OPHIR®
Photonics
A Newport Company

Helios

Helios User Guide

High Power Industrial Laser Measurement

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OPHIR® Photonics
A Newport Company

About this Guide

This guide describes how to operate and control the Ophir **Helios** power meter with the following interfaces:

- Profinet
- RS232

How the Document is Organized

This guide describes installation and operation in the following order:

- How the **Helios** power meter works, Specifications
- **Helios** setup
- Profinet communication
- RS232 communication
- PC control application

Chapter 1 – Helios Operating Principle

Overview

The Helios sensor measures high power industrial lasers by measuring the energy of a short time exposure of the CW laser. The laser should be set to pulse from 0.1 to several seconds. The Helios measures the energy and exposure time of this sample of the power, and from this calculates the CW power.
The Helios can measure power up to 12 kW and energy to 10 kJ. The short exposure time enables power measurement by a small sensor without water cooling. (See the table in Chapter 2 for recommended exposure times by power level.)

Physical Principle

The core of Helios is a high power copper thermopile disk that can measure short exposures of very high power lasers.
The response time is 2-3 seconds so only energy of single-shots can be measured at such short exposure times.
An internal, uncalibrated photodiode detects the backscattered light to measure the exposure time.
Average power is then calculated by,

$$P = \frac{E}{\Delta t},$$

where P is power, E is energy, and Δt is the time interval.
All this allows short measurements of multi-kW lasers in a small, uncooled body.

Example of Use: Laser Welder in a Robotic Cell

A typical application of the Helios is to check the power of a laser welder in between welds. This process can be automated and optimized to take the least time away from production possible.
Here's a typical sequence of events:

1. Welding production "Item A" is almost done
2. Open Helios shutter and check sensor is "Ready"
3. Finish welding production "Item A"
4. Turn off laser
5. Move laser to Helios
6. Turn on laser for preset amount of time (0.1-10 s)
7. Move laser back to production
8. Start welding production "Item B"
9. Read measurement (~3 seconds after laser measurement)

Chapter 2 – Specifications

The latest specifications can be found here:
http://www.ophiropt.com/laser--measurement/sites/default/files/Helios.pdf

Chapter 3 – Setup

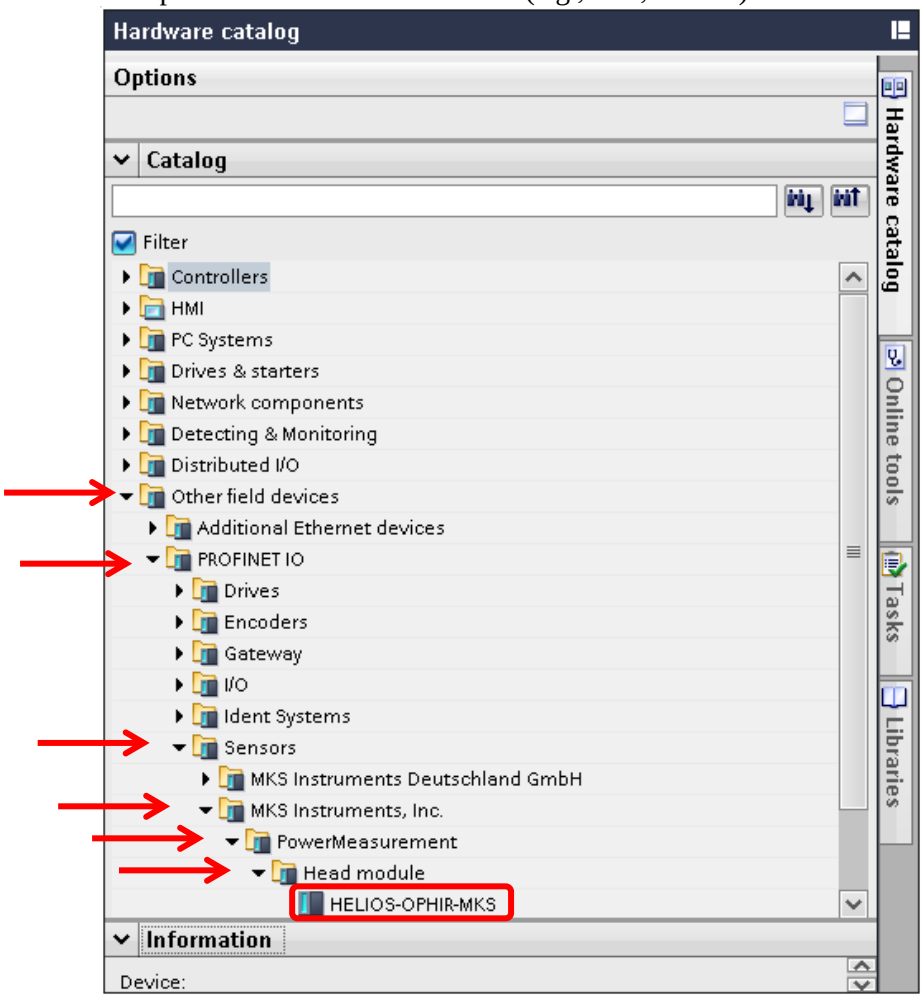
There are three ways to interface with the Helios laser power meter:

1. Profinet
2. RS232 commands (e.g., with HyperTerminal)
3. PC application

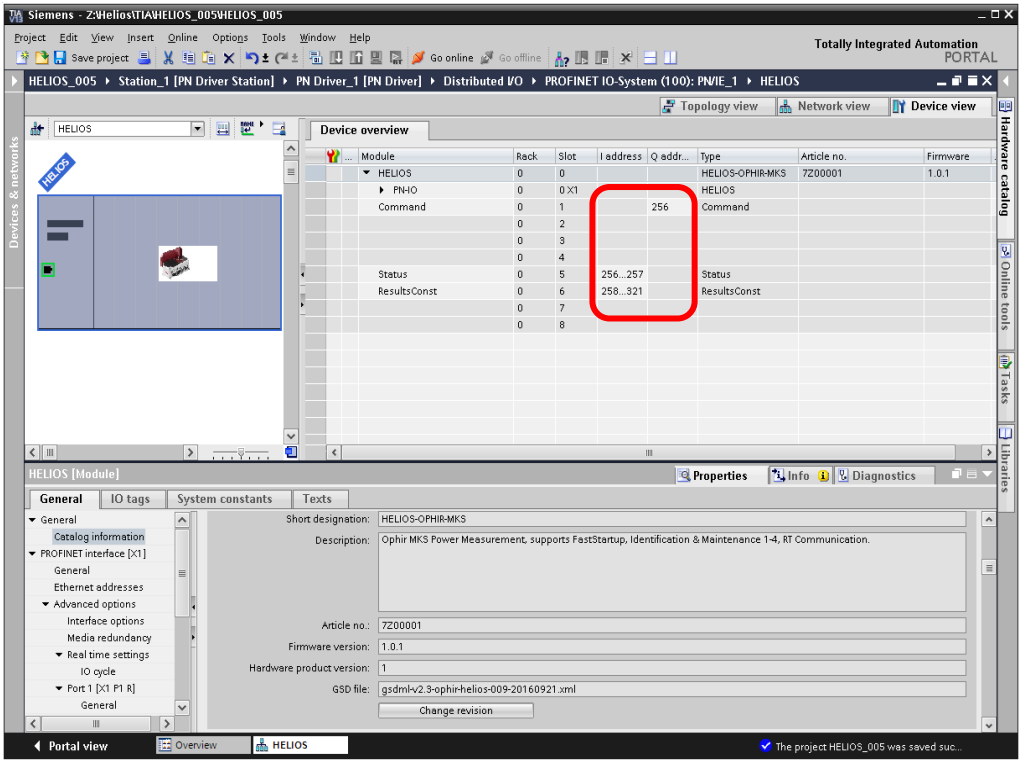
The setup of Helios depends on the mode of operation.

Profinet Setup

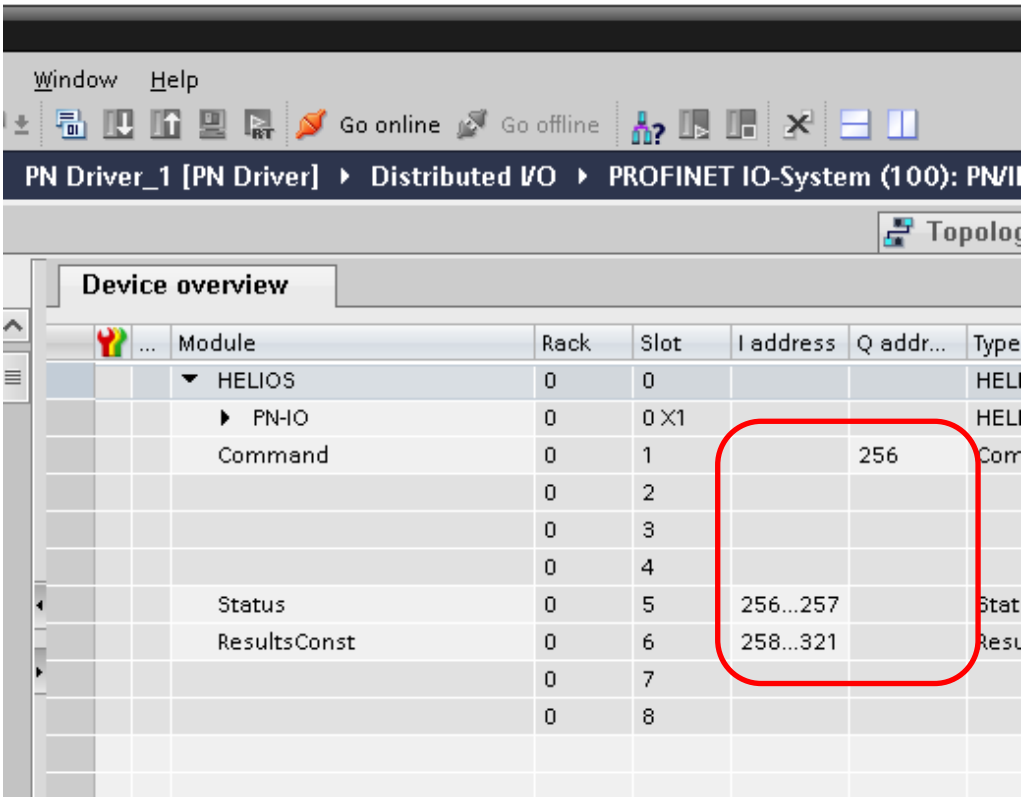
- Place the Helios where it will be convenient to measure the laser (can bolt down to the chassis with M6 screws).
- Connect 24 V DC to standard Profinet jack. (It is compatible, for example, with Harting part 09 35 431 0401.)
- Connect Profinet RJ45 cable to jack. (It is compatible, for example, with Harting part 09 35 226 0401.)
- Integrate the device into the network. (Need: GSDML file from CD; customer's network administrator.)
- Set up Profinet network in software (e.g., TIA, STEP7):



- Set up device addresses as marked inside the red circle:



Zoomed-In:



- Integrate the power measurement into the customer software (controlled by the PLC) as fits their application and needs.
- See Chapter 7 for more details on Profinet setup and read/write registers (called "submodules").
- Begin test measurements.
- Integrate into production line routine.

RS232 Setup

- Place the Helios where it will be convenient to measure the laser (can bolt down to chassis with M6 screws).
- Connect 24 V DC to standard Profinet jack (It is compatible, for example, with Harting part 09 35 431 0401.)
- Connect a standard RS232 to the D9 jack.
- Install the "Helios Control Application" by copying it from the included CD and following the installation wizard steps.
- Integrate the power measurement into customer software (by scripting commands) as fits their application and needs. See Chapter 8 for more detail and a list of commands.
- Integrate into the production line routine, using RS232 program.

PC Application

- The PC application is needed to upgrade the Helios firmware.
- It can also be used to measure with the Helios without any programming. This can be useful for pre-integration testing.
- To begin test measurements, follow these steps:
    - Set scale to be above the max expected energy
    - Press "Open" cover
    - Turn on laser and wait for measurement results to appear
- Can also use RS232 commands directly by enabling the terminal.
- Options include: logging, instantaneous power reading, housing temperature, and the terminal

Chapter 4 – Check before Use

Be sure to check the laser parameters before turning it on to ensure no damage to Helios. Specifically, the power, beam size, and exposure time must be within the specifications. (Use this calculator to easily find the power density from laser power and beam size.)

Preliminary test

Here's a sample test to be sure everything is operating as it should:

(1) Setup the Helios. (See section 3.)
(2) Cover test:
    a. Open and close the cover, then open again.
(3) Measurement test prep:
    a. Select the desired energy scale. The selection should be greater or equal to the maximum energy expected.
    b. Set "current power" in options menu, to see the instantaneous power.
    c. Set laser parameters to below 50% damage for the first test.
    d. Check that status is "Ready" (not "Wait" or "Integrating")
(4) Measurement test:
    a. Fire laser.
    b. Confirm reasonable power in "current power" screen.
    c. Wait for energy results. (Status will be "integrating" until the results come in.)
    d. Read power, energy, and exposure time. Confirm these are reasonable, too.

Timing Considerations

There are a few criteria to consider when setting up a measurement timing scheme:

- Each pulse or "shot" of the laser must of course be within spec (under 10 kJ, as well as within the maximum power, time range, and damage threshold; see section 2).
- Wait at least 12 seconds between shots.
- When the Helios reaches 60 °C it must be left to cool down, which typically takes 10-20 minutes. (This temperature is reached after about 40 kJ of accumulated exposure.)

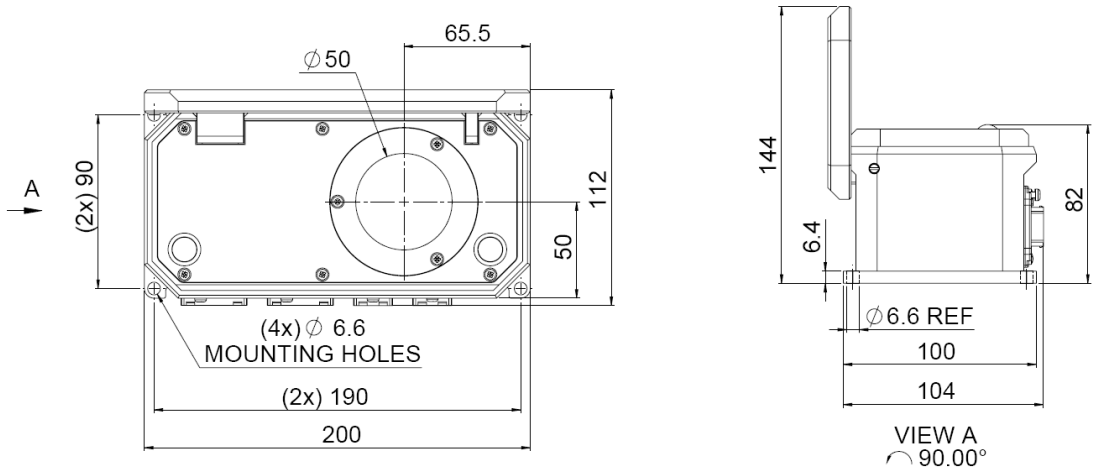
Recommended beam sizes and exposure times for various laser powers can be found in the specifications table (Chapter 2).

Temperature Failsafe

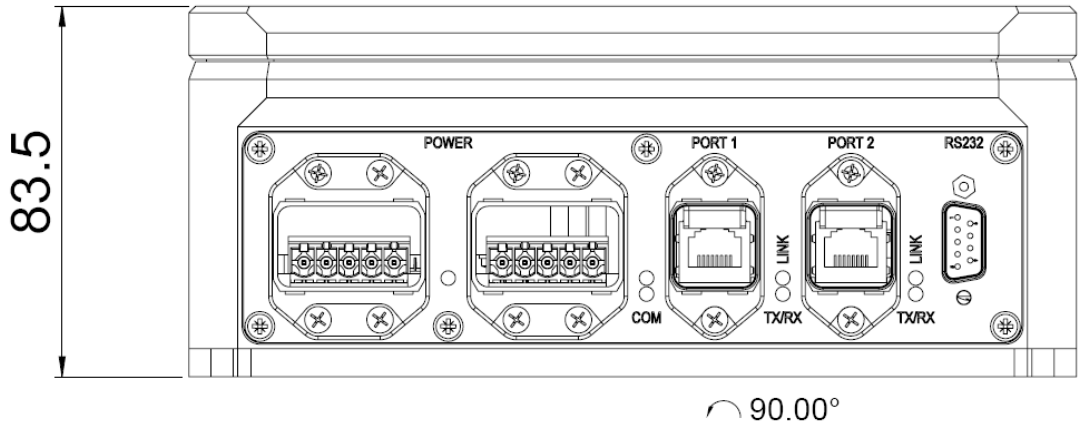
The Helios should not be used when the housing temperature exceeds 60 °C. To ensure this is always the case, there is a bit (when using Profinet) and a command (when using RS232) that measures the current temperature and checks it against the maximum temperature (60 degrees).
It is the responsibility of the customer software integrator to include a condition in the laser control that automatically shuts off the laser if the temperature is exceeded.

Chapter 5 – Mechanical dimensions

Helios with Cover Open



Helios with Cover Closed



Cover closed (bottom): 200 x 100 x 84 mm (length by width by height)
Cover open (top): 200 x 123 x 144 mm (length by width by height)

Note the cover opens farther than the picture shows. When the cover is open at 90° as shown, the width is 112 mm. When the cover is open as far as possible, the width will be 123 mm. (In practical use, the width when open will be in between these figures as the motor control doesn't allow the cover to reach the mechanical stop-point.)

Chapter 6 – Connectors

From left to right, the connectors above are:

(1) Two power connectors, both 5-pin Han Push-Pull Power.
(2) Two RJ45 Profinet connectors, both Han Push-Pull RJ45 PN (compatible with Harting part 09 35 226 0401. Standard IP20 cables can also be used, but without a locking mechanism.)
(3) One D9 connector for RS232

Power Connectors

The power sockets are Harting Han PP Power, part 09 35 004 3003 (pin connector) and part 09 35 002 0303 (metal hood). It is compatible with (for example) Harting part 09 35 431 0401.

Pinout, with pin 1 at left:

Pin	Function
1	24 V DC, Sensor (used by Helios)
2	Sensor Ground
3	24 V DC, Actuator (not connected to Helios circuit; used only for daisy-chaining)
4	Actuator Ground
5	Chassis

RJ45 Connectors

The RJ45 sockets are Hirose, part TM21R5C88(50) and Harting, part 09 35 002 0301. It is compatible with (for example) Harting part 09 35 226 0401.

Pin	Function
1	TX+
2	TX-
3	RX+
4	[NC]
5	[NC]
6	RX-
7	[NC]
8	[NC]

RS232 Pinout

RS232 can be used by connecting a standard RS232 cable to the D9 connector.

Pin	Function
1	[NC]
2	TX
3	RX
4	[NC]
5	Ground
6	[NC]
7	[NC]
8	[NC]
9	[NC]

Chapter 7 – Profinet

LED indicators table

There are seven LEDs for different status/error indications. From left to right (and top to bottom), the LEDs are:

1. Power
2. COM (Green)
3. COM (Red)
4. Link (Port 1)
5. TX/RX (Port 1)
6. Link (Port 2)
7. TX/RX (Port 2)

Here is a more detailed explanation of what each LED means:

LED	On	Flashing	Off
Power	Power is connected		No power
COM (Green)		DCP signal service is initiated via the bus	No error
COM (Red)	No configuration; slow or no physical link	No data exchange	No error
Link (Port 1)	Port 1 is connected to Ethernet		Port 1 is NOT connected
TX/RX (Port 1)		Port 1 is sending/receiving	Port 1 is NOT sending/receiving
Link (Port 2)	Port 2 is connected to Ethernet		Port 2 is NOT connected
TX/RX (Port 2)		Port 2 is sending/receiving	Port 2 is NOT sending/receiving

Modules and Registers

Status: 16-bit Register

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Shutter Ack.	Scale Ack.	Undefined Cmd.	Exp. Time Error	Sensor Too Hot	Meas. Complete	Meas. in Progress	Meas. Ready	(Spare)	(Spare)	(Spare)	Shutter Other Error	Shutter Timeout	Shutter in Motion	Shutter Closed	Shutter Open

Byte : Bit	Register	Length	Read/Write
0:0	Shutter is open	1 bit	Read
0:1	Shutter is closed	1 bit	Read
0:2	Shutter in motion	1 bit	Read
0:3	Shutter timeout error	1 bit	Read
0:4	Shutter other error	1 bit	Read
0:5	(Spare)	1 bit	Read
0:6	(Spare)	1 bit	Read
0:7	(Spare)	1 bit	Read

1:0	Sensor is ready to measure laser	1 bit	Read
1:1	Laser measurement in progress	1 bit	Read
1:2	Laser measurement complete	1 bit	Read
1:3	Sensor is too hot; let device cool 10-20 minutes	1 bit	Read
1:4	Exposure time error	1 bit	Read
1:5	Undefined command	1 bit	Read
1:6	Energy scales change – acknowledge	1 bit	Read
1:7	Shutter command – acknowledge	1 bit	Read

Constants:

Byte	Register	Units	Length	Read/Write
2-5	Maximum energy that can be measured	mJ	4 bytes	Read
6-9	Minimum energy	mJ	4 bytes	Read
10-11	Maximum exposure time	ms	2 bytes	Read
12-13	Minimum exposure time	ms	2 bytes	Read
14-15	Maximum power	W	2 bytes	Read
16-17	Minimum power	W	2 bytes	Read
18-19	Maximum allowed temperature of Helios	°C	2 bytes	Read
20-21	(Spare)			

Measurement Results:

Byte	Register	Units	Length	Read/Write
22-25	Latest power measurement	W	4 bytes	Read
26-29	Latest irradiation time measurement	µs	4 bytes	Read
30-33	Latest energy measurement	mJ	4 bytes	Read
34-37	Current power	mW	4 bytes	Read
38-39	Temperature of Helios device	°C	2 bytes	Read
40-41	Current energy scale (index)		2 bytes	Read
42-45	Maximum energy in current scale	J	4 bytes	Read
46-63	(Spare)			

Commands:

Command	Register	Length	Read/Write
0x00	Clears bits 13-15 of status register	1 bytes	Write
0x01	Set energy scale to 10 kJ (max)	1 bytes	Write
0x02	Set energy scale to 1 kJ (max)	1 bytes	Write
0x03	Set energy scale to 100 J (max)	1 bytes	Write
0x08	Open cover	1 bytes	Write
0x10	Close cover	1 bytes	Write

Chapter 8 – RS232

General Information:

1. All commands are initiated by PC; Helios responds to them ONLY AFTER RECEIVING THE FINAL [CR] symbol
2. All communications with PC are in ASCII symbols – not binary values
3. All commands from PC begin with '$' symbol
4. All commands and replies END with Carriage Return symbol (#13, '[CR]','\r' in "C" language)
5. All commands are defined by two ASCII characters that can be lower or upper case
6. All REPLIES begin with a '*' symbol (for 'OK') or a '?' (for an error)
7. The FIRST parameter of any command CAN be placed next to the letters of the command (e.g. 'WB0 …') OR there can be a space (#32) between the letters and the first parameter
8. The SECOND+ parameters ALWAYS must be separated by at least one SPACE

Standard Error Messages:

If a command is not recognized or the parameters are incorrect, the following standard error messages are returned:

1. ?BAD PARAM[CR] – if incorrect parameters received, for example the wrong number or missing parameters, when they are needed.
2. ?UC[CR] <the 2 first characters received which were not recognized>
3. ?BAD COMMAND 66,65 – if a single character instead of a double character command code is entered

Details of RS232 Commands:

Test communications ("Ping"):
$HP[CR] -> *[CR] [LF]

Send Version:
$VE 1[CR] -> *UU1.04[CR][LF] {Returns software version. Note – exactly one space between 'E' and '1'}
$VE[CR] -> *404[CR] [LF] {Any other parameter, or no parameter: Returns s/w version code in different format}

Reset:
$RE[CR] -> *[CR][LF] {Resets the MCU software – begins code running from 0. Should RETURN the *[CR] BEFORE doing the reset…}

Head Information:
$HI[CR] -> *<2 letter head code> <S/N of head> <name of head> <capability code>[CR][LF]
Returns information on the head, including its name and S/N.

Write Head Range:
$WN 0[CR] –> *[CR] {changes range: 0,1,2 parameter, 0=highest, or least sensitive, range. Power-up settings will be defined using $HC command, see below. NOTE that after using the $WN command, the software should wait ~3s before resuming power measurements with the $SP command.}

Read Head Range:
$RN[CR] –> *1[CR] {Reads head range, returns as parameter defined in $WN}

All Ranges:
$AR[CR] –> *0 10.0KJ 1.00KJ 100J[CR][LF] {Returns a list of all available energy ranges (scales) including an index value showing which range is presently selected. In the Helios, top scale (index 0) is 10.0kJ, scale 1=1.00kJ, and scale 2=100J. The "0" is the index and indicates that range 0 (10.0kJ) is currently selected. See also $RN and $WN commands, the index value is the same as defined for those commands.}

Save Head Configuration Settings:
$HC S[CR] -> *[CR] {Saves the CURRENT SETTINGS of energy scale as the power-up defaults}
Note: In order to change the power-up defaults, the following sequence is necessary:
a. Set desired power scale using $WN command
b. Save chosen settings using $HC S command

Calibration Query:
$CQ <0|1|2> <new-factor>[CR] ->*<User energy factor> <User laser factor> <Overall laser factor> <Overall power sensitivity in A/W>[CR] {Query and set presently active calibration factors. Sending the command with no parameter (or parameter 0) queries the current factors. Send parameter "1" followed by a new factor to change the user energy factor. Send parameter "2" followed by a new factor to change the user laser factor, which only affects the current laser setting (wavelength).}
Note: The overall laser factor is affected by the user laser factor and an Ophir calibration factor that cannot be changed by the user. The overall sensitivity is a composite of the User Energy factor, the Laser factors in use, and an Ophir overall sensitivity factor that cannot be adjusted by the User. Note that changes in the Energy Factor affect this field for all Lasers. Changes in the User Laser Factor affect this field only for the present laser in use.
New-factor is a floating-point number between 0.0002 and 2.0 scaled up by 10000 (2 to 20000).
Examples:
$CQ->*1.0000 1.0000 1.0000 2.5926E-8 – Query – The user energy factor, user laser factor, and overall laser factor are all set to 1. The overall sensitivity is 2.5926E-8.
$CQ 1 11000->*1.1000 1.0000 1.0000 2.5926E -8 – The energy factor is adjusted, but the power sensitivity remains the same. (It is affected by power factor but not energy factor which was adjusted now.)
$CQ 2 11000->*1.1000 1.1000 1.1000 2.1426E-8 – Notice changing the user laser factor also affects the overall laser factor and overall power sensitivity.

Cover Control:
$CC<1 | 2>[CR] ->*1 C | 2 O | 3 M | OK[CR] {Controls cover movement. Sending the command with no parameter queries the current status: 1 C means cover is closed, 2 O means cover is open; 3 M means cover is in motion or error; ?ERROR means the device senses the cover is both open and closed. Sending parameter "1" closes the cover, sending parameter "2" opens the cover.}
Examples:
$CC 1 – closes the cover, returns "*OK"
$CC 2 – opens the cover, returns "*OK"
$CC – status query, command returns:
*1 C – if cover is closed
*2 O – if cover is closed
*3 M – if cover is in motion

Send Exposure Time (Photodiode):
$SW[CR] ->*<Latest exposure time measurement in µs>[CR] {This command sends the latest laser exposure time measurement or zero if the sensor is in the middle of measuring a pulse. It can return measurements up to a maximum rate of 15 times per second.}
Examples:
*123456 for 0.123456s
*2345678 for 2.345678s

Send Complete Measurement:
$SC[CR] ->*<power> <energy> <exposure time>[CR] {This command sends the latest laser measurements, power (W), energy (J), exposure time (s), separated by a space between each, and ended by [CR]. It can return measurements up to a maximum rate of 15 times per second.}
Example:
9.876E3 4.938E3 5.000E-1[CR] for 9876W, 4938J, 0.5s

Send Temperature
$RT[CR] ->* <Internal temperature> <maximum allowed temperature>[CR] {This command sends the internal temperature of the power meter, in degrees Celsius, followed by the maximum allowed temperature, and terminated with [CR]. It can return measurements up to a maximum rate of 15 times per second. The integrator should use this to ensure that the Helios is left to cool down when the internal temperature reaches or exceeds the maximum allowed temperature.}
Example:
* 33.5 60 – current temperature of 33.5 °C and maximum temperature of 60 °C.

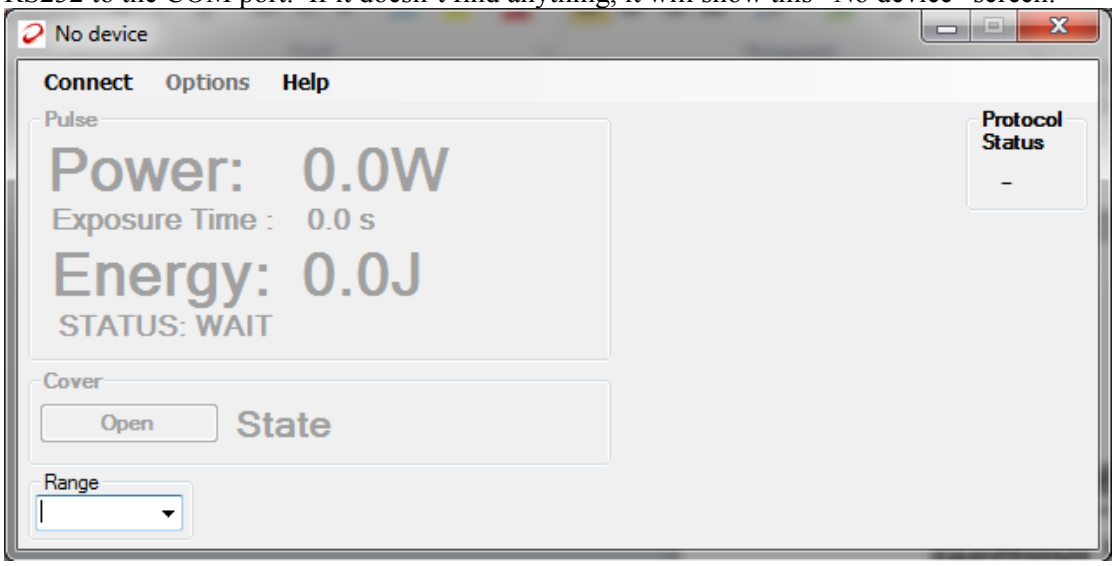
MAC Address
$MC[CR] ->*<MAC Address from Hilscher module>[CR]
Example:
*00:02:A2:34:5B:91[CR]

Chapter 9 – PC Application

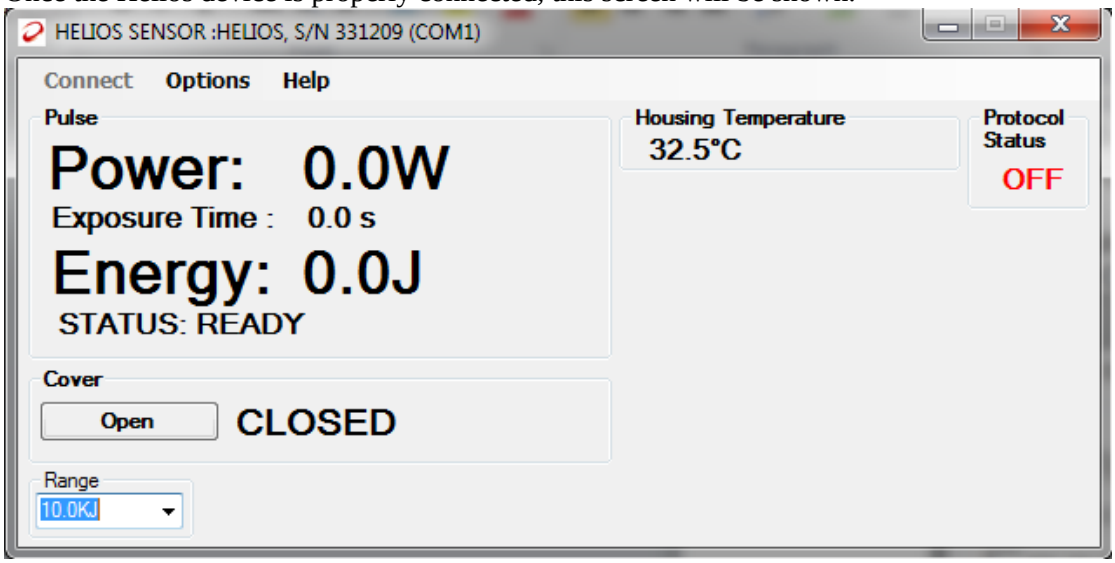
Getting Started

The PC application can be found in the CD directory. Copy the executable file to your local computer and run it (as an administrator) to install.
Follow the steps in the installation wizard to complete.

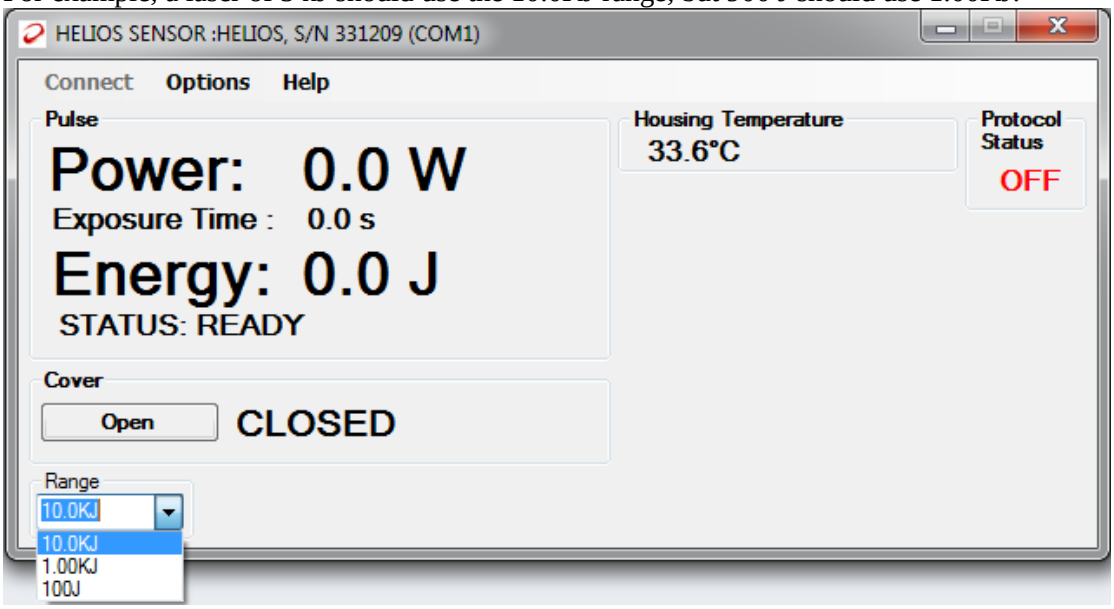
This is the initial screen. Upon startup, the program will check for a device connected with RS232 to the COM port. If it doesn't find anything, it will show this "No device" screen:



Once the Helios device is properly connected, this screen will be shown.

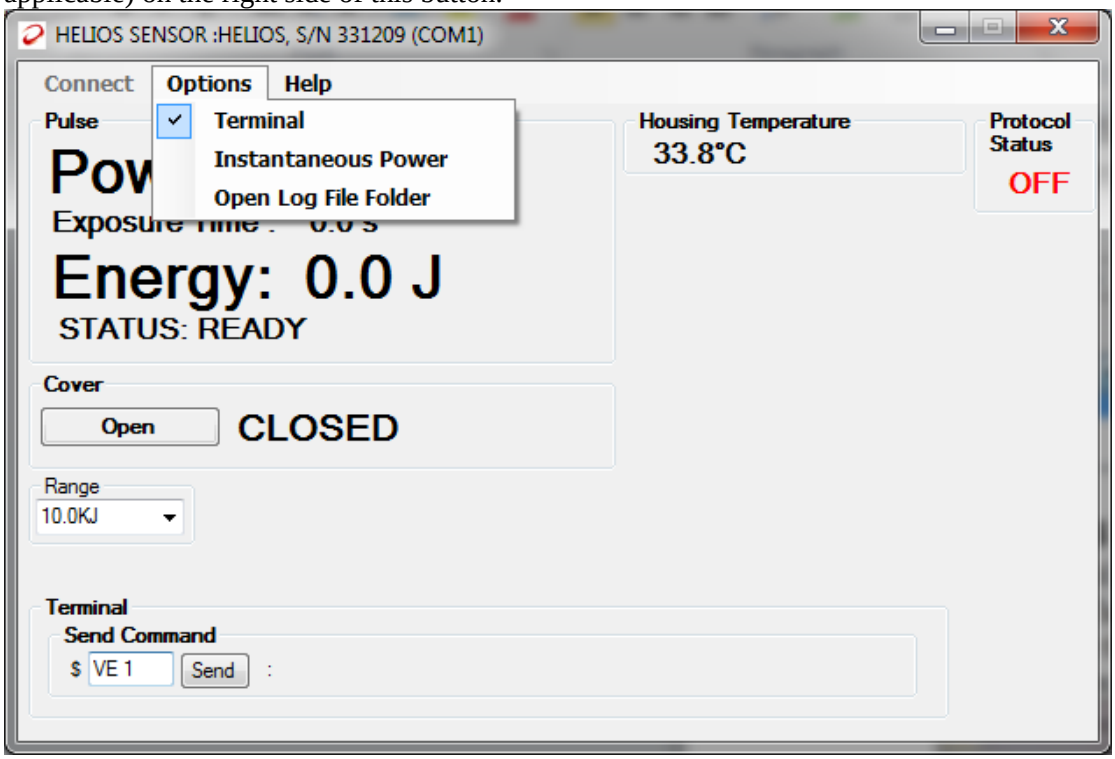


Use the “Range” dropdown to select the desired energy range (or scale). Keep in mind that the expected energy should be lower than this number, but greater than 10% of it.
For example, a laser of 5 kJ should use the 10.0KJ range, but 900 J should use 1.00KJ.

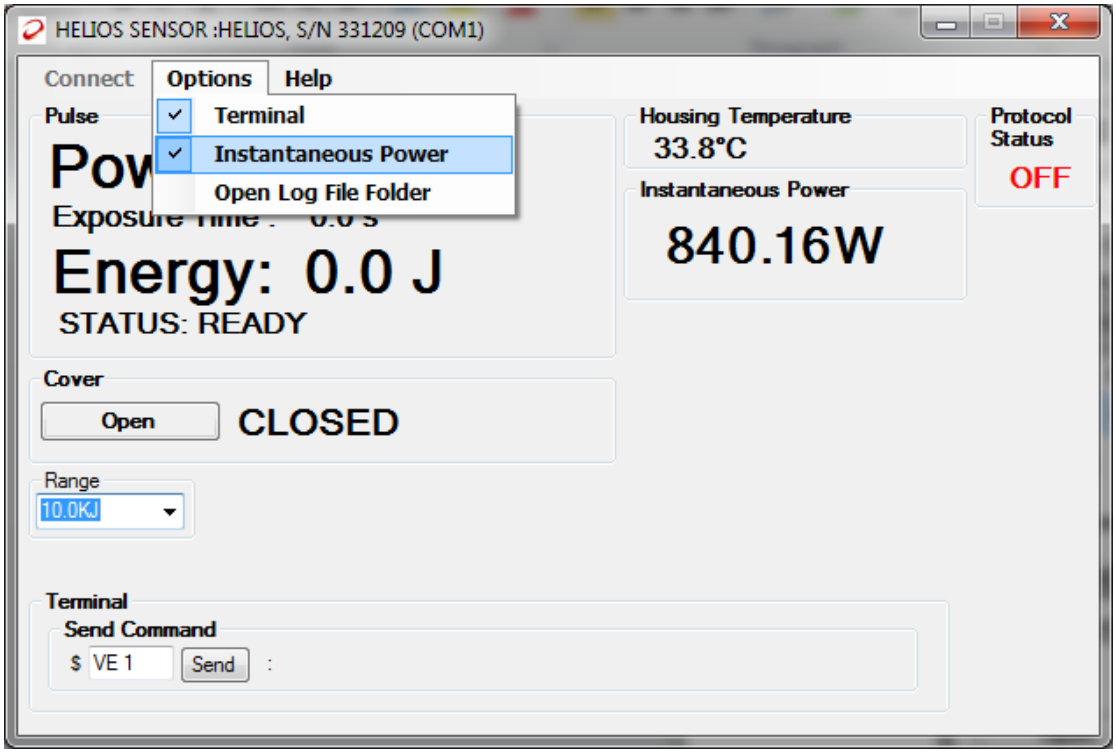


Options

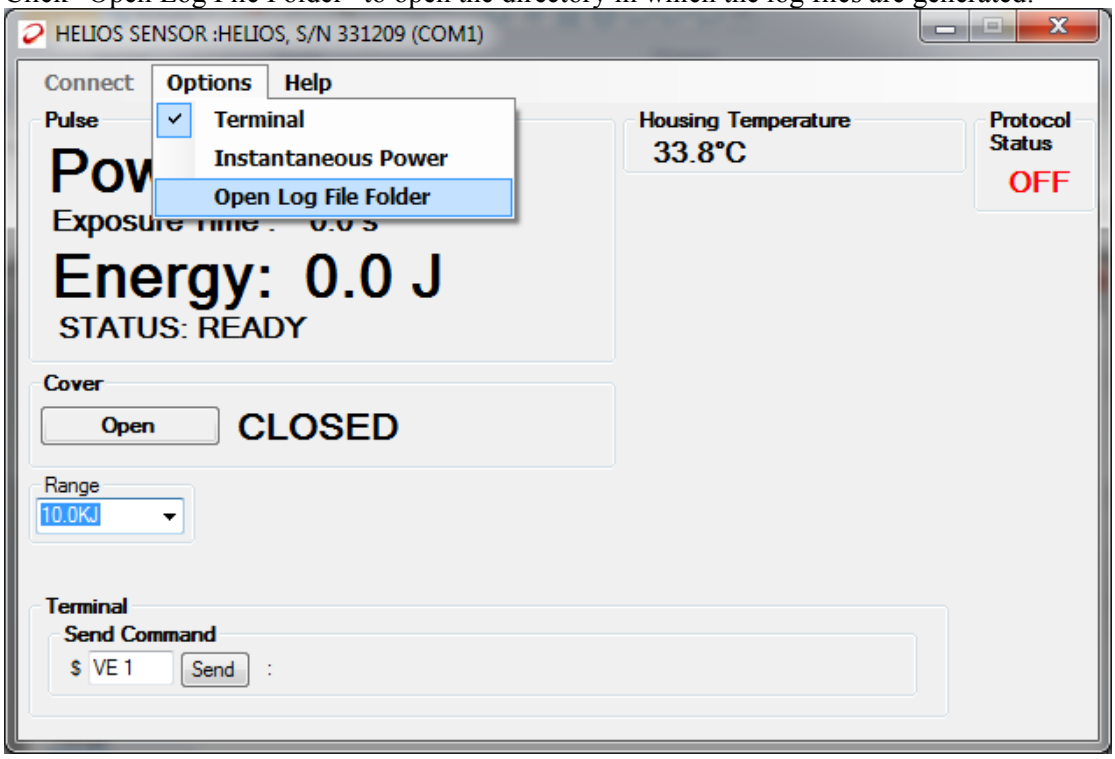
For advanced operations using the commands from the previous chapter, select Options > Terminal. The Terminal section can be seen at the bottom of the screen. Commands are entered after the ‘$’ sign and are sent by clicking “Send.” Messages are returned (when applicable) on the right side of this button:



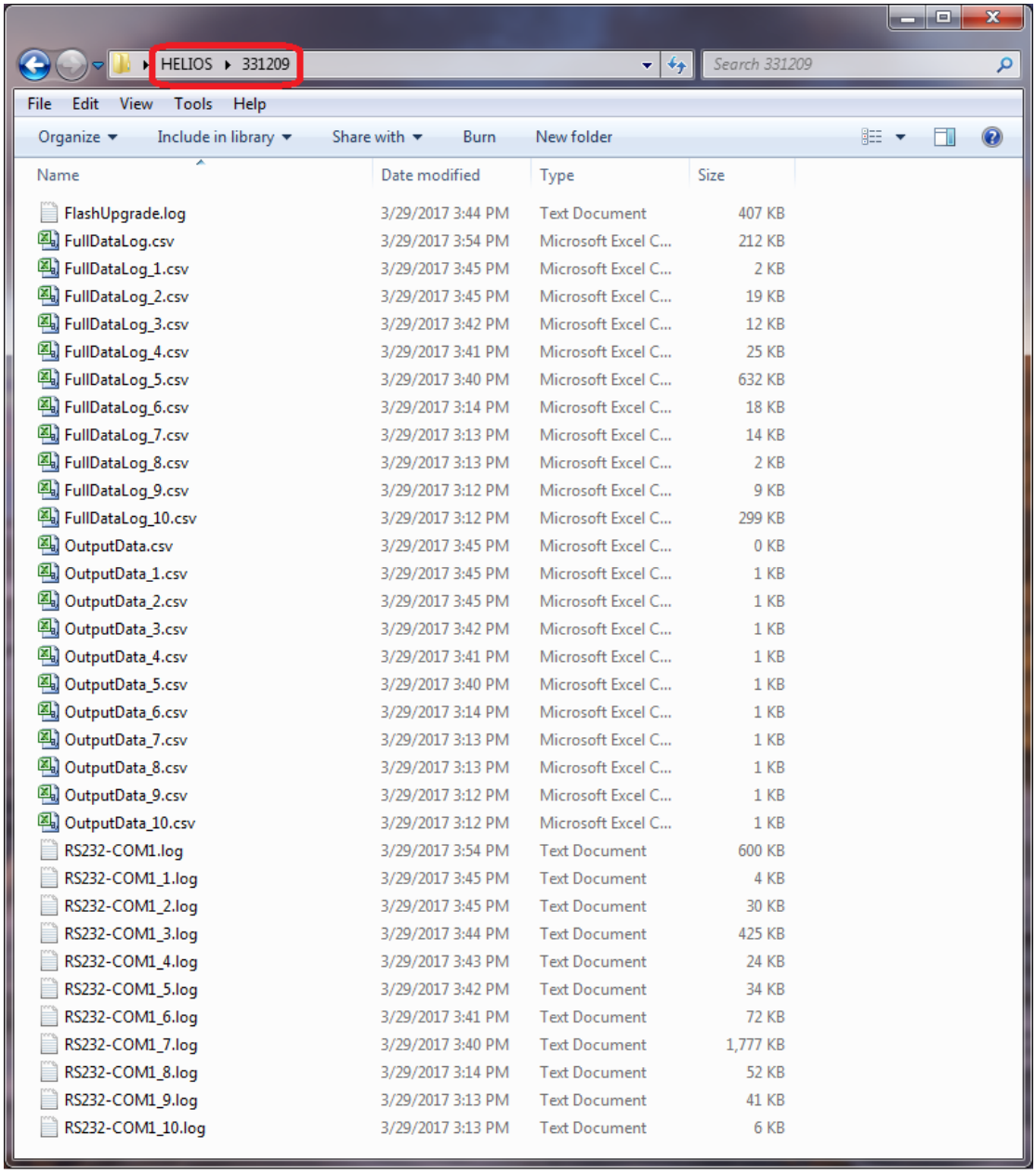
"Instantaneous Power" can be selected to show the power of the laser at any given moment. This is not generally useful for accurate power reading, since the thermopile has a 2-3 second response time and a typical use-case of the Helios is for times shorter than this. In any case, it can be used to double-check that the laser is on.



Click "Open Log File Folder" to open the directory in which the log files are generated:



Note, the log file is found inside a folder named by the serial number of Helios device used. This folder is found within the Helios installation directory.

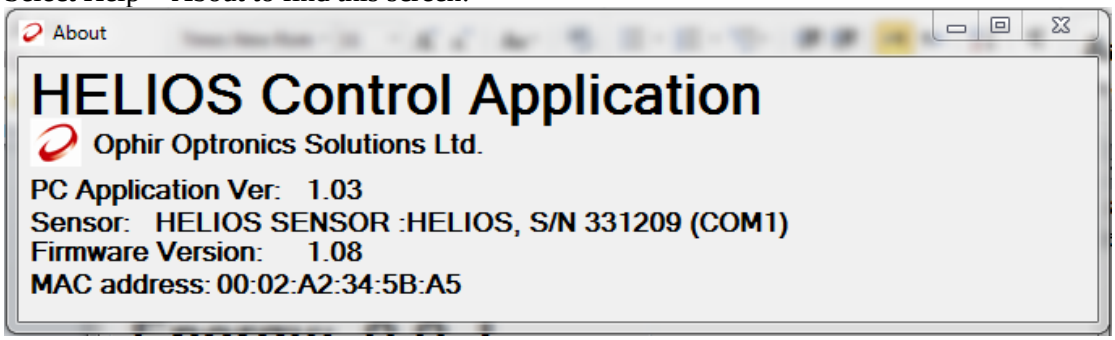


Three types of files are created here: The CSV file is a list of all the measurements taken, including:

1. "FullDataLog.csv" – This file includes all the data from the latest use of the PC application. It includes power, energy, and exposure of each laser shot, as well as instantaneous power, temperature, Profinet status, and pulse status (wait / ready / integrating)
2. "OutputData.csv" – This file includes only the data on each laser shot.
3. "RS232-COM1.log" – This text file includes all the communication via RS232 (whether through the PC application or by sending direct commands, e.g., with the Terminal feature).

Additionally, a file called "FlashUpgrade.log" can be seen above. That file will only be generated when the Helios firmware is updated (see below).

Select Help > About to find this screen:



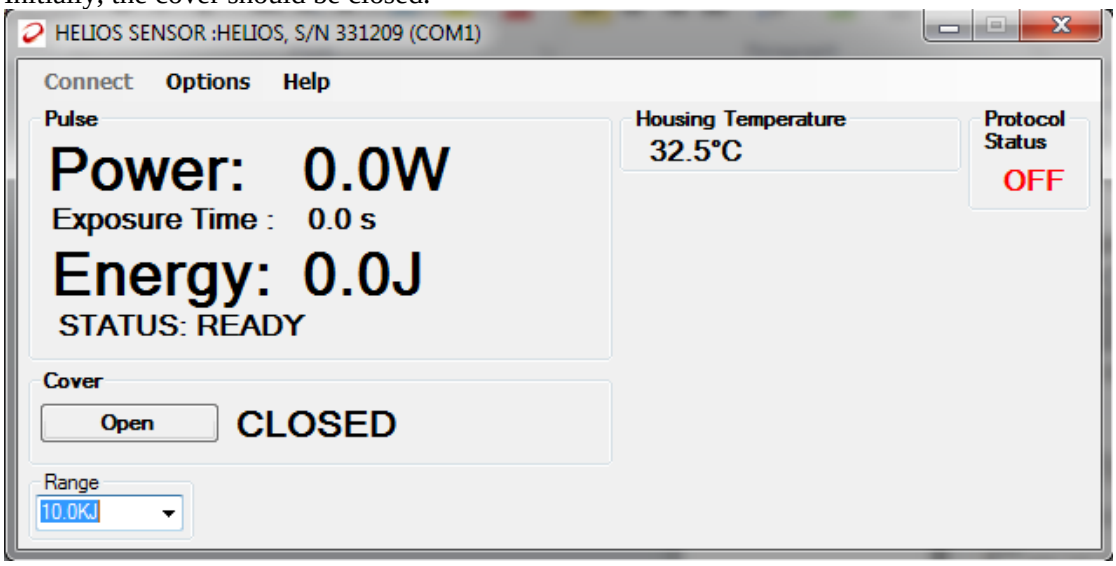
It contains:

- Software name
- Company name
- Software version
- Device name and serial number
- Firmware version
- MAC Address

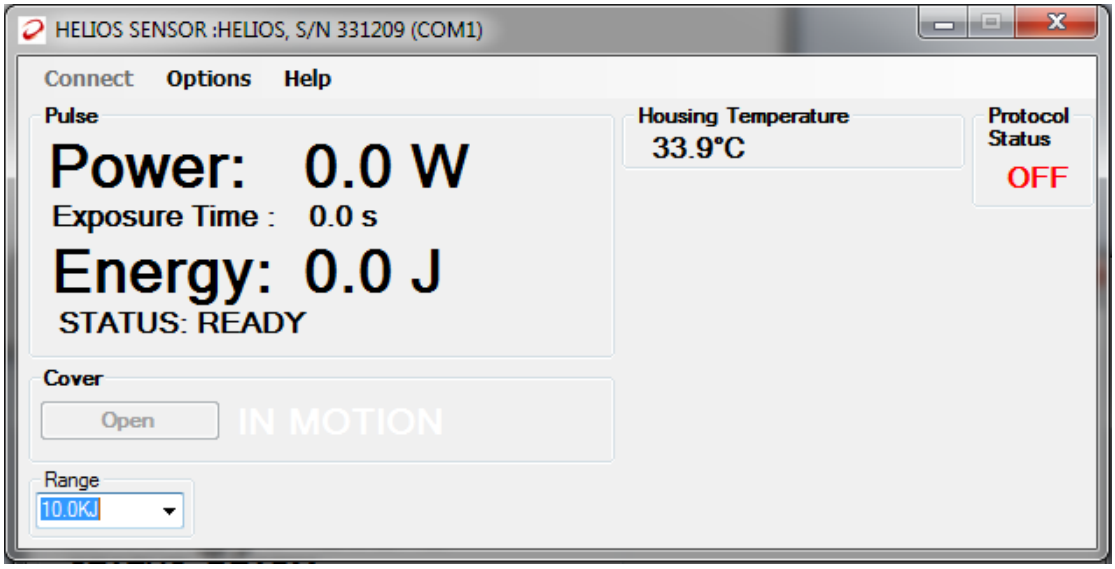
The "Help" menu also contains an option for upgrading firmware as new versions are released.

Cover Operation

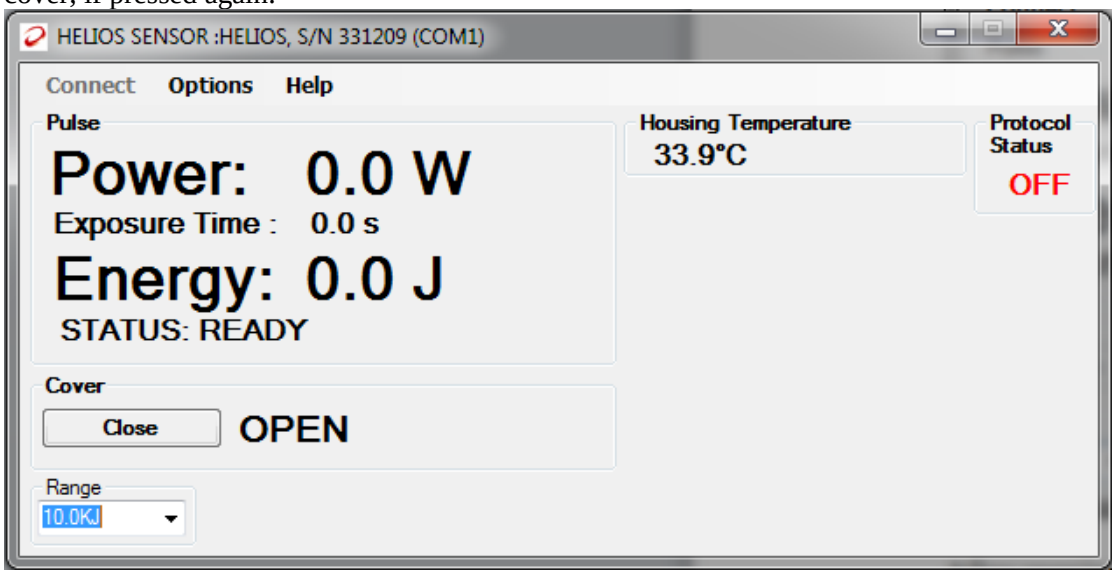
Initially, the cover should be closed.



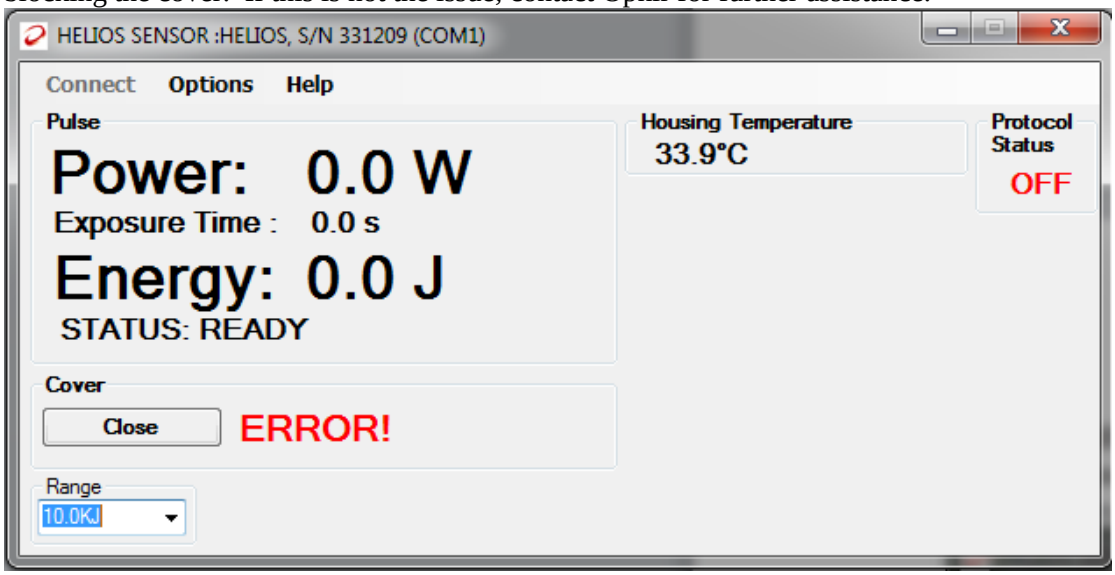
After clicking "Open," the message "IN MOTION" flashes until the cover is in a fully open or closed position.



After opening completely, the status changes to “OPEN” and the button will now close the cover, if pressed again.



The “ERROR!” message means the cover is neither completely open nor closed, and has timed out (and so isn’t considered “in motion” anymore). This usually indicates something blocking the cover. If this is not the issue, contact Ophir for further assistance.



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