ORTMASTER ORTM-1 and ORTM-2

RECLOSER TEST SET ACCESSORY

INSTRUCTION MANUAL

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GENERAL INFORMATION

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SECTION I

GENERAL INFORMATION

INTRODUCTION

The P S Technology ORTMASTER is an electronic current monitoring accessory used in conjunction with an IBM PC compatible computer and any system for primary injection testing of oil and vacuum type reclosers and sectionalizers. It incorporates advanced circuitry and software, which provide an accurate, inexpensive and efficient means for monitoring output current and time for proper testing and calibration. Real time digital waveform recording and analysis provides true RMS (root-mean-square) reading of current, including DC offset and decay, for excellent correlation of results with manufacturers' calibration.

The ORTMASTER interface module is designed to connect to the output of ANY recloser test set. It interfaces to the parallel port of any IBM compatible computer, and a software program displays trip current, trip times, and reclose times for up to five recloser operations.

A precision 12 bit A/D converter reads the current flowing through the bus bar or cable connection at the bottom of the rugged steel enclosure, and stores the waveform in memory. A continuous readout of TRUE RMS current is indicated at all times, and accurate readings of time and current for each operation are displayed as they occur.

After the test, one may view and analyze the waveform of each shot, and this waveform can be saved to disk for future reference. Upon exit from the program, current and time readings are saved to a disk file.

Optional software is available which can interface to databases of various recloser types, and can compare readings to manufacturers' data for immediate GO/NOGO verification of test results. Data can be saved and formatted reports printed.

The ORTMASTER has been fully tested on an EIL Model ORT-560 recloser test set, and has been proven to provide much better accuracy and consistency, especially on waveforms with moderate to severe current decay. The exclusive software controlled TRUE RMS computation always gives the correct current reading, and properly reads waveforms with DC offset and distortion. This system was designed and tested by Paul E. Schoen, now president of P S Technology. He was awarded patent #4,307,345 for a recloser test set.

GENERAL DESCRIPTION

The P S Technology ORTMASTER is a self-contained unit consisting of:

1. A rugged steel enclosure which may be bolted to the frame of the recloser test set.

2. A high-current capacity copper bus (ORTM-1) or shunt (ORTM-2) for simple connection to the output of the test set.

3. A 120 VAC line cord for connection to a source of power.

4. Internal noise filtering and surge protection.

5a. (ORTM-1) An air-core current sensor and integrator circuit for wide range and accuracy.

5b. (ORTM-2) A high current shunt and protection circuitry for reliability and accuracy when measuring currents with DC components.

6. Precision low-noise amplifiers and solid-state range switching.

7. A highly accurate 12 bit analog-to-digital converter.

8. A high-speed interface to a standard parallel port.

9. Easy-to-use real-time software for accurate current and time measurements.

10. A fused, filtered and grounded convenience outlet for connection of PC compatible computer.

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LOW VOLTAGE TESTING

To appreciate how the ORTMASTER works, it is important to have an understanding of the effects of low-voltage testing of reclosers. When a fault occurs on a power line protected by a recloser, typically 14.4 KV AC, the impedance of the power line circuit is also fairly high, so that fault currents are in the order of 5 to 20 times continuous rated current. A 100 ampere recloser will typically see a fault current of about 1000 amperes, which translates to an impedance of about 14 ohms.

When a recloser operates, a plunger is drawn into a coil, which causes an increase in impedance. A 100 ampere, type 4E recloser has an impedance change from 0.072 ohms to 0.227 ohms, as the plunger moves inside the coil. In the example given, at high voltage, this change in impedance has minimal effect on the current. Recloser curves assume current flow to remain constant. The impedance change at high voltage has a negligible effect on timing.

Practical test methods for reclosers are limited by reasonable available power, and safe voltage levels. The power involved in this example is 14.4 MVA, which is far beyond available power. Most recloser test sets are 10 to 50 KVA, which limits power available for testing.

The manufacturer recommends a test voltage of 138 VAC for this recloser, for a test current of 800 amps. If a solid 138 VAC is applied to the recloser, it will begin its operation at 1916 amps, which requires over 200 KVA, but will complete its operation at only 608 amps. Obviously, this will make it difficult to measure the current unless a true RMS computation of the entire pulse is utilized.

Most recloser test sets incorporate some sort of resistive compensation, which can limit the current change to about 10-20%, but even this amount of decay can affect the current metering.

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INSTRUMENTATION

Several methods of current measurement are utilized by different recloser test sets. Some systems read the current near the beginning of the operation, and others track the current and read it near the end of the operation. However, the recloser operates on the true RMS value of the current over the entire length of the pulse.

For example, assume the recloser is a 100 Amp type L, with a D curve, and current decay of 20%. The expected trip time at 1000 Amps is 0.3163 seconds, but 0.4914 seconds at 800 Amps. The average current is actually about 900 Amps, with an expected trip time of 0.3807 seconds. If the 0.3807 second trip time is compared to the curve at 1000 amps, the time would appear to be about 17% slow. If your test set measures at the end of the operation, reading 800 Amps, the recloser would appear to be about 29% fast. Either reading would appear to be out of tolerance.

HOW ORTMASTER WORKS

The ORTMASTER records the entire waveform of each current pulse, by taking 2000 samples per second, or about 33 samples per cycle. After each operation has completed, a true-RMS computation is performed, taking into account any distortion, decay, or DC offset, which directly affect recloser operation and timing. Extensive testing has determined that timing will closely match that which will be produced at high voltages and minimal decay under actual operating conditions.

In addition to its unequaled accuracy of current measurement, the ORTMASTER also excels in timing measurement. At 2000 samples per second, a precision of 0.5 mSec is possible. When interfaced with the TCC software, test results can be instantly verified.

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SPECIFICATIONS

INPUT POWER

105-130 VAC, Single Phase, 50/60 Hz, 15 VA

OUTPUT

Standard parallel port for control and data acquisition.
120 VAC convenience outlet for computer (1.5 A Maximum).

MEASUREMENT SYSTEM

CURRENT INPUT (50% duty cycle, 5 minutes max.):
 (ORTM-1) Copper bus, 1/4" x 2", 600 Amperes
 (ORTM-2) Shunt, with 1/2"-13 hardware, 1000 Amperes

CURRENT RANGES:
 0-50/100/250/500/1K/2.5K/5K/10K Amperes Full Scale

CURRENT ACCURACY (add 1% if not field calibrated):
 +/- 1% Full Scale (Continuous)
 +/- 2% Full Scale (Pulse)

TIMING:
Range:	0-99.999 seconds
Resolution:	0.0005 seconds (standard)
	0.0017 sec (at 582.6 samples/sec)

 Timebase Accuracy: based on PC internal clock:
  Typically +/- 0.0025% of reading

TIMING ACCURACY:
 +/- 0.01 Seconds

DIMENSIONS AND NET WEIGHT

Height:	13.00 in.	(330 mm)
Width:	8.0 in.	(203 mm)
Depth:	6.0 in.	(152 mm)
Weight:	18 lb.	(8.2 kg)

HOUSING

14 gauge gray steel enclosure with neoprene gasketing.
Removable cover with captive plated screws.
External flange mounting.

STANDARD ACCESSORIES

Parallel cable ass'y, 10 ft (3.05 m)	1 pc.
Removable line cord, 6-8 ft (1.8-2.4 m)	1 pc.
Operation Manual	1 pc.

SECTION II

DETAILED DESCRIPTION

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SECTION II

DETAILED DESCRIPTION

Theory of Operation - Hardware

The 120 VAC input power for the ORTMASTER enters the unit through a standard three wire grounding type line cord with an IEC connector. A two ampere fuse provides short circuit protection. A rocker switch allows AC power to be switched on or off as desired. An internal line filter provides immunity from high frequency noise on the AC line. This filtered and fused AC power is available for use by a computer through a convenience outlet.

The internal circuit board has a linear power supply consisting of a transformer, bridge rectifier, filter capacitors, and standard three-terminal regulators, for outputs of 5 VDC at 0.25 A, and +/- 15 VDC at 0.1 A. A solid-state LED lamp provides external indication of 5 volt power.

(ORTM-1) The recloser test current passes through the copper bus bar, which is formed in the shape of two "L's" placed back to back in a "T" shape, and joined so that this current creates an intense magnetic field between the two vertical conductors. An air-core inductor, consisting of many turns of fine wire, is placed in this field, and produces a voltage which is proportional to the rate of change (differential) of the applied current. A circuit consisting of several resistors and a capacitor provide an integrating function, which produces a voltage proportional to the applied current.

(ORTM-2) The recloser test current passes through a shunt, rated at 100 mV at 1000 amperes (700 amps true continuous). The output millivolt signal is directly proportional to input current, and accurately reproduces the current waveform even when large DC components or distortion are present. It will also work on test systems using DC (although not usually recommended by recloser manufacturers).

A precision instrumentation amplifier provides common mode rejection and gain as required. Another operational amplifier, in conjunction with a precision voltage divider and an analog multiplexer, provides an additional programmable gain of 1, 2, 5, 10, 20, 50, 100, or 200, for corresponding full-scale input currents of 10,000 to 50 Amperes. The amplified voltage is fed to the input of a 12 bit analog-to-digital converter. A sinusoidal input equal to full scale of any range is processed to have a peak value of about 50% of the input range of the A/D converter.

The range is selected by setting the appropriate bits of the 8 bit data output of the Centronics port, PA2, PA3, and PA4, which represent a three bit address for the eight ranges.

Data acquisition and control are accomplished by means of the 4 bit control output port, PC0, PC1, PC2, and PC3, and the 5 bit status input port, PB3, PB4, PB5, PB6, and PB7. PC3 serves as an ENABLE output, which is initially set LOW, driving all outputs of the 74LS138 decoder to their HIGH state. To initiate a conversion, PC0-PC2 are set for an address of 3, so that when the ENABLE line is set HIGH, a CONVERT signal is sent to the A/D converter. Its internal circuitry samples and holds the voltage appearing at its

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input, and performs a conversion in approximately 100 microseconds. When the conversion is complete, the BUSY- signal goes high, and the inverse EOC- signal, which is readable as bit PB3, goes low. The 12 bit result of the conversion is now available to be read. This result is multiplexed as three nybbles into the other four bits of the input port, PB4-PB7, by sequentially changing the address of the decoder, which enables the tristate 74LS244 buffers.

Verification of the parallel port adapter is accomplished by reading address 4, which reads the status of output port bits PA4-PA7, and also by performing a test conversion on the A/D.

Theory of Operation - Software

When loaded and run, the ORTRUN software reads a calibration file, ORTRUN.CAL, which contains calibration factors and other low level information which affects the performance of the software. These variables are explained in detail under CALIBRATION.

If the software does not detect the ORTMASTER hardware, as described above, it enters DEMO mode, using a waveform file. The waveform file has a special format, consisting of header information and up to 32500 integer values corresponding to A/D readings, so that a waveform with a total length of about 55 seconds may be processed at a conversion rate of 582.6/sec, or 16.25 seconds at 2000 samples per second.

Next, the ORTRUN software reads a setup file, ORTRUN.SET, which contains information used to configure the software for testing. Some of this is explained under INSTALLATION. The complete list of parameters in this file are as follows:

NAME	TYPICAL VALUE	RANGE OF VALUES
RANGE:	4	1 TO 8
MAX ON TIME:	5.0	0.1 TO 55 SECONDS
MAX OFF TIME:	5.0	0.1 TO 55 SECONDS
DATA FILE:	ORTRUN.DAT	Any Valid File Name, or PRN:
WINDOW COL:	22	1 TO 50
WINDOW ROW:	5	1 TO 15
NORM MSG COLOR:	30	1 TO 255
RUN MSG COLOR:	110	1 TO 255
BOX COLOR:	47	1 TO 255

If desired, this file may be modified by an ASCII text editor, or by a software program, before ORTRUN is executed. The optional TCC software modifies this file, particularly the range and maximum times, to match the recloser to be tested. All values are checked for validity, and adjusted if necessary.

Two command line parameters are accepted by the ORTRUN program. A "/M" sets up the program for MINIMUM PICKUP mode, as described below. A file name, if valid, will be used as a waveform file, and will set up the program in simulator mode, even if the hardware is connected.

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If in simulator mode, the program will attempt to allocate a maximum amount of memory (65000 bytes) for the simulator file. If there is not enough memory, a smaller block will be allocated. If this is not at least 1000 bytes, an error message appears and the program cannot be run. The user will be prompted to enter the name of a waveform file to use for simulation; default is "DEFAULT.WAV". A directory of all waveform files is available by pressing <ESC>. When <Enter> is pressed, the software will attempt to read the file name that appears. If this file is not available, an approximate waveform will be simulated. The waveform file will determine the A/D conversion rate. The simulator memory will be reallocated, based on the size of the waveform file.

Memory is allocated for the waveform buffers by using the given max. on time and the A/D sampling rate. If memory is insufficient for the requested maximum on times, the max. on times will be adjusted. This is done by dividing the total available time so that the first and fifth shots will have 1/8 of the total, and the second, third and fourth shots are allotted 1/4 of the total.

The main screen will now appear, and the program will test the interrupt service routine (ISR) at a rate 1/2 that requested. A calculation is performed to determine the overhead at the requested rate. If any errors are detected, or excessive overhead would be produced, an error message is displayed; the calibration menu may be accessed to adjust the A/D conversion rate before exiting, or <ALT-R> may be pressed to retry. If the ISR works properly, normal values are restored, and the program enters the normal TEST mode.

If the computer does not have a numeric coprocessor, or is otherwise slow, the display may not follow the actions of the recloser in real time, particularly for long trip times. This will not affect the accuracy of the results, but merely delays their processing. This delay is caused by the tedious process of true RMS computation, described below.

Once the software is "ARMED", it samples the input at a standard rate of about 2000 times per second, or optionally from 250 to 2500 times per second. This rate is derived from 14 to 137 times the normal "timer tick" interrupt of 18.2065 times per second. This sample rate provides nearly 5 to more than 40 samples per cycle at 60 Hz, and is sufficient to provide accurate measurement of the current waveform and reasonable harmonics. The results of each A/D conversion are stored in a queue several samples deep, which provides a pretrigger function. Detection of current flow is determined when A/D readings exceed a preset threshold, or the difference of successive readings exceed a value determined by the expected change at a zero crossing. Each such reading increments an "on counter", while readings below threshold decrement it. When the "on counter" exceeds a preset "on delay", current is determined to be flowing, and subsequent A/D readings are stored in the appropriate waveform buffer. During this phase, a timer is incremented at the sample rate, which indicates trip time. When the current drops below this threshold for a period of time equal to the "on delay", a "current off" condition is determined, and the software reverts to timing the reclose interval and waiting for the next pulse of current.

The continuous current is updated at approximately 4.5 times per second. This calculation may be based on true RMS, average, or RMS calibrated average. The value is determined using a window of 0.05 to 0.50 seconds, consisting of the most recent data. Faster A/D conversion rates and longer times require more processor time, and

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could affect the display update rate.

In MINIMUM PICKUP mode, the maximum continuous current sample is displayed, time-out is disabled, and normal trip and reclose operations are not indicated. They are, however, internally sensed, and may be displayed by toggling to the FULL CYCLE mode, as described below. These modes may be selected by using the command line parameter "/M", or toggled by pressing <ALT>-M.

During the "current on" phase, the trip current is calculated for a small sample of most recent readings, using a true RMS calculation. This process involves squaring each sample, adding it to a total, dividing by the number of samples, and taking the square root of the result. For a moderate number of samples, nominally 116 for 0.2 seconds at 582.608 samples per second, the time required is little enough to allow a visually readable update rate of about 4 per second. However, a long trip time of perhaps two seconds requires the processing of 1165 points, and the time required becomes significant. A numeric coprocessor greatly improves the visible performance of the software in such cases.

If any on time exceeds the max. on time, a time-out error message will be displayed, and the user may retry the test by pressing <ALT>-R. This will readjust the A/D sampling rate to 582.608, and try the test at this slower rate, which may allow more on time. This does not function in simulator mode.

After each operation, during the reclose intervals, the actual trip current is determined by analyzing the waveform data and performing a full true-RMS computation on the entire waveform. This computation is modified to compensate for waveform distortion caused by DC offset. On very fast current pulses, especially when considerable DC offset is present, the air-core CT and integrator (used in ORTM-1 only) may not be able to reproduce the exact waveform of the current. This is generally evidenced by an offset at the end of the waveform, which slowly decays to zero. The true waveform is shifted from the zero reference by approximately this amount. The compensation algorithm subtracts one-half the value of this offset from each of the samples in the pulse, which gives more accurate readings.

Percentage drop-off, or decay, is calculated by the ratio of the true RMS value of a cycle at the end and beginning of the current pulse, adjusted by the time of these cycles compared to the total time of the pulse. If they overlap, "N/A" is displayed.

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Upon exit from the program, data is saved in a file as named in ORTRUN.SET, normally ORTRUN.DAT. The format of this ASCII file is as follows:

```
TRIP CURR 1:      0.00
TRIP TIME 1:      0.0000
RECL TIME 1:      0.0000
TRIP CURR 2:      0.00
TRIP TIME 2:      0.0000
RECL TIME 2:      0.0000
TRIP CURR 3:      0.00
TRIP TIME 3:      0.0000
RECL TIME 3:      0.0000
TRIP CURR 4:      0.00
TRIP TIME 4:      0.0000
RECL TIME 4:      0.0000
TRIP CURR 5:      0.00
TRIP TIME 5:      0.0000
RECL TIME 5:      0.0000
```

Decay readings are the ratio of last cycle to first cycle

```
DECAY 1:          1.000
DECAY 2:          1.000
DECAY 3:          1.000
DECAY 4:          1.000
DECAY 5:          1.000
```

The maximum average reading indicates minimum pickup:

```
MAX AVERAGE:      0.00
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If overrange occurs, the trip current will be indicated as a negative number.

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SECTION III

OPERATING INSTRUCTIONS

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SECTION III

OPERATING INSTRUCTIONS

INSTALLATION - Hardware

The ORTMASTER is very simple to install on any recloser test set. It was designed for use with the EIL model ORT-15 or ORT-560, but should be adaptable to any comparable unit.

Requirements for installing the ORTMASTER are as follows:

(1) A reliable source of 120 VAC power with a properly grounded outlet.

(2) A short length of flexible cable, preferably #4-0, terminated with 3/8" lugs (ORTM-1) or 1/2" lugs (ORTM-2).

(3) An IBM compatible computer, preferably a 286-12 MHz or better, with a parallel port, running MS-DOS 3.3 or higher.

(4) A 25 conductor shielded cable terminated with male and female D-sub connectors.

If permanent installation of the ORTMASTER is desired, it should be mounted to the chassis of the recloser test set, close to the output connections. For temporary hook-up, the ORTMASTER may be placed on its back on the floor, taking care to protect the line cord, switch, fuse holder, and indicator lamp from damage, and assuring that the current-carrying bus connections will not contact anything.

The enclosure MUST BE SOLIDLY GROUNDED to the test set chassis. If not permanently bolted on, connect a flexible lead of least #2 AWG from an enclosure mounting hole WITH PAINT REMOVED to a solid ground point on the test set. This will ensure sufficient ground current capacity in case an energized test lead should contact the case.

The flexible cable should be solidly connected between the output COMMON of the recloser test set, and one side of the ORTMASTER bus connection (ORTM-1) or shunt (ORTM-2). It should be routed so that it follows a short and direct path that does not significantly cross over the enclosure. **ACCURACY MAY BE ADVERSELY AFFECTED** if output cables lay on or wrap around the ORTMASTER. The common cable should be heavy enough to allow maximum current flow required with minimal heating and voltage drop.

THE COMMON CONNECTION MUST BE AT OR NEAR GROUND POTENTIAL. If it is not, erroneous readings or damage to the ORTMASTER may occur. This ground connection is normally made inside the test set. If it is not, a separate connection from COMMON to the chassis **MUST BE SUPPLIED**.

BEFORE ATTEMPTING TO USE THE ORTMASTER, adequate internal grounding **MUST** be verified as follows:

(1) Connect a recloser (preferably rated 100 Amps or greater) to the test set as recommended by the manufacturer.

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(2) Connect an AC voltmeter from the output COMMON connection to the frame of the test set (which **MUST** be grounded).

(3) Initiate the output of the test set and apply rated current to the recloser.

(4) While current is flowing, read the AC voltmeter. A reading of 0.1 VAC or less (at 100 amps) indicates adequate internal grounding.

(5) If more than 0.1 VAC is detected, a ground connection must be supplied before connecting the ORTMASTER. Wire size should be based on input current rating of the test set - #6 AWG or heavier is recommended. This connection should be made directly from the test set COMMON to the frame, with a low impedance path back to earth ground.

(6) When this ground connection has been made, repeat the test described above. If excessive voltage is still present, carefully check for proper internal ground connections, or insulation breakdown of output transformer.

The computer should be set up for maximum convenience for the test technician, and for optimum connection of the parallel port cable. This cable should be routed away from any current-carrying conductors, and should be as short as practical. It should also be protected from physical damage, and placed so that the operator or other personnel will not trip over it. The computer power cord should be plugged into the convenience outlet on the ORTMASTER, or into the same duplex outlet.

The cable connectors should be firmly inserted into the corresponding receptacles on the ORTMASTER and the computer. For reliability, the connectors should be screwed in place, and be sure that mating contacts are seated firmly. D-sub connectors are rated for only several hundred insertion and removal cycles before degradation occurs and replacement becomes necessary. If frequent reconnection is necessary, it would be advisable to procure a short extension cable to be attached to the computer or the ORTMASTER, and disconnect the cable only at this point. When contacts become unreliable, just those connectors on the ribbon cable may be replaced at minimal cost.

The ORTMASTER is normally configured to connect to the LPT1 port of the computer. If a printer is connected to the computer on LPT1, and an alternate parallel port is not available, a switchbox may be installed on the parallel port. It will be necessary to switch to the ORTMASTER before running the software; otherwise, the program will enter DEMO mode. The ORTMASTER can use any available parallel port, but this must be set up in the calibration sub-menu.

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INSTALLATION - Software

To install the software on the computer, basic knowledge of MS-DOS is assumed. The real-time software may interfere with some memory-resident programs or drivers, and is not designed to run under Windows or similar systems. If problems occur, it may be necessary to alter the AUTOEXEC.BAT and CONFIG.SYS files to remove conflicting device drivers and programs.

Boot up the computer with MS-DOS 3.3 or greater, and access the operating system. Create and change to a subdirectory for the software; \TCC is suggested for compatibility with the optional TCC software. From this subdirectory, copy the following files from the distribution diskette:

**ORTRUN.EXE
ORTRUN.SET
ORTRUN.CAL
ORTRUN.HLP
DEFAULT.WAV**

The ORTRUN.CAL file is designed to be READ ONLY. This serves to protect the unique calibration data that has been supplied with your hardware. To set this attribute, perform the following step:

ATTRIB ORTRUN.CAL +R

If everything has been installed as described above, plug in the ORTMASTER, and plug the computer into the auxiliary outlet. Turn the POWER switch ON, verify that the POWER light glows, and test the system with the software by typing:

ORTRUN

If the hardware is properly connected and operational, a window box should pop up in the center of the screen, as shown in the illustration. The OUTPUT CURRENT value should read a minimal value less than 1% of the RANGE, and the message at the bottom of the window should read:

ARMED -- INITIATE FULL CYCLE TEST

If there is a problem with the hardware, a different window box will appear, stating that the hardware was not found, and indicating DEMO mode with the DEFAULT.WAV file. A different waveform file may be selected by using the editing keys. The <Enter> key will bring up the normal window, which will indicate DEMO mode with the selected file name. If the file did not exist, default values will be generated and used.

If the window colors or location are not suitable, they may be adjusted by pressing the key combination <ALT>-A. This toggles the display to ADJUSTABLE mode. The UP, DOWN, LEFT, and RIGHT cursor keys may be used to move the window to any desired location on the screen. The <PgUp> and <PgDn> keys may be used to change the color of the message bar before and after the test to any one of 256 possible combinations (some of which may be unreadable!). To change the color of the running message bar, initiate the test, and use the <PgUp> and <PgDn> keys while the test is running. When the test has completed, the <PgUp> and <PgDn> keys adjust the window foreground and background colors. Press <ESC> or <F10> to exit from the program, and the new loca-

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tion and colors will be saved to the ORTRUN.SET file.

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NOTE:

If hard copy printout of waveforms are desired, it may be advisable to load GRAPHICS.COM from MSDOS version 5.0 or greater, before running the software. This may be facilitated by adding the command "GRAPHICS", with appropriate switches, to the AUTOEXEC.BAT file. Consult the MSDOS manual for details. This will allow you to print the graphics image to a variety of printers by using the familiar SHIFT-PrtScr key combination.

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Figure 1: ORTRUN Screen Displays

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======== P S Technology, Inc. Version 3.11 ========
| OPER | CURRENT | DECAY | TRIP TIME | RECL TIME |
|------|---------|-------|-----------|-----------|
|  1   |  0.0 A  |       |   0.000   |   0.000   |
|  2   |  0.0 A  |       |   0.000   |   0.000   |
|  3   |  0.0 A  |       |   0.000   |   0.000   |
|  4   |  0.0 A  |       |   0.000   |   0.000   |
|  5   |  0.0 A  |       |   0.000   |   0.000   |

CURRENT:     0.6 A              RANGE: 250 A
======================================= +/- to adjust =======
STATUS:    ARMED -- INITIATE FULL CYCLE TEST
============== Serial Number: 950000 =============
```

```
======== P S Technology, Inc. Version 3.11 ========
| OPER | CURRENT | DECAY  | TRIP TIME | RECL TIME |
|------|---------|--------|-----------|-----------|
|  1   |  488 A  | -24.6% |  0.1262   |  1.7315   |
|  2   |  404 A  | -28.6% |  0.1825   |  1.6183   |
|  3   |  508 A  | -27.4% |  0.5723   |  1.5732   |
|  4   |  499 A  | -28.3% |  0.5561   |  5.0000   |
|  5   |   0 A   |        |  0.0000   |  0.0000   |

CURRENT:       6 A              RANGE: 1.0 kA
======================================= +/- to adjust =======
STATUS:    TEST COMPLETE -- PRESS <Esc>
============== Serial Number: 950000 =============
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OPERATING INSTRUCTIONS - Basic Software

The ORTMASTER software, ORTRUN.EXE, may be run in stand-alone mode by simply typing "ORTRUN". If the software does not detect the presence of the ORTMASTER hardware, it enters a DEMO mode, in which it reads a waveform file, or generates default values, which are "played back" by the software to simulate an actual recloser. The name of the waveform file for demo purposes is DEFAULT.WAV, but any valid file name may be entered. DEMO mode may also be invoked by typing a valid file name, to be used as the waveform file, as a command line parameter.

The normal information window for ORTRUN consists of a header bar which indicates the software version, a footer bar which indicates the unit serial number, or waveform file used in DEMO mode, a message area which indicates program status and other information, and a grid of test information. This information includes operation number (from 1 to 5), trip current, decay percentage, trip time, and reclose time for each operation. There is also a display of continuous current and RANGE. Starting with version 3.02, a linear vertical bargraph is included to the right of the display, indicating continuous current as a percentage of full-scale reading.

The message area normally will indicate "ARMED - INITIATE FULL CYCLE TEST", denoting that the software is ready to read and process information from the ORTMASTER hardware. In MINIMUM PICKUP MODE, which may be selected by using "/M" as a command line parameter, or by pressing <ALT>-M, this message will read "ARMED - INITIATE MIN PICKUP TEST". The continuous current display will normally indicate a small current, typically 1/4% to 1% FS, which represents internal noise in the circuitry, but will not significantly affect accuracy. In DEMO mode, this reading indicates the amount of current represented by one count of the A/D converter. In this "ARMED" mode, the RANGE may be adjusted up or down by means of the + and - keys. The corresponding precision of measurement is indicated by the number of decimal places on the current displays.

When the test begins, either by applying current to the ORTMASTER, or by pressing the <Enter> key in DEMO mode, the message area will read "RUNNING - PLEASE STAND BY", and the RANGE no longer may be adjusted manually. If the current exceeds the limitations of the A/D converter, however, the current readings will indicate "OVER", and the range will automatically be increased. This autoranging, however, will invalidate the test results, so it is important to preset the range properly before starting the test. The <ALT>-R key may be pressed to restart the test, but be certain to adjust the range before proceeding.

In FULL CYCLE MODE, the display will normally indicate the progress of the test as the recloser sequences through its operations. When lockout occurs, the reclose time after the last shot will advance until it exceeds the MAX OFF TIME programmed in the SETUP file, and the software will assume the test to be complete, and will indicate this in the message box: "TEST COMPLETE - Press <ESC>". If the maximum ON time is exceeded, the test will stop, but the display will read "*** TIMEOUT ERROR ** Press <ESC> ***". If the test ended normally, the readings may be recorded. In this case, when the escape key is pressed, the window will disappear, and the original screen will be restored. At this time, the test results will be written to the file selected in the

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ORTRUN.SET file, (normally ORTRUN.DAT), for possible use by another program. If a time-out error has occurred, the prompt " PRESS <ALT>-R TO RETEST " will appear. If this is done, the program will try to reset the ADC sampling rate to 582.608, and perform the test with this new value.

Before or after testing, on-screen help may be accessed by pressing F1 or <ALT>-H. The contents of the ORTRUN.HLP file will be displayed, and subsequent pages may be viewed by pressing the space bar. The <ESC> key may be pressed at any time to exit and return to the main menu screen.

A new feature in version 3.02 and above is a reading of maximum average current for the minimum pickup test, which is accessed by using the "/M" command line parameter, or by pressing <ALT>-M. To perform the minimum pickup test, set up the recloser test set for minimum compensation, and initiate the unit with a current well below the expected minimum pickup level. Slowly raise the applied voltage, and observe the linear bargraph. The message box should read "Maximum average: nnn.nn A", When the bargraph begins to go down while the test set output is raised, stop the test. If the message box reads "Maximum average: 100.00 A", this indicates a minimum pickup value of 100 amperes. It is important to raise the current slowly. It is advised to repeat this test several times to obtain correct and consistent readings. The maximum average current is saved in the ORTRUN.DAT file. In MIN PICKUP mode, the software does not detect when the current stops. In this mode, simply exit from the program when minimum pickup has been detected.

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OPERATING INSTRUCTIONS - Waveform Viewing and Analysis

After test results have been computed and displayed, the operator can view and analyze the waveforms of each operation of the recloser, by pressing the <ALT>-W key combination. The message box will indicate: "ENTER SHOT NUMBER TO VIEW: 1". After entering the desired number, and pressing <Enter>, the screen will display a view of the first several cycles of the selected operation. A series of menu selections at the bottom of the screen allow several functions to be performed, as follows:

|	
START <	Moves the starting point to the left by about 1/8 screen
START >	Moves the starting point to the right by about 1/8 screen
REF 1 <	Moves a green cursor to the left
REF 1 >	Moves a green cursor to the right
REF 2 <	Moves a red cursor to the left
REF 2 >	Moves a red cursor to the right
END <	Moves the end point in (expands the display)
END >	Moves the end point out (contracts the display)
SMOOTH	Fills in the data points with a smooth line
QUIT	Erase screen and return to previous screen

The **<+>** and **<->** keys may be pressed to expand or contract the waveform display vertically.

The top of the display indicates the time between the green and red cursors, and the true RMS value represented by that portion of the waveform.

The waveform display may be used to determine if a suspected erroneous reading may have been caused by noise, excessive decay, distortion, or DC offset. To end waveform viewing, when prompted for shot number, press **<ESC>**. You will be prompted with "WAVEFORM FILE: TEST.WAV". You may edit this waveform filename, which is set by default to "TEST.WAV". If the file exists, you may elect to overwrite it. All operations, and reclose intervals, are saved in the waveform file. If you press <ESC>, the waveform is not saved. To "play back" the waveform file, run the program in simulator (DEMO) mode, using the name of the desired waveform file. To obtain the same results, all calibration values must be identical, and the range must be set as it was when saved.

The waveform display may be printed to an EPSON or IBM graphics compatible printer, by pressing the "<ALT-P>" key. Any key may be pressed during the printing process to abort printing. This feature has been tested with a VGA type display. EGA, MCGA, and Hercules displays may produce results of lesser quality, or may be unreadable. It is also necessary to set the "color" variable in the calibration submenu to zero (0), to disable color display, to obtain proper results. **NOTE:** If GRAPHICS.COM has been loaded (see Installation), press SHIFT-PrtScr to print.

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Figure 2: Waveform Display

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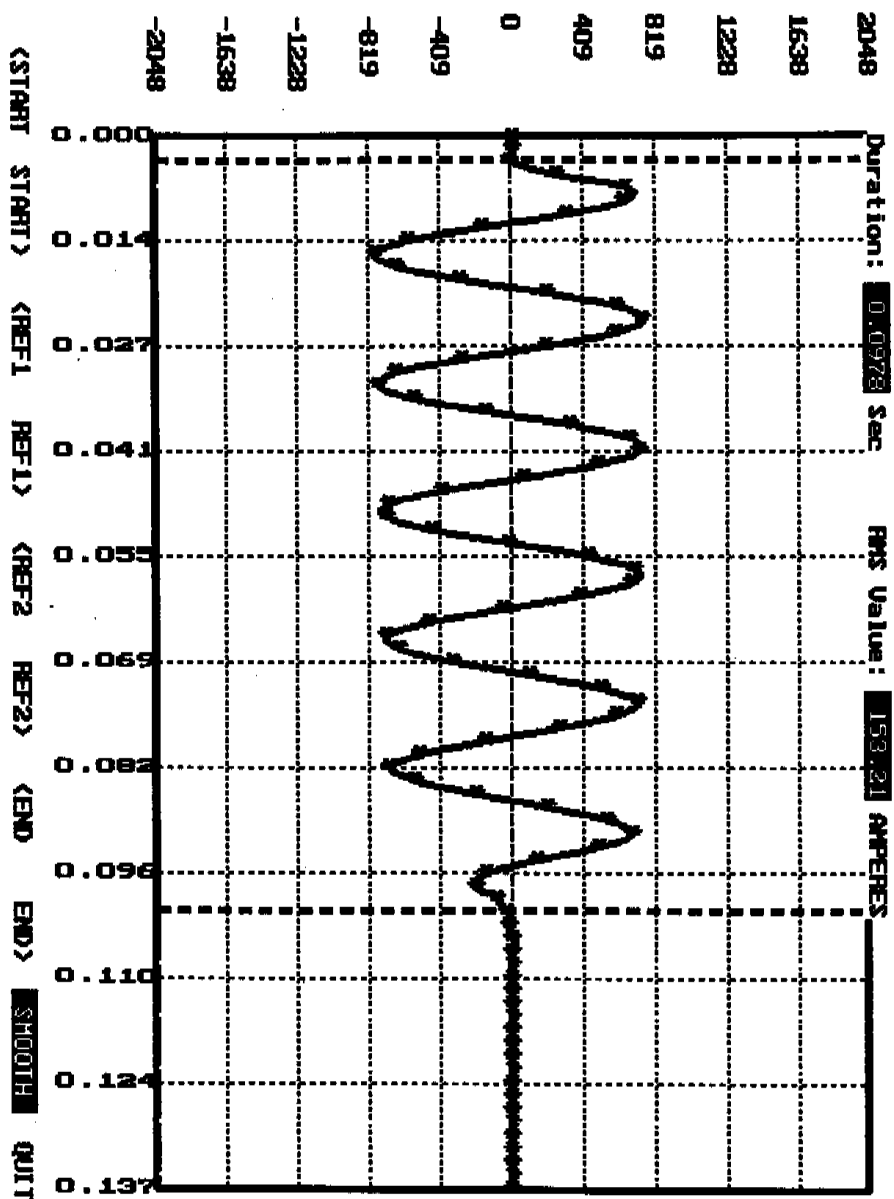
OPERATING INSTRUCTIONS - Software Calibration

Calibration may be performed by pressing the <ALT>-C combination. You will be prompted to enter a four digit access code. Upon successful entry, and pressing <Enter>, the calibration menu will be displayed. There are eight calibration factors, each of which should be nearly equal. Typical values are 0.00100 to 0.00200. Also selectable are on_threshold, on_delay, pretrigger, and several measurement modes. There is also an option to provide several intermediate data points for calculating RMS value. Since these points are determined by a tedious cubic spline function, as well as multiplying the number of data points, any more than three points seriously slows down processing, and accuracy does not seem to be improved. Detailed explanations are as follows:

The **Calibration Factors** are essentially values that are multiplied by the true RMS value from the A/D converter, which may vary in the range of +/- 2048 maximum, or 1448 RMS for a sine wave. The integral overrange detector causes a range change when values greater than about 2000 are detected, so an RMS value of 1414 is the practical maximum. The actual reading in amperes is multiplied by the range factor. In order to allow for higher peak values caused by DC offset and current drop-off with minimal compensation, the normal steady-state current for a nominal range value is about 50% of its maximum. Thus, a nominal calibration value would be 1/700, or 0.001428.

To perform calibration on a given range, read a current pulse of about 50% to 80% of full scale with a pulse-reading standard instrument connected. Calculate the ratio of the true current reading to the displayed reading, and multiply this value by the calibration factor. The result is the new calibration factor. The current readings with the new value may be observed by toggling the ADJUST mode on with <ALT>-A, and moving the display window with the cursor keys.

The **ON Threshold ADC Counts** value is the initial threshold required to sense that current is flowing. Since the nominal peak value is about 1000 counts for full-scale, a threshold of 10% to 20% of that value (100-200) is generally appropriate. If the value is too low, noise may cause false triggering, and residual DC at the end of fast shots may cause erroneously long times and low current readings. If the value is too high, sensing of current turn-on may be delayed, especially when current is much less than the full-scale range value, or when turn-on occurs just prior to a zero crossing.

The differential threshold, which is also displayed, is calculated by the expected change in value of two successive data samples at zero crossing of a sine wave with peak value equal to the on threshold.

The **ON Delay ADC Conversions** are the number of successive readings above the threshold value, or differing from previous values by a calculated amount, to indicate current is flowing. Once current flow has been detected, this same value is used as the number of successive readings below and differing by LESS THAN 80% of these thresholds to indicate current flow has stopped. The nominal sampling rate of 2000 per second corresponds to about 33 samples per cycle. It is generally recommended to use a value corresponding to about 1/4 cycle. If there is much noise in the waveform, a longer delay may be necessary. The normal value used is 3 at 582.608 samples per second, and 8 for 2000. The ON Delay does not directly affect timing or calibration, since the

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same value is used before starting and stopping the ON timer, and the RMS pulse algorithm compensates by shifting the starting point of its calculation by this value. However, it may affect the discrimination between noise and significant data for distorted or noisy waveforms.

The **Pretrigger Counts** are the number of additional readings that are stored in the waveform file before the calculated start of current. This allows examination of noise, such as contact bounce, which may have preceded the detection of current. This value should be set to a value greater than on_delay. Since it adds to the overhead of the ADC interrupt service routine, however, it should not be set to a large number, especially when used on slower machines.

The **Pulse Mode** denotes the means by which the program calculates the amplitude of the current waveform. Even values, such as 0, 2, and 4, check for the presence of a math coprocessor, and revert to a faster, but less accurate method of average reading if none is found, and the pulse is longer than several cycles. The odd values, 1, 3 and 5, force the use of the selected method, which may involve the slow process of software emulation. Mode 0/1 uses the entire waveform for calculation of RMS value. Mode 1 is the preferred method. For this calculation, the beginning of the waveform is determined by using the On Delay and Pretrigger values, and an explicit true-RMS calculation is performed over the entire waveform. Mode 2/3 locates the first zero crossing of the waveform, and performs the RMS calculation over an integral number of half-cycles. This method can give more consistent results, especially when noise is present at turn-on and turn-off, but is not an accurate representation of true-RMS current. Mode 4/5 is an old method which performs a true-RMS calculation of short pulses of up to about 30 cycles (0.5 seconds), then switches to a method which samples a window of about thirty cycles in the center portion of the waveform. This method is a fast way to obtain fairly accurate results, especially for waveforms with very little decay (such as electronic reclosers). However, it makes the assumption that current decay in the recloser is linear, which may not be correct.

Measurement Mode is the method used to calculate the continuous current displayed digitally and on the vertical analog bargraph. A value of zero (0) uses an average reading method calibrated in RMS for AC sine wave current, and is used for slow machines. Method one (1) is for DC reading, which is for specially modified hardware. Method two (2) uses a true RMS calculation based on the most recent block of readings, and is recommended for all purposes, unless the computer is extremely slow, and lacks a numeric coprocessor.

Interpolation Points are calculated readings between actual ADC samples, which effectively increases the sampling rate. It uses a cubic spline interpolation method which works well on sinusoidal waveforms. This option is usually not necessary, and adds considerable processing time, which can become unacceptable for long pulses and when used without a math coprocessor. Testing has determined that no significant advantage is gained by using this option. The number of interpolation points is normally set to zero, which effectively disables this option.

Color signifies the use of default colors when viewing the waveform. A value of zero (0) signifies monochrome mode, and should be used on monochrome monitors and non-color LCD displays. It is also necessary to use monochrome mode to print the

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waveform screen using the internal algorithm for EPSON graphics printers. Any non-zero value signifies COLOR mode, and produces a more pleasing waveform display.

Port Number signifies the printer port to which the ORTMASTER hardware is to be connected. By default, this is set to 1, for LPT1. The hardware address of this port, normally 378H (Hex), is displayed with the option. Other ports, if they exist, may be selected; If not valid, the selection reverts to LPT1.

ADC Rate is the speed, in samples per second, that the A/D converter samples the current waveform. Any value from 250 to 2500 may be selected. If an incorrect value is entered, the default nominal value of 582.608 will be used. For correct values, the corresponding divisor and clock factors will be calculated, and they will be displayed along with the corresponding exact A/D rate.

Average Time is the time, in seconds, used to compute the continuous current reading, which is displayed in digital format and on the vertical linear bargraph. The corresponding number of samples, based on A/D conversion rate, is also displayed.

Serial Number is an eight character number uniquely assigned to the ORTMASTER hardware. When calibrating or using the unit, verify that this number matches that on the ORTMASTER box.

Undocumented Features: A hidden menu selection (99) is reserved to display the amount of free memory left, the overhead of the ADC interrupt service routine, and number of ISR errors. The overhead value indicates the amount by which the system may be slowed down, and is related to processor speed, A/D conversion time, and settings of ON Delay and Pretrigger. A low value indicates minimal overhead. Problems may occur if overhead exceeds about 0.75. Another value displayed is the ADC ISR Error Count, which is the number of times the ISR was called before completion of processing. This number should always be zero. The addresses of the first 32 interrupt vectors are also displayed.

Another hidden menu selection (98) is used to test the operation of the A/D converter and the parallel port. This is intended for hardware troubleshooting.

Allowing Range Changing During Calibration: As explained in INSTALLATION above, <ALT>-A may be used to adjust the window location and colors. It also allows RANGE changing after testing, and since all trip currents are recalculated whenever the window is moved, the values are updated using new calibration factors and interpolation points. This is handy for calibration purposes. This method may not give predictable results if other calibration-related variables, such as threshold and on delay, are changed.

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ISR MONITOR:

The operation of the interrupt service routine (ISR), that controls A/D conversion and measurement, is constantly monitored. If the interrupt occurs before completion of the previous ISR, most of the processing is suspended until an "ISR ERROR" message is displayed, at which time normal processing is resumed. This error will not normally affect operation, unless it occurs while a test is in progress. The most common cause for this error is a keyboard interrupt (INT 9). Starting with version 3.10, this interrupt is synchronized with the end of the ADC ISR. If it occurs, it is probably due to another hardware interrupt with a lot of overhead.

ISR conflicts and erratic operation are more likely when using protected mode programs such as EMM386 and Windows. Best results are obtained with a minimal installation of MSDOS. The program will run under Windows 95, but only in MSDOS Real Mode.

Figure 3: Calibration Menu

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Calibration menu
SEL   VALUE PURPOSE

 0    <EXIT>
 1    0.001250   10000 Amp Cal
 2    0.001250   5000 Amp Cal
 3    0.001250   2500 Amp Cal
 4    0.001250   1000 Amp Cal
 5    0.001250   500 Amp Cal
 6    0.001250   250 Amp Cal
 7    0.001250   100 Amp Cal
 8    0.001250   50 Amp Cal
 9      160 On Threshold ADC Counts
10      7         On Delay ADC Conversions
11      10        Pretrigger counts
12      1         Pulse Mode [0,1=FULL; 2,3=INT; 4,5=MID]
13      2         Measurement Mode [0=AVG, 1=DC, 2=TRMS]
14      0         Interpolation Points [0=None]
15      1         Color [0=None, 1=Color]
16      2         Port Number LPT1, 2, or 3 = addr 0x278
17    2001.983    ADC rate [250-2500], divisor = 596, factor = 110
18      0.200     Average Time ( curr_samples = 116 )
19    960000      Serial Number

Enter selection: 0
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ELECTRICAL TESTS OF RECLOSERS

Since this unit was designed for use with the EIL ORT-15 and ORT-560 recloser test sets, the following general test procedures refer to controls and connections appearing on that unit. Other test sets which may be used with the ORTMASTER may differ, but general principles will still apply.

In most cases, select the output tap with a current rating most nearly matching the name plate rating of the recloser under test. For minimum pickup, set the resistance switch to minimum (15) and use the coarse and fine output controls. For actual operation at 2X to 6X rating, set the coarse and fine controls near maximum and adjust the resistance switch for appropriate desired current.

Before testing any recloser, make sure that the test set is properly grounded, and determine that all access covers and doors on the test set are closed and secured. If possible, turn OFF source of main input power before connecting leads. Determine that the test set main power switch is in the OFF position. Connect the input power leads to the test set input power receptacles, making sure that these connections are secure. Connect the test set input leads to the input power source, and turn power source ON. Make sure that output controls are set to their minimum positions, and turn test set ON.

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Minimum Pick-Up Test

Note - minimum pick-up current should be approximately twice the continuous rating of the recloser operating coil.

1. Connect the recloser under test between the ORTMASTER common terminal and the proper test set output tap.

2. Close the recloser contacts; the control handle on the recloser should be in a horizontal position.

3. Set the resistance compensation to minimum (position 15 on ORT-560).

4. Run the software, using the command parameter "ORTRUN/M". Message should indicate "ARMED - INITIATE MIN PICKUP TEST".

5. Using + or - keys, set RANGE to about 2-4 times recloser rating.

6. Initiate output on the test set.

7. Slowly rotate the output control clockwise. The continuous output current should register on the display and the vertical linear bargraph.

8. Watch the continuous current reading, most easily observed on the vertical linear bargraph. If the current is still increasing at full clockwise rotation of the output control, return the output control to its full counterclockwise position, depress the output switch knob and rotate clockwise to position 2, reinitiate, and continue.

9. Continue to increase the output of the test set until the current begins to decrease. This happens because the recloser plunger is being pulled into its operating coil, and the increasing impedance causes a decrease in current. The displayed value should be the maximum current sensed during this test. Record this as minimum pick-up of the recloser under test. Press <ESC> to exit program.

10. Turn the test set off. Return all controls to their pretest positions.

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Full Cycle Test (Timing and Number of Trips to Lock-Out)

1. Connect the recloser under test between the ORTMASTER common terminal and the proper test set output tap, generally corresponding to recloser rating.

2. Close the recloser contacts; the control handle on the recloser should be in a horizontal position.

3. Set resistance compensation to a nominal value (pos. 7 on ORT-560).

4. Adjust the coarse output switch to maximum (pos. 9 on ORT-560).

5. Adjust the output control to midpoint.

4. Run the ORTRUN software. Message should indicate "ARMED - INITIATE FULL CYCLE TEST".

5. Using + or - keys, set RANGE to just above test current desired (typically 4 to 10 times rating).

6. Set up the test set for MOMENTARY output initiation.

7. Initiate a brief pulse of output on the test set. The recloser may perform its first operation.

8. Should the reading be higher than the desired test current, increase the resistance compensation (a lower numbered position on the ORT-560). Should the reading be lower than the desired test current, decrease the resistance compensation (a higher numbered position on the ORT-560).

9. Use the coarse and fine output controls, and brief current pulses, to make the final adjustment to the test current. Coarse control (tap switch) should be in upper range (at least position 7 on the ORT-560).

10. Set up test set for MAINTAINED output initiation, if desired.

11. Wait several minutes for the recloser to settle (3 to 5 minutes).

12. Initiate the test set. The recloser should function through its normal sequence of instantaneous and time delay operations to lock-out. Deinitiate the output when lock-out or abnormal operation are detected.

13. The computer screen should display trip current and trip and reclose times for each operation. Record these values as test results.

14. Turn the test set off. Disconnect the recloser from the test set and return all controls and switches to their pre-test positions.

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Vacuum Interrupting Type Reclosers

In general, vacuum interrupting type reclosers may be tested in exactly the same manner as oil interrupting reclosers. However, the type of contact used in vacuum interrupting reclosers may exhibit contact bounce. If such bouncing lasts longer than about one cycle, it may be interpreted as a very fast close and reclose interval. This will be indicated on the display as an abnormally fast reclose interval (less than .05 seconds) and an equally fast close interval. If this occurs, the test should be repeated until a normal set of readings is obtained. If normal readings cannot be obtained, it may indicate faulty contacts or other internal problems, which should be corrected. It may also be possible to obtain better results by increasing or decreasing the RANGE. There are also calibration values (such as on delay), which may be adjusted for better results.

Pilot Series Type Reclosers

Pilot series or electronically controlled type reclosers may be tested in a manner similar to hydraulic reclosers, except that lower tap settings may be used because of the low internal impedance of these devices. All AC and DC power sources for relay operation and control function must remain connected; only the main power lines to the recloser terminals must be de-energized and removed. Units with standard high-voltage reclosing coils must be reclosed manually after each shot, but test voltage from the test set should be turned off before attempting to operate the reclosing handle. A remote initiate switch may be used in this case. The "INITIATE" switch may then be used to produce the second, third, or fourth shots. It is important that the manual reclosing operation be performed as quickly as possible, at least within ten seconds, so that a normal sequence of fast and delayed operations will occur. If the unit is equipped with the low-voltage reclosing option, this may be connected to suitable power, and valid reclosing times as displayed on the screen may be recorded. For three phase reclosers, it is important to check each phase individually. Due to the physical size, configuration, and location of three-phase reclosers, it may be necessary to fabricate longer extension leads to reach from the test set to the recloser terminals. If this is done, it is important that proper precautions be taken to ensure low resistance connections, sufficient size of conductor, and secure, insulated connections to avoid possible contact to ground or operator.

Sectionalizers

Sectionalizers may be tested by applying fault current pulses manually, by means of the "INITIATE" switch in "MOMENTARY" mode, with various on and off times to simulate action of a recloser. For example, a sectionalizer used with a four-shot recloser is normally set to open during the third reclose interval, thus preventing the fourth shot. When a series of fault-current pulses is applied to the sectionalizer, using the test set, it should be observed that the sectionalizer locks out during the third reclose interval, and when the "INITIATE" button is pressed for the fourth shot, the test voltage will be applied but no current should flow. At this time the output should be de-energized, and the

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current readings for each shot should be recorded. The sectionalizer should then be reset, allowed to stabilize, and the test repeated at several current values. It is recommended that tests be performed at rated current to ensure that the sectionalizer does not operate at normal current levels, but only under fault conditions above pick-up.

Low Voltage Power Circuit Breakers

These devices may be tested using a recloser test set or other high current source with the ORTMASTER. Normally, only the first operation would be observed, but the breaker could be reset and retested up to five times without exiting from the software. For more details refer to the test procedures in the manuals for breaker test sets such as the EIL BTS-1000, BTS-500, BTS-300, BTS200 or BTS-100.

Molded Case Circuit Breakers

See "Low Voltage Power Circuit Breakers" above.

Motor Overload Relays

See "Low Voltage Power Circuit Breakers" above. Since these devices are typically "shunt trip", they do not stop current flow when they operate. It may be possible to modify a recloser test set or other high-current test source to de-initiate when the contacts open, so that timing measurement is possible.

Other Devices

The ability of the ORTMASTER to measure high currents with excellent accuracy allows it to be used in conjunction with a high-current source for testing and calibrating other devices, particularly shunts, CT's and high-current AC meters.

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SECTION IV

SERVICE INFORMATION AND DOCUMENTATION

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SECTION IV

SERVICE INFORMATION AND DOCUMENTATION

PREVENTIVE MAINTENANCE

Periodically, the following maintenance should be performed to ensure proper operation.

1. Unplug the ORTMASTER from the 120 VAC supply.

2. Disconnect the parallel cable to the computer.

3. Remove high current leads from the bus bar or shunt connection.

4. Remove the ORTMASTER from the chassis of the test set (optional).

5. Thoroughly clean the enclosure and bus bar or shunt.

6. Check all hardware for tightness. If loose, it may be necessary to remove the cover.

7. Tighten the bolts on the bus bar (ORTM-1) or check the millivolt signal connections (ORTM-2).

8. Inspect the surface of the busbar (ORTM-1) or shunt (ORTM-2), and clean or file smooth if necessary.

9. Clean and inspect the 25 pin D-sub connector.

10. Re-install and perform basic operational tests to determine proper operation.

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FIELD CALIBRATION:

Field calibration is recommended at minimum on a yearly basis, or whenever inaccuracy is suspected. Refer to illustration for calibration hook-ups. A standard current transformer or shunt of 500 ampere capacity and companion true RMS digital meter are recommended as the calibration references. Use the following procedures.

1. Connect the standard meter and shunt or CT to a 500 Amp or greater output tap.

2. Turn on the test set and ORTMASTER. Allow 20 minutes warm-up.

3. Run the ORTRUN software and set to 50 Ampere range.

4. Continuous current should read less than 0.50 Amperes. If greater, internal adjustment is required. (See major calibration)

5. Set ORTMASTER range to 500 Amperes.

6. Initiate and set the unit output to 400 amperes as read on the ORTRUN display.

7. The standard ammeter should read 400 +/- 5.0 amps.

8. Spot checks should be performed on ranges most often used

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MAJOR CALIBRATION:

Major calibration is recommended if field calibration indicates inaccuracy, or on a yearly basis. Refer to illustration for calibration hook-ups. A multi-tapped current transformer, shunts of 100 ampere and 1000 Ampere capacity, a true RMS digital meter, and a waveform analyzer, are recommended as the calibration references. Use the following procedures.

1. Apply power to the ORTMASTER, turn ON, and allow 20 minutes warm up.

2. Run ORTRUN software, and set RANGE to 50 Amperes.

FOR SERIAL NUMBER 950004 and under:

3.1. Open cover. Connect a digital multimeter from analog ground to U6 pin 1.

3.2. Using R4, adjust voltage to 0.00 +/- 0.5 mVDC.

3.3. Connect multimeter from analog ground to U6 pin 8.

3.4. Using R21, adjust voltage to 0.00 +/- 1.0 mVDC.

3.5. Change ranges to 100, 250, etc. Adjust R4 and R21 slightly to minimize effect.

3.6. Remove multimeter. Set range to 50. Offset should be less than 0.50 A. Adjust R4 if required.

FOR SERIAL NUMBER 950005 and above (ORTM-2 PCB):

3.1. Open cover. Connect a digital multimeter from analog ground to U6 pin 7.

3.2. Using R6, adjust voltage to 0.00 +/- 0.5 mVDC. Remove multimeter.

3.3. Change range to 10 kA. Adjust R21 for minimum reading. Should be no more than 25 Amperes (0.25% FS).

3.4. Change range to 50 A. Adjust R6 slightly for minimum offset. Should be no more than 0.5 A (1% FS).

3.5. Try all ranges. Offset should be no more than 1% FS on any range. Adjust R6 or R21 slightly if necessary.

4. Close cover.

5. Connect ORTMASTER to test set output or current source.

6. Connect 100 Ampere shunt and true RMS voltmeter in series with output.

7. Apply 40.0 Amperes as read on ORTMASTER display. Read actual current on standard.

8. Divide standard reading by 50. This is the error ratio.

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P S Technology, Inc.

9. Access the calibration menu by pressing <ALT>-C, and enter access code.

10. Select 50 A calibration factor. Multiply by error ratio and enter.

11. Return to normal screen. Reading should be almost exact.

12. Check for linearity at 20, 40, and 60 amperes.

13. Increase current until OVERRANGE is detected. Record this value. Should be between 75 and 125 amperes.

14. Adjust cal factors using continuous current at 80% FS for 100, 250, and 500 A ranges, changing shunt as required.

15. For ranges over 500 Amperes, initiate pulses, and use waveform analyzer.

16. Set range to 1000. Initiate one or more pulses of about 800 Amps, and about 0.1 seconds long.

17. Read actual value on waveform analyzer. Divide actual value by value displayed for each pulse, and take the average. Access the calibration menu, and multiply the appropriate calibration value by this average.

18. Return to main screen. Set adjustable mode by pressing <ALT>-A. Move the screen by pressing one of the arrow keys. The pulse current readings should change according to the new calibration value. Use these readings as final values.

19. Check timing with analyzer. Times should be within +/- 0.007 sec.

20. Repeat pulse tests for 2.5 K, 5.0 K, and 10.0 K ranges.

21. (Optional) Check performance with several actual reclosers. Readings should be within specifications.

22. Record the values of all calibration factors, and attach a copy inside the unit, or keep on file. Calibration files should be copied to a floppy disk.

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TROUBLE-SHOOTING GUIDE:

If the unit is suspected to be malfunctioning, refer to the following guide for testing the unit and isolating the problem. Some minor repairs can be made in the field. Otherwise, call the factory for assistance.

A. Software does not recognize hardware - Enters DEMO mode

1. ORTMASTER not plugged in or turned ON, or blown fuse in ORTMASTER.

2. Loose or broken connection in parallel cable.

3. Defective Centronics port in computer.

B. Always reads constant value or "OVER"

1. Loose or broken connection in parallel cable.

2. Defective Centronics port in computer.

3. Hardware "lockup". Turn power OFF and back ON.

C. Inaccurate Readings

1. Range too high or too low.

Readings should be about 50% to 80% of full scale.

2. Noise spikes in signal. Check with WAVEFORM view.

Try rerouting parallel cable, check grounds, relocate recloser.

3. Excessive DC offset or decay.

Increase resistive compensation; change output tap.

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PARTS LIST:

The overall schematic is on the next page. The parts list is provided below. Please refer to both when ordering replacement parts.
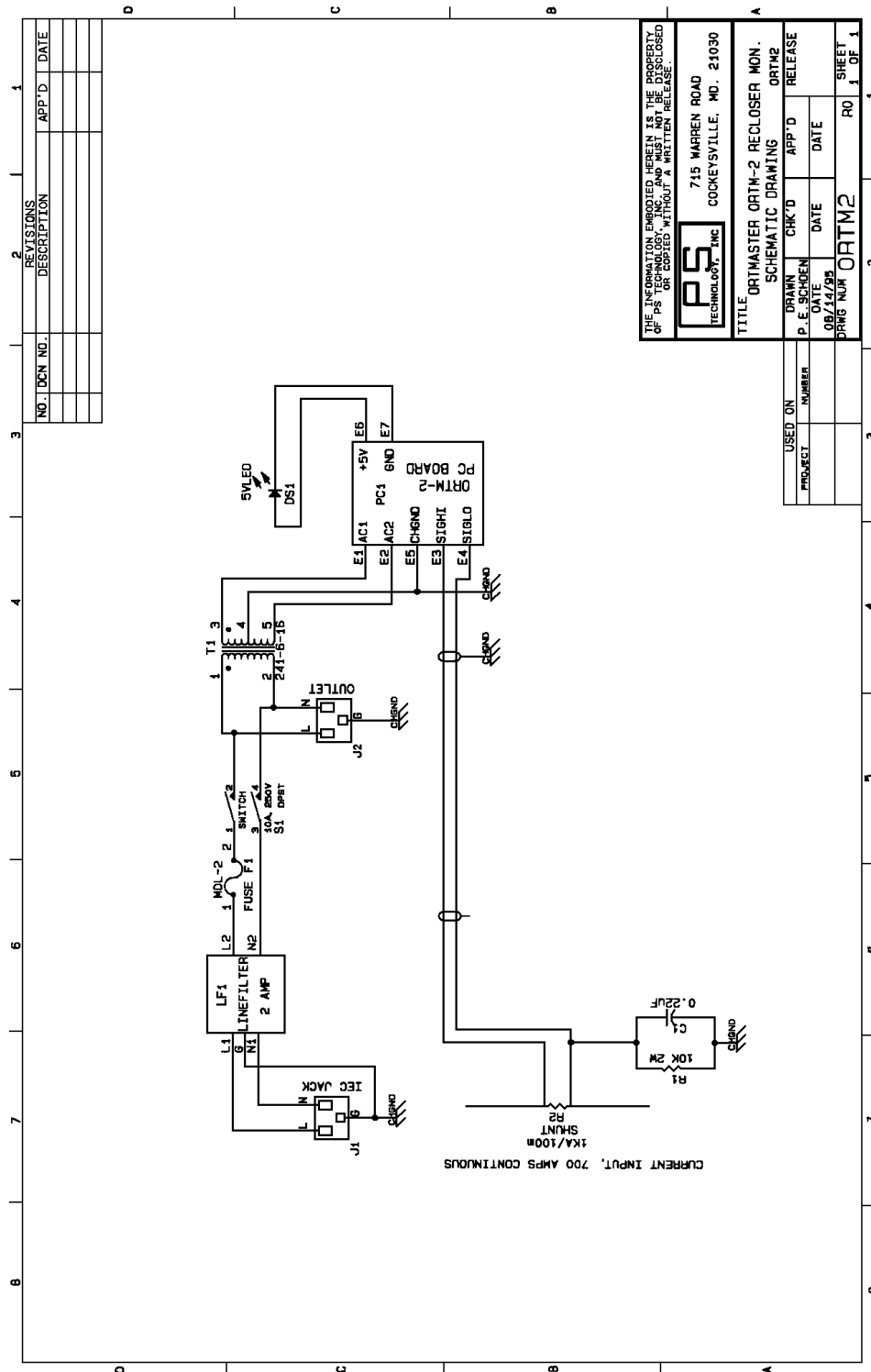
ORTM-1:

Description	Vendor	Part Number
Enclosure	Wiegmann	B-1086SC
Line Cord, 6ft, #18-3, SPT	Dayton	2W685
Fuse, 2 Amp	Bussman	AGC-2
Fuse Holder	Bussman	HTB-26I
Lamp, Indicator, LED, 5VDC	Dialight	559-0202-003
Resistor, 10K, 2W, 10%	Allen-Bradley	HB1031
Capacitor, 0.22 uF, 600V	Sprague	715P22456MD3
Line Filter, 2A	Corcom	2VR1
PC Board Assembly	P S Technology	PC-ORTM-2
Current Sensor Assembly	P S Technology	CS-ORTM-1

ORTM-2:

Description	Vendor	Part Number
Enclosure	Wiegmann	B-1086SC
Line Cord, 8ft, #18-3, SJT	Qualtec	312010-01
Fuse, 2 Amp	Bussman	MDL-2
Lamp, Indicator, LED, 5VDC	Dialight	559-0202-003
Resistor, 10K, 2W, 10%	Allen-Bradley	HB1031
Capacitor, 0.22 uF, 600V	Sprague	715P22456MD3
Line Filter Ass'y, 2A	Corcom	2EDL1S
PC Board Assembly	P S Technology	PC-ORTM-2
Shunt, 1000A, 100 mV	EMPRO	MLC-1000-100

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OVERALL SCHEMATIC:

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WARRANTY

P S Technology, Inc., will for one year after date of purchase of any P S Technology product, correct any defect in workmanship or material. Such corrective measures will be limited to repairing or replacing the unit, at P S Technology's option. This limited warranty shall not apply to equipment which has been subjected to negligence, accident or damage by operation, maintenance or storage, or to other than normal use or service. This limited warranty does not cover reimbursements for transportation, removal, installation, repair or replacement, except as may otherwise be specifically agreed to in writing by P S Technology. The foregoing is in lieu of all other warranties expressed or implied, and all other obligations or liabilities whether arising under contract, negligence or otherwise, on the part of P S Technology. In no event shall P S Technology be liable for consequential or special damages, including but not limited to loss of use, loss of income, loss of profit or cost of replacement.

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