HIGHLAND TECHNOLOGY

Model P940

Modular Power System

Technical Manual

February 5, 2024

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Contents

1 *Introduction*

The P940 is a modular power instrument intended primarily for aerospace testing. It consists of a 3U rackmount enclosure with main controller, power supply and cooling, and provision for installation of up to eight power, load, switching, or measurement modules.

Features include:

- 1000 watt universal-input 48-volt power supply that is distributed to all modules
- Uniform, rational SCPI command set with Ethernet and USB interfaces
- All modules include full measurement capability; each module's measurable values (such as output voltage, current, and frequency) can be read remotely via Ethernet/USB
- All modules include microsecond-resolution user-programmed parameter sequence tables
- The P940 can also be controlled manually via front panel color LCD and controls
- Four BNC connectors are provided to monitor selected voltage and current waveforms
- Atomic strobe allows a group of settings to be initiated simultaneously across modules

Module functions include:

- DC power supplies with programmable voltage and current limits
- Permanent-magnet alternator simulators
- Isolated AC power supplies with programmable voltage and current limits; AC output channels can operate independently or in frequency and phase coordinated groups
- Programmable AC/DC loads, constant current/voltage/resistance
- Cable fault insertion
- High voltage power supplies
- Magnet trim supplies and gradient drivers
- Additional specialized or custom/combo boards, based on Highland's existing suite of aero-space signal processing functions

Individual plugin modules are described in separate manuals.

2 *Specifications*

FUNCTION	Modular power system with 8 plugin units
PACKAGING	3U x 20" deep rackmount chassis Optional slides
AC POWER IN	120-240 VAC 50-60 Hz single phase
POWER OUT	1000 watts total max 800 watts with 120 VAC power
INTERFACES	Gbit Ethernet and USB
DISPLAY	Status LEDs, 4.3" color LCD
SIGNAL MONITORS	Four front-panel BNC selectable signal monitors. 50Ω output, ±5V typ. into high-impedance input
SCOPE TRIGGER	1µs positive pulse, 50Ω output, 3–3.6V (3.3V typ.) high level into high-impedance input
10 MHZ CLOCK OUTPUT	AC-coupled square wave. 50Ω output, 2.7–3.3V (3.0 typ.) peak-to-peak into high-impedance input ±5ppm typ.
10 MHZ CLOCK INPUT	500Ω input Sine-wave: -10 to +20 dBm Square-wave: 200mV to 10V peak-to-peak

3 *P940 Operation*

3.1 *Front Panel*

3.1.1 *Fans*

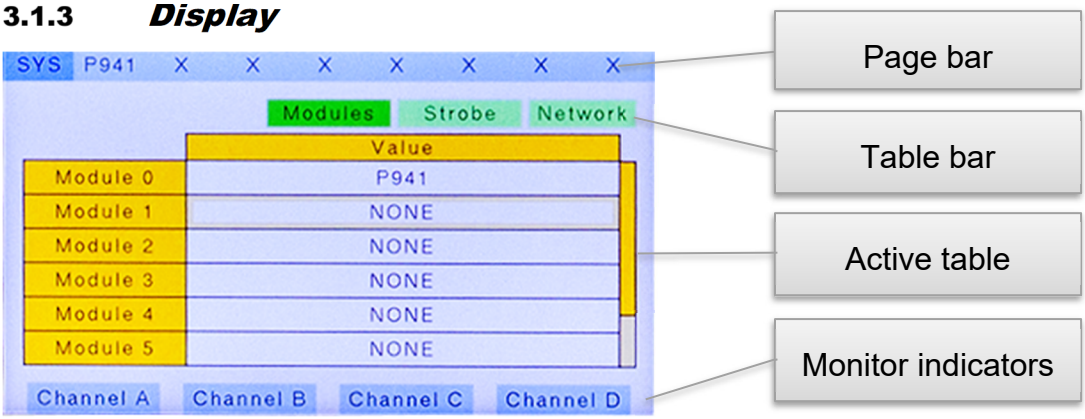
The P940 features two intake fans on the front panel. These fans are speed adaptive and will run faster as the internal temperature of the P940 system rises. Please ensure that neither the front panel intakes nor rear exhaust are blocked.

3.1.2 *LEDs*

From top to bottom, the LEDs on the front of the P940 are:

- PWR — Steady green light indicating system power
- ERR — Red light indicating system error
- STROBE — Orange light that flashes when a system strobe occurs
- SEQ — Orange light indicating the system sequencer is enabled
- COMM — Blue light indicating system communication over USB or Ethernet.

3.1.3 *Display*



The P940 display allows a system operator to view and change parameters of the P940 and its modules. The P940 display is divided into “pages”, where the leftmost page represents the P940 system itself, and pages to the right represent the modules in slots 0-7 respectively.

The top “page bar” of the display indicates the currently selected page, which can be changed using the page left and right buttons, the display can be switched between the P940 system and the modules, with pages to the right corresponding to modules to the right (as viewed from the front). If the text for a page appears in red, then some error has been reported by the corresponding module.

Beneath the top bar, in green, is the “table bar”. When the cursor is on the table bar either the control knob or left and right navigation buttons will switch between the available tables for this page. The navigation down button moves the cursor from the table selection bar to the currently visible table.

The table contains information or controls for the selected page and can be navigated with the navigation buttons and the control knob. Editable fields can be changed by pressing the select button, or equivalently the control knob. From the top row of the table, the navigation up button moves the cursor from the table up onto the green table bar.

3.1.4 *Monitors*

The P940 features 4 waveform monitor outputs, and a TRIG digital pulse output that can be triggered simultaneously with a system strobe. The monitor outputs can be assigned using either the **SOURce:ROUTe** command or using the buttons above the waveform connectors to route waveforms, such as real-time voltages and currents, from the modules to the outputs. Analog outputs have a 50Ω output impedance and a range of ±5V.

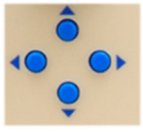
When selecting monitor signals from the front-panel buttons, the only monitors available to select will be those signals present on the module for the currently visible page. Monitors persist as pages are changed, so the monitors can be used to inspect waveforms across multiple modules by going to each module’s page and assigning some of the monitors to signals on that page.

3.1.5 *Control Knob*

Turning the control knob navigates between fields or modifies values. Pressing the knob is equivalent to pressing the select button.

3.1.6 *Cursor Navigation Buttons*

The up/down/left/right navigation buttons are used to move the cursor between fields in the table, and to move between the table and the table selection bar.



3.1.7 *Select Button*

The select button toggles on/off values or enters an editing mode for other values. Pressing the control knob is equivalent to pressing the select button.

3.1.8 *Page Navigation Buttons*

The page left and page right buttons select installed modules' pages, as indicated on the page bar at the top of the display.

3.1.9 *USB Connector*

The P940 front panel has a USB-B peripheral connector. As the speed of this interface is far less than that of the Ethernet interface, it is recommended that this interface be primarily used for temporary diagnostic connections.

3.2 *Rear Panel*

Rear panel shown with P941 and P945 modules installed in slots 0-2, no modules installed in slots 3-7 with blank plates covering slots 6-7 (eight blank plates furnished with purchase)

3.2.1 *AC Power Inlet*

The P940 has a universal AC power inlet and can be connected to 50 or 60 Hz power at either 110 or 220V using a line cord with a standard IEC C13 connector.

The power switch on the inlet should be turned off when connecting or disconnecting AC power, or when the P940 top cover from the P940 is removed.

3.2.2 *CLK Connector (J27)*

The CLK connector can accept or generate a 10 MHz reference clock signal. As an input, CLK is compatible with either sine or square wave reference signals. As an output, CLK provides an AC-coupled square wave.

3.2.3 *AUX Connector (J25)*

The AUX connector is reserved for future use.

3.2.4 *SYNC Connector (J26)*

The SYNC connector is used to connect multiple P940 systems together to allow the simultaneous update of modules in multiple chassis, using BNC cables and tee connectors. See Multiple P940s and the Global Sync for more information.

3.2.5 *Ethernet Connector (J11)*

The Ethernet connector will provide, for most users, the primary interface to the P940. It supports the ubiquitous 1000BASE-T (Gigabit Ethernet) and 100BASE-TX (Fast Ethernet) standards.

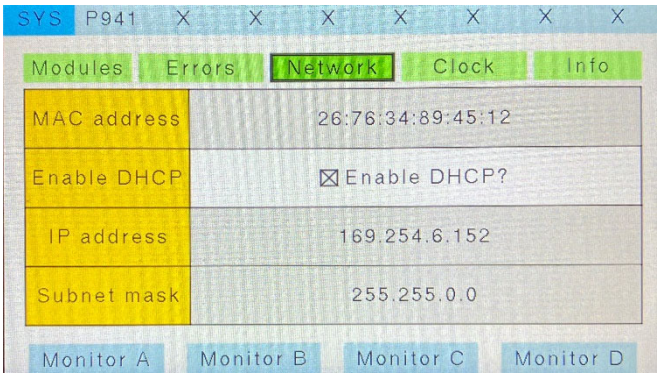
3.2.6 *Module Slots*

Module rear panels make the module I/O interfaces available at the back of the P940. Looking at the rear panel the slots are numbered with 7 as the leftmost slot down to 0 at the rightmost.

3.3 *Network Configuration*

Configuration of the P940 network interface is most easily performed from the front panel:

- Check the box next to “Enable DHCP” to enable DHCP or uncheck box to enable a static address. When disabled, the IP address will default to 192.168.0.10 and the subnet mask will default to 255.255.255.0.
- The IP address and subnet mask can be edited whenever DHCP is disabled.



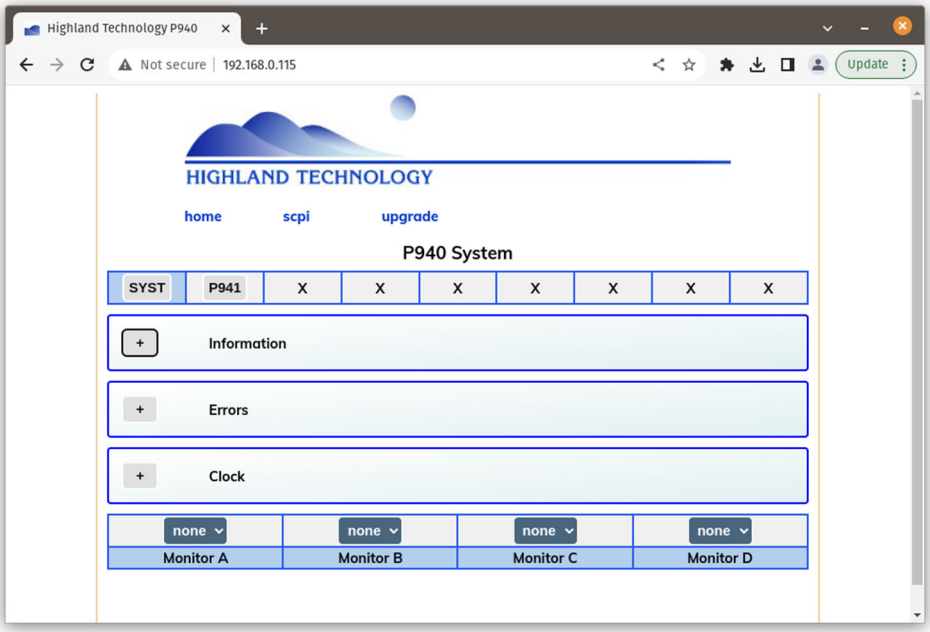
The P940 network interface can also be configured from either an existing network interface or over USB using ASCII commands.

- To have the P940 use DHCP to receive its IP information, send the **`SYSTem:COMMunicate:SOCKet:DHCP`** command.
- To have the P940 use a static IP address, send the **`SYSTem:COMMunicate:SOCKet:ADDRess`** command, followed by the **`SYSTem:COMMunicate:SOCKet:SUBNet`** command if the default subnet mask of 255.255.255.0 is incorrect.
- In either case, reset the network interface by sending the **`SYSTem:COMMunicate:SOCKet:ReSeT`** command, which will drop and reinitialize the

network connection, allowing the new settings to take effect. Rebooting the P940 unit will have the same effect.

3.4 *Web Interface*

The P940's web interface provides basic control and status for the instrument and its modules. To access this, navigate to http://<module-ip-address> in a web browser. The main page, as shown below, provides system information and links to pages for any modules (such as the P941 in slot 0 in this example).



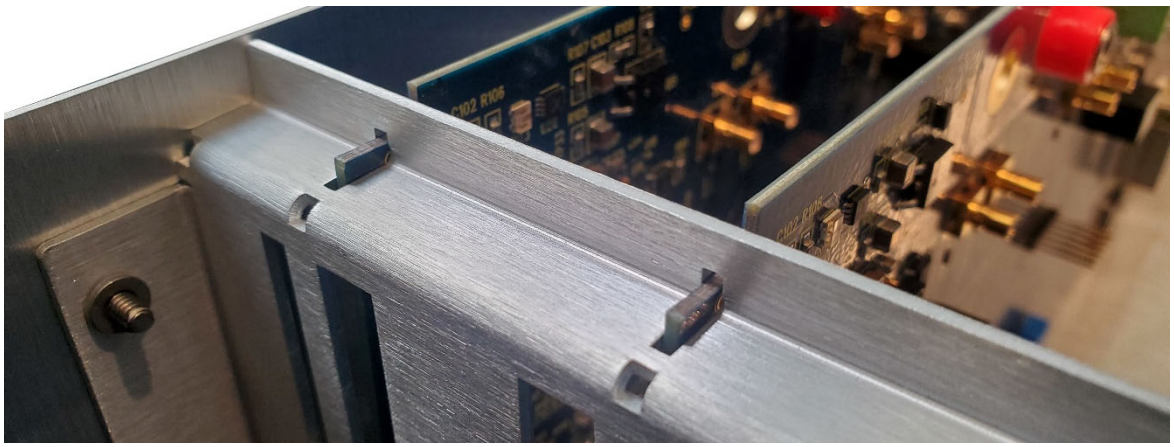
4 *Field Updates*

Plug-in modules are available for purchase separately and can be moved easily from one P940 system to another. This allows systems to be dynamically configured as necessary.

4.1 *Module Installation*

> ⚠ WARNING: Do not attempt to open the P940 chassis or perform any operations on an open P940 chassis with the power on. Module damage or operator injury may occur.

1. To install new modules in the P940 chassis, first power down the system using the rear-panel power switch and unplug the AC line cord.
2. Remove the top cover from the P940 by removing the three screws from each side of the chassis, and the three screws at the back of the top cover.
3. Remove the interior board retainer by removing the two screws on each side of the chassis and sliding the retainer up and out of the chassis.
4. Remove the two screws in the back holding the rear-panel cover plate to the chassis. Remove the rear-panel cover plate and store in a safe place.
5. Insert the new module by sliding it down into place, fitting the rear-panel plate of the module inside of the chassis rear panel, and plugging the connector into the appropriate slot on the mainboard. Replace the two rear panel screws to secure the new module into place.
6. Slide the board retainer back down into the chassis above the mainboard, fitting the module corners into the retaining slots as shown below.



7. Secure the board retainer to the chassis sides using the four board-retainer screws.
8. Replace the top cover and secure it using the nine top-cover screws.
9. Reconnect the AC line cord.

4.2 *Software Upgrades*

The P940 system supports software upgrades in the field. These upgrades may be necessary to allow the P940 to support new modules or new functionality for existing modules. The upgrade

process is atomic and will automatically upgrade modules in the chassis as necessary. Additionally, the P940 system will automatically upgrade modules that are installed into it.

Field upgrades must be explicitly downloaded by the user and uploaded to the P940. In the interests of product longevity and customer privacy, the P940 will never contact Highland Technology to attempt to download this upgrade itself.

To upload the upgrade file, use a web browser to go to http://<module-ip-address>/cgi-bin/start_field_upgrade.cgi and follow the instructions on the webpage.

Note: The installation of a module with newer firmware than is supported by the chassis in which it is installed may cause that module to operate with reduced, or no, functionality. The P940 will never downgrade a module and will provide a notification indicator if an upgrade is needed to operate the modules in the chassis.

5 *Software Interface*

5.1 *ASCII Command Interface*

The primary means of interfacing with a P940 system is through the ASCII command/reply interface. The ASCII interface can be used in one of two ways:

- **TCP** — The P940 can be connected over Ethernet and presents a TCP server on port 2000. This is a raw TCP socket easily connected from any programming language and is compatible with standard telnet utilities[1]. By default, the P940 uses DHCP to acquire an IP address, but this can be changed via the front-panel (see Front Panel) or via ASCII commands.
- **USB** — The front-panel USB port is a standard FTDI serial port interface, and runs at 115000 kbaud with 8 data bits, no parity, and 1 stop bit. This is meant primarily as a diagnostic interface or to configure network settings.

ASCII commands fall into three categories; those associated with the P940 itself, those general to all P940 plug-in modules, and those specific to individual modules. The last of these categories is discussed in the specific modules' manuals.

5.1.1 *Commands and Queries*

The P940 uses a command syntax similar to the SCPI standard. Commands and queries are sent to the device using ASCII characters terminated by a newline character. Following this, the response is sent from the P940, also terminated with a newline. Commands, queries, and replies are case-insensitive outside of quoted text strings.

A command does not end with a question mark and modifies the instrument state. Setting relays, setting output voltages, and controlling operation mode are all examples of commands.

A query ends with a question mark and requests data from the instrument. Determining which modules are present and finding out the instantaneous output current are examples of queries. Error Codes

For either commands or queries, short and long forms are both available and usable interchangeably. In the command listings below the short form is indicated by literal uppercase letters and the long form by both the uppercase and lowercase letters. Intermediate forms are not available; if any of the optional letters are present for a given term then all must be present. For example, the system reset command **`SYSTem:ReSeT`** is legal and equivalent in any of the following ways:

```
SYST:RST
SYSTEM:RST
SYST:RESET
```

[1] This includes the standard Linux telnet client, and the open-source PuTTY terminal emulator. Notably, this does *not* include the Microsoft telnet client available as a Windows optional feature.

SYSTEM:RESET

On the other hand, **SYSTE:RESET** would not be legal as the first term is midway between the short and long forms.

Many commands also have optional terms, indicated in the command listings below in square brackets. These optional terms are equivalent whether included or excluded; including them is entirely at the user's discretion for clarity. For example, the first two queries below are equivalent, but the third is not.

SYST:MOD?

SYST:MOD:SHORT?

SYST:MOD:LONG?

The argument list of a command accepting multiple arguments will be comma delimited, with no spaces on either side of commas.

5.1.1.1 *Multiple Commands and Queries*

Multiple commands and queries may be specified on a single line using a semicolon as the delimiter. Responses to semicolon-delimited commands and queries will be returned delimited by semicolons, ending with a single newline character.

5.1.1.2 *Command Modes*

Two command modes, classic mode and response mode, are supported. The system mode on power-up is always classic mode, but it can be changed with **SYSTem:COMMunication:CMode**.

In classic mode:

- Commands produce no output
- Queries that cannot be executed because of an error produce no output
- Queries that do not result in an error produce output
- Commands and queries that cannot be executed because of an error place an error into the error queue

In response mode:

- Commands produce either:
  - **OK**, if the command was executed; or
  - An error response (e.g., **ERROR_COMMAND**), if the command could not be executed
- Queries produce either:
  - The expected query response (identical to classic mode), if the query was executed
  - An error response (e.g., **ERROR_COMMAND**), if the query could not be executed
- Errors are never submitted to the error queue in response to a command or query unless the command or query explicitly specifies otherwise

5.1.1.3 *Error Queue*

Errors from system functions, such as BIST, or errors resulting from commands or queries in classic mode, are placed in the error queue. Items can be popped from this queue with the **SYSTem:ERRor[:NEXT]?** query. The syntax for each item is a numeric error code and a textual error message pair in the format

<error_code>,"Error description[;Additional information]"

For example, the following error would report an error executing a command missing a parameter:

-109,"Missing parameter;SYST:STRB"

An absence of error (i.e., an empty error queue) will be reported as **0,"No error"**.

5.1.1.4 *Error Codes*

The errors in the following table are returned by the P940. In this table,

- The "Error code" and "Error description" columns give values for error used to create a value for the error queue
- The "Error response" column gives values returned when errors are encountered while executing a command or query in response mode.

Error code	Error description	Error response	Description
0	None	OK	No error
-100	Command error	ERROR_COMMAND	Generic error in SCPI command
-102	Syntax error	ERROR_SYNTAX	Unrecognized SCPI command or data received
-104	Data type error	ERROR_DATA_TYPE	SCPI command data is of the wrong type
-108	Parameter not allowed	ERROR_TOO_MANY_PARAMETERS	More parameters were received than expected
-109	Missing parameter	ERROR_TOO_FEW_PARAMETERS	Fewer parameters were received that required
-114	Header suffix out of range	ERROR_SUFFIX_OUT_OF_RANGE	Integer parsed from SCPI command (e.g., slot number) was out of range
-200	Execution error	ERROR_EXECUTI	Generic error executing SCPI command

		ON	
-203	Command protected	ERROR_COMMAND_PROTECTED	Command requires password to execute
-220	Parameter error	ERROR_PARAMETER	Non-specific error using SCPI command parameter
-221	Settings conflict	ERROR_SETTINGS_CONFLICT	SCPI command parameter conflicts with current device state
-222	Data out of range	ERROR_DATA_OUT_OF_RANGE	SCPI command parameter is out of range
-224	Illegal parameter value	ERROR_ILLEGAL_PARAMETER	SCPI command parameter value is not one of the expected value
-240	Hardware error	ERROR_HARDWARE	Generic hardware error executing SCPI command
-241	Hardware missing	ERROR_HARDWARE_MISSING	Hardware or hardware capability not present
-258	Media protected	ERROR_WRITE_PROTECTED	Internal medium is write-protected (e.g., because P940 is in locked mode) so operation is impossible
-300	Device error	ERROR_DEVICE	Generic device error executing SCPI command
-310	System error	ERROR_SYSTEM	Generic system error executing SCPI command
-313	Calibration memory lost	ERROR_CALIBRATION_LOST	Calibration data cannot be read or recovered
-365	Timeout	ERROR_TIMEOUT	Timeout occurred while executing SCPI command

5.1.2 *Addressing Commands to Modules*

Some commands and queries are intended for the P940 itself. Because the P940 is a modular system, other commands and queries will target the module in a specific slot. The P940 solves this through geographic addressing. A command or query meant for the module in a specific slot will be prefaced with **SLOT<n>** where **<n>** is the slot (0-7) that the module is installed in. Thus, commands for the module installed in slot 2 will be prefaced with **SLOT2**, for the module in slot 7 with **SLOT7**, and so on. Which commands are available to a module are a function only of that module's type.

Some module-targeted commands are available for all modules. These deal primarily with module identification and status. Other commands will be for the specific functionality of a module and will apply only to certain types of modules.

5.1.3 *Monitor Channel Arguments*

Monitor channel arguments begin with the `@` character, followed by the channel letter (A, B, C, or D) or the channel index (0, 1, 2, or 3, respectively). For example, **`@A`** and **`@0`** both indicate channel A.

5.1.4 *Integer Arguments*

Integer arguments conform to C-language formatting, which is an optional sign character followed by

- **`0x`** or **`0X`**, to be parsed as hexadecimal
- Otherwise, **`0`** to be parsed as octal
- Otherwise, to be parsed as decimal

5.1.5 *Float Arguments*

Floating-point arguments conform to C-language formatting, which is an optional sign character, a sequence of digits with an optional decimal point, and optional exponent.

5.1.6 *Boolean Arguments*

Boolean arguments must be **`0`** for false or **`1`** for true.

5.2 *ASCII System Strobe*

As a system power platform, rather than a collection of individual boxes, the P940 is designed to allow multiple actions to be engaged simultaneously. As such, most parameters are strobed parameters; updates to these parameters must be committed by having the P940 send a strobe to the affected module. This allows multiple parameters to become effective simultaneously, whether within a single channel, across all channels of a module, or across multiple modules.

The most common mechanism for generating a strobe is a user-generated **`SYSTem:STRoBe`** command, with an argument specifying which slots to send the strobe to. There is also a global strobe mechanism that extends this concept to simultaneous action across multiple P940s; see Multiple P940s and the Global Sync**.**

Generally, SCPI commands related to strobed parameters are found in pairs, which are nearly, but not completely, symmetrical. Each pair consists of a command that sets the pre-strobe (pending) parameter value and a query that gets the post-strobe (effective) parameter value. The query will not be guaranteed to return the value from a successful command until a strobe to the targeted module has been performed.

The following example illustrates the two-step process of setting a strobed parameter.

```
SLOT0:OUTPut? @A          # Get initial value
```

```
0
SLOT0:OUTPut 1,@A          # First, set pending value
SLOT0:OUTPut? @A           # Effective value has not changed
0
SYST:STRB 0x1              # Second, propagate pending values
SLOT0:OUTPut? @A           # Effective value has changed
1
```

5.3 *Multiple P940s and the Global SyncP940 System Commands*

System commands and queries relate to the P940 system as a whole rather than specific modules and are not addressed to a specific slot.

5.3.1 *IEEE 488-2 Globals*

***IDN?**

```
*IDN?
HTI,P940,123,23E940A-1.0
```

Retrieves build information in the form of:

<company_name>,<model>,<serial_number>,<firmware_version>

***CLS**

Clears the SCPI error queue and status byte.

***OPC?**

Wait until all pending operations are complete, returns 1 when complete.

***RST**

Reboots the P940.

***TST?**

Run a system test of both the P940 and connected modules, including checking that all power supplies are within an acceptable range and all modules are correctly recognized by the P940. Returns the number of errors detected; 0 for no errors detected. Details on those errors can be queried from the error queue using the SYST:ERR? queries.

5.3.2 *SOURce Commands*

SOURce:ROUTe <source>,@<channel>

SOURce:ROUTe? @<channel>

SOUR:ROUT slot0-a-voltage-output,@B

Routes the source to one of the front-panel monitor connectors. Available sources will be a function of the modules in the system, as will the scaling of the actual signals onto the monitors. See specific module manuals for information about the available monitors. Monitor channels are A-D.

In query form, returns the source for the front-panel monitor.

5.3.3 *SYSTem Commands*

SYSTem:CLOCk <mode>

SYSTem:CLOCk?

Configures the 10 MHz system clock connector for either IN, OUT, or NONE. In query form returns the current mode.

SYSTem:CLOCk:LOCK?

Queries the system lock status to an external 10 MHz clock. Returns 1 if the clock mode is IN and the external clock is locked, 0 otherwise.

SYSTem:COMMunicate:CMODe CLASSIC|RESPONSE

Sets the command mode of the system to classic mode (with **CLASSIC**) or response mode (with **RESPONSE**). The new mode will be effective for the return of this command. See Command Modes.

SYSTem:COMMunicate:CMODe?

Returns the command mode of the system as either **CLASSIC** or **RESPONSE**. See Command Modes.

SYSTem:COMMunicate:SOCKet:ADDRess 192.168.1.10

SYSTem:COMMunicate:SOCKet:ADDRess?

As a command configures the system to use static IP address and sets that static IP address. Applied on network or device reset. Setting the IP address automatically configures a subnet mask of 255.255.255.0; a different subnet mask than this must be requested explicitly after this command.

As a query returns the IP address regardless of source. If the P940 is configured to use DHCP, and does not yet have an address, the return value will be 0.0.0.0.

SYSTem:COMMunicate:SOCKet:SUBNet 255.255.0.0

SYSTem:COMMunicate:SOCKet:SUBNet?

As a command sets the subnet mask of a previously provided static IP address. Applied on network or device reset.

As a query returns the subnet mask regardless of source. If the P940 is configured to use DHCP, and does not yet have an address, the return value will be 0.0.0.0.

SYSTem:COMMunicate:SOCKet:DHCP

SYSTem:COMMunicate:SOCKet:DHCP?

As a command configures the system to use DHCP. Applied on network or device reset.

As a query returns 0 if the system uses a static IP address or 1 for DHCP.

SYSTem:COMMunicate:SOCKet:MAC?

Returns the system MAC address.

SYSTem:COMMunicate:SOCKet:ReSeT

Resets the network interface, applying any updated network parameters.

SYSTem:CTYPe? <n>

Identifies the module in slot n, with a response in the same format as that of the ***IDN?** query. Equivalent to **SLOT<n>:IDN?**

SYSTem:ERRor[:NEXT]?

Returns the next unread item in the system event/error queue as a comma-delimited integer error code and descriptive string. If the queue is empty, the response is 0,"No error"

SYSTem:ERRor:ALL?

Queries the error/event queue for all the unread items and removes them from the queue. The response is a comma separated list of number, string pairs in FIFO order. If (and only if) the queue is empty, the response is 0,"No error"

SYSTem:ERRor:COUNt?

Returns the number of unread items in the system error/event queue. Returns 0 if the queue is empty.

SYSTem:IDENtify:HARDware?

SYST:IDEN:HARD?

```
P940-1B,123,2023-06-01
```

Returns chassis hardware information in the form <hardware>,<serial number>,<calibration date> where the hardware identifier includes the hardware version and dash number, and the date is in YYYY-MM-DD format.

SYSTem:IDENtify:SOFTware?

SYST:IDEN:SOFT?

```
23E940B-1.0,23C940B-1.2
```

Returns chassis software information in the form <software version>,<logic processor version>

SYSTem:LOCK?

Returns 0 if the mainboard switch is set to the *NORM* position and 1 if the mainboard switch is set to the *LOCK* position.

SYSTem:MODules[:SHORt]?

SYST:MOD?

```
P941,P941,P941,P945,P941,NONE,NONE,NONE,NONE
```

Returns a comma delimited list of the model information for slots 0-7. Slots without modules present will report NONE in the respective position. See **SLOT<n>:MOD?**

SYSTem:MODules:LONG?

SYST:MOD:LONG?

```
HTI,P941,331,28C941B-1.0,HTI,P941,335,28C941B-1.0,HTI,P941,308,28C941
B-1.0,HTI,P945,108,28C945B-1.2,HTI,P941,340,28C941B-1.0,NONE,NONE,NON
E,NONE,NONE,NONE,NONE,NONE,NONE,NONE,NONE,NONE,NONE,NONE,NONE
```

Returns a comma delimited list of 32 pieces of module identification information, the four field **SLOT<n>:IDN?** query for slots 0-7. Slots without modules present will have NONE in each of the 4 respective positions.

SYSTem:ReSeT

Resets all the boards in the chassis to a power-up state.

SYSTem:STRoBe[:LOCal] <slot_bitmask>

Strobes queued commands for synchronous start across boards. Bits 0-7 of the bitmask correspond to strobing the modules in slots 0-7; a bitmask of 255 strobes all slots in the system. Bit 8 corresponds to the front-panel TRIG connector.

SYSTem:STRoBe:GLOBal

Send a global sync to all connected P940 chassis.

SYSTem:STRoBe:GMASk <slot_bitmask>

SYSTem:STRoBe:GMASk?

As a command, configures slots to accept the inter-chassis global strobe. Bits 0-7 of the bitmask correspond to enabling global strobe to the modules in slots 0-7; a bitmask of 255 enables global strobe to all slots. Bit 8 corresponds to the front-panel TRIG connector.

As a query, returns the current global strobe bitmask.

Receipt of a global strobe on the STROBE connector sends a strobe to all modules selected by the GMASK and resets the strobe mask to zero. See Multiple P940s and the Global Sync.

5.3.4 *TEST Commands*

TEST:POWer[:LOCal]?

TEST:POW?

```
"+5V",5.000,5.017,0,"+5_MOD",5.000,3.118,1,"+12V",11.813,11.431,0,"-
10V",-10.083,-9.984,0
```

Tests the P940 chassis power supplies. Returns a comma delimited list N*4 entries long, where each 4 entries are “Supply Name”, nominal voltage, measured voltage, and a 0 to indicate a supply in range or a 1 to indicate a supply out of range.

TEST:MODules?

TEST:MOD?

```
OK,OK,FW,OK,OVP,NONE,NONE,NONE
```

Tests the modules in the P940 chassis. Returns 8 comma delimited statuses representing slots 0-7, with each status selected from:

- OK – This module is detected and operating normally.
- BIST – A BIST failure has been reported by this module.

- CAL – This calibration has been lost for this module.
- COMM – Communication failed with this module.
- FAIL – This module has an unspecified hardware failure.
- FW – This module has firmware that cannot interoperate with the chassis; chassis firmware must be updated to use this module
- OVP – This module has been deactivated due to an overpower condition
- NONE – There is no module detected in this slot.See **SLOT<n>:TEST:MODule?**

5.4 *Generic Module Commands*

Generic module commands are those that are universal across all modules. They must be addressed to a specific slot n where n is 0-7. A command or query targeting a slot outside this range will return -114,“Header suffix out of range”

5.4.1 *Module Globals*

SLOT<n>:IDN[:SHORt]?

SLOT0:IDN?

HTI,P941,331,28C941B-1.0

Returns module information in the form of:

<company_name>,<model>,<serial_number>,<firmware_version>. Reports NONE,NONE,NONE,NONE if module is not present.

SLOT<n>:IDN:LONG?

SLOT0:IDN:LONG?

HTI,P941-1B,331,28C941B-1.0,2023-06-01

Returns module information in the form of:

<company_name>,<model>,<serial_number>,<firmware_version>,<calibration date> where model includes hardware revision and dash number and the calibration date is in YYYY-MM-DD form. Reports NONE,NONE,NONE,NONE,NONE if module is not present.

SLOT<n>:MODule[:SHORt]?

SLOT0:MOD?

P941

Returns the board model information, the second field of the **SLOT<n>:IDN?** query. Reports NONE if module is not present.

SLOT<n>:MODule:LONG?

SLOT0:MOD:LONG?

P941 Dual DC Supply

Returns the board descriptive information. Reports NONE if module is not present.

SLOT<n>:ReSeT

Resets the module to the default power-on state.

SLOT<n>:TEMPerature[:ALL]?

Returns a comma-delimited list describing all temperature sensors on the module. Three entries are given for each temperature sensor, in the following order:

- Sensor name (in quotes)
- Temperature, in Celsius
- Temperature status. A zero value indicates a temperature in range, and a non-zero value indicates a temperature out of range

SLOT<n>:TEMPerature:ERRor?

Returns the module “temperature error”, the number of degrees Celsius above or below the target maximum operating temperature of the module. A positive number is a request for additional fan speed.

SLOT<n>:TEST:MODule?

Tests the module in slot n. Returns a status selected from:

- OK – This module is detected and operating normally
- BIST – A BIST failure has been reported by this module.
- CAL – This calibration has been lost for this module.
- COMM – Communication failed with this module.
- FAIL – This module has an unspecified hardware failure.
- FW – This module has firmware that cannot interoperate with the chassis; chassis firmware must be updated to use this module.
- OVP – This module has been deactivated due to an overpower condition
- NONE – There is no module detected in this slot.

SLOT<n>:TEST:POWer?

SLOT0:TEST:POW?

```
"+5V",5.000,5.017,0,"+5_MOD",5.000,3.118,1,"+24V",23.784,23.912,0,"+1
2V",11.813,11.431,0,"-10V",-10.083,-9.984,0
```

Tests the module power supplies. Returns a comma delimited list N*4 entries long, where each 4 entries are “Supply Name”, nominal voltage, measured voltage, and a 0 to indicate a supply in range or a bitmask of 1 (supply DC < limit), 2 (supply DC > limit) and 4 (supply AC > limit) to indicate an error.

6 *System Level Concerns*

6.1 *Multiple P940s and the Global Sync*

A P940 can be synchronized with other P940 systems, or with external devices, using the global sync mechanism. The global sync is a communication whereby a device (including a P940) generates an active low pulse on the SYNC connector on the rear-panel of the P940 lasting at least 1 µs. Any P940 can be configured to generate an internal strobe pulse (see ASCII System Strobe) in response to the falling-edge of this pulse.

To configure a P940 to receive a global sync pulse, use the **`SYSTem:STRoBe:GMASk`** command to select a group of channels that will be strobed when the next global sync is received. Then generate the sync pulse, either with an external contact closure or from a P940 with the **`SYSTem:STRoBe:GLOBal`** command.

Upon receipt of the sync pulse, the global strobe mask will be cleared; another **`SYSTem:STRoBe:GMASk`** command must be used to respond to the next global sync.

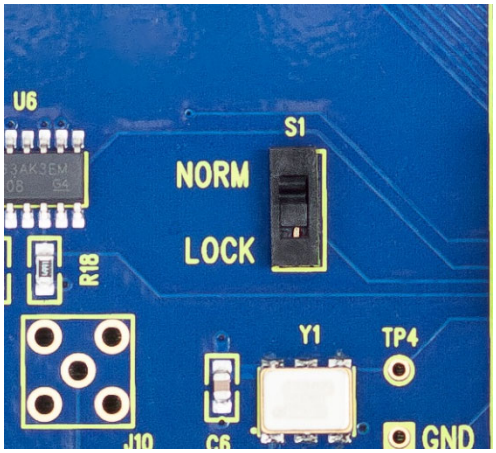
To synchronize multiple modules, it is recommended that the P940 generating the global sync pulse issue its strobe via **`SYSTem:STRoBe:GMASk`** rather than issue a separate strobe command for the local modules. This ensures that the timing of the global sync pulse governs synchronization, rather than the command receipt.

6.2 *Nonvolatile Storage*

Many applications require the ability to secure the P940 to ensure it is not modified, and that it is not storing non-volatile data. To do this, the P940 has a switch on the mainboard, located behind the display, with positions *NORM* and *LOCK*. By setting this switch to *LOCK* the P940 will reject all attempts to modify the non-volatile storage, including:

- Updating system and module firmware
- Changing network settings
- Modifications to the device calibration table

It is recommended that customers requiring this security also install a tamper seal across one or more top-cover screws on the P940, to ensure that the switch has not been changed since being set to *LOCK*.



7 Versions

P940-1: Modular Power System

8 Customization

Consult factory for information about additional custom versions.

9 Revision History

9.1 Hardware Revision History

23A940-1B	July 2023 Initial release

9.2 Firmware Revision History

23E940-2-1.1	July 2023 Initial release in field
23E940-2.1.2	August 2023 Added web interface for status and control. Improved display, including adding access to error table, restructuring network table, and enforcing run-time P941 limits. Added mDNS so P940 can be discovered on some networks at p940-$(serialnumber).local. Corrected BIST temperature readings, which were 20°C too low. Implemented other minor corrections and changes.
23E940-2.1.3	September 2023 Added auto-current feature for P941, with updates to the display and web interface.
23E940-2.1.4	November 2023 Introduce support for P945.

Recognize numeric channel IDs for monitor channels and channels on modules.

Introduce BIST return value for **`TEST:MODules?`** and **`SLOT<n>:TEST:MODule?`** for modules with active BIST failure.

Detect module communication failure in BIST; report active failure condition in error queue; and avoid additional HW_ERROR generation for modules experiencing this failure condition.

Provide response command mode with error responses returned immediately. **`SYSTem:COMMunicate:CMODe CLASSIC|RESPONSE`** switches between the existing **`CLASSIC`** mode and the new **`RESPONSE`** mode.

Return response to semicolon-separated commands as semicolon-separated response.

Indicate module failure in display status bar with module name in red.

Implement clock mode selection in display with in-cell radio buttons.

Correct links in status table on web interface home page.

Count all BIST failures as errors in **`*TST?`**.

Additional core, display, and web interface changes.

23E940-2-1.5 November 2023

Correct error from early BIST failure that could lead to unresponsive communication.

23E940-2-1.6 December 2023

Complete support for P945. Support constant current mode with **`SLOT<n>:OUTPut:CURRent`**. Support getting over-temperature and over-temperature shutdown status with **`SLOT<n>:TEST:OVERtemp?`** and **`SLOT<n>:TEST:OVERtemp:SHUTdown?`**. Support getting verbose BIST results with **`SLOT<n>:TEST:BIST:VERBose?`**. Updates to BIST testing with **`SLOT<n>:TEST:BIST`**. Change **`SLOT<n>:OUTPut:SHORT`** to **`SLOT<n>:OUTPut:SHORt`**

Accumulate SCPI response text to reduce packetization.

Start network interfaces in background to reduce boot time.

Make sure TCP connections close. Previously, connection over TCP to the P940 for SCPI command execution could have been blocked after many connections were made and closed by the client.

Correct module firmware upgrade failure safety feature that prevents

endless retries of firmware upgrade when errors are encountered.

Correct implementation of **`SLOT<n>:ReSeT`** for P941 and P945. Previously, this command left the P941 or P945 in an uninitialized state.

10 *Accessories*

J91-1: Blank plate for rear panel (eight installed standard with purchase)

J93-1: 6’ 5-15P IEC AC power cord (furnished with purchase)

J95-1: 3U rack slide