Operations Manual

OM-001-01000-000-04.0

APS-1000 Series Power Converters

TM

ADAPTIVE Power Systems

Worldwide Supplier of Power Conversion Equipment

Contents

Front Matter

Chapter 1 Introduction

Chapter 2 Specifications

Chapter 3 Unit Description

Chapter 4 Operating Instructions

Chapter 5 External Interfaces

Chapter 6 System Calibration

Chapter 7 System Maintenance

Contact Information

Adaptive Power Systems, Inc.

17711 Mitchell North • Irvine, CA 92614 USA

Telephone: (949) 752-8400

FAX: (949) 756-0838

E-mail: sales@adaptivepower.com

Web: http://www.adaptivepower.com

APS-1000 Series Power Converters Limited Warranty

Adaptive Power Systems, Inc. (APS) warrants each unit to be free from defects in material and workmanship. For the period of one (1) year from the date of shipment to the purchaser, APS will either repair or replace, at its sole discretion, any unit returned to the APS factory in Irvine, California. It does not cover damage arising from misuse of the unit or attempted field modifications or repairs. This warranty specifically excludes damage to other equipment connected to this unit.

Upon notice from the purchaser within (30) days of shipment of units found to be defective in material or workmanship, APS will pay all shipping charges for the repair or replacement. If notice is received more than thirty (30) days from shipment, all shipping charges shall be paid by the purchaser. Units returned on debit memos will not be accepted and will be returned without repair.

This warranty is exclusive of all other warranties, expressed or implied..

APS-1000 Series Service and Spare Parts Limited Warranty

APS warrants repair work to be free from defects in material and workmanship for the period of ninety (90) days from the invoice date. This ***Service and Spare Parts Limited Warranty*** applies to replacement parts or to subassemblies only. All shipping and packaging charges are the sole responsibility of the buyer. APS will not accept debit memos for returned power sources or for subassemblies. Debit memos will cause return of power sources or assemblies without repair.

This warranty is exclusive of all other warranties, expressed or implied.

Chapter 1
Introduction

Overview

Chapter 1 contains important information you should read BEFORE attempting to install and power-up your APS-1000 Series Power Converter. The information in this chapter is provided for use by experienced operators. Experienced operators understand the necessity of becoming familiar with, and then observing, life-critical safety and installation issues. Topics in this chapter include:

- Safety Notices
- Warnings
- Cautions
- Preparation for Installation
- Installation Instructions
- Transportation
- Storage

Introduction to the APS-1000 Power Converter

APS-1000 Series Power Converters have been designed for long-life trouble-free operation in the shop-floor testing environment. The input to APS-1000 units is commercially available power at fixed voltage and frequency. The output from APS-1000 units is programmable power at user-controlled voltages and frequencies.

There are several operational modes: (1) front panel manual control; (2) manually programmed test sequences; (3) external control of the manually programmed instruction test sequences.

The APS-1000 Series of Power Converters have been designed to provide frequency and voltage conversion in a controlled test environment. Both manually adjustable and remotely-programmable settings are provided. All APS-1000 Series Power Converters provide 1-phase output power. Different models cover the power range from 2 kVA to 60 kVA. All units provide user-controlled 1-phase output power within the frequency range of 45 – 500 Hz.

All APS-1000 Series units operate as double-conversion power converters. The first conversion is AC to DC. The second conversion is DC back to AC. Three units (APS-1002, APS-1003, and APS-1005) operate with 1-phase input power. All other units operate with 3-phase input power. After rectification, filtering removes high-frequency content. Low-ripple DC is subsequently converted to 1-phase AC by a high-frequency pulse-width-modulated (PWM) switcher. Precise control is maintained by using a highly stable digital oscillator.

APS-1000 Series Power Converters are designed for long-term continuous operation in sheltered (no rain) environments. Because there are no batteries, APS-1000 units operate reliably over a wide ambient temperature range. Through the use of switching technology the equipment is efficient (about 85%). Power Converter units are relatively tolerant of high dust environments.

Safety Notices

- APS-1000 Series Power Converters can transfer very large amounts of electrical energy very quickly.
- The rapid transfer of large amounts of electrical energy is fundamental to any high-performance power source.
- **Only experienced operators who have both read and understood the information in this manual should attempt to operate the unit.**
- The following warnings and cautions herein must be observed at all times.

WARNINGS indicate potentially hazardous situations which, if not avoided, could result in death or serious injury. All warnings throughout this manual will appear as follows:

–

WARNING

THIS EQUIPMENT CONTAINS HIGH ENERGY, LOW IMPEDANCE CIRCUITS!!
LETHAL POTENTIALS ARE CONTAINED WITHIN THE CABINET.

CARE MUST BE EXERCISED WHEN OPERATING, CALIBRATING, OR SERVICING THIS EQUIPMENT, IN ORDER TO PREVENT SERIOUS OPERATOR INJURY OR EQUIPMENT DAMAGE.

OBSERVE THE FOLLOWING WHEN SERVICE AND MAINTENANCE ARE REQUIRED:

1) **REMOVE ALL JEWELRY FROM ARMS AND NECK WHEN SERVICING THIS EQUIPMENT. THIS PREVENTS THE POSSIBILITY OF SHORTING THROUGH THE JEWELRY AND CAUSING BURNS TO THE OPERATOR.**
2) **WEAR SAFETY GLASSES WHEN SERVICING THIS EQUIPMENT TO PREVENT EYE INJURY DUE TO FLYING PARTICLES CAUSED BY ACCIDENTAL SHORT CIRCUIT CONDITIONS.**
3) **DO NOT REMOVE ANY PANEL OR COVER WITHOUT FIRST REMOVING THE INPUT POWER BY OPENING ALL CIRCUIT BREAKERS.**
4) **SERVICE OTHER THAN REGULARLY SCHEDULED CALIBRATION OR EXTERNAL CLEANING SHOULD BE REFERRED TO PERSONNEL AUTHORIZED BY THE FACTORY TO SERVICE THIS EQUIPMENT.**

WARNING

IF THIS EQUIPMENT IS NOT USED IN A MANNER SPECIFIED BY THE MANUFACTURER, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED

CAUTIONS indicate a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It also may be used to alert against unsafe practices. Cautions will appear as shown below. All cautions should be rigorously observed.

CAUTION

Read the *INSTALLATION* and *OPERATION* instructions of this manual before installing or operating this equipment.

To protect the equipment from damage, caution statements are used as follows:

CAUTION

Refer to *INDUSTRY STANDARDS* for the safe correct size of the power input cables. The incorrect use of small-gauge input cables may cause overheating and damage the cables or the equipment.

- **Before using this AC converter, please read all the safety labels that are attached to this unit.**
- **Before turning on the input power source to this equipment, please check to make sure that the input voltage selection is correct.**

WARNING

Before turning on the input power source to this equipment, please check to make sure that a good earth ground is connected to the proper terminal.

Preparation for Installation

Important Information and Instructions

This section contains instructions for unpacking, inspecting, preparing and storing your APS-1000 Power Converter.

Unpacking and Inspection

APS-1000 Power Converters are well packed to provide protection in the normal shipping environment. If the shipping box appears damaged upon receiving, please inspect the power source for scratches or damage. If the product has been damaged, please alert the freight company and contact APS or the distributor. Please keep the original box and packing to assist in determining how the damage occurred.

What to do if Damage has Occurred

If your APS-1000 Power Converter was damaged in shipment, you must file a damage claim with the freight company. Do not return the product before contacting APS to receive a Returned Merchandise Authorization (RMA) number.

Please retain all the original packing materials. If the APS-1000 Power Converter must be sent back for repair, use the original packing materials for packing.

Installation Instructions

Input and Output Circuit Breakers

APS-1000 Power Converter input and output circuit breakers and their connections are on the rear of the unit. Please check to make sure all wires are connected correctly and secured. Cooling fans, located at the sides and rear of the unit, provide air circulation for cooling and heat removal.

A typical wiring diagram is shown on the following page.

AC Line Input Current Requirements

TheAC input requirement for the APS Power Converter depends on the configured AC input voltage and total power level of the specific APS 1000 model. For three phase AC input models, the current shown in the table below is for each phase.

Input wire sizes must be chosen to support the maximum currents shown in this table and must conform to local electrical safety codes. **Note** that these values are based on the AC input circuit breaker rating for each model. The actual AC input currents are lower than the values shown.

AC Line Input Current Requirements

Model		1003	1005	1010	1020	1030	1040	1060
Input Phase		1-phase / 2-wire + GND		3-phase				
Rated Power	Total Power	3 KVA	5 KVA	10 KVA	20KVA	30KVA	40KVA	60KVA
Phase	230V, 1ø	20 A	36 A	-	-	-	-	-
	208V, 3ø	-	-	40 A	100 A	125 A	175 A	250 A
	220V, 3ø	-	-	40 A	100 A	125 A	150 A	250 A
	240V, 3ø	-	-	40 A	75 A	100 A	150 A	225 A
	380V, 3ø	-	-	30 A	50 A	75 A	100 A	150 A
	415V, 3ø	-	-	20 A	40 A	60 A	100 A	125 A
	480V, 3ø	-	-	20 A	40 A	50 A	75 A	125 A

Input Voltage Requirement and Selection

APS-1000 Series Power Converters are delivered with a universal input transformer. You will receive your unit factory-connected and tested at the voltage specified at the time of order. Please check the unit data plate to verify the voltage is correct.

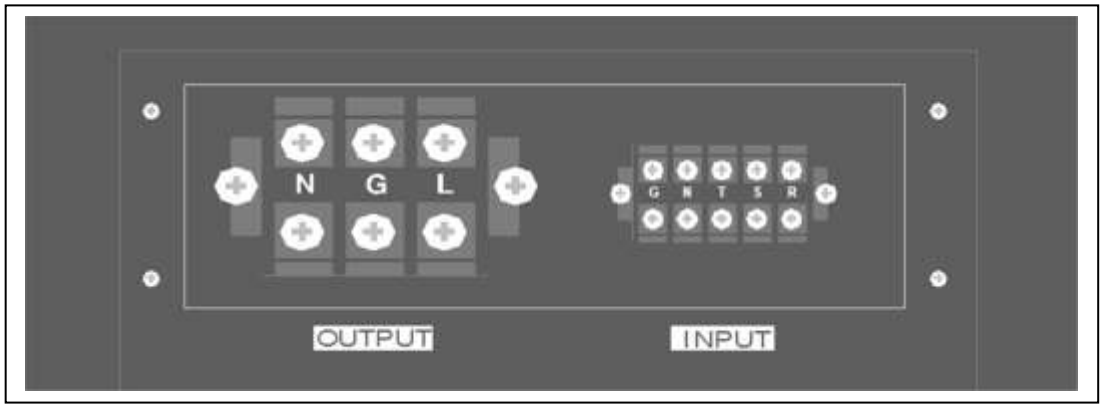
Operating Environment

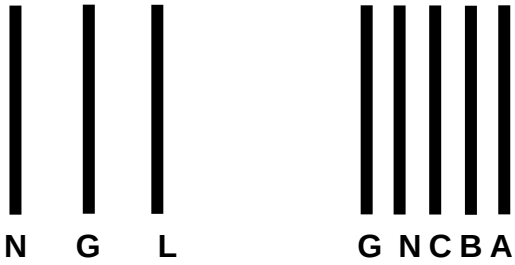
APS-1000 Series Power Converters are designed to operate reliably over a wide range of environmental conditions. Please operate within the following limits:

- Temperature: 0 °C – 40 °C (32 °F – 104 °F)
- Humidity: 20% – 80% (Non-condensing)
- Altitude: Below 2,000 meters (6,500 feet) of elevation

Example Wiring Diagram

INPUT / OUTPUT Power Panel at Rear of APS Unit (typical)





OUTPUT CONNECTIONS **INPUT CONNECTIONS**

NOTE: Input Terminal Phases R, S, T are North American (U.S.) A, B, C

NOTE: Other terminal configurations are possible. For example, there is no neutral terminal for 3-phase delta-winding inputs. In addition, depending on voltage range, there may be no neutral terminal. All units provide 1-phase outputs. Inputs are 3-phase, except for APS-1002, APS-1003, and APS-1005, which have 1-phase inputs (2-wire plus ground).

WARNING

THIS EQUIPMENT CONTAINS HIGH ENERGY, LOW IMPEDANCE CIRCUITS!!

LETHAL POTENTIALS ARE CONTAINED WITHIN THE CABINET.

ONLY FULLY-QUALIFIED PERSONNEL SHOULD ATTEMPT TO MAKE INPUT OR OUTPUT POWER CONNECTIONS.

Storage and Transportation

Packing Instructions

Please retain all the original packing materials. If the equipment must be sent back for repair, use the original packing materials for packing. Please contact the APS repair center or factory before returning equipment. Be sure to send all accessories and indicate the symptoms and cause of failure if known.

Other packing Material

If the original packing material is missing, please follow the instructions below:

- Wrap the equipment in PU (polyurethane) foam or Styrofoam.
- The equipment must be protected by shock-resistant material, about 70 to 100mm thick (3 to 4 inches).
- The front panel must be protected with cardboard.
- Secure packing tightly and insert unit into a wooden crate if possible.
- Label the box "fragile" and transport carefully.

Non-Operating Environment

The APS-1000 Series Frequency Converter can be stored and transported under the following environment:

- Temperature: –40 °C – 55 °C (–40 °F – 131 °F)
- Altitude: 7,620 meters (25,000 feet)

Avoid sudden temperature changes. Sudden changes in temperature may result in condensation inside the equipment.

Chapter 2
Specifications

Overview

Chapter 2 summarizes the capabilities and general features of the APS-1000 family of Power Converters. Functional capabilities are similar for all units. APS units convert fixed line voltage at a fixed frequency to user-selected 1-phase output voltages and frequencies. The primary differences between units are size, weight, type of external data interface, and specific power handling capability. All units provide built-in PLC remote control for three program memories.

The Displays and Controls Table in this section provides summary information about the programmable memories and external control. More detailed information about external interface control is found in Chapter 5.

This Chapter includes five summary tables and a surge-current performance graph. The tables summarize different capabilities and features of APS-1000 Power Converters. The graph illustrates over-current (start-up surge-current) capabilities.

Introduction

APS-1000 Power Converters are rugged versatile workhorses. The intended location for APS-1000 units is the test floor, not a laboratory workbench. The smallest unit, the APS-1002, weights 177 lbs. The largest unit, the APS-1060, weighs 1960 lbs. Users can select from several modes of operation:

- full-manual operation
- manually programmed operation
- remote PLC operation

In keeping with their workhorse nature, all APS-1000 units feature a 200% start-up surge-current capability. The ability to source initial surge currents prevents the programmed over-current protection from disabling a test.

APS-1000 Specifications

The following five tables and surge current graph provide detailed information about the entire family of APS-1000 Series of power converters.

- Input Electrical Specifications
- Output Electrical Specifications
- Displays and Controls
- Mechanical Specifications
- Environmental Specifications
- Surge-Current Rating Graph

Input Electrical Specifications

Model	1003	1005	1010	1020	1030	1040	1060
Input Phase	1-phase / 2-wire + Ground		3-phase				
Input Voltage(VAC L/L)	230 V ± 15%		208,220,240(3W+G)380,415,480(4W+G)±10%				
Input Frequency	47 – 63 Hz						

Output Electrical Specifications

Total Power			3 KVA	5 KVA	10 KVA	20 KVA	30 KVA	40 KVA	60KVA
Maximum Amps	0 – 150 V		25.2 A	42.0 A	84.0 A	168.0 A	252.0 A	336.0 A	504.0 A
	0 – 300 V		12.6 A	21.0 A	42.0 A	84.0 A	126.0 A	168.0 A	252.0 A
Phase			1-phase / 2-wire + Ground						
Voltage	Low Range		0 – 150 V						
	High Range		0 – 300 V						
	Resolution		0.1 V						
	Accuracy		± (1% + 0.2 V)						
Frequency	Range		45 – 500 Hz						
	Resolution		0.1 Hz at 45 – 99.9 Hz, 1 Hz at 100 – 500 Hz						
	Accuracy		± 0.2%						
Parameters			1003P	1005P	1010P	1020P	1030P	1040P	1060P
Current	Range	L	0.000 – 3.5 A		0.00 – 35.00 A				0.0-350A
		H	3.00 – 35.00 A		30.00 – 350.0 A				300-3500A
	Resolution	L	0.001 A		0.01 A				0.1A
		H	0.01 A		0.1 A				1A
	Accuracy	L	± (1% of reading + 0.005		± (1% of reading + 2 counts)				
		H	± (1% of reading + 0.01 A)		± (1% of reading + 1 count)				
Power	Range	L	0.0 – 350.0 W		0.000 – 3.500 kW				0.0-35.0kW
		H	300 – 5000 W		3.00 – 60.00 kW				30.0-
	Resolution	L	0.1 W		0.001 kW				0.01kW
		H	1 W		0.01 kW				0.1kW
	Accuracy	L	± (1.5% of reading + 0.5		± (1.5% of reading + 5 counts)				
		H	± (1.5% of reading + 1.0		± (1.5% of reading + 1 count)				
Power Factor	Range		0.001 – 1.000						
	Resolution		0.001						
	Accuracy		Depends on the accuracy of V, A, W						
Harmonic Distortion			≤ 1% (Resistive Load)						
Crest Factor			≥ 3 to 1						
Load Regulation			± 0.5%						
Protection			Over-Current, Short-Circuit, Over-Temperature						
Efficiency			≥ 85% (at full load)						

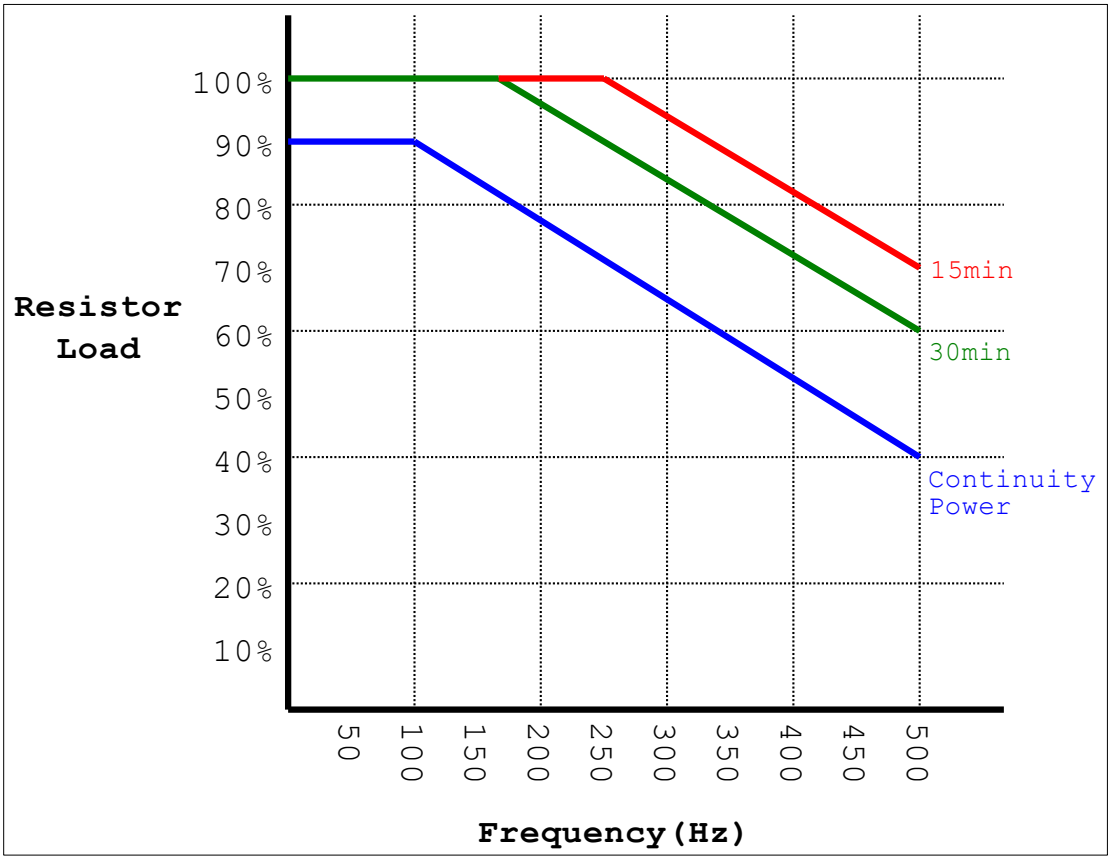
Isolation Data

The following isolation specifications apply to standard APS1000 Models.

Isolation Data	
Input to Output Isolation	Working: 1000Vac, Max. 2500 Vac for 60 secs
Input to Chassis Isolation	Working: 1000Vac, Max. 1500 Vac for 60 secs
Output to Chassis Isolation	Working: 600Vac, Max. 945 Vdc for 60 secs

Power versus Output Frequency Rating Chart

The following thermal ratings apply to models 1020, 1030 and 1040 as a function of load and programmed output frequency at an ambient temperature of 25°C. This derating is caused by heat build-up in the output transformer.



Output load ratings expressed as restive load reflecting % of full load for frequency ranges at which the power source can operate continuously are as follows:

45Hz ~ 100Hz	90% resistive load
< 200Hz	77% resistive load
< 300Hz	65% resistor load
< 400Hz	52% resistor load
< 500Hz	40% resistor load

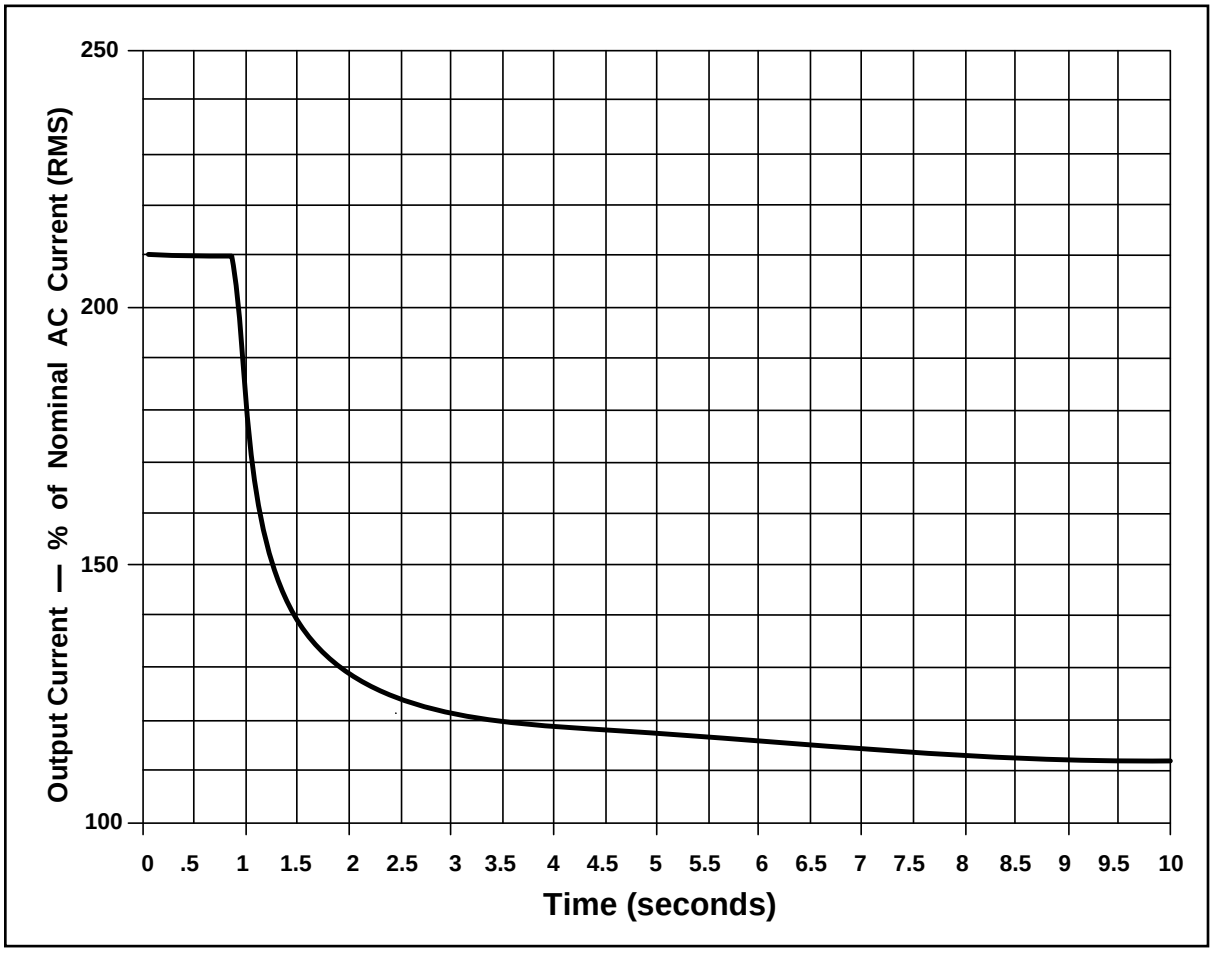
At an output frequency of 500Hz and output power into 70% resistor load, the power source can operate for a period of 15 minutes then instrument output will shut down because output transformer is too hot.

Displays and Controls							
Model	**1003**	**1005**	**1010**	**1020**	**1030**	**1040**	**1060**
4 Digital LED meters	Frequency, Voltage, Current, Power or Power Factor (simultaneously)						
PLC Remote	Output ON/OFF Selection of programmable memories: P1, P2, P3						
Memory	8 Memories, 5 Programmable Steps per Memory for: Voltage, Frequency, Test Time, Delay Time, Current, Power, and Power Factor Hi/Lo Limit Setting Note: Programmable memories can be manually programmed and used independently of the External RS-232 or GPIB Interface. They can also be independently programmed through these external interfaces.						
Calibration	Front Panel Calibration						
PLC (external) Interface	PLC interface controls execution of programmed steps in Memories 1, 2, or 3. The PLC interface is a standard feature of all APS Power Converters.						
Auto-Voltage Adjust	Provides improved voltage regulation						

Mechanical Specifications								
Model		**1003**	**1005**	**1010**	**1020**	**1030**	**1040**	**1060**
Power Rating		**3 KVA**	**5 KVA**	**10 KVA**	**20 KVA**	**30 KVA**	**40 KVA**	**60KVA**
Dimensions (In.)	H	12	12	28	33	43	43	66
	D	26	26	29	29	39	39	39
	W	17	17	17	17	24	24	32
Weight	Kg	95	125	228	350	592	663	885
	lbs	210	275	503	772	1305	1462	1951

Environmental Specifications	
Operating Temperature	32 ºF – 104 ºF (0 ºC – 40 ºC)
Relative Humidity	< 80 % (Non-condensing)
Altitude	≤ 6,500 feet

Output Surge-Current Capability



Output Surge-Current Rating

Rated Short-Term Overload Current vs. Time

Peak instantaneous current to approximately 200% of nominal AC RMS current is allowed. The actual operating time before thermal shutdown, or before the circuit breaker trips, will always vary. The exact time depends upon the temperature and line conditions.

Chapter 3
Unit Description

Overview

Chapter 3 helps you locate controls and understand their functions. More importantly, the names used throughout this manual to identify controls and functions are defined. You need to know the vocabulary of the APS-1000 Series to take full advantage of the information in this manual. Information in this chapter is in three sections:

- Location and function of front panel displays and controls
- Cabinet controls and connectors
- Chassis features and details

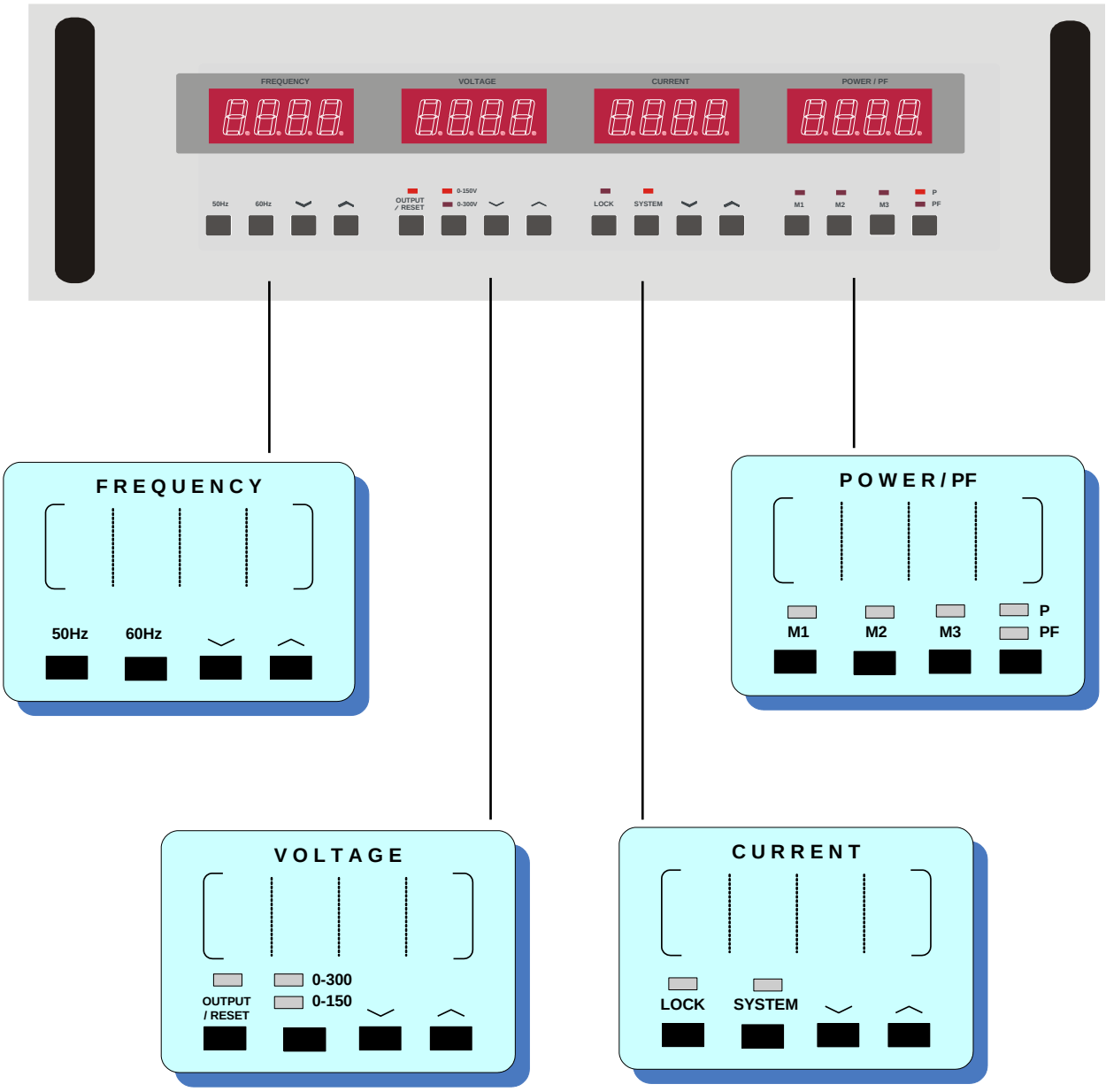
Use the information in this chapter to gain a general understanding of the locations and functionality of indicators, controls, connectors, and mechanical details of your APS-1000 unit.

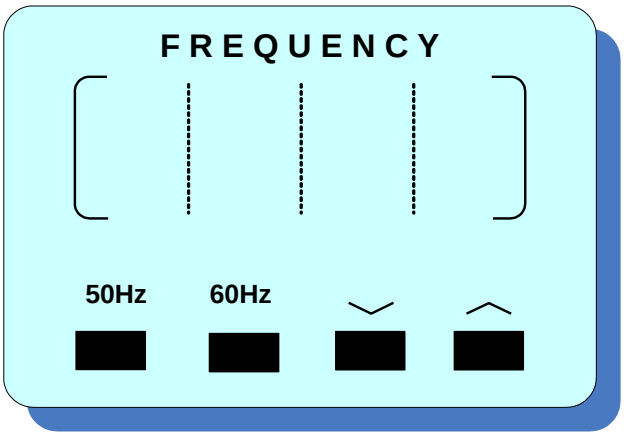
Front Panel Organization

The front panel of your APS-1000 unit is organized for efficiency of operation. It is laid out to simplify operation in a test environment. The layout features:

- 4 Display Groups
  - Frequency Display
  - Voltage Display
  - Current Display
  - Power / Power Factor Display
- 16 7-segment Display Indicators
- 16 Pushbutton Switches
- 10 LED Indicators

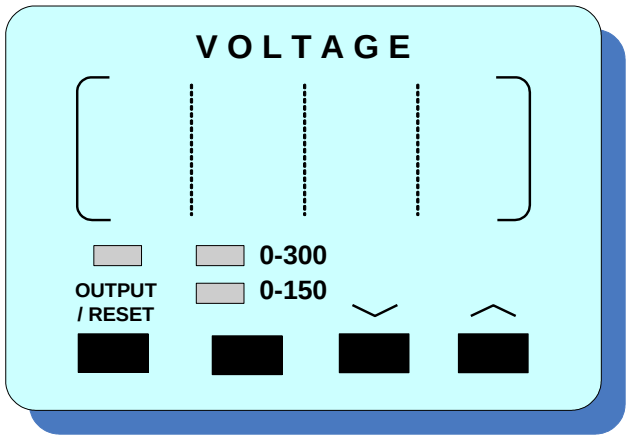
APS-1000 Front Panel





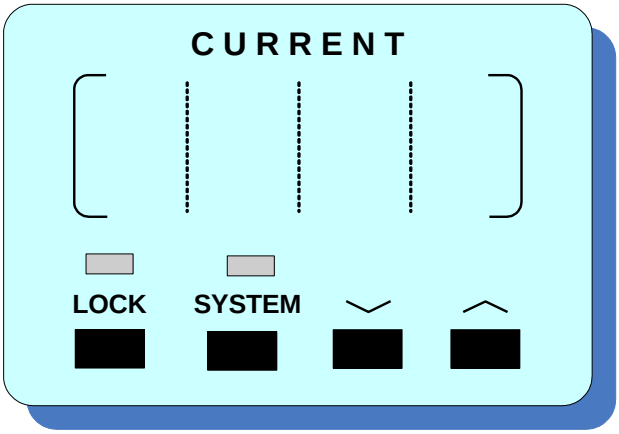
APS-1000 Frequency Display

Frequency Selection	
FREQUENCY display	Displays the: • Selected frequency value when output is OFF. • Frequency value during selection or adjustment. • Output frequency during normal operation. • System parameters during System set-up. • Error messages when an output error occurs.
50 Hz button	Sets the output frequency to 50 Hz.
60 Hz button	Sets the output frequency to 60 Hz.
﹀ button	Steps the output frequency down to a minimum of 45 Hz.
﹀ button	Steps the output frequency up to a maximum of 500 Hz.



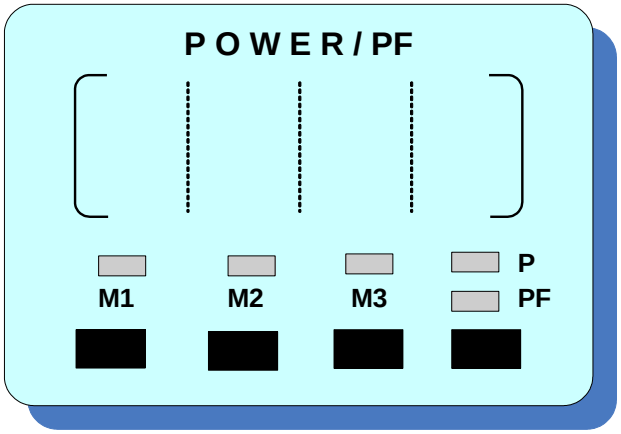
APS-1000 Voltage Display

Voltage Selection	
VOLTAGE display	Displays the: • Selected voltage value when Output is OFF. • Voltage value during voltage adjustment. • Output voltage during normal operation. • System parameters during SYSTEM / PROGRAM set-up.
150V indicator	When ON, the system is in low-voltage range (0 - 150 VAC).
300V indicator	When ON, the system is in high-voltage range (0 - 300 VAC).
OUTPUT / RESET indicator	• When ON, the system is in normal operation. • When BLINKING, the system has encountered an error.
LOW / HIGH button	Located below the two voltage range indicators; toggles voltage range.
OUTPUT / RESET button	• Toggles System Output ON/Off, under normal operation. • Resets the System after an Output error has occurred.
﹀ button	Steps the output voltage down; SYSTEM / PROGRAM parameter select.
﹀ button	Steps the output voltage up; SYSTEM / PROGRAM parameter select.



APS-1000 Current Display

Current Selection	
CURRENT display	Displays the: • Selected current value when Output is OFF. • Current value during current adjustment. • Output current during normal operation. • System parameters during System set-up.
LOCK indicator	When ON, the panel is in a locked state; all buttons except the RESET and P/PF buttons are deactivated.
SYSTEM indicator	When ON, the SYSTEM parameter setting mode is active.
LOCK button	Locks all panel controls, except the P/PF button.
SYSTEM button	Enters / exits SYSTEM parameter set-up.
﹀ button	Steps the current / SYSTEM / PROGRAM parameters value down; status select.
﹀ button	Steps the current / SYSTEM / PROGRAM parameters value up; status select.



APS-1000 Power / PF Display

Power / PF Selection	
POWER / PF display	Displays the: • Power (in kW) • Power Factor
P indicator	When ON, displays output Power (kW).
PF indicator	When ON, displays Power Factor.
M1 indicator	When On, indicates Program Memory 1 is selected.
M2 indicator	When On, indicates Program Memory 2 is selected.
M3 indicator	When On, indicates Program Memory 3 is selected.
M1 button	Selects Program Memory 1, as the active instruction set.
M2 button	Selects Program Memory 2, as the active instruction set.
M3 button	Selects Program Memory 3, as the active instruction set.

Cabinet Controls and Connections

The APS-1000 controls and connections are conveniently located for ease of use and accessibility. Included are:

- Power ON/OFF
- PLC Control Port
- Input Power Connection
- Input Power Circuit Breaker
- Output Power Connection
- Output Power Circuit Breaker

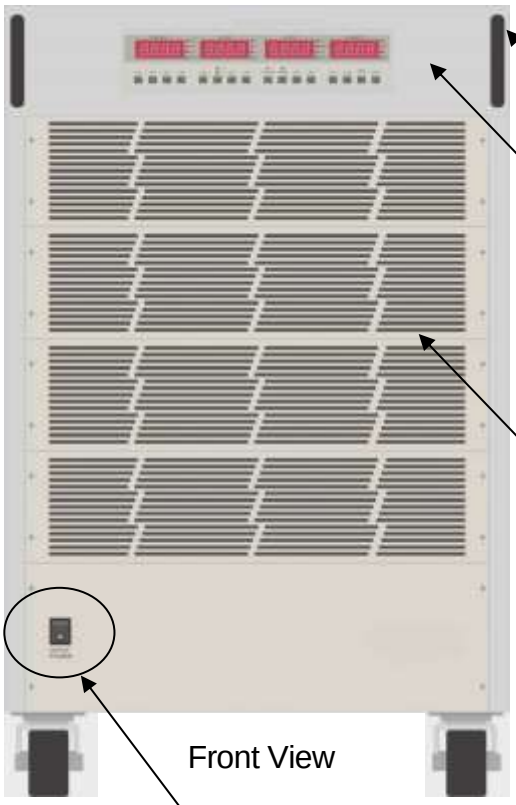
See the following page for illustrations. The Cabinet Controls Table on page 3-9 provides additional information about each of these items.

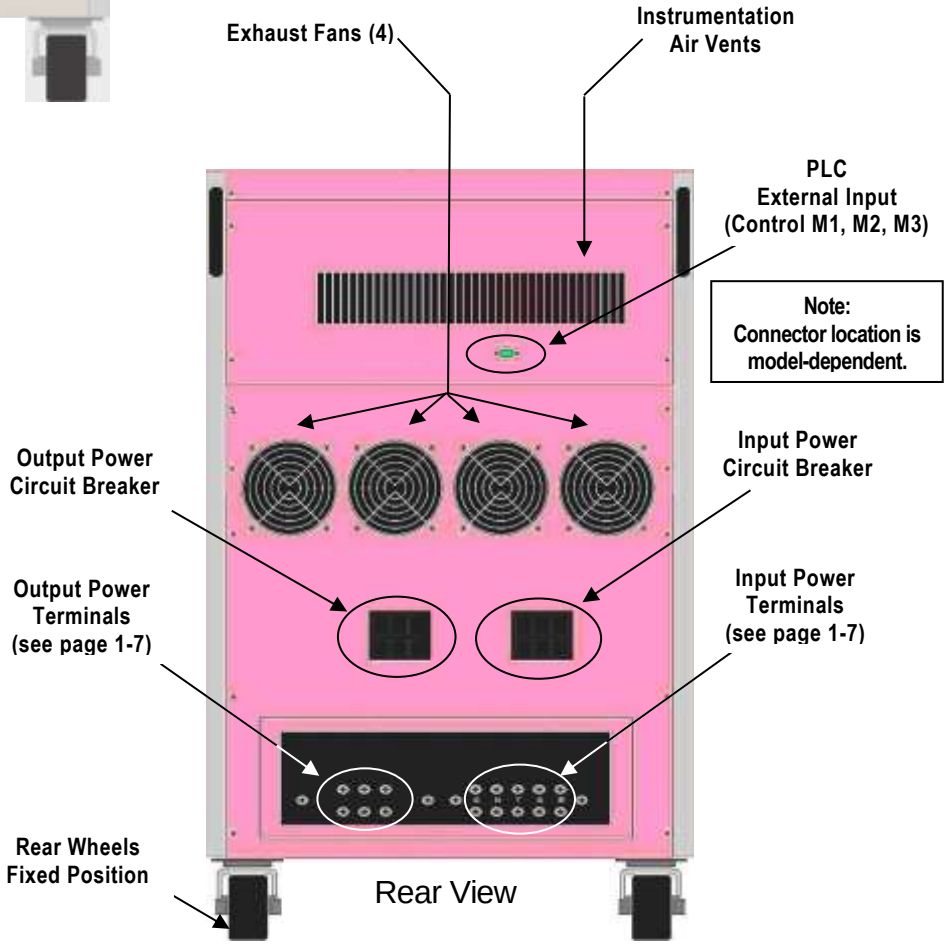
Chassis Details

The APS-1000 is built on a rugged chassis for use in demanding test environments. Important elements of the design include:

- Handles
- Wheels
- Fans
- Vents

See the following page for illustrations. The Chassis Details Table on page 3-9 provides additional information about each of these items.





APS-1000 Series Unit (typical)

Note:
The exact configuration of your unit may be different from the illustration, depending on the model number.

Cabinet Features

CABINET CONTROLS	
Power ON / OFF	At the lower left side of the front of the unit. This is the main power switch that enables operation. NOTE: The unit is always in STANDBY mode when the Input Circuit Breaker is ON.
PLC Control Port	On the rear panel, DE-9 connector for external switchable selection and control of three stored programs; typically switched by a PLC. NOTE: DO NOT use this port for RS-232 or GPIB data and control.
Input Power Connection	The power input terminals are located at the lower right of the real panel. Three-Phase terminals are labeled "N" neutral; “G” Chassis / Earth Ground; and R, S, T for the power line phases (phases A, B, and C by North American convention). Two-phase terminals are labeled "N" neutral; "G" Chassis / Earth Ground; and "L" Line.
Input Pwr Circuit Breaker	This is located just above the input power terminals.
Output Power Connection	The power output terminals are located at the lower left of the real panel. The terminals are labeled "G Chassis / Earth Ground; "N" neutral; and "L" Line.
Output Pwr Circuit Breaker	This is located just above the output power terminals.

CHASSIS DETAILS	
Handles	Located at the upper front and rear of the unit. These are mounted to the frame and may ONLY be used for moving the unit. In other words, the handles must NOT be used for lifting.
Wheels	The front wheels swivel for steering. They may be locked to prevent accidental movement. The rear wheels are fixed-direction only.
Fans and Vents	The unit draws air from front to back. Please keep the intake vents on the front and the fan exhausts on the rear clear of obstructions. Adequate cooling airflow is essential in maintaining proper operation.

Chapter 4
Operating Instructions

Overview

This chapter provides the details to help you be successful in setting up your APS-1000 Power Converter. Familiarity with material in Chapters 2 and 3 is also necessary. Chapter 2 provides general information about the APS-1000 Series. Chapter 3 illustrates the locations and functions of the front panel displays.

There are many ways you can operate your unit. Consequently, you should begin getting acquainted with your APS-1000 Converter by NOT attaching a load. You can first learn to select simple parameters by observing the front panel status displays. After you are comfortable with your ability to enter safe and realistic operating parameters, you should power-down completely before connecting a test load.

The information in this chapter guides you through the process of first turning on the unit and then verifying the configuration.

How Chapter 4 is Organized

Chapter 4 is where you will return when you forget how to use a control or want to verify a command or parameter. This chapter includes many detailed sections. The information begins with an explanation of what to expect when you power-up the unit. The order of information in this chapter is intended to help you learn to operate your APS-1000. The sections are arranged by four major topics:

- Basic Operation
- System Parameters
- Program Parameters
- Error Messages

Basic Operation

System Information

When the power is turned ON, the front panel momentarily displays:

- The model number, in the VOLTAGE display.
- The installed firmware version number, in the CURRENT display.

Overview of Capabilities

System parameters and program parameters are identified and explained in this chapter. This overview is provided to give you an idea of capabilities. You must read and study this chapter to understand how to effectively and safely use the APS-1000.

When the unit is turned ON, but the output power is OFF, you can manually set values for Voltage, Frequency, and Current. When you begin a test (output ON), the selected values will be output to the connected load.

During a test, you can make changes to the values being output. Alternatively, you can lock the front panel controls, so values will not accidentally be changed.

In addition, you can store up to three different sets of voltage, frequency and current parameters in memories M1, M2, and M3. You will be able to manually recall these stored values. Or, you can use an external interface controller (typically a PLC), to execute the stored programs. During a manual or PLC-managed test, you can switch between the stored programs in M1, M2, or M3.

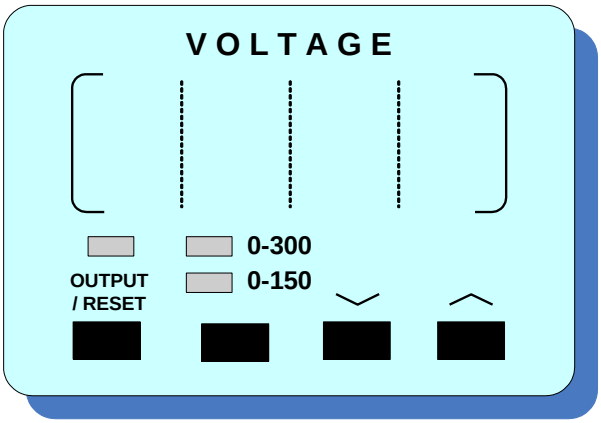
System Parameters: Displays and Controls

To operate the APS-1000, you should become thoroughly familiar with the front panel displays, controls, and indicators. Once you understand the basics, you will be able to concentrate on testing. Chapter 3 provided summary information about displays and controls. More in-depth information follows, about:

- Voltage (Display) Setting
- Frequency (Display) Setting
- Current (Display) Setting
- Power / PF (Display) Setting

Voltage (Display) Setting

When the system is in RESET (Standby) or the TEST (Output ON) mode, you can adjust the voltage value. There are two ranges: high and low. The high voltage range is 0 – 300V and the low range is 0 – 150V.



Voltage Display ⌃ and ⌄ Buttons

Pressing the ⌃ or ⌄ Voltage Display buttons causes the value to increase/decrease one step every 0.3 seconds. Holding a button "in" causes the rate of change to accelerate. After a voltage adjustment has been completed, and the voltage selection remains unchanged for 2 seconds, the voltage display will flash once. The unit will memorize the current voltage setting. The system then exits the voltage-setting mode.

NOTE: If you have a series of tests, and any of those tests requires a voltage in excess of 150V, you must start your test sequence in the high voltage mode. The unit does not automatically switch from the 150V to the 300V range. Although the unit's rated maximum power is available in either voltage range, the maximum current in the 300V range is one-half that in the 150V range.

Voltage Display High / Low Output Range Button

To switch between the high and low range, press the voltage range button (located beneath the 0 – 150V and 0 – 300V LEDs. In the low range, the voltage can be set between 0 – 150V. Available current capacity is higher, thus maintaining full power

capacity. In the high voltage range, 0 – 300V, the current capacity is one-half (see Product Specifications, Chapter 2).

During TEST (Output ON), you can switch between high and low voltage modes. Switching between high/low voltage modes will not affect the voltage setting. However, there will be a brief interruption of the output (about 20 milliseconds), during the change.

If your test is unable to tolerate a 20 millisecond drop-out, you should not exercise this feature.

The system remembers your previously entered limit settings. Thus, the system will not accept a switching command which would direct operation outside the range limits. For example, if you have specified a 200V lower voltage limit, the system will not allow you to switch to the low voltage (150V max) range.

Voltage Display OUTPUT / RESET Button

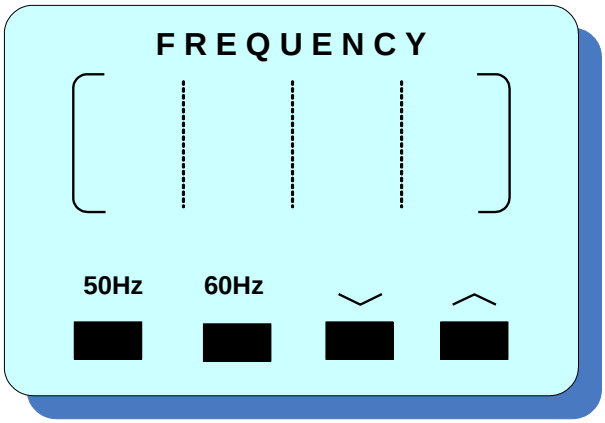
Use the OUTPUT / RESET button to turn the system output ON or OFF. The LED above the pushbutton switch will be illuminated when the system is ON.

CAUTION: Before turning the system output ON, please determine that the load is properly connected, the instrument leads are safely configured, and all personnel are in a safe location.

Note: Manual voltage adjustments will not automatically change the voltage values stored in memory locations M1, M2, or M3. To change stored voltage parameter values, please refer to the Section *Program Memory Setting Procedure*.

Frequency (Display) Setting

When the system is in RESET (Standby) or the TEST (Output ON) mode, you can adjust the output frequency.



Frequency Display ⌃ and ⌄ Buttons

Pressing the ⌃ or ⌄ frequency adjust buttons causes the value to increase/decrease one step every 0.3 seconds. Holding a button "in" forces the rate of change to accelerate. When the frequency selection remains unchanged for two seconds, the frequency display will flash once. The unit will memorize the current frequency setting. The system will then exit the frequency-setting mode. For frequencies between 45 – 99.9 Hz, the adjustment is 0.1 Hz per step. For frequencies between 100 Hz – 500 Hz, the adjustment is 1 Hz per step.

Frequency Display 50Hz and 60Hz Buttons

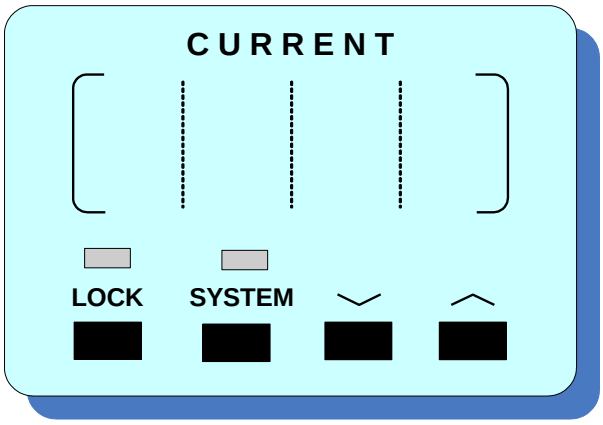
At any time you can press one of these buttons and the frequency will change from its present value to either 50 Hz or 60 Hz (depending on which button you press).

Note: Manual frequency adjustments will not automatically change the frequency values stored in memory locations M1, M2, or M3. To change stored frequency parameter values, please refer to the Section *Program Memory Procedures.*

Note: If your unit shuts down due to a detected Error condition, the FREQUENCY display shows an abbreviation for that error. For example, an over-current condition will result in OCP being displayed. For a listing and discussion of all displayed error conditions, see the Error Messages section of this chapter.

Current Limit (Display) Setting

When the system is in RESET (Standby) or the TEST (Output ON) mode, you can change the Current Limit value.



Current Display ⌃ and ⌄ Buttons

Press the ⌃ or ⌄ buttons to adjust the current limit. When unchanged for two seconds, the current limit adjustment terminates and the system returns to the previous setting interface. When the current limit value is OFF, the system will protect itself by limiting the current according to output capacity (see Specifications).

Current Display LOCK Button

This button locks the front panel control, except for the RESET and P/PF. Use this button to eliminate the possibility of unexpected (accidental) changes.

Current Display SYSTEM Button

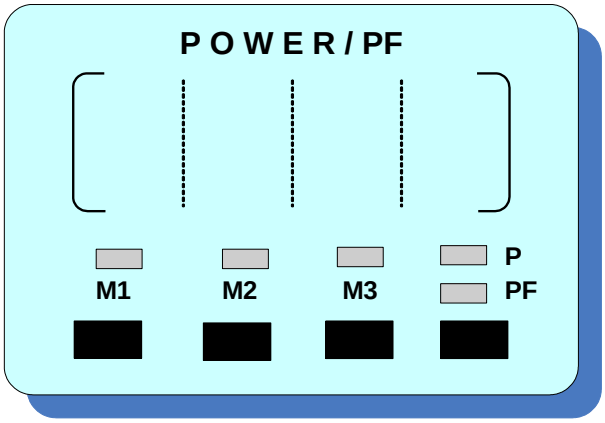
This button enables the setting of SYSTEM parameters. See the Section in this chapter called *System Parameter Settings*.

Note: Manual current adjustments will not automatically change the current limit values stored in memory locations M1, M2, or M3. To change stored parameter values, please refer to the Section *Program Memory Procedures*.

Note: If your unit shuts down due to a detected Over-Current condition, the FREQUENCY display shows OCP.

Power / PF (Display) Setting

When the system is in RESET (Standby) or the TEST (Output ON) mode, you can switch between Power and Power Factor (PF) mode. However, unless the system is in TEST (Output ON) you will not have a displayed value.



Power / PF Display P and PF Buttons

Use the button beneath the P / PF indicators to switch between modes.

Power / PF Display M1, M2, and M3 Buttons

These buttons are used to command the system to store (program) a set of values: voltage, frequency, and current limit. The buttons are also used to recall the stored set of values for output, during a test.

During RESET (Standby), press and holding "down" a button to command the system to store a set of values. When you first depress the button, The related indicator begins to flash. When the flashing stops, release the button and the values will be stored in that memory set.

During TEST (Output ON), press and release a button to command the system to output a set of stored values.

For more detailed information about the M-buttons, see the Section *Program Memory Procedures*.

Operations

Start Output

BEFORE pressing the OUTPUT button (on the Voltage display), check to ensure every setting is correct. Press the OUTPUT button to start the output. The LED (above the OUTPUT / RESET button) will light, indicating normal voltage output.

Stop Output

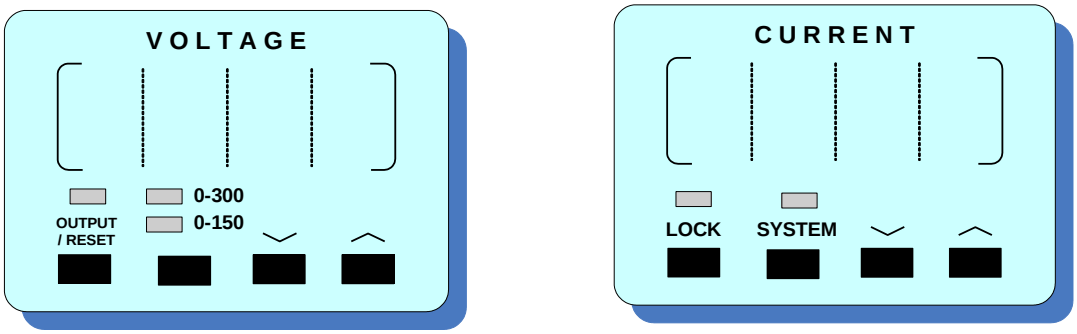
Press the RESET button to stop any test. When in the Output OFF (Standby) mode, the LED above the OUTPUT / RESET button will be OFF.

Stop Alarm

When the system encounters an overload, short-circuit, over-temperature, over-current, or power/power-factor beyond the preset limit, the unit will shut down. Output power will turn off, and an alarm will sound. The OUTPUT / RESET LED will flash.

When an error occurs, an error message will appear on either the Voltage or Current Display (see *Interpreting Error Messages*, page 4-17).

Pressing the OUTPUT / RESET button (on the Voltage display) once, will disable the alarm. Pressing it again, will reset the error message and return the unit to standby status. Pressing the OUTPUT / RESET button a third time will resume output (test).



NOTE: Please determine the cause (source) of any alarm and correct the problem — before pressing OUTPUT — to start the output again.

Lock Button

Pressing the LOCK/LOCAL button (on the CURRENT display) will light the LOCK LED (on the CURRENT display) and disable the other controls, except the P / PF button on the (on the POWER / PF display). Pressing the LOCK/LOCAL button again unlocks the front panel. This procedure is used to avoid accidental adjustments to the system.

External Switching Control

You can attach a simple external switches, relays, or a PLC, to the 9-pin D-sub connector on the rear panel. External switching can be used to control the output ON/OFF or to switch between any of three pre-programmed control memories (M1, M2, or M3). Chapter 5, External Interface, describes the external switching operations.

NOTE: The 9-pin D-sub connector is NOT an input/output port for RS-232 serial data or for GPIB parallel data.

System Parameter Settings

The APS-1000 front panel displays are used to present status, test data, and system parameters. This is the normal mode of display during operation. However, setting system parameters requires a special operator-selected mode (described below). System parameters are persistent. This means the system parameters are in effect regardless of whether you are operating the system manually, running from stored programs, or even powering up after the system has been shut down.

Entering the System Parameter Setting Mode

To enter the System Parameter Setting Mode, begin from the RESET (Standby) mode. Press the SYSTEM button (on the CURRENT display). The SYSTEM LED (above the SYSTEM switch) lights up. System Parameters are shown in the FREQUENCY and VOLTAGE displays. The present status and values are shown in the CURRENT display (see page 4-12 for details).

- Press the VOLTAGE ⌃ or ⌄ buttons to select parameters for adjustment.
- Press the CURRENT ⌃ or ⌄ buttons to set status and values for each item.

A table of parameters and values is shown in the next section. Following the table, you will find a set of detailed instructions for entering each system parameter.

Sequence of System Parameters

The System Parameter items are displayed in the following order:

- PLC Remote
- Auto Voltage Adjust
- Power-Up
- Frequency Hi-Limit
- Frequency Low-Limit
- Voltage Hi-Limit
- Voltage Low-Limit
- Over-Current Foldback

After the last item appears, the system cycles back to the first item on the list. When you have finished entering the System Parameters, press SYSTEM (on the CURRENT Display), to exit the System Parameter Setting mode.

System Parameter Table			
FREQUENCY DISPLAY	**VOLTAGE DISPLAY**	**CURRENT DISPLAY**	**DESCRIPTION**
	ΠΛΧ	ΟΦΦ	External Control / PLC Remote ON/OFF
	ΠΛΧ	Ον	
Αυτο	Αδφ	ΟΦΦ	Auto Voltage adjust function (AGC) enable / disable. When ON, output voltage regulation is improved.
Αυτο	Αδφ	Ον	
	Π–ΥΠ	ΟΦΦ	Power-Up output status
	Π–ΥΠ	Ον	
	Π–ΥΠ	ΛΑΣτ	
ΦρΕθ	ΗΙ	500.0	Maximum frequency setting limit
ΦρΕθ	ΛΟ	45.0	Minimum frequency setting limit
Υολτ	ΗΙ	300.0	Maximum voltage setting limit
Υολτ	ΛΟ	0.0	Minimum voltage setting limit
ΟΧ	Φολδ	Ον	Constant Current output mode, ON / OFF
ΟΧ	Φολδ	ΟΦΦ	

Setting System Parameters

Frequency Display	Voltage Display	Current Display
	ΠΛΧ	Ον / Οφφ

PLC Remote. Press the CURRENT ⌃ or ⌄ buttons to toggle the PLC ON / OFF in the current display.

- **OFF** The system is controlled directly from the front panel.
- **ON** The system is controlled by an external controller that is connected to the 9-PIN D-sub PLC connector on the rear panel.

Pressing any button on the front panel will cause the display to show PLC-ON, the buzzer to beep twice, and the display to return to RESET (Standby) mode. The LOCK / LOCAL, SYSTEM, and P ? PF buttons are the only ones that will function when the PLC feature is ON.

NOTE: DO NOT use the PLC port for RS-232 serial or GPIB parallel data.

Frequency Display	Voltage Display	Current Display
Αυτο	Αδφ	Ον/ Οφφ

Auto Voltage Adjust. Press the CURRENT ⌃ or ⌄ buttons to toggle ON / OFF. When ON, the automatic gain control circuit is activated and voltage regulation improves. The voltage will be automatically adjusted to maintain ± 0.1V of the set value.

Frequency Display	Voltage Display	Current Display
	Π–ΥΠ	Ον/ Οφφ/ ΛΑΣτ

Power Up. Press the CURRENT ⌃ or ⌄ buttons to step the current display between OFF/ON/LASt.

- **OFF** The system will start in standby mode.
- **ON** The system will power up using default output settings.
- **LASt** The system will power up using the output settings that were active when it was last shut down.

Frequency Display	Voltage Display	Current Display
ΦρΕθ	HI	500.0

Frequency Hi Limit. Press the CURRENT ⌃ or ⌄ buttons to adjust the frequency limit value in the current display within the available range: 45.0 – 500.0 Hz. This value sets the upper frequency limit that can be adjusted during normal operation. The FrEq HI value must be higher than the FrEq LO value.

Frequency Display	Voltage Display	Current Display
ΦρΕθ	ΛΟ	45.O

Frequency Lo Limit. Press the CURRENT ⌃ or ⌄ buttons to adjust the frequency limit value in the current display within the available range: 45.0 – 500.0 Hz. This value sets the lower frequency limit that can be adjusted during normal operation. The FrEq LO value must be lower than the FrEq HI value.

Frequency Display	Voltage Display	Current Display
Yoλτ	HI	3OO.O

Voltage Hi Limit. Press the CURRENT ⌃ or ⌄ buttons to adjust the voltage limit value in the current display within the available range: 0.0 – 300.0 V. This value sets the upper voltage limit that can be adjusted during normal operation. The Volt HI value must be higher than the Volt LO value.

Frequency Display	Voltage Display	Current Display
Yoλτ	ΛΟ	O.O

Voltage Lo Limit. Press the CURRENT ⌃ or ⌄ buttons to adjust the voltage limit value in the current display within the available range: 0.0 – 300.0 V. This value sets the lower voltage limit that can be adjusted during normal operation. The Volt LO value must be lower than the Volt HI value.

Frequency Display	Voltage Display	Current Display
OX	Φoλδ	Ov/ Oφφ

Constant Current Output. Press the CURRENT ⌃ or ⌄ buttons to toggle between ON/OFF.

- **OFF** The system will operate as a constant voltage power source only. If the load current exceeds the current high limit (A-HI), the unit will shut down.
- **ON** The system will limit the output current to a maximum value set by the current high limit (A-HI). For loads requiring less current than the A-HI value, the unit maintains a steady voltage output as set. If the load impedance is low enough, this function is activated when the load current attempts to exceed the current high limit (A-HI). The output current will then remain constant at the A-HI value and the output voltage will decrease accordingly.
-

Program Memory Procedures (Programming)

Use the procedures in this section to program the three memories: M1, M2, and M3. Each program has three stored parameters: voltage, frequency, and current limit. Note: The Persistent System Parameters (described in the previous section) take precedence over any parameters stored in program memories.

- Output Voltage
- Output Frequency
- Current High Limit

Setting Memory Parameters

- Begin in the RESET (standby) mode. The indicator above the OUTPUT/RESET button on the Voltage Display should be OFF. To set the desired parameter values for voltage, frequency, and current limit, press the ⌃ or ⌄ buttons on the respective displays.
- Check to make sure the values are what you want to store, then
- Press and hold the M-button (1, 2, or 3) for the memory in which you want to store the displayed parameters. The indicator above the selected M-button will flash. When the flashing stops, release the button. The parameter values are now stored and ready for recall. **Note:** Nothing will be stored if you release the button while the indicator is still flashing.
- Repeat the process until you have stored three sets of parameters.

Recalling Memory Parameters

- Recall a set of stored values when the system is in RESET (Standby) mode by momentarily pressing and releasing one of the M-buttons.
- When in RESET (Standby), use this recall approach to verify you have stored the values you want; or, you can establish values before you power-up.
- Recall a set of stored values when the system is in OUTPUT (Power ON) mode by momentarily pressing and releasing one of the M-buttons.
- Recall a set of stored values when the system is in OUTPUT (Power ON) mode and PLC is ON, through the external interface (see Chapter 5).

Note: Switching between stored programs during OUTPUT (Power ON) mode will cause a brief interruption of the output. The system first turns OFF the power and then ramps-up to the new voltage value.

Error Messages

Why are there Errors?

Setup mistakes happen. Overloads occur. Systems under test fail. When the APS-1000 unit encounters a fault condition, an error has occurred. The result is:

- The front panel display presents a message.
- The output turns OFF.
- An alarm sounds.
- The "FAIL" LED flashes.
- The "PROTECT" LED lights

CAUTION

Any error message signifies a fault was detected in the system or in the operating environment. Please carefully record the error message. The error MUST be resolved before resuming operation. If you are unable to resolve the error, please contact APS or the distributor for service. Contact information is found on page "*v*" of this manual.

Clearing an Error

- Press RESET (once) to disable the alarm.
- Make a note of the error message.
- Re-read the CAUTION (above)
- Refer to following **Error Message Table**.
- Refer also to the more detailed explanation of error messages in the Error Message Section.
- Press RESET (again) to clear the error message and return to RESET (Standby) status.
- If you are unable to resolve the difficulty, please see page *"v"* of this manual for APS contact information.

Error messages are displayed because of the following conditions:

- Fail Under voltage occurred during startup
- OCP Output current exceeded 110% of units maximum-rated value
- Hi-A Output current exceeded the set current high limit value
- LoDC Inverter power supply voltage less than 80% of internal bus voltage
- HiDC Inverter power supply voltage greater than 120% of internal bus voltage
- AcLP Input power was interrupted and then resumed
- FUSE Fuse opened
- Igbt Insulated Gate Bipolar Transistor (IGBT) overloaded
- OtP System's critical temperature was exceeded
- OVP Output voltage was high
- LVP Output voltage was low
- OPP Output power was high

Error Message Table			
FREQUENCY DISPLAY	**VOLTAGE DISPLAY**	**CURRENT DISPLAY**	**DESCRIPTION**
	ΦAIΛ		Under-voltage occurred during startup
OXΠ			Output current exceeded 110% of maximum rated value
HI–α			Output current exceeded set current high-limit value
ΛO–α			Output current was less than the set low-limit value
Λoδχ			Inverter power supply voltage was less than 80% of the rated internal bus voltage
HIδχ			Inverter power supply voltage was greater than 120% of the rated internal bus voltage
αχΛΠ			Input power was interrupted and then resumed
ΦYΣE			Fuse opened
I6βτ			Insulated Gate Bipolar Transistor (IGBT) overloaded
Oτπ			System's critical temperature was exceeded
Oϖ Π			Output voltage exceeded limit
Λς Π			Output voltage below limit
OΠΠ			Output power exceeded limit

Interpreting Error Messages

Voltage Display	*ΦAIΛ*

Under-Voltage Occurred During Startup. During power up, if the inverter voltage does not reach the specified level, the VOLTAGE display will show FAIL, an alarm will sound, and all buttons will be disabled. Turn off the input power to reset the message.

Frequency Display	*OXΠ*

Output Current Exceeded 110%. If the output current exceeds 110% of the set value, the FREQUENCY display will show OCP (Over Current Protect); an alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show the corresponding values at the time of overload.

Frequency Display	*H1–α*

Output Current Exceeded Hi-A Limit. If the output current exceeds the set current high limit value, the FREQUENCY display will show HI-A; an alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show the corresponding values.

Frequency Display	*Λoδχ*

Inverter Power Supply Voltage Below Operating Range. If the inverter power supply voltage is less than 80% of the input voltage, the FREQUENCY display will show Lodc (Low DC voltage). This means the INVERTER supply voltage is less than the normal working range for the APS-1000. An alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show their corresponding values.

Frequency Display	*H1δχ*

Inverter Power Supply Voltage Exceeded Operating Range. If the inverter power supply voltage is greater than 120% of the input voltage, the FREQUENCY display will show HIdc (Hi DC voltage). This means the INVERTER supply voltage is greater than the normal working range for the APS-1000. An alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show their corresponding values.

Frequency Display	AcLP

AC Power Momentarily Interrupted. If the input power is interrupted and then resumed, the FREQUENCY display will show AcLP (AC Line Power). This signifies a power abnormality. An alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show their corresponding values.

Frequency Display	FUSE

Blown Fuse. If a fuse opens, the FREQUENCY display will show FUSE. This means the internal bus was overloaded. An alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show their corresponding values.

Frequency Display	16bt

Insulated Gate Bipolar Transistor Overloaded. If an insulated gate bipolar transistor (IGBT) is overloaded, the FREQUENCY display will show Igbt. The Insulated gate bipolar transistors are the main power transistors in the power conversion circuit. An alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show their corresponding values.

Frequency Display	OtP

System Critical Temperature Exceeded. If any of the system's critical temperatures are exceeded, the FREQUENCY display will show OVP (Over temperature Protect). This signifies overheating. An alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show their corresponding values.

Frequency Display	OvP

Output Voltage Limit Exceeded. If the output voltage exceeds the voltage setting by more than 5V on the 0-150V range or 10V on the 0-300V range, the FREQUENCY display will show OVP (Over Voltage Protect); an alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show the corresponding values.

Frequency Display	LVP

Output Voltage Below Limit. If the output voltage is lower than the voltage setting by more than 5V on the 0-150V range or 10V on the 0-300V range, the FREQUENCY display will show LVP (Under Voltage Protect); an alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show the corresponding values.

Frequency Display	OPP

Output Power Limit Exceeded. If the output power exceeds 125% of the rated output for 0.3 seconds or 110% of the rated output for 1.0 seconds the FREQUENCY display will show OPP (Over Power Protect); an alarm will sound; the OUTPUT/RESET LED will flash; and the VOLTAGE and CURRENT displays will show the corresponding values at the time of over-power.

Chapter 5
External Interface

Overview

Chapter 5 provides information about the APS-1000 external interface. Use the information in this chapter to learn how to use the remote control capabilities of your unit. You will probably find that test operations controlled from the front panel are relatively intuitive. However, external control requires an understanding of how to enter parameters into M1, M2, M3, described in Chapter 4. In addition, in this chapter you will learn how to connect external switches, relay contacts, or Programmed Logic Controller (PLC).

The external interface connector is not intended for RS-232 or GPIB control.

All APS Power Converters can be externally controlled by a PLC, or equivalent. Read the following section for details about the PLC External Interface.

PLC External Interface

All APS Power Converters have a built-in PLC External Interface. Consequently, all APS Power Converters can be operated remotely. The PLC external interface is particularly useful for tests that require the use of independent metering and external data acquisition instrumentation. The PLC external interface allows remotely located contact closures to start / stop one of three sets of pre-programmed test parameters. The test parameters are entered in memory sets M1, M2, and M3.

Operation of the PLC remote interface does not require a true PLC, as simple switch closures are effective at starting and stopping an APS-1000 stored test program. However, although simple switches can be used, they require manual operation. The use of a PLC permits external automatic control of the test programs in memories M1, M2, or M3.

In preparation for external control, connect an external switch / controller. The controller is attached using the PLC External Interface D-Sub DE-9 connector located on the rear panel of your APS-1000 Power Converter (see page 3-8).

To activate the APS PLC internal circuitry, set the system parameter PLC to ON.

NOTE: Do not attempt to use the PLC D-Sub DE-9 connector as an RS-232 or GPIB data port.

When the PLC system parameter is set to ON in the Systems parameters, the OUTPUT button on the front panel is disabled. If the OUTPUT button is pressed, PLC ON will be displayed on the panel, an alarm will sound, and the system will return to its previous status. If the system encounters an error, the front panel RESET button or the ON/OFF control at the PLC remote can be enabled to perform a system reset.

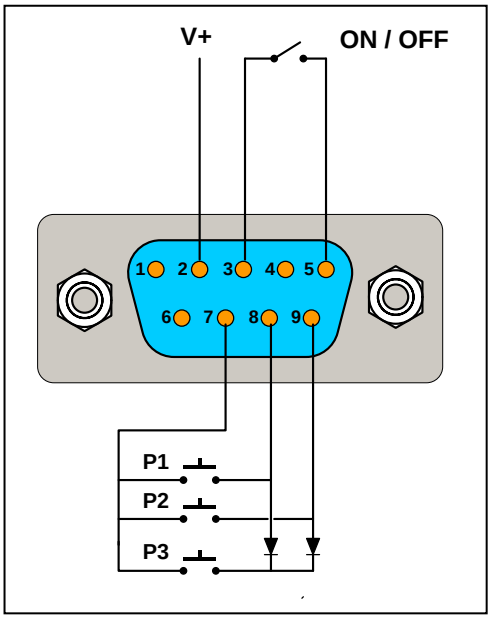
A sketch of the APS PLC DE-9 pinouts and simple switch configuration is shown on the following page.

Manual Switcher (Three-Program Control)

A commercial PLC is not required to control your APS-1000. If you have access to a few parts, some cable and a connector, you can build a simple switcher. Use the following information to build a cable and switch-box.

Note: Do not use long unshielded cables and/or poor-quality switches. The length of control cable you can use will depend on the type of shielding, ground quality, and the electrical environment you are operating in. Use good instrumentation wiring techniques to minimize problems.

DE-9	Item	Comments
2	+ 12 VDC	Low Power, Current Limited
3 to 5	SPST Switch	ON/OFF Dry Contact
7 to 8	SPST, NO	M1 Momentary, Dry Contact
7 to 9	SPST, NO	M2 Momentary, Dry Contact
7 to 8 and 9	SPST, NO	M3 Momentary, Dry Contact
8 and 9	Diodes (+ side)	1N4148 or 1N914, etc.



PLC DE-9 Connector and Control

Chapter 6
System Calibration

Overview

Chapter 6 explains how to calibrate your APS-1000 Series Power Converter. Although each APS unit is carefully calibrated at the factory prior to shipment., periodic calibration is appropriate. Normal system maintenance requires calibration once a year (See Chapters 7).

Whether you perform calibration prior to a critical test or as a scheduled annual maintenance task, the procedures for calibration are identical.

Note, the values of some calibration parameters are different for different sizes of APS models. This chapter includes tables of all calibration parameters for all models. Please use the calibration values that are for your particular model.

APS-1000 Series Calibrations Modes

Six separate procedures are provided for the six calibration modes.

- Low-voltage mode (*Y–LO*) calibration:
- High-voltage mode (*Y–HI*) calibration:
- Low-current mode (*A–LO*) calibration:
- High-current mode (*A–HI*) calibration:
- Low-power mode (*P–LO*) calibration:
- High-power mode (*P–HI*) calibration:

Each of the six calibration modes is explained in a separate section. As necessary, sections contain calibration parameters relative to that calibration mode.

Calibration Setup

APS-1000 calibration is straightforward. However, you must use the appropriate calibration instrumentation and text fixtures. In addition to test cables and connectors, you will need:

- RMS Voltmeter, ± 0.2%, at least 300 VAC
- RMS Ammeter, ± 0.2%, (See Calibration Settings Table for your APS model)
- Restive Load Bank, Calculated for your APS model (See following Example)

How to Calculate the Size of the Test Load (Example)

For an example, suppose your system is an APS-1010.

The High Current Calibration Procedure (later in this chapter) specifies an output voltage of 120 VAC, for all models. From the Table of Calibration Settings, you see the **A HI (A)** calibration test current for the (example) APS-1010P is specified at 80 A.

CALIBRATION SETTINGS							
Parameter	**1002**	**1003**	**1005**	**1010**	**1020**	**1030**	**1040**
V LO (VAC)	150.0	150.0	150.0	150.0	150.0	150.0	150.0
V HI (VAC)	300.0	300.0	300.0	300.0	300.0	300.0	300.0
A LO (A)	3.000	3.000	30.00	30.00	30.00	30.00	30.00
A HI (A)	16.00	25.00	42.00	80.00	160.0	250.0	330.0
P LO (kW)	0.3000	0.3000	3.000	3.000	3.000	3.000	3.000
P HI (kW)	2.000	3.000	5.000	9.000	18.00	27.00	36.00

For 120 VAC and 80 A, your load should have a resistance of

$$R = \frac{V_{rms}}{I_{rms}} = \frac{120 \text{ volts}}{80 \text{ amps}} = 1.50 \text{ ohms.}$$

The power handling capability of the test load must be at least

$$P = \frac{(V_{rms})^2}{R} = \frac{(120 \text{ volts})^2}{1.50 \text{ ohms}} = 9600 \text{ watts} = 9.6 \text{ kW.}$$

WARNING

THIS EQUIPMENT CONTAINS HIGH ENERGY, LOW IMPEDANCE CIRCUITS!!
LETHAL POTENTIALS ARE CONTAINED WITHIN THE CABINET.

CARE MUST BE EXERCISED WHEN OPERATING, CALIBRATING, OR SERVICING THIS EQUIPMENT, IN ORDER TO PREVENT SERIOUS OPERATOR INJURY OR EQUIPMENT DAMAGE.

OBSERVE THE FOLLOWING WHEN SERVICE AND MAINTENANCE ARE REQUIRED:

1) **REMOVE ALL JEWELRY FROM ARMS AND NECK WHEN SERVICING THIS EQUIPMENT. THIS PREVENTS THE POSSIBILITY OF SHORTING THROUGH THE JEWELRY AND CAUSING BURNS TO THE OPERATOR.**
2) **WEAR SAFETY GLASSES WHEN SERVICING THIS EQUIPMENT TO PREVENT EYE INJURY DUE TO FLYING PARTICLES CAUSED BY ACCIDENTAL SHORT CIRCUIT CONDITIONS.**
3) **DO NOT REMOVE ANY PANEL OR COVER WITHOUT FIRST REMOVING THE INPUT POWER BY OPENING ALL CIRCUIT BREAKERS.**
4) **SERVICE OTHER THAN REGULARLY SCHEDULED CALIBRATION OR EXTERNAL CLEANING SHOULD BE REFERRED TO PERSONNEL AUTHORIZED BY THE FACTORY TO SERVICE THIS EQUIPMENT.**

Calibration Instructions

General Information about Calibration

- At the MULTIMETER Display, pressing the RESET button aborts the calibration process.
- The system must be restarted after all calibration operations have been completed.

Entering the Calibration Mode

- At the Multimeter Display, press and continue to hold the LOCK / LOCAL button while turning the power on.
- After about 2 seconds, the unit will execute the calibration program that is appropriate for your particular unit, based on the APS model number. The panel will display the (firmware) version number. XY corresponds to the model number and nominal power rating of your unit.

Frequency Display	Voltage Display
XAA	*10 XY*

OUTPUT ELECTRICAL SPECIFICATIONS									
Model: 1 0 X Y		**1002P**	**1003P**	**1005P**	**1010P**	**1020P**	**1030P**	**1040P**	**1060P**
Total Power		**2 KVA**	**3 KVA**	**5 KVA**	**10 KVA**	**20 KVA**	**30 KVA**	**40 KVA**	**60KVA**
Maximum Amps	0 – 150 V	16.8 A	25.2 A	42.0 A	84.0 A	168.0 A	252.0 A	336.0 A	504.0
	0 – 300 V	8.4 A	12.6 A	21.0 A	42.0 A	84.0 A	126.0 A	168.0 A	252.0

- You do not have any use for the version number during calibration.
- Confirm the displayed model number agrees with your unit's external model number. The internal calibration program uses this model number in its activities .

- If there is disagreement between the displayed model number and unit's external model number, you should stop the process, turn off the unit, and contact your distributor or the factory. Please refer to page *"v"* of this manual for factory contact information.

Selecting Calibration Parameters

- Following the controlled power-up, your APS unit enters the Low Voltage (*Y–ΛO*) calibration mode.
- Press the FREQUENCY ﹀ or ﹀ buttons to select the system parameter you are going to calibrate.
- Pressing FREQUENCY ﹀ proceeds to the next calibration mode. Pressing FREQUENCY ﹀ returns to the previous step.
- Low-voltage mode (*Y–ΛO*) calibration
- High-voltage mode (*Y–HI*) calibration
- Low-current mode (*A–ΛO*) calibration
- High-current mode (*A–HI*) calibration
- Low-power mode (*Π–ΛO*) calibration
- High-power mode (*Π–HI*) calibration

Calibration Frequency

Please note, the calibration frequency is internally selected to be 60 Hz. Consequently, there is no user-selectable calibration frequency setting. Please use resistive loads for all of your load-calibration procedures. Resistive loads are not sensitive to frequency.

Low-Voltage Mode (U-LO) Calibration

1. At the FREQUENCY Display, press the ⌃ or ⌄ buttons to select *Y–ΛO* (V-LO). The low-voltage parameter is calibrated (first) at the beginning of calibration.
2. At the OUTPUT Terminals, with no load attached, carefully connect a certified, calibrated RMS voltmeter, of at least 0.2% accuracy, to the output.
3. At the VOLTAGE Display, press the OUTPUT/RESET button. The APS unit will automatically perform a low-voltage output reading and will output approximately 150 VAC. The external RMS voltmeter will display the actual voltage output, and the current display will show the calibration value (see Calibration Table below).

Frequency Display	Voltage Display	Current Display
Y–ΛO	*150.0*	*150.0*

Calibration Settings

Parameter	1002	1003	1005	1010	1020	1030	1040	1060
V LO (VAC)	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
V HI (VAC)	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
A LO (A)	3.000	3.000	30.00	30.00	30.00	30.00	30.00	300.0
A HI (A)	16.00	25.00	42.00	80.00	160.0	250.0	330.0	500.0
P LO (kW)	0.3000	0.3000	3.000	3.000	3.000	3.000	3.000	30.0
P HI (kW)	2.000	3.000	5.000	9.000	18.00	27.00	36.00	54.0

4. At the CURRENT Display Adjust the voltage using the CURRENT ⌃ or ⌄ buttons until the metered values match.
5. At the CURRENT Display, press the LOCK button to finish low-voltage calibration.
6. Proceed to the next calibration function, unless this completes system calibration.
7. Note, to exit the Calibration Mode, your APS system must be restarted after you have completed ALL calibration operations.

High-Voltage Mode (U-HI) Calibration

1. At the FREQUENCY Display, press the ﹀ buttons to select ***Y–HI*** (V-HI). The high-voltage parameter is calibrated after you calibrate the low voltage.
2. At the OUTPUT Terminals, with no load attached, carefully connect a certified, calibrated RMS voltmeter, of at least 0.2% accuracy, to the output.
3. At the VOLTAGE Display, press the OUTPUT/RESET button. The APS unit will automatically perform a high-voltage output reading and will output approximately 300 VAC. The external RMS voltmeter will display the actual voltage output. The CURRENT Display shows the calibration value (See Calibration Table, below).

Frequency Display	Voltage Display	Current Display
Y–H1	*300.0*	*300.0*

Calibration Settings								
Parameter	**1002**	**1003**	**1005**	**1010**	**1020**	**1030**	**1040**	**1060**
V LO (VAC)	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
V HI (VAC)	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
A LO (A)	3.000	3.000	30.00	30.00	30.00	30.00	30.00	300.0
A HI (A)	16.00	25.00	42.00	80.00	160.0	250.0	330.0	500.0
P LO (kW)	0.3000	0.3000	3.000	3.000	3.000	3.000	3.000	30.0
P HI (kW)	2.000	3.000	5.000	9.000	18.00	27.00	36.00	54.0

4. At the CURRENT Display. adjust the voltage using the CURRENT ﹀ or ﹀ buttons until the metered values match.
5. At the CURRENT Display, press the LOCK button to finish high-voltage calibration.
6. Proceed to the next calibration function, unless this completes system calibration.
7. Note, to exit the Calibration Mode, your APS system must be restarted after you have completed ALL calibration operations.

Low-Current (A-LO) Mode Calibration

1. At the FREQUENCY Display, press the ﹀ button to select *A–LO* (A LO).
2. At the OUTPUT Terminals, carefully connect a resistive load and connect a certified, calibrated RMS ammeter, of at least 0.2% accuracy.
3. The size of the resistive load should be calculated based on the low-current parameter for your particular APS unit, as shown in the following Calibration Settings Table. Use 120 VAC for the voltage.
4. An example calculation is shown on page 6-2 in the Section *Calculation Setup,* subsection *How to Calculate the Size of the Load.*

Calibration Settings

Parameter	1002	1003	1005	1010	1020	1030	1040	1060
V LO (VAC)	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
V HI (VAC)	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
A LO (A)	3.000	3.000	30.00	30.00	30.00	30.00	30.00	300.0
A HI (A)	16.00	25.00	42.00	80.00	160.0	250.0	330.0	500.0
P LO (kW)	0.3000	0.3000	3.000	3.000	3.000	3.000	3.000	30.0
P HI (kW)	2.000	3.000	5.000	9.000	18.00	27.00	36.00	54.0

5. At the VOLTAGE Display, press the OUTPUT/RESET button. The APS unit will automatically perform a low-current output reading and will output approximately 120 VAC.
6. The external RMS ammeter will display the actual current output. The CURRENT Display shows the calibration value (see Calibration Table, above).

Frequency Display	Voltage Display	Current Display
A–LO	*120.0*	*XX.XX*

7. Adjust the load or the output voltage until the RMS ammeter displays the value shown in the Calibration Table (above). Please note, the value for your unit will depend on the model.
8. At the CURRENT Display, adjust the metered current using the ﹀ or ﹀ buttons until the metered values match.

9. At the CURRENT Display, press the LOCK button to complete low-current calibration.
10. Proceed to the next calibration function, unless this completes system calibration.
11. Note, to exit the Calibration Mode, your APS system must be restarted after you have completed ALL calibration operations.

High Current (A-HI) Mode Calibration

1. At the FREQUENCY Display, press the ﹀ button to select ***A–HI*** (A HI).
2. At the OUTPUT Terminals, carefully connect a resistive load and connect a certified, calibrated RMS ammeter, of at least 0.2% accuracy.
3. The size of the resistive load should be calculated based on the high-current parameter for your particular APS unit, as shown in the following Calibration Table. Use 120 VAC for the voltage.
4. An example calculation is shown on page 6-2 in the Section *Calculation Setup*, subsection *How to Calculate the Size of the Load.*

Calibration Settings

Parameter	1002	1003	1005	1010	1020	1030	1040	1060
V LO (VAC)	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
V HI (VAC)	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
A LO (A)	3.000	3.000	30.00	30.00	30.00	30.00	30.00	300.0
A HI (A)	16.00	25.00	42.00	80.00	160.0	250.0	330.0	500.0
P LO (kW)	0.3000	0.3000	3.000	3.000	3.000	3.000	3.000	30.0
P HI (kW)	2.000	3.000	5.000	9.000	18.00	27.00	36.00	54.0

5. At the VOLTAGE Display, press the OUTPUT/RESET button. The APS unit will automatically perform a high-current output reading and will output approximately 120 VAC.
6. The external RMS ammeter will display the actual current output. The CURRENT Display shows the calibration value (see Calibration Table, above).

Frequency Display	Voltage Display	Current Display
A–H1	*120.0*	*XX.XX*

7. Adjust the load or the output voltage until the RMS ammeter displays the value shown in the Calibration Table (above). Please note, the value for your unit will depend on the model.
8. At the CURRENT Display, adjust the metered current using the ﹀ or ﹀ buttons until the metered values match.

9. At the CURRENT Display, press the LOCK button to complete high-current calibration.
10. Proceed to the next calibration function, unless this completes system calibration.
11. Note, to exit the Calibration Mode, your APS system must be restarted after you have completed ALL calibration operations.

Low-Power (P-LO) Mode Calibration

1. At the FREQUENCY Display, press the ﹀ button to select *Π–ΛO* (P LO).
2. At the OUTPUT Terminals, carefully connect a resistive load and connect a certified, calibrated RMS power meter, of at least 0.2% accuracy.
3. The size of the load should be calculated based on the low-current parameter for your particular APS unit, as shown in the following Calibration Table. Use 120 VAC for the voltage.
4. An example calculation is shown on page 6-2 in the Section *Calculation Setup*, subsection *How to Calculate the Size of the Load.*

Calibration Settings

Parameter	1002	1003	1005	1010	1020	1030	1040	1060
V LO (VAC)	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
V HI (VAC)	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
A LO (A)	3.000	3.000	30.00	30.00	30.00	30.00	30.00	300.0
A HI (A)	16.00	25.00	42.00	80.00	160.0	250.0	330.0	500.0
P LO (kW)	0.3000	0.3000	3.000	3.000	3.000	3.000	3.000	30.0
P HI (kW)	2.000	3.000	5.000	9.000	18.00	27.00	36.00	54.0

5. At the VOLTAGE Display, press the OUTPUT/RESET button. The APS unit will automatically perform a low-power output reading and will output approximately 120 VAC.
6. The external RMS power meter will display the actual power output. The CURRENT Display shows the calibration value (see Calibration Table, above).

Frequency Display	Voltage Display	Current Display
Π–ΛO	*120.0*	*X.XX*

7. Adjust the load or the output voltage until the RMS power meter displays the value shown in the Calibration Table (above). Please note, the value for your unit will depend on the model.
8. At the CURRENT Display, adjust the metered power using the ﹀ or ﹀ buttons until the metered values match.

9. At the CURRENT Display, press the LOCK button to complete low-power calibration.
10. Proceed to the next calibration function, unless this completes system calibration.
11. Note, to exit the Calibration Mode, your APS system must be restarted after you have completed ALL calibration operations.

High-Power (P-HI) Mode Calibration

1. At the FREQUENCY Display, press the ﹀ button to select *ΠHI* (P HI).
2. At the OUTPUT Terminals, carefully connect a resistive load and connect a certified, calibrated RMS power meter, of at least 0.2% accuracy.
3. The size the load should be calculated based on the high-current parameter for your particular APS unit, as shown in the following Calibration Table. Use 120 VAC for the voltage.
4. An example calculation is shown on page 6-2 in the Section *Calculation Setup*, subsection *How to Calculate the Size of the Load.*

Calibration Settings

Parameter	1002	1003	1005	1010	1020	1030	1040	1060
V LO (VAC)	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
V HI (VAC)	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
A LO (A)	3.000	3.000	30.00	30.00	30.00	30.00	30.00	300.0
A HI (A)	16.00	25.00	42.00	80.00	160.0	250.0	330.0	500.0
P LO (kW)	0.3000	0.3000	3.000	3.000	3.000	3.000	3.000	30.0
P HI (kW)	2.000	3.000	5.000	9.000	18.00	27.00	36.00	54.0

5. At the VOLTAGE Display, press the OUTPUT/RESET button. The APS unit will automatically perform a high-power output reading and will output approximately 120 VAC.
6. The external RMS power meter will display the actual power output. The CURRENT Display shows the calibration value (see Calibration Table, above).

Frequency Display	Voltage Display	Current Display
ΠHI	*120.0*	*X.XX*

7. Adjust the load or the output voltage until the RMS power meter displays the value shown in the Calibration Table (above). Please note, the value for your unit will depend on the model.
8. At the CURRENT Display, adjust the metered power using the ﹀ or ﹀ buttons until the metered values match.

9. At the CURRENT Display, press the LOCK button to complete high-power calibration.
10. Proceed to the next calibration function, unless this completes system calibration.
11. Note, to exit the Calibration Mode, your APS system must be restarted after you have completed ALL calibration operations.

Chapter 7
System Maintenance

Overview

Chapter 7 describes the maintenance procedures you should perform. This is a very short chapter because, other than keeping air filters clean, there is almost no user maintenance required.

Introduction

No internal parts require user maintenance. If the equipment appears to have a malfunction, please contact APS or the distributor for service (see page *"v"*). The wiring and block diagram are for reference only.

Scheduled Maintenance

The APS-1000 Series Frequency Converters should be inspected and calibrated once per year to ensure safety and accuracy of the equipment. Air vents must be kept clear of obstructions. If the equipment is used on a regular basis in a dusty environment, more frequent cleaning may be necessary.

Modification

Do not modify this equipment. Any modifications void the warranty automatically, and violate the tested safety standards of the unit. APS does not take responsibility for such equipment. Parts or accessories not certified by APS will not be covered under the warranty. If any modification is detected in equipment returned for service, the equipment will be returned immediately by APS and the customer will be charged for this inspection / service.

System Design

APS-1000 Series power converters are high power Pulse Width Modulated (PWM) switching amplifiers. The internal switching frequency is 10 kHz. This frequency is 200 times higher than the lowest operating frequency (50 Hz) and 25 times higher than the highest operating frequency (400 Hz). The choice of switching frequency provides high resolution and ensures removal of high frequency harmonics. The all-digital control circuitry meters and displays system outputs, in addition to generating control signals. The system is microprocessor-based. Firmware in a proprietary EEPROM allows APS-configuration upgrades.

WARNING

**THIS EQUIPMENT CONTAINS HIGH ENERGY, LOW IMPEDANCE CIRCUITS!!
LETHAL POTENTIALS ARE CONTAINED WITHIN THE CABINET.**

**CARE MUST BE EXERCISED WHEN SERVICING THIS EQUIPMENT
IN ORDER TO PREVENT SERIOUS OPERATOR INJURY OR EQUIPMENT DAMAGE.**

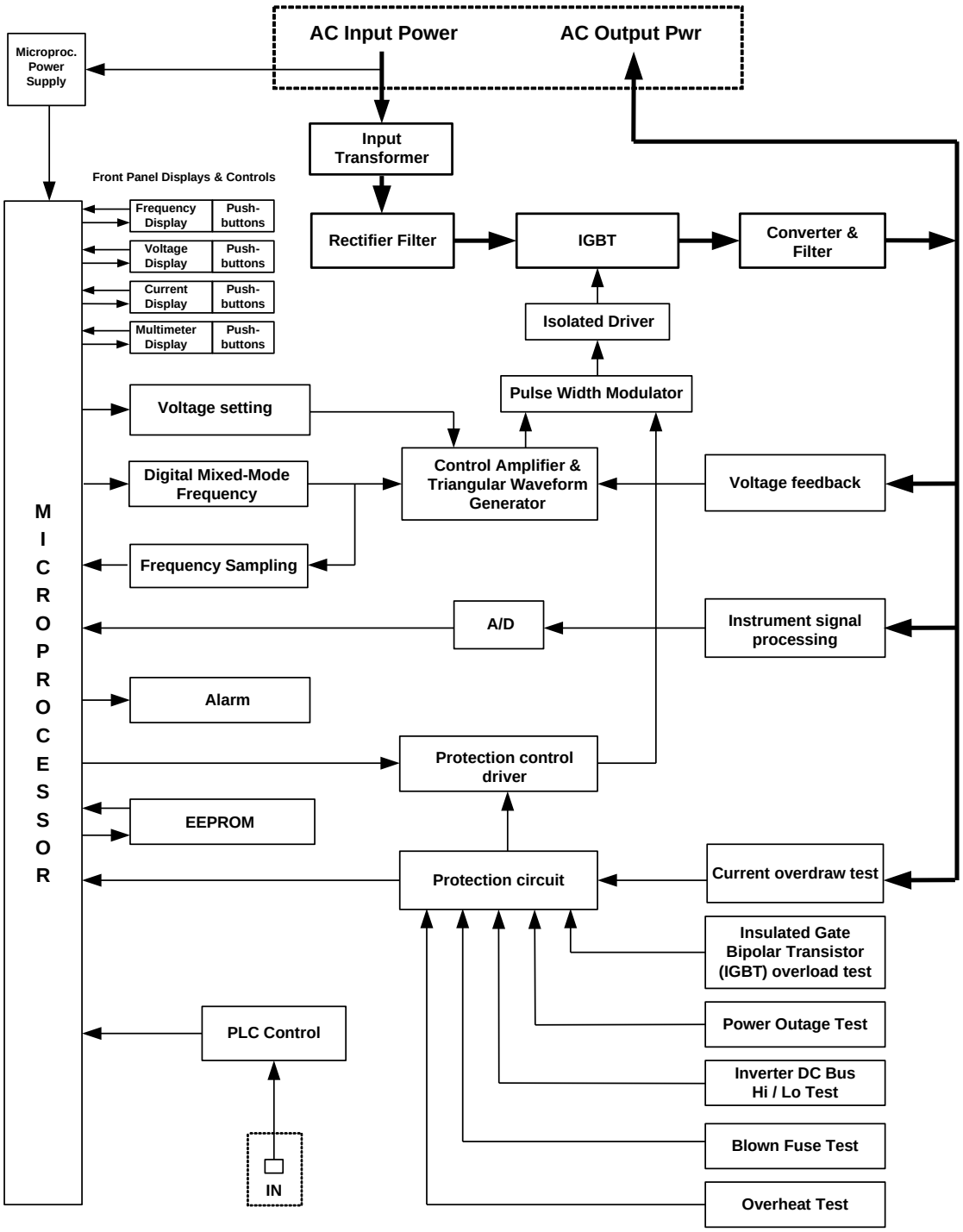
OBSERVE THE FOLLOWING --- WHEN SERVICE AND MAINTENANCE ARE REQUIRED:

- **REMOVE ALL JEWELRY FROM ARMS AND NECK WHEN SERVICING THIS EQUIPMENT. THIS PREVENTS THE POSSIBILITY OF SHORTING THROUGH THE JEWELRY AND CAUSING BURNS TO THE OPERATOR.**
- **WEAR SAFETY GLASSES WHEN SERVICING THIS EQUIPMENT TO PREVENT EYE INJURY DUE TO FLYING PARTICLES CAUSED BY ACCIDENTAL SHORT CIRCUIT CONDITIONS.**
- **DO NOT REMOVE ANY PANEL OR COVER WITHOUT FIRST REMOVING THE INPUT POWER BY OPENING ALL CIRCUIT BREAKERS.**
- **SERVICE OTHER THAN EXTERNAL CLEANING SHOULD BE REFERRED TO PERSONNEL AUTHORIZED BY THE FACTORY TO SERVICE THIS EQUIPMENT. THERE ARE NO USER-SERVICABLE INTERNAL PARTS.**

System Block Diagram

If you are interested in how the APS-1000 works, you can learn more by reviewing the System Block Diagram on the following page. Please note, the block diagram is supplied for information purposes only. There are no serviceable components available to the user.

APS-1000 Series Block Diagram



APS-1000 Series System Block Diagram