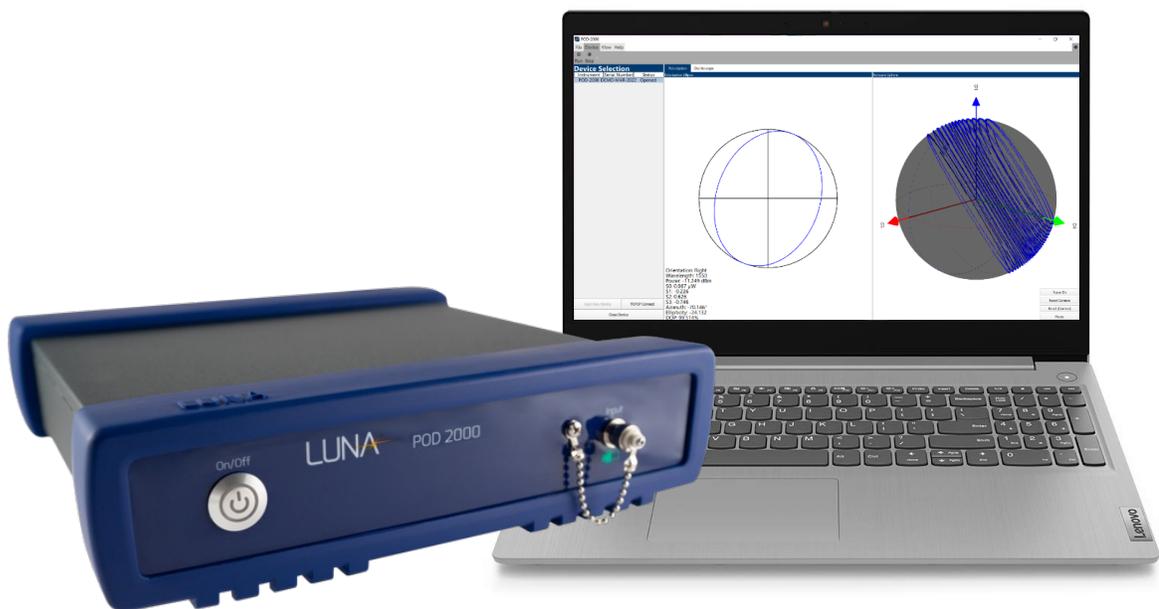


LUNA

User Manual | POD 2000



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Many regions prohibit the disposal of WEEE (Waste Electrical and Electronic Equipment) in the normal waste stream, to comply with the Restriction of Hazardous Substances (RoHS) released into the environment. Please contact your local waste authority for instructions on proper recycling of the electronic product(s) described in this *User Manual*.

POD 2000 User Manual

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1. Safety

The advisory words **Danger**, **Warning** and **Caution** used in this manual identify the level of hazard that may be encountered by the user.

- **DANGER** means if the danger is not avoided, it will cause death or serious injury.
- **WARNING** means if the warning is not heeded, it can cause death or serious injury.
- **CAUTION** means if the precaution is not taken, it may cause minor or moderate injury.



Warning

The protection provided by the equipment may be impaired if the equipment is used in a manner not specified by the manufacturer, resulting in serious injury or death.

The power cord is the main electrical disconnect for this equipment. If it is necessary to ensure no power to the unit, remove the power cord.

The use of controls, adjustments, performance, or procedures other than those specified herein may result in hazardous laser radiation exposure and one or more safety protections may be impaired or rendered ineffective.



Attention

La protection fournie par l'équipement peut être compromise si l'équipement est utilisé d'une manière non spécifiée par le fabricant, entraînant des blessures graves ou la mort.

Le cordon d'alimentation est le principal disjoncteur électrique de cet équipement. S'il est nécessaire de ne pas mettre l'appareil hors tension, retirez le cordon d'alimentation.

L'utilisation de commandes, d'ajustements, de performances ou de procédures autres que celles spécifiées ici peut entraîner une exposition dangereuse au rayonnement laser et une ou plusieurs protections de sécurité peuvent être altérées ou rendues inefficaces.

2. Technical Support

If you have concerns with or questions about the information contained in this document, contact our technical support staff using one of the following methods:

2.1. Mail

Luna Innovations Inc.
3155 State Street
Blacksburg, VA 24060

2.2. Phone

Main Phone: (540) 961-5190
Toll-Free Support: 1.866.LUNA OVA (866.586.2682)

2.3. E-mail

support@lunainc.com

www.lunainc.com

3. Overview

The Luna POD 2000 is an advanced polarimeter powered by digital signal processing (DSP). It is specifically designed for high-speed polarization characterization, analysis, and monitoring of light beams. With its four-channel configuration, this instrument can simultaneously acquire the four Stokes parameters, allowing precise measurements of the instantaneous state of polarization (SOP) and degree of polarization (DOP).

The POD 2000 features a USB 2.0 interface, enabling direct data transfer to a computer. This allows users to conveniently access and process the measured data on a computer for further analysis. The polarimeter supports a high sampling rate of up to 100 KS/s, ensuring accurate monitoring and analysis of fast polarization changes in real time. Additionally, it provides a standard 100BASE-TX Ethernet interface, allowing for measurement and control over a network.

The POD 2000 is equipped with a user-friendly interface that offers real-time graphic displays of the polarization state. Two display options are available:

Poincaré Sphere Window: This window presents the polarization state as traces on a Poincaré Sphere, providing a visual representation of how the SOP changes over time.

Oscilloscope Window: This window allows users to monitor polarization changes over time, akin to observing waveforms on an oscilloscope. It offers a dynamic view of the polarization state, facilitating the observation of temporal variations.

This document serves as a comprehensive guide for setting up and using the application software of the POD 2000. For instructions on properly setting up the hardware, please refer to the POD 2000 Quick Start Guide.

Note: The POD 2000 Quick Start Guide provides detailed information on hardware setup, which should be followed to ensure proper installation and operation

There are 2 configurations available:

POD 2000-15-FC/APC: POD 2000 1-port terminated high speed polarimeter, 1480 nm to 1640 nm, with POD-2000 user interface software, FC/APC connector; POD 2000 main frame for S, C and L band. Power cable, USB 2.0 A to B cable, USB drive for GUI and documents.

POD 2000-13-FC/APC: POD 2000 1-port terminated high speed polarimeter, 1240 nm to 1380 nm, with POD-2000 user interface software, FC/APC connector; POD 2000 main frame for O band. Power cable, USB 2.0 A to B cable, USB drive for GUI and documents.

POD 2000-10-FC/APC: (Coming) POD 2000 1-port terminated high speed polarimeter, 960 nm to 1160 nm, with POD-2000 user interface software, FC/APC connector; POD 2000 main frame for 960nm to 1160 nm. Power cable, USB 2.0 A to B cable, USB drive for GUI and documents.

POD 2000-35-FC/APC: (Coming) POD 2000 1-port terminated high speed polarimeter, 1240nm to 1380nm and 1480 nm to 1640 nm, with POD-2000 user interface software, FC/APC connector; POD 2000 main frame for S, C, L, and O band. Power cable, USB 2.0 A to B cable, USB drive for GUI and documents.

4. Hardware and Physical Setup

4.1. Unpacking

Inspect the POD-201 for any physical damage resulting from shipping and transportation. If any damage is found, please contact the carrier immediately. Additionally, carefully review the packing list to verify if any parts or accessories are missing. This information is crucial for the user manual.

Packing List

Item #	Description
1	POD 2000
2	Power Cord
3	USB Cable
4	Ethernet Cable
6	USB key containing User Interface Installation Package, User Manual, Packing lists

4.2. Communication Connection

4.2.1. USB Communications

To communicate with the POD-2000 over an USB connection, connect a USB cable with a USB-B male connector to the USB-B female connector on the back panel. The other end of the USB cable must then be directly connected to the PC. The cable cannot be connected to an external USB hub as it would performance issues when streaming measurement data to the PC.

4.2.2. Ethernet Communications

To communicate with the POD-2000 over an Ethernet connection, connect a Cat-5e or greater cable to the Ethernet female connector on the back panel (distinguished with the tab pointing down). Be careful not to connect to one of the two LVDS female connectors (distinguished with the tab pointing up).

The other end of the cable can then be connected to an Ethernet router that a host PC is also connected to or be connected directly to a PC. When connected to an Ethernet router, the POD-2000 will have the static IP address of 192.168.1.150 by default. Please refer to the SCPI commands section, on how to change the IP address or enable dynamic IP addressing.

When connecting directly to a PC, one must set the IP address strategy to DHCP to allow the POD-2000 to acquire a link-local IP address.

4.3. Starting the system

To start the system, press the power button on the front panel. The power button will light. The system is ready for the communication.

4.4. Shutting the system down

To turn off the system, press and hold power button for about 0.5 second. If the system does not begin to shut down, press and hold the power button for about 2 seconds to force the system to turn off.

5. Working Modes

5.1 Single Value Query

Single Value Query is the work mode of the POD-2000 upon power-on. To get data from the POD-2000 in this work mode, one must send the SCPI query, `:READ[:VALUE]?` (which can be shortened to `:READ?`). The response to this query is a string consisting of an array of 5 integers separated by commas. From left to right, the values are as follows: the S0 value, the S1 value, S2 value, the S3 value, and the light power value. The S0 value and light power values will always be positive and the S1, S2, and S3 values can be either positive or negative. The light power value may differ for a given intensity of light depending on the currently applied measurement unit for light power.

By default, the response to the `:READ?` query will immediately be sent to the host as the POD-2000 uses an internal automatic trigger source. However, the response can be deferred to a later time if the trigger source of the POD-2000 is set to use an external TTL signal. If the trigger source is an external TTL signal, the response to the query will only be sent upon the next time the TTL signal goes high.

5.2 Continuous Stream

The Continuous Stream work mode automatically sends measurement data samples to the host over the ancillary data port (i.e., endpoint 0x82 for USB connections and port 5026 for TCP/IP connections) of the connection.

The timing of the data samples is determined by the trigger source and the downsample average ratio. The downsample averaging process combines 1, 10, or 100 raw data samples into one effective data sample. A higher downsample averaging ratio can reduce the noise in a set of data samples at the cost of having a lower effective sampling rate. By default, the trigger source is an internal automatic trigger, which means as soon as an effective data sample is generated it queued up for transmission to the host. If the trigger source is instead an external TTL signal, then the effective data sample will only be queued for transmission if the trigger signal went high prior to the effective data sample being generated; otherwise, that data sample will be discarded.

Keep in mind that the absolute smallest timestep between any two data samples only goes down to 10 μ s as the highest effective sampling rate is that of 100 kHz. Setting the trigger source to external TTL and providing a signal with frequency higher than 100 kHz will not result in a faster sampling rate.

6. POD 2000 PC software

The Luna POD-2000 enables communication with a computer through Ethernet and USB and all operations are centralized within the User. We provide a convenient software installation package to ensure smooth software installation.

Let us take a tour of the application's User Interface (UI). The tour will start with an introduction to the UI layout, then further explains each UI components.

6.1. Installation Package

6.1.1. System Requirements

Minimum:

CPU: i3 5th Generation

RAM: 1 available Gigabyte

Recommended:

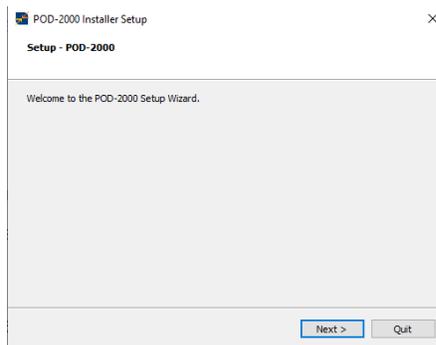
CPU: i5 11th Generation or better

GPU: Nvidia GeForce GTX 780 or better

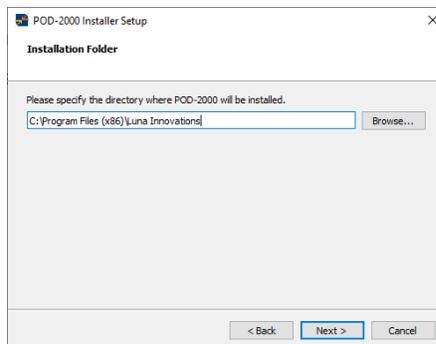
RAM: 2 available Gigabytes or better

6.1.2. Software Installation

To install the POD-2000 software, run the installer.

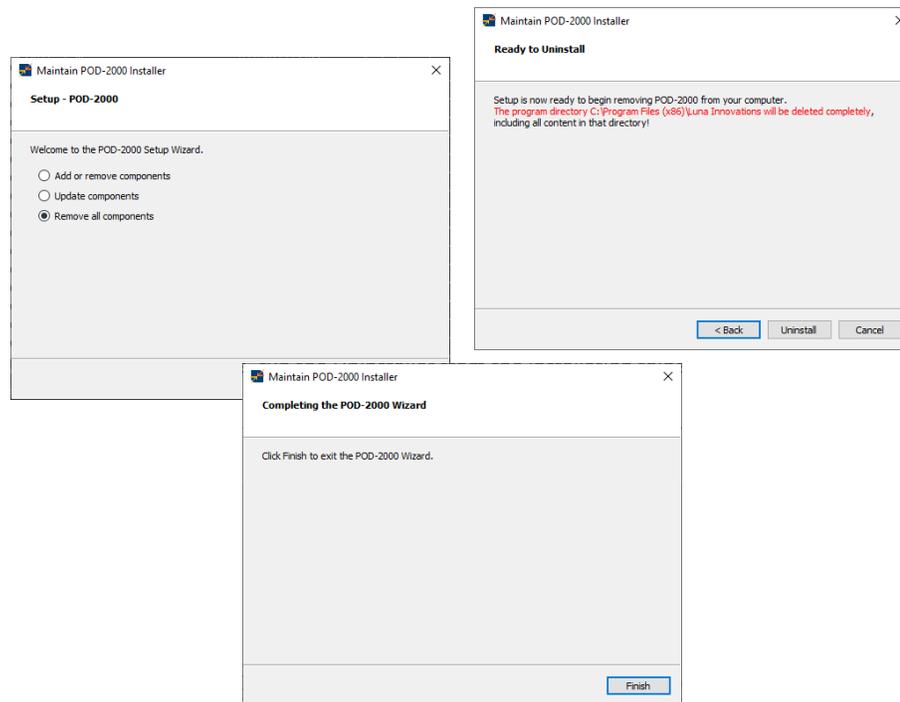


Specify the installation folder.



6.1.3. Software Removal

To Uninstall the software, run the Uninstaller from the installation folder. Select Remove all components and click next and uninstall to continue through the process.



6.2. User interface overview

After starting the Luna Instruments desktop application, the application UI screen will appear on the PC screen. The image below (Figure 1) is an illustration of a typical UI screen layout with all optional displays turned on for a POD-2000 instrument.

The central section of the UI is the Main Page Area.

The upper section of the UI screen is for the display of the Menu Ribbon.

The left section of the UI screen is the optional Device Selection Area where the user can select the current active device.

The right section of the UI is the optional Controls Area with more specific controls for the given page loaded in the Main Page Area.

Each of the above UI components is further explained in the following titled sections, respectively.

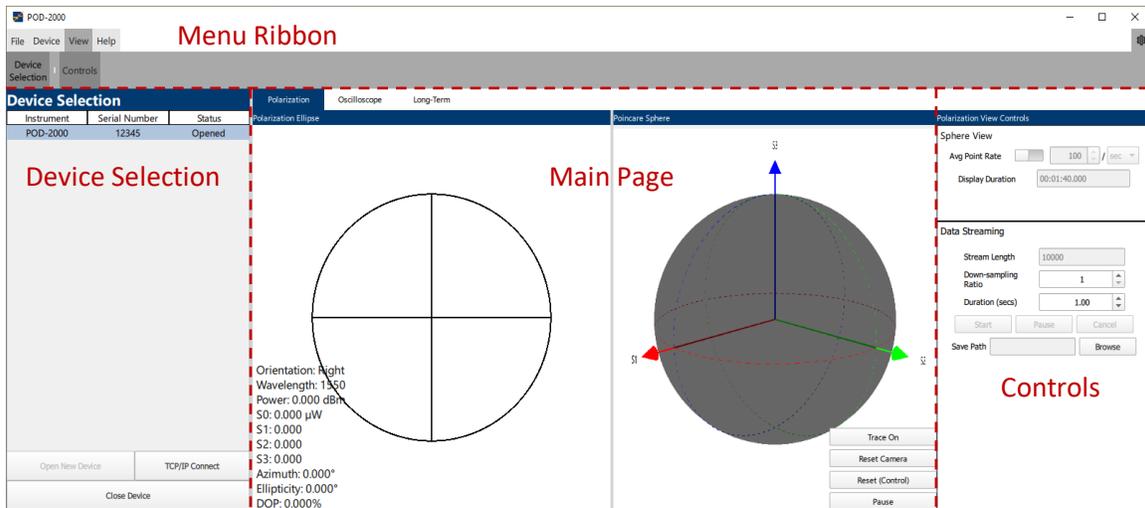


Figure 1 UI Screen Layout

6.3. Opening and Closing Devices

Device Selection is open by default when opening the application. Device Selection can be toggled on/off from the View Tab in the Menu Ribbon.

6.3.1. Setting the Active Device

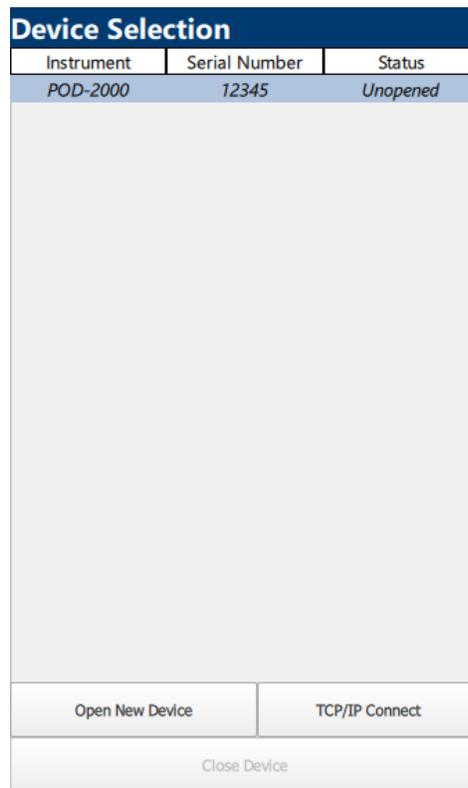


Figure 2 Device Selection

Devices can be opened either via USB or TCP/IP Connection.

USB connected devices will automatically populate in the list and can be selected and opened via the “Open New Device” button.

TCP/IP connected devices must be connected via the “TCP/IP Connect” button.

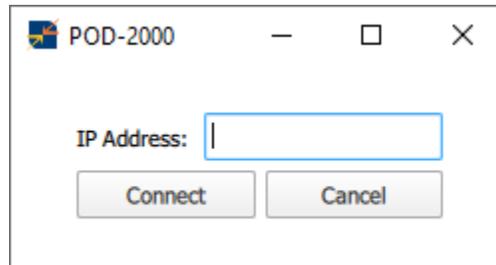


Figure 3 TCP/IP Connect Dialog Box

To complete the TCP/IP connection, enter the devices IP Address and click connect. If it successfully connects, the device will then be listed in the Device Selection area.

6.3.2. Closing Devices

Devices can be closed by selecting them in the Device Selection area and then pressing the “Close Device” button.

6.4. Measurement Data viewer

6.4.1. Poincaré Sphere and Polarization parameters SOP

The Polarization screen displays both a 2D and 3D representation of real-time continuous streaming data points from the POD-2000 in the form of the Polarization Ellipse and the Poincaré Sphere.

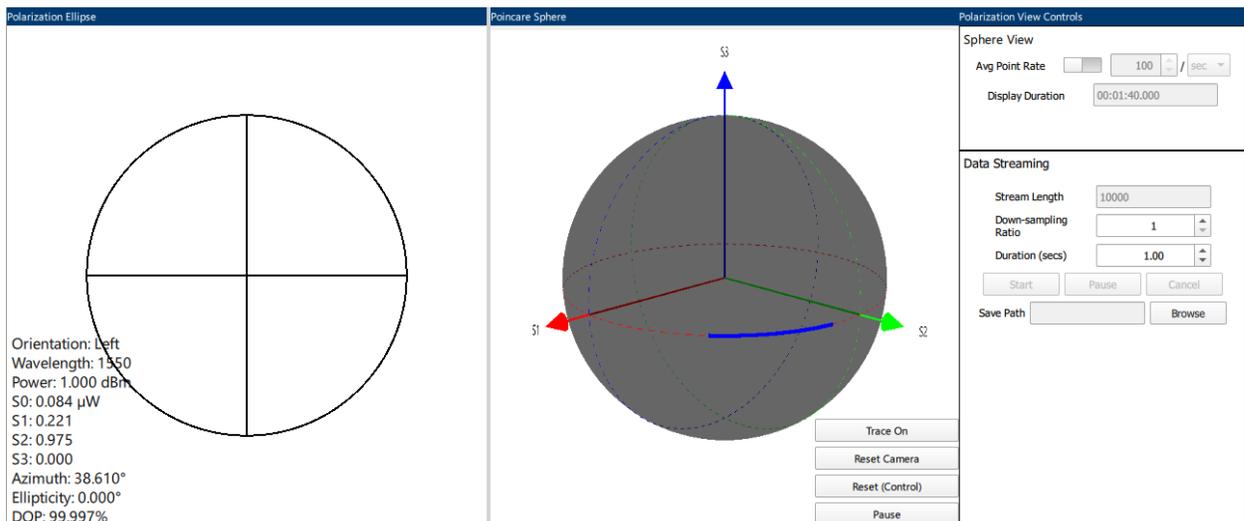


Figure 4 Polarization

The Polarization Ellipse shows the 2D Representation of the most recent point read from the POD-2000. It also displayed current information in the bottom left corner. This data includes: Orientation, Wavelength, Power, S0, S1, S2, S3, Azimuth Angle, Ellipticity, and the Degree of Polarization(DOP). Furthermore, the Ellipse by default shows the cross section of the S1 and S2 axis, and can be changed by selecting which Axis cross section the user wants by selecting them in the top right corner of the Polarization Ellipse section.

The Poincaré Sphere is an interactable 3D view of the points read from the POD-2000. The view can be rotated by holding down the right mouse button and moving the mouse. The view can also be zoomed in/out by scrolling on the mouse wheel. Various controls have been placed on the bottom right to control the view:

Trace On/Off: Turns on the point trace for the sphere, showing the path the points have taken.

Reset Camera: Resets the camera view of the sphere to its default location.

Reset (Control): Clears the data on the sphere

Pause/Continue: Pauses/Continues the updates to the sphere.

The Polarization Controls have two sections: Sphere View and Data Streaming.

The Sphere View controls allow for changing the rate at which points are added to the sphere. It ranges from 1-60 points per seconds/minutes. It also shows the Duration of which the points on the sphere represent.

The Data Streaming Controls allow for the user to save data as it streams from the POD-2000. After selecting a file to save to, the user can designate a time frame between 1-10,000 seconds. The User Interface will display how many points that translates to. Data Streaming will start when the user presses the Start Button. Data Streaming can be paused and continued. If the user decides to stop the data streaming early, the user can press the Cancel Button.

6.4.2. Oscilloscope viewer and Polarization parameters

The Oscilloscope screen displays the data read from the POD-2000 over a short period of time.

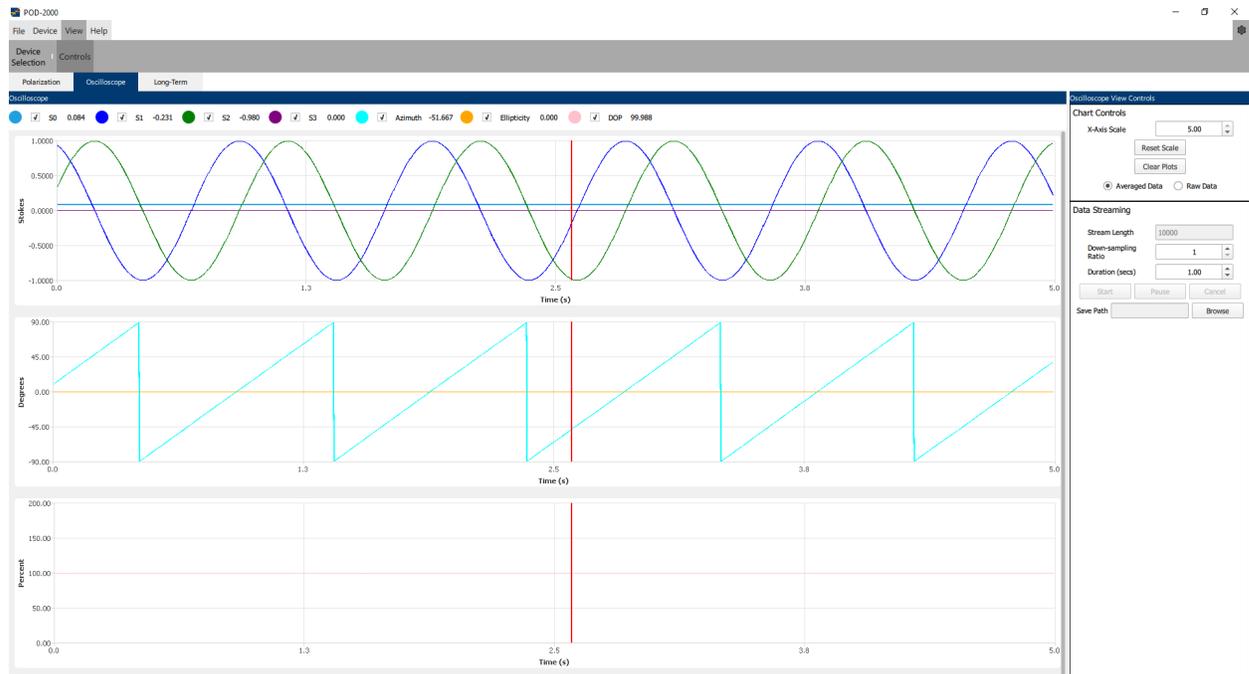


Figure 5 Oscilloscope

The Oscilloscope has three main plots: Stokes Parameters, Angles, and DOP.

Each individual chart can be interacted with in these ways:

Zoom in/out X and Y Axis: Mouse Wheel

Zoom in/out X-Axis: Hold Right click and move up and down

Zoom in/out Y-Axis: Hold Right click and move left and right

Pan: Hold Left click and move up/down and/or left/right

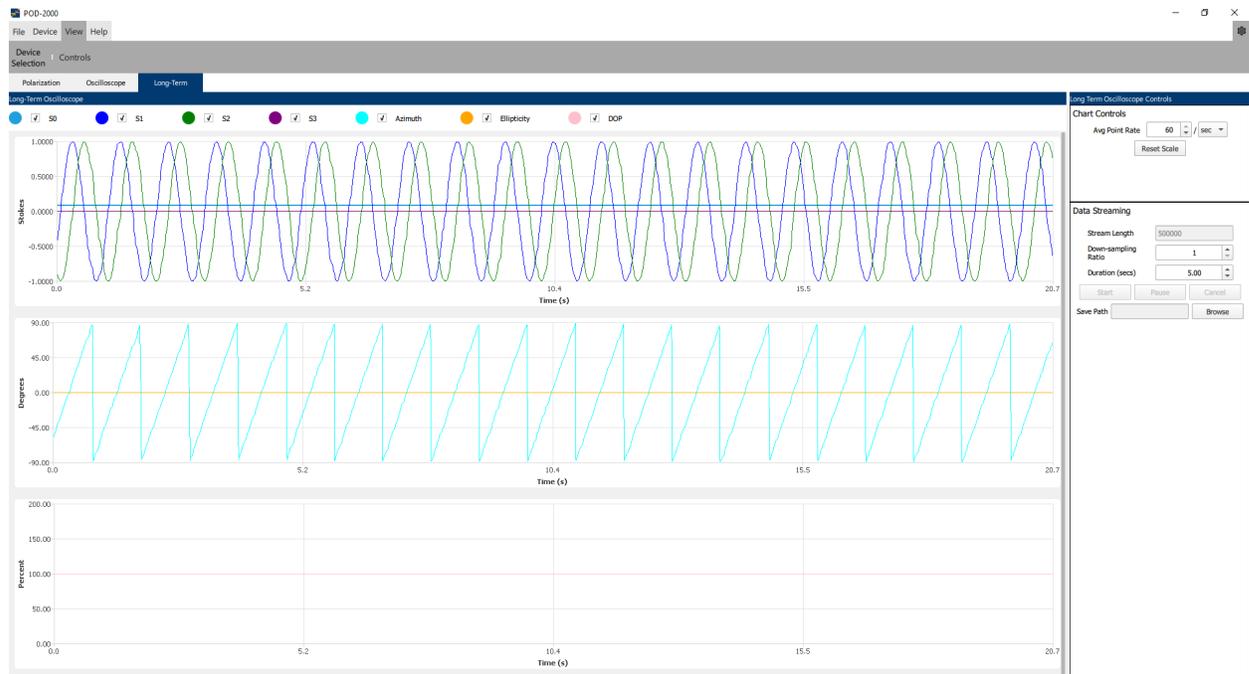
The Oscilloscope Controls have two sections: Chart Controls and Data Streaming.

The Chart Controls allow for changing the X-Axis scale. This can be done by changing the value manually or by resetting it to its default value (1). The user can also use the Clear Plots button to clear all data from the Charts.

The Data Streaming Controls allow for the user to save data as it streams from the POD-2000. After selecting a file to save to, the user can designate a time frame between 1-10,000 seconds. The User Interface will display how many points that translates to. Data Streaming will start when the user presses the Start Button. Data Streaming can be paused and continued. If the user decides to stop the data streaming early, the user can press the Cancel Button.

6.4.3. Long-Term data viewer

The Long-Term Oscilloscope screen displays the data read from the POD-2000 over a longer period of time.



The Long-Term Oscilloscope has three main plots: Stokes Parameters, Angles, and DOP.

Each individual chart can be interacted with in these ways:

Zoom in/out X and Y Axis: Mouse Wheel

Zoom in/out X-Axis: Hold Right click and move up and down

Zoom in/out Y-Axis: Hold Right click and move left and right

Pan: Hold Left click and move up/down and/or left/right

The Oscilloscope Controls have two sections: Chart Controls and Data Streaming.

The Chart Controls has two functions.

Avg. Point Rate: Change the rate at which points are added to the oscilloscope.

Reset Scale: Reset the X-Axis scale to its current max value.

The Data Streaming Controls allow for the user to save data as it streams from the POD-2000. After selecting a file to save to, the user can designate a time frame between 1-10,000 seconds. The User Interface will display how many points that translates to. Data Streaming will start when the user presses the Start Button. Data Streaming can be paused and continued. If the user decides to stop the data streaming early, the user can press the Cancel Button.

6.5. User interface menu and setup



Figure 6 Menu Ribbon

6.5.1. File Tab



Figure 7 File Tab

The File Tab has two functions: Save and Load.

Save: Opens a File Dialog to pick a new or existing file and save the currently displayed data into the designated CSV file.

Load: Opens a File Dialog to pick a previously saved file and load it into the displays of the Polarization and Oscilloscope Pages.

6.5.2. Device Tab

The Device Tab has two functions: Run and Stop.



Figure 8 Device Tab

Run: Initiates the data stream from the POD-2000 to the Desktop Application. This will start displaying any incoming data to the GUI.

Stop: Stops the data stream from the POD-2000 to the Desktop Application. All Desktop elements will not be updated due to the lack of incoming data, essentially pausing the screen.

6.5.3. View Tab



Figure 9 View Tab

The View Tab has two functions: Device Selection and Controls.

Device Selection: Opens the Device Selection Area

Controls: Opens the Controls Area for the current Page.

6.5.4. Help Tab



Figure 10 Help Tab

The Help Tab has two functions: Help and About.

Help: Opens the Help Guide for the Luna Instruments Desktop Application.

About: Opens the About Window contain details about the application itself.

6.5.5. Settings

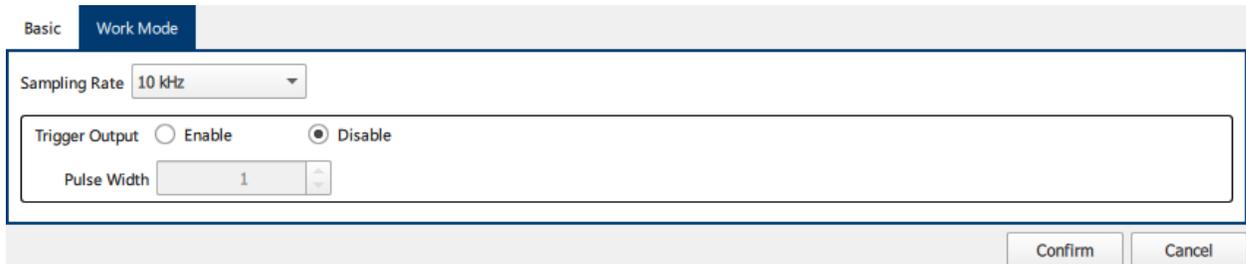


Figure 11 Settings

The Settings Menu opens by pressing the gear icon in the top right of the application. Any changes made are not final until the Confirm button is pressed. Otherwise, if the gear icon or the Cancel Button is pressed, all changes are discarded.

6.5.5.1. Basic Settings

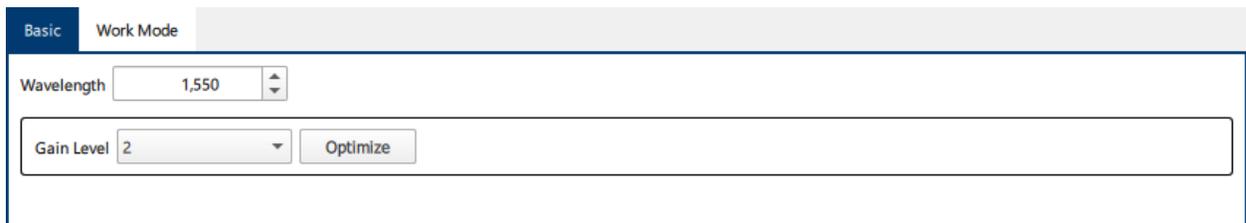


Figure 12 Basic Settings

The Basic Settings tab lets the user change the wavelength of the device. This option is only enabled when there is a currently open device. The Work Mode Tab has three functions: Sampling Rate, Trigger Output, and Pulse Width.

Wavelength: Changes the wavelength of the device.

Gain Level: Changes the Gain Level of the device between 1-5. Auto will automatically increase or decrease the Gain Level to match the current input light power. Optimize will perform a one-time automatic adjustment of the gain.

6.5.5.2. Work Mode Settings

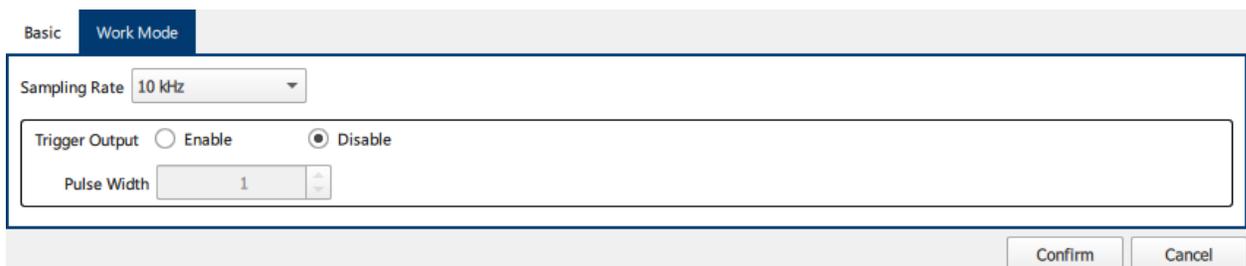


Figure 13 Work Mode Settings

The Work Mode Tab has three functions: Sampling Rate, Trigger Output, and Pulse Width.

Sampling Rate: Changes the sampling rate of the device between 1 kHz, 10kHz, and 100kHz.

Trigger Output: Enabling the trigger output results in an active-high trigger pulse being emitted every time a new sample point is generate. The width of the pulse is controlled by the “Pulse Width” value.

Pulse Width: Sets the width of the trigger output pulse. The unit of the pulse width is in microseconds.

7. Remote Control Configuration

7.1. USB Configuration and Programming Guide

Custom PC applications that wish to communicate with the POD-2000 through a USB connection will need to use a language appropriate library for USB communication. For C and C++ application, developers will need to use libusb. For Python, one will need to use PyUSB (with a libusb backend).

SCPI commands and queries will be sent over endpoint 0x01 and query responses will be received over endpoint 0x81. Streamed measurement data traffic will be received over endpoint 0x82.

7.2. TCP/IP Configuration and Programming Guide

Custom PC applications that wish to communicate with the POD-2000 through a TCP/IP connection can do using the language appropriate libraries for socket communication. When creating client sockets to connect to the POD-2000, one must use port 5025 for commands and queries and port 5026 for streamed measurement data.

7.3. Processing Streamed Data

The structure of the stream data packet sent by the POD-2000 to the host (regardless of if it is a USB or TCP/IP connection) consists of a 4-byte header followed by 10 or more data bytes up to 1020 bytes; thus, a POD-2000 stream packet will have a maximum size of 1024 bytes. The 4-byte header has a value of 0xFFFFFFFF and should be checked for and excluded from computations when processing a buffer of multiple packets.

Header (4 bytes) 0xFFFFFFFF	Measurement Data (10 to 1020 bytes)
--------------------------------	-------------------------------------

The data bytes of a packet are grouped into 10-byte datapoints (or samples). The 10 bytes of a datapoint describes 5 16-bit integer values: S0, S1, S2, S3, and the lightpower in the currently applied lightpower unit. The structure of a datapoint is shown below.

S0 2 bytes unsigned 16-bit int	S1 2 bytes signed 16-bit int	S2 2 bytes signed 16-bit int	S3 2 bytes signed 16-bit int	Light Power 2 bytes unsigned 16-bit int
--------------------------------------	------------------------------------	------------------------------------	------------------------------------	---

When using automatic internal triggering, the packets received by the host will always be at the maximum size of 1024-bytes. However, when using external hardware triggering, depending on the

frequency of the trigger signal and the value of the downsample averaging setting one may get less than 1024 bytes per packet.

8. Standard Commands for Programmable Instruments (SCPI) Interface

11.1 Overview

	Subsystem/Register	Commonly Used Commands/Bits
Commands	IEEE Commands	<ul style="list-style-type: none"> • *IDN? • *RST • *CLS • *SAV • *RCL
	:SYSTEM	<ul style="list-style-type: none"> • :SYSTEM:ERRor? • :SYSTEM:VERSion • :SYST:COMMunicate:LAN:ADDRess
	:STATUS	<ul style="list-style-type: none"> • :STATus:OPERation[:EVENT]? • :STATus:OPERation:CONDition? • :STATus:QUESTionable[:EVENT]? • :STATus:QUESTionable:CONDition?
	:CONFigure	<ul style="list-style-type: none"> • :CONFigure:GAIN[:VALue] • :CONFigure:GAIN:LPRange? • :CONF:WAVElength
	:READ	<ul style="list-style-type: none"> • :READ[:VALue]? • :READ:AVErage:LENgth
	:UNIT	<ul style="list-style-type: none"> • :UNIT:POWer
	:OUTPut	<ul style="list-style-type: none"> • :OUTPut:TRIGger[:STATe] • :OUTPut:TRIGger:PWIDth
Status Structure	Status Byte	<ul style="list-style-type: none"> • Error/Event Queue Summary • Questionable Status Register Summary • Operation Status Register Summary • Standard Event Status
	Standard Event Status Register	<ul style="list-style-type: none"> • Operation Complete • Query Error • Device Dependent Error • Execution Error • Command Error • Power On
	OPERation Status Register	<ul style="list-style-type: none"> • Auto Gain On
	QUESTionable Status Register	<ul style="list-style-type: none"> • Voltage Summary • Power Summary • Command Warning

	QUEStionable:VOLTage register	<ul style="list-style-type: none"> • Over Voltage • Under Voltage
	QUEStionable:POWer register	<ul style="list-style-type: none"> • Saturation • Low Lightpower
Error/Event	Command Errors	<ul style="list-style-type: none"> • Invalid Character • Invalid Separator • Data type error • Parameter not allowed • Missing parameter
	Execution Errors	<ul style="list-style-type: none"> • Parameter error • Settings conflict • Data out of range
	Query	<ul style="list-style-type: none"> • Query error • Query INTERRUPTED • Query UNTERMINATED • Query DEADLOCKED
	Device-Specific Errors	<ul style="list-style-type: none"> • Queue overflow • Communication error • Input buffer overrun • Circuit over-voltage • Circuit under-voltage • Circuit over-current • Circuit under-current
	Events	<ul style="list-style-type: none"> • Power on • User request • Request control • Operation complete

11.2 Commands Reference

11.2.1 IEEE 488.2 Commands

Because the SCPI standard is based upon the IEEE 488.2 standard, the SCPI standard inherits certain required commands that are defined in the IEEE 488.2 standard.

11.2.1.1 *IDN?

*IDN?

Retrieves the device's identification information in a string of the following format:

```
LUNA,POD2000,<Serial Number>,<Firmware Version>
```

11.2.1.2 *RST

*RST

Resets the device to factory default settings.

11.2.1.3 *CLS***CLS**

Clears the device's status registers.

11.2.1.4 *STB?***STB**

Reads the value of the status byte register.

11.2.1.5 *SRE***SRE**

Sets the service request enable mask of the status byte register.

Note: As a result of the device connection design, this command has no effect on the operation of the device.

11.2.1.6 *SRE?***SRE?**

Queries the service request enable mask of the status byte register.

11.2.1.7 *ESR?***ESR?**

Queries the event values of the Standard Event Status Register.

11.2.1.8 *ESE***ESE**

Sets the enable mask of the Standard Event Status Register.

11.2.1.9 *ESE?***ESE?**

Sets the enable mask of the Standard Event Status Register.

11.2.1.10 *WAI***WAI**

The Wait-to-Continue has no effect on this device.

11.2.1.11 *OPC***OPC**

The Operation Complete Command will set bit 0 of the Standard Event Status register once all device operations are finished and the device returns to idle.

11.2.1.12 *OPC?

```
*OPC?
```

The Operation Complete Query will result in the integer 1 being sent to the host once all device operations are finished and the device returns to idle.

11.2.1.13 *TST?

```
*TST?
```

The device self-test command. In this implementation of the device, this command has no effect on the device.

11.2.1.14 *SAV

```
*SAV <integer>
```

Saves the current device settings to an area of non-volatile memory specified by the integer parameter.

Note: The value only accept value of the parameter is the integer 1.

11.2.1.15 *RCL

```
*RCL <integer>
```

Loads the saved device settings from non-volatile memory

Note: The value only accept value of the parameter is the integer 1.

11.2.1.16 *TRG

```
*TRG
```

Sends a software trigger to the device.

11.2.2 :SYSTEM Subsystem

The commands under SYSTEM subsystem pertain to settings that relate to the instrument itself as oppose to any sort of instrument behavior.

11.2.2.1 :SYSTEM:COMMunicate:LAN:ADDRes

```
:SYSTEM:COMMunicate:LAN:ADDRes <string>
:SYSTEM:COMMunicate:LAN:ADDRes? [CURRent|STATic]
```

Sets the static IP address used by the device when used as a command. The IP address is to be provided in the parameter to this command as a quote string of the address in dot-decimal notation.

When used as a query, one can provide an optional choice parameter to get either the current IP address using CURRent or the static IP address using STATic. Omitting the parameter is equivalent to providing CURRent as the parameter.

- **Command Example:**
 - :SYST:COMM:LAN:ADDR "192.168.1.101"
- **Query Response Example:**
 - "192.168.1.101"

11.2.2.2 :SYSTem:COMMunicate:LAN:SUBN

```
:SYSTem:COMMunicate:LAN:SUBNet <string>
:SYSTem:COMMunicate:LAN:SUBNet? [CURRent|STATic]
```

Sets the static subnet mask used by the device when used as a command. The subnet mask is to be provided in the parameter to this command as a quote string of the address in dot-decimal notation.

When used as a query, one can provide an optional choice parameter to get either the current subnet mask using CURRent or the static subnet mask using STATic. Omitting the parameter is equivalent to providing CURRent as the parameter.

- **Command Example:**
 - :SYST:COMM:LAN:SUBN "255.255.255.0"
- **Query Response Example:**
 - "255.255.255.0"

11.2.2.3 :SYSTem:COMMunicate:LAN:GATEway

```
:SYSTem:COMMunicate:LAN:GATEway <string>
:SYSTem:COMMunicate:LAN:GATEway? [CURRent|STATic]
```

Sets the static network gateway address used by the device when used as a command. The address of the network gateway is to be provided in the parameter to this command as a quote string of the address in dot-decimal notation.

When used as a query, one can provide an optional choice parameter to get either the current gateway address using CURRent or the static gateway address using STATic. Omitting the parameter is equivalent to providing CURRent as the parameter.

- **Command Example:**
 - :SYST:COMM:LAN:GATE "192.168.1.1"
- **Query Response Example:**
 - "192.168.1.1"

11.2.2.4 :SYSTem:COMMunicate:LAN:DHCP

```
:SYSTem:COMMunicate:LAN:DHCP 0|1|ON|OFF
:SYSTem:COMMunicate:LAN:DHCP?
```

Enable or disables the use of DHCP in acquiring a network address for the device. If enabled, the device will use a DHCP server to get an address. If disabled, the device will use the static IP address defined in :SYSTem:COMMunicate:LAN:ADDRESS.

- **Command Example:**
 - :SYS:COMM:LAN:DHCP ON
- **Query Response Example:**
 - 0

11.2.2.5 :SYSTem:COMMunicate:ANCillary

```
:SYSTem:COMMunicate:ANCillary USB|LAN
:SYSTem:COMMunicate:ANCillary?
```

Select whether to receive streamed data over a USB or LAN connection.

- **Default**
 - USB
- **Command Example**
 - :SYST:COMM:ANC LAN
- **Query Response Example**
 - USB

11.2.2.6 :SYSTem:ERRor[:NEXT]?

```
:SYSTem:ERRor[:NEXT]?
```

Get the next error in the device's error queue. When there are no errors, the response is 0, "No error".

- **Query Response Example:**
 - -110, "Command header error"

11.2.2.7 :SYSTem:VERSion?

```
:SYSTem:VERSion?
```

Gets the version of the SCPI standard to which this device adheres to. The response is always "1999.0".

- **Query Response Example:**
 - "1999.0"

11.2.3 :STATus Subsystem

The commands under STATus subsystem are mainly used for querying the status structures of the instrument.

11.2.3.1 :STATus:OPERation[:EVENT]?

```
:STATus:OPERation[:EVENT]?
```

Queries the event value of the Operation Status Register.

Note: Querying the event value will clear it from the register.

- **Query Response Example:**
 - 8

11.2.3.2 :STATus:OPERation:CONDition?

```
:STATus:OPERation:CONDition?
```

Queries the condition value of the Operation Status Register.

- **Query Response Example:**
 - 8

11.2.3.3 :STATus:OPERation:ENABLE

```
:STATus:OPERation:ENABLE <integer>
:STATus:OPERation:ENABLE?
```

Sets the enable mask of the OPERATION Status Register. When the bits in the enable mask value match that of the event value, bit 7 in the Status Byte register will be set for this register.

- **Command Example:**
 - :STAT:OPER:ENAB 4
- **Query Response Example:**
 - 8

11.2.3.4 :STATus:QUESTionable[:EVENT]?

```
:STATus:QUESTionable[:EVENT]?
```

Queries the event value of the Questionable Status Register.

Note: Querying the event value will clear it from the register.

- **Query Response Example:**
 - 8

11.2.3.5 :STATus:QUESTionable:CONDition?

```
:STATus:QUESTionable:CONDition?
```

Queries the condition value of the Questionable Status Register.

- **Query Response Example:**
 - 8

11.2.3.6 :STATus:QUESTionable:ENABLE

```
:STATus:QUESTionable:ENABLE <integer>
:STATus:QUESTionable:ENABLE?
```

Sets the enable mask of the Questionable Status Register. When the bits in the enable mask value match that of the event value, bit 3 in the Status Byte register will be set for this register.

- **Command Example:**
 - :STAT:QUES:ENAB 4
- **Query Response Example:**
 - 8

11.2.3.7 :STATus:PRESet

```
:STATus:PRESet
```

Clears all the status registers and resets the enable masks to pre-defined values. This command has no query form.

11.2.4 :CONFigure Subsystem

11.2.4.1 :CONFigure:GAIN[:VALue]

```
:CONFigure:GAIN[:VALue] GAIN1 | GAIN2 | GAIN3 | GAIN4 | GAIN5 | UP | DOWN | AUTO | OPTImize
:CONFigure:GAIN[:VALue]?
```

Sets the signal gain of the device. The GAIN1, GAIN2, GAIN3, GAIN4, and GAIN5 parameter values set the signal gain to a specific level with GAIN1 being the weakest gain for when the incoming light is at a high power and GAIN5 being the strongest gain for when the incoming light is at a low power.

The AUTO parameter value enables continuous automatic gain level adjustment based on the power of the incoming light. If the power increases, then a weaker gain will automatically be applied. If the power decreases, then a stronger gain will be applied. The OPTImize parameter value also automatically adjusts the gain to match the lightpower, however it only does so one time. If the gain value is AUTO, then providing a specific gain or OPTImize as the parameter value, will end the continuous automatic gain adjustment.

The UP and DOWN parameter values increase or decrease the gain from the current gain level. The UP and DOWN parameter values only work when the gain is not AUTO. If the UP or DOWN values are sent while the gain level is AUTO, then the command will result in a “-221,Settings Conflict” error. If the UP value is sent while the gain level is GAIN5, then the command will result in a “-221,Settings Conflict” error. If the DOWN value is sent while the gain level is GAIN1, then the command will result in a “-221,Settings Conflict” error.

- **Default**
 - AUTO
- **Command Example:**
 - :CONF:GAIN GAIN2
- **Possible Query Responses**
 - GAIN1
 - GAIN2
 - GAIN3

GAIN4
 ○ GAIN5
 AUTO

- **Query Response Example:**
 - GAIN2

11.2.4.2 :CONFigure:GAIN:LPRange?

```
:CONFigure:GAIN:LPRange? [GAIN1|GAIN2|GAIN3|GAIN4|GAIN5]
```

Queries the power range for the current gain (if it is not AUTO) or for a specific gain level.

- **Query Response Example:**
 - -4.0, 5

11.2.4.3 :CONFigure:WAVElength

```
:CONFigure:WAVElength <float>  
:CONFigure:WAVElength?
```

Sets the wavelength (in nanometers) of light given to the optical input of the device. If the device is a C-Band model, then valid wavelength values will range from 1530 nm to 1565 nm, inclusively. If the device is a O-Band model, then valid wavelength values will range from 1260 nm to 1360 nm, inclusively.

- **Default**
 - 1550 (C-Band model)
 - 1310 (O-Band model)
- **Min**
 - 1530 (C-Band model)
 - 1260 (O-Band model)
- **Max**
 - 1565 (C-Band model)
 - 1360 (O-Band model)
- **Command Example:**
 - :INP:WAVE 1550.1
- **Query Response Example:**
 - 1550.1

11.2.4.4 :CONFigure:TRANSfer

```
:CONFigure:TRANSfer MANual|CONTInuous  
:CONFigure:TRANSfer?
```

Sets the transfer mode. A value of MANual disables the streaming of measurement data to the host and a value of CONTInuous enables the streaming of measurement data to the host.

- **Default**
 - MANual
- **Command Example:**

- :CONF:TRAN CONT
- **Query Response Example:**
 - CONTInuous

11.2.5 :READ Subsystem

11.2.5.1 :READ[:VALue]?

```
:READ[:VALue]?
```

Performs a one-time read of the polarization state and power of the incoming light.

11.2.5.2 :READ:AVERage:LENGth

```
:READ:AVERage:LENGth AVG1|AVG10|AVG100
```

```
:READ:AVERage:LENGth?
```

Sets the sample rate of the device.

- **Default**
 - AVG1
- **Command Example:**
 - :INP:WAVE AVG10
- **Query Response Example:**
 - AVG100

11.2.6 :UNIT Subsystem

11.2.6.1 :UNIT:POWER

```
:UNIT:POWER UW|NW
```

```
:UNIT:POWER?
```

Sets the unit used for measuring the incoming lightpower. UW sets the unit to microwatts and NW sets the unit to nanowatts.

It is recommended that the user to switch to using nanowatts if the power value in microwatts is 32 or less, to maintain adequate precision. Likewise, it is recommended to switch to microwatts, if the power value in nanowatts is 60000 or more, to avoid integer saturation.

- **Default**
 - UW
- **Command Example**
 - :UNIT:POWER NW
- **Query Response Example**
 - UW

11.2.7 :OUTPut Subsystem

11.2.7.1 OUTPut:TRIGger[:STATe]

```
OUTPut:TRIGger[:STATe] 0|1|ON|OFF
```

```
OUTPut:TRIGger[:STATe]?
```

Enable or disable the trigger out signal.

- **Default**
 - OFF
- **Command Example**
 - OUTP:TRIG ON
- **Query Response Example**
 - 0

11.2.7.2 OUTPut:TRIGger:PWIDth

```
OUTPut:TRIGger:PWIDth <float>
```

```
OUTPut:TRIGger:PWIDth?
```

Sets the pulse width of the output trigger signal. The pulse width is measured in microseconds.

- **Default**
 - 1
- **Min**
 - 0.1
- **Max**
 - 5
- **Command Example**
 - OUTP:TRIG:PWID 3.5
- **Query Response Example**
 - 2.5

11.3 Status Structures

11.3.1 Status Byte

Bit #	Name
0	Unused
1	Unused
2	Error/Event Queue Summary
3	Questionable Status Register Summary
4	Output Queue Summary
5	Standard Event Status
6	Master Summary Status
7	Operation Status Register Summary

11.3.2 Standard Event Status Register

Bit #	Name
0	Operation Complete
1	Request Control
2	Query Error
3	Device Dependent Error
4	Execution Error
5	Command Error
6	User Request
7	Power On

11.3.3 OPERation Status Register

Bit #	Name
0	Auto Gain On
1	Unused
2	Unused

3	Unused
4	Unused
5	Unused
6	Unused
7	Unused
8	Unused
9	Unused
10	Unused
11	Unused
12	Unused
13	Unused
14	Unused

11.3.4 QUESTIONable Status Register

Bit #	Name	Description
0	Unused	
1	Unused	
2	Unused	
3	Power Summary	Displays warnings about the incoming light power
4	Unused	
5	Unused	
6	Unused	
7	Unused	
8	Unused	
9	Unused	
10	Unused	
11	Unused	

12	Unused	
13	Unused	
14	Command Warning	

11.3.5 QUESTIONable:POWER Status Register

Bit #	Name	Description
0	Power Unit Over-ranged	The nanowatt unit of light power is nearing the maximum value of its integer representation at the current light power.
1	Power Unit Under-ranged	The microwatt unit of light power is not expressing the current light power with sufficient resolution.
2	Oversaturation	The light power is too high for the current gain level.
3	Undersaturation	The light power is too low for the current gain level.
4	Unused	
5	Unused	
6	Unused	
7	Unused	
8	Unused	
9	Unused	
10	Unused	
11	Unused	
12	Unused	
13	Unused	
14	Unused	

11.4 Event/Error Codes

11.4.1 Command Errors

Error Code	Error String
-101	Invalid Character

-103	Invalid Separator
-104	Data type error
-108	Parameter not allowed
-109	Missing parameter
-110	Command header error
-113	Undefined header
-120	Numeric data error
-130	Suffix error
-140	Character data error
-150	String data error
-151	Invalid string data
-170	Expression error

11.4.2 Execution Errors

Error Code	Error String
-200	Execution error
-210	Trigger error
-220	Parameter error
-221	Settings conflict
-222	Data out of range
-223	Too much data
-224	Illegal parameter value
-230	Data corrupt or stale
-240	Hardware error
-250	Mass storage error
-260	Expression error
-280	Program error
-290	Memory use error

11.4.3 Query Errors

Error Code	Error String
-400	Query error
-410	Query INTERRUPTED
-420	Query UNTERMINATED
-430	Query DEADLOCKED
-440	Query UNTERMINATED after indefinite response

11.4.4 Device-Specific Errors

Error Code	Error String
-300	Device specific error
-310	System error
-313	Calibration memory lost

-314	Save/recall memory lost
-315	Configuration memory lost
-320	Storage fault
-330	Self-test failed
-340	Calibration failed
-350	Queue overflow
-360	Communication error
-363	Input buffer overrun

11.4.5 Events

Event Code	Event String
-500	Power on
-600	User request
-700	Request control
-800	Operation complete

12 Appendix A Theory of Operation

Measurable polarization parameters are defined as follows:

SOP: State of polarization of light, expressed in normalized Stokes parameters S_0 , s_1 , s_2 , and s_3 .

The Stokes parameters are related to the electric field by

$$S_0 = E_{0x}^2 + E_{0y}^2$$

$$S_1 = E_{0x}^2 - E_{0y}^2$$

$$S_2 = 2E_{0x}E_{0y} \cos \delta$$

$$S_3 = 2E_{0x}E_{0y} \sin \delta$$

where δ is the relative phase between the two orthogonal electric field components.

They are calculated from measured values by

$$\begin{bmatrix} S_0 \\ S_1 \\ S_2 \\ S_3 \end{bmatrix} = M \begin{bmatrix} V_0 \\ V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} m_{00}, m_{01}, m_{02}, m_{03} \\ m_{10}, m_{11}, m_{12}, m_{13} \\ m_{20}, m_{21}, m_{22}, m_{23} \\ m_{30}, m_{31}, m_{32}, m_{33} \end{bmatrix} \begin{bmatrix} V_0 \\ V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

where $V_0 \sim V_3$ are analog output voltages from the polarimeter, M is a calibration matrix, and $S_0 \sim S_3$ are the Stokes parameters corresponding to $V_0 \sim V_3$.

The POD-201 provides normalized Stokes parameters defined as follows:

S_0 is the measured power.

$$s_1 = \frac{S_1}{\text{norm}(\vec{S})}$$

$$s_2 = \frac{S_2}{\text{norm}(\vec{S})}$$

$$s_3 = \frac{S_3}{\text{norm}(\vec{S})}$$

$$\text{where } \text{norm}(\vec{S}) = \sqrt{(S_1)^2 + (S_2)^2 + (S_3)^2}$$

s_1 , s_2 , and s_3 are the Stokes parameters normalized to the surface of the sphere. They satisfy the normalization condition

$$s_1^2 + s_2^2 + s_3^2 = 1.$$

DOP: Degree of polarization of light

$$DOP = \frac{\text{norm}(\vec{S})}{S_0}$$

dREF: The angle between the current SOP and the reference SOP

$$dREF = \frac{180}{\pi} \cos^{-1}(s_1 * s_1^{ref} + s_2 * s_2^{ref} + s_3 * s_3^{ref})$$

where s_1 , s_2 , and s_3 are the normalized Stokes parameters of the current SOP and s_1^{ref} , s_2^{ref} , and s_3^{ref} are the normalized Stokes parameters of a reference polarization state specified by the user.

DLP: Degree of linearity

$$DLP = \frac{\sqrt{(S_1)^2 + (S_2)^2}}{S_0}, \quad 0 \leq DLP \leq 100\%$$

DCP: Degree of circularity

$$DCP = \frac{S_3}{S_0}, \quad 0 \leq DCP \leq 100\%$$

Azimuth and ellipticity refer to the polarization ellipse.

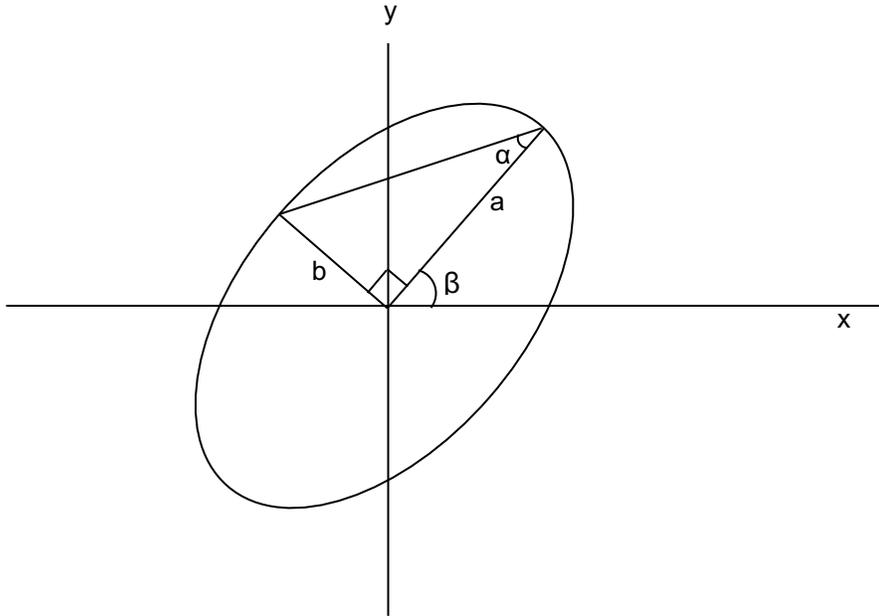


Figure 14 Polarization ellipse

For a light beam with propagation direction z (out of the paper) and polarization ellipse as shown in Figure 14, with semimajor axis $a >$ semiminor axis b , the azimuth is defined as the angle between the x axis and the semimajor axis of the ellipse. The ellipticity is defined as

$$\text{Ellipticity} = \tan \alpha = \pm \frac{b}{a} = \tan \left(\frac{1}{2} \sin^{-1} \left(\frac{S_3}{\text{norm}(\vec{S})} \right) \right)$$

where the positive sign is used for right-handed rotation, and the negative sign for left-handed rotation. The range for β is 0° to 180° , while the range for ellipticity is -1 to 1 . Ellipticity = -1 for LHC, 0 for linear, and $+1$ for RHC polarization states.

Azimuth angle β

when $-\pi/2 < \tan^{-1}(x) < \pi/2$:

- $s_1 > 0$, $\beta = \frac{1}{2}\Theta$
- $s_1 < 0$, $s_2 > 0$, $\beta = \frac{\pi}{2} + \frac{1}{2}\Theta$
- $s_1 < 0$, $s_2 < 0$, $\beta = -\frac{\pi}{2} + \frac{1}{2}\Theta$
- $s_1 = 0$, $s_2 > 0$, $\beta = \frac{\pi}{4}$
- $s_1 = 0$, $s_2 < 0$, $\beta = -\frac{\pi}{4}$
- $s_1 = 0$, $s_2 = 0$, $\beta = 0$

where Θ is a spherical coordinate angle on the Poincaré sphere.

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13 REVISION HISTORY

REVISION	DATE	NOTE
1.0	9/21/2023	Original document