7500 Series

Power Analyzer

User's Manual

Purchase Record

Please record all model numbers and serial numbers of your
Magtrol equipment, along with the general purchase information.
The model number and serial number can be found on either
a silver identification plate or white label affixed to each unit.
Refer to these numbers whenever you communicate with a
Magtrol representative about this equipment.

Model Number: _____

Serial Number: _____

Purchase Date: _____

Purchased From: _____

While every precaution has been exercised in the compilation of this document to
ensure the accuracy of its contents, Magtrol, Inc. assumes no responsibility for errors or
omissions. Additionally, no liability is assumed for any damages that may result from the
use of the information contained within this publication.

MAGTROL

Safety Precautions

1. Make sure that all Magtrol dynamometers and electronic products are earth-grounded, to ensure personal safety and proper operation.
2. Securely ground the 7500 Series Power Wattmeter case by connecting a good earth ground at the ground stud located on the rear panel of the unit. Use a number 12 AWG, or larger wire.
3. Check line voltage before operating.
4. Make sure that dynamometers and motors under test are equipped with appropriate safety guards.

Revisions To This Manual

The contents of this manual are subject to change without prior notice. Should revisions be necessary, updates to all Magtrol User's Manuals can be found at Magtrol's web site at www.magtrol.com/support/manuals.htm.

Please compare the date of this manual with the revision date on the web site, then refer to the manual's Table of Revisions for any changes/updates that have been made since this edition.

REVISION DATE

2nd Edition rev. D – June 2023

TABLE OF REVISIONS

Date	Edition	Change	Section(s)
06/21/23	2nd Edition rev. D	All references to DSP7000 changed to DSP7010.	Entire manual
02/04/20	2nd Edition rev. C	The term phase input module changed to channel input module.	1.3, 3.3
10/22/19	2nd Edition rev. B	The bandwidth was changes from 100 kHz to 80 kHz.	1.3, 4.4.2
09/26/18	2nd Edition rev. A	Mag.net commands updated	5.7

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4. OPERATING PRINCIPLES

5. COMPUTER CONTROLLED OPERATION

6. CALIBRATION

Preface

PURPOSE OF THIS MANUAL

This manual contains all the information required for the installation and general use of the 7500 Series Power Analyzer. To achieve maximum capability and ensure proper use of the instrument, please read this manual in its entirety before operating. Keep the manual in a safe place for quick reference whenever a question should arise.

WHO SHOULD USE THIS MANUAL

This manual is intended for those operators who are planning to use the 7500 Series Power Analyzer for power measurement purposes either as a stand-alone instrument or in conjunction with any Magtrol Hysteresis, Eddy-Current or Powder Brake Dynamometer, any Magtrol Dynamometer Controller and M-TEST Motor Testing Software.

MANUAL ORGANIZATION

This section gives an overview of the structure of the manual and the information contained within it. Some information has been deliberately repeated in different sections of the document to minimize cross-referencing and to facilitate understanding through reiteration.

The structure of the manual is as follows:

Chapter 1: INTRODUCTION - Contains the technical data sheet for the 7500 Series Power Analyzer, which describes the unit and provides its mechanical and electrical characteristics.

Chapter 2: CONTROLS - Description of the elements located on the front and rear panels of the unit.

Chapter 3: INSTALLATION/CONFIGURATION - Provides information needed for setup of the 7500 including wiring mode, measurement filter, external sensor, current scaling and voltage scaling along with phase setup instructions and special functions available.

Chapter 4: OPERATING PRINCIPLES - Information pertaining to theory of operation including analog processing, digital processing, measurement modes and measurement methods.

Chapter 5: COMPUTER CONTROLLED OPERATION - How to run a test when the 7500 is used with a PC. Includes information on IEEE-488 and RS-232 Interface, data format, programming and command set.

Chapter 6: CALIBRATION - Provides recommended calibration schedules along with step-by-step instructions for the calibration procedure.

Chapter 7: OPTIONAL FEATURES - Provides information regarding various optional features available with the 7500 including analog outputs.

Chapter 8: TROUBLESHOOTING - Solutions to common problems encountered during setup and testing.

Appendix A: SCHEMATICS - For the main board, input modules, key pad and analog output.

CONVENTIONS USED IN THIS MANUAL

The following symbols and type styles may be used in this manual to highlight certain parts of the text:

☞	Note:	This is intended to draw the operator's attention to complementary information or advice relating to the subject being treated. It introduces information enabling the correct and optimal functioning of the product to be obtained.

⚠	CAUTION:	THIS IS USED TO DRAW THE OPERATOR'S ATTENTION TO INFORMATION, DIRECTIVES, PROCEDURES, ETC. WHICH, IF IGNORED, MAY RESULT IN DAMAGE BEING CAUSED TO THE MATERIAL BEING USED. THE ASSOCIATED TEXT DESCRIBES THE NECESSARY PRECAUTIONS TO TAKE AND THE CONSEQUENCES THAT MAY ARISE IF THE PRECAUTIONS ARE IGNORED.

STOP	WARNING!	THIS INTRODUCES DIRECTIVES, PROCEDURES, PRECAUTIONARY MEASURES, ETC. WHICH MUST BE EXECUTED OR FOLLOWED WITH THE UTMOST CARE AND ATTENTION, OTHERWISE THE PERSONAL SAFETY OF THE OPERATOR OR THIRD PARTY MAY BE PUT AT RISK. THE READER MUST ABSOLUTELY TAKE NOTE OF THE ACCOMPANYING TEXT, AND ACT UPON IT, BEFORE PROCEEDING FURTHER.

⚡	DANGER:	THE SYMBOL INDICATES DANGER OF INJURY OR DEATH FROM ELECTRIC SHOCK DUE TO HIGH VOLTAGES AND CURRENT. DO NOT TOUCH. USE EXTREME CAUTION. AC VOLTAGES OVER 33 V RMS, 46.7 V PEAK AND DC VOLTAGES OVER 70 V ARE DEEMED TO BE HAZARDOUS IN TERMS OF IEC 61010. FURTHER MATERIAL DAMAGE MAY HAPPEN.

	CAT II 1000V:	THIS CATEGORY REFERS TO LOCAL-LEVEL ELECTRICAL DISTRIBUTION, SUCH AS THAT PROVIDED BY A STANDARD WALL OUTLET OR PLUG IN LOADS. EXAMPLES OF MEASUREMENT CATEGORY II PER IEC 61010-1 ARE MEASUREMENTS PERFORMED ON HOUSEHOLD APPLIANCES, PORTABLE TOOLS, AND SIMILAR MODULES. 1000V IS WORKING VOLTAGE.

1. Introduction

1.1 UNPACKING YOUR 7500 SERIES POWER ANALYZER

Your 7500 Series Power Analyzer was packaged in reusable, shock resistant packing material that will protect the instrument during normal handling.

1. Make sure the carton contains the following:
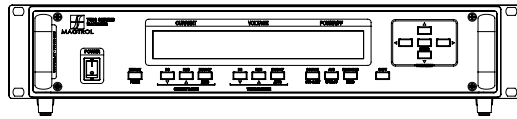
7500 Series Power Analyzer
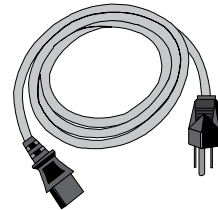
Line cord
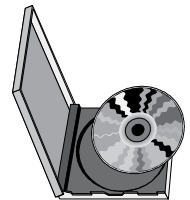
Magtrol
User Manual
DVD-Rom
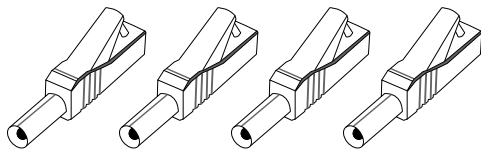
Banana Jack Connectors (4 each per phase)
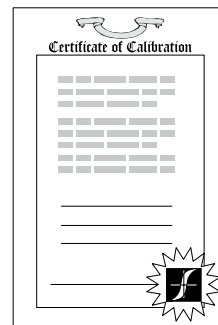
Calibration Certificate

USB cable
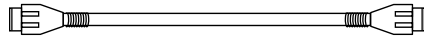
Isolated BNC Sensor
Connectors (1 each per phase)

2. Inspect the contents for any evidence of damage in shipping. In the event of shipping damage, immediately notify the carrier and Magtrol's Customer Service Department.

☞ Note: Save all shipping cartons and packaging material for reuse when returning the instrument for calibration or servicing.

1.2 NEW FEATURES OF THE 7500 SERIES POWER ANALYZER

Magtrol's new 7500 Series Power Analyzer is an upgraded version of the 6510e/6530. The new features that make the unit unique include:

*   CAT II approval per IEC 61010-1
*   Expanded interfacing capabilities with USB, GPIB/IEEE-488, and ethernet inputs

1.3 DATA SHEET

MAGTROL

7500 SERIES

7500 SERIES
POWER ANALYZER

FEATURES

- **Single/Three-Phase Capabilities:** For single (7510) or three-phase (7530) power measurements

- **Ranges:** Up to 600 V_{rms} @ 20 A continuous duty

- **Interfaces:** USB & GPIB/IEEE-488 & Ethernet

- CAT II 1,000 V inputs

- **Data Transfer Rates:** Up to 100 per second

- **Accuracy:** Up to 0.1%

- **Vacuum Fluorescent Display:** High-quality, easy-to-read, customizable readout displays volts, amps, power and power factor

- **Measurement:** Continuous or cycle-by-cycle

- **Bandwidth:** DC up to 80 kHz

- **Input Power:** Accepts 85/264 V_{rms}, 60/50 Hz power at 20 VA max

- **Auto Ranging:** Automatically scales instrument for most accurate range

- **Isolation:** 1000 V_{rms} to earth, 750 V_{rms} line-to-line

- **Average:** Displays running average of amps, volts and watts

- **Peak Hold:** Stores the highest value read. Values can include amps, watts and volts in any combination

- **External Shunt Input**

- **Calibration Certificate:** NIST Traceable

- **Rack Mounting:** 19" (482.6 mm) with handles

Fig.1 : 7500 Series Power Analyzer

APPLICATIONS

- AC/DC Motors
- Lighting Fixtures/Ballasts
- Office Equipment
- Household Appliances
- Power Tools
- HVAC Equipment
- Calibration of Test and Measuring Instruments
- Transformers

The 7500's data transfer rate makes it ideal for both static and dynamic tests.

DESCRIPTION

The Magtrol 7500 Series Power Analyzer is an easy-to-use instrument ideal for numerous power measurement applications. From DC to 80 kHz AC, the 7500 measures volts, amps, watts, volt-amps, frequency, crest factor, Vpeak, Apeak and power factor in one convenient display. They may be used either as stand-alone instruments or in conjunction with any Magtrol Hysteresis, Eddy-Current or Powder Brake Dynamometer; any Magtrol Dynamometer Controller and M-TEST Software for more demanding motor test applications.

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SYSTEM CONFIGURATIONS

DSP7011 Dynamometer Controller

Motor Under Test

Magtrol Dynamometer

AC/DC Input Power

USB

PC

M-TEST

MODEL 7530
THREE PHASE POWER ANALYZER

RS-232 or GPIB

Appliances, Ballasts, Drives, etc.

AC/DC Input Power

PC

MODEL 7510
SINGLE-PHASE POWER ANALYZER

FRONT PANEL

Ready for Rack Mounting

Custom Display Setup

Current Readings (DC, RMS, Peak, Crest Factor and Peak Hold/Inrush)

Voltage Readings (DC, RMS, Peak, Crest Factor and Peak Hold/Inrush)

Cycle-by-Cycle Synchronized Source

Averaging of Voltage, Current and Power

Phase and Summation Data

Current Auto Ranging

Voltage Auto Ranging

Continuous or Cycle-by-Cycle Measurement Mode

Calculate Power, V_{rms} x A_{rms} and Power Factor

Holds Current Value

BACK PANEL

Channel Input Module 3 for 7530 (as shown), 1 for 7510

Current Input

GPIB/IEEE-488 Interface (for Connection to Personal Computer)

External Sensor Input

Voltage Input

USB Connection

Ethernet Connection

MAGTROL

7500 SERIES

SPECIFICATIONS

	VOLTAGE INPUT	CURRENT INPUT	EXTERNAL SENSOR INPUT	POWER
Ranges	30 V, 150 V, 300 V, 600 V	1 A, 5 A, 10 A, 20 A	50 mV, 250 mV, 500 mV, 1 V	---
Maximum Voltage	750 V AC/DC terminal (V) to terminal (±) and 1000 V AC/DC terminal to earth ground	1000 V AC/DC terminal to earth ground	±1 V AC/DC	---
Crest Factor	1.7 @ full scale input	2.7 @ full scale input	2.4 @ full scale input	---
Impedance	2 mΩ	12 mΩ	17 KΩ	---
Display Range	5 digits with 1 mV resolution	5 digits with 1 mA resolution	5 digits with 1 µV resolution	5 digits with 1 mW resolution

ACCURACY				
DC	±(0.1% Reading + 0.2% Range)			0.4% of VA range
5 Hz - 500 Hz	±(0.1% Reading + 0.1% Range)			0.2% of VA range
500 Hz - 10 kHz	±((0.015 × F(kHz)% Reading) + 0.3% Range)			0.6% of VA range
10 kHz - 80 kHz	±((0.015 × F(kHz)% Reading) + 0.3% Range)			0.6% + (0.03% × F(kHz)% of VA range)
> 80 kHz	N/A (measurement band limited to DC–80 kHz)			

FREQUENCY	
Source	V_1, A_1, V_2, A_2, V_3, A3 (For Vx and Ax, source input must be >10% of range setting)
Accuracy	20 Hz to 500 Hz; 0.05%

DIMENSIONS		
Width	19.0 in	483 mm
Height	3.5 in	89 mm
Depth	12.4 in	315 mm
with handles	13.8 in	351 mm
Weight (max)	12.97 lb	5.88 kg

DATASHEET

www.magtrol.com

MAGTROL   **7500** SERIES

OPTIONS AND ACCESSORIES

EXTERNAL SHUNTS/SENSORS

If currents continuously reach above 20 amps, an external sensor must be used. Magtrol offers three different types of external shunts for use with Magtrol Model 7500 High-Speed Power Analyzer.

The HA Series shunt, designed for power cable hook-up utilizing 3/8-16 screws, has an insulating base and can be mounted on conductive surfaces. The LAB Series shunt also comes with an insulating base, along with thumb screws for the power leads and knurled nuts on the sensing terminals. The FL Series is a relatively small bus, bar-mounted shunt with large end blocks. The comparatively large end blocks and short spacing aid in cooling and allow the shunt to operate in more extreme environments. All shunts are calibrated on equipment with current certifications traceable to N.I.S.T.

SPECIFICATIONS

	HA Series	LAB Series	FL Series
Rated Current	50 to 500 A	750 to 1000 A	2000 to 3000 A
Output	50 mV		
Bandwidth	DC to 60 Hz		
Accuracy	± 0.25% (± 0.1% accuracy with calibration certificate is available for an additional cost)		
Operating Temperature	For optimum accuracy, temperature of shunt should be 30 °C to 70 °C		

AVAILABLE MODELS

Type	P/N	Current
HA	004640	50
HA	004641	100
HA	004642	150
HA	004643	200
HA	004644	250
HA	004645	300
HA	004646	400
HA	004647	500
LAB	004648	750
LAB	004649	1000
FL	005214	2000
FL	005286	3000

SENSOR SUBSTITUTION WIRING CONNECTION
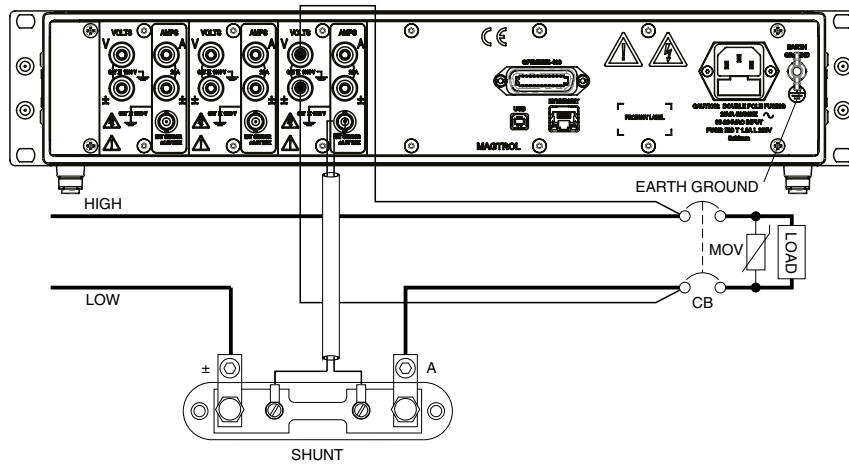
Ordering Information

7510	Single-Phase Power Analyzer
7530	Three-Phase Power Analyzer

2. Controls

2.1   FRONT PANEL

The front panel provides a power switch, sixteen control buttons and a Vacuum Fluorescent Display (VFD).

Figure 2–1 Front Panel

2.2   FRONT PANEL CONTROLS AND BUTTONS

The front panel controls and buttons, from left to right, are:
- Power switch
- Ten double-function control buttons:

Primary Function	Secondary Function
PHASE	DISPLAY
▼ CURRENT RANGE	DC (current)
▲ CURRENT RANGE	RMS (current)
AUTO CURRENT RANGE	PEAK-CF (current)
▼ VOLTAGE RANGE	DC (voltage)
▲ VOLTAGE RANGE	RMS (voltage)
AUTO VOLTAGE RANGE	PEAK-CF (voltage)
CYC-CONT	SOURCE
W-VA-PF	AVG
HOLD	PEAK HOLD

- SHIFT - enables secondary functions printed in blue above control buttons
- Five USER MENU buttons
    - Left Arrow ◄
    - Right Arrow ►
    - Up Arrow ▲
    - Down Arrow ▼
    - **ENTER**

2.2.1 ENABLING SECONDARY FUNCTIONS

To enable the secondary function of the double-function control buttons:

1. Press the blue SHIFT button and release it. The word "SHIFT" appears in the display:

```
┌─────────────────────────────────────────────────────────┐
│   CURRENT            VOLTAGE              POWER/PF        │
│  ┌──────────────────────────────────────────────────┐   │
│  │   0.000 AXXX       0.00 VXXX        0.000 XXXX    │   │
│  │                                                   │   │
│  │      000XX           000V             SHIFT       │   │
│  └──────────────────────────────────────────────────┘   │
└─────────────────────────────────────────────────────────┘
```
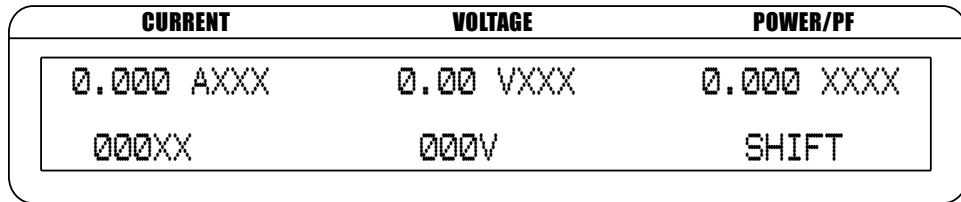
Figure 2–2 Secondary Function Menu

2. Press any control button to enable the function shown in blue letters above the button.

2.2.2 USING FRONT PANEL CONTROLS AND BUTTONS

2.2.2.1 Controls/Single-Function Buttons

Button	To Use	Function
POWER	Press I to turn power ON Press O to turn power OFF.	Turns power ON or OFF.
SHIFT	Press this button and release; then press desired control button.	Enables the function written in blue above control button.
User Menu		
ENTER	Press this button.	Enables/Disables USER MENU.
◄	Press this button.	When USER MENU is enabled, toggles between fields, selections or the digits in a numerical value.
►	Press this button.	When USER MENU is enabled, toggles between fields, selections or the digits in a numerical value.
▲	Press this button.	When USER MENU is enabled, toggles between selections or increases the selected digit of a numerical value.
▼	Press this button.	When USER MENU is enabled, toggles between selections or decreases the selected digit of a numerical value.

GENERAL
INFORMATION

2.2.2.2 **Double-Function Buttons**

Button	To Use	Function
DISPLAY	Press SHIFT and release; then press this button. (For further instruction, see Section 3.3.7.4 - Custom Display.)	Shows custom display.
PHASE	Press this button.	Toggles through phase 1, 2, 3 and summation.
Current		
DC	Press SHIFT and release; then press this button.	Selects DC current measurement.
RMS	Press SHIFT and release; then press this button.	Selects RMS current measurement.
PEAK-CF	Press SHIFT and release; then press this button.	Selects displayed current measurement. Continue to press SHIFT then PEAK-CF and the displayed values toggle through the following: • Acf (current crest factor readings) • A~↑ (current peak hold/inrush readings) • Apk (current peak readings)
Current Range		
▼	Press this button.	Decrements current range.
▲	Press this button.	Increments current range.
AUTO	Press this button.	Selects/deselects current auto range.
Voltage		
DC	Press SHIFT and release; then press this button.	Selects DC voltage measurement.
RMS	Press SHIFT and release; then press this button.	Selects RMS voltage measurement.
PEAK-CF	Press SHIFT and release; then press this button.	Selects displayed voltage measurement. Continue to press SHIFT then PEAK-CF and the displayed values toggle through the following: • Vcf (voltage crest factor readings) • V~↑ (voltage peak hold/inrush readings) • Vpk (voltage peak readings)
Voltage Range		
▼	Press this button.	Decrements voltage range.
▲	Press this button.	Increments voltage range.
AUTO	Press this button.	Selects/deselects voltage auto range.
SOURCE	Press SHIFT and release; then press this button.	Selects the signal that the cycle-by-cycle measurement will be synchronized with. Continue to press SHIFT then SOURCE and the source toggles through the following: • V1, V2, V3 (voltage input) • A1, A2, A3 (current input) NOTE: Selecting SHIFT then SOURCE will automatically switch unit to cycle-by-cycle mode.
CYC-CONT	Press this button.	Selects continuous or cycle-by-cycle measurement method.
AVG	Press SHIFT and release; then press this button.	Enables averaging mode.

Button	To Use	Function
W-VA-PF	Press this button.	Selects what calculated value is to be displayed.Continue to press W-VA-PF and the displayed values toggle through the following: • W↑ (inrush watts) • W (watts) • VA ($V_{rms} \times A_{rms}$) • PF (power factor)
PEAK HOLD	Press SHIFT and release; then press this button.	Resets peak hold/inrush values.
HOLD	Press this button.	Holds displayed values until hold is pressed again. NOTE: All internal machine functions will be halted except auto-ranging when the HOLD feature is enabled.

2.3 VACUUM FLUORESCENT DISPLAY (VFD)

The VFD provides information about the control functions, phase voltages and currents.

Top Row	Bottom Row
Current	Current Range
Voltage	Voltage Range
Power/PF	Source/Status

2.3.1 CONTRAST SETTINGS

The 7500 Series Power Analyzer is shipped with the Contrast Setting on low in order to prolong display life. If it is necessary to increase the Contrast for improved readability, execute the following steps using the USER MENU located on the front panel of the unit.

1. Press the ENTER button. The display should appear as follows:
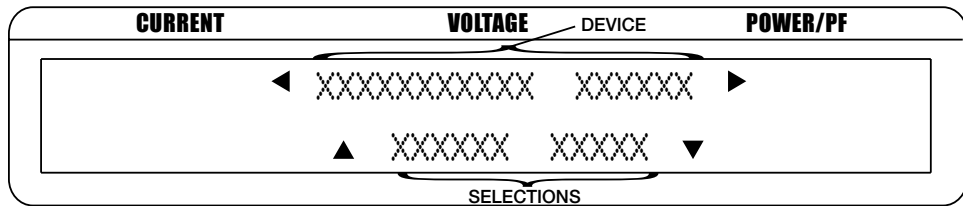
Figure 2–3 Device Setup Menu

2. Press ▶ and ◀ buttons until "I/O" appears in the display.

3. Press ENTER button.

4. Press ▶ and ◀ buttons until "DISPLAY BRIGHTNESS" appears in the display.

5. Use the ▲ and ▼ buttons until desired brightness is reached.

6. Press ENTER button to return to main menu.

☞   Note: There are three settings available; low, medium and high. Make
                          sure the lowest possible setting is used to achieve desired result.
                          Using a setting higher than necessary may cause display segments
                          to burn-in over a period of time, resulting in uneven illumination
                          from segment to segment.

2.3.2   DISPLAY GUIDE

Following is a reference for symbols, abbreviations and messages that are used in the 7500.

Symbol/Abbreviation/Message	Meaning
SHIFT	Shift button was pressed
V	Volts
A	Amps
W	Watts
PF	Power Factor
pk	Peak
cf	Crest Factor
1	Phase 1
2	Phase 2
3	Phase 3
✳	Scaling function is activated
⊕	Average function is activated
I	Peak Hold/Inrush function is activated
Σ	Summation
↑	Peak Hold/Inrush
...	DC
~	RMS (AC+DC)

2.4   REAR PANEL

The rear panel provides connectors and receptacles for connecting to appropriate equipment.
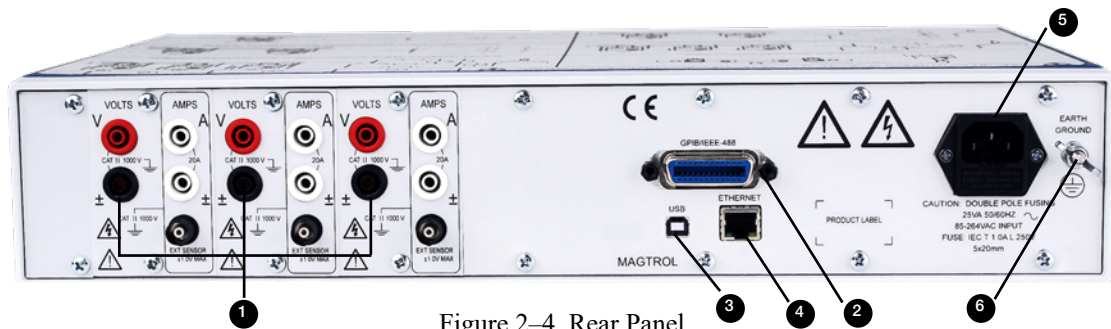
Figure 2–4 Rear Panel

2.5   REAR PANEL INPUTS AND OUTPUTS

① INPUT
MODULE

Contains the Voltage Input, Current Input and External Sensor connectors for each phase.
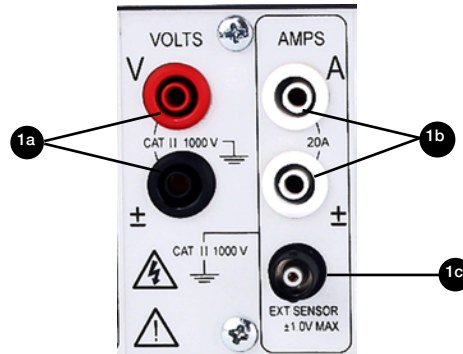
Figure 2–5 Input Module

1a Voltage Input

Connect wires to measure voltage across the load (parallel).

⚠	CAUTION:	VOLTAGE SHOULD NOT EXCEED 750 V AC/DC TERMINAL (V) TO TERMINAL (±) AND 1000 V AC/DC EITHER TERMINAL TO EARTH GROUND.

1b Current Input

Connect wires to measure current through the load (series).

⚠	CAUTION:	CURRENT SHOULD NOT EXCEED 20 A CONTINUOUS. VOLTAGE SHOULD NOT EXCEED 1000 V AC/DC EITHER TERMINAL TO EARTH GROUND.

1c External Sensor

Alternate current input for current sensor or shunt.

⚠	CAUTION:	VOLTAGE SHOULD NOT EXCEED ±1 V AC/DC TERMINAL TO GROUND AND VOLTAGE SHOULD NOT EXCEED 1,000 V AC/DC EITHER TERMINAL TO EARTH GROUND.

② GPIB/
IEEE-488

Use this socket for GPIB cable (meets IEEE-488 specifications).

| 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 |
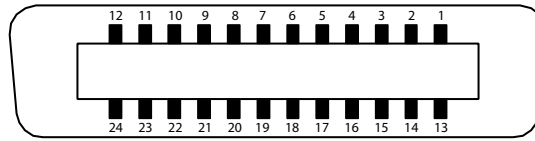
1. D1   13. D5
2. D2   14. D6
3. D3   15. D7
4. D4   16. D8
5. E01   17. REN
6. DAV   18. DAV-COM
7. NRFD   19. NRFD-COM
8. NDAC   20. NDAC-COM
9. IFC   21. IFC-COM
10. SRQ   22. SRQ-COM
11. ATN   23. ATN-COM
12. SHIELD   24. SIGNAL GROUND

Figure 2–6 GPIB/IEEE-488 Interface

③ USB INTERFACE   Connect PC USB cable here.
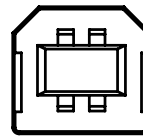
Figure 2–7 USB Interface

④ ETHERNET   Attach Ethernet cable here.
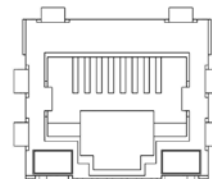
Figure 2 –8 Ethernet Connector

⑤ POWER   Attach power cord here.

☞   NOTE: Only one interface at a time may be used.

❻ EARTH
GROUND

Attach earth ground here.

STOP

WARNING: MAKE SURE THAT ALL MAGTROL DYNAMOMETERS AND ELECTRONIC PRODUCTS ARE EARTH-GROUNDED, TO ENSURE PERSONAL SAFETY AND PROPER OPERATION. SECURELY GROUND THE 7500 SERIES POWER ANALYZER CASE BY CONNECTING A GOOD EARTH GROUND AT THE GROUND STUD LOCATED ON THE REAR PANEL OF THE UNIT. USE A NUMBER 12 AWG, OR LARGER WIRE.

3. Installation/Configuration

☞ Note: Before installing the 7500, you should become familiar with the front and rear panels, as outlined in Chapter 2 – Controls.

3.1 POWERING UP THE 7500

STOP WARNING! TO REDUCE THE RISK OF ELECTRIC SHOCK, MAKE SURE THE 7500 IS EARTH GROUNDED BEFORE STARTING!

3.1.1 LINE VOLTAGE

The 7500 will operate from 85 to 264 VAC on a 50/60 Hz line voltage.

3.1.2 DISPLAY SEQUENCE

After turning the power on to the 7500, the Initial Display panel will appear:

CURRENT	VOLTAGE	POWER/PF
	7500 SERIAL KEYPAD REV XX	
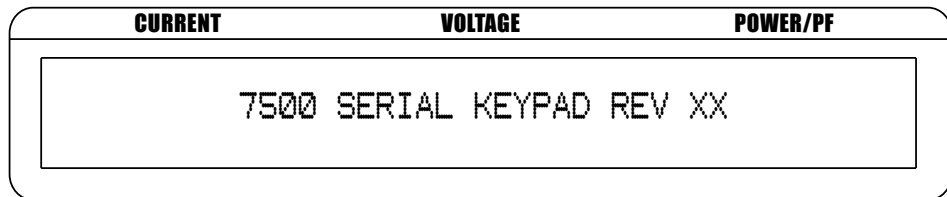
Figure 3–1 Initial Display

followed by the Title Display.

CURRENT	VOLTAGE	POWER/PF
	MAGTROL 7500	
	#-PHASE POWER ANALYZER	
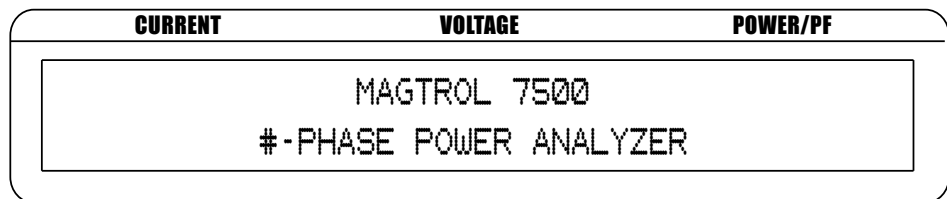
Figure 3–2 Title Display

Then an additional display will appear indicating the version of your Magtrol 7500 Series Power Analyzer.

```
┌──────────────────────────────────────────────────────────────┐
│   CURRENT              VOLTAGE              POWER/PF           │
│  ┌────────────────────────────────────────────────────────┐   │
│  │              MAGTROL 7500                              │   │
│  │         FW REV: XX FPGA REV: XX                        │   │
│  └────────────────────────────────────────────────────────┘   │
└──────────────────────────────────────────────────────────────┘
```
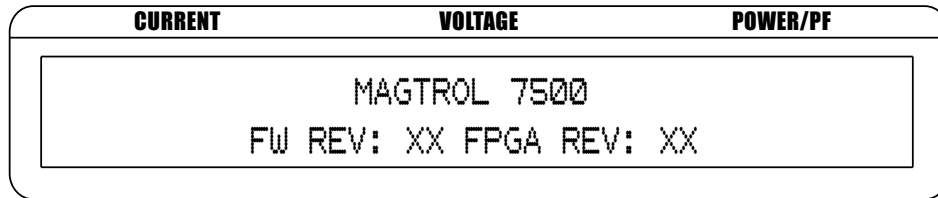
Figure 3–3 Revision Display

3.1.3   MAIN MENU

When the 7500 is completely powered up and ready for use, the main menu will appear on the display. The main menu is defined by the last configuration that was used. This could include one of three different menus: phase, summation or custom.

The phase menu could be a representation of phase 1, 2 or 3 and will appear as follows.

```
┌──────────────────────────────────────────────────────────────┐
│   CURRENT              VOLTAGE              POWER/PF           │
│  ┌────────────────────────────────────────────────────────┐   │
│  │   0.000 AXXX        0.000 VXXX        0.000 XXXX        │   │
│  │                                                        │   │
│  │   000XX             000V                               │   │
│  └────────────────────────────────────────────────────────┘   │
└──────────────────────────────────────────────────────────────┘
```
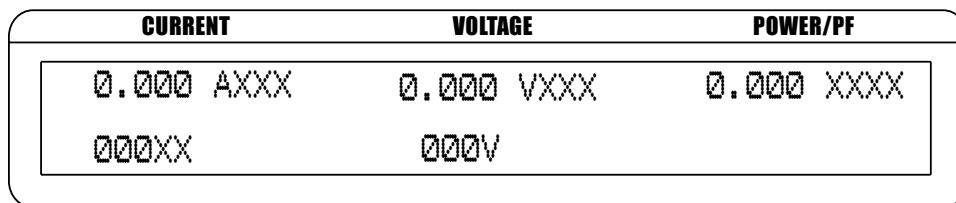
Figure 3–4 Phase Main Menu

The summation menu contains information pertaining to all 3 phases. The voltage value represents an average of the 3 phases and the current and power values represent the sum of the phases.

```
┌──────────────────────────────────────────────────────────────┐
│   CURRENT              VOLTAGE              POWER/PF           │
│  ┌────────────────────────────────────────────────────────┐   │
│  │   0.000 AΣX         0.000 VΣX         0.000 WΣX         │   │
│  │                                                        │   │
│  └────────────────────────────────────────────────────────┘   │
└──────────────────────────────────────────────────────────────┘
```
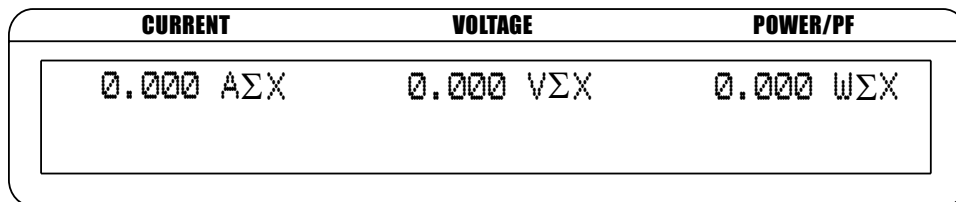
Figure 3–5 Summation Main Menu

☞   Note: The summation menu is not available for 7510 device.

The custom menu can include up to 6 fields with selections dependent on the measurement mode.

CURRENT	VOLTAGE	POWER/PF
0.000 XXXX	0.000 XXXX	0.000 XXXX
0.000 XXXX	0.000 XXXX	0.000 XXXX

Figure 3–6 Custom Main Menu

3.2   PROTECTING YOUR 7500

Before the 7500 is used for power measurement, guidelines regarding transient overloads, current overload, surge protection and circuit breakers must be followed.

3.2.1   TRANSIENT OVERLOADS

Connect an appropriate transient suppressor in parallel with all inductive loads. Consult the suppressor vendor's application literature for proper selection and sizing.

> CAUTION: DAMAGE TO THE 7500 CAN RESULT FROM EXCESSIVE VOLTAGE TRANSIENTS GENERATED BY UNSUPPRESSED INDUCTIVE LOADS. THIS DAMAGE IS NOT WITHIN THE SCOPE OF THE NORMAL INSTRUMENT SERVICE AND IS NOT COVERED BY THE MAGTROL WARRANTY.

3.2.2   CURRENT OVERLOAD

There are no fuses in the 7500 measuring circuits. Therefore, excessive current passed through the current terminals will cause excessive internal heating and possible unit damage.

> CAUTION: THIS OVERLOAD ABUSE IS NOT COVERED BY THE MAGTROL WARRANTY.

 Know your load conditions and double check all connections. If an overload should occur, immediately remove all power and locate and correct the problem before re-energizing your circuit. If a circuit breaker is installed, it must be installed on the load side of the 7500 (downstream). This will keep the low impedance of the input line connected to the 7500 for surge suppression. If the line side must also contain a breaker, it should be delayed in operation to open after the load side breaker has opened.

3.2.3   SURGE PROTECTION

Use Metal Oxide Varistors (MOV) or other equivalent transient suppressors connected between lines at the load (across the load). These suppressors are an absolute necessity when inductive loads are used. In three-phase systems, each load must have a suppressor.

$$V_{MOV >} \; V_{LINE\ TO\ LINE}$$

$$V_{MOV >} \; \tfrac{1}{\sqrt{3}} \; V_{LINE\ TO\ LINE}$$

**DELTA CONNECTED
THREE-PHASE LOAD**

**WYE CONNECTED
THREE-PHASE LOAD**

SETUP

$$V_{MOV >} \; V_{LINE\ TO\ LINE}$$

**SINGLE PHASE
TWO-WIRE LOAD**
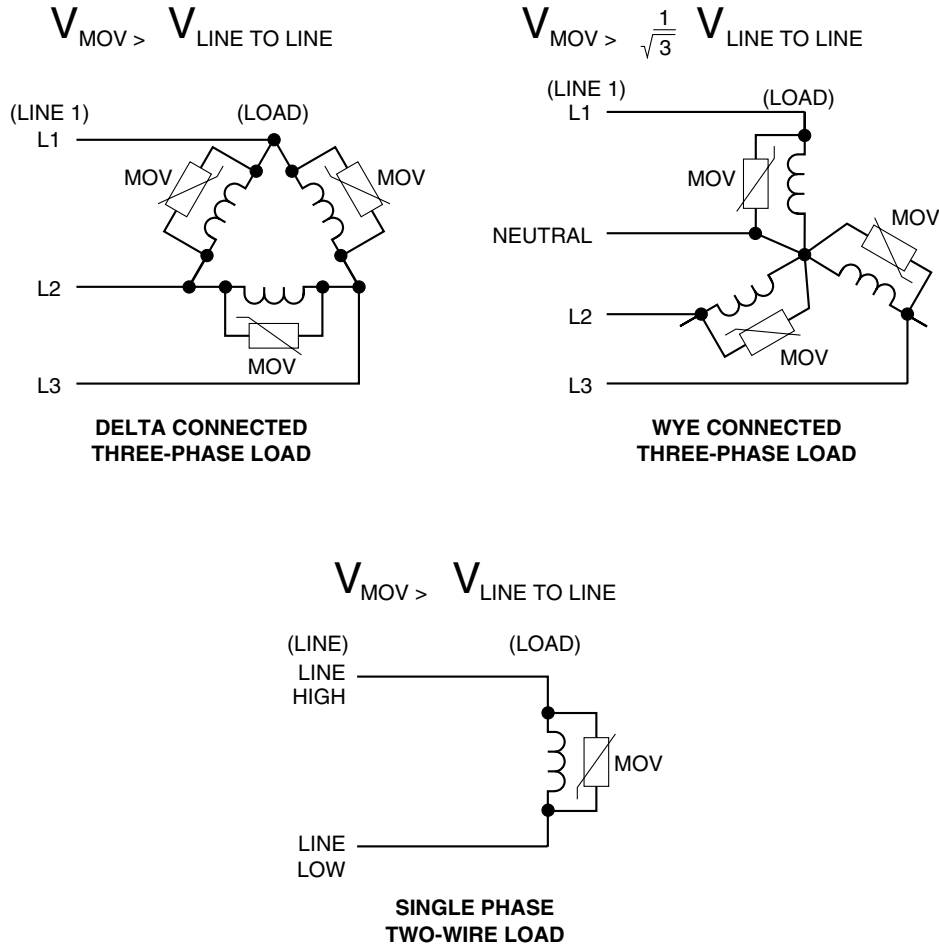
Figure 3–7 Transient Voltage Suppression

3.2.4   CIRCUIT BREAKERS

With the circuits described in Section 3.3.1.1 - Hardware Connections, use the 7500 remote voltage sense by measuring the voltage at the load. This increases measurement accuracy by eliminating line voltage drop from the power measurement. For safety, an overload circuit breaker removes all load voltage during an over-current condition. The voltage sense lines are connected at the line side of the circuit breaker to help prevent inductive transients from entering the 7500 as the circuit breaker opens. Make sure that connections from the circuit breaker to the load are heavy conductors and short as possible.

> CAUTION: IF A CIRCUIT BREAKER IS USED IN THE INPUT LINE TO THE 7500 , A CIRCUIT SHOULD BE USED THAT PREVENTS THE BREAKER FROM OPENING UNTIL AFTER THE LOAD SIDE BREAKER HAS OPENED. OTHERWISE, POTENTIALLY DAMAGING INDUCTIVE TRANSIENTS CAN BE APPLIED TO THE 7500 . DAMAGE CAUSED BY THESE TRANSIENTS ARE OUTSIDE THE SCOPE OF THE MAGTROL WARRANTY.

3.3   TESTING INSTRUMENTATION SETUP

Before the 7500 can be utilized, it must be configured and connected to the devices intended for power measurement.

3.3.1   WIRING MODE

The 7500 has the ability to support a combination of up to 3 phases, therefore, there are a number of different ways in which the unit can be wired.

☞   Note: The 7510 can only support a 1-phase, 2 wire connection

3.3.1.1   Hardware Connections

The wiring mode selections include:

- 1-Phase, 2-Wire
- 1-Phase, 3-Wire
- 3-Phase, 3-Wire
- 3-Phase, 4-Wire
- 3-Volt, 3-Amp

The following pages provide more detail on the power measurement, as well as wiring connection diagrams and schematics, of the different wiring modes.

☞   Note: Active Power is the sum of the instantaneous volts multiplied by the instantaneous current inputs.

                    Apparent Power is the product of voltage root mean square and current root mean square.

1-Phase, 2-Wire

• Measures single-phase power.
 • Can be wired on any input module.
 • The Power Factor is derived from the following equations:
     Current $\Sigma = A_x$, Voltage $\Sigma = V_x$
     Active Power $= W_\emptyset$
     Apparent Power $= V_{rms\emptyset} \times A_{rms\emptyset} = V_\emptyset \, A_\emptyset$
     Power Factor $= W_\emptyset / V_\emptyset \, A_\emptyset$
     (Where $\emptyset$ is the phase of operation)
 • Most commonly used for single phase AC and DC motor applications.

The following diagrams show the connections for a 1-Phase, 2-Wire measurement. Only one phase has been shown for clarity, but any of the three phases may be used.
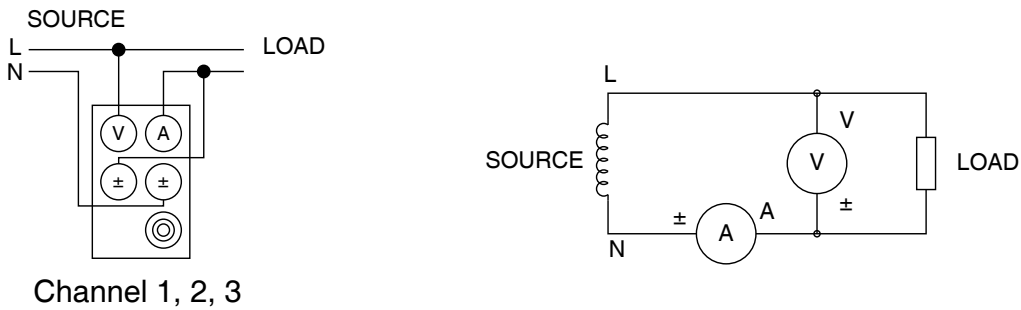
Figure 3–8 Single-Phase, Two-Wire Wiring Schematic
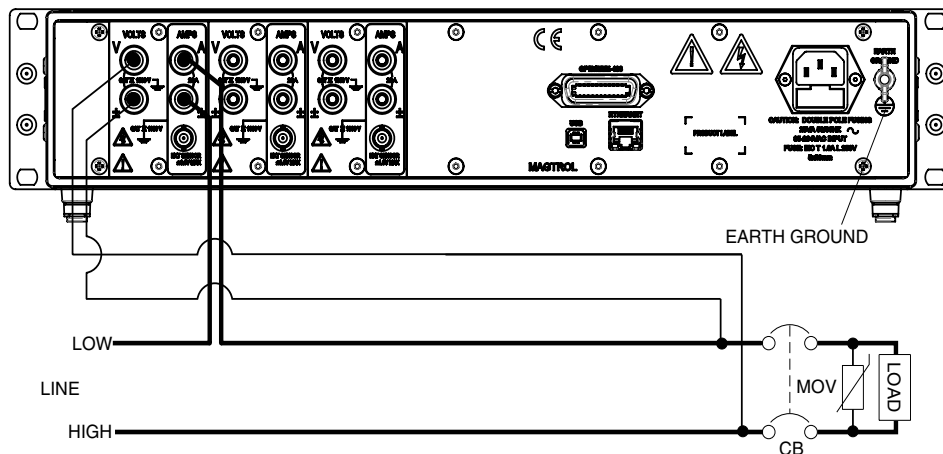
Figure 3–9 Single-Phase, Two-Wire Wiring Connection

1-Phase, 3-Wire

- Measures single-phase power.
- Utilizes input modules one and three.
- The Power Factor is derived from the following equations:

Current $\Sigma = (A_1 + A_3)/2$, Voltage $\Sigma = (V_1 + V_3)/2$

Active Power $= \Sigma W = W_1 + W_3$

Apparent Power $= (V_{rms1} \times A_{rms1}) + (V_{rms3} \times A_{rms3}) = V_1 A_1 + V_3 A_3$

Power Factor $= \Sigma W/(V_1 A_1 + V_3 A_3)$

The following diagrams show the connections for a 1-Phase, 3-Wire measurement. Notice that only phase one and three are used.
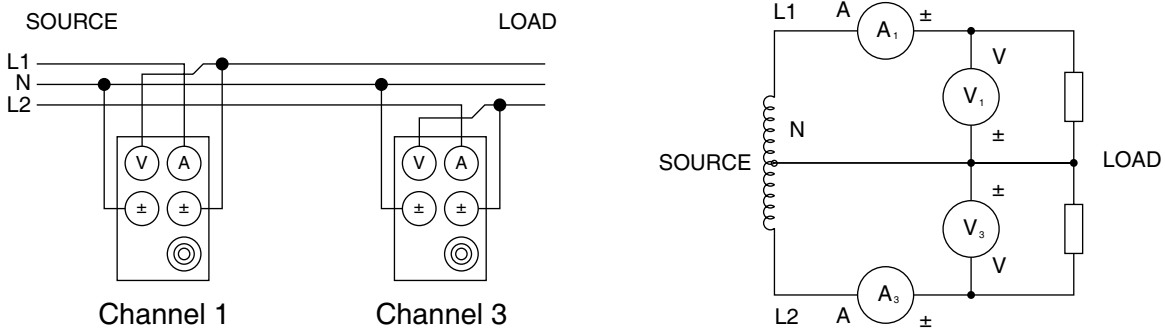
Figure 3-10 Single-Phase, Three-Wire Wiring Schematic
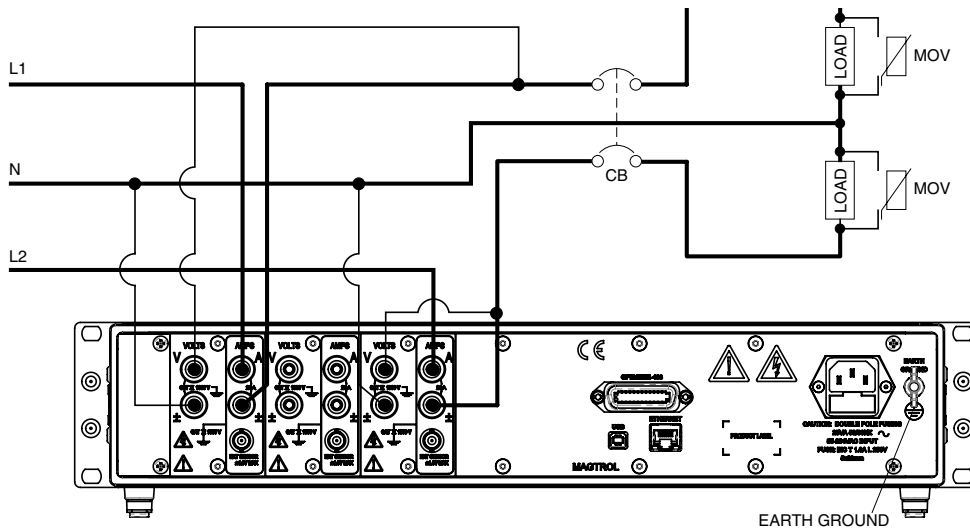
Figure 3–11 Single-Phase, Three-Wire Wiring Connection

3-Phase, 3-Wire

- Measures three-phase power.
- Utilizes input modules one and three.
- The Power Factor is derived from the following equations:

Current $\Sigma = (A_1 + A_3)/2$, Voltage $\Sigma = (V_1 + V_3)/2$

Apparent Power $= \dfrac{\sqrt{3}}{2}\left(\left(V_{rms1} \times A_{rms1}\right) + \left(V_{rms3} \times A_{rms3}\right)\right) = \dfrac{\sqrt{3}}{2}\left(V_1 A_1 + V_3 A_3\right)$

Active Power $= \Sigma W = W_1 + W_3$

Power Factor $= \Sigma W / \dfrac{\sqrt{3}}{2}\left(V_1 A_1 + V_3 A_3\right)$

The following diagrams show the connections for a 3-Phase, 3-Wire measurement. Notice that only phase one and three are used.
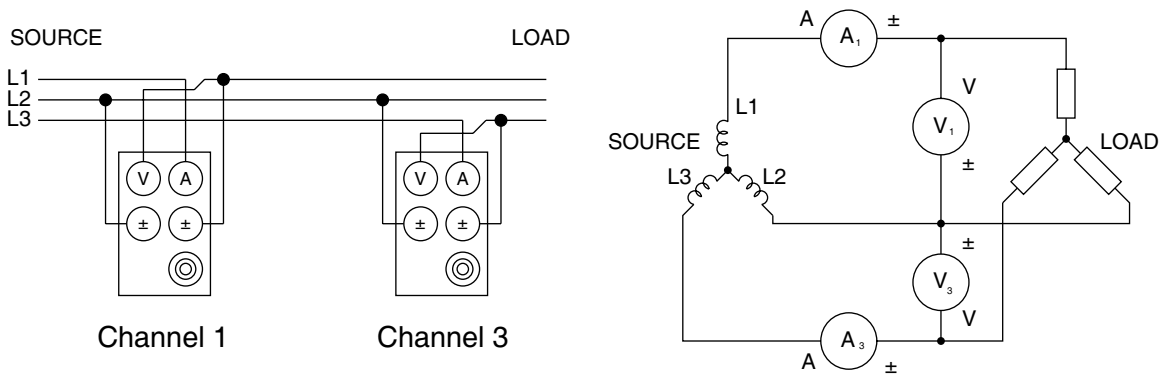
Figure 3–12 Three-Phase, Three-Wire Wiring Schematic
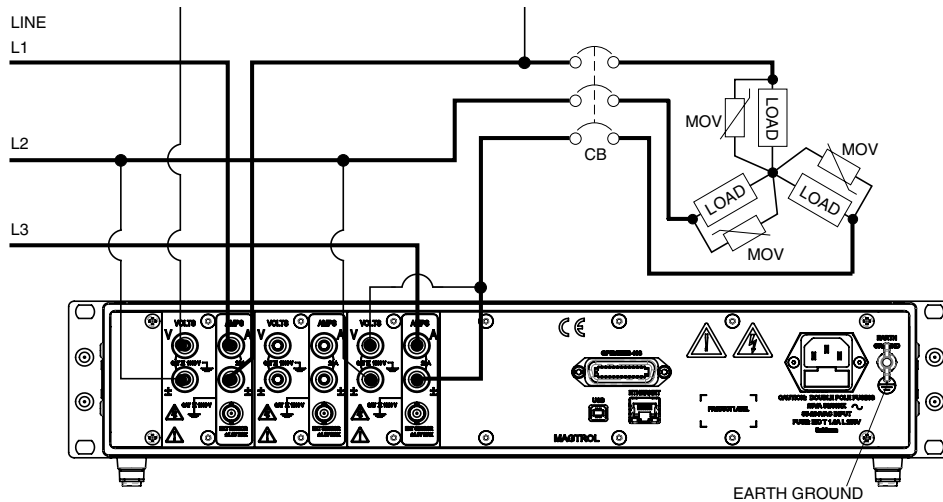
Figure 3–13 Three-Phase, Three-Wire Wiring Connection

SETUP

3-Phase, 4-Wire

- Measures three-phase power.
- Utilizes all three phases.
- The Power Factor is derived from the following equations:

Current $\Sigma = (A_1 + A_2 + A_3)/3$, Voltage $\Sigma = (V_1 + V_2 + V_3)/3$

Active Power $= \Sigma W = W_1 + W_2 + W_3$

Apparent Power $=$

$\quad (V_{rms1} \times A_{rms1}) + (V_{rms2} \times A_{rms2}) + (V_{rms3} \times A_{rms3}) = V_1 A_1 + V_2 A_2 + V_3 A_3$

Power Factor $= \Sigma W/(V_1 A_1 + V_2 A_2 + V_3 A_3)$

The following diagrams show the connections for 3-Phase, 4-Wire measurement.
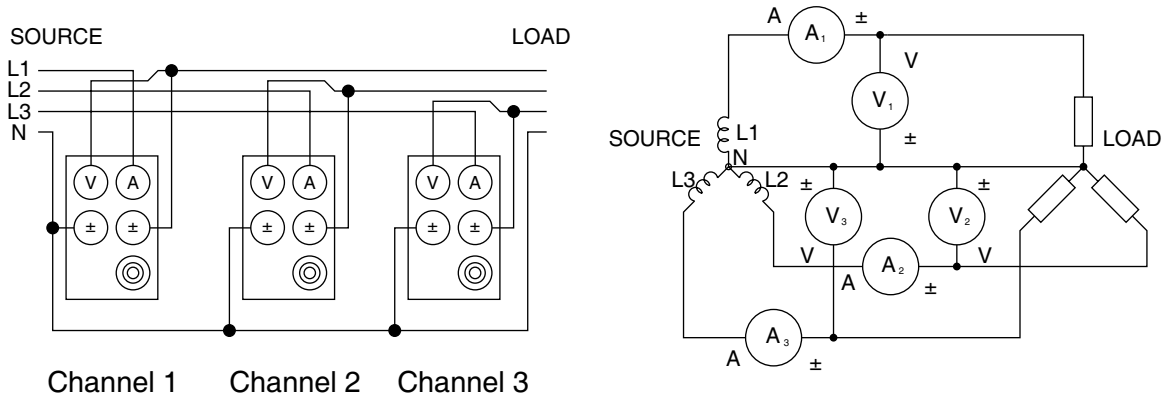
Figure 3–14 Three-Phase, Four-Wire Wiring Schematic
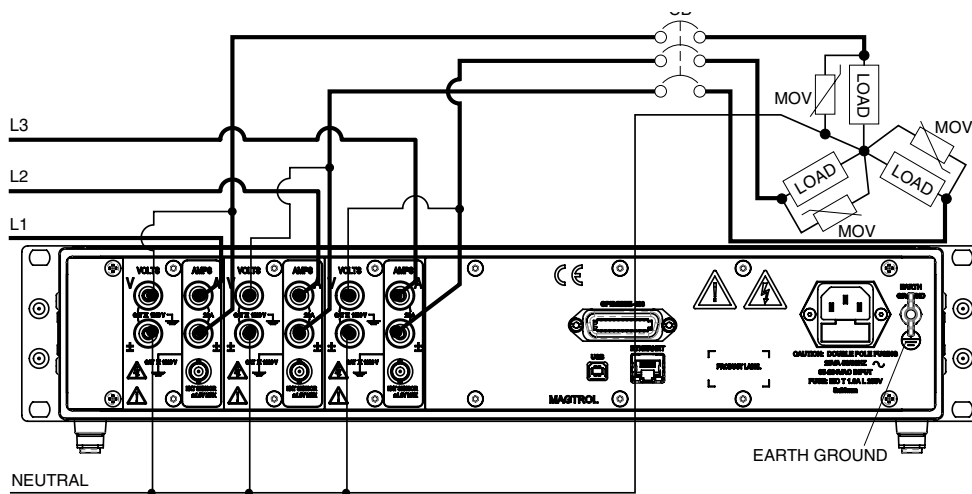
Figure 3–15 Three-Phase, Four-Wire Wiring Connection

3-Volt, 3-Amp

- Measures three-phase power.
- Utilizes all three phases.
- The Power Factor is derived from the following equations:

  Current $\Sigma = (A_1 + A_2 + A_3)/3$, Voltage $\Sigma = (V_1 + V_2 + V_3)/3$

  Active Power $= \Sigma W = W_1 + W_3$

  Apparent Power $= \dfrac{\sqrt{3}}{3}\left(\left(V_{rms1} \times A_{rms1}\right) + \left(V_{rms2} \times A_{rms2}\right) + \left(V_{rms3} \times A_{rms3}\right)\right) = \dfrac{\sqrt{3}}{3}\left(V_1 A_1 + V_2 A_2 + V_3 A_3\right)$

  Power Factor $= \Sigma W / \dfrac{\sqrt{3}}{3} (V_1 A_1 + V_2 A_2 + V_3 A_3)$

- Most common hookup for three-phase motors.

The following diagrams show the connections for a 3-Volt, 3-Amp measurement.
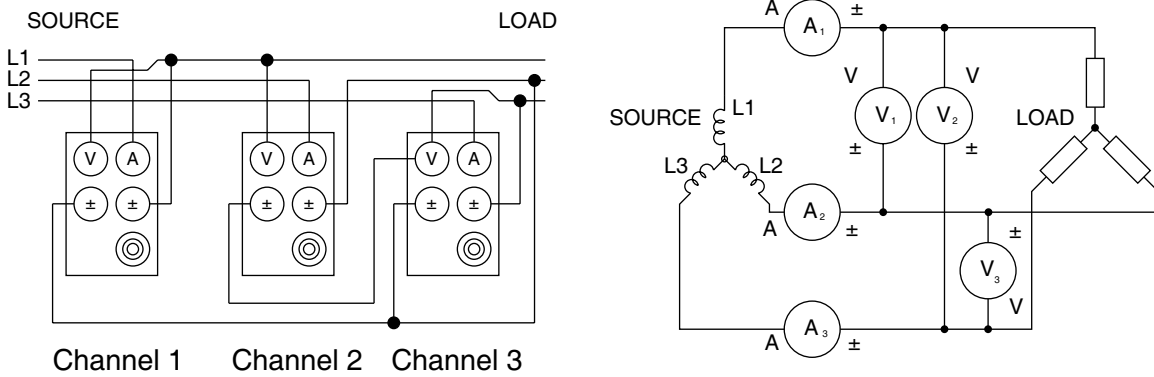
Figure 3–16 Three-Voltage, Three-Ampere Wiring Schematic
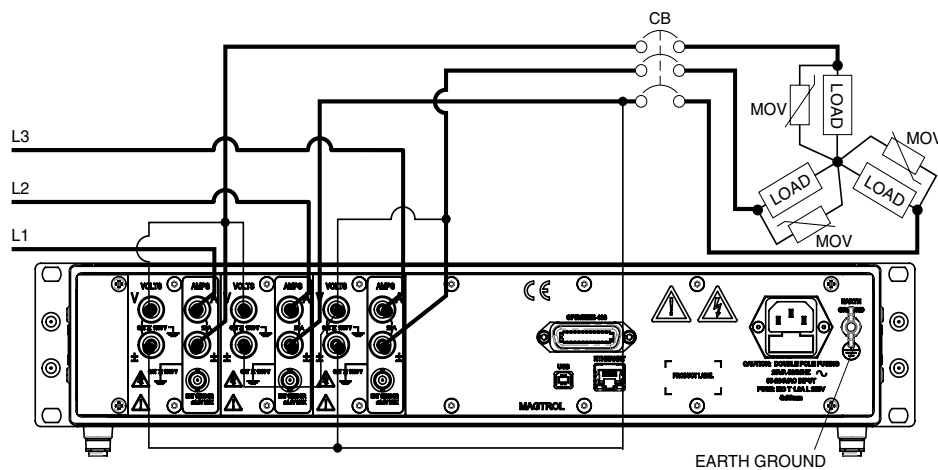
Figure 3–17 Three-Voltage, Three-Ampere Wiring Connection

3.3.1.2   Software Configuration

To configure the 7500 to coincide with the wiring on the rear panel, complete the following steps utilizing the USER MENU located on the front panel of the unit.

1. Turn on the 7500 . See Section 3.1 – Powering Up the 7500 .
2. Press ENTER button. The display should appear as shown in Figure 2–3 Device Setup Menu.
3. Press ◄ and ► buttons until WIRING MODE appears in the display.
4. Press ▲ and ▼ buttons until desired wiring mode is reached.
5. Press ENTER to exit Device Setup Menu.

☞

| Note: | The 7510 default wiring mode is set at 1-phase, 2-wire, therefore no software configuration is needed. |

3.3.2   MEASUREMENT FILTER

During the RMS calculations, in the signal-processing path, there is a digital low-pass filter. The user can program the filter's cutoff frequency.

| Measured Value | ⇒ | (Value)² | ⇒ | Filter | ⇒ | Square Root |
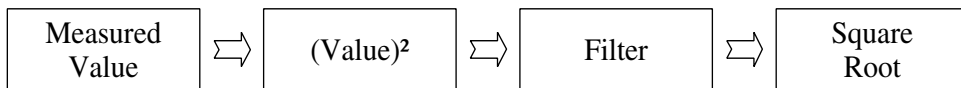
- Selections include 1 Hz, 2 Hz, 5 Hz, 10 Hz, 20 Hz, 50 Hz and 100 Hz .
- Correlation between filter setting and response is as follows:

Filter Setting	Response to Signal Change	Outcome
Low	Slow	Stable Reading
High	Fast	Unstable Reading

For more detailed information on theory, see Chapter 4 – Operating Principles.

3.3.2.1   Software Configuration

To configure the 7500 measurement filter, complete the following steps utilizing the USER MENU located on the front panel of the unit.

1. Turn on the 7500 . See Section 3.1 – Powering Up the 7500 .
2. Press ENTER button. The display should appear as shown in Figure 2–3 Device Setup Menu.
3. Press ◄ and ► buttons until MEASUREMENT FILTER appears in the display.
4. Press ▲ and ▼ buttons until desired measurement filter is reached.
5. Press ENTER to exit Device Setup Menu.

3.3.3   EXTERNAL SENSOR

If currents continuously reach above 20 amps, an external sensor must be used.

3.3.3.1   Hardware Connection

In any of the wiring modes, any one of the amp meters may be replaced. The following diagram illustrates the connection.
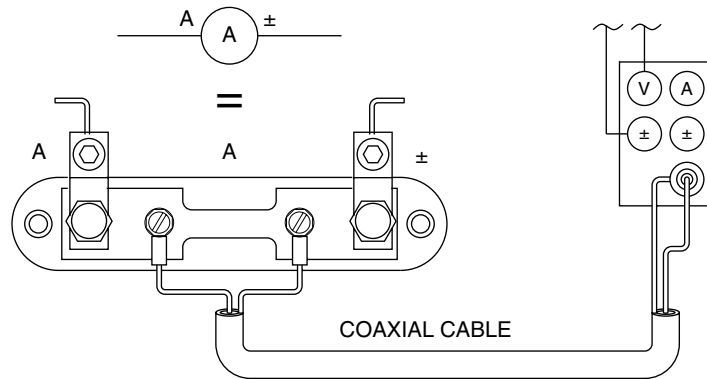
Figure 3–18 Sensor Substitution Wiring Schematic
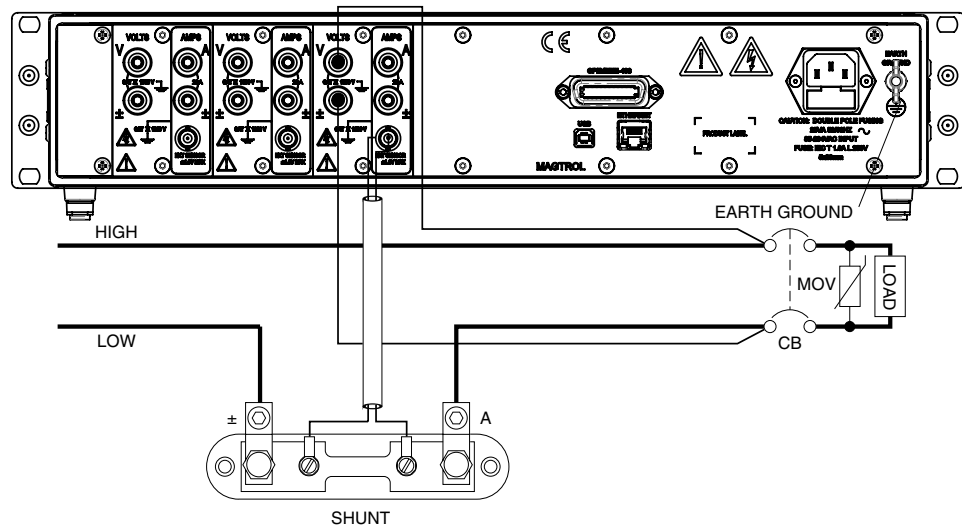
Figure 3–19 Sensor Substitution Wiring Connection

3.3.3.2   Software Configuration

To configure the 7500 external sensor, complete the following steps utilizing the USER MENU located on the front panel of the unit.

1. Turn on the 7500 . See Section 3.1 – Powering Up the 7500 .
2. Press ENTER button. The display should appear as shown in Figure 2–3 Device Setup Menu.
3. Press ◀ and ▶ buttons until EXTERNAL SENSOR appears in the display.
4. Press ENTER button. The display will appear as follows.

CURRENT	VOLTAGE	POWER/PF
1.0000A/mV	1.0000A/mV	1.0000A/mV
A1	A2	A3

Figure 3–20 External Sensor Scale Factor Setup Menu

5. To set the scale factor for A1, press the RMS button under A1 and use the ▲▼◀▶ buttons in the USER MENU to adjust the value.
6. To set the scale factor for A2, press the RMS button under A2 and use the ▲▼◀▶ buttons in the USER MENU to adjust the value.
7. To set the scale factor for A3, press the AVG button under A3 and use the ▲▼◀▶ buttons in the USER MENU to adjust the value.
8. Press ENTER to exit the Device Setup Menu.

SETUP

3.3.4   CURRENT SCALING

The current measurement range can be extended by using a current transformer. Frequency response will be determined by the characteristics of the transformer used.

3.3.4.1   Hardware Connection
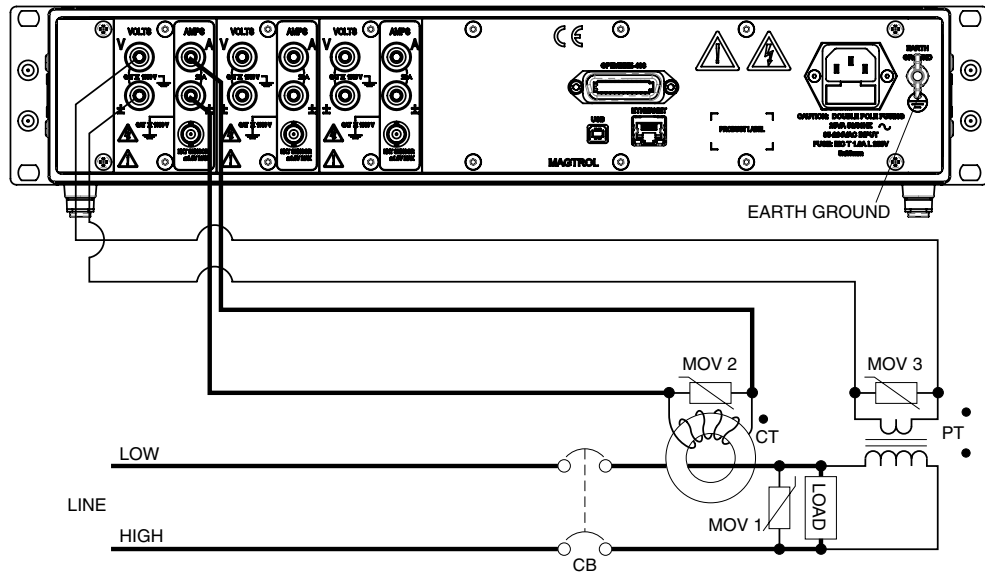
Figure 3–21 Current/Potential Transformer Connection

3.3.4.2   Software Configuration

To configure the 7500 current scaling for a current transformer, complete the following steps utilizing the USER MENU located on the front panel of the unit.

1.   Turn on the 7500 . See Section 3.1 – Powering Up the 7500 .
2.   Press ENTER button. The display should appear as shown in Figure 2–3 Device Setup Menu.
3.   Press ◄ and ► buttons until AMP SCALING appears in the display.
4.   Press ENTER button. The display will appear as follows.

Figure 3–22 Current Scaling Setup Menu

5.   To set the current scaling for phase 1, press the RMS button under A1 and use the ▲▼◄► buttons in the USER MENU to adjust the value.
6.   To turn phase 1 scaling ON, press the PEAK-CF button under OFF until ON is reached.
7.   To set the current scaling for phase 2, press the RMS button under A2 and use the ▲▼◄► buttons in the USER MENU to adjust the value.

8. To turn phase 2 scaling ON, press the PEAK-CF button under OFF until ON is reached.

9. To set the amp scaling for phase 3, press the AVG button under A3 and use the ▲▼◄►
    buttons in the USER MENU to adjust the value.

10. To turn phase 3 scaling ON, press the PEAK HOLD button under OFF until ON is reached.

11. Press ENTER to exit the Device Setup Menu.

☞   Note: When current scaling has been activated, "*" will appear in the main
                       menu next to the current range as shown in the following figure.

SETUP

```
        CURRENT                VOLTAGE               POWER/PF

    0.000 AXXX            0.000 VXXX            0.000 XXXX

        000XX*                000V*                 SHIFT
```

⌗ SCALING ACTIVATED

Figure 3–23 Current/Voltage Scaling Activated

3.3.5   Voltage Scaling

The voltage measurement range can be extended by using a potential transformer. Frequency response will be determined by the characteristics of the transformer used.

3.3.5.1   Hardware Connection

See Figure 3–21 Current/Potential Transformer Connection.

3.3.5.2   Software Configuration

To configure the 7500 volt scaling for a potential transformer, complete the following steps utilizing the USER MENU located on the front panel of the unit.

1. Turn on the 7500 . See Section 3.1 – Powering Up the 7500 .
2. Press ENTER button. The display should appear as shown in Figure 2–3 Device Setup Menu.
3. Press ◄ and ► buttons until VOLT SCALING appears in the display.
4. Press ENTER button. The display will appear as follows.

```
 ┌─────────────────────────────────────────────────────────┐
 │   CURRENT              VOLTAGE              POWER/PF       │
 │ ┌───────────────────────────────────────────────────────┐│
 │ │  1.0000 V/V         1.0000 V/V         1.0000 V/V     ││
 │ │                                                        ││
 │ │     V1    XXX          V2    XXX          V3    XXX    ││
 │ └───────────────────────────────────────────────────────┘│
 └─────────────────────────────────────────────────────────┘
```

Figure 3–24 Volt Scaling Setup Menu

5. To set the volt scaling for phase 1, press the RMS button under V1 and use the ▲▼◄► buttons in the USER MENU to adjust the value.
6. To turn phase 1 scaling ON, press the PEAK-CF button under OFF until ON is reached.
7. To set the volt scaling for phase 2, press the RMS button under V2 and use the ▲▼◄► buttons in the USER MENU to adjust the value.
8. To turn phase 2 scaling ON, press the PEAK-CF button under OFF until ON is reached.
9. To set the volt scaling for phase 3, press the AVG button under V3 and use the ▲▼◄► buttons in the USER MENU to adjust the value.
10. To turn phase 3 scaling ON, press the PEAK HOLD button under OFF until ON is reached.
11. Press ENTER to exit the Device Setup Menu.

☞   Note: When volts scaling has been activated, "*" will appear in the main menu next to the volts range as shown in Figure 3–23 Current/Voltage Scaling Activated.

3.3.6   PHASE SETUP

Once the wiring mode, measurement filter, external sensor, current scaling and voltage scaling have been connected and configured, the unit is ready to be configured for each individual phase.

☞ | Note: The PHASE button on the 7510 is not activated.

1. To select phase, press PHASE button until desired phase is reached.
2. Select current measurement mode (DC, RMS, peak, crest factor or peak hold).
    a. To select DC press SHIFT and release, then press DC button located in CURRENT RANGE section of front panel.
    b. To select RMS press SHIFT and release, then press RMS button located in CURRENT RANGE section of front panel.
    c. To select peak, crest factor or peak hold, press SHIFT and release, then press PEAK-CF button located in CURRENT RANGE section of front panel. Keep pressing SHIFT and PEAK-CF buttons until desired selection appears in display. For more information on peak, crest factor and peak hold, see Section 4.3 – Measurement Modes.
3. Select current range by using the ▲ and ▼ buttons located in CURRENT RANGE section of front panel. Selections include 50 mV, 250 mV, 0.5 V and 1 V when using an external sensor and 1 A, 5 A, 10 A and 20 A when using current input.
4. Select voltage measurement mode (DC, RMS, peak, crest factor or peak hold).
    a. To select DC press SHIFT and release, then press DC button located in VOLTAGE RANGE section of front panel.
    b. To select RMS press SHIFT and release, then press RMS button located in VOLTAGE RANGE section of front panel.
    c. To select peak, crest factor or peak hold, press SHIFT and release, then press PEAK-CF button located in VOLTAGE RANGE section of front panel. Keep pressing SHIFT and PEAK-CF buttons until desired selection appears in display. For more information on peak, crest factor and peak hold, see Section 4.3 – Measurement Modes.
5. Select voltage range by using the ▲ and ▼ buttons located in VOLTAGE RANGE section of front panel. Selections include 30 V, 150 V, 300 V and 600 V.
6. Press W-VA-PF button until desired selection is reached. Selections include Wx↑, Wx, VAx and PFx where "x" is equivalent to the selected phase.
7. Repeat steps 1-6 for each phase.
8. Once the individual phases have been configured, cycle-by-cycle or continuous must be chosen. See Section 4.4 – Measurement Methods.
    a.1. For cycle-by-cycle mode, press CYC-CONT button until display shows source reading in lower right corner similar to the following figure.
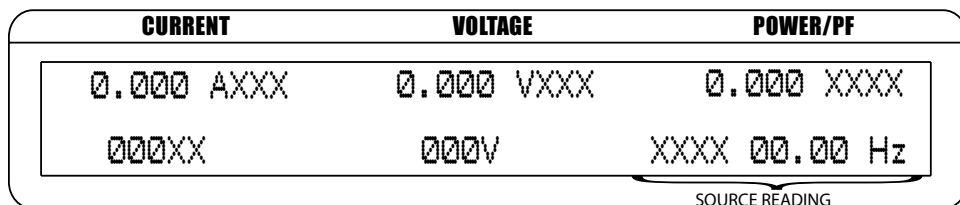
Figure 3–25 Cycle-by-Cycle Mode

a.2. A source now needs to be selected. Press SHIFT button and release, then press SOURCE button. Keep repeating until desired source selection is reached. Selections include V1, A1, V2, A2, V3 and A3.

b. For continuous mode, press CYC-CONT until display does not show any readings in the lower right corner.

3.3.7   SPECIAL FUNCTIONS

3.3.7.1   Hold

- • Freezes display values.
- • To set, press and release HOLD button. The display will appear as follows, indicating that the hold function is enabled.

CURRENT	VOLTAGE	POWER/PF
0.000 AXXX ●	0.000 VXXX ●	0.000 XXXX
000XX	000V	

● HOLD MODE INDICATORS
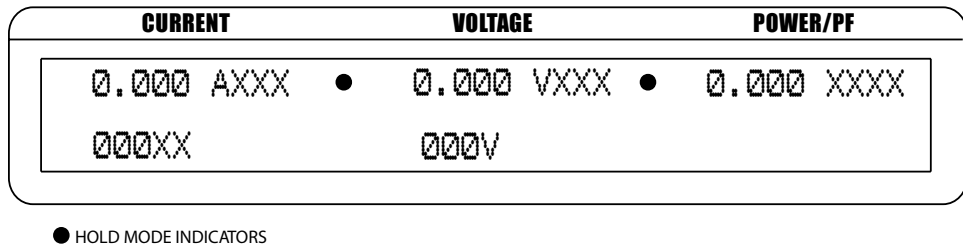
Figure 3–26 Hold Mode

- • To disable, press and release HOLD button.

3.3.7.2   Average

- • Mode in which the power analyzer displays the running average of current, voltage and power.
- • Used to stabilize mildly fluctuating readings or to determine watt-hours when used in conjunction with a timer.
- • To set, press SHIFT button and release, then press AVG. The display will appear as follows, indicating that the Average Function is enabled.

CURRENT	VOLTAGE	POWER/PF
0.000 AXXX 🕐	0.000 VXXX 🕐	0.000 XXXX
000XX	000V	

🕐 AVERAGE MODE INDICATORS
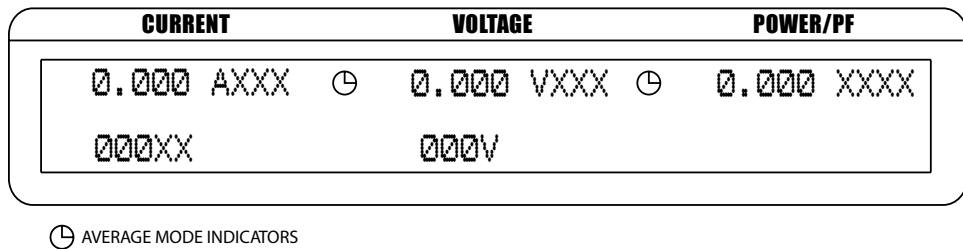
Figure 3–27 Average Mode

- • To disable, press SHIFT button and release, then press AVG.

SETUP

3.3.7.3   Peak Hold

- Clears peak hold/inrush reading.
- To enable, press SHIFT button and release, then press PEAK HOLD. The display will flash the following, then return to the main menu.

CURRENT	VOLTAGE	POWER/PF
	PEAK HOLD CLEAR	
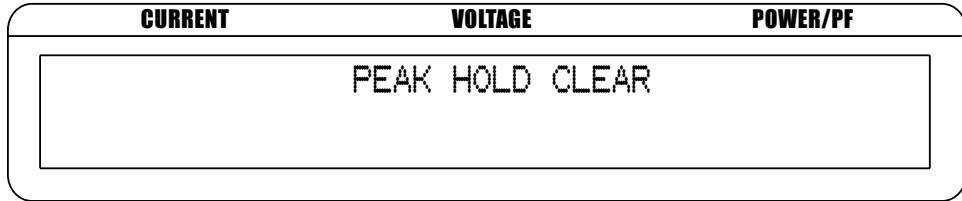
Figure 3–28 Peak Hold Clear Display

3.3.7.4   Custom Display

- The display can be configured to present data in any format.
- To set, press SHIFT button and release, then press DISPLAY. The display will appear as follows.

CURRENT	VOLTAGE	POWER/PF
▶		
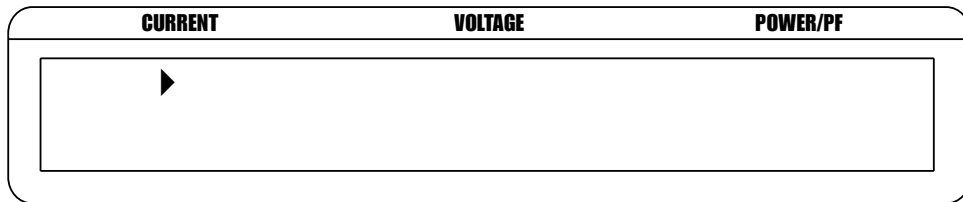
Figure 3–29 Custom Display

- There are 6 fields in the display that can be customized with information based on previous individual phase setups. To set, from the USER MENU control buttons, toggle from field to field by using the ◀ and ▶ buttons and make selections using the ▲ and ▼ buttons. If there is not a preferred value for a specific field, press ENTER when the field is selected and it will be deleted from the display.

CURRENT	VOLTAGE	POWER/PF
0.000 XXXX	0.000 XXXX	0.000 XXXX
0.000 XXXX	0.000 XXXX	0.000 XXXX
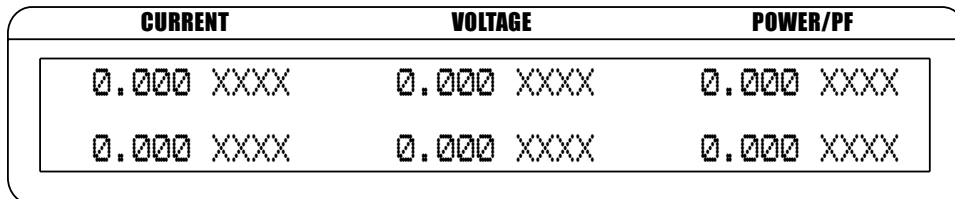
Figure 3–30 Custom Display Menu

4. Operating Principles

4.1   ANALOG PROCESSING

4.1.1   VOLTAGE

The voltage signal is brought in through a precision voltage divider of 2 M and 2.4 k resistors. The gain is 0.0012. This signal is buffered (GAIN = 1) and passed into a programmable gain section. The gains for the voltage ranges are given below.

Range	Resistors	Gain (Amplifier)
30 V	12 k / 620	-19.350
150 V	2.4 k / 620	-3.871
300 V	1.2 k / 620	-1.936
600 V	620 / 620	-1.000

The signal is then presented to an AD7722AS 16-bit analog to digital converter. The part accepts an input signal of ± 1.25 volts centered on a 2.5 VDC volt bias. The chart below shows system input at 10% and 100% of range.

Range	Voltage In (VDC)	Gain (total)	Voltage at A/D Input	Bits
30 V	3	-0.023220	-0.0697	1826
	30	-0.023220	-0.6966	18261
150 V	15	-0.004645	-0.0697	1826
	150	-0.004645	-0.6968	18265
300 V	30	-0.002323	-0.0697	1827
	300	-0.002323	-0.6969	18269
600 V	60	-0.001200	-0.0720	1887
	600	-0.001200	-0.7200	18874

Converter Resolution: 2.5 / 2^16 = 2.5 / 65536 = 0.00003814697

4.1.2   CURRENT

The current signal is brought in through a precision shunt of 0.012 ohms. This signal is amplified by 2 and passed into a programmable gain section. The gains for the voltage ranges are given below.

Range	Resistors	Gain (Amplifier)
1 A	12 k / 620	-19.350
5 A	2.4 k / 620	-3.871
10 A	1.2 k / 620	-1.936
20 A	620 / 620	-1.000

The signal is then presented to an AD7722AS 16-bit analog to digital converter. The part accepts an input signal of $\pm$ 1.25 volts centered on a 2.5 VDC volt bias. The chart below shows system input at 10% and 100% of range.

Range	Current (ADC)	Shunt Volts	Frist Stage Current	Gain	Voltage at A/D Input	Bits
1 A	0.1	0.0012	-0.0024	-19.35000	0.0464	1217
	1.0	0.0120	-0.0240	-19.35000	0.4644	12174
5 A	0.5	0.0060	-0.0120	-3.87100	0.0465	1218
	5.0	0.0600	-0.1200	-3.87100	0.4645	12177
10 A	1.0	0.0120	-0.0240	-1.93600	0.0465	1218
	10.0	0.1200	-0.2400	-1.93600	0.4646	12180
20 A	2.0	0.0240	-0.0480	-1.00000	0.0480	1258
	20.0	0.2400	-0.4800	-1.00000	0.4800	12583

Converter Resolution: 2.5 / 2^16 = 2.5 / 65536 = 0.00003814697
Shunt resistance = 0.012

THEORY

4.1.3 EXTERNAL SHUNT

The external shunt signal is brought in through a precision voltage divider of 9.1 k and 9.1 k resistors. The gain is 0.50. This signal is buffered and passed into a programmable gain section. The gains for the voltage ranges are given below.

Range	Resistors	Gain (Amplifier)
50 mV	12 k / 620	-19.350
250 mV	2.4 k / 620	-3.871
500 mV	1.2 k / 620	-1.936
1000 mV	620 / 620	-1.000

The signal is then presented to an AD7722AS 16-bit analog to digital converter. The part accepts an input signal of +/- 1.25 volts centered on a 2.5 VDC volt bias. The chart below shows system input at 10% and 100% of range.

Range	Voltage In (VDC)	Gain (total)	Voltage at A/D Input	Bits
50 mV	0.005	-9.67500	-0.0484	1268
	0.050	-9.67500	-0.4838	12681
250 mV	0.025	-1.93550	-0.0484	1268
	0.250	-1.93550	-0.4839	12684
500 mV	0.050	-0.96800	-0.0484	1269
	0.500	-0.96800	-0.4840	12688
1000 mV	0.100	-0.50000	-0.0500	1311
	1.000	-0.50000	-0.5000	13107

Converter Resolution: 2.5 / 2^16 = 2.5 / 65536 = 0.00003814697

4.2 DIGITAL PROCESSING

Starting at the AD7722AS analog to digital converter, the input clock to the device is 14.31818 MHz. This clock frequency gives a sample rate or data output rate of 14318180 / 64 = 223721.5625 samples per second.

The 7500 Power Analyzer uses FPGA technique to implement DSP computing and IIR filter. The data can be stored up to 64 bit.

The following math is achieved by FPGA. N= 256

$$V_{rms} = \sqrt{\frac{1}{n} * (v_1^2 + v_2^2 + \ldots + v_{n-1}^2 + v_n^2)}$$

$$I_{rms} = \sqrt{\frac{1}{n} * (i_1^2 + i_2^2 + \ldots + i_{n-1}^2 + i_n^2)}$$

$$P = \frac{1}{n} * \sum_{k=1}^{n} v[k] * i[k]$$

THEORY

4.2.1   AC DETAILS

4.2.1.1   Interrupt Driven

The power analyzer will automatically update its data every 4.469 microseconds by completing the following sequence of events:

- The voltage input is read and checked for an over range condition. The offset is then added to the reading and the reading is negated and saved.
- The current input is read and checked for an over range condition. The offset is then added to the reading and the reading is negated and saved.
- The voltage reading is checked to see if it is the peak and if so is stored.
- The current reading is checked to see if it is the peak and if so is stored.
- The voltage reading is squared and the squared reading is summed.
- The voltage and amp reading is multiplied and the multiplied value is summed.
- The current reading is squared and summed.

☞	Note: After 256 readings are summed, the sums are transferred to a 64-bit V^2 register, a 64-bit VI register, and a 64-bit I^2 register. A sample ready flag is set.

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4.2.1.2   FPGA Program

The program reads that a sample is ready.

Divide the V^2 register by 256.
Store V^2 in a 32-bit register.
The result is appended to a 32 word circular buffer.
Add buffer contents and divide by 32.
The result is appended to a 2cd 32 word circular buffer.

Divide the I^2 register by 256.
Store I^2 in a 32-bit register.
The result is appended to a 32 word circular buffer.
Add buffer contents and divide by 32.
The result is appended to a 2cd 32 word circular buffer.

Divide VI register by 256.
Store VI in a 32-bit register.
The result is appended to a 32 word circular buffer.
Add buffer contents and divide by 32.
The result is appended to a 2cd 32 word circular buffer.

Add 2cd V^2 buffer contents and divide by 32. Save this value.
Add 2cd I^2 buffer contents and divide by 32. Save this value.
Add 2cd VI buffer contents and divide by 32. Save this value.

Each sample is now 256 X (32 + 32) (16384) a/d samples. At 223721.5625 samples per second that is 73.23388 ms for a new input to fully average.

The VI sample is applied to an RC filter algorithm.
The output of the filter is multiplied by a gain value.
This value is stored for output.

The V^2 sample is applied to an RC filter algorithm.
The square root of the output is taken.
The result is multiplied by a gain value.
This value is stored for output.

The I^2 sample is applied to an RC filter algorithm.
The square root of the output is taken.
The result is multiplied by a gain value.
This value is stored for output.

These values are updated at 873.912 readings per second.

Every 8th time through the loop or at a rate of 109.239 the V and I peak values are stored for output and the data ready flag is set.

THEORY

4.2.2   DC DETAILS

4.2.2.1   Interrupt Driven

The power analyzer will automatically update its data every 4.469 microseconds by completing the following sequence of events:

- The voltage input is read and checked for an over range condition. The offset is then added to the reading and the reading is negated and saved.
- The current input is read and checked for an over range condition. The offset is then added to the reading and the reading is negated and saved.
- The voltage reading is checked to see if it is the peak and if so, is stored.
- The current reading is checked to see if it is the peak and if so, is stored.
- The voltage reading is summed.
- The current reading is summed.
- The voltage and amp reading is multiplied.
- The multiplied value is summed.

☞   Note: After 256 readings are summed the sums are transferred to a 64-bit V register, a 64-bit I register, and a 64-bit VI register. A sample ready flag is set.

THEORY

4.3   MEASUREMENT MODES

4.3.1   PEAK

The peak value is defined as the highest value that occurs in the cycle of a repetitive waveform.

The graph below shows one cycle of a repetitive waveform. The peak value is shown. The absolute value of the reading is used to determine the peak value.
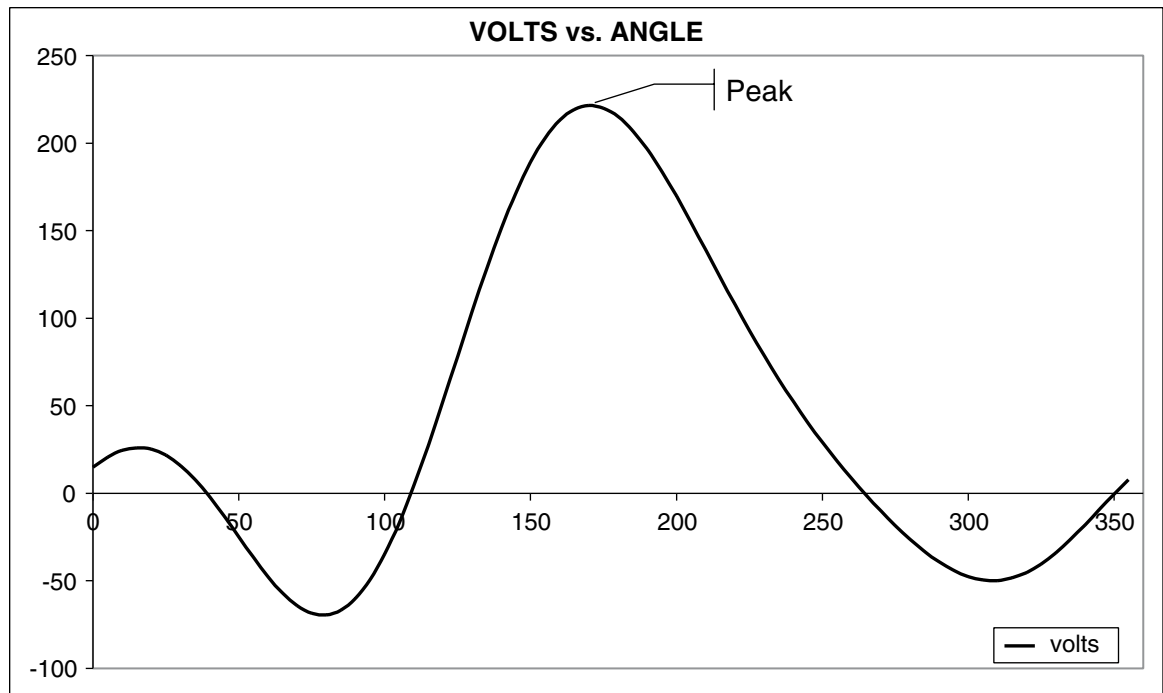
Figure 4-1 Peak Example

THEORY

4.3.2   PEAK HOLD / INRUSH CURRENT

Peak hold/inrush current allows the 7500 to store the highest value read in a designated period of time, the designated period of time being the time span since the last peak hold clear occurred. Values include current, power and voltage in any preferred combination. See Section 3.3.7.3 – Peak Hold.

The graph below shows the current draw from a 1/3 horsepower motor during initial startup. At startup the current inrush peaks at about 14 amps then settles to 4.25 amps. When the unit is in peak hold/ inrush mode of operation, the front panel current reading displays 14.033 amps. The current reading indicates the peak inrush current, which is determined by the RMS value.

The operation of the voltage and power peak hold follows the same operation as explained for the current above.
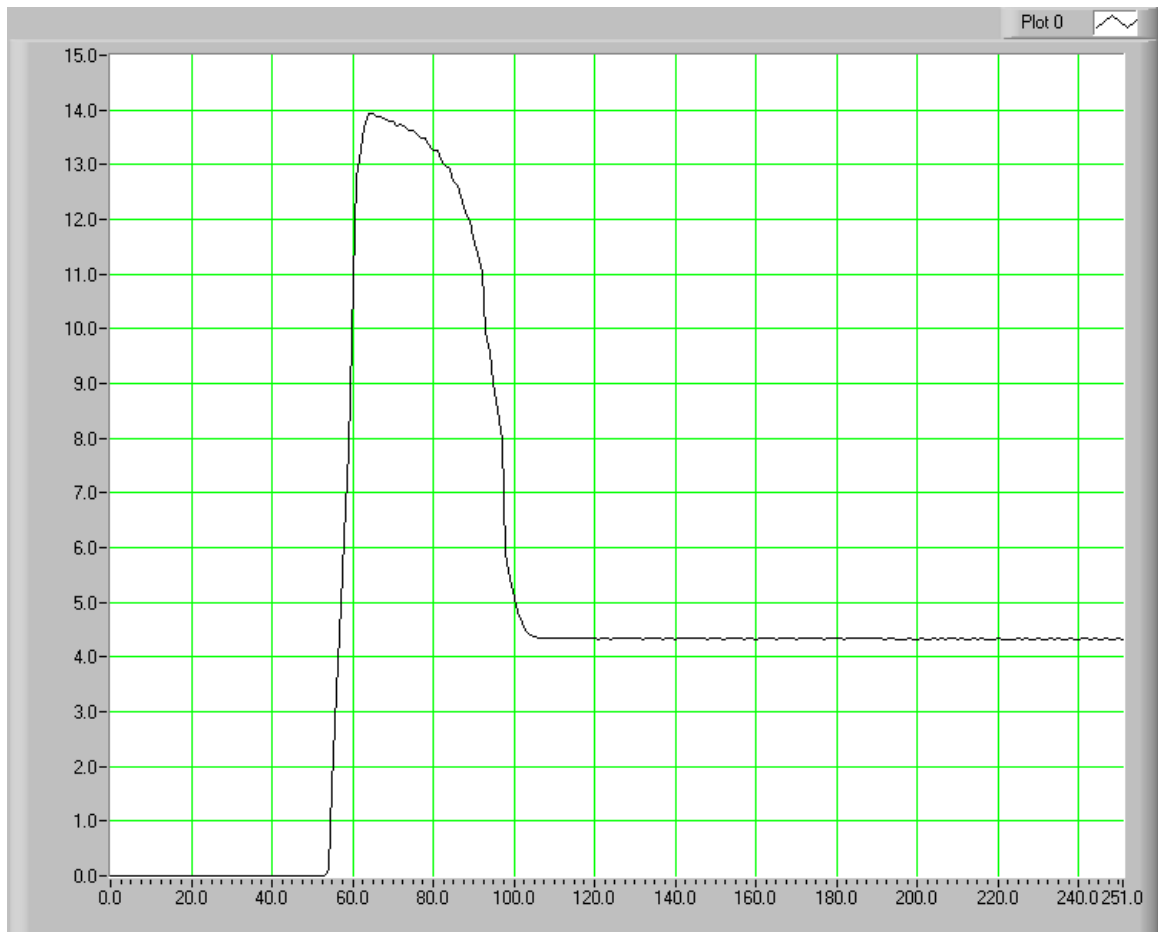
Figure 4–2 Peak Hold/Inrush Current Example

4.3.3   DC

See Section 4.2.2 – DC Details.

4.3.4   RMS

See Section 4.2.1 – AC Details

4.3.5   CREST FACTOR

The crest factor measurement is determined by dividing the peak measurement by the RMS measurement. See the following graph for reference.
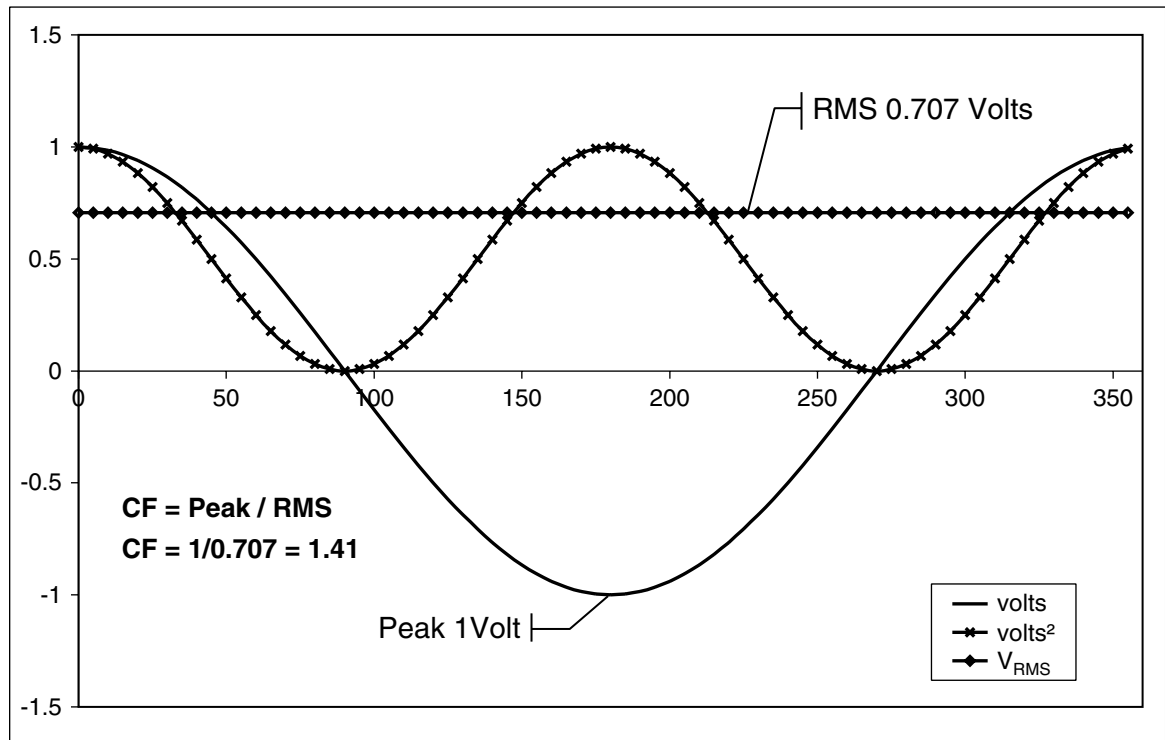
Figure 4–3 Crest Factor Example

4.4   MEASUREMENT METHODS

4.4.1   CYCLE-BY-CYCLE MODE

In the cycle-by-cycle mode the power analyzer looks at each complete cycle of the incoming waveform. The measurements are valid from 20 Hz to 500 Hz. The power analyzer may be synchronized from any of the phase voltage or current inputs, the line voltage or the back panel external sync input. If using voltage or current for synchronization, the input must be greater than 10% of the range setting.

4.4.2   CONTINUOUS MODE

In the continuous mode the measurement values are determined from continuously processed and filtered voltage and current input values. The measurements are valid from DC to 80 kHz and the output data rate from the process is about 109.24 samples per second. The power analyzer does not have to be synchronized to the measured waveform and the user may select the filter to be used in the mean process of the RMS value.

5. Computer Controlled Operation

Using the 7500 with a personal computer (PC) enables the unit to perform at its full capacity.

5.1   ABOUT THE GPIB INTERFACE

Magtrol prefers the GPIB (General Purpose Interface Bus)/IEEE-488 Standard for computer-to-instrument interfacing because:

- The GPIB parallel interface is faster than serial interfaces.
- The GPIB enables testers to access up to 15 instruments on one port. Because typical motor testing requires that at least five separate parameters be synchronized, a system of easy, fast access to more than one instrument is essential.
- The GPIB has rigid data formatting and hardware standards. These standards help to ensure that all functions will work properly when the hardware and software are installed.

☞   Note: The GPIB interface is not standard on most personal computers. An interface card and driver software must be installed. An IEEE-488 cable must also be installed between the computer and the 7500. Magtrol recommends National Instruments Corporation hardware and software.

5.1.1   INSTALLING THE GPIB/IEEE-488 CONNECTOR CABLE

⚠   CAUTION: MAKE SURE BOTH THE COMPUTER AND 7500 ARE TURNED OFF BEFORE INSTALLING THE GPIB CONNECTOR CABLE.

1. Connect one end of a high-quality, double-shielded cable to the 7500 GPIB connector.
2. Connect the other end to the GPIB interface in your PC.
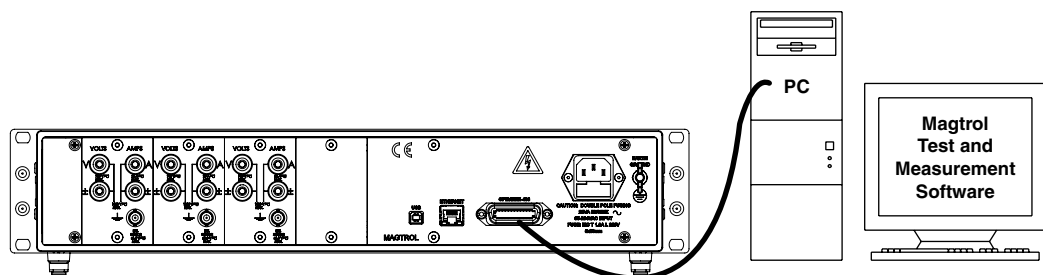
Figure 5–1 GPIB Installation

5.1.2   CHANGING THE GPIB PRIMARY ADDRESS

Each instrument serviced by the GPIB has its own primary address code, which enables the computer to obtain readings from the instrument. The factory default of the GPIB address on the 7500 is 14.

Some PC interfaces can access from one to fifteen 4-bit primary addresses. Other interfaces can access as many as thirty-one 5-bit primary addresses. The 7500 uses the 4-bit format. For setup,

complete the following instructions utilizing the USER MENU control buttons.

1. Press ENTER.
2. Use the ◀ and ▶ buttons until I/O is reached.
3. Press ENTER.
4. Use the ◀ and ▶ buttons until GPIB ADDRESS is reached. The display should appear as follows:
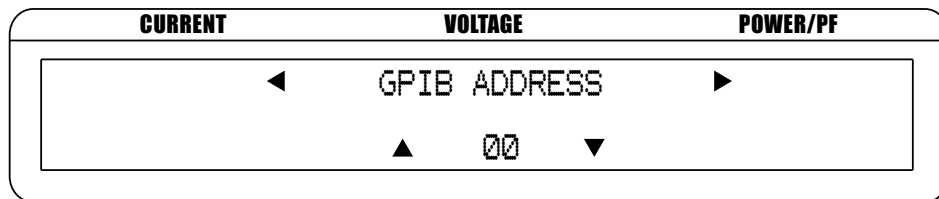
Figure 5–2 GPIB Address Setup Menu

5. Use the ▲ and ▼ buttons until desired primary address is reached (range 0-15).
6. Press ENTER to return to main menu.

5.2   ABOUT THE USB DRIVER

A high quality A-Male to B-Male cable is required to connect between the PC and the 7500. The USB-CDC class and the USB-TMC class are used on the 7500 Series Power Analyzer. In order to communicate through USB, first install the USB driver.

5.2.1   USB DRIVER SETUP FOR WINDOWS OPERATION SYSTEM

Copy the 7500.drivers.msi from the Magtrol Manual CD at programs\7500 Drivers directory into local drive of your PC.

☞   NOTE: If your PC is 64 bit operation system, then you need to run 7500.x64.msi to setup USB driver. If your PC is 32 bit operation system, then you need to run 7500.x86.msi to setup USB driver.

1. Power on the 7500. A window in the right corner will show "Installing device driver software".
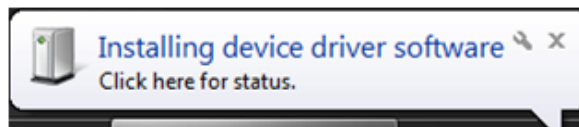
2. Click on the balloon depicted below will show which drivers did not install successfully.
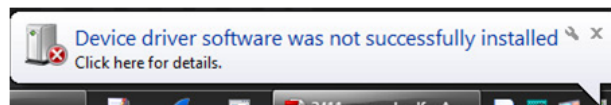
3. The 7500 is a composite device meaning that it offers more than one USB interface to your PC. The first device is a communications device class, also known as a virtual COM port. This interface allows the USB to act as a legacy RS-232 device, and allows you to use

programs such as Hyperterminal to control the 7500. The second interface is a USB Test and Measurement device. Drivers for this interface may already be installed on your computer. They are included as part of the MTEST 7 software. LabVIEW installations also include a version of compatible drivers to use with a test and measurement class interface. If you have either of these programs installed on your computer, when you click on the aforementioned balloon, the following window will appear.
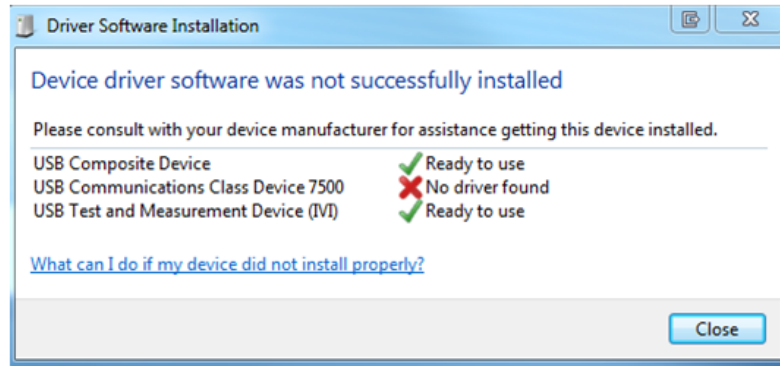
4. Locate 7500.driver.msi and double click 7500.drivers.msi. The following window will pop up.
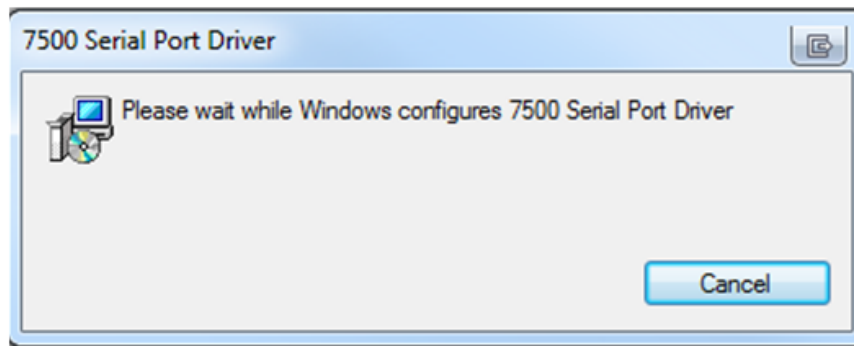
5. Ignore the warning and click yes to continue installation.
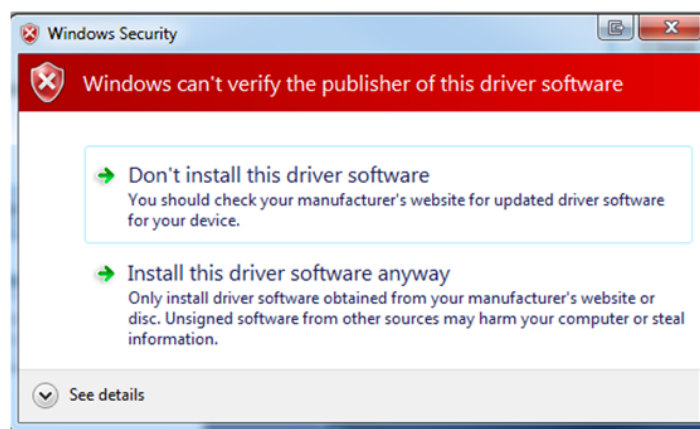
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6. This successfully installs the Virtual COM port drivers to your 7500.
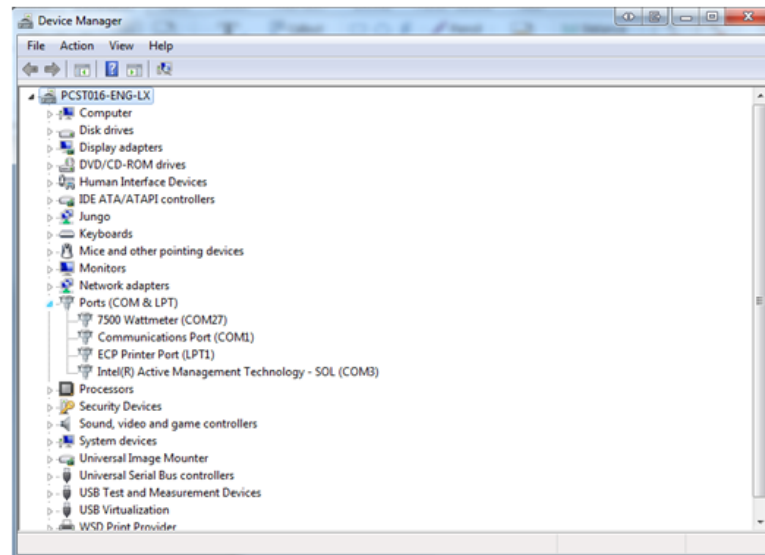
5.3   ABOUT THE ETHERNET INTERFACE

A RJ45 cable is used to connect between PC and 7500 device.

5.3.1   ETHERNET CONNECTION

You may use LabVIEW or any other programming language to write a custom program using sockets to open a connection to the 7500. The unit listens on port 7500 for any incoming connections. It is beyond the scope of this manual to discuss sockets programming, however, there are examples of programs implementing this technique available on the Magtrol website. Download the Mag.NET zip located in the downloads section of the web page. This page can be found under the support menu tab.

5.4   CHECKING THE 7500-TO-PC CONNECTION

☞   Note: Make sure that the 7500 and its host computer are communicating before acquiring data. Only one communication interface can be used at a time.

1. Issue output data command "*IDN?" through the GPIB, USB or ethernet interface.
2. Follow the two required data termination characters CR and LF. See Section 5.5 – Programming.

Desired Results

•   output_string = "Magtrol,7530,17A75000001,A0,A0"<delimiter>

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☞ Note: If the desired results did not occur, please see Chapter 8 – Troubleshooting.

☞ Note: Termination characters CR and LF are not required for ethernet and USB-TMC connection.

5.5 DATA FORMAT

- All measurement values are returned as an ASCII-string floating point in E notation.
- The same data format will be used for IEEE-488, USB and ethernet interface. See Section 5.6 – 7500 Communication Commands.
- Data is separated by commas.

Character	Definition
\s	space
\r	carriage return
\n	line feed
^	Located in the first returned character position indicating peak input value is above range, user needs to increase range. NOTE: If a space is located in the first returned character position, the input signal is within range and no changes need to be made.

Sections 5.4.1 through 5.4.3 contain return data format examples for the following:

- Output Total (MEAS:ALL)
- Output Voltage (MEAS:VOLTS)
- Output Element (MEAS:PHASE)
- Output Power (MEAS:WATTS)
- Output Current (MEAS:AMP)
- Output Frequency (MEAS:FREQ)

5.5.1 MEAS:ALL EXAMPLE

Total = 183 characters

Output String: (1-182) = measurement value float E notation (ANSI)

Data Position: A1, V1, W1, A2, V2, W2, A3, V3, W3, ΣA, ΣV, ΣW, Frequency

5.5.1.1 Good Response

\s\s1.86707E-01,\s\s1.19568E+02,\s\s1.32201E+01,\s-1.10599E-03,\s-3.28546E-02,\s\s0.00000E+00,\s-3.17532E-04,\s\s4.00554E-02,\s\s0.00000E+00,\s\s6.18068E-02,\s\s3.98861E+01,\s\s1.32390E+01,\s\s5.99982E+01\r\n

5.5.1.2 Over-Range Condition

\s\s1.85048E-01,^\s4.94537E+01,^\s4.20193E+00,\s-1.08896E-03,\s-3.04530E-02,\s\s0.00000E+00,\s-3.81305E-04,\s\s4.70035E-02,\s\s0.00000E+00,\s\s6.14162E-02,^\s1.65010E+01,^\s4.23552E+00,\s\s5.99860E+01\r\n

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5.5.2   MEAS:PHASE EXAMPLE

Total   = 43 characters

Output String: (1-42) = measurement value float E notation (ANSI)

Data Position: Ax, Vx, Wx (where x = requested phase)

5.5.2.1   Good Response

\s\s1.83352E-01,\s\s1.19342E+02,\s\s1.29812E+01\r\n

5.5.2.2   Over-Range Condition

\s\s1.84250E-01,^\s4.95238E+01,^\s4.26064E+00\r\n

5.5.3   MEAS:AMPS/MEAS:VOLTS/MEAS:WATTS/MEAS:FREQ EXAMPLE

Total   = 15 characters

Output String: (1-14) = measurement value float E notation (ANSI)

5.5.3.1   Good Response

\s\s1.19494E+02\r\n

5.5.3.2   Over-Range Condition

^\s4.94796E+01\r\n

5.6   PROGRAMMING

Note: Check the manual provided with your software for full instructions.

5.6.1   DATA TERMINATION CHARACTERS

Use the following information to answer the formatting questions asked when installing your GPIB software. All GPIB data acquisition systems require the use of data termination characters. The 7500 uses the GPIB standard termination characters Carriage Return (CR) and Line Feed (LF). Provide them in that order.

5.6.1.2   Codes for CR-LF

	BASIC	HEX	DEC
CR =	CHR$(13)	OD	13
LF =	CHR$(10)	OA	10

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5.7   MAG.NET COMMANDS

Each Magtrol instrument has a set of commands used to control it with a PC. These commands have a specific syntax. All commands fall under a COMMAND-GROUP. There are 11 Command Groups, shown below in Figure ??. Each command group organizes common commands under a single heading. Each COMMAND-GROUP has 4 characters, and is separated from the COMMAND by a colon. If the command has one or more parameters, they are separated from the COMMAND by a single space. Parameters are separated by a comma.

Each command has the following form:

COMMAND-GROUP:COMMAND<space>[parameter, [parameter]]

The 10 COMMAND-GROUPs are:

|*| (Common) – used for commands common to all instruments, includes *IDN?

|CALI|bration – performs all calibration sequences and queries calibration settings.

|CONF|igure – used to configure instrument settings.

|COMM|unication – used for all communication settings, including network, USB and GPIB

|DISP|lay – formats onboard display unit.

|FORM|at – formats the output of an instrument's measurements to a specific form.

|FUNC|tion – orders instrument to perform a specific task.

|MEAS|ure - used to query values of quantities the instrument measure, including speed, torque, and voltage.

|OUTP|ut – turn on/off instruments outputs

|STAT|us – monitor instruments status and alarm control. STAT:FAULT STAT:ALARM

IMPLIED ? PARAMETER

Every command which sets something through a parameter will also have as a parameter the '?', which will act as a way to find other what is currently set. This '?' parameter will be implied. "<SPACE> ?"

COMMAND RESPONSES

The Mag.NET Protocol enforces that every command will provide some type of meaningful response. The response will either consist of the information asked for, or the simple string "OK" to ensure the command completed without failure. When an error occurs, one of four error strings will be

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returned to signify what type of error occurred.

The identified error strings are:

ERR:SYNTAX – returned when there is a "typo" in the command (|MEES|)

ERR:PARAMETER COUNT – when the number of parameters given is not what is expected.

ERR:INVALID PARAMETER – when a parameter given is not an excepted value for the command

ERR:UNKNOWN – covers various situations and helps to identify programming errors made in code. This is the default error.

ERR:NO COMMAND GROUP – when the first four characters of a given string are not a valid command group.

IEEE-488	Address:	0-15
	Terminator:	carriage return followed by a line feed
USB-CDC Class	Terminator:	carriage return followed by a line feed

When entering a command code:

1. Type all characters in uppercase ASCII format.
2. End all commands with a carriage return followed by a line feed.
3. Do not string multiple commands together in one line.

Note: If a command is not recognized, error information will be returned. Please see Appendix C for detailed explanations.

Note: Terminator is not available on the Ethernet connection and USB-TMC class.

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5.7.1 |*| COMMANDS

Command Code	Function	Explanation
*IDN?	Returns Magtrol device identification, serial numbers and firmware and fpga revisions	Magtrol,75N0, SSSSSS,FIRM,FPGA Where N is the channel count (1, 2,3, 4) Where SSSSS is serial number of the assembly Where FIRM is revision firmware Where FPGA is revision firmware Example Magtrol,7530,17A75000001,A0,A0

5.7.2 |MEAS|URE COMMANDS

Command Code	Function	Explanation
MEAS:ALL	Outputs all available measurement values as a single comma delimited string. Values are given in E notation.	Output: A1, V1, W1, A2, V2, W2, A3, V3, W3,∑A, ∑V,∑W, f
MEAS:AMPS <phase>,<type>	Returns current measurement value at current instant.	<phase> indicates input phase. Valid values for <phase> are: 0 Sum of current phases 1 phase 1 2 phase 2 3 phase 3 <type> indicates the type of measurement. Valid values for <type> are: 0 RMS / DC (dependent on mode) 1 peak (instantaneous) 2 crest factor 3 peak hold / inrush
MEAS:CONF	Returns the measurements the CONF:MEAS currently has configured to return.	
MEAS:DISPLAY	Retrieves displayed values of current, voltage and power format as the OE command in average mode.	
MEAS:FREQ	Returns the current output frequency.	
MEAS:PHASE <phase>	Returns the current, voltage and power measurements of the requested phase.	<phase> indicates the the desired phase measurements Valid values for <phase> are 0 sum of phases (wiring dependent) 1 phase 1 2 phase 2 3 phase 3
MEAS:VOLTS <phase>,<type>	Returns voltage measurement value at the current instant.	<phase> indicates input phase. Valid values for <phase> are: 0 average of voltage phases 1 phase 1 2 phase 2 3 phase 3 <type> indicates the type of measurement. Valid values for <type> are: 0 RMS / DC (dependent on mode) 1 peak (instantaneous) 2 crest factor 3 peak hold / inrush

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Command Code	Function	Explanation
MEAS:WATTS <phase>,<type>	Returns the power measurement at the current instant.	<phase> indicates input phase. Valid values for <phase> are: 0 sum of power phases 1 phase 1 2 phase 2 3 phase 3 <type> indicates the type of measurement. Valid values for <type> are: 0 watts 1 VA 2 Power factor 3 Watts peak hold

5.7.3 |CONF|IGURATION COMMANDS

☞ NOTE: The current configuration can be read by replacing the parameter with a question mark "?"Example: CONF:MEASFILTER ? will return the current filter setting

Command Code	Function	Explanation
CONF:AMPS <phase>,<?|range>	Sets auto or manual range mode for the current phases.	<phase> indicates the input phase Valid inputs for <phase> are: 0 all phases 1 phase 1 2 phase 2 3 phase 3 Valid inputs for <range> are: ? returns the phases current setting 0 manual range 1 auto range
CONF:VOLTS <phase>,<?|range>	Sets auto or manual range mode for the voltage phases.	<phase> indicates the input phase Valid inputs for <phase> are: 0 all phases 1 phase 1 2 phase 2 3 phase 3 Valid inputs for <range> are: ? returns the phases current setting 0 manual range 1 auto range

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Command Code	Function	Explanation
CONF:IRMSDC <phase>, <?|RMS|DC>	Sets the measurement mode of the current phases to either RMS or DC.	<phase> indicates the input phase Valid inputs for <phase> are: 0 all phases 1 phase 1 2 phase 2 3 phase 3 <RMS|DC> indicates measurement mode Valid inputs for <RMS|DC> are: ? returns the current phases setting 0 RMS (AC and DC) 1 DC
CONF:VRMSDC <phase>, <?|RMS|DC>	Sets the measurement mode of the voltage phases to either RMS or DC.	<phase> indicates the input phase Valid inputs for <phase> are: 0 all phases 1 phase 1 2 phase 2 3 phase 3 <RMS|DC> indicates measurement mode Valid inputs for <RMS|DC> are: ? Returns the current phases setting 0 RMS (AC and DC) 1 DC
CONF:FREQSRC <?|source>	Sets the frequency source for the cycle-by-cycle mode.	<source> indicates the input to use as the fundamental source. Valid values for <source> are: ? returns current setting 0 V1 1 A1 2 V2 3 A2 4 V3 5 A3
CONF:MEAS <str>,<str>, …	Configures what data is output to the user, and the order in which it appears. See MEAS:CONF command to obtain the configured measurements	Values for <str> are CURRENT DISPLAY FREQ PHASE VOLTAGE POWER Choose one to … parameters in any order. ? is valid as well, but can be the only parameter. It will return the current configured measurement. Example: CONF:MEAS AMPS,1,0,VOLTS,2,0 CONF:DISPLAY,A,DISPLAY,V,DISPLAY,W

Command Code	Function	Explanation
CONF:MEASFILTER <?|filter>	Sets the AC and DC measurement filter.	<filter> indicates the low pass frequency filter used. Valid values for <filter> are: ? returns the current filter choice 0 1 Hz 1 2 Hz 2 5 Hz 3 10 Hz 4 20 Hz 5 50 Hz 6 100 Hz
CONF:IRANGE <phase>,<?|range>	Sets the input source and acceptable current range.	<phase> indicates the input phase Valid input s for <phase> are: 0 all phases 1 phase 1 2 phase 2 3 phase 3 <range> indicates current range. Valid values for <range> are: ? returns the phases current setting 0 20 A 1 10 A 2 5 A 3 1 A 4 1 V (ext sensor input range) 5 500 mV (ext sensor input range) 6 250 mV (ext sensor input range) 7 50 mV (ext sensor input range)
CONF:ISCALE <phase>,<?|scale>	Sets the current scaling constant.	<phase> indicates the input phase Valid input s for <phase> are: 0 all phases 1 phase 1 2 phase 2 3 phase 3 <scale> indicates the current scaling constant in A/A. Valid values for <scale> are ? to return the current scale setting floating point numbers within the following range: 0.01 < scale < 10000.0 When <scale> is set to 0 scaling mode will be cleared
CONF:VRANGE <phase>,<?|range>	Sets the voltage input range for a certain phase	<phase> indicates the input phase Valid input s for <phase> are: 0 all phases 1 phase 1 2 phase 2 3 phase 3 <range> indicates voltage range. Valid values for <range> are: ? returns current voltage range setting 0 600 V 1 300 V 2 150 V 3 30 V

OPERATION

Command Code	Function	Explanation
CONF:VSCALE <phase>,<?|scale>	Sets the voltage scaling constant	<phase> indicates the input phase Valid input s for <phase> are: 0 all phases 1 phase 1 2 phase 2 3 phase 3 <scale> indicates the voltage scaling constant in Volts/Volts. Valid values for <scale> are: ? return current voltage scale setting floating point numbers within the following range: 0.01 < scale < 10000.0 When <scale> is set to 0, the voltage scaling mode will be cleared
CONF:MEASMODE <?|type>	Sets the continuous or cyclic measurement mode filter.	<type> indicates whether the measurement mode is continuous or cyclic Valid values for <type> are: ? return the current mode 0 continuous 1 cycle-by-cycle
CONF:EXTISCALE <phase>,<?|scale>	Sets the external sensor scaling constant	<phase> indicates the input phase Valid input s for <phase> are: 0 all phases 1 phase 1 2 phase 2 3 phase 2 <scale> indicates the current scaling constant in A/mV . Valid values for <scale> are ? returns the current external sensor scale setting floating point numbers within the following range: 0.0001 < scale < 99999.0 NOTE: External sensor voltage input values are divided by this value to give output in current when using the external sensor input current ranges.
CONF:WIREMODE <?|wiremode>	Sets the wiring mode for the sum measurement values	<wiremode> indicates the wiring mode. Valid values for <wiremode> are ? returns the current wiremode 0 1-phase, 2-wire 1 1-phase, 3-wire 2 3-phase, 3-wire 3 3-phase, 4-wire 4 3-volt, 3-amp

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5.7.4 |FUNC|TION COMMANDS

Command Code	Function	Explanation
FUNC:AVERAGE <start|clear>	Starts average mode or clears average mode depending on the given parameter	<start> starts averaging mode <clear> clears averaging mode
FUNC:CLRPEAK	Clears peak hold values	No parameters

5.7.5 |COMM|UNICATION COMMANDS

Commnad Code	Function	Explanation
COMM:DHCP <0|1|?>	Turns DHCP on/ off. You must send the COMM:UPDATE command following the DCHP command for the change to take place. When disabling DHCP, you must set a static IP address, gateway, and subnet mask prior to sending the COMM:UPDATE command. Contact your network administrator for the appropriate network settings.	Possible Parameters are: 0 Disables DHCP 1 Enables DHCP ? Tells the current state Returns OK
COMM:GATEWAY <?|xxx.xxx.xxx.xxx>	Sets the current gateway address used. You must send the COMM:UPDATE command after changing the gateway for the new setting to take effect.	Possible Parameters: ? returns the current gateway address xxx.xxx.xxx.xxx is a valid IP address
COMM:HOSTNAME <?|name>	Sets the hostname of the device. This hostname may be used in a web browser instead of an IP address to view the web interface.	Possible Parameters: ? returns the current hostname name sets the current hostname, must be 15 characters or less. Invalid character list: \, /, :, *, ?,", <, >, |
COMM:IP <?|xxx.xxx.xxx.xxx>	Sets a static IP address. You must send the COMM:UPDATE command after changing the IP address for the new setting to take effect.	Possible Parameters: ? returns the current IP address xxx.xxx.xxx.xxx is a valid IP address
COMM:MAC <?|XXXXXXXXXXXX>	Sets the current MAC address.	Possible Parameters: ? returns the current MAC address XXXXXXXXXXXX is a valid MAC address, only 0-9, A, B, C, D, E, F are valid characters.

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Commnad Code	Function	Explanation
COMM:NETMASK <?|xxx.xxx.xxx.xxx>	Sets the current netmask. You must send the COMM:UPDATE command after changing the netmask for the new setting to take effect.	Possible Parameters: ? returns the current gateway address xxx.xxx.xxx.xxx is a valid netmask
COMM:UPDATE	Saves all LAN settings to non-volatile memory and activates them. To disable DHCP, a static IP, gateway, and netmask must have been set prior to calling the UPDATE command. If a static IP is already in use, UPDATE can be used to change any single static network setting, i.e. netmask, or gateway.	No Parameters Returns OK, or error if the update cannot be completed.

5.8   WEB INTERFACE OPERATION

Use the Ethernet cable to connect the 7500 to a switch, a router, or a wall outlet. To access the web interface of the 7500, you must know the IP address of your unit. By default, the 7500 is assigned an IP address by DHCP. To discover what IP address it has been assigned, send the command "COMM:IP ?" via USB and get the IP address. Alternatively, 7500 can use a static IP address and a crossover Ethernet cable should be used. At the same time the PC network needs to be set up accordingly. Once the units IP address is know, open a web browser on any computer in the same local network as your 7500 and type the units IP into the address bar. Alternatively, you can use http://magtrol7500/ to access the web interface. The web interfaces home page is depicted below. It will mirror the display of the 7500.

Figure 5–3 Web Interface Home Page

6. Calibration

6.1   CLOSED-BOX CALIBRATION

The 7500 features closed-box calibration. The advantage of closed-box calibration is that the user does not have to disassemble the case or make mechanical adjustments.

6.2   CALIBRATION SCHEDULE

Calibrate the 7500:
- After any repairs are performed.
- At least once a year (recommended); more frequently to ensure required accuracy.

6.3   CALIBRATION COMMANDS

| Command Code	Function	Explanation
	Calibrates current measurement value of present input range.	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates the calibrated input value applied to the input. When m2 is equal to 0, the unit assumes zero calibration is requested and zero current are on input. When m2 is greater than 0, the unit assumes gain calibration is requested and m2 current are on input.
	Calibrates voltage measurement value of present input range.	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates the calibrated input value applied to the input. When m2 is equal to 0, the unit assumes zero calibration is requested and zero voltage are on input. When m2 is greater than 0, the unit assumes gain calibration is requested and m2 volts are on input.
CS<terminator>	Saves calibration values to EEPROM.	---
CR<terminator>	Restores all calibration values from EEPROM (used for testing only).	---
BCALm1<terminator>	Set the device to calibration mode	Value for m1 are: 0 = Disable Calibration Mode 1 = Enable Calibration Mode

6.4   BASIC CALIBRATION PROCESS
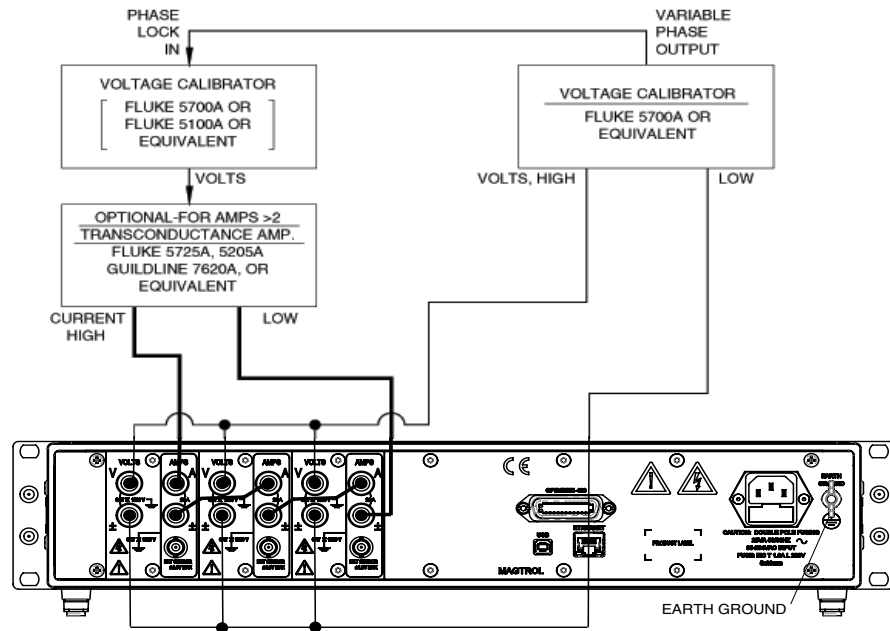
Figure 6–1 Calibration/Verification Test Setup

The 7500 must be used with a personal computer to complete the calibration process.

1. Begin the process with the 7500 turned OFF.
2. Remove any external input connections.
3. Connect the current and voltage source.
4. Turn the power ON. Set the 7500 device in calibration mode by the following command code BCAL1.
5. Set voltage and current range by entering the following command codes.
    VOLTAGE => RV0,m2 where m2 = 0 to 3
    CURRENT => RA0,m2 where m2 = 0 to 3
6. Set calibrator to 0 volts (DC) and 0 amps (DC).

☞   Note: DC is used for zero.

7. Enter the following commands.
    VOLTAGE => CV0,0
    CURRENT => CA0,0
8. Set calibrator to full scale range for voltage (AC) and current (AC).

☞   Note: AC 80 Hz is used for gain.

9. Enter the following commands.
    VOLTAGE => CV0,xx.xx
    CURRENT => CA0,xx.xx

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Where xx.xx is the voltage/current on the inputs (full scale).

10. Repeat steps 5 through 9 for all ranges.
11. Remove current and voltage inputs.
12. Attach external input to calibrator voltage.
13. Set current range by entering the following command code.
    CURRENT => RAØ, m2 where m2 = 4 to 7
14. Set calibrator to 0 volts (DC).

☞   Note: DC is used for zero.

15. Enter the following command.
    CURRENT => CA0,0
16. Set calibrator to voltage full scale range (AC).

☞   Note: AC 80 Hz is used for gain.

17. Enter the following command.
    CURRENT => CA0,xx.xx

    Where xx.xx is the voltage on the inputs (full scale).
18. Repeat steps 13 through 17 for all ranges.
19. When the calibration for all ranges is complete, enter the CS command to save.

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7. Troubleshooting

Problem	Reason	Solution
No GPIB communication.	Setup error and/or hardware fault.	Check: • GPIB address of power analyzer. • GPIB cable - should be functioning and attached to power analyzer and computer interface card.
No USB communication.	Setup error and/or hardware fault.	Check: • USB driver installation • Cable attachment to power analyzer and serial interface port of computer.
No ethernet communication	Setup error and/or hardware fault	Check: • Ethernet cable attachment to power analyzer • Ethernet port number and IP address

If you require additional assistance, please contact Magtrol Customer Service at 1-716-668-5555.

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Appendix A: Schematics

A.1   BLOCK DIAGRAM
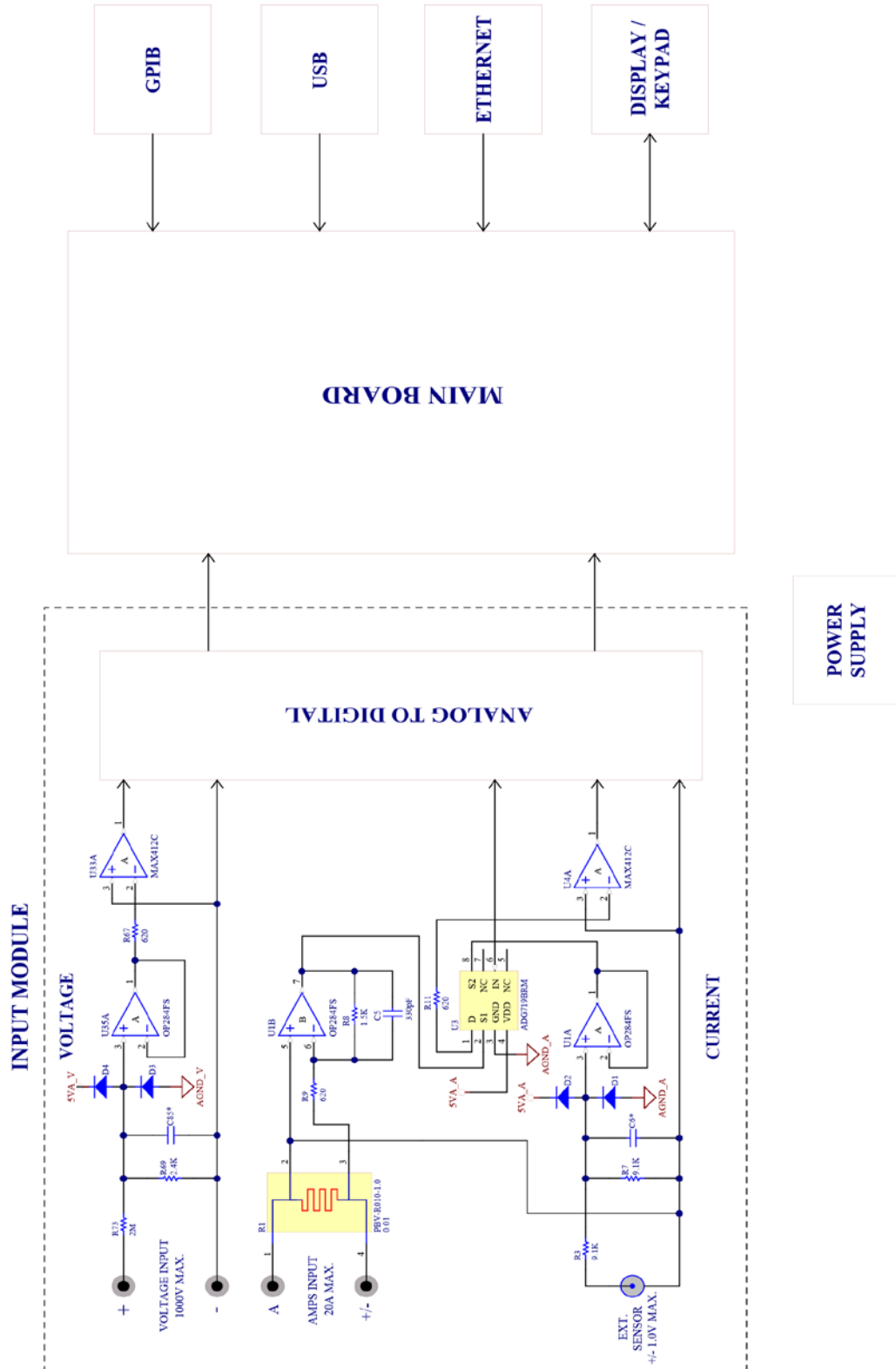
Appendix B: 6510e/6530 Compatible Commands

B.1 CONFIGURATION COMMANDS

Command Code	Function	Explanation
*IDN?	Returns Magtrol device identification, serial numbers and firmware and FPGA revisions	Magtrol,75X0,Serial#####,Firm,FPGA Where X is the channel count (1,2,3,4) Where Serial##### is the serial number fo the unit Where Firm is the firmware revision Where FPGA is the firmware revision Example: Magtrol,7530,17A75000001,A0,A0
*IDN? \<terminator\>	Identification query.	Returns model number and code revision.
	Sets auto or manual range mode for the current ranges.	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates whether range mode is auto or manual. Values for m2 are: 0 = manual range 1 = auto range
	Sets auto or manual range mode for the voltage ranges.	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates whether range mode is auto or manual. Values for m2 are: 0 = manual range 1 = auto range
FSm\<terminator\>	Sets the frequency source for cycle-by-cycle mode.	"m" indicates the input to be used as the fundamental source. Values for m are: 0 = V1 1 = A1 2 = V2 3 = A2 4 = V3 5 = A3
IS \<terminator\>	Starts average mode.	---
IC \<terminator\>	Clears average mode.	---

APPENDICES

Command Code	Function	Explanation
	Sets the RMS or DC measurement mode of current phases.	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates measurement mode. Values for m2 are: 0 = RMS (AC + DC) 1 = DC
	Sets the RMS or DC measurement mode of voltage phases.	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates measurement mode. Values for m2 are: 0 = RMS (AC + DC) 1 = DC
MCm<terminator>	Sets the continuous or cyclic measurement mode filter.	"m" indicates whether the measurement mode is continuous or cyclic. Values for m are: 0 = continuous 1 = cycle-by-cycle
MFm<terminator>	Sets the AC and DC measurement mode filter.	"m" indicates the measurement filter low-pass frequency (response time). Values for m are: 0 = 1 Hz 1 = 2 Hz 2 = 5 Hz 3 = 10 Hz 4 = 20 Hz 5 = 50 Hz 6 = 100 Hz
PC<terminator>	Clears all peak hold values (voltage, current and power).	---
	Sets current range and input source.	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates current range. Values for m2 are: 0 = 20 A 1 = 10 A 2 = 5 A 3 = 1 A 4 = 1 V external sensor input range 5 = 500 mV external sensor input range 6 = 250 mV external sensor input range 7 = 50 mV external sensor input range

APPENDICES

Command Code	Function	Explanation
	Sets voltage range.	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates voltage range. Values for m2 are: 0 = 600 V 1 = 300 V 2 = 150 V 3 = 30 V
	Sets the current scaling constant (current transformer).	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates the current scaling constant in A/A and must be set within the following range: 0.01 < m2 < 10000. When m2 = 0, the current scaling mode will be cleared.
	Sets the voltage scaling constant (potential transformer).	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates the voltage scaling constant in V/V and must be set within the following range: 0.01 < m2 < 10000. When m2 = 0, the voltage scaling mode will be cleared.
	Sets the external current sensor scaling constant.	"m1" indicates the input phase. Values for m1 are: 0 = all phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates the external current sensor scaling constant in A/mV and must be set within the following range: 0.0001 < m2 < 99999. NOTE: External sensor voltage input values are divided by this value to give output in amps in external sensor input current ranges.
WMm\<terminator\>	Sets the wiring mode for sum measurement values.	"m" indicates the wiring mode. Values for m are: 0 = 1-Phase, 2-Wire 1 = 1-Phase, 3-Wire 2 = 3-Phase, 3-Wire 3 = 3-Phase, 4-Wire 4 = 3-Volt, 3-Amp

B.2   DATA OUTPUT COMMANDS

Command Code	Function	Explanation
	Requests current measurement value.	"m1" indicates the input phase. Values for m1 are: 0 = sum of current phases 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates the measurement value. Values for m2 are: 0 = normal (RMS/DC) depending on measurement mode setting) 1 = peak (instantaneous) 2 = crest factor 3 = peak hold/inrush (RMS/DC)
	Requests voltage measurement value.	"m1" indicates the input phase. Values for m1 are: 0 = average of voltage phases (wiring mode dependent) 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates the measurement value. Values for m2 are: 0 = normal (RMS/DC) depending on measurement mode setting) 1 = peak (instantaneous) 2 = crest factor 3 = peak hold/inrush (RMS/DC)
	Requests power measurement.	"m1" indicates the input phase. Values for m1 are: 0 = sum of power phases (wiring mode dependent) 1 = phase 1 2 = phase 2 3 = phase 3 "m2" indicates the measurement value. Values for m2 are: 0 = watts 1 = VA 2 = power factor 3 = watts peak hold
OF\<terminator\>	Requests output of frequency.	---
OEm\<terminator\>	Requests phase measurement values (current, voltage, power).	"m" indicates the input phase. Values for m are: 0 = sum of phases (wiring mode dependent) 1 = phase 1 2 = phase 2 3 = phase 3
OAVE \<terminator\>	Retrieves displayed values of current, voltage and power. Returns data in the same format as the OE command.	Displays values in average mode only
OT\<terminator\>	Requests all measurement values.	---

APPENDICES

Appendix C: Error Information

C.1   ERROR INFORMATION

ERR: SYNTAX – Returned when there is a "typo" in the command (|MEES|).

ERR: PARAMETER COUNT – When the number of parameters given is not what is expected.

ERR: INVALID PARAMETER – When a parameter given is not an excepted value for the Command.

ERR: UNKNOWN – Covers various situations and helps to identify programming errors. Is the default error.

ERR: NO COMMAND GROUP – When the first four characters of a given string are not a valid command group.

APPENDICES

Service Information

RETURNING MAGTROL EQUIPMENT FOR REPAIR AND/OR CALIBRATION

Before returning equipment to Magtrol for repair and/or calibration, please visit Magtrol's Web site at http://www.magtrol.com/support/rma.htm to begin the Return Material Authorization (RMA) process. Depending on where the equipment is located and which unit(s) will be returned, you will be directed to either ship your equipment back to Magtrol, Inc. in the United States or Magtrol SA in Switzerland.

Returning Equipment to Magtrol, Inc. (United States)

When returning equipment to Magtrol, Inc.'s factory in the United States for repair and/or calibration, a completed Return Material Authorization (RMA) form is required.

1. Visit Magtrol's Web site at http://www.magtrol.com/support/rma.htm to begin the RMA process.
2. Complete the RMA form online and submit.
3. An RMA number will be issued to you via e-mail. Include this number on all return documentation.
4. Ship your equipment to: MAGTROL, INC.
    70 Gardenville Parkway
    Buffalo, NY 14224
    Attn: Repair Department
5. After Magtrol's Repair Department receives and analyzes your equipment, a quotation listing all the necessary parts and labor costs, if any, will be faxed or e-mailed to you.
6. After receiving your repair estimate, provide Magtrol with a P.O. number as soon as possible. A purchase order confirming the cost quoted is required before your equipment can be returned.

Returning Equipment to Magtrol SA (Switzerland)

If you are directed to ship your equipment to Switzerland, no RMA form/number is required. Just send your equipment directly to Magtrol SA in Switzerland and follow these shipment instructions:

1. Ship your equipment to: MAGTROL SA
    After Sales Service
    Route de Montena 77
    1728 Rossens / Fribourg
    Switzerland
    VAT No: 485 572

2. Please use our forwarder : TNT • 1-800-558-5555 • Account No 154033
    Only ship ECONOMIC way (3 days max. within Europe)
3. Include the following documents with your equipment:
    *   Delivery note with Magtrol SA's address (as listed above)
    *   Three pro forma invoices with:
        *   Your VAT number
        *   Description of returned goods
        *   Noticed failures
        *   Value - for customs purposes only
        *   Origin of the goods (in general, Switzerland)
4. A cost estimate for repair will be sent to you as soon as the goods have been analyzed. If the repair charges do not exceed 25% the price of a new unit, the repair or calibration will be completed without requiring prior customer authorization.