Operator's Manual for

Diode-Pumped Solid-State Software

This manual covers the following power supplies:

58 PSM 290
58 PSM 300
58 PSM 310
58 PSM 320

MELLES GRIOT

Manufactured by
Melles Griot Laser Group

2051 Palomar Airport Road, 200 □ Carlsbad, California □ 92009 □ USA
Tel: (760) 438-2131 □ Fax: (760) 438-5208 □ E-mail: sales@carlsbad.mellesgriot.com
www.mellesgriot.com

L10706-1 (A) 032411

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Wenn andere als die hier angebenen Kontrollfunktionen oder Einstellungen oder die Ausführung von Abläufen erfolgen, kann zu einer Aussetzung von gefährlicher Strahlung führen.

NOTICE: This manual contains specifications, descriptions, and drawings for diode-pumped solid-state lasers manufactured by Melles Griot.

Product specifications contained in this manual are subject to change by Melles Griot Laser Group without prior notice. Melles Griot will not be responsible for errors or omissions in this manual, or for incidental or consequential damages in connection with the furnishing or use of this information.

Comments or suggestions regarding this manual are appreciated and should be sent to the following address:

Melles Griot Laser Group
2051 Palomar Airport Road, 200
Carlsbad, California 92008, USA
Attention: Customer Service
Phone (760) 438-2131
Fax (760) 438-5208
E-mail: sales@carlsbad.mellesgriot.com

Publication date: August 2003

Table of Contents

Laser Control Interface Software

1.1 Operating the System Using a Personal Computer

Your laser can be controlled by a computer using the included DPSS Laser Controller Interface software via your computer's serial port or via user developed code using a RS-232 command set. The 9-pin RS-232 port on the power supply provides access to a variety of functions that are not available on the front panel or through the External Interface connector on the front of the supply. These include:

- The ability to operate in automatic power control (APC) or automatic current control (ACC)
- The ability to vary the laser output power
- The ability to pulse-modulate the laser output
- Access to detailed diagnostic information

The DPSS Laser Controller Interface software is provided on a 3½-inch floppy disk with each power supply. The software may be used with any personal computer operating in a Windows 95/98/2000/NT/Me environment.

The RS-232 command set and syntax are discussed in detail in Chapter 2.

Error codes can be found in Chapter 3.

1.2 Installing the Software

1. Insert the disk in your floppy drive. The disk contains a file named MG_GUI_10d_Installation.zip. This file must be unzipped by a program such as WinZip, StuffIt Expander or equivalent decompression software. Run WINZIP32.EXE (or a like program) and follow the instructions to unzip the installation program.

2. Double-click Setup.exe and follow the instructions to install the software on your hard drive. The installer will install a program entitled Melles Griot Laser Controller.

1.3 Connecting Your Computer to the Power Supply

Connect the laser and power supply following the instructions in the Hardware manual (included with your laser).

Connect your computer to the RS-232 port on the front panel of the power supply with a standard RS-232 serial cable (cable not included).

Turn the Laser Enable/Laser Disable key switch on the front panel of the power supply to the Laser Enable position and switch the AC Input rocker switch on the rear panel to the | (on) position.

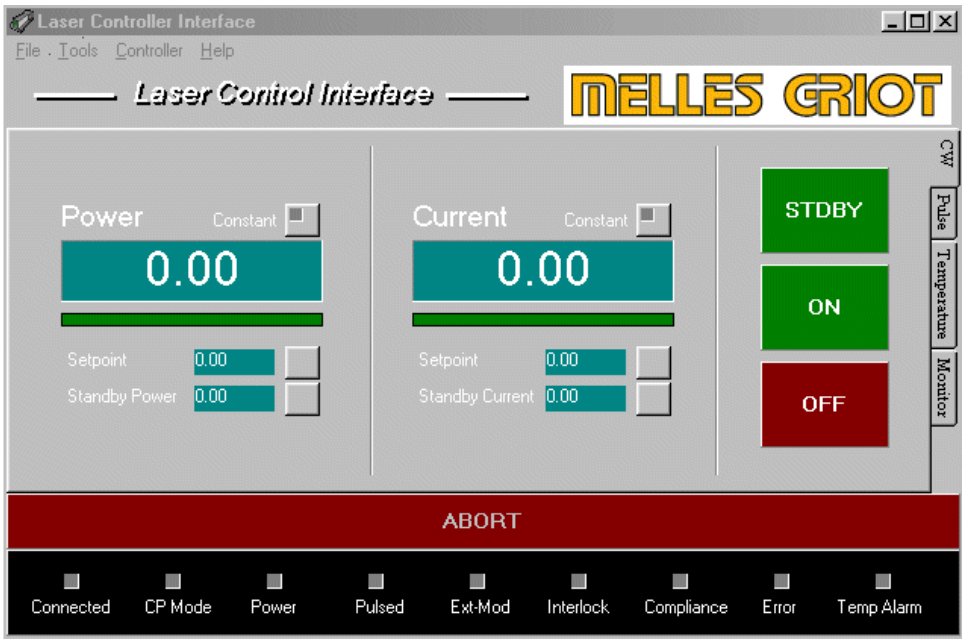
Double-click on the Melles Griot Laser Controller icon to launch the program and to bring up the CW screen of the laser control interface software shown in Figure 1-1.

Confirm the RS-232 communication port number, usually COM 1 or COM 2, for your computer using the following procedure:

a. Select "Comm Settings…" from the "Controller" menu
b. Select the port number to which the power supply is connected and click the OK button

Select "Connect" from the "Controller" menu to establish a serial connection with the power supply and note that at the bottom of the window, the "Connected" indicator turns green.

Figure 1-1
Laser control interface main screen



1.4 CW Window

The CW window is divided into three main sections: Power, Current, and control buttons. In addition to these main sections, there is a red ABORT button that can be used to shut down the laser system at any point in case

of an emergency only, and an indicator section that shows the status of the system at any time.

The Power and Current sections display the laser output power and pump diode operating current, respectively, a selection button that activates constant power or constant current mode, and two input boxes, one for the respective parameter during operation and the other for the parameter when in the standby mode. To enter a parameter, click in the appropriate text box. The box will be activated and an arrow (→) will appear in the box at the right of the window. Type the desired parameter, and then click on the arrow to register the value. *(Note: Pressing* the Enter key *on the keyboard* will not *initiate the new value.)*

1.5 Configuring Automatic Power Control (APC)

When in APC mode, the laser light output is maintained at a constant level and the current to the pump diode is continuously adjusted to maintain this level.

To place the system in APC mode, press the Constant button in the Power section of the screen. Enter the desired operating power in the Setpoint box and press the arrow (→) button to the right.

Note: You will not be able to select a power value that causes the laser to exceed the factory specified output power limit.

1.6 Configuring Automatic Current Control (ACC)

When in ACC mode, the pump diode current is maintained at a constant level and the laser light output will fluctuate.

To place the system in ACC mode, press the Constant button in the Current section of the screen. Enter the desired operating current in the Setpoint box and press the arrow (→) button to the right.

Note: You will not be able to select a current value that causes the laser to exceed the factory specified output power limit.

1.7 Operating the Laser

To turn the laser on, click the ON button at the right of the display.

Note: If the system is in APC mode, the Power indicator will remain constant at the level entered in the Setpoint box, and the Current indicator will vary with time. If the system is in ACC mode, the opposite will be true.

To put the laser in the standby mode, click on the STDBY button. The current or power will drop to the preset standby value.

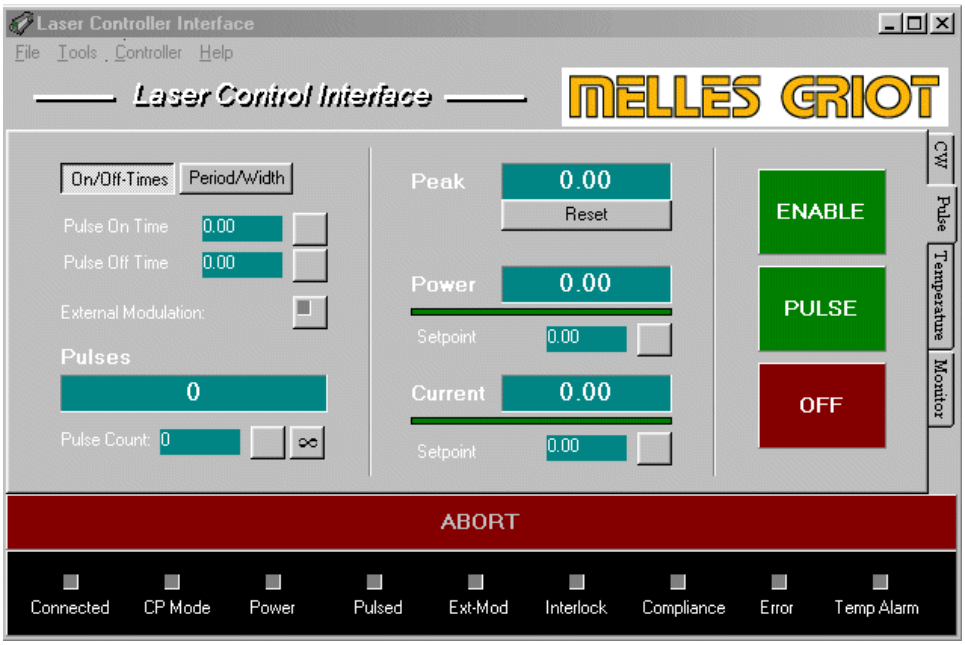
To turn the diode laser current off and stop laser emission, click on the OFF button.

1.8 Pulse Window

The Pulse window, shown in Figure 1-2 , is accessed by clicking on the Pulse tab at the right of the control screen. Pulses may be specified either by entering the pulse on and off times (by clicking on the On/Off-Times button), or by entering the pulse width and period (by clicking on the Period/Width button). As on the CW screen, when a text box is clicked, an arrow (→) will appear in the adjacent box. Type in the appropriate parameters and click on the arrow to register the parameter.

The total number of pulses may be specified by entering a parameter in the Pulse Count entry box. During operation the number of pulses is displayed in the Pulses window. When the prescribed number of pulses is reached, pulsing is discontinued. The system can be set to continuous pulsing by clicking on the infinity (∞) button or by entering "0" for the pulse count.

Figure 1-2
Pulse Window



As in the case of cw operation, pulse power and current can be specified by entering values in the appropriate parameter boxes. If the system is in the APC mode, the Power indicator will remain constant at the level entered in the Setpoint box, and the Current indicator will vary with time. If the system is in ACC mode, the opposite will be true.

During operation, only the Peak power readout is accurately displayed. Depending upon the repetition rate, one may have to frequently click the "Reset" button on the screen under the Peak optical power reading. Both peak current and average power are not displayed accurately due to an unsynchronized sample circuit. Peak power is displayed on a sample and hold basis.

The laser can be pulsed using an external TTL modulator by clicking on the External Modulation button and applying a TTL signal to the External Interface connector pins 1 (TTL in) and 15 (chassis ground). Maximum bandwidth of the external TTL input is approximately 3 kHz. A high signal level (+5 Vdc) turns the laser on, while a low signal voltage sets the laser at the standby current or the standby power level. The laser output power depends on the standby current or standby power setting.

To initiate pulsing, click on the ENABLE button. To discontinue pulsing, click on the DISABLE or OFF button. In DISABLE the pump diode laser current remains at approximately four amps if the system is in constant power mode, which is below its lasing threshold level. If the system is in APC mode and in DISABLE, the pump diode laser current returns to the Standby Current set by the user in the CW screen or the factory setting of approximately 5.0 amps.

After clicking the OFF button, the pump diode laser current returns to zero amps.

1.9 Temperature Window

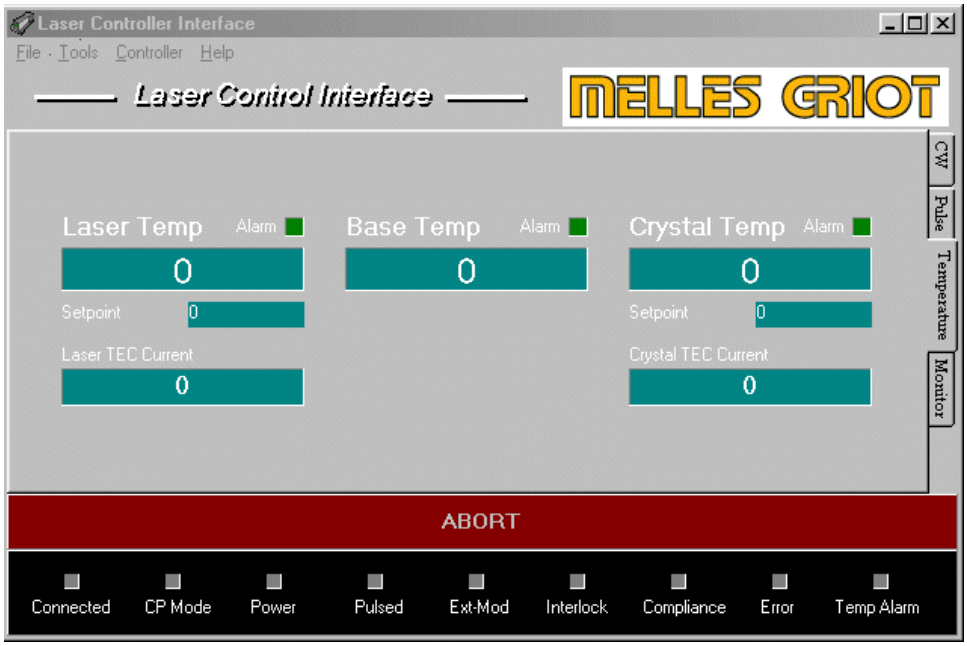
The Temperature window, shown in Figure 1-3, displays the temperature, in ohms, of the various components in the system. The laser head has three 10,000 ohm thermistors whose resistance values correlate to operating temperature. A reading of 10,000 ohms is approximately 25^{o}C (for a temperature versus resistance table, please refer to the Hardware Operator's Manual). As the resistance value decreases the actual temperature is increasing. As the resistance value increases the actual is thus decreasing. There are no user accessible controls in this window; the values are for diagnostic purposes only. The ABORT button functions in this screen for laser system shut down.

The Laser Temp and Crystal Temp readings should match their respective setpoint values within approximately 100 ohms when the laser is on for proper operation.

If the Base Temp reading approaches 4500 ohms, the laser head heat sink is starting to reach its maximum thermal capacity. One should verify that the ambient air temperature at the inlet of the heatsink is within the temperature range specification for the system. Also, ensure that there is adequate circulation in and out of the laser head. A temperature protect circuit will automatically shut down the diode laser current and both thermal electric coolers inside the laser head upon a Base Temp reading of 4000 ohms or approximately 46^{o}C.

Figure 1-3
Laser control interface temperature screen

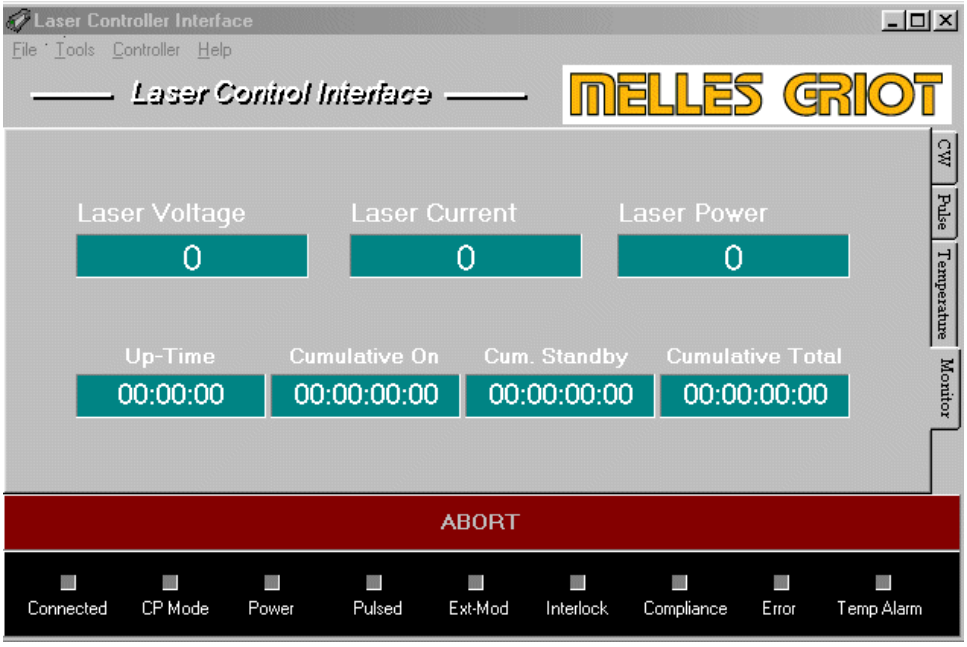
Figure 4.4
Laser control interface information screen



1.10 Monitor Window

The Monitor window, shown in Figure 1-4, displays the pump laser diode voltage and current, laser output power, along with cumulative operating times. “Up-Time” is the total amount of time that ac power has been applied to the power supply. “Cumulative On” is the total amount of lasing time for the laser head. “Cum. Standby” is the total amount of time the laser has been in the Standby mode. “Cumulative Total” is the total of both Standby and On time.

Figure 1-4
Monitor screen



RS-232 Command Set

2.1 Available Commands

General System Commands

ABOR	*CLR	*IDN	*RST
STOP	SYS:ERR	TIME?	

Laser Control Commands

LAS:CUR:REF	LAS:INIT:TIME	LAS:MODE	LAS:ON:TIME
LAS:POW:REF	LAS:RAMP:TIME	LAS:STAN:TIME	LAS:STAT
LAS:TOT:TIME	READ:LAS:CUR?	READ:LAS:POW?	READ:LAS:VOLT?
READ:PEAK?	STAN:CUR:REF	STAN:POW:REF	

Pulsing Commands

PULSE:COUN	PULSE:INIT	PULSE:ON:TIME	PULSE:OFF:TIME
PULSE:PER	PULSE:PROG	PULSE:STAT	PULSE:WID

External Modulation Commands

EX:MODU:STAT

General Utility Commands

'	"	COM:BAUD:RATE	COM:ECHO
COM:TERM:TYPE	LOAD:FACT	PASS	SAVE
SET:PASS			

2.2 Commands in Alphabetical Order

‘ or “

Command: Repeat Last Command

Function**:** After entering a valid command (e.g. `PULS:INIT 5`), pressing the apostrophe or quote-mark key will cause the power supply to re-execute the last command *without preceding data or query supplied*. For example, if `PULS:INIT 5` had been entered, supplying " will cause the power supply to execute `PULS:INIT. "? 10` will cause the power supply to execute `PULS:INIT? 10`

*CLR

Command: Clear System Status
Function: This causes all error bits and all pending command error listings to be cleared. It does not reset the lower bits of the `STAT:COM` flag, the operational/status bits of the `STAT:LAS`, `STAT:LTEC`, `STAT:XTEC`, etc. flags.

*IDN?

Command: System Identification

Function: Identify -- query only, ignores any supplied arguments. The command returns a comma-separated string consisting of four fields similar to the following:

`Melles Griot,58-PSM-290,1051_x66,1.03a`

The fields are:

Manufacturer, Model, Serial Number_Hardware Revision, Software Revision.

This string is echoed to the host upon successful power-up as part of the power-on sequence.

*RST

Command: Reset
Function: Performs a system reset by ignoring watchdog timer resets.

ABOR

Command: Emergency Abort
Function: Immediately shuts off laser. Has no effect if laser is currently OFF.

COM:BAUD:RATE?[9600/19K/38K/4800/2400/1200/600/300]

Command: Set Communications Baud Rate in bits per second
Function: Specifies baud rate to send/receive data from host. If baud rate is supplied, change is immediate: the prompt character following (either "> " or "* ", depending on error condition), will be transmitted at the specified rate.

NOTE: Factory default setting is 9600 baud. Baud rate must match DPSS Control software setup or no link shall be made. Each character sent is 10 bits.

COM:ECHO[?][state]

Command: Set Communications Echo
Function: State may be either 1 (on) or 0 (off). If echo is on , all characters received from the host are echoed back immediately. When a CR or LF is received, the COMM:TERM:TYPE termination sequence is echoed back to the host instead of the CR or LF received.

NOTE: Factory Default setting is ON.

COM:TERM:TYPE[?][crlf/cr/lf]

Command: Set End-of-Line Mode
Function: Specifies the end-of-message sequence sent from the power supply back to the host. Valid settings are:

CRLF	both carriage return & line feed are echoed.
CR	carriage return only echoed
LF	linefeed character only echoed.

Factory default setting is CRLF

EXT:MODU:STAT? [off/on]

Command: External Modulation State
Function**:** Specifies whether external (TTL) modulation is active when the laser is placed in the ON state. If active, the output follows the TTL state applied at the external modulation input, between the Standby (low) and ON (high) states.

Example:
```
> ext:modu:stat?
0,OFF
> ext:modu:stat? on
1,ON
>
```

LAS:CURR:REF? [amperes]

Command: Pump Diode Operating Current
Function: Specifies the operating current for the pump diode in the ON state. amperes may be 0.010 to LAS:CURR:LIM amperes.

NOTE: During operation, this value may limit the LAS:POW:REF setting, since laser power, after many hours of operation, may require increased current. In the constant power mode

of operation, this is effectively a primary current limit for the laser head.

Example:
```
> las:curr:ref?
15.00
>
```

LAS:INIT:TIME? [milliseconds]

Command: Laser Turn-On Delay Time
Function: Specifies the amount of time (in milliseconds) that should elapse from the OFF to Standby or ON laser state. `milliseconds` may be between 3000 and 60000. Factory default time is 3000 milliseconds.

Example:
```
> las:init:time?
3000
> las:init:time? 5000
5000
>
```

LAS:MODE? [pow/curr]

Command: Laser Operating Mode
Function**:** Places the laser in the constant output power (APC) or constant diode current (ACC) mode of operation. Command is immediate, regardless of laser state.

Example:
```
> las:mode?
1,CUR
>
```

LAS:ON:TIME?

Command: Laser Cumulative Run Time
Function: Returns the total amount of time the laser head has been in the ON state. The command is query-only.

Format returned is `HHHH:MM:SS`

Example:
```
> las:on:time?
00:00:22
>
```

LAS:POW:REF? [watts]

Command: Laser Output Power Level in watts
Function: Sets the operating power for the laser in the ON state (valid only for `LAS:MODE pow`). It is possible that the desired

operating power cannot be reached due to either a low setting on `LAS:CURR:REF` or `LAS:CURR:LIM`.

Example:
```
> las:pow:ref?
1.000
> las:pow:ref? 1.5
1.500
>
```

LAS:RAMP:TIME? [milliseconds]

Command: On-Ramp Time in milliseconds

Function: Specifies the amount of time to reach Standby or ON operating level from the OFF condition. The ramp-up occurs *after* `LAS:INIT:TIME` has expired.

Ramp time does not occur when switching between ON and Standby levels.

Example:
```
> las:ramp:time?
1000
>
```
(one second ramp)

```
> las:ramp:time? 2000
2000
>
```
(two second ramp)

LAS:STAN:TIME?

Command: Laser Cumulative Standby Time

Function: Returns the total amount of time the Laser has been in the Standby mode. Command is query-only.

Format returned is `HHHH:MM:SS`

Example:
```
> las:stan:time?
00:00:38
>
```

LAS:STAT? [off/on/stan]

Command: Laser State

Function: Places the laser in the specified state.
If the laser is currently off, the laser will reach the specified condition after `LAS:INIT:TIME` delay.
If the laser is currently in the `standby` or `on` mode, the command has immediate effect.
Specifying `off` from any state executes immediately.

Example:
```
> las:stat? on
3,PEND
>
```

From a laser-off state, the command `laser:state? on` will return the string

`3,PENDING`

immediately. This is because execution takes precedence over query in dual-context statements.

LAS:TOT:TIME?

Command: Laser Cumulative On Time

Function: Returns the total amount of run-time (both standby and on) that the laser head currently has. This is a query-only command. This is kept in non-volatile memory and is updated between power cycles and resets. The `ON` and Standby times are sampled while the laser is being internally modulated and the corresponding `LAS:ON:TIME` or `LAS:OFF:TIME` is updated accordingly during that sample period.

Example:
```
> las:tot:time?
00:01:00
>
```

LOAD:FACT?

Command: Recall Stored Operating Parameters

Function: This command reloads factory default values as shipped from Melles Griot. The command also replaces the existing user password with the default user password: `admin`

Example:
```
> load:fact?
0,No errors
>
```

PASS? [password]

Command: Enter/Leave Password Mode

Function: Entering `PASS` with no query and no (or incorrect) password clears password mode.

Entering `PASS?` leaves current mode intact, and returns state (0, disabled or 1,enabled)

Entering `PASS? <password>` enters password mode. (supplying the query will return success or failure)

NOTE: Factory default password is `admin`**.** Passwords are case sensitive, and must be between 1 and 15 chars.

PULS:COUN? [integer]

Command: Pulse Count

Function: This command specifies the number of pulses to initiate. Internal pulsing must NOT be presently taking place, or the power supply will ignore the `integer` value. `integer` may range from 0 to 65535, where 0 means "an infinite number of pulses".

Example:
```
> puls:coun?
1
> puls:coun? 6
6
>
```

PULS:INIT? [value]

Command: Pulse Sequence Initiation

Function: If the laser is in the standby state, this command initiates internal modulation (pulsing). `value` is optional -- if supplied, `PULS:COUN` is over-written and the sequence produces `value` pulses. If not supplied, the system uses `PULS:COUN` number of pulses.

Example:
```
> puls:init 5
>
```

PULS:OFF:TIME? [value]

Command: Pulse OFF-Time

Function: Specifies the amount of time an internal pulse should be OFF. `value` may be 0.25 to (60000 - `PULS:ON:TIME`). Time is rounded to nearest 0.25 millisecond value by the power supply. The factory default value is 5.0 milliseconds. Using this command will adjust the values currently in `PULS:WID` and `PULS:PER`.

Example:
```
> puls:off:time?
1.00
>
```

PULS:ON:TIME? [milliseconds]

Command: Pulse On Time

Function: Specifies the amount of time an internal pulse should be on. `milliseconds` may be 0.25 to (60000 - `PULS:OFF:TIME`). Time is rounded to nearest 0.25 millisecond value. Using this command will adjust the values currently in `PULS:WID` and `PULS:PER`. Factory default value is 5.0 milliseconds.

Example:
```
> puls:on:time?
1.00
>
```

PULS:PER? [milliseconds]

Command: Pulse Period
Function: Specifies the total amount of time for a complete pulse, which includes the initial on time and the dead (Standby level) time in between. Value may be `PULS:WID` + 0.25 milliseconds to 60,000 milliseconds. Resolution is 0.25 milliseconds.

Example:
```
> puls:per?
2.00
>
```

PULS:PROG?

Command: Pulse Progress
Function: This is a query-only command which returns the number of pulses which have currently completed. The number (count) returned may not be accurate, depending on the combination of `PULS:PER / PULS:WID / PULS:ON:TIME / PULS:OFF:TIME` and the baud rate currently selected. If pulsing is currently not active, the last completed number will be returned instead.

Example:
```
> puls:prog?
10
>
```

PULS:STAT? [off/on]

Command: Pulse Status
Function: If the laser is in standby, this command turns the internal modulation on or off. The command has no effect unless the laser is currently in standby. The command may be used to stop pulsing if internal modulation is currently taking place. The `STOP` command will also stop internal modulation and place the laser in standby.

example:
```
> puls:stat?
0,Off
> puls:stat? on
0,Off
* sys:err?
200,Setting conflict  // -- laser was NOT
          in standby mode…
>
```

PULS:WID? [milliseconds]

Command: Pulse Width
Function: Specifies the amount of time for the on time of a pulse. Value may be 0.25 milliseconds to `PULS:PER` - 0.25 milliseconds. Resolution is 0.25 milliseconds.

Example:
```
> puls:wid?
1.00
>
```

NOTE: It is *strongly* recommended that the user adhere to using *either* `PULS:OFF:TIME` and `PULS:ON:TIME` *or* `PULS:PER` and `PULS:WID` commands. For hardware (internal timer) reasons, the times are evaluated as a period and a width by the embedded software.

READ:LAS:CURR?

Command: Read Laser Current
Function: Returns laser current (amps, 0 to 30 Amps, 10 mA resolution)

READ:LAS:POW?

Command: Read Laser Power
Function: Returns laser power (watts, 0 to 5 watts, 1 mW resolution)

READ:LAS:VOLT?

Command: Read Laser Voltage
Function: Returns laser voltage (volts, 0 to 5 volts, 1 mV resolution)

READ:PEAK?

Command: Read Peak Detector
Function: Returns a "dimensionless" number between 0 and 1023 from the internal 10-bit peak detector. Reading this value immediately resets the peak detector. The number may be

scaled by the user as desired to correlate readings to "power" or "current".

SAVE[?]

Command: Save Current Operating Parameters
Function: The system must be in password mode. This command will cause the power supply to save all current settings (operating current, operating power, standby current, serial baud rates, echo, line termination, etc.). Factory default settings may be recovered using the `LOAD:FACT` command.

SET:PASS? [new_password]

Command: Set New Password
Function: Command has no effect unless unit is already in password mode.

New_password takes effect immediately upon success.

To recover default password, the `LOAD:FACT` command must be used, which will also restore all other parameters to default values.

STAN:CURR:REF? [amps]

Command: Laser Standby Levels
Function: Specifies the operating current for the laser in the standby state. Amps may be 0.010 to `LAS:CURR:REF` amperes.

NOTE: During operation, this value may limit the `STAN:POW:REF` setting, since laser power, after many hours of operation, may require increased current. In the constant power mode of operation, this is effectively a primary current limit for the laser head.

Example:

```
> stan:curr:ref?
5.00
> stan:curr:ref? 20
5.00
* sys:err?
201,Data range err
>
```

STAN:POW:REF? [watts]

Command: Standby Operating Power
Function: Sets the operating power for the laser in the standby state (valid only for `LAS:MODE pow`). Watts may be any value from 0.001 to `LAS:POW:REF`

It is possible that the desired operating power cannot be reached due to either a low setting on `STAN:CURR:REF` or `LAS:CURR:LIM`.

Example:

```
> stan:pow:ref?
0.005
> stan:pow:ref? 0.5
0.500
>
```

STOP

Command: Stop Command
Function:

Stops internal modulation and places laser in Standby mode. If Laser was ON, places laser in Standby mode. Has no effect if laser is already off.

SYS:ERR?

Command: Retrieve Command Errors
Function:

Causes a last-in-first-out reply of any previous commands or queries that did not parse properly, whose arguments were not within allowable limits, or errors that have been internally generated by the system. These typically include misspelled commands and/or arguments, properly formatted commands with out-of-range data supplied, or commands that could not be implemented due to current conditions (such as "`LAS ON`" with a severe system error condition present). If an error is pending in the buffer, the prompt changes from "> " to "* " at the ANSI console. Reading the last error changes the prompt back to the "> " condition.

In addition to `STAT` command bytes, this query returns a string containing a number, a comma, and a string representation of the error.

Errors are returned on a last-in first-out basis, with a maximum error list quantity of six. Syntax: `SYS:ERR?`

TIME?

Command: System Up Time

Function: Returns the amount of time since the power supply has been powered up or since the last reset. Rolls over after 2^{32} milliseconds (49.7 days or 1192.8 hours).

Time is returned in `HHHH:MM:SS` format.

Example:
```
> time?
120:07:10
```

Error Codes

3.1 Error Codes

The following code are returned if an error is asked for by `SYS:ERR?`

```
NO_ERR,          // 0,No errors
SAVE_OK,         // 0,Save OK
CMD_ERR,         // 100,Command Error
SYNTAX_ERR,      // 101,Syntax Error
IGNORE_PARM,     // 102,Parameter ignored
PASS_NEEDED,     // 103,Password Required
PARM_NEEDED,     // 104,Missing Parameter
UNDEF_HEADER,    // 105,Undefined Header
BAD_STRING,      // 107,Invalid string data
BAD_NUMBER,      // 108,Invalid numeric data
SET_CONFLICT,    // 200,Settings conflict
RANGE_ERROR,     // 201,Data range err
BAD_SELF_TEST,   // 400,Self-test failed
LOST_CAL,        // 300,Cal memory lost
LOST_CONFIG,     // 301,Config mem lost
LOST_FACT,       // 302,Fact config lost
LOST_USER,       // 303,User config lost
LOST_INFO,       // 304,Unit Info lost
LOST_TIMES,      // 305,On/Off Times lost
NO_ARGS,         // 500,No Value Supplied
EE_WRITE_FAIL,   // 501,EE Write Failed
INSECURE,        // 502,Security Failure
ILLEGAL,         // 503,Value Not Allowed
HARDWARE,        // 600,Hardware Error
```

All 60X series codes are also conveyed by a flashing System Fault LED blinking (601 = 1 blink, 602 = 2 blinks, etc.)

```
INTERLOCK_OPEN,   // 601,Interlock Open
COMPLIANCE_LIM,   // 602,Compliance Limit
BASE_OVR_UNDR,    // 603,Base Temp Err
XTAL_OVR_UNDR,    // 604,Xtal Temp Err
LASE_OVR_UNDR,    // 605,Las Temp Err
PWR_SUPP_ERR,     // 606,Pwr Supply Err
AD_READ_ERR,      // 607,Hdwe Read Err
TEMP_INTLK_MSG,   // 608,Temp Interlock
INTERLOCK_FAIL,   // 609,Intlock Ctl Fail
PD_FAIL,          // 610,Photodiode Fail
AC_FAIL,          // 611,AC Mains Fail
DC_FAIL,          // 612,DC Supply Fail
MISS_HDWE,        // 613,Missing Hardware

Q_OVERFLOW,       // 999,Queue Overflow
UNDEF_ERROR,      // -1,Undefined error
```