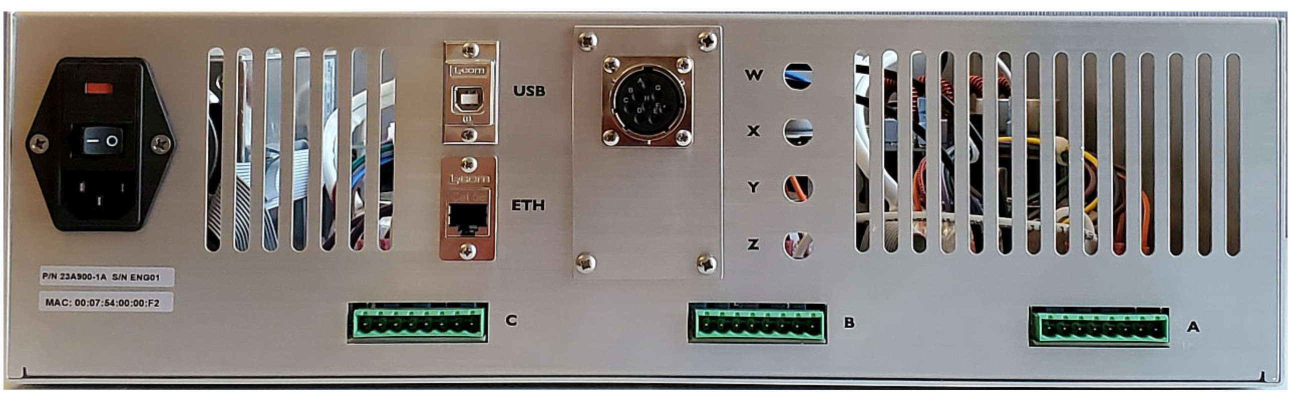
HIGHLAND TECHNOLOGY

Model P900

3-Phase Power Source and

PM Alternator Simulator



Technical Manual

October 9, 2023

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This product has finite failure rates associated with its hardware, firmware, design, and documentation. Do not use the product in applications where a failure or defect in the instrument may result in injury, loss of life, or property damage.

Table of Contents

1 Introduction

This is the technical manual for the Highland Model P900-1 rackmount 3-phase AC power source and permanent-magnet (PMA) alternator simulator.

For a FADEC application quick start example, refer to section 9.

Features of the P900 include:

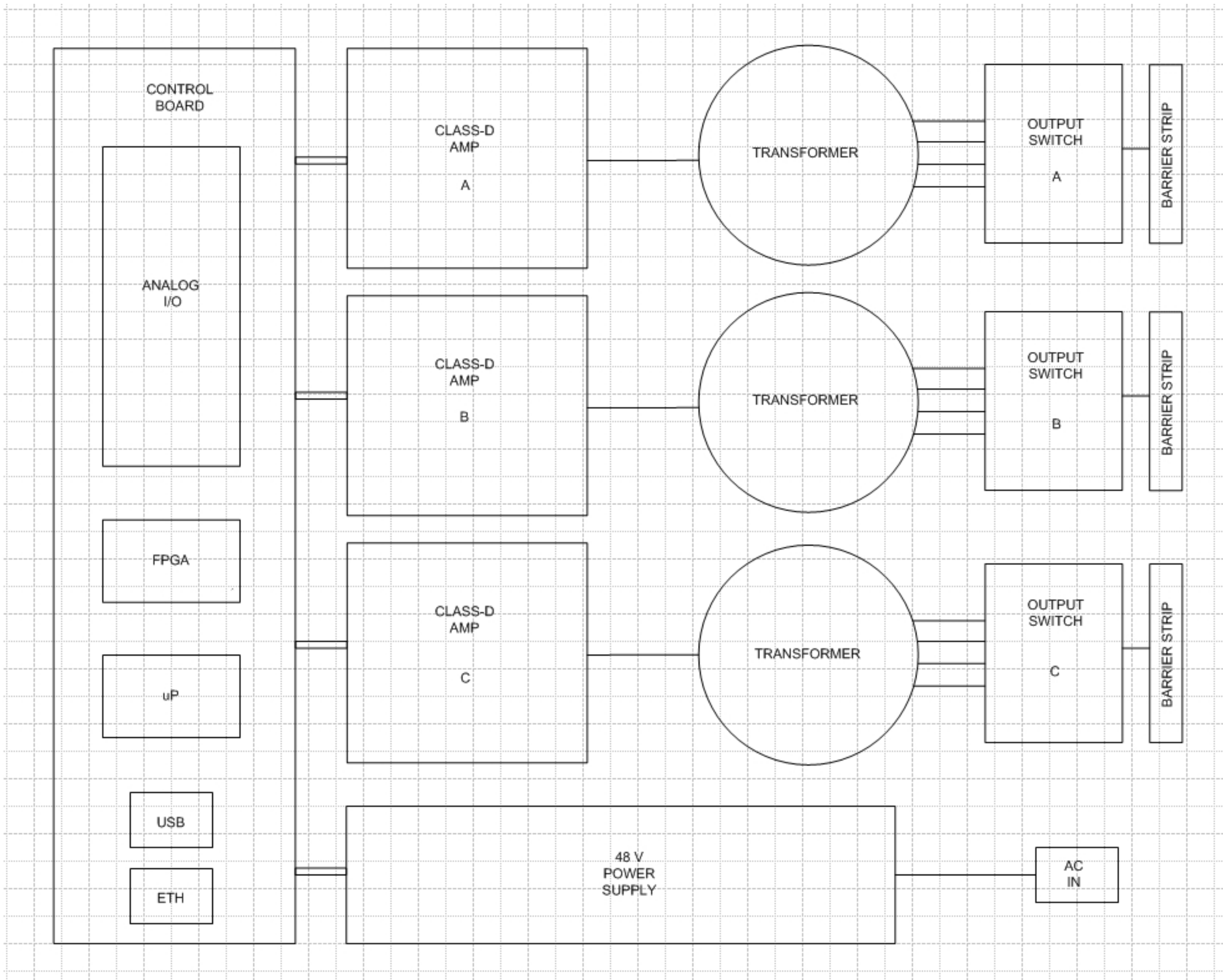
- Isolated, transformer-coupled 3-phase sine wave outputs
- Frequency range 120 Hz to 4 KHz
- Output up to 200 VA per channel, 600 VA total
- Four voltage ranges: 0-40, 0-80, 0-120, and 0-160 VRMS per phase
- VOLTAGE (low impedance) and ALTERNATOR (simulated impedance) modes
- Programmable voltage, frequency, and current limits
- Simulates aircraft power busses and PMA permanent-magnet alternators
- Measures and reports RMS voltages and currents
- Front-panel voltage and current scope monitors
- Powered from single-phase 90-264 VAC, 47-63 Hz
- USB and Ethernet interfaces

2 Specifications

FUNCTION	Three phase programmable power sine wave source
OUTPUTS	Isolated 3-phase wye Up to 200 VA per phase, 600 VA total 120 Hz to 4 KHz Usable to 50 Hz at reduced voltages
VOLTAGE RANGES AND PROGRAMMABLE CURRENT LIMITS	Range 1 0-40 VRMS current limit 1-10 amps peak Range 2 0-80 VRMS current limit 1-5 amps peak Range 3 0-120 VRMS current limit 1-3.3 amps peak Range 4 0-160 VRMS current limit 1-2.5 amps peak Multiply voltages by 1.73 for line-line wye connection
POWER IN	90-264 VAC, 47-63 Hz, single phase PFC, 800 watts max
MONITOR OUTPUTS	Scaled voltage and current scope monitors per channel
CONTROLS	USB and Ethernet Front-panel POWER STBY/ON rocker switch Front-panel OUTPUTS ON/OFF rocker switch
CONNECTORS	Monitors, front panel BNC Outputs, rear panel pluggable barrier strips, MIL circular AUX i/o, rear panel BNCs AC power in, standard IEC connector USB type B Ethernet RJ45
PACKAGING	3U 19" rackmount, 18" deep, approx. 40 lbs
COOLING	Internal fans

3 Overview

The P900 overall block diagram is as follows:



The P900 consists of:

3U rackmount enclosure with fans

One commercial 48-volt, 1KW, universal-input power-factor-corrected switching power supply

One control board with microprocessor, FPGA, and interfaces

Three class-D power amplifiers

Three custom toroidal power transformers

Three output range switch boards.

The 3-phase wye connected output is programmable for phase voltage, frequency, and peak current limit.

The P900-1 is internally jumpered for 3-phase open wye connection to the MS connector. Neutral and grounds are also accessible on three Phoenix barrier strips.

The output switch boards provide the four AC voltage ranges by switching transformer windings. An output on/off/fault relay is also provided per channel.

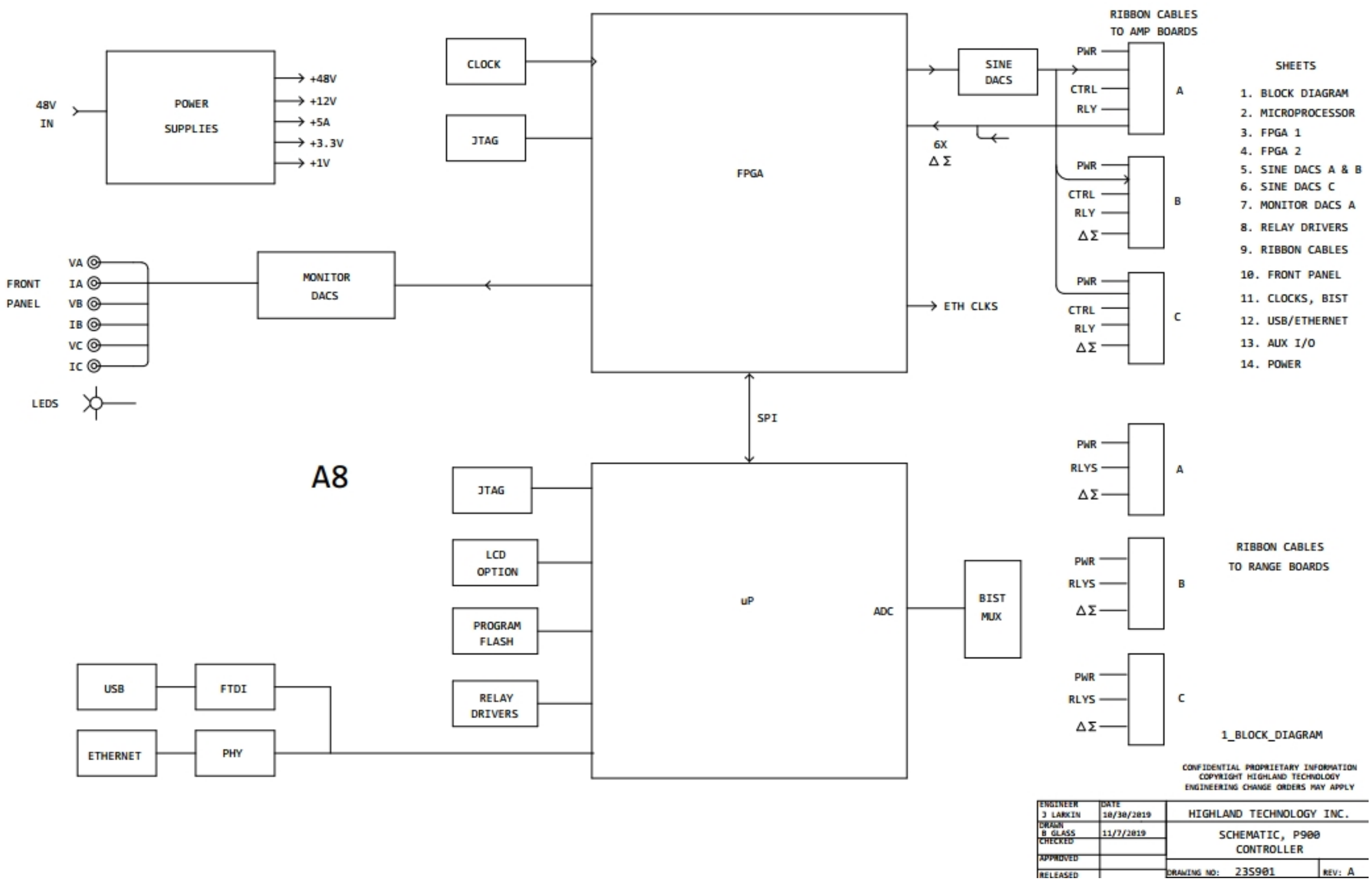
The P900 can be programmed to operate in Voltage mode (low impedance outputs, no added inductance) or in Alternator mode, with added inductance suited to driving FADEC power supplies or similar switchmode shunt regulators. The added inductance is about 200 uH on range 1, which is suitable for driving switchmode shunt regulators that operate in the 15-50 KHz range.

In both modes, a user-programmable peak current limit is available. Programming a relatively high AC voltage and a suitable current limit simulates a permanent-magnet alternator which usually works in essentially a constant-current mode.

Each channel is equipped with isolated voltage and current sensors. Voltage and current waveform monitors are provided on front-panel BNC connectors. RMS voltages and currents are computed by the FPGA and can be acquired over the USB/Ethernet interface.

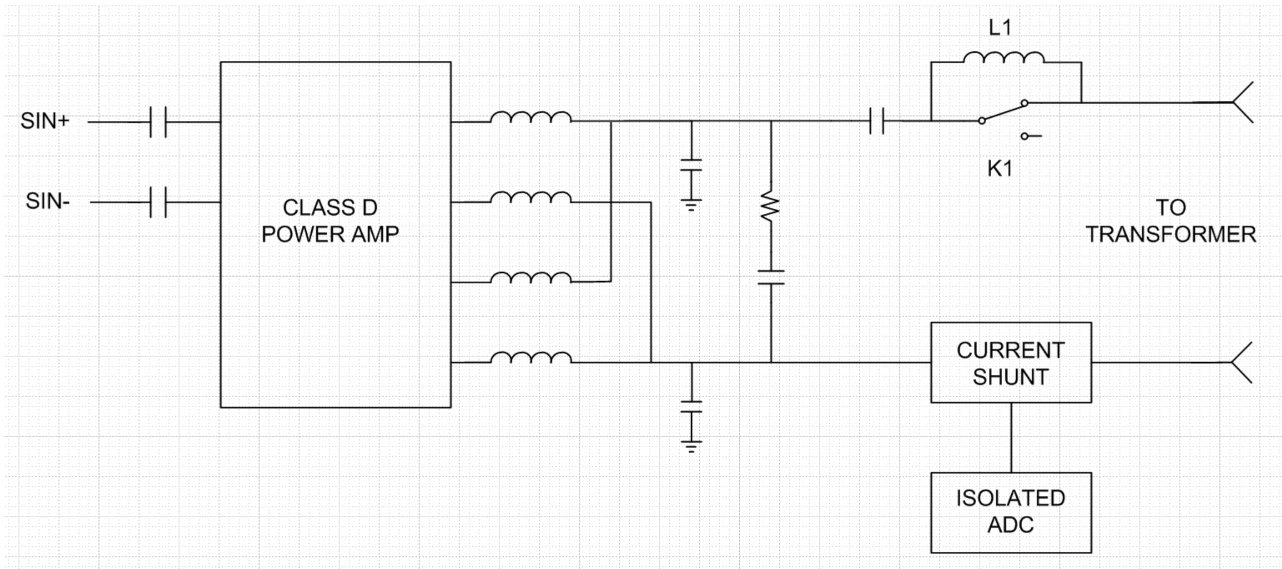
3.1 Controller Board

The controller board block diagram is



3.2 *Class D Amplifiers*

There are three switchmode class D power amplifier boards. The block diagram of one such board is



The amplifier receives a synthesized sinewave analog input signal from the control board. The amplifier output is filtered to remove switchmode components and drives the output transformer.

In Alternator mode, L1 simulates an alternator inductance compatible with a typical FADEC switchmode shunt regulator.

The L1 value appears as 200 uH, 800 uH, 1.8 mH, and 3.2 mH line-neutral on the respective four voltage ranges. Wye connected, that inductance is effectively doubled.

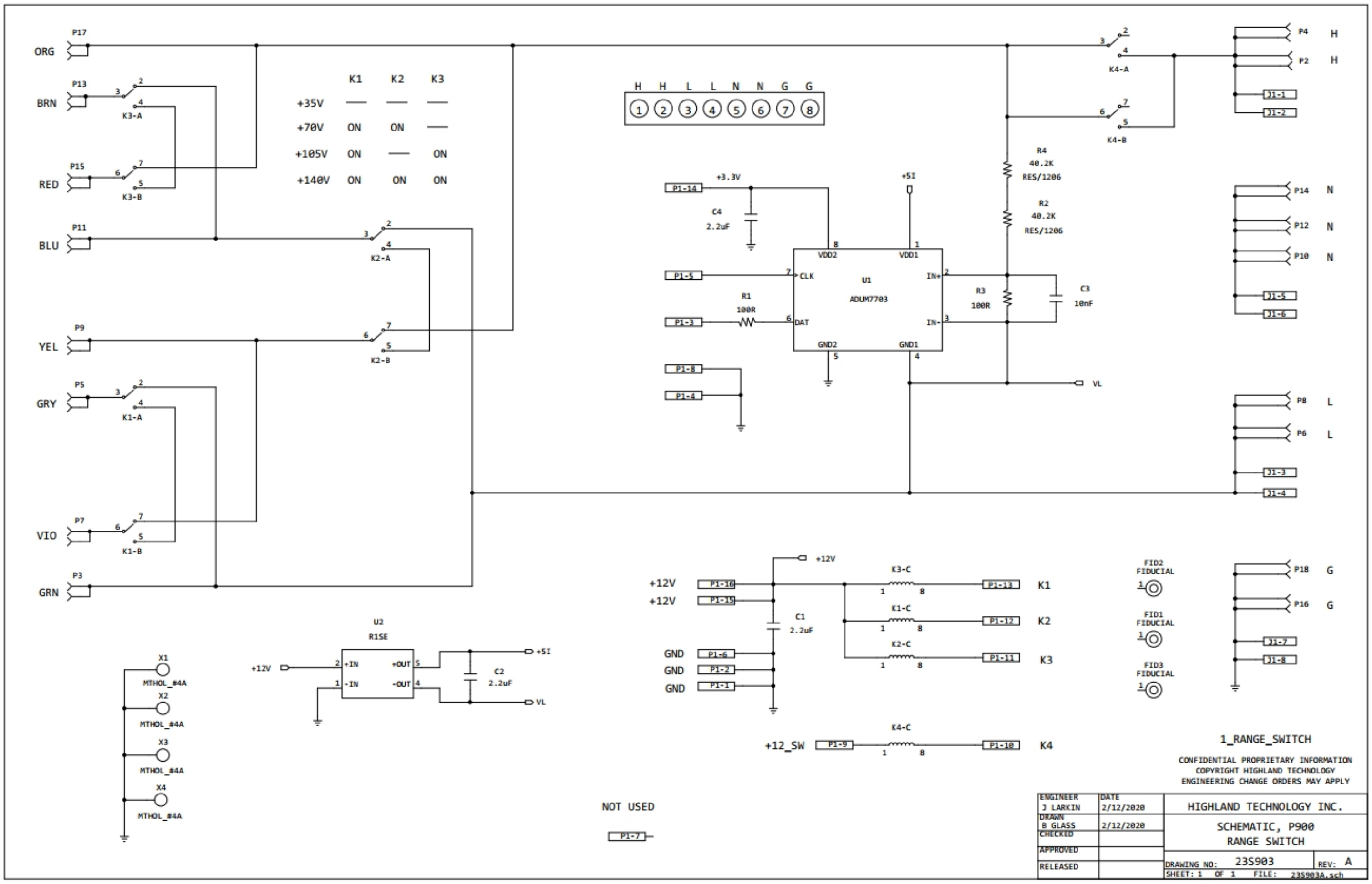
Relay K1 shorts L1 in Voltage output mode, for applications that need a low impedance 3-phase voltage source.

The amplifier receives power and signals from the controller board and returns status signals and the current shunt waveform. Each amp board includes its own heat sink, fan, current shunt, and temperature sensors.

3.3 Output Range Switching Boards

Each channel has an isolated output transformer with four secondary windings. Each transformer connects to a range switch board, which provides the rear-panel outputs.

The range-switch board schematic is



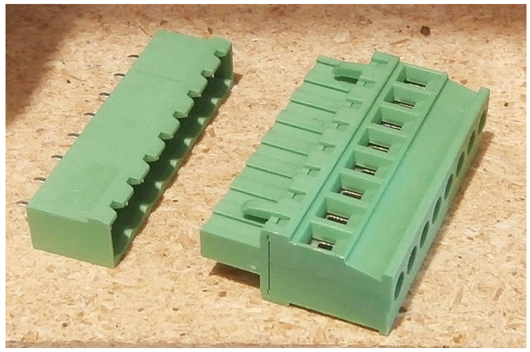
The four transformer secondaries enter on the left. The relays allow various combinations of windings to be connected in series and/or parallel to provide the four output voltage ranges. The programmable fault relay K4 enables outputs and is open whenever a channel is programmed OFF or the front-panel OUTPUT switch is set OFF.

Each range board also includes two 175-volt MOV transient supressors, one from VH to VL, and another from VL to chassis ground. These clamp ESD and inductive transients above about 300 volts peak.

The **OUTPut:DROP** command can be used to generate a programmed-duration output open-circuit simulated fault event.

An isolated 16-bit ADC acquires the output voltage waveform and sends it to the FPGA and to the front-panel voltage monitor BNC connector.

Rear-panel outputs are via a pluggable 8-pole Phoenix barrier strip and a circular MIL connector.



In the picture above, the smaller connector is captive to the range board and is accessed through a cutout in the rear panel. The larger Phoenix is pluggable into the box, and provides for customer wire termination. Pins are numbered 1..8 left to right on the rear panel. The pinout is of each phase is

PIN	NAME	FUNCTION
1	VHI	AC out high side left
2	VHI	
3	VLO	AC out low side
4	VLO	
5	N	neutral
6	N	
7	GND	chassis ground
8	GND	right

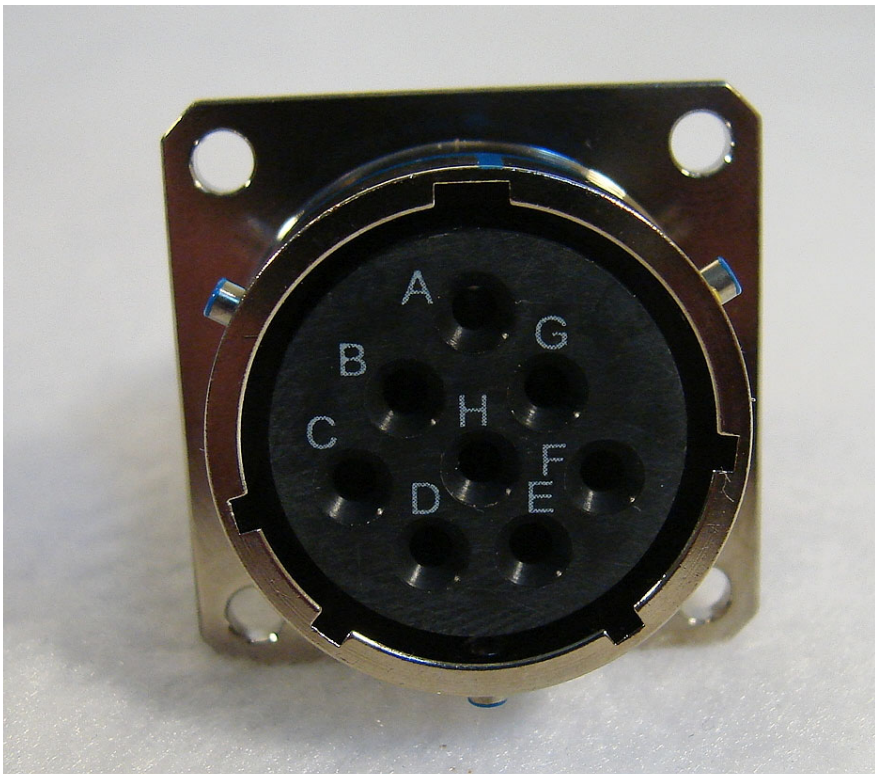
The three transformers and their range boards are independent and fully floating. Each range board includes eight internal 0.187" male faston connector tabs, which allow internal jumpering to neutral or ground as desired.

The P900-1 is internally jumpered to form a three phase ungrounded open-neutral WYE source. The Neutral is established by faston jumpers which strap all three VLO phases together.

Strapping could be removed to provide three isolated phases.

The MS circular connector is type MS3470L16-08S. Each output phase connects to two pins. Neutral is not brought out on this connector

Phase A high goes to pins A and B.
Phase B high goes to pins C and D.
Phase C high goes to pins G and H.



4 Physical Interface

4.1 LEDs

The front-panel LEDs are

POWER. This green LED, on the right side of the front panel, is dim in standby mode and bright with a uP heartbeat modulation in normal operation, with the front-panel power switch ON.

On the left side, there are

ON. Blue LED illuminates when the OUTPUT switch is ON.

LIM. Orange LED lights if some setting or condition might produce an unexpected output. For example, requesting more voltage than the current range allows.

ERR. Red LED lights for a serious error. The P900 powers up with ERR on, and it will go out in a few seconds after normal initializations. Afterward a blinking pattern will indicate one of the following two error conditions:

Error condition	**Blink pattern**
Failure to load firmware application:	Steady on or 1s toggle
Failure to load calibration table:	One blink every 2 seconds
Power supply voltage out of tolerance:	Two blinks every 2 seconds

Each AC output channel has two LEDs, near its monitor connector pair.

The yellow ON led indicates that the channel output is enabled.

The red LED indicates some problem with the channel.

4.2 Monitor Connectors

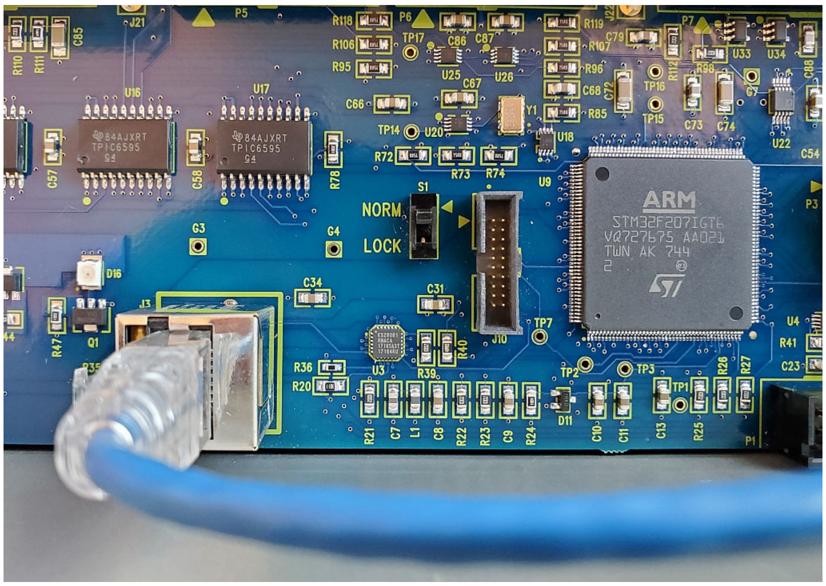
Each channel A, B, and C, has two front-panel BNC monitor connectors, labeled VMON and IMON. The VMON connectors are voltage waveform monitors, and the IMON connectors are output current waveform monitors. Each is intended to drive a high impedance oscilloscope or DVM. The BNC barrels are chassis ground.

Monitor currents are scaled 0.1 volts per output amp of each phase, namely 0.1 VRMS per amp RMS output current.

Voltage monitors are attenuated 100:1 from channel phase outputs, namely 0.01 volt RMS per L-N output volt RMS.

4.3 Lock Switch

Some secure applications may require that all nonvolatile memory within the P900 be disabled. A switch is provided interior to the unit to disable flash writes. To access this switch, remove the top cover, set the switch to LOCK, and replace the cover. Security stickers may then be applied over the cover mounting screws.

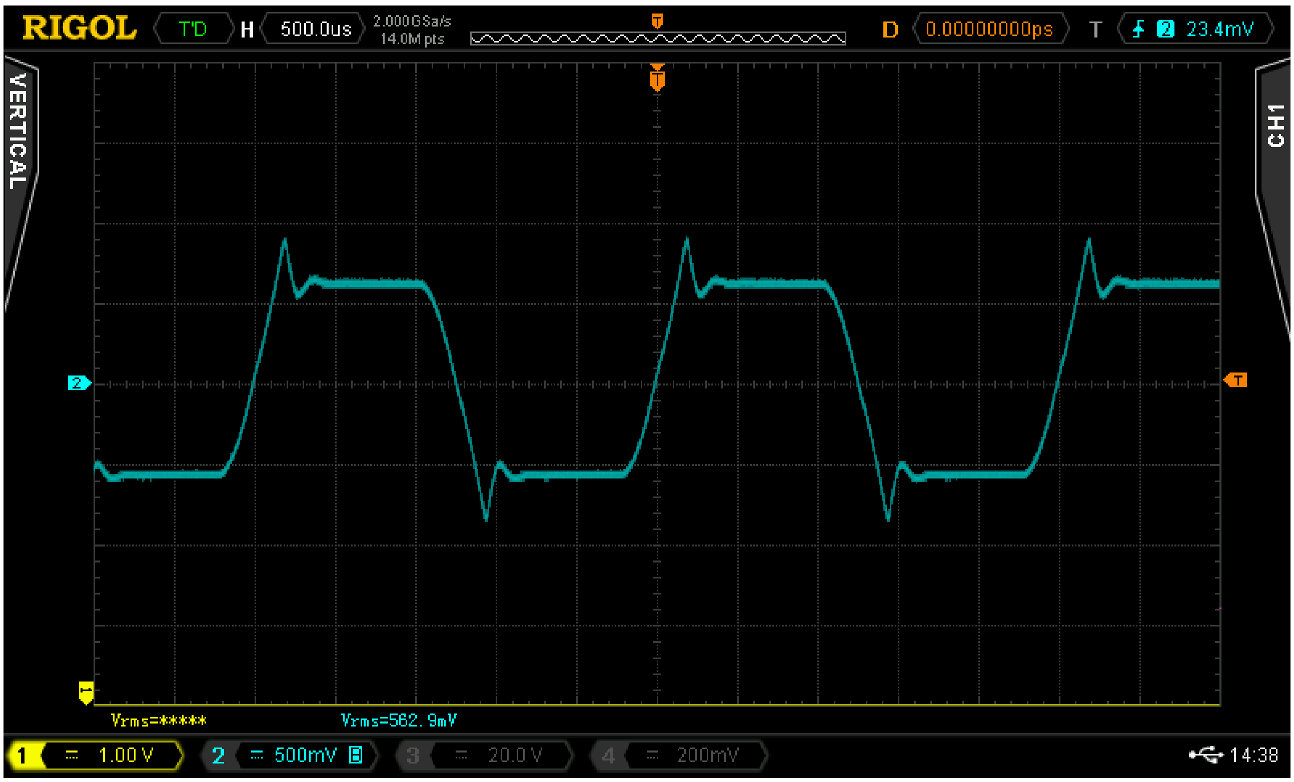


When set to LOCK, the FLASh:UNLock (and by corollary FLASh:WRITe and FLASh:ERASe) serial commands will not execute. The switch is shipped set to NORM by default. The state of the switch may be queried using STATus:LOCk.

5 Output Matching

PM alternators are virtually constant-current sources and can generate very high voltages at high RPMs when lightly loaded. The P900 cannot generate extremely high AC voltages, but the programmable voltage and current limit can model the behavior of a PM alternator when used to drive a typical FADEC with a shunt PWM regulator.

A typical current limiting waveform is shown below. This is single-phase output current for a channel programmed for maximum output on range 1, specifically 40 volts RMS and 10 amps peak, into a short-circuit load. When driving a 3-phase full-bridge rectifier, P900 current waveforms will closely resemble actual alternator waveforms. The P900 will tolerate an indefinite short.



Given the 3-phase open wye current-limited output of the P900, into a typical FADEC 3-phase rectifier and shunt regulator, one would typically set the channel voltages and current limits higher than the DC requirement of the FADEC and allow the FADEC PWM shunt regulator to bypass the excess current.

The 120 Hz low frequency specification is constrained by transformer saturation, but the P900 is usable to lower frequencies at correspondingly reduced output voltage, which generally tracks alternator behavior.

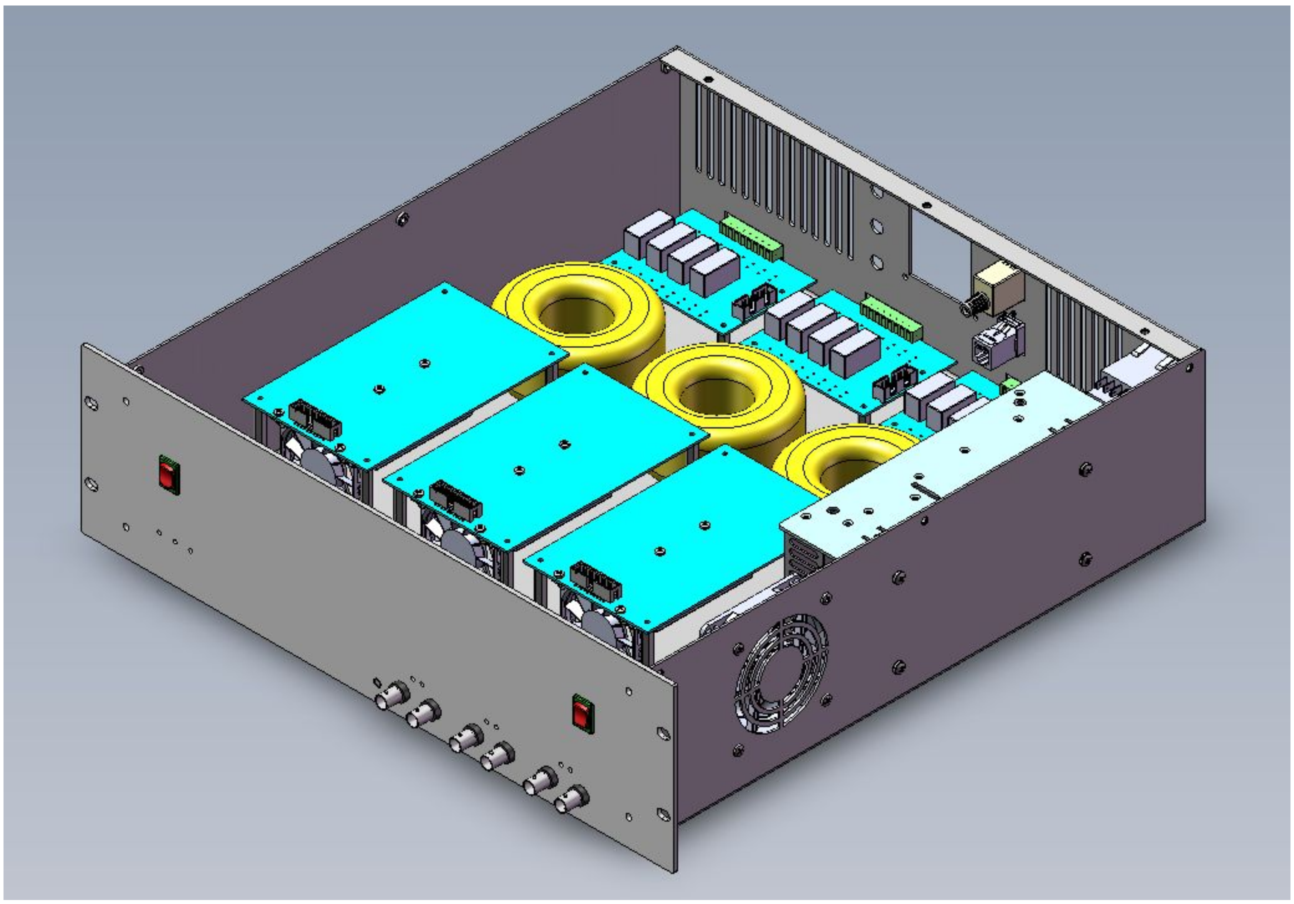
See section 9 for specific programming examples.

6 Installation and Power

The P900 is a 3U x 18" deep rackmount enclosure. It should be securely grounded, via the power cord and the ground stud on the rear panel.

The rear panel power entry module accepts a standard IEC power cord. The power supply operates from 90 to 264 VAC, 47-63 Hz. The main AC power switch is on the power entry module on the rear. The front panel ON/STBY switch enables the DC side of the power system.

Air intake is on the right side, near the front panel, and exhaust is through the slots on the rear panel. Air flow should not be impeded.



7 Communications and Programming

7.1 USB Interface

All standard ASCII commands can be sent through the USB interface.

The P900 emulates a serial port using the FTDI FT230XS USB interface chip. This is the most common USB/serial interface chip, so many operating systems will include appropriate drivers.

Documentation and drivers are available at http://www.ftdichip.com

The serial port protocol is:

Baud	115200
Data Bits	8
Stop Bits	1
Parity	None

7.2 TCP/IP Interface

By default, the P900 uses a DHCP client to request an IP address from the network's DHCP server. This may be changed to a static IP address using the SYST:COMM:LAN subsystem of commands described below. (Note that for network settings to be saved for the next boot cycle, the NORM/LOCK switch must be in the NORM position.)

The P900 has a default hostname of "P900-xxxxx", where xxxxx is the serial number of the unit padded with zeroes on the left to 5 digits, for example "P900-00001".

Port 2000 is used for ASCII serial commands. Only one TCP session may be connected to port 2000 at a time. If a remote client disconnects improperly (without sending the appropriate RST packet to the P900, for example), the port will be unusable until the P900's TCP-keepalive timeout, approximately thirty seconds.

7.3 UDP Interface

In addition to TCP, the P900 accepts UDP packets containing serial commands. It listens on Port 2000. To prevent spurious information being sent, either the UDP datagram length must be no longer than the length of the serial command text, or the text must end with a octet equal to zero (the NUL character commonly expressed as '\0'). Multiple serial commands may exist in a single packet, delimited by either a semicolon or a newline. However, a single serial command may not be fragmented across multiple packets.

Caution: While executing any serial command that affects the range, the P900 may block processing of other serial commands for ten milliseconds. It is possible to overflow the P900's UDP server with packets this way, causing the P900 to miss commands. We recommend appending the "*OPC?" query to any non-query UDP packet and wait for a reply before sending the next serial command packet.

7.4 General Syntax

The commands follow SCPI syntax. If a command takes multiple arguments, the arguments are delimited from each other by a comma ‘,’. The P900 replies to query commands (commands which end with a question mark ‘?’) but not set commands. Replies to queries in compound commands (multiple commands on the same line) are delimited from each other by semicolons and terminated by a newline. No command in a compound command will be executed until an end-of-line character (ASCII 10 or 13) is received. After the end-of-line character is received, the compound commands on the line will be executed in the order in which they are received.

If any error is encountered during a compound command, execution of the remainder of the compound command will be aborted. If any reply had already been sent due to previous queries on the command line, then end-of-line will be replied; otherwise no reply will be made.

Commands described in the following subsections are written such that their short-form mnemonic is in upper-case and the remaining letters of their long-form mnemonic is in lower-case. For example, a command mnemonic written as DEFault may be sent to the P900 as either DEF or DEFAULT.

Regardless of how they are written in this manual, all commands are case-insensitive. Any command arguments of SCPI type “character program data” are also case-insensitive.

Whether using USB or TCP/IP, replies to serial commands should take less than fifty milliseconds per command, except as noted in the detailed command description below regarding some special-case serial commands.

7.5 Note About Critical Systems

SCPI does not reply to non-query commands. To ensure that a command was received and executed without error, we recommend appending the `*OPC?` query to every non-query command line. If the reply to *OPC (‘1’ followed by a newline) is not received within a timeout period (which can be polled, for example, by using the *select* system call on Linux-based operating systems), the error may be queried using the `SYST:ERR?` query. (As noted above, on the P900, all compound commands on a line are executed in the order that they are received.)

For example, to change the range and ensure that the command was received and executed without error, send

```
SOUR:VOLT:RANGE Y,2;*OPC?
```

and test for a reply of *`1`*, or send

```
SOUR:VOLT:RANGE Y,2;RANGE? Y
```

and test for a reply of the expected range, in this example *`2,2,2`*.

7.6 Command Detailed Description

In the examples, commands sent to the P900 are shown in `THIS FONT`, and replies from the P900 are shown in *`THIS FONT`*.

7.6.1 Common and Miscellaneous Commands

***CLS**

Clears the SCPI error queue and status byte.

***IDN?**

The query-only *IDN? command returns the company, model, serial number, and firmware version. E.g.:

```
*IDN?
HTI,P900,123,23E900A
```

***OPC?**

The query-only *OPC? command waits until all pending operations are complete, then responds with ‘1’. This is useful as a handshaking mechanism to ensure previous commands have completed before proceeding on.

***RST**

The *RST command reboots the P900.

***TST?**

The query-only *TST? Command replies ‘1’ if the following are true:

- All power supplies are within acceptable range
- No channel has been shut down due to overtemperature or overcurrent
- The calibration data has loaded with a successful checksum test
- No channel configuration error exists (i.e. no condition exists that would light the front panel LIM led).

Otherwise it will reply ‘0’.

TEST:POWer?

The query-only TEST:POWer command replies the P900’s six power supply voltages, delimited by commas, in the following order: +3.3V, +5V, +12V, +1.5V, +1.8V, and +48V.

The P900 scans these power supplies in a loop. The reply data contains the last-measured value for each power supply.

7.6.2 Alternator Simulator Commands

Note on <*chan*> arguments:

All arguments described as <*chan*> are SCPI-type “character program data.” They may be A, B, or C, or a combination of these to execute a command on multiple channels (e.g. ABC for all channels). For queries, if multiple channels are requested, the replies will be delimited by commas and replied in the order that the channels are written in the argument (*not* necessarily in the order of A, B, C!).

Note on *Y* arguments:

Arguments described below as “Y” are literally Y for dash-1 P900s.

DEFault

The DEFault command sets the P900 to its startup default without rebooting. The default settings are:

- Outputs range 0
- Alternator mode
- Frequency 400 Hz
- Voltages 0
- Current limits 10 amps peak
- Fault relays open
- FLASh:WRITe and FLASh:ERASe disabled

OUTPut:MODe <VOLTage|ALTernator>
OUTPut:MODe?

The OUTPut:MODe command sets the output operation mode. If not a query, its argument is either VOLTage or ALTernator. Any MODE command sets channel ranges to 0 and all output voltages to zero and all frequencies to 400 Hz.

`OUTP:MOD VOLT`	sets the P900 outputs into low-impedance voltage-out mode
`OUTP:MOD ALT`	sets the P900 to work in alternator mode. The output inductors are engaged.
`OUTP:MOD?`	queries the current mode. Its reply will be either VOLT or ALT.

SOURce:VOLT:RANGe Y,<range>
SOURce:VOLT:RANGe? Y

There are five output voltage ranges for each channel, numbered 0 to 4, set by the "RANGe" command.

RANGE	MAX RMS VOLTS	MAX PEAK AMPS
0	0	0
1	40	10
2	80	5
3	120	3.3
4	160	2.5

The first argument is always Y for the P900-1.

If not a query, the second argument is the range number, 0 to 4.

`SOUR:VOLT:RANG Y,3`   sets the range to 3 on all channels

The act of setting ranges or mode sets all phase voltages to zero and all output/fault relays open and frequency to 400 Hz. Use the OUTp:RELay:ON command to enable outputs.

Setting Range to 0 holds programmed output voltage to 0 and opens all relays on the associated range board. ON is inoperative for a channel set to range 0.

Range is queried as `RANG? Y`

SOURce:VOLT:LEVel   Y,<level>
SOURce:VOLT:LEVel? Y

The VOLTs command sets the programmed open-circuit RMS L-N voltage of all channels.

```
SOUR:VOLT:LEV  Y,27.5
```

The first argument is always Y for the P900-1.

If not a query, the second argument is the number of volts RMS. The only accepted unit suffix is V and/or an exponent. E.g. "2.75 E+01 / V" is an equivalent argument to "27.5."

If a requested voltage exceeds the current range limit on any channel, the actual voltage will be set to the maximum for that range and the front-panel orange LIM constraint LED will illuminate.

To prevent transformer saturation, the internal firmware will reduce the programmed voltage as necessary when frequency is programmed below 100 Hz, and illuminate the LIM LED.

Replies to queries are number of programmed volts in fixed-decimal notation, precise to 100mV.

```
VOLT? Y
```

130.2

SOURce:FREQuency Y,<frequency>
SOURce:FREQuency? Y

The SOURce:FREQuency command sets all channel sine wave frequencies, in Hertz. The allowed range is 100 to 4000.

The first argument is always Y for the P900-1.

If not a query, the second argument is the frequency, in Hertz. The only accepted unit suffixes are HZ or KHZ, with or without an exponent. E.g. the following are equivalent:

`SOUR:FREQ Y,2150` sets all frequencies to 2150 Hz

`SOUR:FREQ Y,2.15 KHZ`

Replies are decimal integer number of Hertz. The query form is

```
SOUR:FREQ? Y
2150
```

OUTPut:LIMit Y,<amps>
OUTPut:LIMit? Y

The OUTPut:LIMit command programs all channels to have a peak current limit, in amps. Current limiting is operative in voltage or alternator mode.

The first argument is always Y for the P900-1.

If not a query, the second argument is the peak current, in Amperes. No unit suffixes will be accepted, except an exponent.

`OUTP:LIM Y,7` programs all channels to have a 7 amp peak limit

If the requested current is not compatible with the selected range, the setting will be clipped to the range limits and the LIM led will light.

Query replies are float-point amps. If multiple channels are queried, the reply for each requested channel will be delimited from each other by a comma ‘,’. E.g.:

OUTP:LIM? Y
+7.00000E+00,+7.00000E+00,+7.00000E+00

OUTPut:OVERload? <chan>

The query-only OUTPut:OVERload command returns ‘1’ if a channel is currently shutdown due to overload, or ‘0’ if it is not. The first argument is the channel list, described at the beginning of this section. If multiple channels are queried, the channels' replies will be delimited from each other by a comma.

OUTPut:RELay:ON <chan>
OUTPut:RELay:OFF <chan>
OUTPut:RELay:ON? <chan>

The OUTPut:RELay:ON command closes the final "fault" relay of each channel output. The OUTPut:RELay:OFF command opens it.

The first argument is the channel list, described at the beginning of this section.

`OUTP:REL:ON C`	enables the C channel output switch relay
`OUTP:REL:OFF ABC`	opens all outputs, also used as fault state

Replies to queries are either '1' to indicate the output switch relay is enabled, or '0' to indicate the output relays are opened. If multiple channels are queried, the channels' replies will be delimited from each other by a comma ','. E.g.:

```
OUTP:REL:ON? AB
1,1
```

OUTPut:DROP <chan>,<milliseconds>
OUTPut:DROP? <chan>

The OUTPut:DROP command opens a channel's final "fault" relay for a requested number of milliseconds. After the timeout, the relay will close again.

The first argument is the channel list, described at the beginning of this section.

The second argument is the number of milliseconds to keep the relay open. This condition can be cancelled later by sending this command with <milliseconds> set to zero, or by sending an OUTPut:RELay command. Any other value will be limited to no less than ten milliseconds.

Replies to queries are the number of milliseconds remaining on the timeout.

NOTE: The minimum time of ten milliseconds is not guaranteed. Some serial commands, including the SOURce:VOLT:RANGe and OUTPut:MODe, will block relay operations for this amount of time.

7.6.3 Measurement Commands

Note: All commands in the MEASure hierarchy will report zero if either the output fault switch is open (ie. a reply to "OUTP:REL:ON?" will be '0') or the output enable switch on the front panel is turned off (ie a reply to "STAT:OUTP?" will be '0'). Otherwise they will reply as described below.

MEASure:ALL?

```
MEAS:ALL?
110.3,0.118,0.115,108.2,1.126,107.62,109.9,0.318,0.301
```

Replies a list of 9 values: *vA,iA,pA,vB,iB,pB,vC,iC,pC* where *vX* is the RMS voltage at the channel X connector, *iX* is the RMS current at the channel X connector, and *pX* is the average real power delivered on channel X. These should be interpreted as described in the MEAS:CURR?, MEAS:VOLT? and MEAS:POW? queries respectively.

MEASure:CURRent? <chan>

Replies the RMS current draw in amperes. The argument is the channel list, described at the beginning of this section. If multiple channels are requested, then the channels' replies will be delimited from each other by a comma.

MEASure:POWer? <chan>

Replies the average real power output in watts. The argument is the channel list, described at the beginning of this section. If multiple channels are requested, then the channels' replies will be delimited from each other by a comma.

When driving a purely resistive load, real power will be roughly equal to the product of voltage and current, differing only by rounding errors and misalignment in request time. When driving a general load, the product of voltage and current provides apparent power (in VA) which will be higher than real power (in W).

MEASure:VOLTage? <chan>

Replies the RMS voltage output in volts. The argument is the channel list, described at the beginning of this section. If multiple channels are requested, then the channels' replies will be delimited from each other by a comma.

7.6.4 Status Commands

STATus:LOCK?
Replies with the state of the flash lock switch. '1' means the switch is set to LOCK mode, and the device flash cannot be written. '0' means the switch is set to NORM mode, allowing for changes to be written. The switch cannot be changed via command

STATus:OUTPut?

Replies with the state of the output lock switch on the front panel of the P900. '1' means the switch is on, and the channel output relays can be enabled. '0' means the switch is off, and the channel output relays cannot be enabled. The switch cannot be changed via command.

7.6.5 System Commands

SYSTem:COMMunicate:LAN:ADDress "<ip-address>"
SYSTem:COMMunicate:LAN:ADDress?

The ADDress subcommand sets or queries the P900's IP address. <ip-address> must be wrapped in single or double quotes. It must be expressed as one of the following:

- A period-delimited static IP address, e.g. "192.168.0.123"
- An all-zeros IP address to use the P900's DHCP client: "0.0.0.0"
- "dhcp" (case-insensitive) to use the P900's DHCP client.

Replies to queries will always be the last user-requested IP address. If DHCP is used, an address of "0.0.0.0" will be relied. To see the actual IP address provided by a DHCP server, use SYST:COMM:LAN:NST (described below).

SYSTem:COMMunicate:LAN:SMASk "<ip-address>"
SYSTem:COMMunicate:LAN:SMASk?

The SMASk subcommand sets or queries the P900's subnet mask. This value will only be used if the ADDress subcommand is configured for a static IP address. If using a DHCP, use SYST:COMM:LAN:NST to query the server-provided subnet mask currently used by the P900. The <ip-address> argument must be wrapped in single or double quotes. It must expressed as four decimal-delimited numbers, e.g. "255.255.255.0".

SYSTem:COMMunicate:LAN:DGATeway "<ip-address>"
SYSTem:COMMunicate:LAN:DGATeway?

The DGATeway subcommand has the same rules as the SMASk subcommand, except it is for the default gateway. Currently this setting will not be necessary, since the only network client on the P900, the DHCP client, does not use it.

SYSTem:COMMunicate:LAN:MAC?

The MAC subcommand queries the P900's MAC address.

SYSTem:COMMunicate:LAN:HNAMe?

The HNAMe subcommand queries the P900's hostname. If the P900's DHCP client is being used and has connected with a DHCP server on the network, it can be reached using this hostname, which is typically "p900-" followed by a five-digit serial number, e.g. "p900-00123."

SYSTem:COMMunicate:LAN:NSTat?

The NSTat subcommand queries the "real" network settings. If a static IP address is being used, then these values will be the same as those queried from the SMASK, ADDress, and DGATeway subcommands. The reply will be three comma-delimited numbers. The first is the IP address; the second is the subnet mask; the third is the default gateway. For example, the reply may look like:

```
192.168.0.123, 255.255.255.0, 192.168.0.0
```

SYSTem:COMMunicate:LAN:SAVe

The SAVe command will store the network settings into the P900's non-volatile RAM. This action requires the NORM/LOCK switch to be in the NORM position.

SYSTem:ERRor?
SYSTem:ERRor:NEXT?

```
SYST:ERR?
-222,"Parameter Data Out of Range"
SYST:ERR?
+0,"No Error"
```

Returns the top-most error message in the SCPI error queue, in the form (error code, error string), and removes it from the queue. If the queue is empty returns (0, No Error). If the error queue is full and an additional error occurs, the last entry in the error queue will be replaced with (-350, Queue overflow). The :NEXT form of this command is a synonym for the shorter, and behaves identically.

7.6.6 Firmware Upgrade Commands

Refer to the section "Remote Firmware Upgrade" on how to use these serial commands properly.

All of the following flash-access serial commands except for FLASh:CHECksum and FLASh:LOCK are protected by the NORM/LOCK switch.

FLASh:LOCK
FLASh:UNLock

FLASh:UNLock enables FLASh:ERASe and FLASh:WRITe. This is a redundant measure to prevent accidental modification of the flash. This state will remain in effect until either the next boot cycle (*RST or power-cycle), the next DEFault command, or the next FLASh:LOCK command.

FLASh:LOCK will prevent future uses of FLASh:ERASe and FLASh:WRITe. This is the power-on default state.

The NORM/LOCK switch must be in the NORM position for FLASh:UNLock to execute.

FLASh:ERASe

FLASh:ERASe erases the portion of the flash that will store the upgrade image. Even if this is the first time a remote upgrade is being performed, FLASh:ERASe should be executed before writing a new binary into the flash.

The NORM/LOCK switch must be in the NORM position and the flash must have been unlocked with the FLASh:UNLock command before FLASh:ERASe may execute.

Note: This may halt some of the P900's functionality for up to thirty seconds. Remove the P900 from normal operation before conducting a remote upgrade.

FLASh:WRITe "<srec>"

FLASh:WRITe writes a line from an S-Record into the serial flash.

<srec> must be wrapped by single or double quotes. It must be a valid S-Record line whose encoded address is within the upgrade-image portion of the P900's on-board flash.

The NORM/LOCK switch must be in the NORM position and the flash must have been unlocked with the FLASh:UNLock command before FLASh:WRITe may execute.

FLASh:CHECksum?

FLASh:CHECksum runs a checksum of the images in the P900's on-board flash and replies the result. This does not modify the flash images, and does not require the flash to be "unlocked."

The reply will be a line of the form:

FF:<reslt>,FP:<reslt>,FH<reslt>,UF:<reslt>,UP<reslt>,UH:<reslt>

For the two-letter headings, the first letter means:

F Factory image
U Upgrade image

The second letter means:

F Firmware (microprocessor) image
P FPGA image
H Additional files used by firmware

<reslt> following each letter is one of:

OK Image is present and checksum passed
NP Image was not found
ER Image was found but its checksum failed

The result for the factory images should always be `OK`. The result for the upgrade images should either be *NP* (if erased or never upgraded) or *OK*. The expected default result for a new P900 is:

`FF:OK,FP:OK,FH:OK,UF:NP,UP:NP,UH:NP`

If any of the upgrade images' results are *ER*, this indicates an incomplete or failed upgrade procedure. If any of the factory images' results are not *OK*, this should be treated as a critical failure.

Note: This may halt some of the P900's functionality for up to five seconds. Remove the P900 from normal operation before running this test.

8 Remote Firmware Upgrade

If the P900's LOCK/NORM switch is in the NORM position, its firmware can be upgraded using SCPI serial commands. An upgrade file is an S-Record with a name of the form "23E901<rev>_upgrade.s28", where <rev> is the revision letter.

Caution: FLASH:ERASE, FLASH:WRITE, and FLASH:CHECKSUM? will prevent the P900 from conducting most of its operations until the operation is complete. The P900 should be removed from its normal operating environment for this procedure.

The upgrade procedure is as follows:

1. Ensure that the LOCK/NORM switch is in the NORM position. This may be queried with the STATUS:LOCK? command.
2. Send the FLASH:UNLOCK command to the P900, to enable modifying the flash.
3. Send the FLASH:ERASE command to the P900. This may take up to thirty seconds. No additional SCPI commands will be processed during this time, so you can be certain that the erasure has completed by appending the *OPC? query to the command and waiting for the reply "1".
4. Open the S-Record file. Perform the following subroutine until you reach end-of-file.
    a. Read a line from the S-Record.
    b. Send the FLASH:WRITE command, with the line from the S-Record as an argument to the P900.
    c. Normal operations will be delayed during execution of the FLASH:WRITE command, so it is advised to append the *OPC? query to the command and wait for the reply "1".
5. Send the FLASH:CHECKSUM? to the P900. Wait up to five seconds for the reply. The expected reply is: `FF=OK,FP=OK,FH=OK,UF=OK,UP=OK,UH=OK`. This indicates that the upgrade image is now present and its firmware checksum tests passed. (FF,FP, and FH should always be "OK".)
6. Either power-cycle the P900 or send a *RST serial command to reboot it. Approximately the first second of the next boot cycle will be spent finalizing the firmware upgrade. *Do not power-off the P900 until its new firmware has loaded and begun running again*.

9 Alternator Programming Example

The P900 is primarily intended to simulate a permanent-magnet 3-phase alternator used to power a FADEC or similar aircraft electronics unit. Such a device will typically have a chopper-mode active bridge rectifier/regulator which PWM shorts the alternator to regulate DC output voltage.

A real alternator has some fixed resistance and inductance per winding, and the generated frequency and open-circuit AC voltage are both proportional to RPMs. For a 6-pole alternator, frequency in Hz is 0.1 times shaft speed in RPM. At high RPMs, a PM alternator will generate a very high open-circuit voltage and approximate a constant-current source. The P900 cannot generate very high voltages, but can be programmed to current limit, to power a chopper shunt regulator properly.

One example is:

Alternator	Unison type 83311
Chopper bridge frequency	30 KHz
Regulated DC voltage	32 volts
DC load	8 ohms, 4 amps typ, 128 watts DC

Suitable programming of the P900 might be

Range 1
Alternator mode
Frequency 400 Hz
Output voltage 40 RMS per phase (69 RMS line-to-line, 98 volts peak)
Current limit 8 amps peak

The FADEC PWM shunt regulator will adjust to provide the required 32 volts DC, and the P900 class-D amplifiers and current limit logic will automatically provide the power required, at high efficiency. The equivalent rectified current into the PWM shunt regulator will be 8 amps DC.

The programming commands in this case could be

```
DEFAULT
OUTPUT:MODE  ALTERNATOR
SOURCE:FREQUENCY  Y, 400
SOURCE:VOLT:RANGE  Y, 1
SOURCE:VOLT:LEVEL   Y, 40
OUTPUT:LIMIT  Y, 8
OUTPUT:RELAY:ON  ABC
```

And, of course, set the front-panel output enable switch ON.

Spice simulations are available to analyze cases in detail. Please contact factory.

10 Versions

P900-1 3-phase power source and permanent-magnet alternator simulator
Open wye connected, with MIL circular connector and Phoenix blocks

11 Customization

Consult factory for information about additional custom versions.

12 Revision History

12.1 Hardware Revision History

23A900	Revision A	August 2020 Initial hardware release

All units were upgraded to use P902 rev B class-D amplifiers in January of 2021

12.2 Firmware Revision History

23E901B	August 2020	Initial firmware release
23E901C	January 2021	For P902B amps with current limiting

13 Accessories

J90-1: Spare pluggable Phoenix terminal block