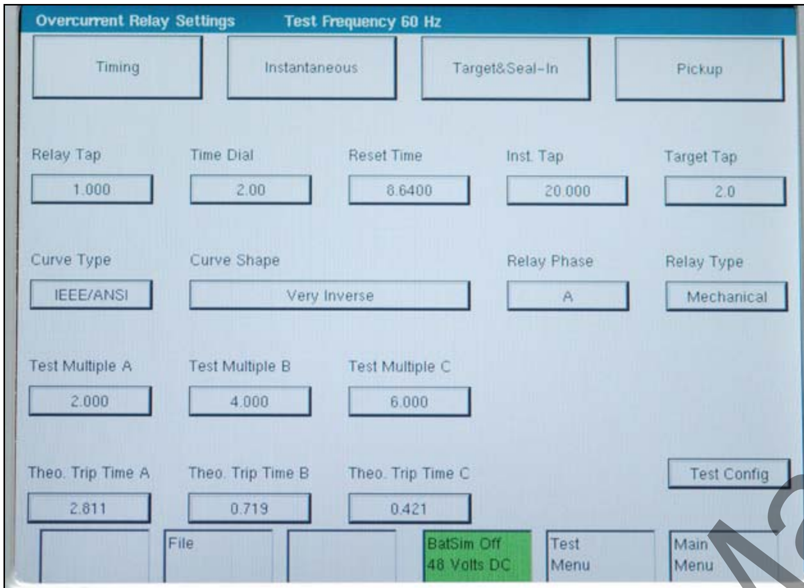


Figure 41 Overcurrent Relay Setting Screen

- The Timing button will change screens and will allow changes to meet the manufacturer specifications.
- The Instantaneous button will change screens and will allow changes to meet the manufacturer's specifications.
- The Target & Seal-In button will change screens and will allow changes to meet the manufacturer's specifications.
- The Pickup button will change screens and will allow changes to meet the manufacturer's specifications.
- Relay Tap, Time Dial, Instantaneous Tap, Reset Time, Target Tap, IEEE/IEC curve type, and test multiple(s) need to be set unless factory defaults are used.

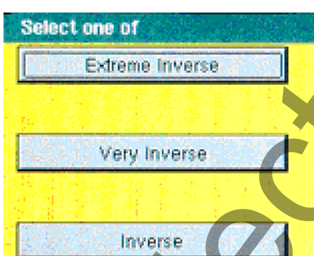


Figure 42 IEEE Time Curve Selection Menu

Once the multipliers are selected the expected (theoretical) trip times are displayed according to the curve type ,curve shape and time dial selected previously.
User defined trip times can be typed into Theo Trip Time Multiples A,B,C fields if the relay does not have an IEEE/ANSI or IEC standard curve.

3.8.3.2 Overcurrent Relay Test Configuration Screen

The test configuration menu is used to adjust the advanced relay testing parameters. The TVI has default test parameters that should not need to be adjusted by the user. If the user has determined these values do need to be adjusted, then following the directions in the TVI Operations section.

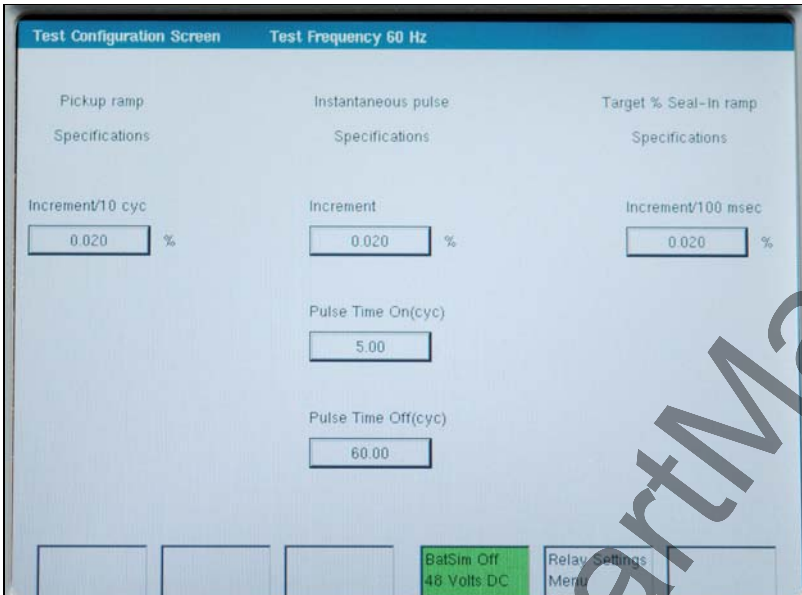


Figure 43 Test Configuration Screen

Pickup Ramp Specifications

Increment % / 10 cycles

This value is used to control the how fast the MPRT will increase the current to determine the pickup value. The value input into this field is in % increase per 10 cycles. The default value for this field is .02 % of pickup. Example: If the pickup value requires 1.0 ampere the MPRT will increase the current magnitude 0.0002 amperes every 10 cycles until the relay operates. For larger increments, use a larger percentage.

Instantaneous Pulse Ramp Specifications

Increment (%)

This value is used to control the how fast the MPRT will increase the current to determine the Instantaneous pickup value. The value input into this field is in % increase per pulse. The default value for this field is .02 % of pickup. Example: If the pickup value requires 10 amperes the MPRT will increase the current magnitude 0.002 amperes for the Pulse Time On value until the

	relay operates. For larger increments, use a larger percentage.
Pulse Time On (cyc)	This value is used to control how long the output pulse is on during an Instantaneous pickup test. This value is in cycles. Note: Set Pulse Time On slightly greater than the operating time of the relay.
Pulse Time Off (cyc)	This value is used to control how long the output pulse is off during an Instantaneous pickup test. This feature is required in order to protect the relay under test against excessive heating due to applying large currents continuously. This value is in cycles. Note: Start with equal amounts of Pulse Time On and Off.

Target & Seal-In Ramp Specifications

Increment % / 100msec	This value is used to control the how fast the MPRT will increase the current to determine the pickup value for the target and seal-in. The value input into this field is in % increase per 100msec. The default value for this field is .02 % of pickup. Example: If the pickup is set for 2.0 amperes the MPRT will increase the current magnitude 0.0004 amperes every 100msec until the relay seal-in contacts close.
Relay Settings	The Relay Settings button will return the user to the Relay Settings Menu.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:

3.8.3.3 Overcurrent Relay Pickup Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

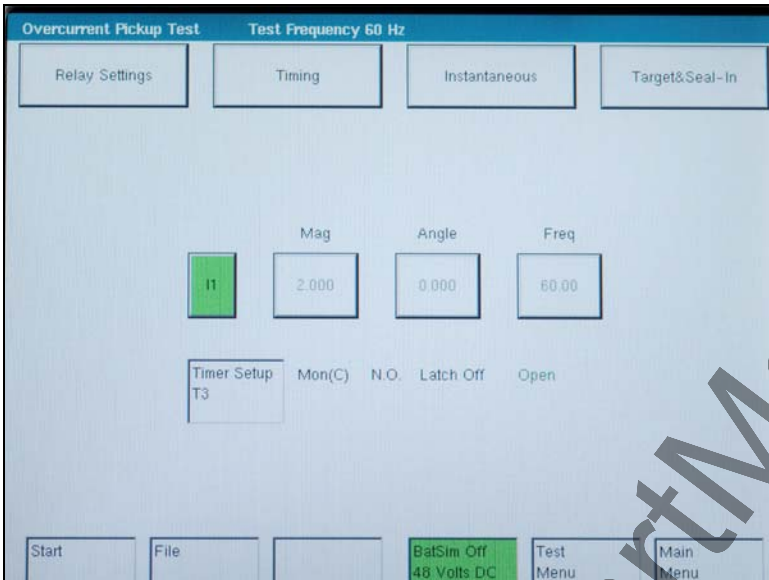


Figure 44 Overcurrent Relay Pickup Test Screen

The Timing, Instantaneous, and Target & Seal-In test screens may be entered to change test settings.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

A timer setup link is available on this screen. Also the Timer Setup configuration is displayed for convenience. The status of the relay contact will be displayed on the screen real time along with the value of the current. The Stop current is the maximum current provided by the test set before test is stopped. This instance is applicable if the relay does not operate when ramping the current up between the Start and Stop values. After the test is completed, the current amplitude will be read out from the screen or stored in the memory.

3.8.3.4 Overcurrent Relay Target & Seal-In Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

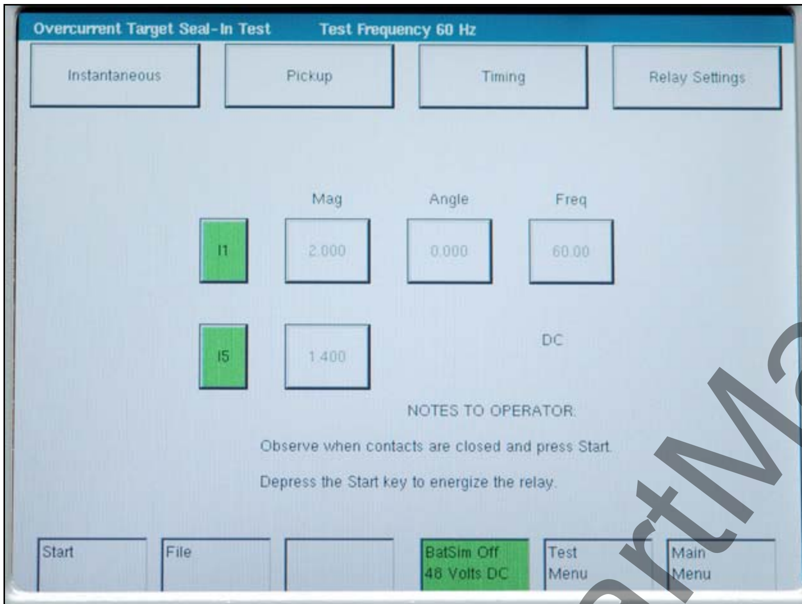


Figure 45 Overcurrent Relay Seal-in Test Screen

The Timing, Instantaneous, and Pickup test screens may be entered to change test settings.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

When running this test, a current (I_1 =2xTap) will be applied first to the relay in order to close the main contact. Once the contact closes, the path for the DC target and Seal-in closes also. Current I_5 is used to ramp a DC current up until the target drops. The user must press the Stop button and record the results.

3.8.3.5 Overcurrent Relay Instantaneous Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

Figure 46 Overcurrent Relay Instantaneous Test Screen

The Timing, Target & Seal-In, and Pickup test screens may be entered to change test settings.

Each current channel must be selected by touching I1, I2, and I3. However, there must be a corresponding V/I Generator.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

A link to Timer Setup configuration is be available on this screen. Also the Timer Setup configuration is displayed for convenience. The user selects the appropriate number of channels required pressing I_1,I_2 and I_3.The amount of current required will be split proportionally between selected current channels. The status of the relay contact will be displayed on the screen real time along with the value of the current(s) and the percentage error.

3.8.3.6 Overcurrent Relay Timing Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

Figure 47 Overcurrent Timing Test Screen

The Instantaneous, Target & Seal-In, and Pickup test screens may be entered to change test settings.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

A link to Timer Setup configuration is be available on this screen. Also the Timer

Setup configuration is displayed for convenience. The user selects the appropriate number of channels required pressing I_1,I_2 and I_3.The amount of current required will be split proportionally between selected current channels. After the test is completed the trip time for all multipliers, the percentage error and current(s) amplitude will be read out from the screen or stored in the memory as can be seen in the figure below:

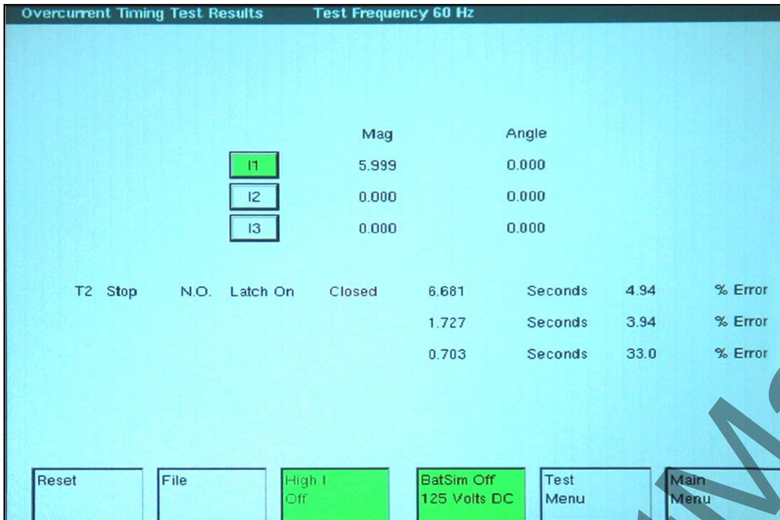


Figure 48 Overcurrent Timing Test Result Screen

3.8.4 **Differential Relay Test Menu**

This menu permits the setting and testing of a differential relay. These tests should be conducted in accordance with the manufacturers relay specifications.

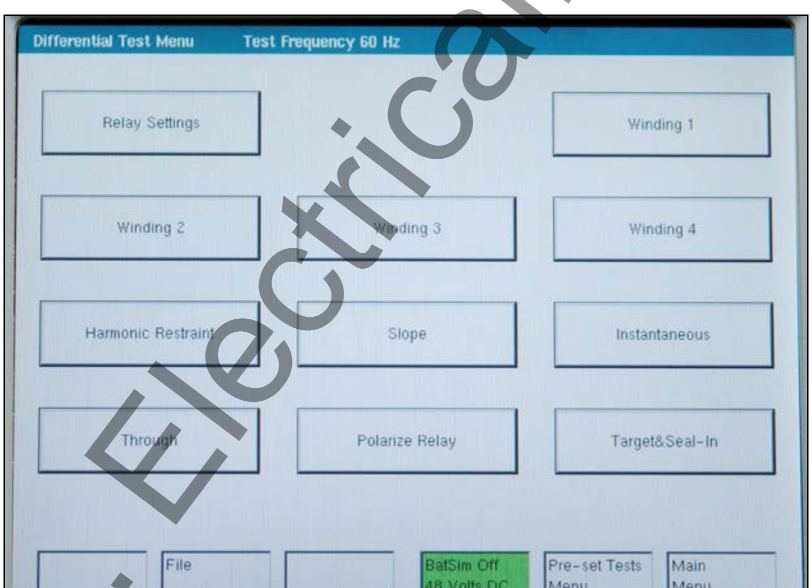


Figure 49 Differential Relay Test Menu Screen

There are several options to further define the tests to be performed. Selecting one of these options will present the test setup screen for that option.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Pre-set Test Menu: This selection will return the controller to the Pre-set Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

3.8.4.1 Differential Relay Setting Screen

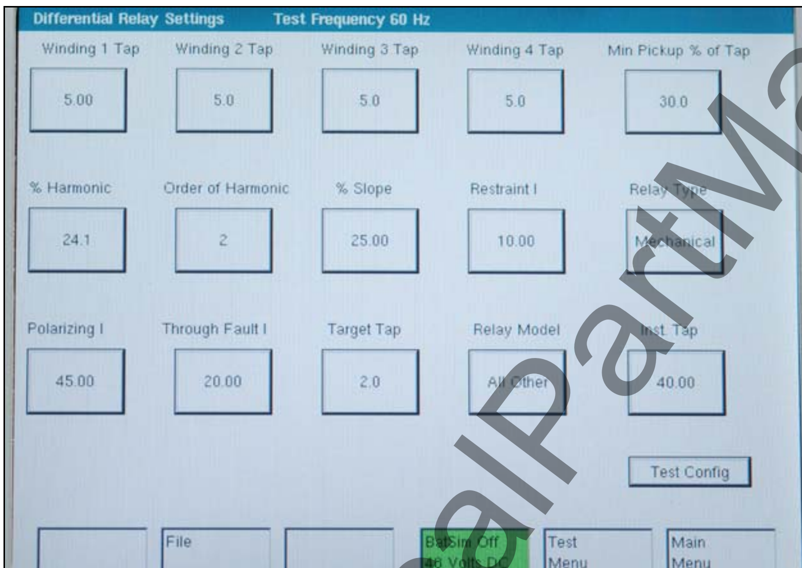


Figure 50 Differential Relay Setting Screen

The Differential setting screen requires some values to be entered or verified before performing the test. The factory defaults may be used to test a relay generically.

The following is a description of the buttons of the Relay Settings screen:

Winding # Tap: The user enters the tap value for each of the relay windings. Default value is 5.0 Amperes.

Min. Pickup % Tap: The user enters the relay minimum percentage of tap where the relay will operate. Default 30 %. Therefore, with a tap value of 5 amperes, the minimum pickup value for the relay on any tap would be 1.5 Amperes (30% of tap).

% Harmonic: The user enters the % of harmonic restraint the relay is set to. The default value is 20 %.

Order of Harmonic	The user enters the order of harmonic restraint that the relay is set for. For example, a second harmonic restraint would be set to 2, third harmonic 3 and fifth harmonic 5. The default value is 2.
% Slope	Enter the % slope of the relay. For example, a 30 % slope , enter value 30. The default value is 25.
Restraint I	Enter the desired restraint current that will be used in the slope test. The default value is 10 Amperes.
Relay Type	Selection is either electromechanical or solid state. If solid state is entered , the user will be required to press the stop button when the relay LED lights up upon pickup.
Polarizing I	Some electromechanical relays require a polarizing current be applied prior to conducting pickup tests. Enter the desired polarizing current. The default value is 50 Amperes.
Through Fault I	This will be the current applied in the through fault test. Consult relay manufacturer literature for appropriate test current value. Default value is 20 Amperes.
Target Tap	The Target Tap has selectable values with a factory default of 0.2 DC amperes.
Relay Model Cal.	The Westinghouse HU relay requires a different calculation for harmonic restraint. If testing an HU select HU, the default is All Other.
Inst. Tap	Enter the instantaneous trip current value. The default value is 40 Amperes.
Test Configuration	This will take the user to a new screen. It was added to simplify the Relay Settings screen. The Test Configuration Screen provides additional input parameters for more complex tests, and for adjusting ramping and pulse ramping values.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Test Configuration	The Test Configuration button will take the user to the Test Configuration Menu. This menu is used to set additional test parameters such as ramp increment and start and stop points. These test parameters should not need to be adjusted.

3.8.4.1 Differential Relay Test Configuration Screen

The test configuration menu is used to adjust the advanced relay testing parameters. The TVI has default test parameters that should not need to be adjusted by the user. If the user has determined these values do need to be adjusted, then following the directions in the TVI Operations section.

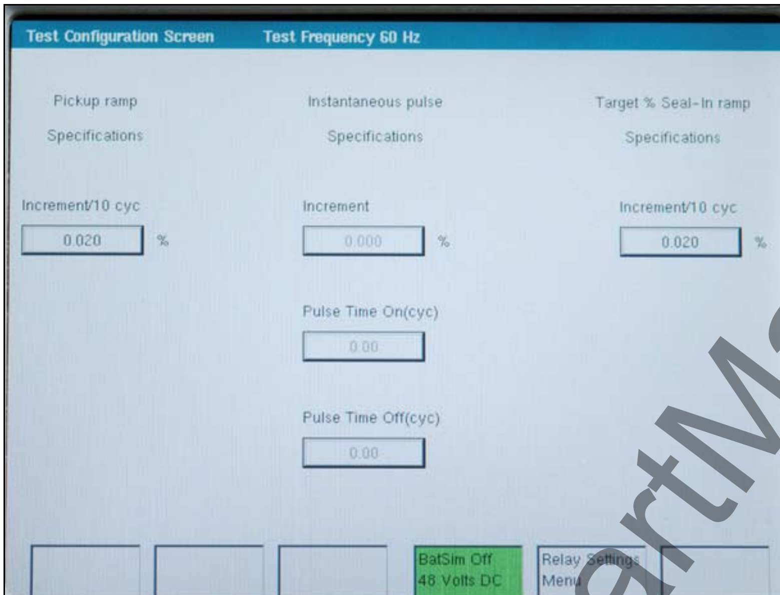


Figure 51 Test Configuration Screen

Pickup Ramp Specifications

Increment % / 10 cycles

This value is used to control the how fast the MPRT will increase the current to determine the pickup value. The value input into this field is in % increase per 10 cycles. The default value for this field is 1 % of pickup. Example: If the pickup value requires 1.0 ampere the MPRT will increase the current magnitude 0.01 amperes every 10 cycles until the relay contacts close. For smaller increments, use a smaller percentage.

Instantaneous Pulse Ramp Specifications

Increment %

This value is used to control the how fast the MPRT will increase the current to determine the Instantaneous pickup value. The value input into this field is in % increase per pulse. The default value for this field is 1 % of pickup. Example: If the pickup value requires 10 amperes the MPRT will increase the current magnitude 0.1 amperes for the Pulse Time On value until the relay contacts close. For smaller increments, use a smaller percentage.

Pulse Time On (cyc)	This value is used to control how long the output pulse is on during an Instantaneous pickup test. This value is in cycles.
Pulsar Time Off (cyc)	This value is used to control how long the output pulse is off during an Instantaneous pickup test. This value is in cycles.
Target & Seal-In Ramp Specifications	
Increment % / 100 msec	This value is used to control the how fast the MPRT will increase the current to determine the pickup value for the target and seal-in. The value input into this field is in % increase per 100 msec. The default value for this field is 1 % of pickup. Example: If the pickup is set for 2.0 amperes the MPRT will increase the current magnitude 0.02 amperes every 100 msec until the relay seal-in contacts close.
Relay Settings	The Relay Settings button will return the user to the Relay Settings Menu.

3.8.4.2 Differential Relay Winding 1, 2 or 3 Pick-Up Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

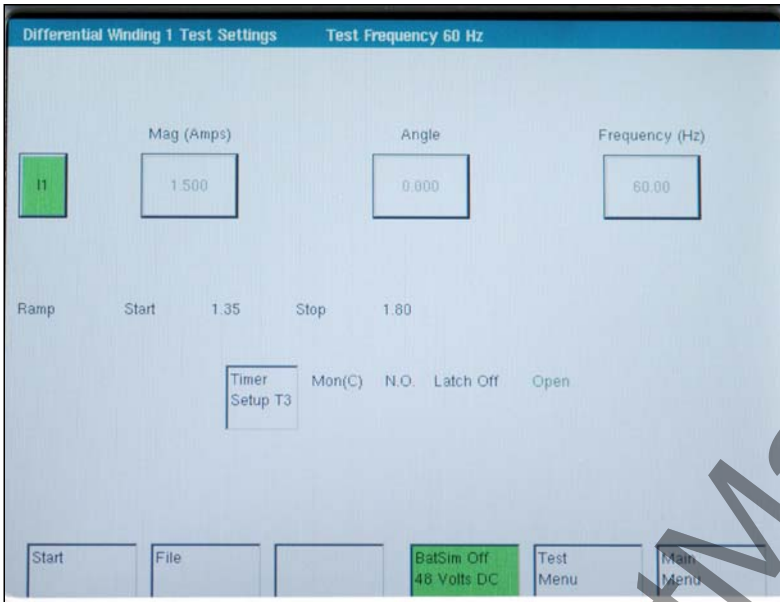


Figure 52 Differential Relay Winding 1 Pickup Test

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

A timer setup link is available on this screen. Also the Timer Setup configuration is displayed for convenience. The status of the relay contact will be displayed on the screen real time along with the value of the current. The calculated Start and Stop current can also be seen on the test screen. The Stop current is the maximum current provided by the test set before test is stopped. This instance is applicable if the relay does not operate when ramping the current up between the Start and Stop values. After the test is completed, the current amplitude will be read out from the screen or stored in the memory.

3.8.4.3 Differential Relay Harmonic Restraint Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

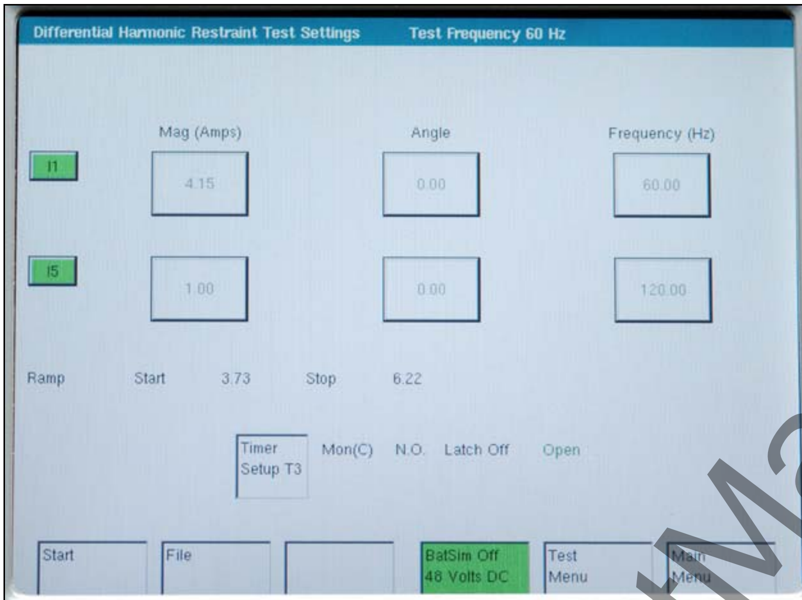


Figure 53 Differential Harmonic Restraint Test

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

A timer setup link is available on this screen. Also the Timer Setup configuration is displayed for convenience. The status of the relay contact will be displayed on the screen real time along with the value of the current. The calculated Start and Stop current can also be seen on the test screen. The Stop current is the maximum current provided by the test set before test is stopped. This instance is applicable if the relay does not operate when ramping the current up between the Start and Stop values. For this test, a fundamental frequency current is provided from the test set along with a higher order harmonic signal (based on settings). Both channels selected (I_1 and I_5) should be wired out in parallel at the relay side. After the test is completed, the currents amplitude will be read out from the screen or stored in the memory.

3.8.4.4 Differential Relay Slope Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

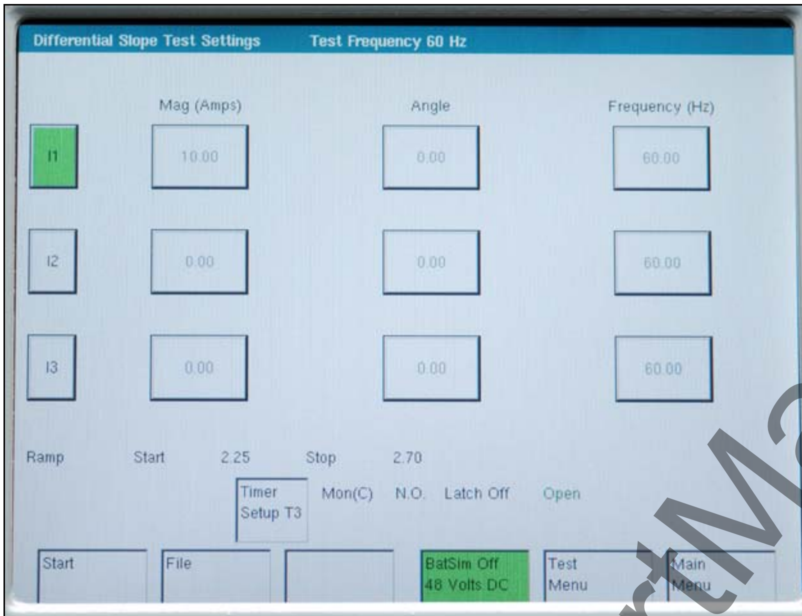


Figure 54 Differential Relay Slope Test

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

A timer setup link is available on this screen. Also the Timer Setup configuration is displayed for convenience. The status of the relay contact will be displayed on the screen real time along with the value of the current. The calculated Start and Stop current can also be seen on the test screen. The Stop current is the maximum current provided by the test set before test is stopped. This instance is applicable if the relay does not operate when ramping the current up between the Start and Stop values. For this test two current channels will be used to energize the two restraint coils of the relay. After the test is completed, the currents amplitude and the Actual Slope (%) will be read out from the screen or stored in the memory.

3.8.4.5 Differential Relay Seal-In Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

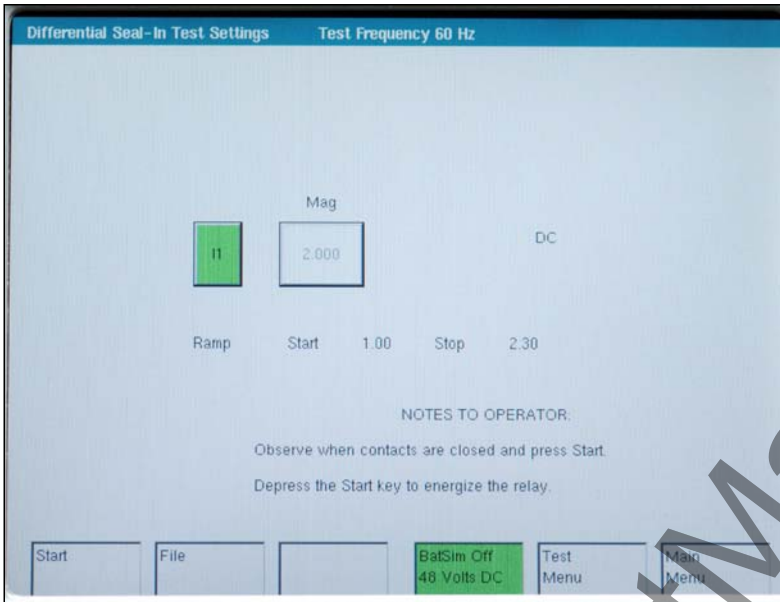


Figure 55 Differential Seal-in Test Screen

The Timing, Instantaneous, and Pickup test screens may be entered to change test settings.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu.
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

When running this test the user should close the main contact manually. Once the contact closes, the path for the DC target and Seal-in is closed also. Current I_1 is used to ramp a DC current up until the target drops. The user must press the Stop button and record the results.

3.8.4.6 Differential Relay Instantaneous Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

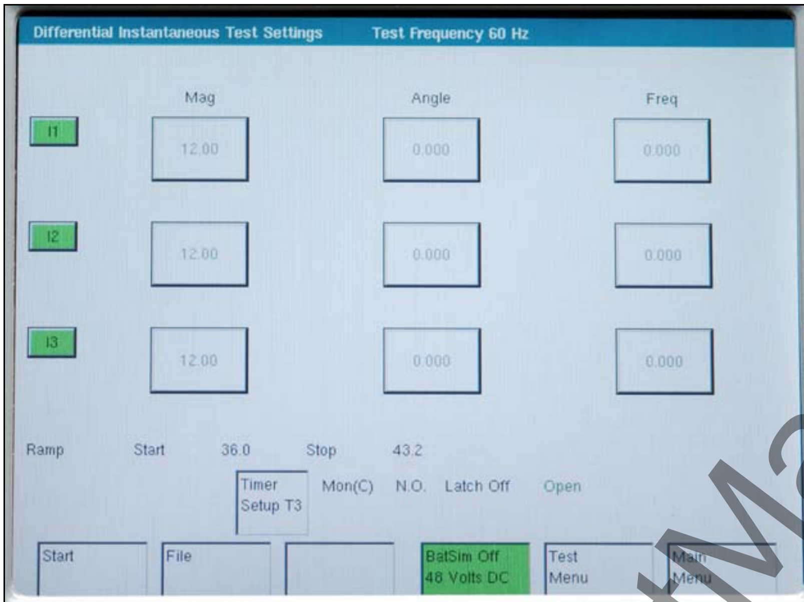


Figure 56 Differential Instantaneous Test Screen

The Timing, Target & Seal-In, and Pickup test screens may be entered to change test settings.

Each current channel must be selected by touching I1, I2, and I3. However, there must be a corresponding V/I Generator.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

A link to Timer Setup configuration is be available on this screen. Also the Timer

Setup configuration is displayed for convenience. The user selects the appropriate number of channels required pressing I_1,I_2 and I_3.The amount of current required will be split proportionally between selected current channels. The calculated Start and Stop current can also be seen on the test screen. The Stop current is the maximum current provided by the test set before test is stopped. The status of the relay contact will be displayed on the screen real time along with the value of the current(s) and the percentage error.

3.8.4.7 Differential Relay Through Fault Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

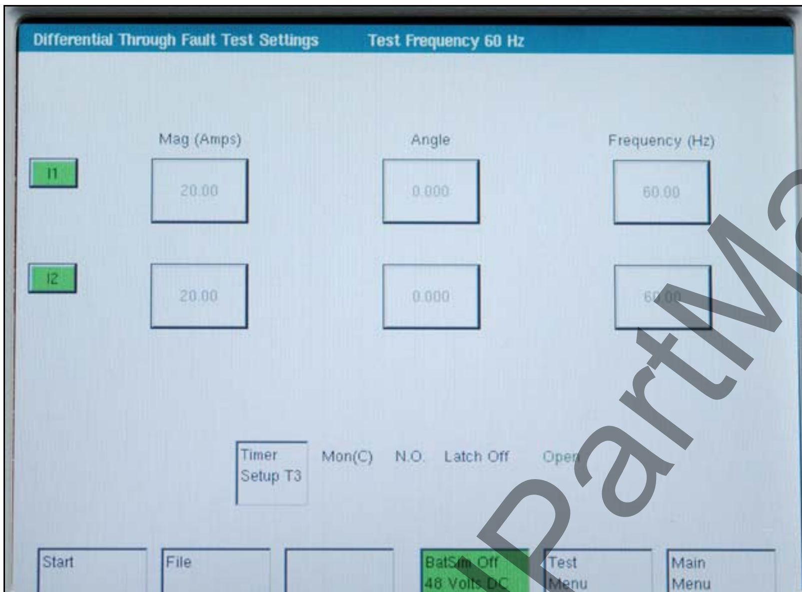


Figure 57 Through Fault Test Screen

This test requires two current channels. A link to Timer Setup configuration is be available on this screen. Also the Timer Setup configuration is displayed for convenience. For this test the currents will be applied to the restraints for a short period of time and the relay should not operate. If it does operate the message “ Test Failed” will appear on the screen.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.4.8 Differential Relay Polarizing Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

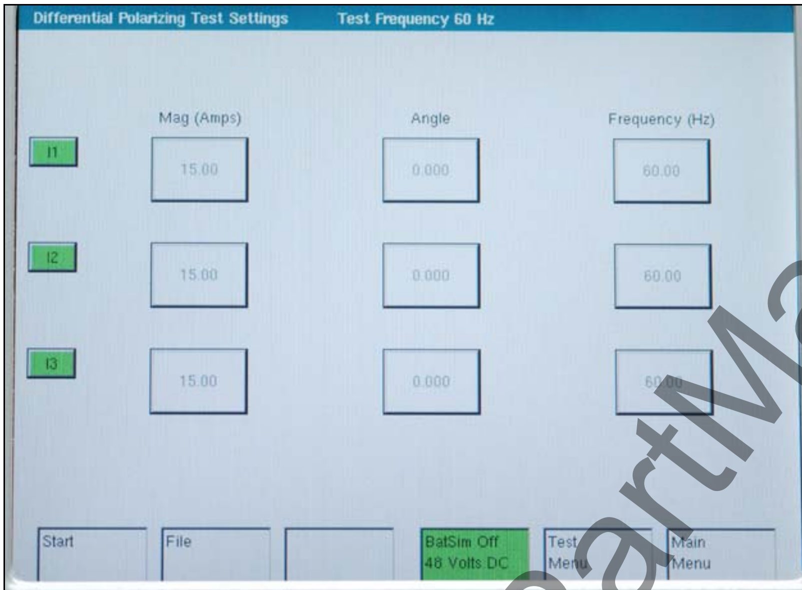


Figure 58 Differential Polarizing Test Screen

This test is suggested by some relay manufacturers. Three currents channels in parallel will be used and there is no need for detecting a change in state of the relay contact. Accordingly, the test itself consists in applying a large amount of current for a very short time.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.5 **Voltage Relay Test Menu**

This menu permits the setting and testing of a voltage relay. These tests should be conducted in accordance with the manufacturers relay specifications.

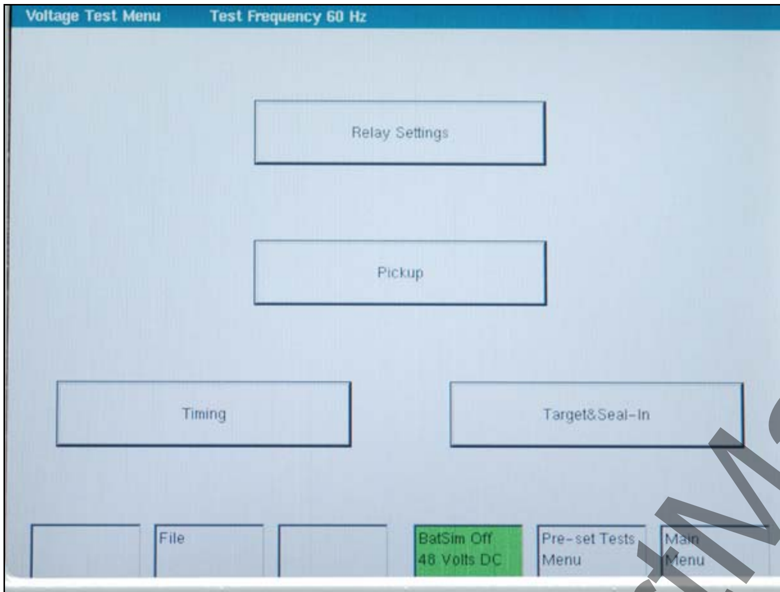


Figure 59 Voltage Relay Test Menu

There are several options to further define the tests to be performed. Selecting one of these options will present the test setup screen for that option.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Pre-set Test Menu:	This selection will return the controller to the Pre-set Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:

3.8.5.1 Voltage Relay Setting Screen

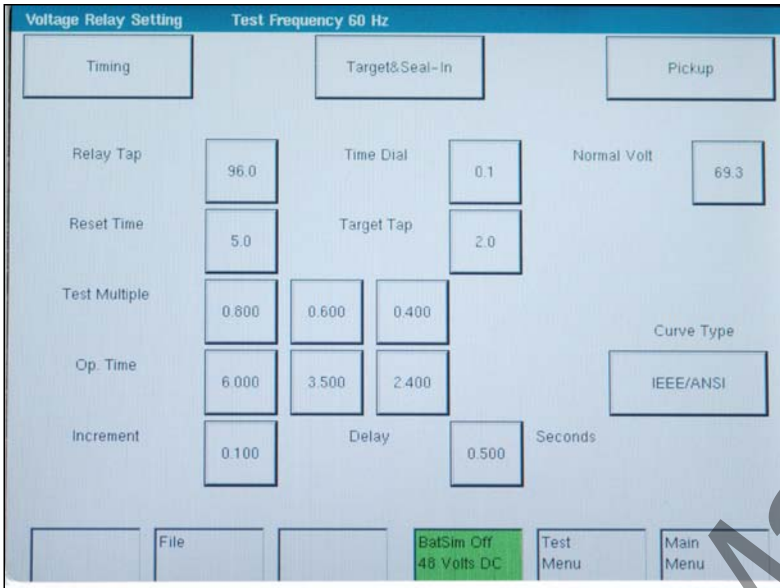


Figure 60 Voltage Relay Setting Screen

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Target & Seal-In Settings button will change screens and will allow changes to meet the manufacturer's specifications.
- The Pickup Settings button will change screens and will allow changes to meet the manufacturer's specifications.
- Relay Tap, Time Dial, Normal Voltage, Reset Time, Target Tap, IEEE curve type, % Error, test multiple(s), and Operation Time(s) need to be set unless factory defaults are used.
- The Timer Setup screen allows the user to define how the time will be used.
- The IEC curves are algorithms and must be selected by the operator using the Time Curve pull-down button.
- For inverse time curves, the IDMT characteristic available on each stage is defined by the following formula:

$$t = \frac{K}{(M - 1)}$$

Where: K = Time multiplier setting (e.g. Vo(rms), etc)
T = Operating time in seconds

$$M = \frac{\text{Residual voltage}}{\text{Setting voltage}}$$

NOTE: The Residual and Setting voltages will need to be furnished if performing a definite time test.

- For under voltage inverse time delay, the under voltage elements may be programmed to have an inverse time delay characteristic. The under voltage delay set point defines a family of curves as illustrated by the following equation:

$$T = D / (1 – V / V_{pu})$$

Where: T = Operating Time
D = Under voltage Delay Set point
V = Voltage as a fraction of the nominal VT Secondary Voltage
V_{pu} = Pickup Level

NOTE: The Under voltage Delay Set point, Voltage, and Pickup Level voltage will need to be furnished if performing a definite time test.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:

3.8.5.2 Voltage Relay Pickup Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

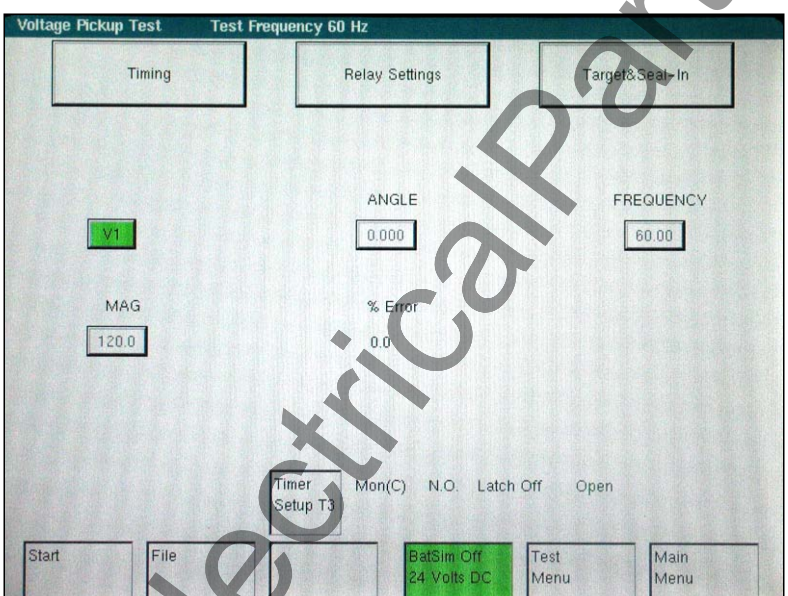


Figure 61 Voltage Relay Pickup Test Screen

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Target & Seal-In Settings button will change screens and will allow changes to meet the manufacturer's specifications.
- To calculate the percent error of the pickup values by comparing Pick Up Voltage with the Relay Tag value:

$$\% \text{ error} = \left(\frac{\text{Pick Up Voltage - Relay Tap}}{\text{Relay Tap}} \right) * 100$$

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.5.3 Voltage Relay Target & Seal-In Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

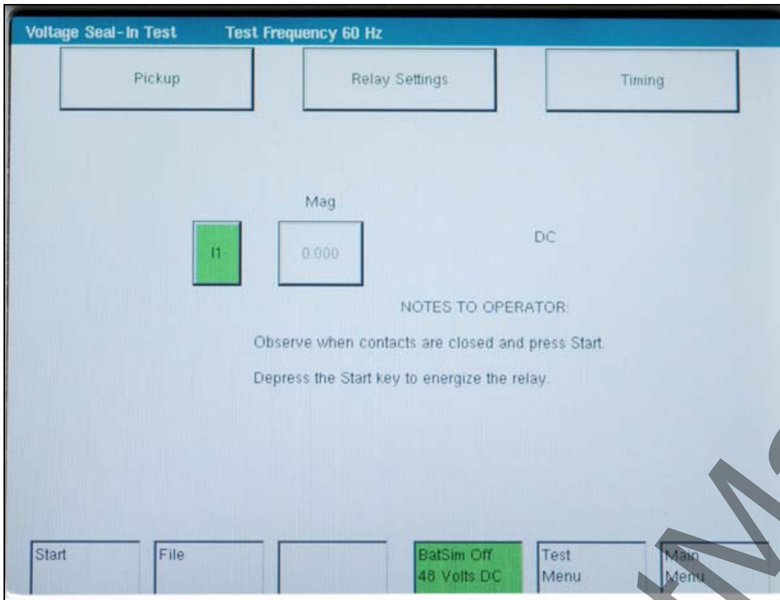


Figure 62 Voltage Relay Target and Seal-In Screen

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Pickup Settings button will change screens and will allow changes to meet the manufacturer's specifications.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.5.3 Voltage Relay Timing Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

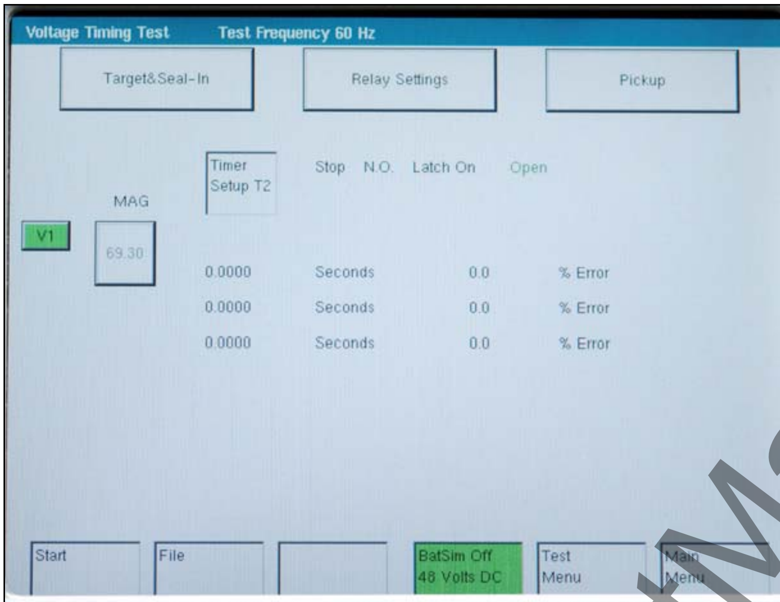


Figure 63 Voltage Relay Timing Test Screen

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Pickup Settings button will change screens and will allow changes to meet the manufacturer's specifications.
- A timing error calculation must be performed based on the actual trip time versus the theoretical time from the time curve algorithms or from the definite time window:

$$\%\,\text{error} = \left(\frac{\text{Actual Time - Theoretical Time}}{\text{Theoretical Time}}\right) * 100$$

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:

Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.6 **Synchronous Relay Test Menu**

This menu permits the setting and testing of a synchronous relay. These tests should be conducted in accordance with the manufacturers relay specifications.

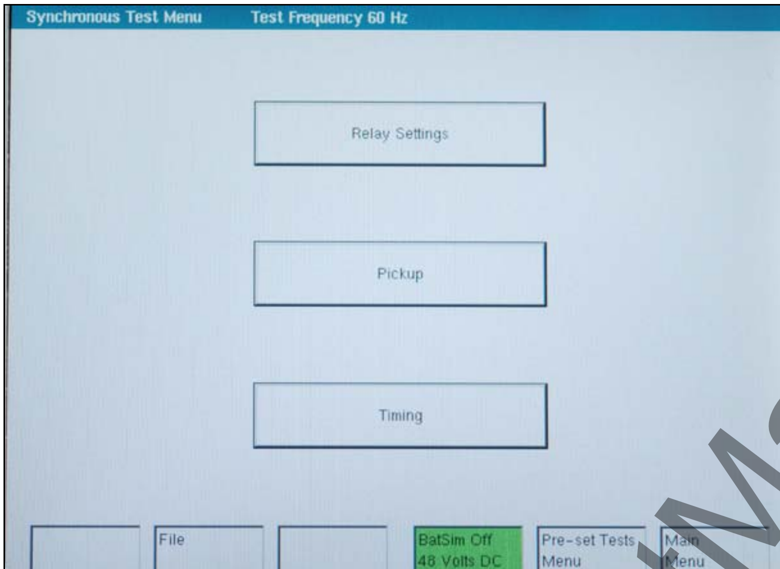


Figure 64 Synchronous Relay Test Menu

There are several options to further define the tests to be performed. Selecting one of these options will present the test setup screen for that option.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

3.8.6.1 Synchronous Relay Setting Screen

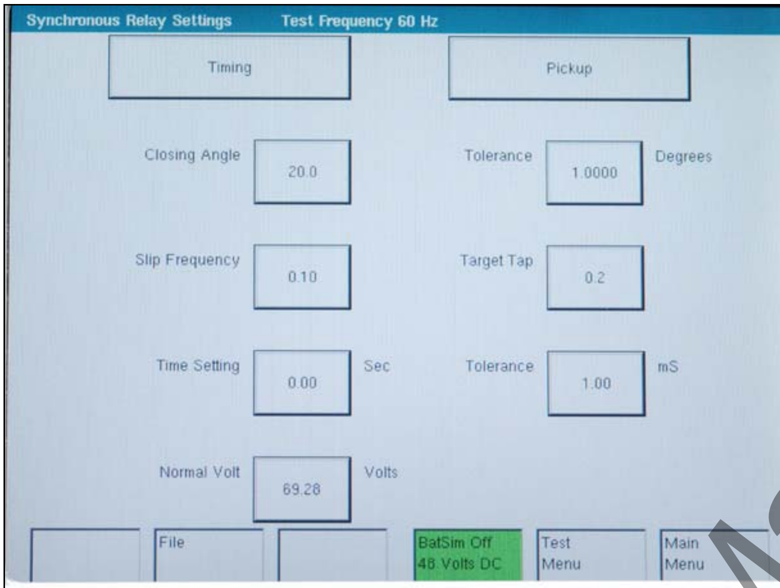


Figure 65 Synchronous Relay Setting Screen

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Pickup Settings button will change screens and will allow changes to meet the manufacturer's specifications.
- Closing Angle with Tolerance, Slip Frequency, Target Tap, Time Setting with Tolerance, and Normal Voltage need to be set unless factory defaults are used.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.6.2 Synchronous Relay Pickup Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

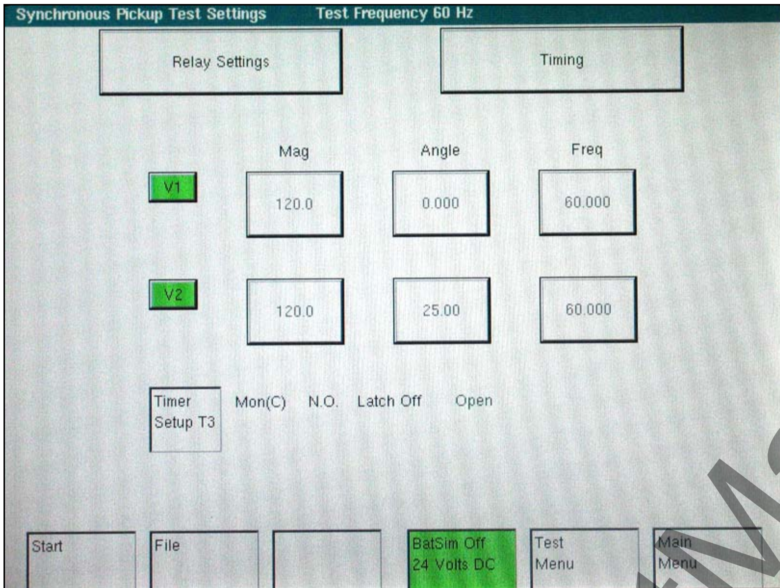


Figure 66 Sync Relay Pickup Test Screen

- The Relay Settings button will change screens and will allow changes to meet the manufacturer specifications.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.6.2.1 Testing Sync-Check, Synchronizing and Auto-Synchronizing Relays

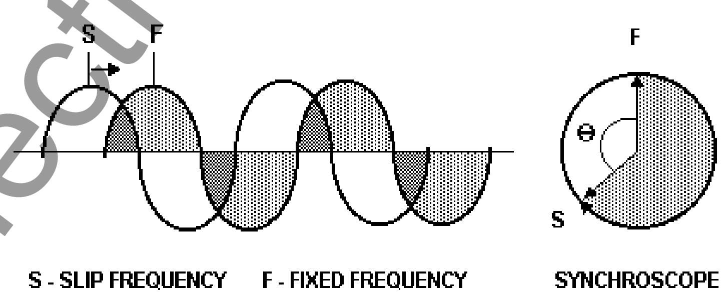
To perform tests on synchronizing type relays requires the use of two voltage output modules.

Pick-up or Closing Angle Tests: To perform Pick-up or Closing Angle tests let one voltage channel be the 0° reference, i.e., V1, and let the second voltage channel provide the variable phase angle adjustment, i.e., V2. This test requires phase angles indicated on V2 will be a **leading angle** (this requires +/- 180° phase angle option). If the relay's closing characteristic is 20° leading, an angle of + 20° will be indicated on voltage channel 2 (assuming V1 is set to the 0° reference).

Set V1 and V2 to Normal Voltage, i.e. 120 Volts each, and turn outputs on.

Ramp V2 phase angle in the CW direction lagging the reference voltage. At some point a set of contacts may open, thus allowing the user to determine the dropout angle (- 20°). If the user selected Normally Closed open, he could automatically capture this angle. The user could set the starting angle of – 30° for V2, thus the contacts would not be closed. If we started the ramp at this point the angle would continue to 180°. Then the sign would change to +. When the relay Normally Open contacts closed we would capture the closing angle, i.e. + 20°. We would then compare the actual closing angle to that specified in the Relay Setting Screen and calculate the error in degrees.

Setting Advance Time: To perform this test let voltage channel 2, V2, provide the slip frequency (generator) and let voltage channel 1, V1, provide the fixed voltage/frequency source (bus). Connect the relay's closing contacts to Timer Start Terminal 1 (first pair of Binary Input terminals), so that when the relay contacts close (at the advance angle) it will start the timer, and capture the closing angle at the same time. Set V1 to the Normal voltage output. Set V2 to the Normal output voltage output and slip frequency. For example: **VOLTAGE, 2, AC, 120, FREQ, 60.100**. V2 ANGLE display should start at 0° (we want V1 and V2 to turn on at 0° together). V2 will turn on in phase with V1, but will slip out of phase at the selected slip frequency. Since the phase angle is measured, the angle should start to change for V2 reading a - number until the angle of 180° is reached, then change to + . The number should fall from + 179° towards the closing angle At the advance angle the relay contacts will close, thus starting the timer. Since the phase angle was changing with the slip, we could capture the closing angle, when we start the timer. When the two voltages slip into phase the Timer will stop. The time indicated will be the advance time setting of the relay. See the following figure for a graphic representation.



As "S" approaches "F", at some point (the advance angle) the relay will send a close signal, which will start the Timer. When "S" and "F" are in synchronous, the Timer will stop. The time indicated on the timer display is the advance time of the relay based on the preset slip frequency.

3.8.6.3 Synchronous Relay Timing Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

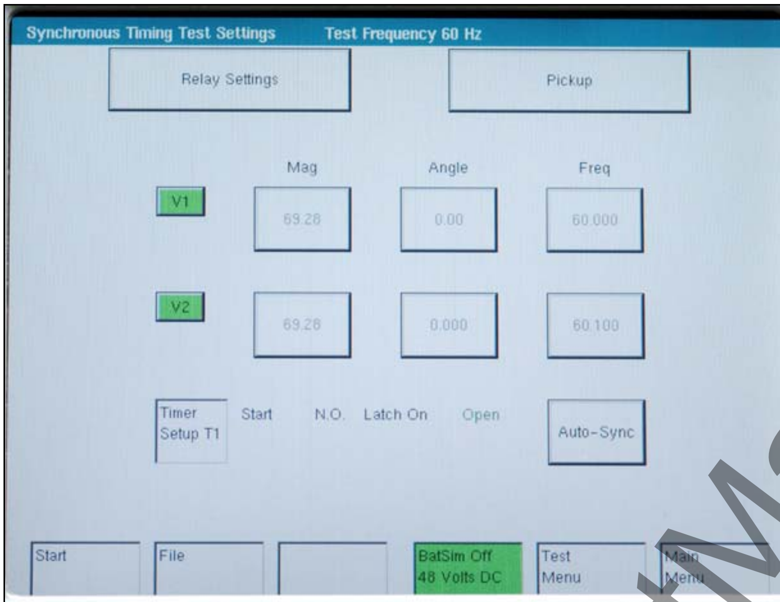


Figure 67 Sync Relay Timing Test Screen

- The Relay Settings button will change screens and will allow changes to meet the manufacturer specifications.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.7 **Power Relay Test Menu**

This menu permits the setting and testing of a power relay. These tests should be conducted in accordance with the manufacturers relay specifications.

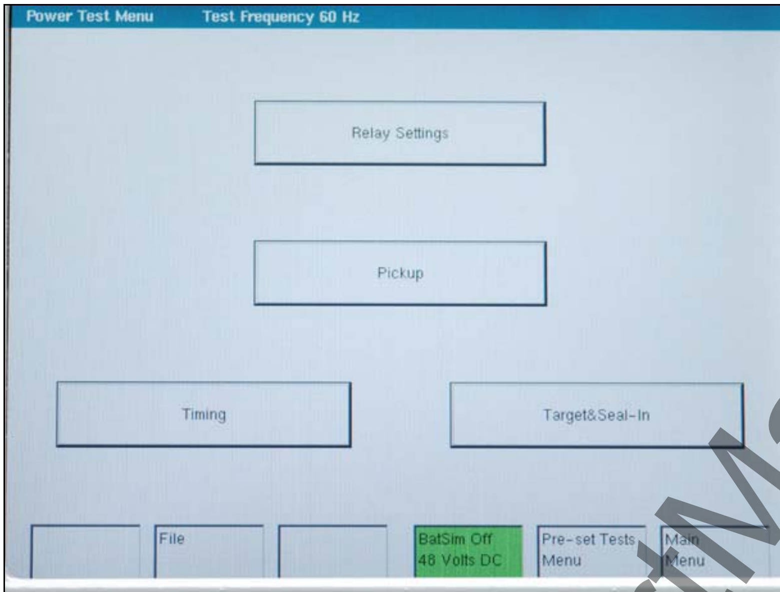


Figure 68 Power Relay Test Menu

This menu permits the setting and testing of a Power relay. These tests should be conducted in accordance with the manufacturers relay specifications.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Pre-set Test Menu: This selection will return the controller to the Pre-set Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

3.8.7.1 Power Relay Setting Screen

The Power Relay Settings Menu is used to input relay settings and relay test parameters. The data input into the relay settings screen will be used by the MPRT to calculate appropriate test currents or voltages to test the relay.

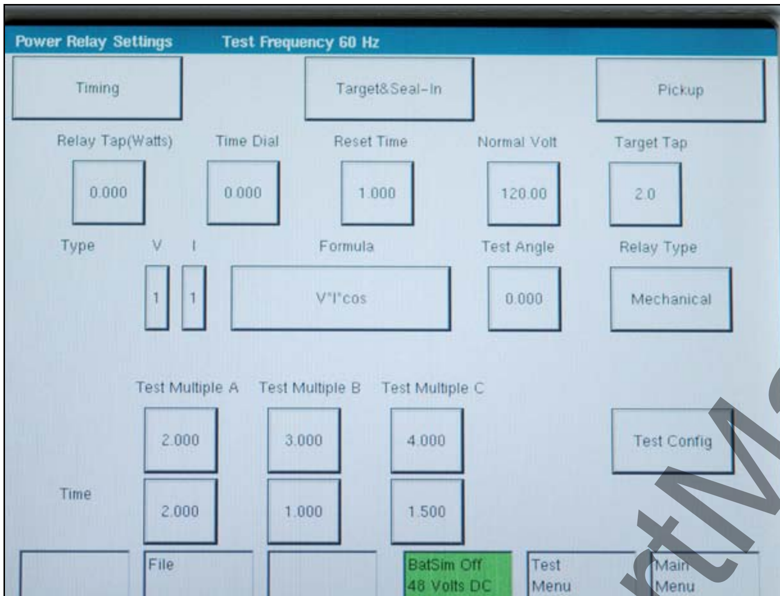


Figure 69 Power Relay Setting Screen

The Power Relay Settings menu is used to input relay settings and test values   To insert the relay settings or test values press the appropriate button and insert the value as described in Touch View Interface Operation. After all pertinent relay settings are keyed in the next step is to select the desired relay test at the top of the screen.

Pickup: The Pickup button will take the user to the Pickup Test Menu.

Timing: The Timing button will take the user to the Timing Test Menu.

Target & Seal-In: The Target & Seal-In button will take the user to the Target & Seal-In Test Menu.

Relay Tap — This value is the relay tap setting or the value at which the relay will start timing. This value is also known as the relay plug setting or pickup value.

Time Dial — This value is the time dial setting or the delay setting. This value is also known as the time leaver setting.

Reset Time — This value is the time it takes the relay to reset from a trip condition. The value inserted in the reset time must exceed the reset time of the relay. This is to insure that all timing tests will be correct.

Normal Volt — The Normal Volts is the desired test voltage per phase. See Formula below for further description.

Target Tap — This value is the target tap setting. This value is either 0.2 A or 2.0 A.

Formula — There are several formulas that comprise the Power Relay testing process as indicated below:

Formula's
Voltage * Current * Cosine θ
$\frac{\text{Voltage * Current * Cosine } \theta}{\sqrt{3}}$
$\sqrt{3}$ * Voltage * Current * Cosine θ
3 * Voltage * Current * Cosine θ
$\frac{\text{Voltage}_{\theta 1 - \theta 2}}{\sqrt{3}}$ * Current * (Cosine θ - 30˚)
$\text{Voltage}_{\theta 1 - \theta 2}$ * Current * Cosine θ
$\sqrt{3}$ * $\text{Voltage}_{\theta 1 - \theta 2}$ * Current * (Cosine θ - 30˚)
$\sqrt{3}$ * $\text{Voltage}_{\theta 1 - \theta 2}$ * Current * Cosine θ
$\frac{\text{Voltage}_{\theta 1 - \theta 2}}{\sqrt{3}}$ * Current * Cosine θ

Each formula represents different types and styles of relays and how they are connected to the power system. The formula selected will be used to calculate the Watts displayed in the test screen. Some are used with single-phase relays for both Watt and VAR applications, where the relay is calibrated in single-phase Watts. Some formulas represent other special applications where the relay is a single phase relay sensing phase to phase voltage and single phase current, or two phase current. One is for three phase voltage and two phase current applications, while another is for three phase voltage and current, 4-wire Y connections. Another is for loss of excitation relay calibrated in Watts. In the Power Relay Setting Screen, the **Normal Volt** is the desired test voltage per phase. Under most single phase applications that would be considered a phase to ground voltage. However, for single phase relays with the potential coil connected phase to phase, and if the relay has a 30˚ lagging phase shift built into the voltage input circuit, the formula

$$\frac{\text{Voltage}_{\theta 1 - \theta 2}}{\sqrt{3}} * \text{Current} * (\text{Cosine } \theta - 30^\circ)$$

will consider the **Normal Volt** set in the Relay Setting Screen as the phase to phase voltage, and takes into account the 30˚ phase shift to calculate Watts. Therefore, it is important that the user consider the relay design, application, the relay manufacturers recommended test connections, relay settings and select the appropriate formula accordingly. For the above example, the manufacturer has the user apply a single phase voltage equal to the phase to phase value, with a single phase current lagging the voltage by 30˚. For this example let us assume a voltage value of 120 volts phase to phase. The technician would enter 120 volts into the **Normal Volt** window. If the relay pickup setting is 180 Watts, then we would expect the relay to operate at about 2.59 Amperes,

$$\frac{120}{\sqrt{3}} * 2.595 * (\text{Cosine } 30^\circ - 30^\circ) = 180 \text{ Watts}$$

where θ is the lagging angle of the test current.

For our next example relay, consider a three phase, three-wire relay that monitors phase-to-phase voltage, and two-phase currents. For a balanced load condition the formula

$$\sqrt{3} * Voltage_{\theta 1 - \theta 2} * Current * Cosine\ \theta$$

would be used to calculate Watts. In this test case the manufacture recommends testing the relay using a single-phase voltage and parallel the voltage to the relay potential sensing coils. Also, a single-phase current is applied in series to the two current input terminals. It should be noted that in using the manufacturer's recommended test procedure, the relay is calibrated in three-phase watts using ½ the pickup current corresponding to the relay pickup in watts using the previous stated formula. Other three-phase relays may also be tested using a single-phase voltage and current source. For example, to test a three phase, four-wire, phase-neutral sensing relay using a single phase voltage and current source requires the use of the following formula to calculate three-phase watts,

$$3 * Voltage * Current * Cosine\ \theta$$

In this case, the single phase voltage output is connected in parallel to all three potential sensing inputs on the relay, and the single phase current is connected in series to all three current inputs. The Voltage applied will be the phase to neutral voltage enter in the **Normal Volt** window. The phase angle relationship recommended by the manufacture is 0˚. Therefore, If the relay pickup setting is 1800 Watts, and the relay voltage is 120 Volts, then we would expect the relay to operate at about 5.0 Amperes,

$$3 * 120 * 5 * 1\ (Cosine\ 0^\circ) = 1800\ Watts$$

For our final example relay, consider a loss of excitation relay, connected phase to phase voltage and single phase current that is calibrated in watts. The formula

$$\frac{Voltage_{\theta 1 - \theta 2}}{\sqrt{3}} * Current * Cosine\ \theta$$

would be used to calculate Watts. In this test case the manufacture recommends testing the relay using a single-phase voltage and a single-phase current. The Voltage applied will be the voltage entered in the **Normal Volt** window. The phase angle relationship recommended by the manufacture is 60˚. Therefore, if the relay pickup setting is 75 Watts, and the relay voltage is 120 Volts, then if the relay operates at 2.16 Amperes,

$$\frac{120}{\sqrt{3}} * 2.16 * (Cosine\ 60^\circ) = 74.91\ Watts$$

Relay Type

This setting selects whether the relay is a solid state or electromechanical relay. If solid state is selected then there are no available contacts for the pick-up test. The user must press Stop when the pick-up LED illuminates.

Test Multiple / Time

These settings determine at what power multiples the timing test will be performed. Common test multiples are 2, 4, and 6. The user enters the desired multiple and the appropriate operating time for that multiple. For example, if the relay to be tested has a tap setting of 40 Watts, and the user selects a test multiple of 2.0, and for a time dial setting of 3 the operating time of the relay is say 2.000 seconds, then the test set will apply 80 Watts to the relay and check to verify that the relay operated in 2.000 seconds.

Test Configuration

The Test Configuration button will take the user to the Test Configuration Menu. This menu is used to set additional test parameters such as ramp increment and start and stop points. These test parameters should not need to be adjusted.

3.8.7.1 Test Configuration Screen

The test configuration menu is used to adjust the advanced relay testing parameters. The TVI has default test parameters that should not need to be adjusted by the user. If the user has determined these values do need to be adjusted, then following the directions in the TVI Operations section.

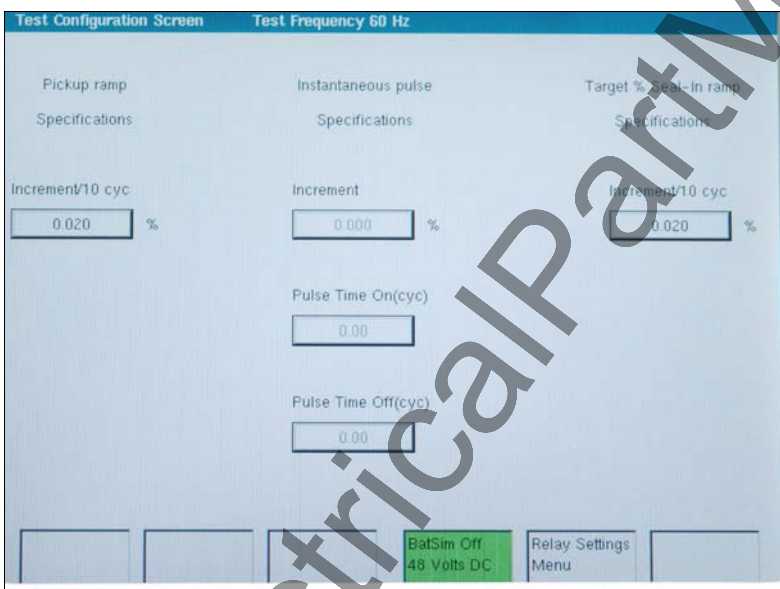


Figure 70 Test Configuration Screen

Pickup Ramp Specifications

Increment % / 10 cycles

For the Power relay the test voltage is fixed at the Normal Volts value and the test current is ramped. This value is used to control the how fast the MPRT will increase the current to determine the power pickup value. The MPRT will calculate the pickup value based on the formula selected and the Normal Volts value entered by the user. The value input into this field is in % increase per 10 cycles. The default value for this field is 0.02 % of pickup. Example:

If the pickup Watts value requires 1.0 ampere the MPRT will increase the current magnitude 0.02 amperes every 10 cycles until the relay contacts close.

Increment %	This value is used to control the how fast the MPRT will increase the current to determine the Instantaneous pickup value. This feature is not used for Power Relays.
Pulse Time On (cyc)	This value is used to control how long the output pulse is on during an Instantaneous pickup test. This value is not used on Power Relays.
Pulsar Time Off (cyc)	This value is used to control how long the output pulse is off during an Instantaneous pickup test. This value is not used on Power Relays.

Target & Seal-In Ramp Specifications

Increment % / 10 cycles.	This value is used to control the how fast the MPRT will increase the current to determine the pickup value for the target and seal-in. The value input into this field is in % increase per 10 cycles. The default value for this field is 0.02 % of pickup. Example: If the pickup is set for 2.0 amperes the MPRT will increase the current magnitude 0.04 amperes every 10 cycles until the relay seal-in contacts close.
Relay Settings	The Relay Settings button will return the user to the Relay Settings Menu.

3.8.7.2 Power Relay Pickup Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

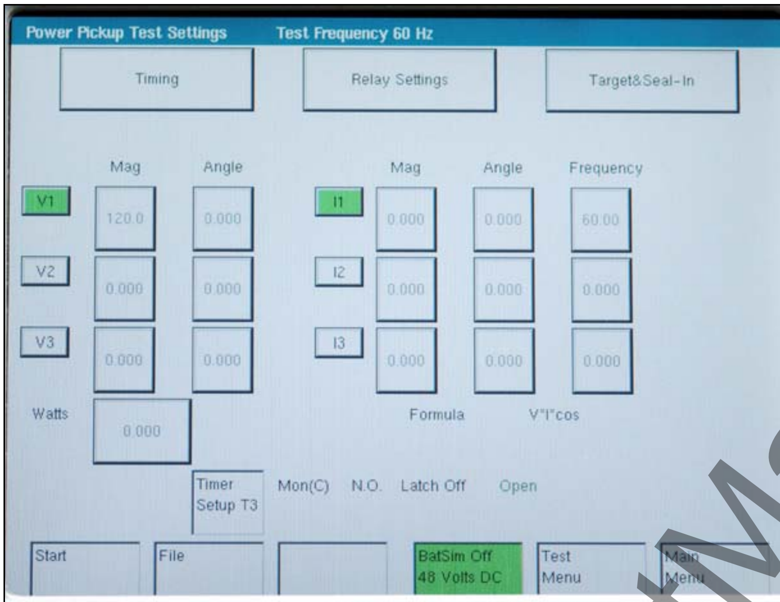


Figure 71 Power Relay Pickup Test Setting Screen

In the power Relay Pickup test Screen only the voltage(s) and current(s) selected in the Relay Setting Screen will be active in the test screen. For example, in the setting screen only 1 voltage and current were selected, therefore, only V1 and I1 are activated in the above figure. Pressing the Start button will start the test. The test voltage specified in the setting screen will be applied, and the appropriate test current will be applied at the appropriate test angle. The current will automatically ramp up until the relay operates, or in case of a solid-state relay the LED lights up indicating pickup. The pickup Watts will be displayed in the Watts box. The formula used to calculate Watts is also displayed.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Test Menu: This selection will return the controller to the Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

A timer setup link is available on this screen. Also the Timer Setup configuration is displayed for convenience. The status of the relay contact will be displayed on the screen real time along with the value of the test quantities. After the test is completed, the current amplitude will be read out from the screen or stored in the memory.

3.8.7.3 Power Relay Target & Seal-In Test and Results

This screen displays the results upon test completion. No data may be entered in this screen.

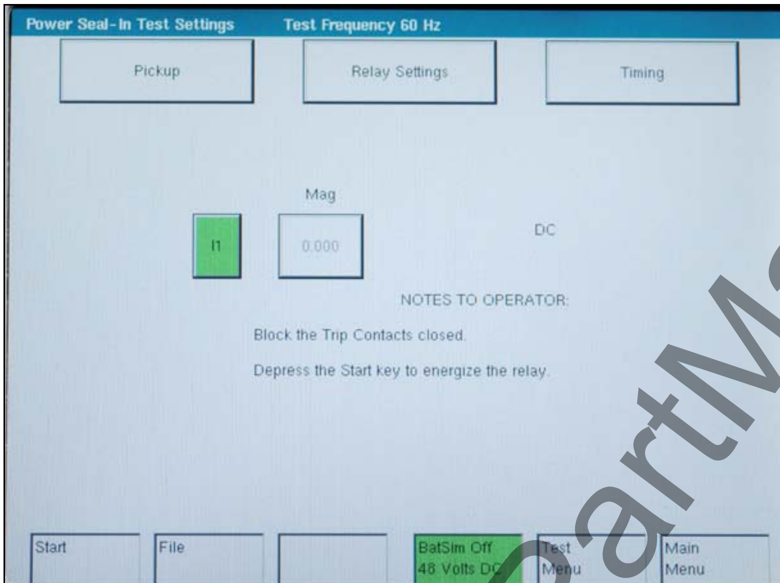


Figure 72 Power Relay Target and Seal-in Test

The Timing and Pickup test screens may be entered to change test settings.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

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3.8.7.4 Power Relay Timing Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

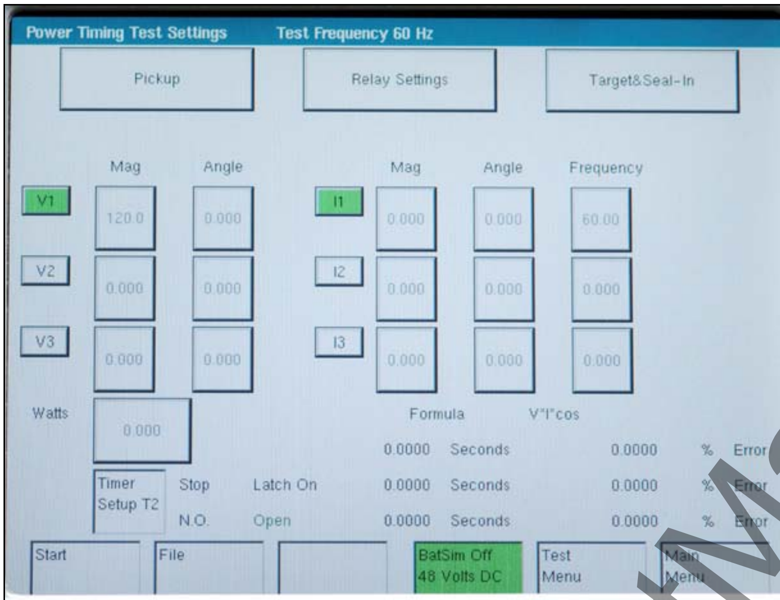


Figure 73 Power Relay Timing Test Setting Screen

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

A timer setup link is available on this screen. Also the Timer Setup configuration is displayed for convenience. The status of the relay contact will be displayed on the screen real time along with the value of the test quantities. After the test is completed the trip time for all multipliers, the expected ones, the percentage error and the test quantities will be read out from the screen or stored in the memory.

3.8.8 **Reclose Relay Test Menu**

This menu permits the setting and testing of a reclose relay. These tests should be conducted in accordance with the manufacturers relay specifications.

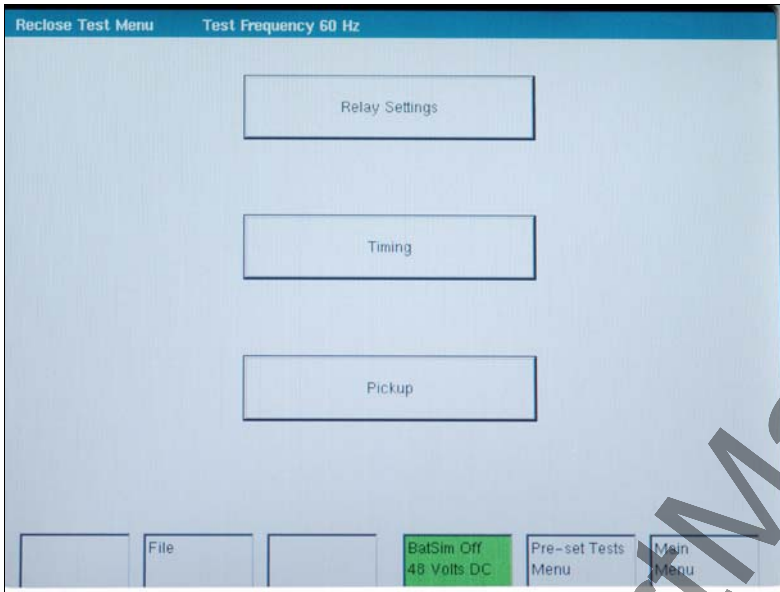


Figure 74 Reclosing Relay Test Menu Screen

There are several options to further define the tests to be performed. Selecting one of these options will present the test setup screen for that option.

For electronic relays, apply a current, get a relay trip and record the trip time, remove the current, toggle the 52a & 52b contacts (Binary Outputs 1 & 2), monitor the reclose contact, toggle the 52a & 52b contacts again, apply current again, and look for lockout. This will be repeated for the total number of operations selected in the setup screen.

For electro-mechanical relays, set the current to zero (trip curve will be ignored), set the number of operations and reclose time, set a current, measure the trip and reclose time, and simulate the 52a & 52b contacts. This will be repeated for the total number of operations selected in the setup screen.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Pre-set Test Menu:	This selection will return the controller to the Pre-set Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:

3.8.8.1 Reclose Relay Setting Screen

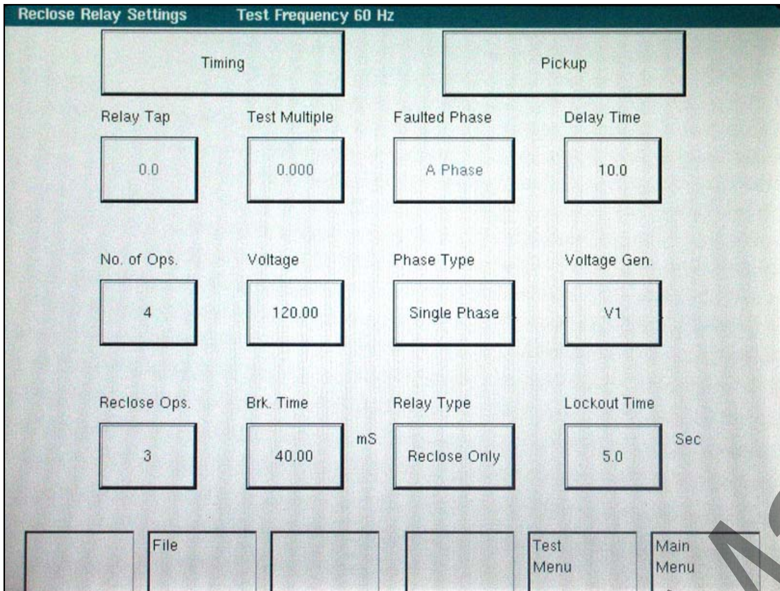


Figure 75 Reclosing Relay Setting Screen

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.
- Relay Tap, Time Dial, Number of Operations, Target Tap, IEEE Curve Type, Reclose Operations, Reclose Time, and Lockout Time to be set unless factory defaults are used.
- The number of 'Reclose Ops' will be one less than the 'No. of Operations'. The time setting for 'Reclose Time' will be the same for each operation. The lockout time is the time that a lockout should occur unless a trip has occurred again.
- The Timer Setup screen allows the user to define how the time will be used.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:

3.8.8.2 Reclose Relay Pickup Test Setting Screen

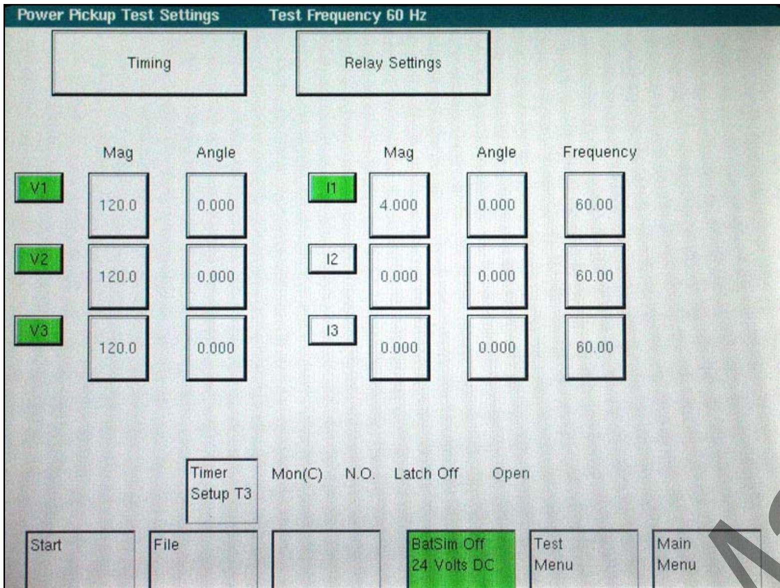


Figure 76 Reclosing Relay Pickup Test Setting Screen

In the Pickup Setting Screen, the user may select single or three-phase voltage and current.

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.8.3 Reclose Relay Timing Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

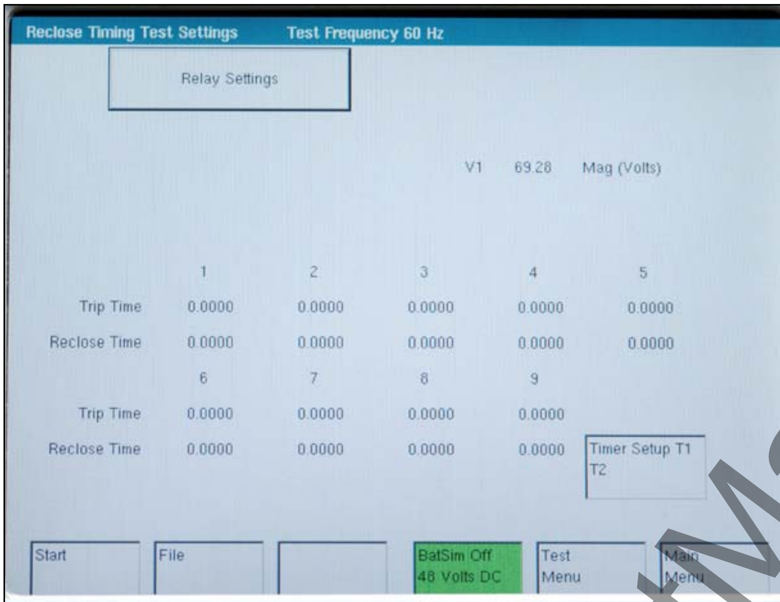


Figure 77 Reclose Relay Timing Test Screen

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.8.3.1 Testing Reclosing Relays - Theory of Operation

There are a variety of reclosing relays. Some have a simple reclose feature (Reclose Only) that does a simple definite timing function by closing a set of contacts to close a breaker. Other relays include trip and reclose functions (trip & reclose). The MPRT can test both types. The electromechanical relay operates from either an AC or DC voltage to drive a motor and cam shaft. This means that the user needs to be able to switch on either an AC single phase or a single dc voltage source. The solid-state trip and reclose relays usually require three phase voltage be applied during the tests. Therefore, the user will need to be able to select single phase or three phase voltages, AC or DC in the relay setting screen. The user will also need to be able to select single phase or three phase test currents for the trip & reclose relays. In some cases the user may need single phase current and three phase voltage. In the case for the trip & reclose relays, the user will be provided a Test Current window to set the test value. The same test current will be applied for each trip test, either single phase or three phase. The Test Voltage will need to be set similar to the Test Current, and be applied during the entire test. The relay does require external stimulus from circuit breaker simulation using the “A” (normally closed) & “B” (normally open) contacts. This will be simulated using the Binary Output contacts 1 & 2. Therefore, the user will need access to the Timer Setup screen for selection and programming of the binary output contacts. The MPRT will also need to have the Binary Input contacts programmed for sensing the relay Trip Contacts and the Reclose Contacts. The purpose of the timing test is to measure the reclose times and sequence of operation to a lockout state for the reclosing relay. For the trip & reclose relays the MPRT needs to record both the trip and reclose times.

Reclose Only Relays

For testing the reclose only relays, the timing test involves simulating a fault tripping a breaker and measure the time for the reclosing relay to operate. Upon initiating the test, the test set will toggle the Binary Outputs 1 (A contact) and 2 (B contact) simulating the circuit breaker opening and start the timer running at the same time. Upon sensing the relay reclose contacts closing (defaulted to Binary Input terminal #2) stops the timer, records T1 reclose time, and after a preset time delay of 0.040 seconds (simulates the closing time of the breaker), toggles the Output Contacts back to the original start state (breaker closed) and resets the timer. While recording and resetting, the MPRT must continue to monitor the Timer Stop contacts looking for the reclosing relay contacts to change state (open). Once the reclose relay closing contacts have opened, wait 0.040 seconds (simulates breaker opening time) and then, repeat this process depending on the No. of Operations (defaulted to 4) selected in the Reclose Relay Test Screen, until the relay goes to a lockout state (after the 4^{th} reclose state as is in this example). The test set will record the reclose times for each individual reclose operation, no trip times are recorded for the reclose only relay. See next figure for example test screen.

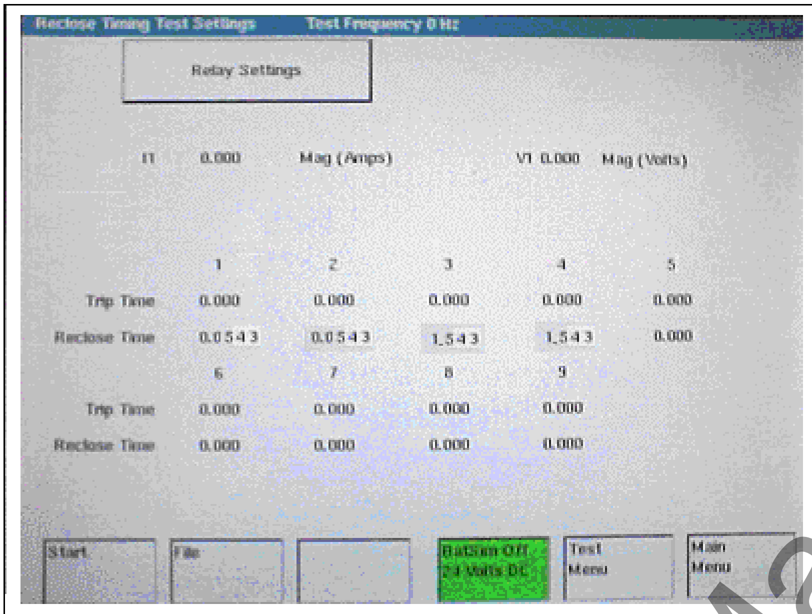
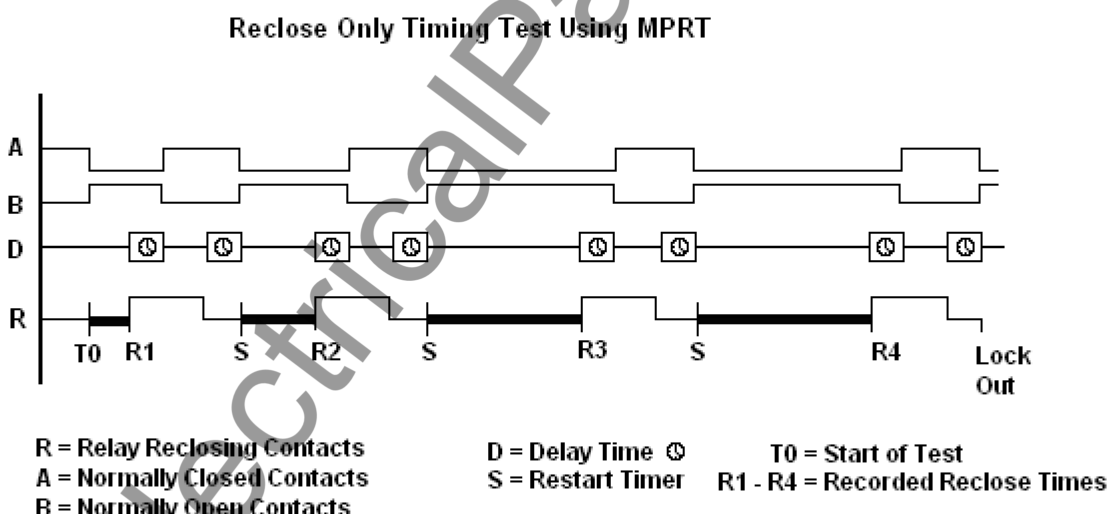


Figure 78 Reclose Only, 4-Shot Reclose Timing Test

The following graphic displays the reclose contacts, the breaker simulator contacts and the delay time between contact operations for Reclose Only relays.



Trip & Reclose Relays

Some of the new distribution protection relays require an AC current to simulate an overcurrent condition, as well as circuit breaker simulation for the reclose operation (Trip and Reclose). In this case, as well as the electronic (ME) recloser, two tests are normally performed. One test is the pickup test, or minimum operation point. This test is performed same as the Overcurrent Pickup Test. The other is a timing test. For testing the trip and reclose relays, the timing test involves applying a fault current, measure the trip time, record the trip time, simulating a circuit breaker opening and measure the time for the reclosing contacts to operate. Upon initiating the test, the test set will apply fault current set in the setting screen and start the Trip timer running. When the relay trip contacts close, record the trip time T1, reset the timer, wait a programmable period of time and toggle the Binary Outputs 1 (A contact) and 2 (B contact) simulating the circuit breaker opening. Start the reclose timer running when the A/B contacts change state. Upon sensing the relay reclose contacts closing (defaulted to Binary Input terminal #2) stops the timer, records R1 reclose time, and after a preset time delay of 0.040 seconds (simulates the closing time of the breaker), toggles the Output Contacts back to the original start state (breaker closed) and resets the timer. Repeat this process depending on the No. of Operations (defaulted to 4) selected in the Reclose Relay Setting Screen, until the relay goes to a lockout state (after the 4th trip operation as is in this example). The test set will record the trip and reclose times for each individual trip and reclose operation. See next figure for example test screen.

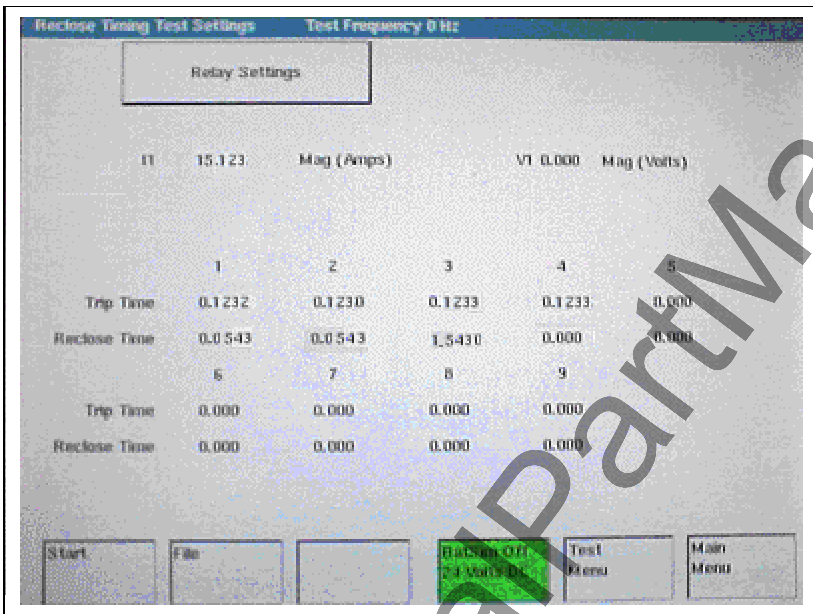
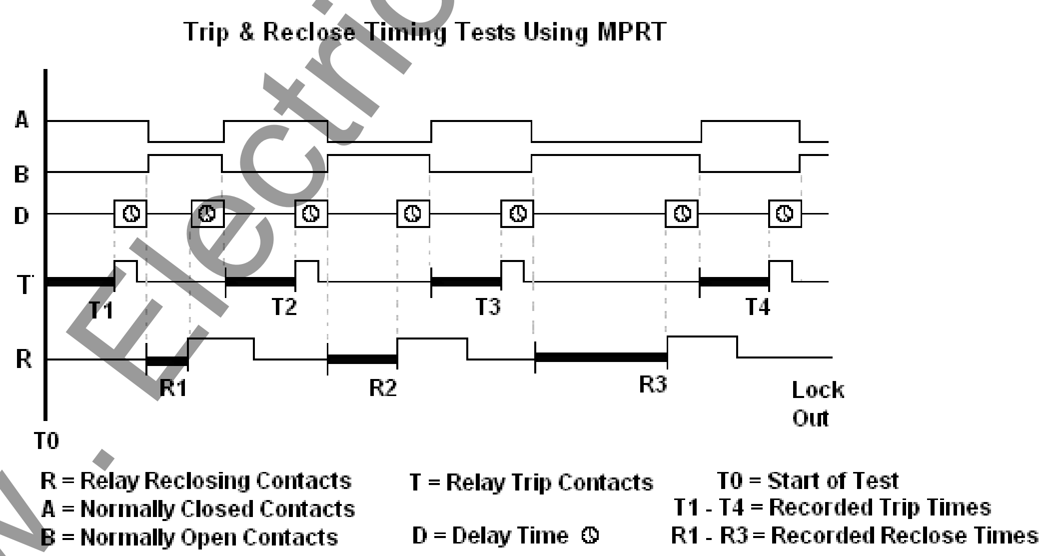


Figure 79: 4-Trip and 3-Reclose Timing Test



3.8.8.3.2 Testing Reclosing Relays (Reclose Only), Timing and Sequence to Lockout

From the **MAIN MENU** Screen, select **RECLOSING RELAY**. The following screen should be displayed.

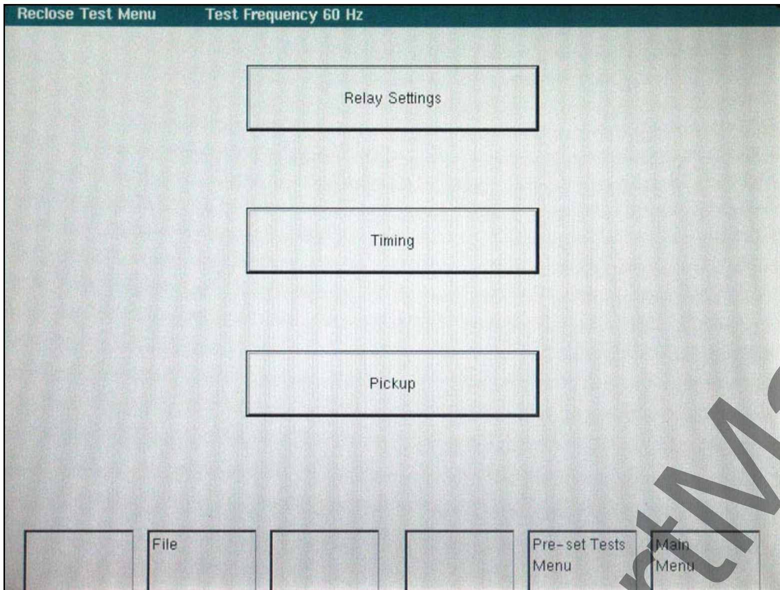


Figure 80 Reclosing Relay Menu Screen

Note: If relay is solid state, or microprocessor-based, and requires a DC logic voltage prior to applying test, connect the relay dc power terminals to the **BATTERY SIMULATOR** terminals. The Battery Simulator voltage may be set and turned on in the Relay Test Screen.

1. Select **Relay Settings**. The following screen should appear. The **Relay Tap**, **Time Dial** and **Test Multiple** should be set to zero (see Testing Distribution Relays with Reclosing for use of these inputs). Set the **No. of Operations** to the desired number of trips you want to simulate (this is the number of times the Binary Output contacts will be toggled). Note, if the reclosing relay is a three shot to lockout, then set the number of operations to 4. Set **Reclose Ops** (Shot Count) to the desired value (the number of reclose operations that the relay is set for). A maximum of 9 reclose operations (shots) may be recorded.

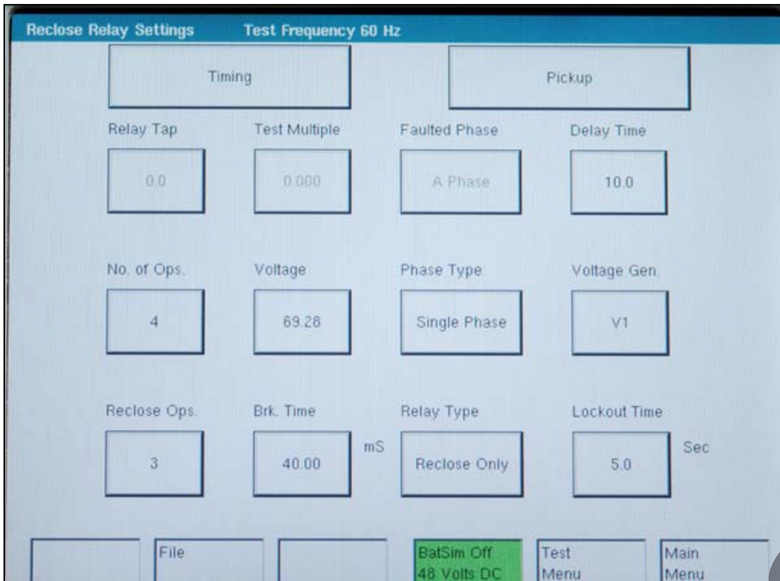


Figure 81 Reclose Relay Setting Screen

2. Press the **Delay Time** window, and enter the desired delay between operations in seconds. Note: this will be the Fault simulation time (normally the time an overcurrent relay may operate). Do not set the delay time too long, or the reclosing relay may reset between operations.

3. Press the **Lockout Time** window, and set the desired total time to lockout. Note: this is the total time to lockout, which includes the relay reclose time delays and the Delay Time that you just entered in the step above. Therefore, allow this time plus an additional second or two for the relay to totally lockout. At the end of the Lockout Time, any voltage output set in the setting screen will be removed from the relay and the test is completed.

4. Press the Timer Setup button. The Timer Setup Screen should appear.

5. In the following figure, the **Timer Setup Screen** has already been modified for testing a reclosing relay. The BINARY INPUT Terminal **T2** was selected and set to **STOP** the Timer upon **N.O.** (Normally Open) contacts closing. The **Latch** was set **On** so that the timer would stop on first contact closure, thus ignoring any contact bounce. The Timer was defaulted to measure time in **Seconds**.

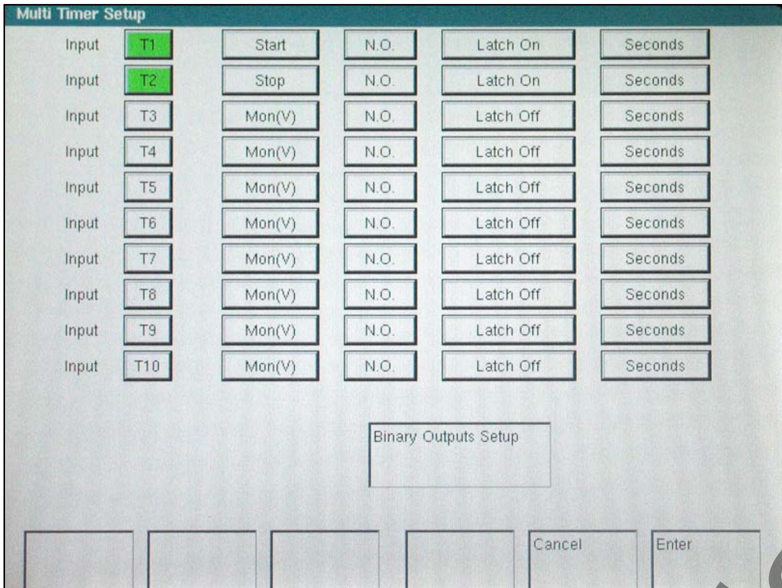


Figure 82 Timer Input Setup Screen

Pressing the Binary Output Setup button provides a setup screen to modify which output contacts will simulate the circuit breaker operation.

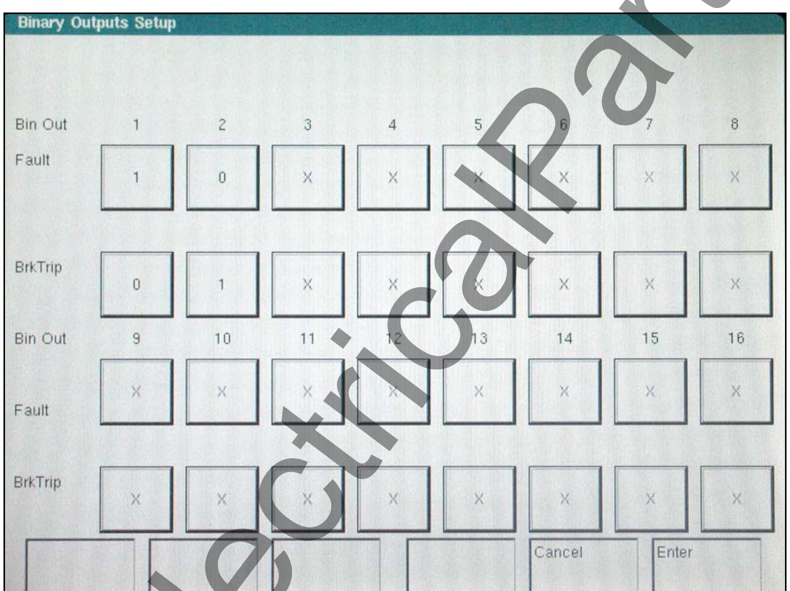


Figure 83 Binary Output Setup Screen

6. From the above figure it can be seen that the BINARY OUTPUT Terminals 1 & 2 have been selected to simulate the circuit breaker 52B and 52A contacts. Pressing the **X** changes the contact to open indicated by the number **0**. Pressing again changes it to be closed indicated by the number **1**. During the **Fault** simulation **Delay Time**, Binary Output #1 will be closed, and Binary Output #2 is open. Note that the opposite is true for the **Brk Trip** simulation. Pressing **Enter** sets the Binary Inputs and Outputs. Pressing **Main Menu** takes you back to the test selection screen.

Note: That the test set will wait for the relay reclosing contacts to close during the Brk Trip simulation. This time will appear in the Test Screen as the Reclose Time. However, if there is a problem with the relay, which prevents the relay from reclosing the breaker, then the output voltage will remain on (assuming an AC or DC voltage was set in the Setting Screen) until the Lockout Time has expired. When the Lockout Time has expired, all outputs will turn off and the test will be aborted.

7. Press the **Timing Test** Button; this will take you to the Reclose Timing Test Screen. Press the **Start** Button in the lower left corner, see Figure below. The test set closes the 52**A** contacts, and opens the 52**B** contacts, simulating the first trip operation. Each time the relay closes it's reclose contacts the reclose time is recorded and displayed. The test set toggles the contacts simulating the breaker reclosing, and then delays the contacts from opening for the Delay Time between each reclose operation.

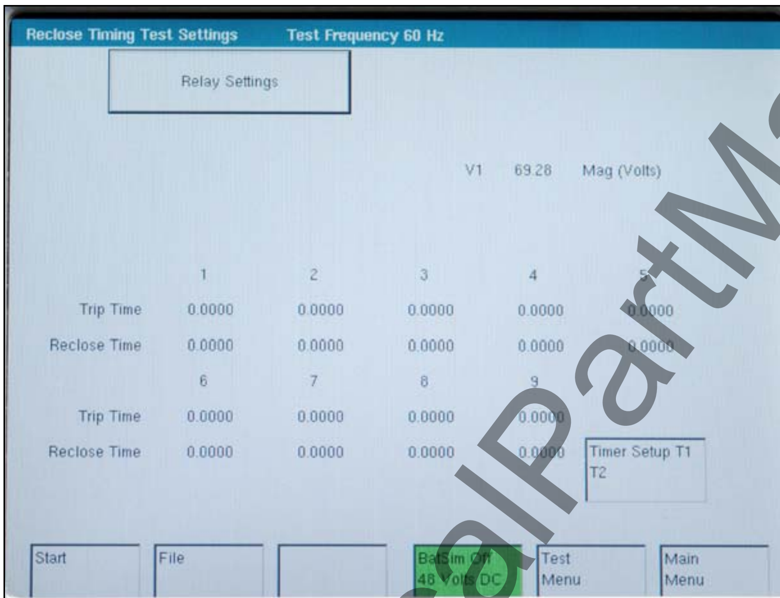


Figure 84 Reclose Timing Test Settings Screen

8. When the relay goes to lock out, the test is stopped and the total number of operations is displayed including Trip (Delay Time) and Reclose Times.

3.8.8.3.3 Testing Distribution Relays with Trip, Reclosing and Sequence to Lockout

From the **MAIN MENU** Screen, select **RECLOSING RELAY**. The following screen should be displayed.

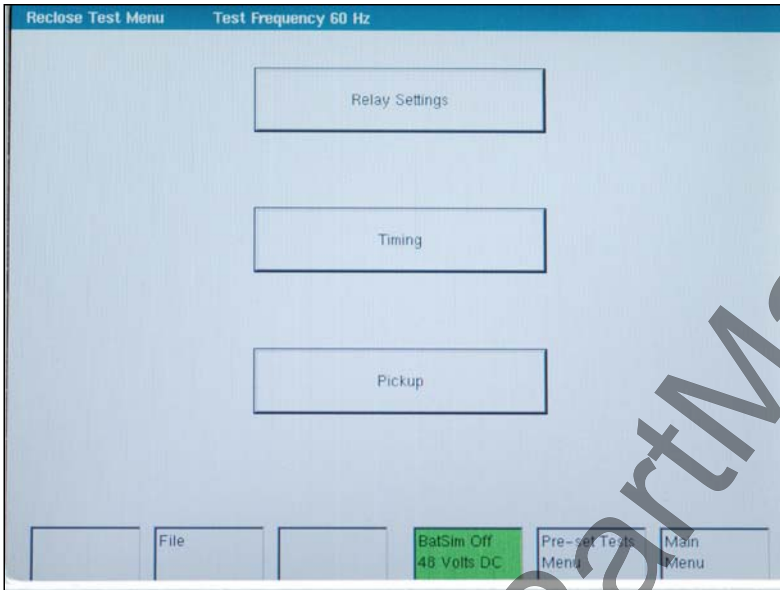


Figure 85 Reclosing Relay Menu Screen

Connect relays' trip contacts to **BINARY INPUT #1**, and the reclosing contacts to the Timer **BINARY INPUT #2**.

Connect the desired **BINARY OUTPUT** contacts to the relays' breaker sensing input (52B and/or 52A Contacts). Later in the Relay Specifications Screen, set the BINARY OUTPUT #1 for Normally Closed and BINARY OUTPUT #2 for Normally Open, using the Timer Setup button. Initially the 52**A** contacts are open and 52**B** contacts are closed, when the breaker is closed. During the test, the BINARY OUTPUT contacts will be toggled to simulate the breaker opening. When the test set senses the reclosing contacts on the BINARY INPUT #2, the BINARY OUTPUT contacts will toggle to simulate the breaker reclose, and will be repeated as programmed in the Relay Specifications Screen.

Connect **I1** output terminals to the appropriate relay current input terminals. Some of the distribution relays show a three-phase voltage input requirement. Most of these relays can be fooled by using a single-phase voltage output in parallel with all three relay voltage inputs. If it is desired to use a single-phase voltage, connect **V1** output terminals in parallel to the relay voltage input terminals. In the Relay Specifications Screen touch the Voltage window and enter the desired voltage value. Press the down arrow and select either single phase AC or DC. If three-phase voltage is required, connect **V1, V2** and **V3** output terminals to the appropriate relay input terminals. Using the down arrow select **3** ∅. The output voltage entered in the window will be applied, with each voltage separated by 120 degrees (V2 lags V1 by 120 degrees, and V3 lags V1 by 240 degrees).

Note: If relay is solid state, or microprocessor-based, and requires a DC logic voltage prior to applying test, connect the relay dc power terminals to the **BATTERY SIMULATOR** terminals. The Battery Simulator voltage may be set and turned on in the Relay Test Screen.

9. Select **Relay Settings**. The following screen should appear. Enter the **Relay Tap**, and **Time Dial** values. Enter the desired **Test Multiple** (the multiplier used to determine the test current to applied to the relay, i.e. Test Multiple * Relay Tap = Test Current). Set the **No. of Operations**. Unlike the standard reclosing relay, the distribution relay will trip the breaker (sensed on BINARY INPUT #1) to toggle the BINARY OUTPUT contacts. Note, if the reclosing relay is a three shot to lockout, then set the number of operations to 4. Set **Reclose Ops** (Shot Count) to the desired value (the number of reclose operations that the relay is set for). A maximum of 9 reclose operations (shots) may be recorded.

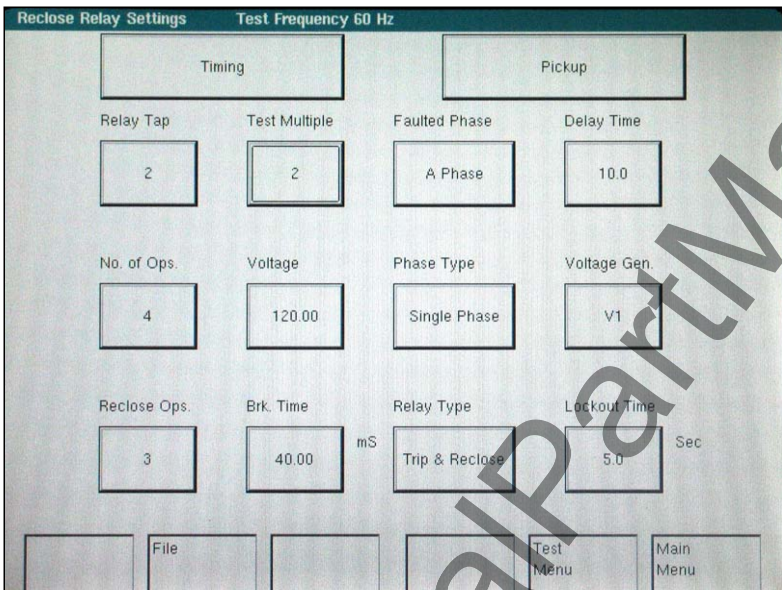


Figure 86 Reclosing Relay Setting Screen

10. Press the **Delay Time** window, and enter 0 (zero). When set to zero the logic in the test set should be to look at BINARY INPUT #1 and wait for the trip contacts to close. When the relay trip contacts close, the trip time is recorded, the output current is turned off and the BINARY OUTPUT contacts will be toggled.

11. Press the **Lockout Time** window, and set the desired total time to lockout. Note: this is the total time to lockout, which includes the relay reclose time delays and the expected total operating (trip) time of the relay's individual tripping operations. Therefore, allow this time plus an additional second or two for the relay to totally lockout. At the end of the Lockout Time, any voltage output set in the setting screen will be removed from the relay and the test is completed.

12. Press the Timer Setup button. The Timer Setup Screen should appear.

13. The **Timer Setup Screen** has already been modified for testing a reclosing relay. The BINARY INPUT Terminals **T1**and **T2** were selected and set to **STOP** the Timer upon **N.O.** (Normally Open) contacts closing. **T1** is associated with the relay trip contacts and **T2** is associated with the relay reclosing contacts. The **Latch** was set **On** so that the timer would stop on first contact closure, thus ignoring any contact bounce. The Timer was defaulted to measure time in **Seconds**.

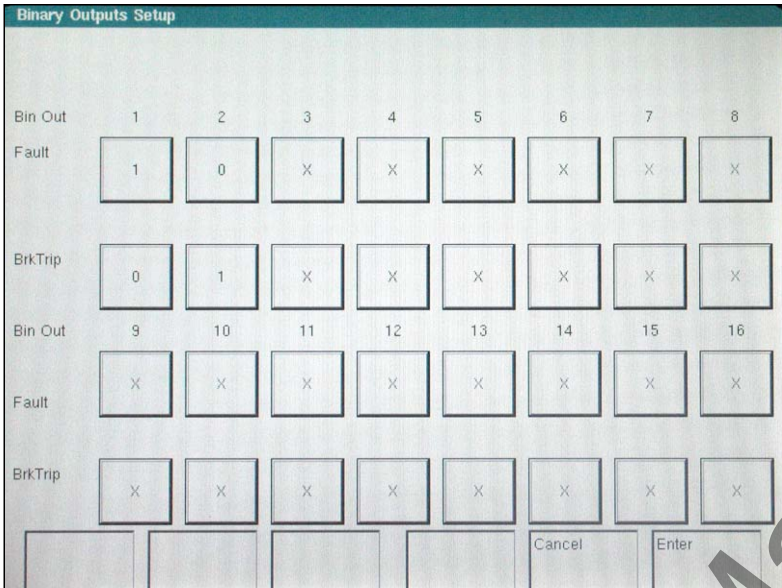


Figure 87 Binary Outputs Setting Screen

14. From the above figure it can be seen that the BINARY OUTPUT Terminals 1 & 2 have been selected to simulate the circuit breaker 52B and 52A contacts. Pressing the **X** changes the contact to open indicated by the number **0**. Pressing again changes it to be closed indicated by the number **1**. Note: while fault current is being applied to the relay, Binary Output #1 will be closed, and Binary Output #2 is open. When the relay trips it will record the trip time for the operation and toggle the BINARY OUTPUT contacts. When the test set toggles the BINARY OUTPUT contacts, it starts the reclose timer. Pressing **Enter** sets the Binary Inputs and Outputs. Pressing **Main Menu** takes you back to the test selection screen.

Note: That the test set will wait for the relay reclosing contacts to close during the Brk Trip simulation. This time will appear in the Test Screen as the Reclose Time. However, if there is a problem with the relay, which prevents the relay from reclosing the breaker, then the test set will wait until the Lockout Time has expired. When the Lockout Time has expired, all outputs will turn off and the test will be aborted.

15. Press the **Timing Test** Button; this will take you to the Reclose Timing Test Screen. Press the **Start** Button in the lower left corner, see Figure below. The test set applies the output voltage(s) and fault current until the relay trips (sensed on BINARY INPUT #1). Upon sensing trip, the output current is turned off and BINARY OUTPUT closes the 52**A** contacts, and opens the 52**B** contacts, simulating the first trip operation. Upon sensing the relays reclose on BINARY INPUT #2, the reclose time is recorded and displayed. The test set toggles the contacts simulating the breaker reclosing, and then reapplies the fault current. This is repeated based on the N0. of Operations that was entered in the setting screen.

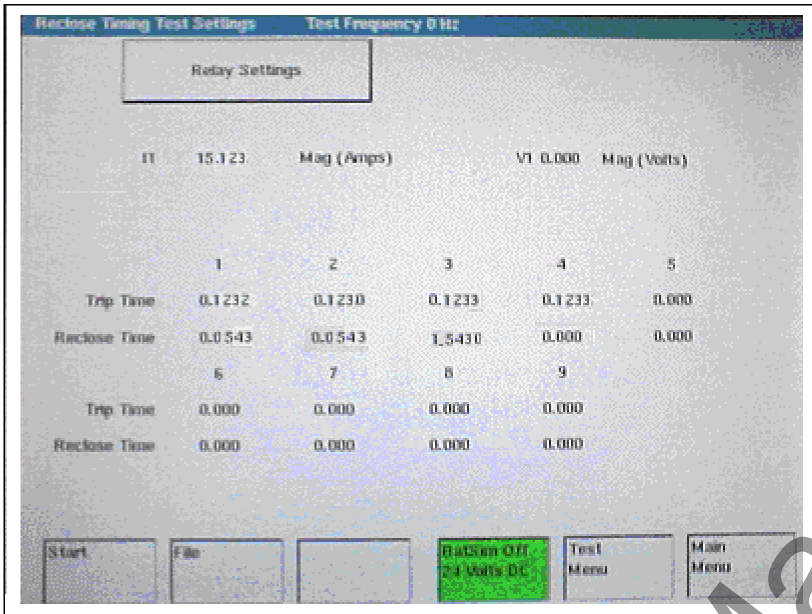


Figure 88 Single Phase Trip and Reclose Test Results

16. When the relay goes to lock out, the test is stopped and the total number of operations is displayed including Trip Times and Reclose Times.

3.8.9 **Frequency Relay Test Menu**

This menu permits the setting and testing of a frequency relay. These tests should be conducted in accordance with the manufacturers relay specifications.

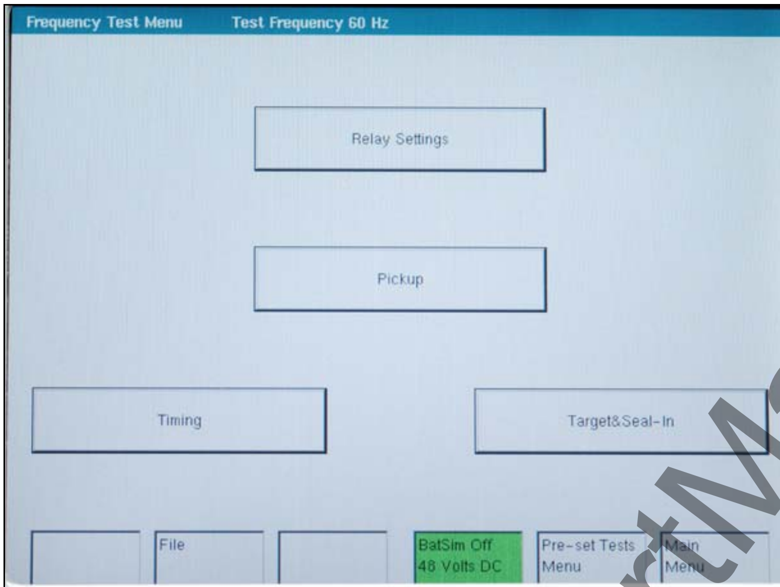


Figure 89 Frequency Relay Test Menu Screen

There are several options to further define the tests to be performed. Selecting one of these options will present the test setup screen for that option.
and

- For electro-mechanical relays, the user needs to have only one set point, set the time dial, and step.
- For solid state relays, there may be multiple set points used, multiple timing, either step and/or ramp that may be a single or double step/ramp. A double step/ramp usually measures the rise and fall time duration. This test process measures the delta frequency divided by delta time.

The bottom of the screen has common buttons.

File: This selection will take the user to the File Manager.

Pre-set Tests Menu: This selection will return the controller to the Pre-set Test Menu Screen.

Main Menu: This selection will return the controller to the Main Menu:

3.8.9.1 Frequency Relay Setting Screen

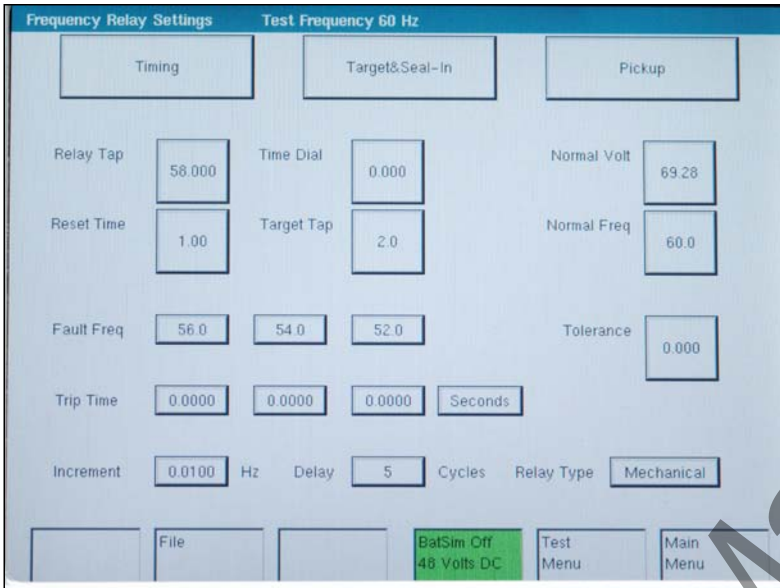


Figure 90 Frequency Relay Setting Screen

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Target & Seal-In Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Pickup Settings button will change screens and will allow changes to meet the manufacturer specifications.
- Relay Tap, Time Dial, Normal Voltage, Normal Frequency, Reset Time, Target Tap, Fault Frequency, and Trip Time to be set unless factory defaults are used.
- The Timer Setup screen allows the user to define how the time will be used.
- The relay will require a fault frequency and trip time to calculate the relay theoretical reclose. The measurement is the delta frequency divided by the delta time where the setting can be either a ramp rate or a step function as selected.
- For electro-mechanical relays, a single set point, time dial, and a step function are required.
- For the solid state relay, multiple set points may be used in conjunction with multiple times plus a step or ramp function.
- The step function or ramp rate may be single or double and the use of step / ramp may be commingled.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:

3.8.9.2 Frequency Relay Pickup Test Results

This screen displays the results upon test completion. No data may be entered in this screen.

Figure 91 Frequency Relay Pickup Test Screen

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Target & Seal-In Settings button will change screens and will allow changes to meet the manufacturer specifications.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.9.3 Frequency Relay Target & Seal-In Test Screen

This screen displays the results upon test completion. No data may be entered in this screen.

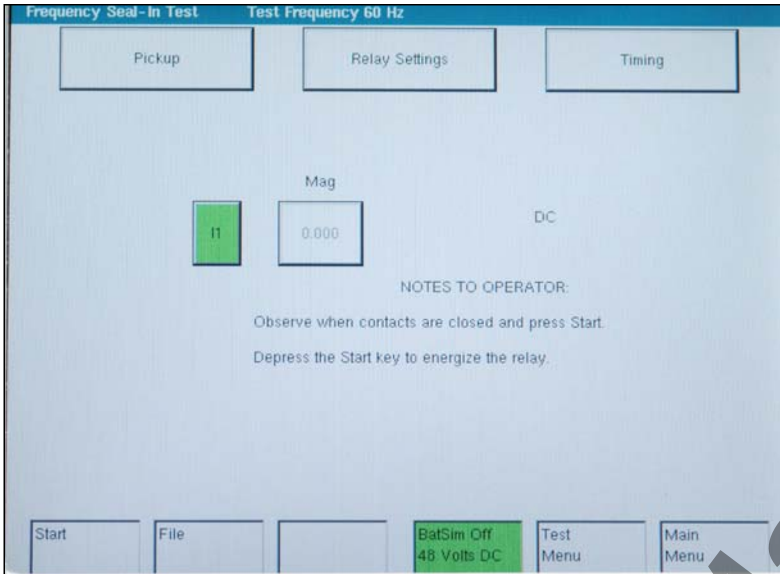


Figure 92 Frequency Relay Target and Seal-in Test

- The Timing Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Pickup Settings button will change screens and will allow changes to meet the manufacturer specifications.

The bottom of the screen has common buttons.

File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Test Menu:	This selection will return the controller to the Test Menu Screen.
Main Menu:	This selection will return the controller to the Main Menu:
Start / Stop:	This selection will apply the set quantities displayed and begin the test. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

3.8.9.4 Frequency Relay Timing Test Screen

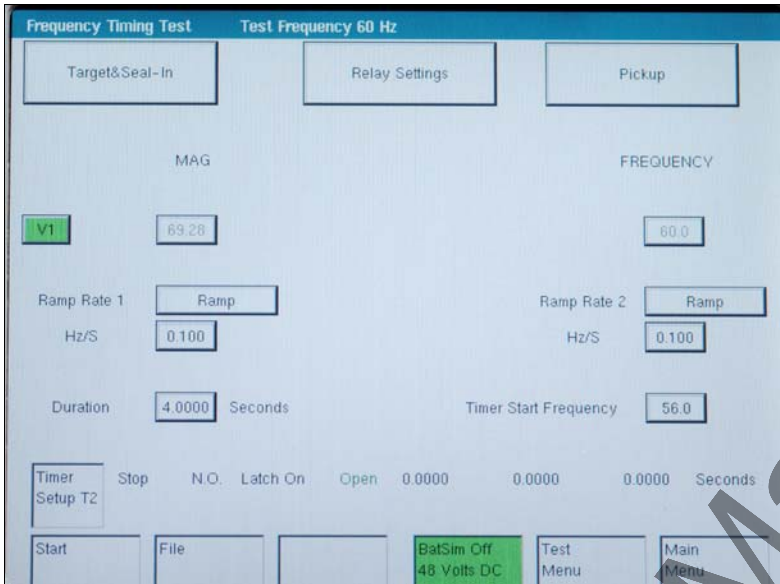


Figure 93 Frequency Relay Timing Test Setting Screen

- The Target & Seal-In Settings button will change screens and will allow changes to meet the manufacturer specifications.
- The Pickup Settings button will change screens and will allow changes to meet the manufacturer specifications.

The bottom of the screen has common buttons.

- The Start button is used to begin testing. The Start button changes to become the Stop button when the test is started. Pressing the STOP button will turn off all V/I Generators immediately and fail the test.
- The File button stores the present test values.
- The Bat Sim ON button is used to turn the battery simulator on/off. When the battery simulator power is on, the button will read Bat Sim OFF and vice versa.
- The Test Menu button returns the user to the Frequency Test Screen.
- The Main Menu button returns the user to the main screen menu. If the Main Menu button is selected the test will be stopped and will return the generators to an inactive state.

3.8.9.4.1 Dynamic Frequency Timing Test

The unit performs a dynamic timing test on all under/over frequency relays either electro-mechanical or solid-state, single or multi-set point. To test a typical multi-set point, solid-state under frequency relay, the following procedure applies.

1. Set the NORMAL Line Frequency and VOLTAGE using the touch screen and numeric keypad. Read the frequency and voltage selected on the appropriate displays.

2. Enter the Relay Tap (or Setting) frequency value in the Relay Tap window. Set the desired FAULT Frequency (normally a value below, under frequency, or above, over frequency, the Tap or Setting value) by using the touch screen and numeric keypad. This is the frequency that the output will delta or step to. For doing a timing test enter the appropriate trip time for that fault frequency.

3. Set the desired TIMER Start Frequency. If using a ramping frequency output, when the output frequency ramps through the TIMER Start Frequency the TIMER will start. If using a Step Function, the TIMER Start Frequency must be equal to the FAULT Frequency.

4. With the relay trip circuit connected to the STOP gate binding posts, select the appropriate TIMER Stop gate. Select the TIMER Start/Stop LATCH ON both the START and STOP circuits. ! NOTE: Failure to LATCH circuits will result in timing error.

5. Set the DURATION Time by using the touch screen and numeric keypad. Time indicated is in seconds. This time is the desired time, which the output frequency will remain at the selected fault frequency. The DURATION Time should be set slightly longer than the operating time of the relay.

6. Set the ΔF_1 rate of change (Ramp Rate 1). For example, if you wish to ramp the output frequency at .1 hertz per second, then press the appropriate touch screen window and increase the frequency until 00.10 Hz/Sec is displayed. However, if you desire to step the frequency, press the touch screen window twice. The word STEP should be displayed.

7. Set the ΔF_2 rate of change (Ramp Rate 2) similarly to the ΔF_1. A different rate may be selected from that of ΔF_1. A step function may also be selected.

8. Press the START button window. The voltage output frequency will begin to delta (or step) down. When the relay trip signal is sensed, the output will de-initiate and the TIMER will stop indicating the trip time.

3.8.10 **Manual Test Menu Screen**

This menu permits the setting and testing of relays in a manual mode. These tests should be conducted in accordance with the manufacturers relay specifications.

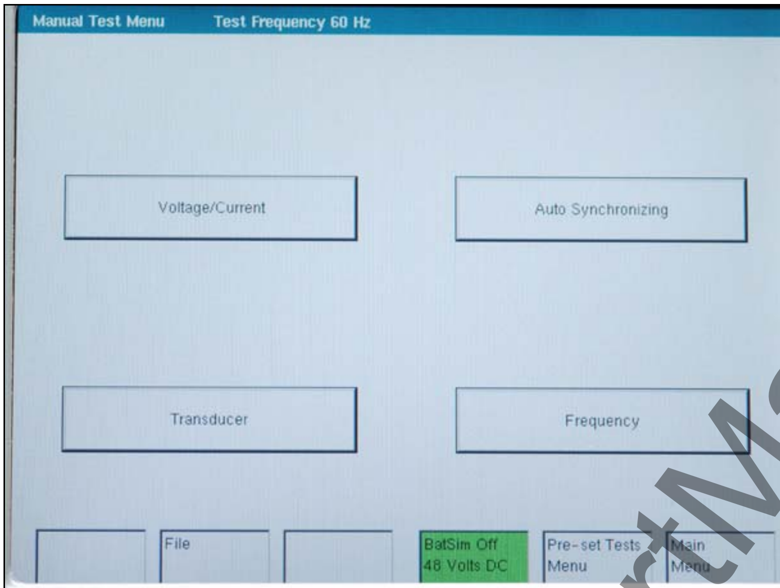


Figure 94 Manual Test Menu Screen

There are several options to further define the tests to be performed. Selecting one of these options will present the test setup screen for that option.

The bottom of the screen has common buttons.

- The File button stores the present test values or reloads the previous set of values.
- The Main Menu button returns the user to the main screen menu. If the Main Menu button is selected the test will be stopped and will return the generators to an inactive state.
- *Remove Pre-Set Menu Selection*

3.8.10.1 **Manual Voltage/Current Test Screen**

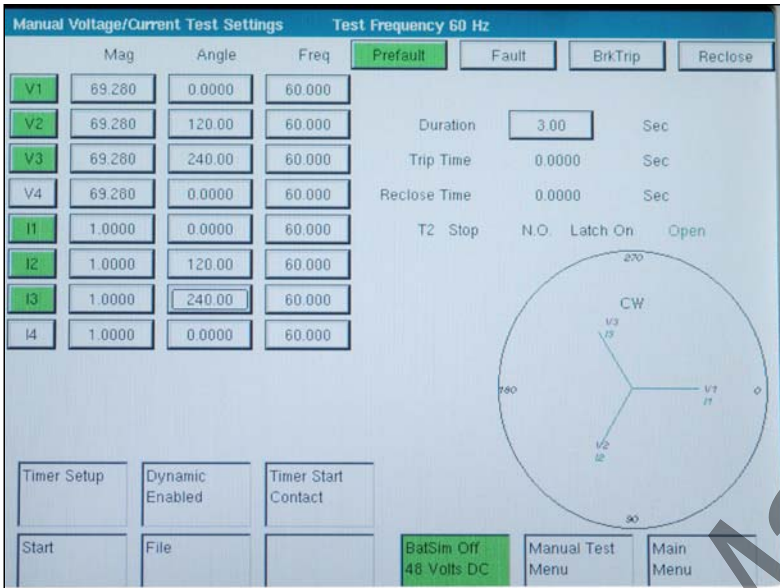


Figure 95 Manual Voltage or Current Test Screen

Description

The Manual Voltage / Current Test screen is designed to permit manual output control of the MPRT and provide simple interface for basic relay testing. This control screen allows the user to apply any value of magnitude, phase angle, or frequency to a protective relay and time the response.

Operation

The Manual Voltage / Current screens can be used to time protective relays in two different modes.

1. This screen can apply set values to visually watch the response of the relay or the unit can apply set values and start the timer and wait a response time from a protective relay.

2. This screen can also simulate four state conditions (Pre-Fault; Fault; BKR Trip; and Reclose) and progress through each state condition. A relay operation time can be monitored by the timer in the Fault or Fault and Reclose conditions.

Controls

V1...V4 & I1…I4: Permits control of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Mag: Controls the Magnitude of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Angle: Controls the Phase Angle of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Freq: Controls the Frequency of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Timer Start Contact / Timer Start Auto: Timer Start Contact selection will start the timer when the first start contact results in a true condition and the timer will stop and the generators will turn off when the first stop contact results in a true condition. The Timer Start Auto selection will start the timer when the Start button is pressed and the timer will stop and the generators will turn off when the first stop contact results in a true condition.

Dynamic Enabled / Dynamic Disabled: The Dynamic Enabled button will simulate four state conditions (Pre-Fault; Fault; BKR Trip; and Reclose) and progress through each state condition. The Timer will start when the unit progresses from the Pre-Fault to the Fault condition and will stop when the first stop contact reaches a true condition or when the Fault Duration has elapsed. If the Reclose Duration is something other than zero, the Reclose Timer will start when the unit progresses from the Fault to the BKR Trip condition and will stop when the first stop contact reaches a true condition or when the BRK Trip Duration has elapsed. If the Dynamic Disabled selection is displayed the system will not progress through the Pre-Fault, Fault, BKR Trip, Reclose operations.

Duration: A Duration time can be selected for each Pre-Fault, Fault, BKR Trip and Reclose state. IF the Duration time is set for zero the unit will skip that state. If the Duration time for Reclose is set to zero the Reclose Time will not be displayed.

File MGR: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Manual Test Menu: This selection will return the controller to the Manual Test Menu.

Main Menu: This selection will return the controller to the Main Menu:

Start / Stop: This selection will apply the set quantities displayed and start the timer or not start the timer depending upon Timer Start selection. If the Dynamic Enabled button is selected the unit will progress through the Pre-Fault; Fault; BKR-Open and Reclose operations. The Start button will always reset the timer to zero. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.

Timer Setup: This selection will display the Timer Setup menu.

Trip Time: The trip time will display the time from initiation of the timer to the time when the first stop post results in a true condition.

Reclose Time: The Reclose time will only be displayed when Dynamic Enabled button is selected and a Duration time is set in the BRK Trip selection. The Reclose time will display the time between the transition from BKR Trip to the time when the first stop post results in a true condition.

The Prefault Settings: With Dynamic Disabled, the user simply uses the selected test sources as a steady-state tester. When Dynamic Enabled is used, the user enters the values for voltage, current, phase angle or frequency, with the Duration time. These values will be applied to the device under test during the Prefault Duration time, and will then switch to the Fault Settings.

The Fault Settings: When Dynamic Enabled is used, the user enters the Fault values of voltage, current, phase angle or frequency, with a Duration time. These values will be applied to the device under test during the Fault Duration time, or until the device trips (which ever comes first) and will then switch to the Breaker Trip Settings.

The Breaker Trip Settings: When Dynamic Enabled is used, the user enters the values of voltage, current, phase angle or frequency, with a Duration time. These values will be applied to the device under test during the Breaker Trip Duration time, or until the device provides a reclose signal to the binary input terminals (which ever comes first) and will then switch to the Reclose Settings.

The Reclose Settings: When Dynamic Enabled is used, the user enters the values for voltage, current, phase angle or frequency, with the Duration time. These values will be applied to the device under test during the post-fault/Reclose Duration time, and will then switch outputs off.

3.8.10.2 **Manual Frequency Test Settings Screen**

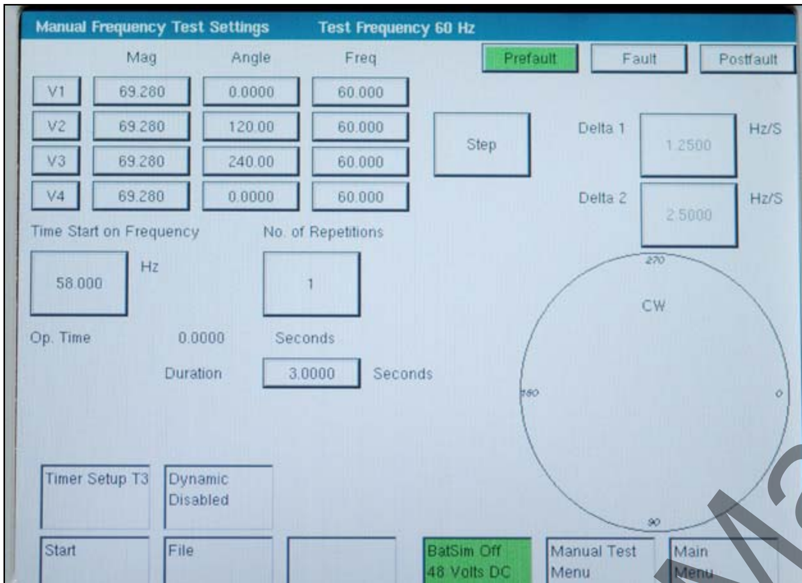


Figure 96 Manual Frequency Test Screen

Description

The Manual Voltage / Current Test screen is designed to permit manual output control of the MPRT and provide simple interface for basic relay testing. This control screen allows the user to apply any value of magnitude, phase angle, or frequency to a protective relay and time the response.

Operation

This screen can apply set values to visually watch the response of the relay, or the unit can apply set values and start the timer and await a response time from a protective relay.

This screen can also simulate a three state conditions (Prefault, Fault and Postfault). A relay operation time can be monitored by the timer in the Fault stage.

Controls

V1...V4 & I1…I4: Permits control of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Mag: Controls the Magnitude of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Angle: Controls the Phase Angle of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Freq: Controls the Frequency of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Timer Start on Frequency: Timer Start Contact selection will start the timer when the first start contact results in a true condition and the timer will stop and the generators will turn off when the first stop contact results in a true condition. The Timer Start Auto selection will start the timer when the Start button is pressed and the timer will stop and the generators will turn off when the first stop contact results in a true condition.

No. of Repetitions: This feature allows the ramping of the output frequency, using the Hz/Sec ramping function, either down / up or up / down, a fixed number of times. This is a powerful tool when testing outputs from frequency stabilizers, which require repetitive frequency ramping. The default setting is 1.

Op. Time: The Op. (operating / trip) time will display the time from initiation of the timer to the time when the first stop post results in a true condition.

Duration: A Duration time can be selected for each Prefault, Fault, and Postfault state. If the Duration time is set for zero the unit will skip that state.

The Prefault button: With Dynamic Disabled, the user simply uses the selected test sources as a steady-state tester. When Dynamic Enabled is used, the user enters the values for voltage, phase angle and frequency, with the Duration time. These values will be applied to the device under test during the Prefault Duration time, and will then switch to the Fault Settings.

The Fault button: When Dynamic Enabled is used, the user enters the Fault values of voltage, phase angle and frequency, with a Duration time. These values will be applied to the device under test during the Fault Duration time, or until the device trips (which ever comes first) and will then switch to the Postfault Settings.

The Postfault button: When Dynamic Enabled is used, the user enters the values for voltage, phase angle and frequency, with the Duration time. These values will be applied to the device under test during the Postfault Duration time, and will then switch outputs off.

.

Step; Hz/S; Ramp button:	When Dynamic Enabled is used, the user selects either Step, Hz/S or Ramp. See section 3.5.5 for detail description of the dynamic frequency selection for Hz/S. Ramp is very similar to Hz/S, with the exception that the same ramp rate is used for both Ramps. The unit defaults to the Step function, which is the simplest of dynamic frequency timing tests. The Step changes from the normal operating frequency set in the Prefault, and changes to the fault frequency setting in the Fault setting screen.
Delta 1 / Delta 2 buttons:	When Dynamic Enabled and Hz/S or Ramp is selected, these value windows are used to set changes in output frequency. If a Step function is used, the Delta 1 and 2 are greyed out and not used. When Hz/S is selected, both Delta 1 and 2 are accessible. If Ramp is selected only Delta 1 is programmable.
Timer Setup:	This selection will display the Timer Setup menu.
Dynamic Enabled / Dynamic Disabled:	The Dynamic Enabled button will simulate four fault conditions (Prefault, Fault, and Postfault) and progress through each state condition. The Timer will start when the unit progresses from the Prefault to the Fault condition and will stop when the first stop contact reaches a true condition or when the Fault Duration has elapsed. If the Dynamic Disabled selection is displayed the system will not progress through the Prefault, Fault, and Postfault operations.
Start / Stop:	This selection will apply the set quantities displayed and start the timer or not start the timer depending upon Timer Start selection. If the Dynamic Enabled button is selected the unit will progress through the Pre-Fault; Fault; BKR-Open and Reclose operations. The Start button will always reset the timer to zero. After Start is pressed this button will turn red and display Stop. Pressing Stop at any time will stop the test and turn the outputs off.
File:	This selection will take the user to the File Manager.
Batt Sim Off / Batt Sim On:	This selection will turn the Battery Simulator On and Off.
Manual Test Menu:	This selection will return the controller to the Manual Test Menu.

Main Menu: This selection will return the controller to the Main Menu:

Dynamic Frequency Operation

The MPRT can be programmed with the TVI to perform dynamic timing test on all under/over frequency relays either electro-mechanical or solid-state, single or multi-set point. To test a typical multi-set point, solid-state under frequency relay, the following procedure applies.

1. In the Prefault setting window, select V1. The Magnitude and Frequency values should already be set to the default normal Line Frequency and voltage values. If not, select the appropriate value(s) and change them using the touch screen and numeric keypad. Set the Duration Time by using the touch screen and numeric keypad. Time indicated is in seconds. This time is the desired time which the output voltage and frequency will remain at the Prefault stage before switching to the Fault stage.

2. Select Fault values by pressing the Fault Settings button. Set the desired FAULT Frequency, normally a value below (under frequency) or above (over frequency) the Tap or Setting value, by using the touch screen and keypad. This is the frequency that the output will delta or step down to during the Fault stage. For doing a timing test enter the appropriate Duration Time for that fault frequency (the Duration time needs to be slightly longer than the expected trip time of the relay under test).

3. Set the desired TIMER Start Frequency. If using a ramping frequency output, when the output frequency ramps through the TIMER Start Frequency the TIMER will start. If using a Step Function, the TIMER Start Frequency must be equal to the FAULT Frequency.

4. Select Postfault values by pressing the Postfault Settings button. Set the desired Postfault Frequency using the touch screen and keypad. This provides a go/no go test for relays that should instantly reset once the frequency conditions (postfault) have stabilized to the prefault conditions. Set a Duration Time long enough that the user can easily determine that the relay has reset properly.

5. With the relay trip circuit connected to the appropriate binary input, Timer STOP gate, binding posts, select the appropriate TIMER Stop gate using the Timer Setup screen. Select the TIMER Start/Stop LATCH ON both the START and STOP circuits. NOTE: Failure to LATCH circuits will result in timing error.

6. The unit defaults to a frequency Step for dynamic timing tests. For testing relays with multiple set points, the user may want to use either Hz/Sec or Ramp. Hz/Sec allows different ramp rates down/up, while the Ramp uses the same frequency rate of change for both ramps. Set the Delta 1 rate of change (Ramp Rate 1). For example, if you wish to ramp the output frequency at .1 hertz per second, then press the appropriate touch Delta 1 window and set the frequency to 0.10 Hz/Sec using the numeric keypad.

7. If using Hz/Sec, set the Delta 2 rate of change (Ramp Rate 2) similarly to the Delta 1.

8. Press the Start button window. The voltage output frequency will begin to delta (or step) down after the Prefault Duration time expires. When the relay trip signal is sensed, the output will de-initiate and the TIMER will stop indicating the trip time.

3.8.10.3 **Manual Auto Synchronizing Test Screen**

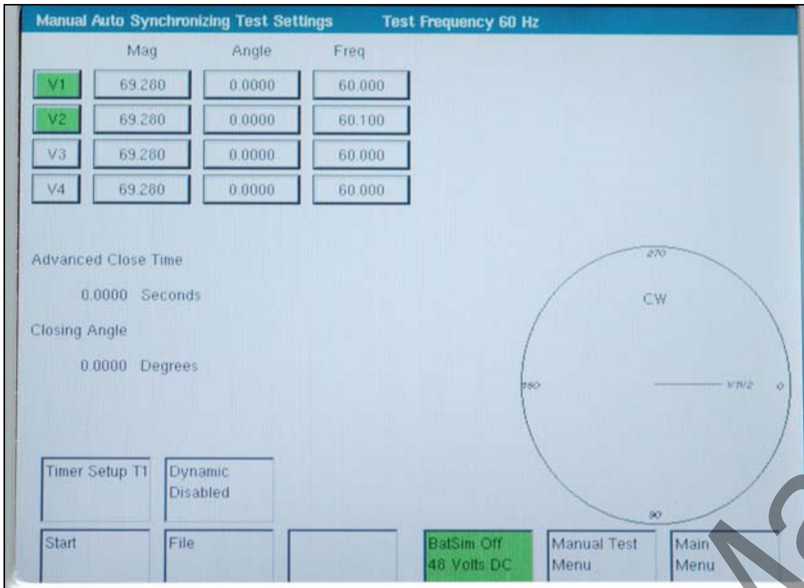


Figure 97 Manual Synchronizing Test Screen

Description

The Manual Auto Synchronizing Test screen is designed to permit manual output control of the MPRT and provide testing of synchronizing and auto synchronizing relays. This control screen allows the user to apply any value of magnitude, phase angle, or frequency to a synchronizing relay and time the response.

Operation

This screen can apply set values to visually watch the response of the relay, or the unit can apply set values and start the timer and await a response time from a synchronizing relay.

Controls

V1...V4 & I1…I4: Permits control of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator. Normally V1 and V2 are used to test synchronizing type relays.

Mag: Controls the Magnitude of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Angle: Controls the Phase Angle of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Freq: Controls the Frequency of any installed voltage (V1, V2, V3, V4) or current (I1, I2, I3, I4) generator.

Timer Setup: This selection will display the Timer Setup menu.

Dynamic Enabled / Dynamic Disabled: With the Dynamic test disabled, the user may manually adjust the phase angle using the control knob to determine the closing angle. The Dynamic Enabled, the MPRT will automatically determine closing angle and advanced closing time for auto-synchronizing relays. See Pickup and Advanced Closing Time Tests for more details.

Start / Stop: This selection will apply the set quantities displayed and start the timer or not start the timer depending upon Timer Start selection. Normally used with the Dynamic Enabled button. When the Start button is pressed the selected voltage outputs will turn on in phase. However, one voltage channel will start to slip out of phase at the selected slip frequency. At the advanced angle, based on the slip frequency, the relay will close the breaker closing contacts, and start the timer. When the two voltages slip back into phase the Timer will stop. See Advanced Closing Time Test for more details.

File: This selection will take the user to the File Manager.

Batt Sim Off / Batt Sim On: This selection will turn the Battery Simulator On and Off.

Manual Test Menu: This selection will return the controller to the Manual Test Menu.

Main Menu: This selection will return the controller to the Main Menu:

Testing Synchronizing and Auto-Synchronizing Relays

To perform tests on synchronizing type relays requires the use of two voltage output modules.

Pick-up or Closing Angle Test: This test is performed with Dynamic Disabled. With the Dynamic test disabled, the user may manually adjust the phase angle using the control knob to determine the closing angle. The output voltages, and frequency, will be the values set in the System Configuration Screen. To perform Pick-up or Closing Angle tests let one voltage channel be the 0° reference, i.e., V1, and let the second voltage channel provide the variable phase angle adjustment, i.e., V2. This test requires phase angles indicated on V2 will be a **leading angle** (this requires +/- 180 degree phase angle option). If the relay's closing characteristic is 20° leading, an angle of + 20 ° will be indicated on voltage channel 2 (assuming V1 is set to the 0° reference).

1. With V1 and V2 set to Normal Voltage, i.e. 120 Volts each, and 60 Hz (for 60 hz relays) turn outputs on by pressing the Start button.

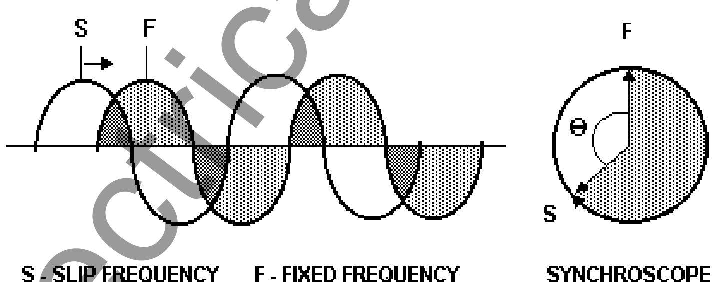
2. The user selects V2 Angle and sets it to Ramp. Using the control knob, Ramp V2 phase angle in the CW direction lagging the reference voltage. At some point a set of contacts may open, thus allowing the user to determine the dropout angle (for example - 20°). The user could set the starting angle of – 30 degrees for V2, thus the contacts would not be closed. If we started the ramp at this point the angle would continue to 180 degrees. Then the sign would change to +. When the relay Normally Open contacts closed we would read the closing angle, i.e. + 20°. We would then compare the actual closing angle to that specified in the Relay Setting Screen and calculate the error in degrees.

Advanced Closing Time Test: This test is performed with Dynamic Enabled. To perform this test let voltage channel 2, V2, provide the slip frequency (generator) and let voltage channel 1, V1, provide the fixed voltage/frequency source (bus). This test will automatically determine closing angle and advanced closing time for auto-synchronizing relays.

1. Connect the relay's closing contacts to Timer Start Terminal 1 (first pair of Binary Input terminals), so that when the relay contacts close (at the advance angle) it will start the timer, and capture the closing angle at the same time.

2. Set V1 to the Normal voltage output. Set V2 to the Normal output voltage and slip frequency. For example: **VOLTAGE, 2, AC, 120, FREQ, 60.100**. V2 ANGLE display should start at 0 degrees (we want V1 and V2 to turn on at 0 degrees together).

3. Press the Start button. V2 will turn on in phase with V1, but will slip out of phase at the selected slip frequency. At the advanced angle, based on the slip frequency, the relay will close the breaker closing contacts, and start the timer. When the two voltages slip back into phase the Timer will stop. The time indicated will be the advance time setting of the relay. The associated closing angle will also be displayed. See the following figure for a graphic representation.



As "S" approaches "F", at some point (the advance angle) the relay will send a close signal, which will start the Timer. When "S" and "F" are in synchronous, the Timer will stop. The time indicated on the timer display is the advance time of the relay based on the preset slip frequency.

3.8.10.4 **Manual Transducer Test Settings Screen**

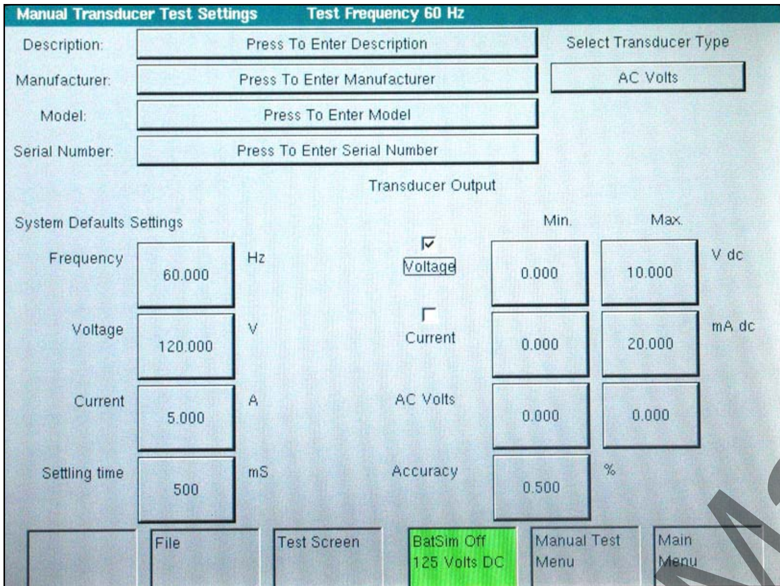


Figure 98 Transducer Setting Screen

This screen is used for selection of single phase or three-phase transducers such as; AC and DC Voltage, AC and DC Current, Frequency, Power (Watts), Reactive Power (VAR's), Apparent Power (VA) and Power Factor. The types of transducers are easily selected in the **Transducer Setting Screen**.

3.8.10.4.1 Select Transducer Type

In the **Transducer Setting Screen**, the user may select from a variety of transducers, see **Select Transducer Type** window. Here the operator may select, by touching the selection window, the type of transducer that he/she needs to test. Watt, VAR and VA transducers come in 1, 1 1/2, 2 , 2 1/2 and 3 element configurations. Selecting the number of elements will automatically select the appropriate number of output voltages and currents needed to test the selected transducer. For example, selection of a single element Watt transducer, V1 and I1 sources will automatically be selected for you. In the case of a three-phase 3 element transducer V1,V2, V3, I1, I2 and I3 will be preselected for your use. Selections available are:

<u>Single Phase</u>	<u>Multi-Phase</u>
AC Volts	Watts / VAR/ VA - 1 1/2 Element
AC Current	Watts / VAR / VA - 2 Element
DC Volts	Watts / VAR / VA - 2 1/2 Element
DC Current	Watts / VAR / VA / Power Factor - 3 Element
Frequency	
Watts / VAR / VA / Power Factor - 1 Element	

3.8.10.4.2 Transducer Description Section

In the description windows the operator enters descriptive information relative to the transducer to be tested. This information will be saved with the test results. The following describes the window entries.

Description: Input a short description of the transducer to be tested. Limited to 36 characters.

Manufacture: Input the name of the transducer manufacturer. Limited to 36 characters.

Model: Enter transducer model number . Limited to 36 charcaters.

Serial Number: Enter the serial number of the transducer. Limited to 36 digits.

3.8.10.4.3 System Default Settings

Some of the system default settings come from the **System Defaults Screen**, which can be accessed from the **Main Menu**.

Frequency: The frequency will automatically default to the system frequency default set in the **System Default Screen**. If the device is to be tested at another frequency, the operator enters the desired frquency by touching the window. A numeric keypad will appear for the user to enter the desired frequency. If the transducer is a DC transducer, the operator will enter a value of 0.0. Upon pressing enter, the frequency window will change to read **DC**.

Voltage: The voltage value will automatically default to the **Voltage Output** default value set in the **System Default Screen**. If the device to be tested does not require an AC or DC voltage, the operator may leave it as is or change it to 0.0. To change the value, press the display window and a numeric keypad will appear. Depending on the transducer selected in the **Select Transducer Type** window, the output may or maynot be automatically selected in the **Transducer Test Screen**.

Current: The current value will automatically default to the value set in the **System Default Screen**. However, it should be noted that if the operator chooses Watt, VAR or VA in the **Select Transducer Type** window, a Full Scale current will automatically be calculated and entered for you. The value will be calculated based on the defaulted **VOLTAGE** value and the **Max.** Watts, VAR or VA value entered in the **Transducer Output** section. The current may be increased or decreased from this value in the **Transducer Test Screen**.

Settling Time: This is the time delay, in milliseconds, the MPRT will wait before making it's first accuracy calculation and freeze the readings. If the transducer is self energized, the operator needs to allow enough time for the transducer to stabilize before making an accuracy calculation. If the transducer needs warmup time prior to testing, the operator needs to account for this time too. On the other hand, if the transducer is already warmed and is powered-up, then the operator only needs to allow for the settling time of the transducer. For example, assume the transducer settling time is 1 second, then the operator needs to enter a settling time of 1,000 milliseconds. When the test values are applied, the system will wait 1,000 milliseconds before calculating the % error deviation. Then, the % error with pass/fail information is displayed and the test values are frozen. At this point the operator may choose to Stop the test and Save results.

3.8.10.4.4 Transducer Output Section

Min. and Max.: The tranducer will have either a dc voltage or dc milliampere output. The default settings are 0 for minimums, 10 Volts dc and 20 milliamperes dc for Maximums. It should be noted that Minimum Value could be a negative dc value. For example, - 1 milliampere, or - 10 Volts dc. It could also be a positive dc value, other than 0. For example, the Minimum could be +4 milliamperes. In other words, the minimum could be +4 mA and the Maximum could be +20 mA. The firmware will calculate the scalling factor based on the minimum and maximum values, and use this scaling factor to calculate the actual output from the transducer (in terms of Volts, Amperes, Watts etc). In addition to Min. and Max., if a **Power Factor** transducer was selected in the **Select Transducer Type** window, then **Min.** and **Max.** will change to **Lead** and **Lag** (see description for Lead and Lag in section 3.2).

Voltage or **Current :** The operator selects one by touching the button associated with either the **Voltage** or **Current**. If the **Min.** and / or **Max.** are different from the defaulted values, the operator touches the appropriate window and a numeric keypad will appear to enter the appropriate value(s). In our example, the transducer is a Watt transducer. When **Watt 3 Element** was selected in the **Select Transducer Type** window, **Watts** appears in the Transducer output window.

In the above example, a value of 1500.0 was entered as the Max. output. The Fullscale Current was set at 1.000 milliamperes. Therefore, the scaling factor will be,

0.0 mA = 0.0 Watts, and 1.000 mA = 1500.0 Watts or,

1mA/ 1500.0 W = 0.00066666 mA / Watt

Therefore, if the transducer had a measured output of .250 mA, then the equvilent Watts output would be,

0.250 mA / 0.00066666 mA/W = 375.0 Watts

Consider another example, where the Min value is a negative value. The following example is an AC Watt Transducer with the following settings:

The transducer will output a -1 mA at -500 Watts, 0 mA at 0 Watts and +1 mA at a +500 Watts.

The scaling factor would look something like the following.

±1.000 mA = ±500.0 Watts or,

1mA/ 500.0 W = 0.002 mA / Watt

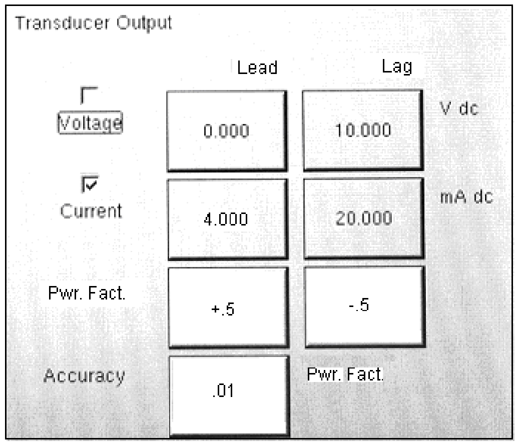
Therefore, if the transducer had a measured output of .250 mA, then the equvilent Watts output would be,

0.250 mA / 0.002 mA/W = 125.0 Watts

And if transducer had a measured output of -.450 mA, then the equvilent Watts output would be,

-0.450 mA / 0.002 mA/W = -225.0 Watts

Consider one more example for a Power Factor transducer, where the **Min** changes to **Lead** and the **Max.** changes to **Lag**, and the associated output currents are +4 mA for a Leading Power factor of .5, and +20 mA for a Lagging Power Factor of -.5. The Transducer Output window would look something like the following,



The scaling factor would look something like the following.

20 + 4 = 24 mA. Dividing by 2 determines the midpoint, or 12 mA = 1.0 PF. Therefore, a rise of 8 mA from 4 to 12 is equal in a change of power factor from a +.500 to 1.000. A change from 12 to 20 mA is equal to a change in Power Factor from 1.0 to - .500 . Therefore, a change in Power Factor of ± 0.1 is equal to a change in output current of ± 1.6 milliamperes. Since the error of some Power Factor transducers are rated to ± 0.015 PF, then we need to carry out the Power Factor to three decimal places, or .001.

Therefore, if the transducer had a measured output of 9.500 mA, then the equvilent Power Factor output would be,

9.500 - 4.000 = 5.500 mA increase (above 4 mA)

5.500 mA / 1.600 mA / 0.1 PF = 0.34375 PF (increase above +.500 PF)

adding .500 + 0.343 = +.843 PF

And, if transducer had a measured output of 15.200 mA (recall anything over 12 mA is a decreasing Power Factor going from 1.0 to -.500), then the equvilent Power Factor output would be,

Calculating towards the midpoint 20 mA - 15.2 mA = 4.8 mA

4.8/ 1.6 / -.1 = -.300

With 20 mA = -.5 PF, then adding -.3 PF results in a -.800 PF output value.

Accuracy: The accuracy value for the transducer is entered here. The default value is 0.500 %. To enter another value, the user touches the value window and a keypad allows another value to be entered.

3.8.10.5 **Manual Transducer Test Screen**

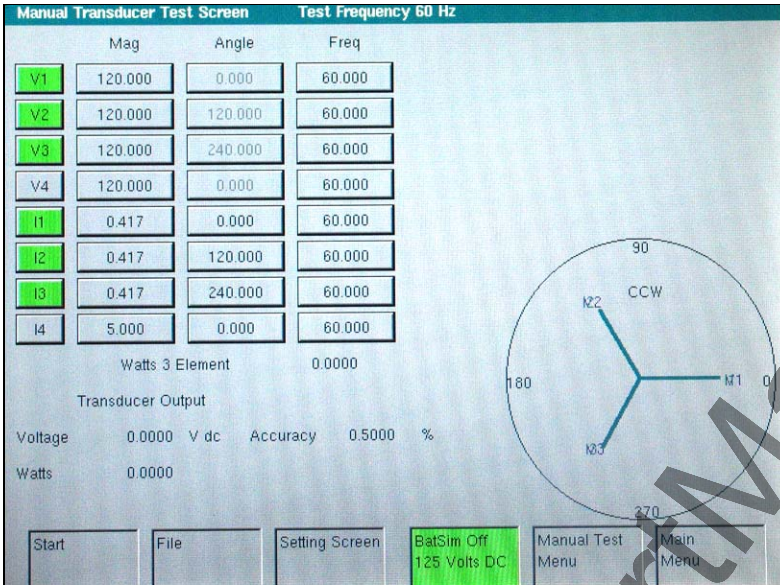


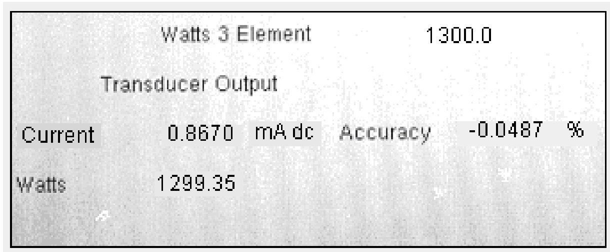
Figure 99 Transducer Test Screen

With all the values entered in the Transducer Setting Screen, the operator will press the **Test Screen** button at the bottom of the screen. The next screen to appear will be the **Transducer Test Screen**. The **Transducer Test Screen** has three parts. The **MPRT Output** section, the **Transducer Output** section and the Vector Section.

3.8.10.5.1 MPRT Output Section

The operator can select which outputs to turn on/off or value to be changed or incremented. When selecting the type of transducer to test in the Setting Screen, the appropriate outputs will automarically be selected for the user. For example, if an AC Voltage or Current transducer had been selected, the V1 or I1 outputs will have changed from grey to green, and the defaulted voltage or current would appear. The default frequency will also be preset. If a DC transducer had been selected, the Freq. Window for the selected voltage or current would read DC. In the example above, a 3 Element Watt transducer was selected in the **Setting Screen**, and the user has set ± 180 degrees in the **System Default** setting screen. In this case, let's say the user has already changed the phase angle of the currents to lag their respective voltages by 30 degrees. The actual measured output three-phase Watts is displayed as 1299.35. This value will be used later to calculate % error and PASS / TEST FAILED.

3.8.10.5.2 Transducer Output Section



The transducer output section displays either the dc output Volts or milliamperes. In addition, it also displays the equivalent output in the select type value. In our example, we see the measured value of 0.8670 mA dc and a calculated value of 1300.0 Watts.

This calculated value is compared to the actual measured value in the MPRT Output section. The accuracy is then calculated and displayed. The accuracy is calculated as follows,

$$\left(\frac{\text{Transducer Output - MPRT Output}}{\text{MPRT Output}}\right) \text{X } 100$$

If the value displayed in the Accuracy window meets the Accuracy specification set in the Transducer Setting Screen, an affirnative PASS will be displayed. If it exceeds the setting specifications, a negative TEST FAILED (in red letters) will appear. Note the PASS or TEST FAILED is delayed by the settling time value in the setting screen.

3.8.10.6 **Testing Transducers**

1. In the Transducer Setting Screen, enter the transducers specific data, such as manufacturer, model number and serial number.
2. Select the transducer type to be tested.
3. Enter the transducer's output in dc volts or milliamperes. Include the min. and max. values for the type of output, which correlates to the voltage or current. Input the transducer's accuracy value.
4. Adjust the system default settings if required, and enter the transducer's settling, or response time in milliseconds.
5. Press the Test Screen button at the bottom of the screen.
6. Based on the type of transducer selected the appropriate outputs will have already been pre-selected for you. The outputs selected will be green in color, indicating the off state. In the case of Watt, VAR or VA transducers, the angles have already been preset. If you desire to test at some other value(s) than those preset, press the window for the value(s) you wish to change and a numeric keypad will appear. Using the keypad, enter the desired value(s).
7. Connect the selected outputs to the appropriate transducer's input terminals.
8. If the transducer requires an external power source (for the AUX. Power input), connect your external power source at this time.
9. Press the **Start** button at the bottom of the screen. The outputs will turn on. To vary amplitudes, press the window(s) of the voltage(s) or current(s), which you desire to change. When the numeric keypad appears, select **Ramp**, and then **Enter** for each output. Then, rotate the control knob to ramp the desired output values.
10. Note the test result in the Transducer Output section of the window.

3.8.10.6.1 **Saving Results**

1. With the test completed, the results and test file need to be saved to the internal solid-state disk. To do this, press the **File** button at the bottom of the window. This will take the user to the **Save/Read** window.
2. Press the Save Data button. Select Save Data, and enter a file name for the test. Press Enter. The test and data are now saved. See **File Manager** section for additional information.

3.8.10.7 **Watt / Var / Va / Power Factor Applications**

As previuously described, Watt and VAR transducers come in 1, 1 1/2, 2, 2 1/2 and 3 Element configurations. In the Transducer Setting Screen, the operator is required to select what type of transducer is to be tested. Once selected, the internal firmware of the MPRT unit will make certain assumptions and calculations based on the number of elements selected. The following are detailed descriptions of the different elements and the calculations required to calculate Watts and / or VARs.

3.8.10.7.1 Watt/VAR 1 Element

The single element watt transducer requires 1 voltage and 1 current to test. The MPRT will automatically select the first voltage and current channels available, **V1** and **I1**. The test will initially start at the default value voltage that is set in the **Default Setting Screen**. For example, 120 Volts L-N. When the user inputs the **MAX.** Watts value in the **Transducer Setting Screen**, the firmware can calculate the required test current for full scale value. Since the default angle will be 0° (zero degrees), the calculation is simple. The formula required to calculate Watts is, V1 * I1 * COS 0° = Watts

Example: The default voltage is 120.00 Volts AC, and the user inputs 500 Watts as Max. Value. The current required for full scale output from the transducer is,

120 * I1 * COS 0° = 500 Watts simplifing,

I1 = 500/120, or I1 = 4.1667 Amperes

Therefore, when the user inputs 500 Watts in the **MAX**. value window, in the Test Screen the test set should automatically show a test current value of 4.167 Amperes at an angle of 0°. Note, the voltage is also in-phase with the current at 0°. Also, note that the current is rounded up to 7 in the last digit displayed.

When the test is Started, the measured voltage and current outputs are displayed and the calculated Watts is based on the measured voltage and current outputs. This is the value that gets displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the Label of **Watt 1 Element** Another value of Watts gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our example transducer, the output is in dc milliamperes. For this example, let us say that 1 milliampere of dc current is equal to the full scale output of 500 Watts. Therefore, the theoretical output Watts from the transducer would be 500 Watts, if the output current is 1 milliampere. For this example, let's say that the measured output voltage is 120.01 Volts, at 0°, and the measured output current is 4.166, Amperes, at 0.0°. The measured output Watts would be,

120.01 * 4.166 * COS 0.0 = 499.96 Watts

For this example, let's assume the measured output current from the transducer is 0.996 mA dc. Based on a Max. value of 1 mA equals 500 Watts, the displayed **Watts** in the **Transducer Output** section of the **Transducer Test Screen** should read 500 * 0.996 = **498.0 Watts**

The **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

(498.0 - 499.96 / 499.96) * 100 = % accuracy or

-0.392 %

If this were a 0.5 % transducer, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **PASS** in the **Transducer Output** section of the test screen. If this were a 0.2 %, then it would display **TEST FAILED**.

Note: All of the calculations are very similar when testing VAR 1 Element transducers. The primary difference is replacing the COS function with the SIN function. For example, let us assume that the test angle for the VAR transducer is 30 degrees. This is an important point, since if they were in phase, the SIN of 0° is 0, thus the Var contribution is 0 at the in-phase condition. Only rotating the phase angle 30 degrees do we create the measured output VAR's would be,

120.01 * 4.166 * SIN 30 = 249.98 VARs

Note: Calculations for VA transducers are the same except there are no COS or SIN functions. Therefore, the apparent power (VA) calculation is simplified as Volts * Amps. For example, for the calculation above the apparent power is,

120.01 * 4.166 = 499.96 VA

3.8.10.7.2 Power Factor 1 Element

The single element power factor transducer requires 1 voltage and 1 current to test. The MPRT will automatically select the first voltage and current channels available, **V1** and **I1**. The test will initially start at the default values for voltage and current that are set in the **Default Setting Screen.** For example, 120 Volts L-N, and 5 Amperes. The Power factor transducer has a range of operation that correlates to the Leading or Lagging phase angle relationship between the voltage and current inputs. Therefore, when the user selects Power Factor 1 Element, the **MIN** and **MAX** nomenclature will change to read **LEAD** and **LAG** power factor values. The user is required to input the **LEAD (MIN)** and **LAG (MAX)** power factor values into the provided spaces (normally the same values, i. e. 0.5). The power factor is the trigonometric decimal equivalent value of the COS of the angle between the V1 voltage and I1 current. For example, when the user inputs the **LEAD** and **LAG** Power Factor values in the **Transducer Setting Screen**, the firmware can calculate the required test angles for full scale values. Thus for a **LAG** Power Factor value of 0.5, the current would need to lag the voltage by 60°. The Lead and Lag phase angles require that the vector display be changed to show angles as ± 180°. If the default angle representation is 0 to 360 LAG, then the angle between the voltage and current will be considered lagging (current lags voltage). In this situation, the typical test angles may vary between 0 to 90 degrees lag and 359.9 to 270 degrees lag (90 degrees leading). This could cause some confusion to the user. By forcing the display to ± 180° simplifies the testing considerably. The test will start at unity power factor, or ±0°. Since the default angle will be 0° (zero degrees), the calculation is simple. The formula required to calculate Power Factor is,

COS ∠0° = 1.000 Power Factor (V1 ∠0° ,I1∠0°)

Example: The default voltage is 120.00 Volts and current is 5 Amperes AC, and the user inputs a Power Factor of ± 0.3 as **LEAD** and **LAG** Values. The angles required for full scale output from the transducer is,

0.3 Power Factor = COS 72.5° or,

+ 72.5° LEAD and -72.5° LAG

When the test is Started, the measured voltage and current outputs are displayed and the calculated Power Factor is based on the measured phase angle bewteen the voltage and current outputs. This is the value that gets displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the Label of **Power Factor 1 Element**.

Another value of Power Factor gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our next example transducer, the output is in dc milliamperes. For this example, let us say that ±1 milliampere of dc current is equal to the full scale Power Factor of ± 0.5. Therefore, the theoretical range of output from the transducer would be - 0.5 Power Factor, if the output current is -1 milliampere, to +0.5 Power Factor, if the output current is +1 milliampere. For this example, let's say that the measured output voltage is 120.0 Volts, at 0°, and the measured output current is 5.000 Amperes, at a lagging angle of -30°. The calculated Power Factor (displayed next to **Power Factor 1 Element**) would be,

COS -30° = **- 0.866**

For this example, let's assume the measured output current from the transducer is -0.489 mA dc. Based on a Lead/Lag value of ±1 mA equals ±0.5 PF, the scaling would be equal to

0.5 PF = COS 60°

1 mA / 60° or 0.016666 mA per degree.

Therefore, the displayed **PF** in the **Transducer Output** section of the **Transducer Test Screen** should read

- 0.489 mA/ 0.016666 mA/Degree = - 29.34 Degrees

COS - 29.34° = **- 0.871 PF**

Power factor transducer accuracies are stated in units of Power Factor, not in % error. Therefor, the **Accuarcy** window for Power factor transducers needs to change from % error to ± **0.000 PF**. The **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

0.871 - 0.866 = **+ 0.005 PF**

If this were a 0.01 PF transducer, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **PASS** in the **Transducer Output** section of the test screen.

3.8.10.7.3 Watt/VAR1 1/2 Element

This transducer is normally used in single-phase, three wire applications, which requires 2 voltages and 2 currents to test. The MPRT will automatically select the first two voltage and current channels available, **V1**, **V2**, **I1** and **I2**. The voltage input to the transducer is supplied with one voltage input terminal. However, we must take into account that the transducer is connected using a PT that is connected line to line. Thus the test will initially start at the default voltage value, that is set in the **Default Setting Screen**, for each Voltage output. However, the V2 output will be 180 degrees out of phase with V1, thus they add across the potential input of the transducer. For example, a default of 120 Volts L-N, means 240 Volts will be impressed across the transducer potential input terminals. Thus V1 will be set to 120 Volts at an angle of 0°, and V2 will be 120 Volts at 180°. I1 and I2 will be in-phase with their respective voltages (0° and 180°). When the user inputs the **MAX.** Watts value in the **Transducer Setting Screen**, the firmware can calculate the required test currents for full scale value.

The formula required to calculate Watts for 1 1/2 Element transducer is,

V1 * I1 * COS ∅ + V2 * I2 COS ∅ = Watts

Example: The default voltage is 120.00 Volts AC, and the user inputs 1000 Watts as Max. Value. The current required for full scale output from the transducer is,

120 * I1 * COS 0° + 120 * I2 * COS 0° = 1000 Watts

Since each phase contibutes half of the power, we can simplify to,

I1 = 500 Watts/120 Volts, or I1= I2 = 4.1667 Amperes

Therefore, when the user inputs 1000 Watts in the **MAX**. value window, in the Test Screen the test set should automatically show a test current value for I1 of 4.167 Amperes at an angle of 0°, and I2 will be 4.167 Amperes at an angle of 180°. Note that the current is rounded up to 7 in the last digit displayed.

When the test is Started, the measured voltage and current outputs are displayed and the calculated Watts is based on the measured voltage and current outputs. This is the value that gets displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the Label of **Watt 1 1/2 Element** Another value of Watts gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our example transducer, the output is in dc milliamperes. For this example, let us say that 1 milliampere of dc current is equal to the full scale output of 1000 Watts. Therefore, the theoretical output Watts from the transducer would be 1000 Watts, if the output current is 1 milliampere. For this example, let's say that the measured output voltages are 120.00 Volts (V1 and V2) and the measured output currents are 4.166, Amperes, at 0°. The measured output Watts would be,

120.00 * 4.166 * COS 0° +120.00 * 4.166 * COS 0° = 999.94 Watts

For this example, let's assume the measured output current from the transducer is 0.998 mA dc. Based on a Max. value of 1 mA equals 1000 Watts, the displayed **Watts** in the

Transducer Output section of the **Transducer Test Screen** should read 1000 * 0.998 = **998.00 Watts**

The **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

(998.0 - 999.98 / 999.98) * 100 = % accuracy or

-0.198 %

If this were a 0.2 % transducer, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **PASS** in the **Transducer Output** section of the test screen.

Note: All of the calculations are very similar when testing VAR 1 1/2 Element transducers. The primary difference is replacing the COS function with the SIN function. For example, let us assume that the test angle for the VAR transducer is 30 degrees. This is an important point, since if they were in phase, the SIN of 0° is 0, thus the Var contribution is 0 at the in-phase condition. Only rotating the phase angle 30 degrees do we create the measured output VAR's would be,

120.00 * 4.166 * SIN 30 + 120.00 * 4.166 * SIN 30 = 499.92 VARs

3.8.10.7.4 Watt/VAR 2 Element

This transducer is normally used in three-phase, three wire delta application, which requires 2 voltages and 2 currents to test. Normally, the PT's and CT's are connected to A and C phases. The MPRT will automatically select two voltage and current channels, **V1**, **V3**, **I1** and **I3** (in the event that there is no V3/I3 channel, then V2 and I2 will be used). The test will initially start at the default voltage value, that is set in the **Default Setting Screen**, for each Voltage output. Thus, for a default voltage setting of 120 volts, V1 will be set to 120 Volts at an angle of 0°, and V3 will be 120 Volts at 300° (delta connected PT's). This assumes that the default phase angle is 0 - 360 Degrees lag, and not +/- 180 degrees. If the +/- 180 degree phase angle option is used, then V3 will be at +60°. I1 and I3 will be phase shifted 30° with their respective voltages, or I1 at 30° lag and I3 at 270° lag (or + 90°). When the user inputs the **MAX.** Watts value in the **Transducer Setting Screen**, the firmware can calculate the required test currents for full scale value.

The formula required to calculate Watts for 2 Element transducer is,

$V1 * \sqrt{3} * I1 * (\cos 30° + \varnothing) + V3 * \sqrt{3} * I3 * (\cos 30° - \varnothing) = \text{Total Watts}$

Where ∅ is the incremental angular change between V1 and I1 and V3 and I 3.

Example: The default voltage is 120.00 Volts AC, and the user inputs 1000 Watts as Max. Value. The current required for full scale output from the transducer is,

$120 * \sqrt{3} * I1 * \cos 30° + 120 * \sqrt{3} * I3 * \cos 30° = 1000 \text{ Watts}$

$I1 = 500 \text{ Watts}/(120 \text{ Volts} * \sqrt{3} * \cos 30°)$, or I1 = 500/180.00

Since I1 = I3, then I1 and I3 will be 2.7777 Amperes each

Therefore, when the user inputs 1000 Watts in the **MAX**. value window, in the Test Screen the test set should automatically show a test current value for I1 of 2.777 Amperes at an angle of 30°, and I3 will be 2.777 Amperes at an angle of 270° (+90°).

When the test is Started, the measured voltage and current outputs are displayed and the calculated Watts is based on the measured voltage and current outputs. This is the value that gets displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the Label of **Watt 2 Element** Another value of Watts gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our example transducer, the output is in dc milliamperes. In this example, let 1 miiliampere of dc current be equal to the full scale output of 1000 Watts. For this example, let's say that the measured output voltages are 120.00 Volts (V1 and V3) and the measured output currents are 2.793, Amperes. The measured output Watts would be,

$$120.00 * \sqrt{3} * 2.793 * \cos 30° + 120.00 * \sqrt{3} * 2.793 * \cos 30° =$$

1005.48 Watts

For this example, let's assume the measured output current from the transducer is 1.001 mA dc. Based on a Max. value of 1 mA equals 1000 Watts, the displayed **Watts** in the **Transducer Output** section of the **Transducer Test Screen** should read 1000 * 1.001 = **1001.00 Watts**

The **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

(1001.00 - 1005.48 / 1005.48) * 100 = % accuracy or

-0.445 %

If this were a 0.5 % transducer, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **PASS** in the **Transducer Output** section of the test screen.

If the user adjusts the phase angle in the lagging direction by an additional 30°, then the Watts output changes.

Using the formula,

$$V1 * \sqrt{3} * I1 * (\cos 30° + \varnothing) + V3 * \sqrt{3} * I3 * (\cos 30° - \varnothing) = \text{Total Watts}$$

Where ∅ is the incremental angular change of 30° between V1 and I1 and V3 and I 3,

$$120.00 * \sqrt{3} * 2.793 * \cos (30°+30°) + 120.00 * \sqrt{3} * 2.793 * \cos (30° - 30°)$$

then,

Total Watts = 283.7099 + 580.5142 or 864.22 Watts

Note: All of the calculations are very similar when testing VAR 2 Element transducers. The primary difference is replacing the COS function with the SIN function. For the example above,

$120.00 * \sqrt{3} * 2.793 * \text{SIN}(30°+30°) + 120.00 * \sqrt{3} * 2.793 * \text{SIN}(30° - 30°)$

then, 502.7397 + 0 = 502.74 VAR

Note: For apparent power, VA, transducers, the calculations remain the same, except there are no COS or SIN functions. For the example above,

$120.00 * \sqrt{3} * 2.793 + 120.00 * \sqrt{3} * 2.793 = 1161.03$ VA

3.8.10.7.5 Watt/VAR 2 1/2 Element

This transducer is normally used in three-phase, four wire Wye applications, which requires 2 voltages and 3 currents to test. The two voltages and three currents are all refernced to ground. The MPRT will automatically select two voltage and three current channels, **V1**, **V3**, **I1, I2** and **I3**. The test will initially start at the default voltage value, that is set in the **Default Setting Screen**, for each Voltage output. Thus, for a default voltage setting of 120 volts, V1 will be set to 120 Volts at an angle of 0°, and V3 will be 120 Volts at 240° lagging. This assumes that the default phase angle is 0 - 360 Degrees lag, and not +/- 180 degrees. If the +/- 180 degree phase angle option is used, then V3 will be at +120°. I1and I3 will be in-phase with their respective voltages, or I1 at 0° and I3 at 240° lag (or + 120°). I2 will be at 120° lag (or -120°). When the user inputs the **MAX.** Watts value in the **Transducer Setting Screen**, the firmware can calculate the required test currents for full scale value.

The formula required to calculate Watts for 2 1/2 Element transducer is,

$V1 * I1 * (\text{COS}\ \varnothing) + V3 * I3 * (\text{COS}\ \varnothing) + V1 * I2 * (\text{COS}\ 60° + \varnothing) + V3 * I2 * (\text{COS}\ 60° - \varnothing) = \text{Total Watts}$

Where ∅ is the incremental angular change between V1 and I1 and V3 and I 3, with I2 changing at the same incremental angle as I1 and I3..

Example: The default voltage is 120.00 Volts AC, and the user inputs 1500 Watts as Max. Value. The current required for full scale output from the transducer is,

$120 * I1 * \text{COS}\ 0° + 120 * I3 * \text{COS}\ 0° + V1 * I2 * (\text{COS}\ 60° + 0°) + V3 * I2 * (\text{COS}\ 60° - 0°) = 1500$ Watts

$I1 = 500$ Watts/(120 Volts $* \text{COS}\ 0°$) , or $I1 = 500/120$

then I1, I2 and I3 will be 4.1667 Amperes each

Therefore, when the user inputs 1500 Watts in the **MAX**. value window, the test set should automatically show a test current value for I1 of 4.167 Amperes at an angle of 0°, I2 will be 4.167 at 120° (-120°) and I3 will be 4.167 Amperes at an angle of 240° (+120°). Note that the current is rounded up to 7 in the last digit displayed.

When the test is Started, the measured voltage and current outputs are displayed and the calculated Watts is based on the measured voltage and current outputs. This is the value that gets displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the

Label of **Watt 2 1/2 Element**. Another value of Watts gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our example transducer, the output is in dc milliamperes. In this example, let 20 milliamps of dc current be equal to the full scale output of 1500 Watts. For this example, let's say that the measured output voltages are 120.02 Volts (V1 and V3) and the measured output currents are 4.166, Amperes. The measured output Watts would be,

120.02 * 4.166 * 0° +120.02 * 4.166 * COS 0°
+ 120.02 * 4.166 * (COS 60° +0°) + 120.02 * 4.166 * (COS 60° - 0°) =

or, 500.0332 + 500.0332 + 250.0166 + 250.0166

1500.10 Watts

For this example, let's assume the measured output current from the transducer is 20.1 mA dc. Based on a Max. value of 20 mA equals 1500 Watts, the displayed **Watts** in the **Transducer Output** section of the **Transducer Test Screen** should read **1507.5 Watts**

The **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

(1507.5 - 1500.10 / 1500.10) * 100 = % accuracy or

0.493%

If this were a 0.5 % transducer, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **PASS** in the **Transducer Output** section of the test screen.

If the user adjusts the phase angle in the lagging direction by 30°, then the Watts output changes.

Using the formula,

V1 * I1 * (COS ∅) + V3 * I3 * (COS ∅) + V1 * I2 * (COS 60° + ∅) + V3 * I2 * (COS 60° - ∅) = Total Watts

Where ∅ is the incremental angular change of 30° between V1 and I1 and V3 and I 3 etc. ,

then,

120 * 4.1667 * COS 30° + 120 * 4.1667 * COS 30° + 120 * 4.1667 * (COS 60° +30°) + 120 * 4.1667 * (COS 60° - 30°) = 1299.05 Total Watts

Note: All of the calculations are very similar when testing VAR 2 1/2 Element transducers. The primary difference is replacing the COS function with the SIN function. For the example above,

120 * 4.1667 * SIN 30° + 120 * 4.1667 * SIN 30° + 120 * 4.1667 * (SIN 60° +30°) + 120 * 4.1667 * (SIN 60° - 30°) = 1250.01 VAR's

Note: All of the calculations are very similar when testing VA 2 1/2 Element transducers. The primary difference is no COS or SIN functions. For the example above,

120 * 4.167 + 120 * 4.167 + 120 * 4.167 = 1500.12 VA

3.8.10.7.6 Watt/VAR 3 Element

This transducer is normally used in three-phase, four wire Wye applications, which requires 3 voltages and 3 currents to test. The three voltages and three currents are all refernced to ground. The MPRT will automatically select three voltage and three current channels, **V1**, **V2**, **V3**, **I1**, **I2** and **I3**. The test will initially start at the default voltage value, that is set in the **Default Setting Screen**, for each Voltage output. Thus, for a default voltage setting of 120 volts, V1 will be set to 120 Volts at an angle of 0°, V2 will be 120 Volts at 120° lagging and V3 will be 120 Volts at 240° lagging. This assumes that the default phase angle is 0 - 360 Degrees lag, and not +/- 180 degrees. If the +/- 180 degree phase angle option is used, then V2 will be at -120° and V3 will be at +120°. I1, I2 and I3 will be in-phase with their respective voltages. When the user inputs the **MAX.** Watts value in the **Transducer Setting Screen**, the firmware can calculate the required test currents for full scale value.

The formula required to calculate Watts for 3 Element transducer is,

V1 * I1 * (COS ∅) + V2 * I2 * (COS ∅) + V3 * I3 * (COS ∅) = Total Watts

Where ∅ is the incremental angular change between V1 and I1, V2 and I2, V3 and I3.

Example: The default voltage is 120.00 Volts AC, and the user inputs 1500 Watts as Max. Value. The current required for full scale output from the transducer is,

120 * I1 * COS 0° + 120 * I2 * COS 0+ 120 * I3 * COS 0° = 1500 Watts

I1 = 500 Watts/(120 Volts * COS 0°) , or I1 = 500/120

then I1, I2 and I3 will be 4.1667 Amperes each

Therefore, when the user inputs 1500 Watts in the **MAX**. value window, in the Test Screen the test set should automatically show a test current value for I1 of 4.167 Amperes at an angle of 0°, I2 will be 4.167 at 120° (-120°) and I3 will be 4.167 Amperes at an angle of 240° (+120°). Note that the current is rounded up to 7 in the last digit displayed.

When the test is Started, the measured voltage and current outputs are displayed and the calculated Watts is based on the measured voltage and current outputs. This is the value that gets displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the Label of **Watt 3 Element** Another value of Watts gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our example transducer, the output is in dc milliamperes. In this example, let 20 milliamps of dc current be equal to the full scale output of 1500 Watts. For this example, let's say that the measured output voltages are 120.01 Volts (V1, V2 and V3) and the measured output currents are 4.167, Amperes. The measured output Watts would be, 120.01 * 4.167 * 0° +120.01 * 4.167 * COS 0° +120.01 * 4.167 * COS 0°

or, 500.0816 + 500.0816 + 500.0816 = 1500.24 Watts

For this example, let's assume the measured output current from the transducer is 20.2 mA dc. Based on a Max. value of 20 mA equals 1500 Watts, the displayed **Watts** in the **Transducer Output** section of the **Transducer Test Screen** should read **1515.0 Watts**

The **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

(1515 - 1500.24 / 1500.24) * 100 = % accuracy or

0.984 %

If this were a 0.5 % transducer, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **Test Failed** in the **Transducer Output** section of the test screen.

If the user adjusts the phase angle in the lagging direction by 30°, then the Watts output changes.

Using the formula,

V1 * I1 * (COS ∅) + V2 * I2 * (COS ∅) + V3 * I3 * (COS ∅) = Total Watts

Where ∅ is the incremental angular change of 30° between V1 and I1, V2 and I2, and V3 and I3 etc. ,

then,

120.01* 4.1666 * COS 30° + 120.01 * 4.1666 * COS 30°
+ 120.01 * 4.1666 * COS 30°

or, 433.0418 + 433.0418 + 433.0418 = 1299.13 Watts

Note: All of the calculations are very similar when testing VAR 3 Element transducers. The primary difference is replacing the COS function with the SIN function. For the example above,

120.01* 4.1666 * SIN 30° + 120.01 * 4.1666 * SIN 30°
+ 120.01 * 4.1666 * SIN 30°

or, 250.0168 + 250.0168 + 250.0168 = 750.05 VAR's

Note: All of the calculations are very similar when testing VA 3 Element transducers. The primary difference is no COS or SIN functions. For the example above,

120.01 * 4.1666 + 120.01 * 4.1666 + 120.01 * 4.1666 = 1500.10 VA

3.8.10.7.7 Power Factor 3 Element

The three element power factor transducer requires 3 voltages and 3 currents to test. The MPRT will automatically select the first three voltages and currents channels available, **V1, V2, V3** and **I1, I2, I3**. The test will initially start at the default values for voltage and current that are set in the **Default Setting Screen**. For example, 120 Volts L-N, 5 Amperes at their respective phase separations of 120 Degrees (note that for three phase Power Factor transducers the transducer requires a balanced three-phase output). The calculated Power Factors will be based on the phase separation between V1 and I1. The Power factor transducer has a range of operation that correlates to the Leading or Lagging phase angle relationship between the voltage and current inputs. Therefore, when the user selects Power Factor 3 Element, the **MIN** and **MAX** nomenclature will change to read **LEAD** (+) and **LAG** (-) power factor values. The user is required to input the **LEAD** and **LAG** power factor values into the provided spaces (normally the same values, i. e. 0.5). The power factor is the trigonometric decimal equivalent value of the COS of the angle between the V1 voltage and I1 current. For example, when the user inputs the **LEAD** and **LAG** Power Factor values in the **Transducer Setting Screen**, the firmware can calculate the required test angles for full scale values. Thus for a **LAG** Power Factor value of 0.5, the current would need to lag the voltage by 60°. The Lead and Lag phase angles require that the vector display be changed to show angles as ± 180°. If the default angle representation is 0 to 360 LAG, then the angle between the voltage and current will be considered lagging (current lags voltage). In this situation, the typical test angles may vary between 0 to 90 degrees lag and 359.9 to 270 degrees lag (90 degrees leading). This could cause some confusion to the user. By forcing the display to ± 180° simplifies the testing considerably. The test will start at unity power factor, or ±0°. Since the default angle will be 0° (zero degrees), the calculation is simple. The formula required to calculate Power Factor is,

COS ∠0° = 1.000 Power Factor (V1 ∠0° ,I1∠0°)

Example: The default voltage is 120.00 Volts and current is 5 Amperes AC, and the user inputs a Power Factor of ± 0.3 as **LEAD** and **LAG** Values. The angles required for full scale output from the transducer is,

0.3 Power Factor = COS 72.5° or,

+ 72.5° LEAD and -72.5° LAG

When the test is Started, the measured voltage and current outputs are displayed and the calculated Power Factor is based on the measured phase angle bewteen the voltage and current outputs. This is the value that gets displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the Label of **Power Factor 3 Element**.

Another value of Power Factor gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our next example transducer, the output is in dc milliamperes. For this example, let us say that ±1 milliampere of dc current is equal to the full scale Power Factor of ± 0.5. Therefore, the theoretical range of output from the transducer would be - 0.5 Power Factor, if the output current is -1 milliampere, to +0.5 Power Factor, if the output current is +1 milliampere. For this example, let's say that the measured output voltage is 120.0 Volts, at 0°, and the measured output current is 5.000 Amperes, at a lagging angle of -

30°. The calculated Power Factor (displayed next to **Power Factor 3 Element**) would be,

COS -30° = **- 0.866 PF**

For this example, let's assume the measured output current from the transducer is -0.489 mA dc. Based on a Lead/Lag value of ±1 mA equals ±0.5 PF, the scaling would be equal to

0.5 PF = COS 60°

1 mA / 60° or 0.016666 mA per degree.

Therefore, the displayed **PF** in the **Transducer Output** section of the **Transducer Test Screen** should read

- 0.489 mA/ 0.016666 mA/Degree = - 29.35 Degrees

COS - 29.35° = **- 0.871 PF**

Power factor transducer accuracies are stated in units of Power Factor, not in % error. Therefor, the **Accuarcy** window for Power factor transducers needs to change from % error to ± **0.000 PF**. For the above example the **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

0.871 - 0.866 = **+ 0.005 PF**

If the accuracy of the transducer were a ± 0.01 PF, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **PASS** in the **Transducer Output** section of the test screen.

3.8.10.8 Single Phase Applications

As previuously described, transducers come in three-phase and single phase configurations. In the Transducer Setting Screen, the operator is required to select what type of transducer is to be tested. Once selected, the internal firmware of the MPRT unit will make certain assumptions and calculations based on the type of transducer selected. The following are detailed descriptions of the single phase AC Volts, AC Current, DC Volts, DC Current and Frequency transducers.

3.8.10.8.1 AC and DC Voltage Transducers

The single phase AC and DC voltage transducer requires 1 voltage output channel to test. The MPRT will automatically select the first voltage channel available, **V1**. The test will initially start at the default value voltage that is set in the **Default Setting Screen**. For example, 120 Volts L-N. When the user inputs the **MAX.** Volts value in the **Transducer Setting Screen**, the firmware can set the required test voltage for full scale value. Note: to power up the amplifier of some transducers, **V2** may be selected to provide the AC voltage source. Remember to select the proper output voltage for V2 (it will default to the MAX value in the setting screen). If V2 is not available, use another appropriate source.

Example: The default voltage is 120.00 Volts AC, and the user inputs 150 Volts AC as Max. Value. When the user inputs 150 Volts in the **MAX.** value window, in the Test Screen the test set should automatically show a test voltage value of 150 Volts at an angle of 0°. Note, the DC voltage transducer is identical, except instead of 50 or 60 Hz as the default output frequency, the display changes to read DC.

When the test is Started, the measured voltage output is displayed. This is the value that gets displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the Label of **AC Voltage** or **DC Voltage**. Another value of Volts gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our example transducer, the output is in dc milliamperes. For this example, let us say that 1 miiliampere of dc current is equal to the full scale output of 150 Volts. Therefore, the theoretical output Volts from the transducer would be 150 Volts, if the output current is 1 milliampere. For this example, let's say that the measured output voltage of MPRT is 150.01 Volts.

For this example, let's assume the measured output current from the transducer is 0.999 mAmperes. Based on a Max. value of 1 mA equals 150 Watts, the displayed **AC Volts** in the **Transducer Output** section of the **Transducer Test Screen** should read 150 * 0.999 = **149.85 Volts**

The **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

(149.85 - 150.01 / 150.01) * 100 = % accuracy or

-0.106 %

If this were a 0.2 % transducer, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **PASS** in the **Transducer Output** section of the test screen.

Note: All of the calculations are very similar when testing DC Voltage transducers

3.8.10.8.2 AC and DC Current Transducers

The single phase AC or DC current transducer requires 1 current to test. The MPRT will automatically select the first current channel available, **I1**. The test will initially start at the default value current that is set in the **Default Setting Screen**. For example, 5 Amperes. When the user inputs the **MAX.** Current value in the **Transducer Setting Screen**, the firmware will automatically set the test current for full scale value. Note: to power up the amplifier of some transducers, **V1** may be selected to provide the AC voltage source. Remember to select the proper output voltage for V1 (it will be set to the System Default value in the setting screen).

Example: The default current is 5 Amperes AC, and the user inputs 5 Amperes AC as Max. Value. Therefore, when the user inputs 5 Amperes in the **MAX**. value window, the test set should automatically show a test current value of 5.000 Amperes at an angle of 0°. Note, the DC current transducer is identical, except instead of 50 or 60 Hz as the default output frequency, the display changes to read DC.

When the test is Started, the measured test current output is displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the Label of **AC Current** or **DC Current**. Another value of Current gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our example transducer, the output is in dc milliamperes. For this example, let us say that 20 milliampere of dc current from the transducer is equal to the full scale output of 5

Amperes. Therefore, the theoretical output Current from the transducer would be 5 Amperes, if the transducer output current is 20 milliampere. For this example, let's say that the measured MPRT output current is 5.001.

For this example, let's say that the measured output current from the transducer is 19.9991 mAmperes. Based on a Max. value of 20 mA equals 5 Amperes, the displayed **AC Amperes** in the **Transducer Output** section of the **Transducer Test Screen** should read **4.9997 Amperes**

If, 20 mA = 5 Amperes or 0.25 A / 1 mA
.
Then, 19.99 mA * 0.25 A/mA = 4.9975 Amperes

The **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

(4.9975 - 5.001 / 5.001) * 100 = % accuracy or

-0.0699 %

If this were a 0.15 % transducer, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **PASS** in the **Transducer Output** section of the test screen..

Note: All of the calculations are very similar when testing DC Current transducers.

3.8.10.8.3 Frequency Transducers

The frequency transducer requires 1 voltage output channel to test. The MPRT will automatically select the first voltage channel available, **V1**. The test will initially start at the default value voltage and frequency that is set in the **Default Setting Screen**. For example, 120 Volts L-N, 60.0000 Hz. When the user inputs the **MAX.** Frequency value in the **Transducer Setting Screen**, the firmware will calculate the required test frequency for full scale value.

Example: The default frequency is 60.00, and the user inputs 65 Hz as Max. Value. Therefore, when the user inputs 65 Hz in the **MAX.** value window, the test set should automatically show a test frequency value of 65 Hz at the default voltage value of 120 Volts.

When the test is Started, the measured voltage and frequency outputs are displayed. The MPRT output frequency is the value that gets displayed in the **Transducer Test Screen** under the **MPRT Output**, next to the Label of **Output Frequency** Another value of Frequency gets calculated using the measured dc Volts or dc milliampere output as displayed in the **Transducer Output** section. Let us assume that in our example transducer, the output is in dc Volts. For this example, let us say that 10 DC Volts is equal to the full scale output of 65 Hz. Therefore, the theoretical output Frequency from the transducer would be 65 Hz, if the transducer output voltage is 10 Volts DC. For this example, let's say that the measured MPRT output frequency is 65.00 Hz., and the measured transducer output voltage is 10.001 Volts. The measured transducer output Frequency would be,
If, 65.00 Hz = 10 Volts DC

Then, 65/10 = 6.5 Hz/V

10.001 V * 6.5 Hz/V = 65.0065 Hz

For this example, the displayed **Hz** in the **Transducer Output** section of the **Transducer Test Screen** should read 65.0091 Hz.

The **Accuracy** displayed in the **Transducer Output** section would be equal to the following,

(65.0065 - 65.0000/ 65.0000) * 100 = % accuracy or

-0.01 %

If this were a 0.02 % transducer, then the firmware would compare the accuracy values between the Setting Screen and the Test Screen and would display **PASS** in the **Transducer Output** section of the test screen..

4.0 External High Current Amplifier

The External High Current Amplifier will use the test screens with the "High I" at the bottom of the display. Otherwise, the screen may not be used by the external amplifier.

Typically this interface is used in relay tests that require a larger amount of current than can be supplied by the unit. The High Current Interface is initiated in the Main Menu Screen.

Note the EPOCH II/20 series products have a minimum frequency limitation of 5 hertz. Also, the output compliance voltage and VA output is derated linearly to 50% of the specification from 20 to 40 hertz.

Connect the EPOCH II or EPOCH 20 to the optional interface at the rear of the unit. The connectors at the rear of the MPRT correlate to the Current Amplifier in the TVI. Channel 1 on the rear option panel correlates to current channel I9, on the TVI, Channel 2 correlates to current channel I10, and Channel 3 correlates to current channel I11, and with the voltage channels converted to currents, I5 correlates to current channel I12, I6 correlates to current channel I13 and I7 correlates to current channel I14. To assign channels, from the Main Menu press the Ext. High Current Amplifier button and the following screen should be displayed.

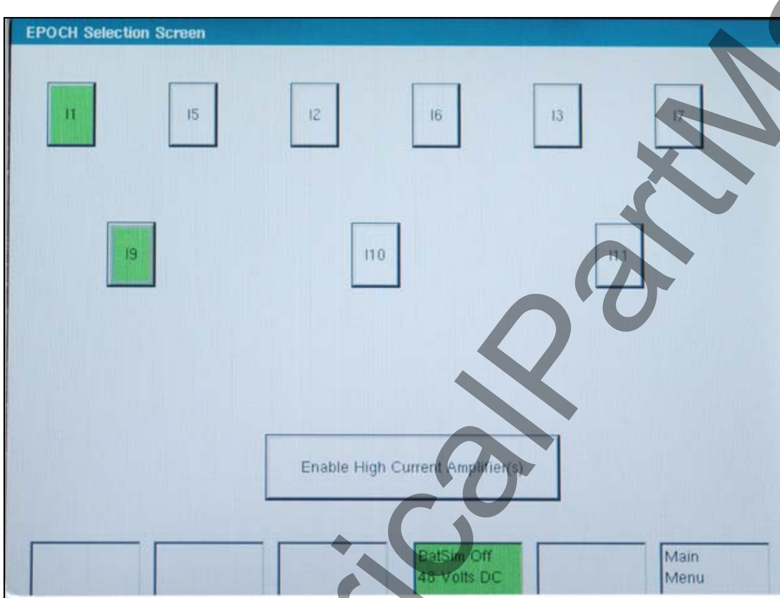


Figure 100 EPOCH Unit Selection Screen

5.0 Warranty Statement

Megger warrants the product is free of defects in material and workmanship for a period of two (2) years from date of shipment. This warranty is non-transferable. This warranty is limited and shall not apply to equipment that has damage, or cause of defect, due to accident, negligence, and improper operation, faulty installation by the purchaser, or improper service or repair by any person, company or corporation not authorized by Megger. Megger will, at its' option, either repair or replace those parts and/or materials it deems to be defective.

The warranty is in lieu of all other warranties, either expressed or implied on the part of Megger and in no event shall Megger be liable for the consequential damages due to the breach thereof.

6.0 **Service Data**

6.1 **Preventive Maintenance**

The unit utilizes surface mount technology (SMT) and other components which require little or no service except for routine cleaning, etc. The unit should be serviced in a clean atmosphere away from energized electrical circuits.

6.1.1 Examine the unit every six months for:

Dust and Dirt	To clean the unit, disconnect the power cord from the unit. Never use spray liquids or industrial cleaners. Some cleaning solvents can damage electrical components, and should never be used. Water and a mild soap may be used. Use a lightly damp cloth (not dripping wet) to wipe off the unit. A dirty heat sink can cause thermal overloads. Remove dust with dry, low pressure, compressed air. Either remove the module from the chassis or simply apply air forcing the dust away from the heat sink.
Moisture	Remove moisture as much as possible by putting the test set in a warm, dry environment.

6.2 **MPRT Ethernet Port and IP Networks**

The Ethernet port on the MPRT serves three very valuable purposes. It is the highest speed communication port in the MPRT unit. This port maybe used to download large blocks of data into the unit. It is used to download digital samples for DFR playback, download software / firmware updates and future use in automated substations using the IEC 61850 standard. Since each output channel is capable of storing up to 256,000 samples of Digital Data, such as in Digital Fault Recordings for DFR playback, and with up to eight channels that equals over 2 million samples. Using the RS-232 port would take several minutes to down load at a 9600 baud rate. The MPRT has selectable baud rates up to 115,200, which would reduce the download time. The Ethernet port on the MPRT would download the same data in less than 1 second. In addition to high speed downloads of DFR data, the port is also used to talk the MPRT unit via a Network.

Through the Ethernet port, the MPRT integrates into a network just like a PC or server. Being able to talk to the unit via a Local Area Network (LAN) is a very important feature of the MPRT unit, since it allows the user to automatically upgrade the unit software / firmware through the internet. This means that it may not be necessary to return the unit to the factory for firmware upgrades. This saves time, money and provides the latest in new added features or firmware updates with the push of a single button. In addition, this makes the MPRT suitable for future use of the IEC 61850 standard and the automated testing of IED's through the substation's Local Area Network. To use this feature requires the user to setup the IP configuration of the MPRT for their LAN. This will probably require assistance from the company's information management department (the department responsible for maintaining your company's network). The information that is needed to setup the MPRT for automatic download of firmware upgrades is, the Default Gateway address and an IP address for the MPRT unit. All this information should be available from your information management department.

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6.2.1 Setting MPRT IP Address Dialog Box

The required Gateway and IP addresses are input in this screen prior to attempting an update of the MPRT software / firmware. To get access to this screen, from the Main Menu press the System Config button. Then, press the IP Address button (it will already have a defaulted IP address preset) and enter the appropriate IP address for your network. Press the Default Gateway button to enter the Gateway Address. After entering the Default Gateway and IP addresses, the unit will calculate the Network Mask. After entering the addresses, press the OK button. Then, Save the new settings values as defaults by going to the File Manager screen, press File, press Save User Sys Def, press Execute, and OK. Your new network settings have been saved to internal memory.

Figure 101 MPRT Network IP Address Dialog Box

6.2.2 Updating MPRT Software / Firmware

Before attempting to execute an update, check to make sure that the proper Gateway and IP addresses have been set in the System Configuration Screen, see 6.2.1 above. To perform an upgrade, from the Main Menu press the **Soft/Firm Update** button. Press the **Update Check** button. The MPRT will then look for the FTP server. Upon finding the server the MPRT will present the user a Upgrade Monitor Screen, which will indicate the status of the upgrade. The MPRT will automatically look to see if there is a newer version of Software /Firmware available, and if there is it will automatically download the firmware into the unit. If not, a message appears informing the user that there are no upgrades available for that unit.

Firmware Upgrade via Compact Disk
A Compact Disk is available with the latest version of firmware available, part number 544323. There is a “Read Me” word document on the CD that provides a step-by-step procedure on how to update the MPRT using the CD. Basically you turn your PC into a “server” that the MPRT calls to download the new firmware.

Firmware Upgrade via Megger Website
Now customers can access the Megger website and download the same data that is on the Compact Disk and update the same as if using the CD version. To download the newest firmware from the Megger website,

1. Go to WWW.Megger.com
2. **Log In**. If the customer has not registered they will need to do so first.
3. Go to **Software Downloads**
4. Click on **MPRT**

5. You will see instructions on how to download and update the firmware in their MPRT unit. Then click on **MPRT Firmware Update**. The firmware will be downloaded onto the users PC ready to update their unit(s).

The fourth way to update the firmware would be to return the unit to Dallas. Any customer with Version 27.4 is required to return their unit to Dallas for upgrades. Those with V28 or higher can update via the three other methods.

6.3 Service and Repair Instructions

It is not always necessary to return the complete MPRT unit to the factory for repair. To save turn-around time and reduce costs, MPRT was designed as a modular unit. In most cases, if any one module should experience a problem it should not cause the test system to be down. Basic troubleshooting information has been provided to guide the technician to the possible source of a problem.

Most of the problems experienced with the MPRT can be corrected with a replacement module. Since MPRT uses Surface Mount Technology, most repairs of the individual modules are beyond the scope of the basic troubleshooting guide, and should be referred to the Service Department at Megger or handled through the Megger Representative.

! If the unit is still within the original warranty period, or limited warranty period following factory servicing, **the factory must be contacted before attempting any repairs or the warranty will be void.**

6.3.1 Basic Troubleshooting

The troubleshooting information relies on the technician to have a through understanding of the operation of the unit. If the technician is unfamiliar with the unit, he or she should not attempt to repair. The technician should contact the factory before attempting repairs. Provide the Megger part number for the part or assembly in question and the serial number of the MPRT when making inquiries.

WARNING It is necessary to energize the MPRT to properly troubleshoot some of the modules. The technician must take all applicable safety precautions for working on energized circuits.

NOTES

Before suspecting a failure in the MPRT, review the Description of Controls and Theory of Operation sections to ensure that the problem is not a result of operating error.

Preliminary testing of the MPRT within its specified limits can help determine if a malfunction actually exists, identify the type of malfunction and define the general area of the failure.

Common causes of malfunctions, other than improper operation, are incorrect power input (voltage above or below specified limits), incorrect test signal voltages applied to the Binary Input Timer Monitor/Start/Stop gates (outside of the specified AC/DC Applied/Removed limits), and contact or circuit resistance too great for the Dry Contact gates to operate properly on the Monitor/Start/Stop gates. Typical malfunctions for the VI-Gen amplifiers are external short circuits on the voltage output and open circuits on the current output. The battery simulator and VI-Gen voltage and current outputs can be easily checked using a voltmeter and ammeter.

NOTE: Proper ESD procedures should be followed when handling any MPRT module. Failure to do so, may damage sensitive parts.

6.3.1.2 Power Input

Input voltage affects the whole unit and may or may not cause permanent damage if voltage is incorrect. These problems can often be corrected by simply using a better source of input power. The rated voltage limits is auto-selectable from 100 to 240 volts, 47 to 63 Hz.

Some symptoms are as follows:

1. Low voltage: Erratic operation, no output, input power circuit breaker operation.

2. High voltage: Circuit breaker operation, power supply failure in Input Power Module.

6.3.1.3 Input Power and Control

Basic troubleshooting of the input power and manual controls are as follows.

1. No power:
   Check power source and line cord.

2. Erratic Manual Control
   A. Individual Output Module is not properly set into the interface board connector, thus cannot receive proper commands.

CAUTION: Turn off main power and unplug line cord before attempting to reseat any module. Observe proper ESD procedure.

Re-seating Voltage / Current (VI Gen) Amplifier Module
To reseat the module in the chassis,

A. Disconnect the power cord from the unit.
B. Carefully remove the cooling fan assembly located in the back of the unit. Note two captive screws at the lower bottom are flat head screws, the other four screws located across the top are Phillip head screws.
C. Remove the two retaining screws located on the back of the VI Gen.
D. Grasp the back the Module with one hand and gently, yet firmly, pull the module from the unit an inch or two. Then, slide the module forward until you feel it completely reseat into the female interconnect. Reinstall the two screws into the module retaining bracket. Reinstall the cooling fan assembly.

After reseating the output module, and reinstalling the cooling fan assembly, reconnect the power cord and power up the unit. Manually turn outputs on and check for proper output. If output does not change, peer through the air intake slots on the top to observe the VI-Gen LED's. Each module has some LED's that stay on continuously and some that blink. If there are no blinking LED's on one or more modules, then the module is not communicating with the operating system. Replace the VI-Gen Module.

6.3.1.4 Binary Inputs and Battery Simulator

If all the items external of the Timer assembly are in proper order, then the problem exists within the Binary Input assembly itself.

Some basic troubleshooting can pinpoint problems to the approximate cause.

Basic troubleshooting is as follows:

1. Timer does not stop:
   Jumper the appropriate Binary Input terminals manually. If LED above the selected input lights, check Timer Setup screen to verify that the selected binary input is properly setup as a Timer Stop post. Check Timer Stop settings as N.O. (Normally Open) and Latch On. If LED does not light up, the TCM backplane will need to be repaired or replaced.

2. Counting errors:
   AC applied or removed Start/Stop signals can create, what appears to be poor repeatability, an inaccuracy or a malfunction in the Timer. The lower the voltage level, the more serious the "error" will be. What appears to be an error, however, is actually a variation in the point on the sine wave at which the voltage is great enough to cause the gate circuit to operate. If the circuit used for the timing test has a low AC voltage and the point at which the contact in the test circuit opens or closes, is at or close to zero on the sine wave, the period of time before the voltage level will be high enough to trigger the gate circuit can be as much as 4 milliseconds. The total timing variation can be as much as 8 milliseconds. The shorter the duration of the timing test, the more significant the variation becomes. Therefore, if small timing variations would present a problem, it is recommended that an AC voltage of 115 volts or above or a DC voltage be used for voltage applied/removed test selections.

   When the MPRT Timer calibration is being tested, the AC voltage variable is often overlooked. This is particularly true when the Timer is compared to a counter and the two are triggered simultaneously with an electronic switch. For best results, a DC voltage should be used to eliminate the variable. If testing the AC voltage Start/Stop characteristics is desired, then the Start/Stop signal must be triggered at the same point on the sine wave to assure that the gate signal will be repeatable. Ideally, the signal should be at a point near peak in the positive direction. In addition, the specified rms AC voltage values for the various Start/Stop control selections must be adhered to.

   Another source of apparent "error" can be the programmable de-bounce feature. If using electro-mechanical contacts for starting and stopping the Timer, and if those contacts have a tendency to bounce, there could be a difference between an external standard timer and the MPRT Timer, depending on the programmed de-bounce period. To determine the programmed value, look at the Timer Setup Screen and see what the De-bounce setting value is.

If a timing error or variation persists after all the suspected causes of error have been eliminated, then it is possible that the Binary Input circuit is malfunctioning. Contact factory for return instructions.

6.3.1.5 Voltage/Current Amplifier Module

It is usually recommended that the complete Voltage/Current Amplifier Module assembly be returned for factory repair if found to be defective. Then any improvements that have been made can be incorporated into it during repair and servicing. Due to the extensive use of Surface Mount Technology in the amplifier module, there is very little that can be repaired without special tools and training. Some basic troubleshooting can pinpoint problems to the approximate cause.

Basic troubleshooting is as follows:

1. Voltage Module, no output when the MPRT is energized:
   Voltage Amplifier Module power supply failure or loose interface connections.

   CAUTION: Turn off main power and unplug line cord before attempting to reseat any module.

   Check for proper input voltage. Check VI-Gen Amplifier Module; make sure it is properly seated into the back plane connector. See instruction under section **6.2.1.3 Input Power and Control** for reseating the VI-Gen module. After reseating the output module, and reinstalling the cooling fan assembly, reconnect the power cord and power up the unit. Manually turn outputs on and check for proper output. If output does not change, peer through the air intake slots on the top to observe the VI-Gen LED’s. Each module has some LED’s that stay on continuously and some that blink. If there are no blinking LED’s on one or more modules, then the module is not communicating with the operating system. Replace the VI-Gen Module.

2. DC voltage output with amplifier turned off:
   It is normal to have a few millivolts of dc voltage with the output switched off, since the amplifier is dc coupled. However, if the power supply starts to fail, the operator may measure 10's of volts dc across the output binding post. This is an indication that the power supply has a problem and needs to be replaced. Contact factory for return instructions.

4. Removal of Voltage / Current (VI Gen) Amplifier Module
   Note: Before removing the VI-Gen module, with the unit powered up, use the TVI and press the System Config button, then press the About button. Write down the Software Version numbers, and Serial Numbers of the associated V/I Gen #’s (you will need this information later). To remove the module from the chassis,
   A. Disconnect the power cord from the unit.
   B. Carefully remove the cooling fan assembly located in the back of the unit. Note two captive screws at the lower bottom are flat head screws, the other four screws located across the top are Phillip head screws.
   C. Remove the two retaining screws located on the back of the VI Gen.
   D. Grasp the back the Module with one hand and gently, yet firmly, pull the module from the unit.

! Contact the factory for a Repair Authorization Number and return instructions if service is required. A Repair Authorization (RA) number will be assigned for proper handling of the unit when it arrives at the factory. Any non-warranty repair cost incurred for the repair or replacement of parts and/or materials shall be the responsibility of the purchaser.

Provide the factory with model number, Unit serial number, serial number of VI-Gen if appropriate, nature of the problem or service, return address, your name, and how to contact you should the factory need to discuss the service request.

You may need to provide a purchase order number, cost limit, billing, and return shipping instructions.

If an estimate is requested, provide the name and contact information.

6.4 Calibration Check

Prerequisites

For best accuracy, it is recommended that tests be conducted at a normal ambient operating temperature of 25° C ± 5° C. When testing AC and DC current outputs it is best to limit the test time to a minimum to make an accurate measurement. This will limit the accuracy drift due to the heating effect of the output current (normally only applicable to test currents of 15 Amperes, or above, for extended test periods). It is also recommended that current measurements start on the low range first and progress to the higher ranges. For best results it is also recommended that the amplifier be allowed to cool down between tests. Cool down time will vary depending on the ambient temperature and the test current applied.

Test Equipment/Minimum Requirements

Measurements must be made with equipment that is more accurate than the Unit Under Test (UUT). The instruments listed below are recommended. If equivalent instruments are not available, then total measured accuracies of the measuring instrument and the UTT will need to be to taken into account.

Digital Multimeter DCV ± 0.0625% Keithley 197A or equivalent.
Current shunt DCA ± 0.0625% w/c.f. or equivalent
Yokogawa ACV ± 0.025%, ACI ± 0.025% WT-3000 or equivalent.
Phase angle meter ± 0.0125°, North Atlantic 2000 or equivalent.
Counter ± 1.8X10-6, H.P. 5335A or equivalent.
Counter ± 3 PPM, Fluke PM6680 or equivalent.
Multi-calibrator ± 0.0125% DCA/DCV
Power Multimeter, Megger Model PMM-1 or equivalent

Notes and Precautions

High voltages and high currents used in this calibration check.

Allow UUT and equipment a minimum of ½ hour warm-up time for best results.

Allow sufficient cool down between tests on the current channels to eliminate possible accuracy drift due to heating.

6.4.1 **Checking Transducer DC IN**

With the MPRT on and warmed up, from Main Menu press the Manual Tests display button. The screen defaults to a DC IN current measurement in Milliamperes. Apply appropriate input as indicated by the following Table to the transducer input using Multi-calibrator. Record readings indicated on TVI. Repeat for all currents listed in the Table 1.

Table 1 Transducer DC IN Milliamperes

DC Milliamperes Input Range	Applied Levels	Tolerance	Measured UUT	MIN.	MAX.
20 mA	1.0	0.05%		0.9995	1.0005
	10.0	0.05%		9.995	10.005
	20.0	0.05%		19.990	20.01

Press the DC IN button on the Manual Voltage/Current Screen. The measurement will change to DC Volts. Input voltage indicated by the following Table. Repeat for all voltages listed in Table 2.

Table 2 Transducer DC IN Volts

DC Volts Input Range	Applied Levels	Tolerance	Measured UUT	MIN.	MAX.
10.0V	1.0	0.05%		0.99950	1.00050
	5.0	0.05%		4.99750	5.00250
	10.0	0.05%		9.99500	10.00500

6.4.2 **Checking Battery Simulator**

From TVI Main Menu select System Config button. Select Battery Simulator button and select 24 Volts. Connect the DC Multimeter to the Battery Simulator output terminals. Set to measure 24 Volts DC. Press the BattSim Off 24 Volt DC Button at the bottom center of the screen. The button window will change from Green to Red indicating output on. Repeat for all voltages listed in the TVI Battery Simulator Window.

Table 3 Battery Simulator Outputs

Battery Simulator	Tolerance	Measured UUT	MIN.	MAX.
24 V	10%		21.6 V	26.4 V
48 V	10%		43.2 V	52.8 V
125 V	10%		112.5 V	137.5 V
250 V	10%		225 V	275 V

6.4.3 **Checking AC Volts / DC Volts**

Connect the appropriate voltage output terminals of the MPRT to the input of the appropriate DMM or Power Multimeter. From Main Menu press the Manual Tests display button. Press the Voltage/Current button. Using TVI, select a voltage output channel by pressing either V1, V2, V3 or V4. Note: The unit is modular and may not have four output modules installed. For example, selecting V4 when there is not a 4th output module will result in an error message to the user that the 4th voltage channel is not in place or operating. To set an output value, press the Magnitude window and enter the desired value. Set the output to the desired voltage as listed in the following Table and initiate the output by pressing the Start button. The selected output indicator will change from Green to Red. UUT output will be displayed on Touch View Interface (TVI). Repeat for all ranges and values listed in the Table. Note: a minor adjustment in the metered output voltage maybe required in order to achieve the desired test voltage. With the output on, touch the Magnitude window and it should change color to Red. Using the Control Knob adjust the output voltage to get the desired output voltage. One click on the Control Knob is approximately 0.01 Volts.

Table 4 AC Volts Output Test Values

AC Volts Output	**Output Voltage**		**Measured Output**		
Range	**Setting**	**Tolerance**	**UUT**	**MIN.**	**MAX.**
30V	3.0	±0.1%		2.97	3.03
	15.0	±0.1%		14.97	15.03
	30.0	±0.1%		29.97	30.03
150V	75.0	±0.1%		74.85	75.15
	150.0	±0.1%		149.85	150.15
300V	300.0	±0.1%		299.7	300.3

To test DC Voltage accuracy change the output frequency to DC by pressing the Freq. button for the appropriate output channel. Enter 0 for the frequency and the Freq window will change to DC. To set an output value, press the Magnitude window. Set the output to the desired voltage as listed in the following Table and initiate the output by pressing the Start button. The selected output indicator will change from Green to Red. UUT output will be displayed on Touch View Interface (TVI). Repeat for all ranges and values listed.

Table 5 DC Volts Output Test Values

DC Volts Output	**Output Voltage**		**Measured Output**		
Range	**Setting**	**Tolerance**	**UUT**	**MIN.**	**MAX.**
30V	3.0	±0.25%		2.925	3.075
	15.0	±0.25%		14.925	15.075
	30.0	±0.25%		29.925	30.075
150V	75.0	±0.25%		74.625	75.375
	150.0	±0.25%		149.625	150.375
300V	300.0	±0.25%		299.25	300.75

6.4.4 Checking AC Amperes / DC Amperes

Connect the current output of the MPRT to the appropriate DMM or Power Multimeter (for DC current connect to the appropriate shunt to the DMM). From Main Menu press the Manual Tests display button. Press the Voltage/Current button. Using TVI, select a current output channel by pressing either I1, I2, I3 or I4. Note: The unit is modular and may not have four output modules installed. To set an output value, press the Magnitude window and enter the desired value. Set the output to the desired current as listed in the following Table and initiate the output by pressing the Start button. The selected output indicator will change from Green to Red. UUT output will be displayed on Touch View Interface (TVI). Note: To adjust current, touch the Magnitude window and it should change color to Red. Using the Control Knob adjust the output current. One click on the Control Knob is approximately 0.001 Amperes.

Table 6 AC Current Test Values

AC Amperes Output Range	Output Current Setting	Tolerance	Measured Output UUT	MIN.	MAX.
6.0A	0.6	±20ma		0.58	0.62
	3.0	±20ma		2.98	3.02
	6.0	±0.1%		5.994	6.006
15.0A	7.5	±0.1%		7.485	7.515
	15.0 [1]	±0.1%		14.985	15.015
30.0A	30.0 [1]	±0.1%		29.97	30.03

To test DC Current accuracy change the output frequency to DC by pressing the Freq. button for the appropriate output channel. Enter 0 for the frequency and the Freq window will change to DC. Set the output to the desired current as listed in the following Table and initiate the output by pressing the Start button. The selected output indicator will change from Green to Red. UUT output will be displayed on Touch View Interface (TVI). Repeat for all ranges and values listed.

Table 7 DC Current Test Values

DC Amperes Output Range	Output Current Setting	Tolerance	Measured Output UUT	MIN.	MAX.
6.0A	0.6	±20ma		0.58	0.62
	3.0	±20ma		2.98	3.02
	6.0	±20ma		5.98	6.020
15.0A	7.5	±0.25%		7.4625	7.5375
	15.0 [1]	±0.25%		14.9625	15.0375
30.0A	30.0 [1]	±0.25%		29.926	30.075

6.4.5 Checking AC Current – Convertible Channel

Connect the current output of the MPRT to the appropriate DMM or Power Multimeter. From TVI Main Menu select System Config button. From System Configuration Menu press the Convertible V/I Control button. Set all available convertible channels from Voltage to Current and press the OK button. From Main Menu press the Manual Tests display button. Press the Voltage/Current button. You should note that all the Voltage Channels have been converted to currents I5, I6, I7 and I8. Using TVI, select a current output channel by pressing either I5, I6, I7 or I8. To set an output value, press the Magnitude window and enter the desired value. Set the output to the desired current as listed in the following Table and initiate the output by pressing the Start button. The selected output indicator will change from Green to Red. UUT output will be displayed on

[1] To reduce possible thermal drift allow 5 minutes cool down after each measurement of 15 Amperes or higher

Touch View Interface (TVI). Note: To adjust current, touch the Magnitude window and it should change color to Red. Using the Control Knob adjust the output current. One click on the Control Knob is approximately 0.001 Amperes.

Table 8 Convertible Channel AC Current Test Values

AC Amperes Output Range	**Output Current Setting**	**Tolerance**	**Measured Output UUT**	**MIN.**	**MAX.**
5.00A	0.5	±12.5ma		0.4875	0.5125
	2.5	±12.5ma		2.4875	2.5125
	5	±12.5ma		4.9875	5.0125

6.4.6 **Checking Phase Angle**

Phase Angle is tested at either an output frequency of 50 or 60 Hz. Two sets of phase angles are tested using one common reference for all tests, Voltage Channel 1. Angles will be checked between V1 and all output current channels and V1 to all voltage channels. Connect appropriate outputs from MPRT to the Phase Angle Meter. Referencing all phase angles to V1, use Touch View Interface (TVI) to apply desired phase angle to the Phase Angle Meter. When testing current use load box to convert current to voltage for input into the North Atlantic Phase Angle Meter. In place of the load box and the North Atlantic Phase Angle Meter, a Megger Model PMM-1 may be used to measure the phase angle of the current directly. However, the error of the PMM-1, ± 0.05 degrees, must be added to the total allowable error (the North Atlantic Phase Angle Meter measures angles between two voltages with an error of ± 0.0125 Degrees). MPRT readings will be displayed on Touch View Interface (TVI). Start with angles between voltage outputs V1 (reference) and V#.

From Main Menu press the Manual Tests display button. Press the Voltage/Current button. Using the TVI, select two voltage output channels by pressing V1 (reference) and then either V2, V3 or V4. Note: The unit is modular and may not have four output modules installed. Set the output voltage 120 Volts for each output voltage channel. To set an output value, press the Magnitude window and enter the desired value. Set the phase angle to the desired voltage channel (V2, V3 or V4) as listed in the following Table and initiate the output by pressing the Start button. The selected output indicator will change from Green to Red. UUT output will be displayed on Touch View Interface (TVI). Repeat for all values listed in the Table.

Table 9 Phase Angles Between V1 and V#

Phase Angle (Ref V1)				
Volts V#	**Levels**			
120 V	0(360)	±0.25º	359.75	0.025
	90	±0.25º	89.75	90.25
	180	±0.25º	179.75	180.25
	270	±0.25º	269.75	270.25

To test angles between V1 and all current channels requires the use of a load box to convert the current outputs to a voltage for input into the Atlantic Phase Angle Meter.

Lacking a load box, use a Megger Model PMM-1 to measure the phase angle of the current directly. Remember to add the error of the PMM-1 to the total allowable error. Use a test current of 5 amperes and repeat the phase angles in the following Table.

Table 10 Phase Angles Between V1 and I#

Phase Angle Ref V1 120V				
Current I#	**Levels**			
5 Amperes	0(360)	±0.25º	359.75	0.025
	90	±0.25º	89.75	90.25
	180	±0.25º	179.75	180.25
	270	±0.25º	269.75	270.25

6.4.7 Checking Frequency

Connect MPRT voltage output to Fluke frequency counter. Set counter to 1MΩ, filter on, auto trigger, and time to 30 sec. Using TVI, apply appropriate output to counter. MPRT frequency readings will be displayed on Touch View Interface (TVI). Repeat for all ranges and values listed in the following table.

Table 11 Output Frequency Test

AC Voltage Output	**Output Frequency**		**Measured Output**		
	Setting (Hz)	**Tolerance**	**UUT**	**MIN.**	**MAX.**
120 V	10	±25 ppm		9.99975	10.00025
	50	±25 ppm		49.99875	50.00125
	60	±25 ppm		59.9985	60.00150
	100	±25 ppm		99.9975	100.0025
	1000	±25 ppm		999.975	1000.025

6.5 Preparation for Reshipment

Save the original shipping container for future use. The shipping container is designed to withstand the rigors of shipping via a common commercial carrier. For example, you may wish to reship your unit to Megger for an annual calibration recertification.

Pack the equipment appropriately to prevent damage during shipment. If a reusable container is utilized, the unit will be returned in the same shipping container if it is in suitable condition.

Add the Return Authorization Number to the address label of the shipping container for proper identification and quicker handling.

NOTE: Ship the equipment without nonessential items such as test leads, etc. These items are not needed by the factory to perform service.