



# KURIOS2

## Kurios® Liquid Crystal Tunable Filter Controller

### User Guide



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## Chapter 1 Introduction

### 1.1 Intended Use

A liquid crystal tunable filter consists of a series of liquid crystal cells and polarizers. The KURIOS2 Liquid Crystal Tunable Filter Controller directly controls the Kurios® Tunable Filters (sold separately). The drive voltages of the liquid crystal cells are calibrated to provide a specific retardance for each cell. This combination of retardances, along with the polarizers used, result in a bandpass filter in which the center wavelength can be adjusted by varying the drive voltages. Special signals are applied to optimize the response when switching between wavelengths (voltages for each cell).

This product is intended for laboratory use only and is not certified for medical applications, including but not limited to life support situations. All statements regarding safety and technical specifications will only apply when the unit is operated correctly.

This product may only be used in accordance with the instructions described in this manual. Any other use will invalidate the warranty.

### 1.2 Explanation of Safety Warnings

#### CAUTION

Caution indicates a hazard with a low level of risk that, if not avoided, could result in minor or moderate injury.

#### NOTICE

Indicates information considered important, but not hazard-related, such as possible damage to the product.



Danger, Warning, or Caution



ESD Component Caution



Shock Warning



The CE/UKCA markings on the product are the manufacturer's declaration that the product complies with the essential requirements of the relevant European health, safety, and environmental protection legislation.



The symbol on the product, the accessories or packaging indicates that this device must not be treated as unsorted municipal waste but must be collected separately.

### 1.3 Description

The KURIOS2 Liquid Crystal Tunable Filter Controller is custom designed for the Kurios® optical filter heads. There are different modes of operation and bandwidth. The center wavelength can be controlled in normal manual mode, as well as externally adjusted via an analog control signal or software. A complete software package that accesses all the functions of the KURIOS2 controller is provided. In addition, a full command-line interface can be used for custom software development. The KURIOS2 is also fully compatible with the command set of CRi VariSpec tunable filters.



Figure 1 KURIOS2 Liquid Crystal Tunable Filter System

1.4 Technical Data

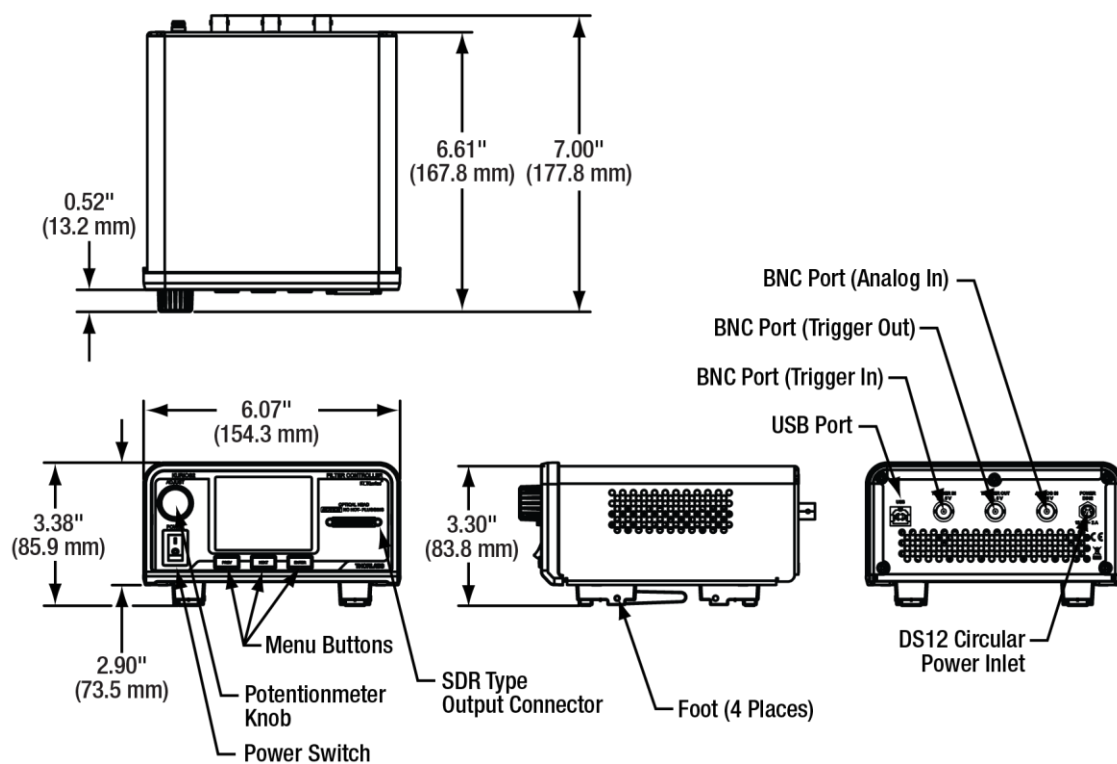
1.4.1 Specifications

Electrical Characteristics	
Adjustable Output Voltage	0 to ±25 V RMS
Voltage Resolution	1.0 mV
Switching Frequency	2000 ± 1 Hz, 50% Duty Cycle
Slew Rate	10 V/μs
DC Offset	±5 mV
Warm-Up Time	30 min
USB Port	USB Standard B Plug
Power Compatibility	110 - 240 VAC, 50 - 60 Hz Operation, Location Specific Power Cord Included

Maximum Ratings	
Maximum External Input Voltage	5 VDC
Maximum Output Current	50 mA
Maximum Heating Current	900 mA
Operating Temperature Range	10 to 40 °C
Maximum Relative Humidity	85%

General Specifications	
Dimensions (L x W x H)	177.8 mm x 154.3 mm x 85.9 mm (7.00" x 6.07" x 3.38")
Weight	0.89 kg

### 1.4.2 Mechanical Drawings



**Figure 2** Mechanical Drawing

1.5 Components

1.5.1 Front Panel

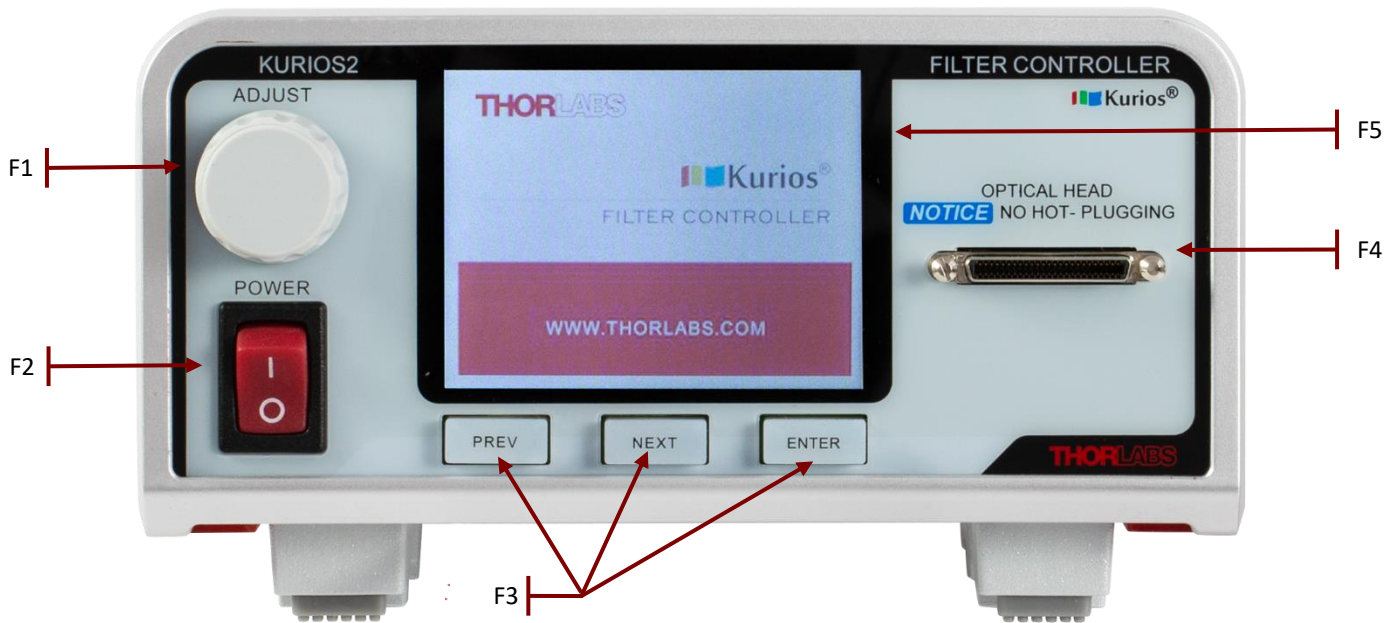


Figure 3 Controller Front Panel

Front Panel	
Callout	Description
F1	Wavelength Adjustment Knob
F2	Power Switch
F3	Operation Buttons (3 Places)
F4	Push-To-Connect Fitting for Filter Head
F5	Display

Table 1 Components of Controller Front panel

1.5.2 Back Panel

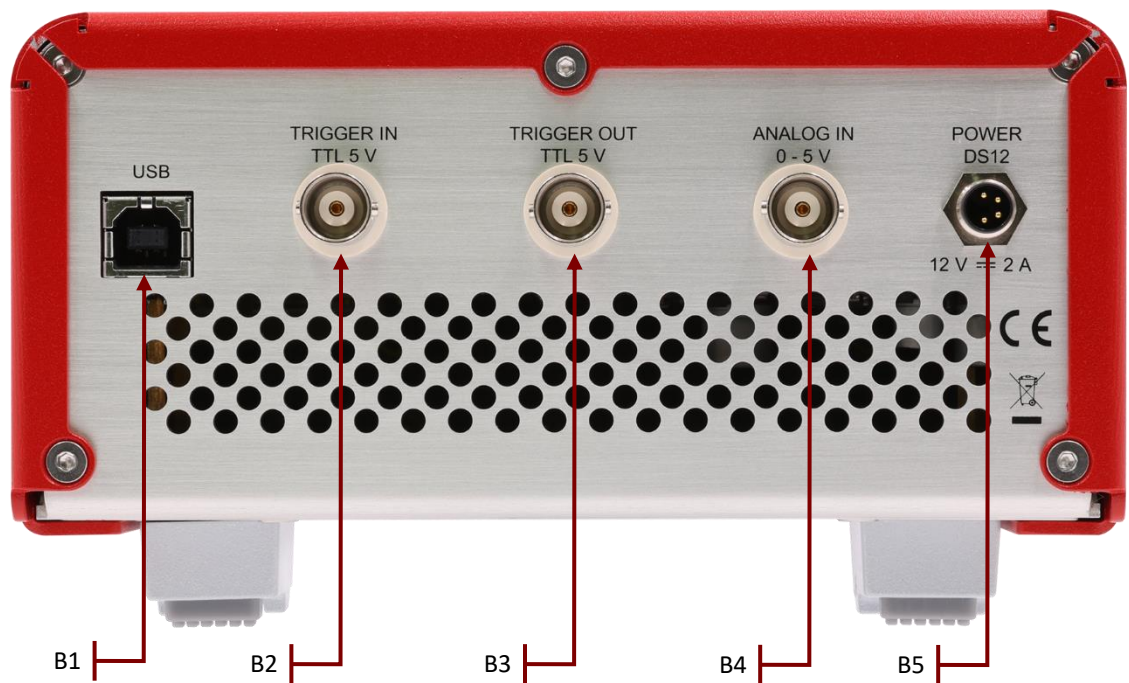


Figure 4 Controller Back Panel

Back Panel	
Callout	Description
B1	USB Port
B2	Trigger In Port
B3	Trigger Out Port
B4	Analog In Port
B5	DC Power Cord Connector

Table 2 Components of Controller Back panel

1.6 Simplified Declaration of Conformity

The full text of the EU declaration of conformity is available at the following internet address:  
[https://www.thorlabs.com/newgrouppage9.cfm?objectgroup\\_id=3488](https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=3488)

1.7 FCC Designation

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is



likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

## Chapter 2 Safety

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly in accordance with this user manual.



### Warning: Risk of Electrical Shock

High voltage inside. To avoid electrical shock, make sure that the ground pin of the power cord is correctly connected to the ground connector in the power socket before powering on. Improper grounding can cause electric shock resulting in severe injury or even death. Do not operate without the cover installed.



### ESD Component Caution

The components inside this instrument are ESD sensitive. Take all appropriate precautions to discharge personnel and equipment before making any electrical connections to the unit.



### Do Not Open Housing

The KURIOS2 controller has no user-serviceable parts. Service should only be performed by trained service personnel.



### Caution

Always connect the optical filter head to the main controller unit before powering on.



### Caution

The maximum current output from the controller connector is 0.9 A, and the optical filter head does not support hot plugging. Plugging or unplugging the connector while the unit is powered on can cause damage to the optical filter head and/or controller.

### NOTICE

This unit must not be operated in explosive environments. Additionally, this unit should not be used in wet/damp conditions. Do not obstruct the air ventilation slots in the housing!

### NOTICE

The KURIOS2 controller includes a Thorlabs DS12 12 VDC Regulated Power Supply, which operates at an input voltage of 100 - 240 VAC. A 115 V power cord is also

included for use in North America only. For all other applications, use an IEC 320 compatible power cord fitted with a plug appropriate for your particular power socket.

**NOTICE**

Mobile telephones, cellular phones, or other radio transmitters should not be used within 3 m of this unit since the electromagnetic field intensity may exceed the maximum allowable disturbance values, according to EN50082-1.

**NOTICE**

Please read the instruction manual carefully before operating the KURIOS2 controller. All statements regarding safety and technical specifications will only apply when the unit is operated correctly. This equipment is intended for laboratory use only and is not certified for medical applications, including but not limited to life support situations.

**NOTICE**

The connector fitting for the optical filter head should not be hot plugged.

**NOTICE**

Once the KURIOS2 controller restarts, it is necessary to manually operate the software to reconnect.

## Chapter 3 Installation

### 3.1 Warranty Information

This precision device is only serviceable if returned and properly packed into the complete original packaging including the complete shipment plus the cardboard insert that holds the enclosed devices. If necessary, ask for replacement packaging. Refer servicing to qualified personnel.

### 3.2 Packing List/Special Tools Required for Installation

The package contains the following items:

- Controller
- USB
- DC Power
- Region-Specific Power Cord



**Figure 5** *Package Contents of KURIOS2 Controller*

### 3.3 Unpacking Instructions

1. Lay the packing box on a flat surface and tear off the adhesive tape on the outside of the packing carton.
2. Open the carton and take out the upper insert.
3. Take out the controller. Remove with care to protect the surface and prevent scratches.
4. Take out the left insert. Open the insert and remove all attachments.

### 3.4 Installation Instructions



#### Caution

Always connect the optical filter head to the main controller unit before powering on.



#### Caution

The maximum current output from the controller connector is 0.9 A, and the optical filter head does not support hot plugging. Plugging or unplugging the connector while the unit is powered on can cause damage to the optical filter head and/or controller.

To prepare the controller for use:

1. Connect the optical filter head to the push-to-connect fittings on the front of the unit.



**Figure 6** *Connect the Optical Filter Head*

2. Connect the included power to the DC inlet located on the back panel.
3. Connect the included power cord to the DC power.



**Figure 7** Connected the Power Cord

4. Plug the power cord into a power outlet to power the device.
5. Turn on the power switch and the user gains a liquid crystal tunable filter.



**Figure 8** Power On

## Chapter 4 Operation



### Warning: Risk of Electrical Shock

Please check the supply voltage of the system before plugging in the unit. Make sure the included power cord is connected to a properly grounded outlet (90 – 240 VAC, 50 – 60 Hz).

### 4.1 Operation Notes

- The operating temperature ranges from 15 °C to 40 °C.
- The KURIOS2 controller connects to the optical head of the Kurios® filter. This should be connected before the controller is turned on. If the cable is not connected while the power is on, then the controller must be restarted. The controller screen will remind the user with the prompt “NO FILTER”.
- The maximum current output from the optical filter head connector is 0.9 A, and it does not support hot plugging. Plugging or unplugging the connector while the unit is powered on can cause damage to the optical filter head and/or controller.
- The system uses a switchable power supply capable of 100 – 240 VAC, 50 – 60 Hz. For support or more info, please contact Thorlabs Tech Support for assistance.

## 4.2 Controls and Connections

### 4.2.1 KURIOS2 Controller Front Panel



**Figure 9**      **Controller Front Panel**

#### Controls

**ADJUST:**

Adjust the center wavelength in MANUAL mode.

**PREV:**

Move cursor backwards or decrease value.

**NEXT:**

Move cursor forward or increase value.

**ENTER:**

Confirm selection or cancel selection.

#### Connectors

**OPTICAL FILTER HEAD:**

Connects to the optical head of the filter. This should be connected before the controller is turned on. If the cable is not connected while the power is on, then the controller must be restarted. The controller screen will remind the user:

 NO FILTER

**Caution**

Always connect the optical filter head to the main controller unit before powering on.

The maximum current output from the optical filter head connector is 0.9 A, and it does not support hot plugging. Plugging or unplugging the connector while the unit is powered on can cause damage to the optical filter head and/or controller.

#### 4.2.2 KURIOS2 Controller Back Panel



**Figure 10**      **Controller Back Panel**

**USB:**

Connects to the computer for software or command-line control.

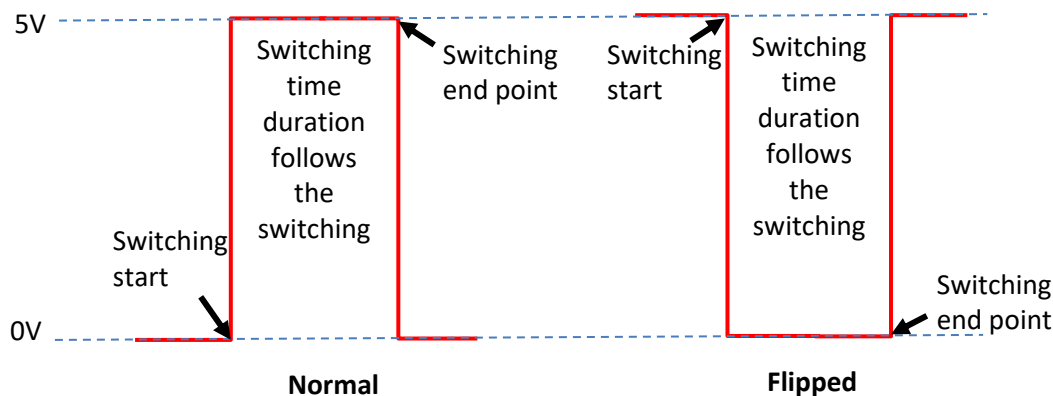
**TRIGGER IN:**

Connect a 5 V TTL signal. It is used in the “SEQUENCE (with external trigger)” and “ANALOG (with external trigger)” modes. In these modes, the TRIGGER IN is used to trigger the controller to switch wavelength.

**TRIGGER OUT:**

A BNC connector output trigger is issued by the controller during every tuning cycle. For normal trigger mode, the TRIGGER OUT raises to 5 V at the beginning of a wavelength tuning cycle. It remains high during the tuning time and drops to 0 V once the filter settles into its new wavelength. The user also can use the command-line or software to flip the trigger out waveform. Please refer to the schematic below of the trigger out signal while choosing Normal or Flipped mode.

**NOTE:** Since the tuning time varies with the specified wavelength and the start and end wavelengths, the duration of the TRIGGER OUT varies accordingly.



**Figure 11** Schematic of KURIOS2 Trigger Out

#### ANALOG IN:

Connect a 0 - 5 V analog signal. It is used in the ANALOG mode. In this mode, the filter adjusts its wavelength according to the voltage of the analog signal. The ANALOG IN signal tunes the filter's center wavelength from the shortest wavelength (0 V,  $W_s$ ) to the longest wavelength (5 V,  $W_l$ ), meaning that the voltage step size for analog tuning is  $\left(\frac{5}{W_l - W_s}\right)$  V/nm.

### 4.3 Starting the KURIOS2

To operate the KURIOS2 controller, ensure that both the power cable and the head cable are securely connected. Press the power switch to turn on the unit. Upon turning on, an initialization screen will appear on the LCD. The device will then enter the home page and begin initializing. During the initialization, the unit is still operational.

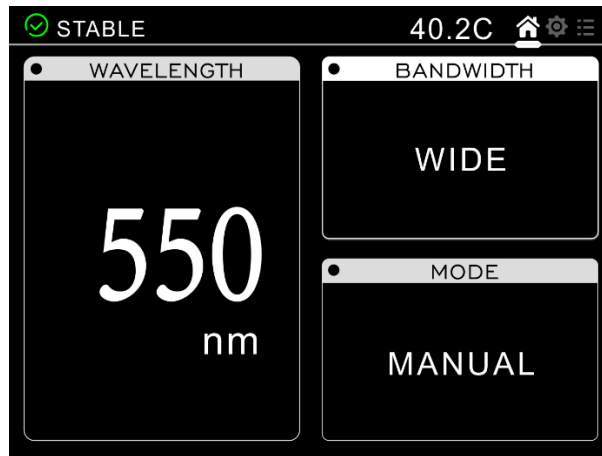


**Figure 12** Initialization Screen of KURIOS2




## 4.4 Home Screen

### 4.4.1 Information



**Figure 13** Home Screen

Pressing the “PREV/NEXT” button to move the cursor to the  icon and pressing the “ENTER” button will reveal the home screen. The following information is displayed on the home screen:

#### WAVELENGTH:

Current center wavelength. In BLACK mode, it shows the most recent center wavelength.

#### BANDWIDTH:

- WIDE:** Filter works in wide bandwidth mode. This is the default filter operation after powering on the K2WB1(/M), K2VB1(/M), and K2WL1(/M) filters.
- MEDIUM:** Filter works in medium bandwidth mode.
- NARROW:** Filter works in narrow bandwidth mode. This is the default filter operation mode after powering on the K2XE2(/M) and K2XL1(/M) filters.
- BLACK:** Beam blocking mode, minimum transmission.

#### MODE:

- MANUAL:** Manual mode.
- SEQ.INT:** Sequenced with internal trigger.
- SEQ.EXT:** Sequenced with external trigger.
- ANA.INT:** Analog signal controlled with internal trigger.
- ANA.EXT:** Analog signal controlled with external trigger.



#### STATUS:

**INITIALIZING:** Filter is in transition from idle to operation state. This initialization procedure takes 120 seconds from power on. The controller screen shows the message:

“INITIALIZING: --s”

where the dashes are replaced by the number of seconds remaining.



-  **WARMING UP**: Filter is being warmed up to 40 °C. During this time, the filter is operational; however, the center wavelength might be shifted from the displayed value, and the wavelength switching speed is not fully optimized.
-  **STABLE**: Filter has reached 40°C and is now fully functional.
- C**: Temperature of the filter, where the dashes are replaced by the temperature value. The value fluctuates around 40°C.

#### 4.4.2 Bandwidth

The KURIOS2 controller has four bandwidth modes: WIDE, MEDIUM, NARROW, and BLACK.

To change the bandwidth, press the “PREV/NEXT” buttons to move the cursor to BANDWIDTH. Press the “ENTER” button to confirm the selection and press the “PREV/NEXT” buttons to change the value. Press “ENTER” again to validate the value change.

K2WB1(/M): WIDE, BLACK.

K2WL1(/M): WIDE, BLACK.

K2XE2(/M): NARROW, BLACK.

K2XL1(/M): NARROW, BLACK.

K2VB1(/M): WIDE, MEDIUM, NARROW, BLACK.

In the software interface, WIDE, MEDIUM, NARROW and BLACK modes are in the Bandwidth Mode section.

The command line can be used to switch between modes using the following commands: BW=1 (BLACK), BW=2 (WIDE), BW=4 (MEDIUM), BW=8 (NARROW).

#### 4.4.3 Mode

To change the mode, press the “PREV/NEXT” buttons to move the cursor to MODE. Press the “ENTER” button to confirm the selection, and press the “PREV/NEXT” buttons to change the value. Press “ENTER” again to validate the value change.

- **Manual**

In MANUAL mode, there are various ways to control the center wavelength:

Turn the ADJUST knob on the KURIOS2 front panel. The center wavelength is directly controlled, and changes take effect immediately.

To change the desired wavelength, move the cursor to WAVELENGTH. Press the “ENTER” button to confirm the selection and either turn the knob or press the “PREV/NEXT” buttons to change the value. Press “ENTER” again to validate the value change.

Use the wavelength slider or directly input the desired wavelength in the software interface.

Issue the command WL=n, where n is the desired wavelength.

When the KURIOS2 controller is first powered on, it defaults to MANUAL mode. In other cases, one of the following steps can be taken to activate MANUAL mode:

Press the “PREV/NEXT” buttons to move the cursor to MODE. Press the “ENTER” button to confirm the selection and press the “PREV/NEXT” buttons to change to MANUAL. Press “ENTER” again to validate.

In the software interface, press Manual in the Control Mode section.

Issue the WL=n command, where n is the desired wavelength.

Issue the OM=1 command.

- **Sequenced**

In SEQUENCED mode, the KURIOS2 controller stores a set of center wavelengths and issues the wavelengths to the optical filter head whenever a trigger is received. The number of wavelengths that can be stored ranges from 1 to 1024. When it reaches the end of the sequence, it loops back to the beginning and starts over again. The switching of wavelengths in SEQUENCED mode can be internally or externally triggered.

To activate SEQUENCED mode, do one of the following:

Press the “PREV/NEXT” buttons to move the cursor to MODE. Press the “ENTER” button to confirm the selection and press the “PREV/NEXT” buttons to change to either SEQ.INT or SEQ.EXT. Press “ENTER” again to validate.

In the software interface, press Sequence in the Control Mode section.

Issue the OM=2 or OM=3 command for SEQ.INT or SEQ.EXT, respectively.

In SEQUENCED mode, the list of wavelengths and their corresponding interval times (for internal trigger mode) are preloaded into the controller via the software interface or command line.

- **Analog Input**

In ANALOG mode, the center wavelength is directly controlled by a 0 – 5 V signal connected to the ANALOG IN port on the KURIOS2 back panel. The 0 V signal corresponds to the shortest wavelength (420 nm or 430 nm for VIS filter, 650 nm for NIR filter) and the 5 V signal corresponds to the longest wavelength (730 nm for VIS filter, 1100 nm for NIR filter). Similar to SEQUENCED mode, the update of the wavelength (according to the ANALOG IN voltage) is triggered by either an internal or external trigger.

To activate ANALOG mode, do one of the following:

Press the “PREV/NEXT” buttons to move the cursor to MODE, Press the “ENTER” button to confirm the selection and press the “PREV/NEXT” buttons to change to either ANA.INT or ANA.EXT. Press “ENTER” again to validate.

In the software interface, press Analog in the Control Mode section.

Issue the OM=4 or OM=5 command for ANA.INT or ANA.EXT, respectively.

- **Internal Trigger vs. External Trigger**

In both SEQUENCED and ANALOG mode, a trigger is needed to update the center wavelength, which is either stored in the preloaded sequence or set by the analog signal input. In particular, during ANALOG mode, the controller does not sample the analog input signal until a trigger is received. The voltage of the analog control signal during other times is ignored. There are two triggering modes: internal trigger and external trigger.

In internal trigger mode, the trigger is provided by an internal clock within the controller. The user can specify the triggering interval time by issuing the command “TI=n”, where n is the setting time that ranges from 1 ms to 60 s. The default triggering interval time is 50 ms. Moreover, in SEQUENCED mode, each wavelength in the sequence list can have its own interval time. The user can also reset all wavelengths to a default interval time. For ANALOG mode, the controller updates the wavelength according to the analog input signal at the interval times set by the user.

In external trigger mode, the trigger is provided by a 5 V TTL signal through the TRIGGER IN BNC port on the back panel. The user can choose whether the trigger occurs on the rising or falling edge of the signal.

In both SEQUENCED and ANALOG modes, the wavelength updates when a trigger is received. During other times, the wavelength remains unchanged.

- **Black**

The BLACK mode is a special beam blocking mode. In this mode, the filter transmission is set to a minimum regardless of the value of center wavelength being set.





To activate BLACK mode, do one of the following:

Press the “PREV/NEXT” buttons to move the cursor to BANDWIDTH. Press the “ENTER” button to confirm the selection and press the “PREV/NEXT” buttons to change to BLACK. Press “ENTER” again to validate.


In the software interface, press Black in the Bandwidth Mode section.

Issue the BW=1 command.

## 4.5 Setting Screen

<div>  STABLE         40.1C            </div>	
Filter Model	K2WB1
Filter SN	00000000
Wavelength Range	420-730 nm
Trigger In	Fall Edge
Trigger Out	Active High

**Figure 14**      **Setting Screen**

Pressing the “PREV/NEXT” buttons to move the cursor to the  icon and pressing “ENTER” will reveal the setting screen. The following information is displayed on the setting screen:

**Filter Model:**

Displays the current filter head model.

**Filter SN:**

Displays the SN number of the current filter.

**Wavelength Range:**

Displays the working wavelength range of the current filter.

**Trigger In:**

Displays the externally triggered edge. By default, the trigger is received via the falling edge. To change the trigger in, do one of the following:

Press the “PREV/NEXT” buttons to move the cursor to Trigger In. Press the “ENTER” button to confirm the selection and press the “PREV/NEXT” buttons to change to either Fall Edge or Rise Edge. Press “ENTER” again to validate.

Issue the TE=0 or TE=1 command for Fall Edge or Rise Edge, respectively.

### Trigger Out:

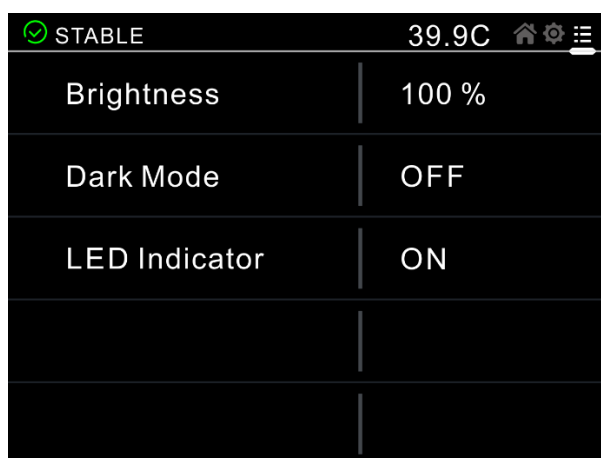
Displays the output waveform while switching wavelengths. By default, the trigger switches low to high while tuning is occurring. To change the trigger out waveform, do one of the following:

Press the “PREV/NEXT” buttons to move the cursor to Trigger Out. Press the “ENTER” button to confirm the selection and press the “PREV/NEXT” buttons to change to either Active Low or Active High. Press “ENTER” again to validate.


In the software interface, the Trigger Out can be set in the options tab.

Issue the TO=0 or TO=1 command for Active Low or Active High, respectively.

## 4.6 Option Screen



**Figure 15**      **Option Screen**

Pressing the “PREV/NEXT” buttons to move the cursor to the  icon and pressing the “ENTER” button will reveal the option screen. The following information is displayed on the option screen:

### Brightness:

Displays the current controller brightness.

To change the brightness, move the cursor to Brightness and press the “ENTER” button to confirm the selection. Either turn the knob or press the “PREV/NEXT” buttons to change the value from 10% to 100%. Press “ENTER” again to validate the value change.

### Dark mode:

OFF: Open controller screen.

ON: Close controller screen.

To enter dark mode, move the cursor to Dark Mode. Press the “ENTER” button to confirm the selection and press the “PREV/NEXT” buttons to change to “ON”. Press “ENTER” again to enter dark mode. When in dark mode, press “ENTER” button to exit.

### LED Indicator:

ON: Open LED of filter.

OFF: Close LED of filter.

To change the LED status on the optical filter head, move the cursor to the LED Indicator. Press the “ENTER” button to confirm the selection and press the “PREV/NEXT” buttons to change the value. Press “ENTER” again to validate the value change.

## Chapter 5 Software GUI

Included with the KURIOS2 is the bundled Kurios® software that accesses all features supported by the controller. Figure 16 shows the main window of the software GUI. In addition to the operation modes and wavelength selection, the software allows the user to enter the wavelengths, time intervals, and bandwidth mode (for K2VB1(/M) only) for the SEQUENCE mode, which are not available directly on the controller itself.

The complete set of configurations, including the wavelength sequence list, can be saved and loaded using the “Save Profile” and “Load Profile” buttons, respectively. The sequence list can also be imported or exported in comma separated value (CSV) format by right-clicking on any text field on the sequence list. The CSV file can be edited by Microsoft Excel or any text editing software. Refer to the documentation within the software GUI for details and operation. The Kurios® software package allows the user to select between the Manual, Sequence, and Analog Modes for setting the center wavelength of the optical filter head. In manual mode, the wavelength slider is enabled, which lets the user choose any center wavelength within the 420 - 730 nm range for VIS filters (K2XL1(/M) within 430 – 730 nm) and 650 - 1100nm for NIR filters. For sequence and analog modes, either internal or external triggering can be chosen; triggers are needed to update the center wavelength. In sequence and analog modes, the user may define sequences of up to 1024 wavelengths to be cycled through by the controller. Each step in the sequence has its own wavelength and duration (1 ms to 60 s), and for K2VB1(/M), the bandpass width mode can also be changed from step to step. Sequences can be saved and loaded in CSV format using the “Save Profile” and “Load Profile” buttons, respectively. We also provide C/C++ and LabVIEW® software development kits for controlling the KURIOS2 with other instruments through the USB port on the controller. Sample C++ code and LabVIEW programs help to illustrate how the C++ commands and LabVIEW VIs can be utilized. Full documentation on the available commands is provided in the SDK manual.

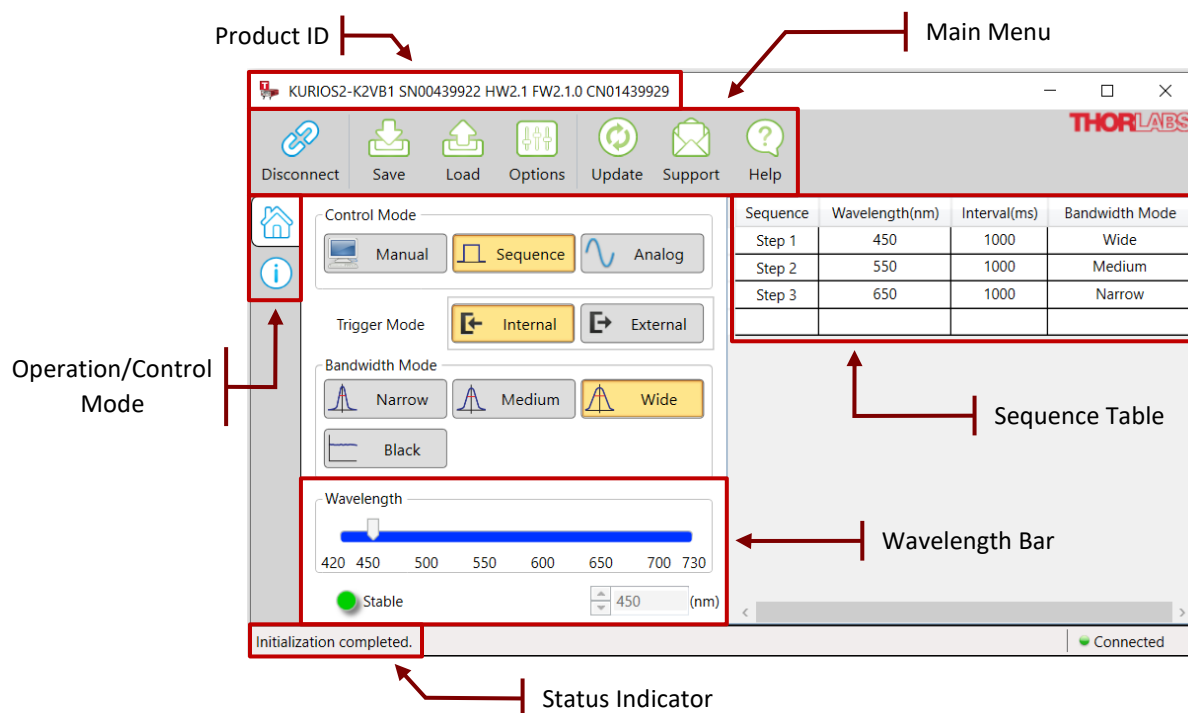


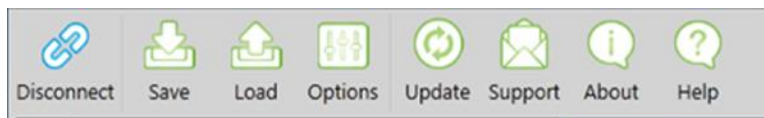
Figure 16 Kurios® Software GUI Main Window

## 5.1 Product ID

Indicates the product ID while a Kurios® optical filter head is connected:

Thorlabs K2xxx SN-xxxxxxx HWxx FWxx CN-xxxxxxx

## 5.2 Main Menu



**Figure 17** Software GUI Main Menu

### Connect/Disconnect

Enable or disable the connection between the KURIOS2 controller and the PC. When clicking **Connect**, all available Kurios® optical filter heads are listed in the pop-up connection table.

### NOTICE

Once the KURIOS2 restarts, it is necessary to manually operate the software to reconnect.

### Save Profile

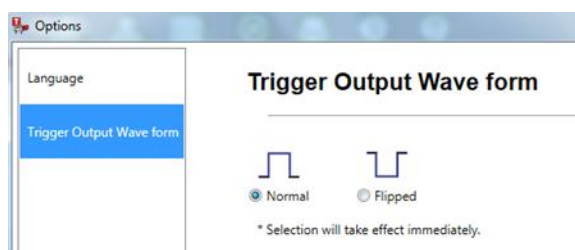
Save the user defined settings in XML format.

### Load Profile

Load the user defined settings in XML format.

### Options

The Trigger Out waveform and language settings can be set in the options tab.



**Figure 18** Software Option Window

### Update

Update the Kurios® software to the most up-to-date version, if available.

### Support

For technical support, Microsoft Outlook launches (if installed) and directly addresses to [techsupport@thorlabs.com](mailto:techsupport@thorlabs.com).

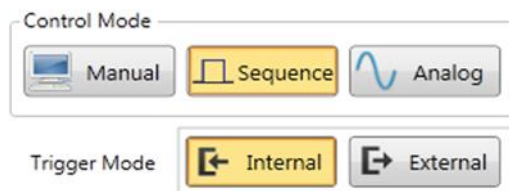
### About

Displays the detailed information about the Kurios® software. Please have these details available when contacting Thorlabs Technical Support.

### Help

Opens the Kurios® software help documentation.

## 5.3 Operation / Control Mode



**Figure 19 Software Control Mode**

**Manual:** Set the filter to manual mode. Tuning the knob at the controller front panel, dragging the wavelength bar, and the wavelength setting frame are available.

**Sequence:** Set the filter to sequence mode. There are two trigger modes available: Internal (default) and External.

**Internal:** The sequence table is available and the filter output wavelength switches according to the sequence interval time in the sequence table.

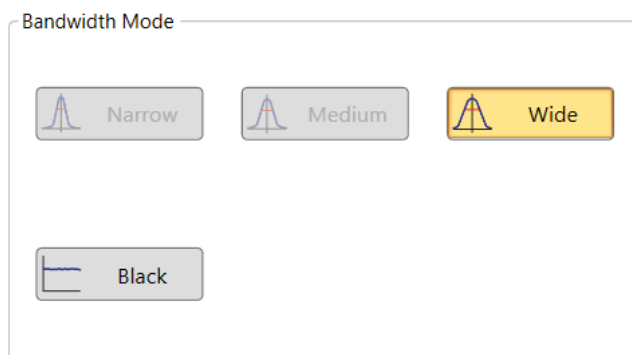
**External:** The sequence table is available and the filter output wavelength switches according to the External Trigger time.

**Analog:** Set the filter to analog mode. There are two trigger modes available: Internal (default) and External.

**Internal:** User inputs a 0 - 5V voltage from the Analog In port at the controller back panel. The switching time is according to the internal time.

**External:** User inputs a 0 - 5V voltage from the Analog In port at the controller back panel. The filter output wavelength switches according to the External Trigger time.

### Bandwidth Mode



**Figure 20 Software Bandwidth Mode**

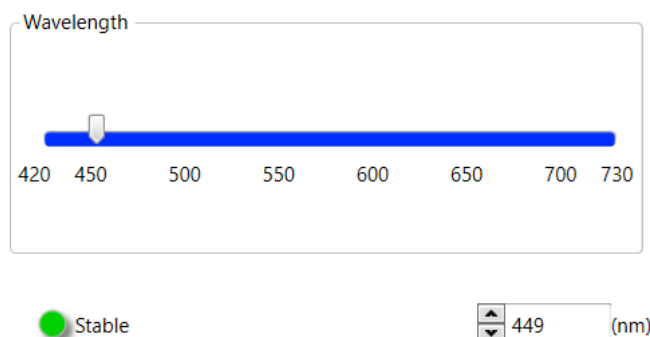
The different models of the Kurios® tunable filters have different bandwidth modes available.

K2WB1(/M), K2WL1(/M): WIDE, BLACK

K2VB1(/M): WIDE, MEDIUM, NARROW, BLACK

K2XE2(/M), K2XL1(/M): NARROW, BLACK

### Wavelength

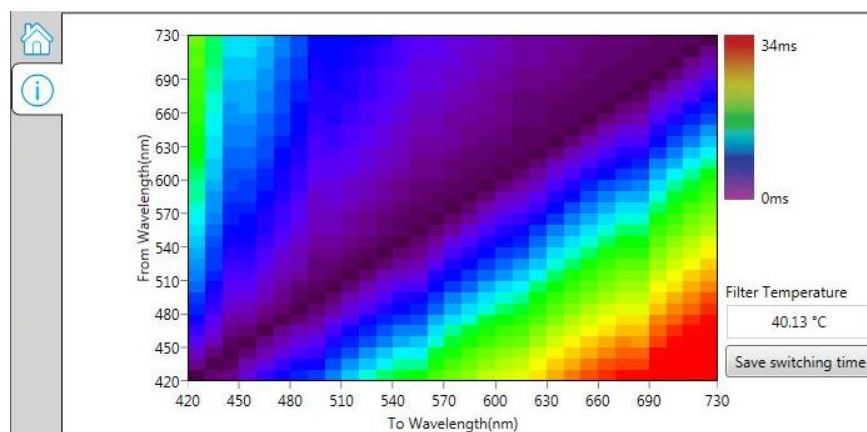


**Figure 21 Software Wavelength**

The wavelength bar indicates the current wavelength setting. Dragging the bar or inputting the wavelength in the frame sets the working wavelength.

### Wavelength Switching Time

All Kurios® filter wavelength switching times are calibrated before packaging and can be read out under the “i” tag. The read-out temperature value indicates the filters current working temperature. For best filter performance, please wait until the filter reaches 40 °C.



**Figure 22 Switching Time Matrix**

### Status Bar

This area shows the Kurios® tunable filter working status:

- Initializing:** While connecting a filter, there is a 120 second initialization time. The indicator is blue during initialization.
- Warm-Up:** The filter is warming up to 40°C. The indicator is yellow during warm-up.
- Ready:** The filter is at 40°C and is fully functional. The indicator is green when the system is ready.

### Sequence Table





- Baud Rate: 115.2 kbps
- Data Bits: 8
- Parity: None
- Stop Bits: 1
- Flow Control: None

If the connection is correct, you will see the following after pressing the Enter key (without any leading commands):

```
CMD_NOT_DEFINED
>
```

The above error indicates that an empty command (which is equivalent to an incorrect command) is sent.

The basic structure of the interface is a keyword followed by either an equal sign (=) or a question mark (?).

The = or ? character determines if the string is a command or a query. All strings, commands and queries, must be terminated by a carriage return (CR).

The command structure is as follows:

```
Keyword=argument (CR)
```

Where “keyword” defines the function and “argument” is a numerical value followed by a carriage return (CR). Note that some commands might have more than one argument, which are separated by a space character.

The query structure is as follows:

```
Keyword? (CR)
```

Where “keyword” defines the function and the question mark (?) indicates a query. The string is terminated with a carriage return (CR).

There are a few exceptions to this which are noted below. Also noted are unique shortcut keys. The following table lists the commands and queries available with this device. The prompt symbol (>) appears on power up and after a command is accepted by the controller, indicating it is ready to receive the next command.

If the command is incorrect, the controller returns `CMD_NOT_DEFINED`; if the setting value is out of range, it returns `CMD_ARG_RANGE_ERR`.

## 6.2 Command Summary

The table below lists all the available commands for the operation of KURIOS2 Controller.

Command	Syntax	Description
Get ID	*idn? or *IDN?	Returns the model number, hardware, and firmware versions
Get Specification	SP?	Returns connected filter's wavelength range
Get Optical filter Head Type	OH?	Returns two bytes integer (int 16), Top 8 bits represents filter spectrum; 0000 0001 = Visible 0000 0010 = NIR Bottom 8 bits represents available bandwidth mode: 0000 0001 = BLACK 0000 0010 = WIDE 0000 0100 = MEDIUM

		0000 1000 = NARROW
<b>Set Output Mode</b>	OM=1	Sets output mode to manual (PC or front panel control)
	OM=2	Sets output mode to sequenced, internal clock triggered
	OM=3	Sets output mode to sequenced, external triggered
	OM=4	Sets output mode to analog signal controlled, internal clock triggered
	OM=5	Sets output mode to analog signal controlled, external triggered
<b>Get Output Mode</b>	OM?	Returns the current output mode
<b>Set Bandwidth Mode</b>	BW=1	Set bandwidth mode to BLACK mode
	BW=2	Set bandwidth mode to WIDE mode
	BW=4	Set bandwidth mode to MEDIUM mode
	BW=8	Set bandwidth mode to NARROW mode
<b>Get Bandwidth Mode</b>	BW?	Returns the current bandwidth mode
<b>Set Wavelength</b>	WL=n	Where n equals a wavelength within the available wavelength range
<b>Get Wavelength</b>	WL?	Returns the current wavelength
<b>Set Sequence 1~1024 Wavelength and Time Interval</b>	SS=1~1024 n1 n2 n3*	Where n1 equals a wavelength within filter's range, and n2 equals time interval, n3 equal bandwidth
<b>Get Sequence 1~1024 Wavelength</b>	SS1~1024?	Returns one entry out of the sequence wavelength and time interval
<b>Get Entire Sequence</b>	SS?	Returns the entire sequence of wavelength and time interval
<b>Insert into Sequence</b>	IS=1~1024 n1 n2,n3*	Inserts an entry into the current sequence. n1 equals wavelength, n2 equals time interval
<b>Delete Item in Sequence</b>	DS=0~1024	Deletes an entry from the current sequence. DS=0, delete all sequence.
<b>Set Default Wavelength for All Elements in Sequence</b>	WD=n	Where n equals a wavelength within the available wavelength range.
<b>Get Default Wavelength for All Elements in Sequence</b>	WD?	Returns the current default wavelength for all elements in sequence.
<b>Set Default Bandwidth Mode for All Elements in Sequence</b>	BD=2	Set bandwidth mode to WIDE mode for all elements in sequence.
	BD=4**	Set bandwidth mode to MEDIUM mode for all elements in sequence.
	BD=8**	Set bandwidth mode to NARROW mode for all elements in sequence.
<b>Get Default Bandwidth for All Elements in Sequence</b>	BD?	Returns the current default Bandwidth Mode for all elements in sequence.
<b>Set Default Time Interval for all Elements in Sequence</b>	TI=n	Where n equals internal trigger default time between 1ms and 60000ms, applies to all all elements in sequence.
<b>Get Internal Trigger Default Time for All Elements in Sequence</b>	TI?	Returns the current internal trigger default time.
<b>Get Sequence Length</b>	SL?	Returns the sequence length
<b>Get Status</b>	ST?	Returns current filter status: 0 - initialization; 1 - warm up; 2 - ready
<b>Get Temperature</b>	TP?	Returns the current filter temperature
<b>Set Trigger Output Waveform</b>	TO=n	Where n equals 0 or 1:

		0 - normal; 1 - flipped
<b>Get Trigger Output Waveform</b>	TO?	Returns trigger output waveform setting
<b>Force Trigger</b>	ET=1	Enforce on step ahead in external triggered sequence mod
<b>Set LED Indicator Status</b>	HL=n	Where n equals 0 or 1: 0 - off; 1 - on
<b>Get LED Indicator Status</b>	HL?	Returns LED indicator status
<b>Set Trigger Input Edge</b>	TE=n	Where n equals 0 or 1: 0 - rising edge; 1 - falling edge
<b>Get Trigger Input Edge</b>	TE?	Returns trigger input edge setting
<b>Set Dark Mode Status</b>	DK=n	Where n equals 0 or 1: 0 - off; 1 - on
<b>Get Dark Mode Status</b>	DK=?	Returns dark mode setting
<b>Set Brightness</b>	BN=n	Where n equals brightness between 10% and 100%
<b>Get Brightness</b>	BN?	Returns the current brightness setting

**NOTE:** \*Only K2VB1(/M) has n3 in sequence representing the bandwidth mode.\*

**NOTE:** \*\* K2VB1(/M) has BD=4 or BD=8 to set bandwidth mode for all elements in sequence. K2XE2(/M) has default BD=8 to set bandwidth mode.\*\*

### 6.3 Description of Commands

#### \*idn? or \*IDN?– Hardware Information

Queries the optical filter head model, controller hardware and firmware versions.

Return:

```
THORLABS KURIOS2-K2VB1 SN-xxxxxxxx HWx.x FWx.x CN-xxxxxxxx
```

where SN is the optical filter head serial number, HW is the controller hardware version, FW is the firmware version, and CN is the controller serial number.

#### SP? – Filter Wavelength Range

Queries the range of wavelength that the optical filter head supports.

For VIS tunable filter return:

```
WLmax=730.000
```

```
WLmin=420.000
```

For NIR tunable filter return:

```
WLmax=1100.000
```

```
WLmin=650.000
```

where WLmax and WLmin are the maximum and minimum wavelengths that can be set, respectively.

#### OH? – Filter Features

Queries the features supported by the connected filter. The OH? command returns a 16-bit number which reports the features and bandwidth modes supported.

Return:

```
OH=n
```

where n is a 16-bit integer. When converted into binary form, n has the following Boolean structure:

```
n = 0000 0000 0000 0000
```

The higher 8-bit represents the spectral range, with

```
0000 0001 = Visible
0000 0010 = Near Infrared
```

Other values are reserved for other future filter models.

The lower 8-bit represents the bandwidth mode supported, with

```
0000 0001 = Black (beam blocking)
0000 0010 = Wide bandwidth
0000 0100 = Medium bandwidth
0000 1000 = Narrow bandwidth
```

Other values are reserved for other future filter models. More than one mode may be supported, depending on filter models.

**NOTE:** For the K2VB1(/M) optical filter head, which is a selectable bandwidth visible filter supporting BLACK, WIDE, MEDIUM, and NARROW modes, then OH? returns 271 (= 0000 0001 0000 1111).

### OM=n; OM? – Operation Mode

The OM command is used to set or query the current operation mode. There are five available modes: MANUAL, SEQUENCE (internal clock), SEQUENCE (external triggered), ANALOG (internal clock), and ANALOG (external triggered).

#### OM=n

Sets the operation mode. The value of n can be one of the following:

- n=1: MANUAL
- n=2: SEQUENCE (internal clock)
- n=3: SEQUENCE (external triggered)
- n=4: ANALOG (internal clock)
- n=5: ANALOG (external triggered)

#### OM?

Queries the current operation mode.

Return:

```
OM=n
```

where n is the current operation mode, see above for values of n.

### BW=n; BW? – Bandwidth Mode

The BW command is used to set or query the bandwidth mode of the filter. The K2WB1(/M) and K2WL1(/M) optical filter heads have two bandwidth modes available: WIDE and BLACK. The K2VB1(/M) optical filter head has four bandwidth modes available: WIDE, MEDIUM, NARROW and BLACK. The K2XL1(/M) and K2XE2(/M) optical filter heads have two bandwidth modes available: NARROW and BLACK.

#### BW=n

Sets the bandwidth mode. The value of n follows the format of the lower 8-bit reported by the OH? command. However, only one mode is supported at a time, with:

- n=1: BLACK mode

n=2: WIDE mode  
n=4: MEDIUM mode  
n=8: NARROW mode

For K2WB1(/M) and K2WL1(/M), valid values for n are 1 (BLACK) and 2 (WIDE).

For K2VB1(/M), valid values for n are 1 (BLACK) and 2 (WIDE), 4(MEDIUM), 8(NARROW).

For K2XE2(/M) and K2XL1(/M), valid values for n are 1 (BLACK) and 8 (NARROW).

### **BW?**

Queries the current bandwidth mode.

Return:

BW=n

where n is the current bandwidth mode, see above for values of n.

### **WL=n; WL? – Center Wavelength**

The WL command can be used to set or query the center wavelength.

WL=n

Sets the center wavelength. The value of n must be within WLmax and WLmin as specified by the SP? command. For the Kurios® VIS tunable filter wavelength range, the applicable range is from 420 nm to 730 nm. For the Kurios® NIR tunable filter wavelength range, the applicable range is from 650 nm to 1100 nm.

**NOTE:** Sending a WL=n command automatically changes the operation mode to MANUAL.

### **WL?**

Queries the current center wavelength.

Return:

WL=n

where n is the current center wavelength.

### **SS=n1 n2 n3 n4; SS=n1 n2; SSn?; SS? – Setup Sequence**

The SS command is used to manipulate the list used in SEQUENCE mode. It is used to adjust the wavelengths and time intervals (for internal clock mode) and bandwidth mode. If only the wavelength value is given, then the time interval is automatically set to the default value (50 ms or defined by the TI command) and the default bandwidth mode is WIDE.

#### **SS=n1 n2 n3 n4**

Sets the wavelength and time interval, where:

n1 is the index of the sequence entry, valid value ranges from 1 to 1024.

n2 is the set wavelength, in the range between WLmin and WLmax (for Kurios® VIS tunable filter wavelength, WLmin=420, WLmax=730, for Kurios® NIR tunable filter wavelength, WLmin=650, WLmax=1100).

n3 is the time interval in ms for the sequence entry before it switches to the next or loops back to the beginning of the sequence if the end of sequence is reached. Valid values of n3 ranges from 1 to 60000. If n3 is not given, then it is set to the default value of 50ms or as defined by the TI command).

n4 is the set bandwidth mode.

K2WB1(/M): valid values SS=n1 n2 n3. n4 is not given, then it is set to the default value n4=2 (WIDE).

K2WL1(/M): valid values SS=n1 n2 n3. n4 is not given, then it is set to the default value n4=2 (WIDE).

K2XE2(/M): valid values SS=n1 n2 n3. n4 is not given, then it is set to the default value n4=2 (NARROW).

K2XL1(/M): valid values SS=n1 n2 n3. n4 is not given, then it is set to the default value n4=2 (NARROW).

K2VB(/M): valid values SS=n1 n2 n3 n4 for n4 are 1 (BLACK) and 2 (WIDE), 4(MEDIUM), 8(NARROW). If n4 is not given, then it is set to the default value n4=2 (WIDE).

### **SSn?**

Queries the wavelength and time interval of a particular sequence entry where n is the sequence index.

Return:

```
SSn=n2 n3 n4
```

where n2 is the wavelength and n3 is the time interval for the enquired sequence index, n4 is the set bandwidth mode (only K2VB1(/M) has this value). If the index of the sequence entry is out of the current list range, the controller returns CMD\_ARG\_RANGE\_ERR.

### **SS?**

Queries the wavelength and time interval of the entire sequence list.

```
SS1=n12 n13 n14
```

```
SS2=n22 n23 n24
```

```
SS3=n32 n33 n34
```

```
:
```

```
:
```

If the sequence has not been initialized for the first time or has been deleted, then SS? returns the following:

```
SS=0
```

**NOTE:** When setting sequence items using the SS command which is greater than the existing sequence list length, the controller automatically fills in the intermediate values with a default wavelength of 550 nm for VIS tunable filter (or 850nm for NIR tunable filter) and time intervals of 50 ms (or values defined by the TI command). For example, if a sequence has not been initialized with the K2VB1(/M) but an SS=3 650 100 8 is sent, then the sequence becomes:

```
SS1=550.000 50 2
```

```
SS2=550.000 50 2
```

```
SS3=650.000 100 8
```

Moreover, if SS1 and SS2 has been defined but deleted (using the DS command) previously, setting values for SS3 restores the previously deleted wavelengths and time intervals for SS1 and SS2.

### **IS=n1 n2 n3 n4; IS=n1 n2 – Insert into Sequence**

The IS command is used to insert sequence entries into the existing sequence list, where:

n1 is the sequence index

n2 is the set wavelength

n3 is the time interval (in ms, from 1 to 60000)

n4 is the bandwidth mode 1 (BLACK) and 2 (WIDE), 4(MEDIUM), 8(NARROW), (K2VB1(/M) only).

The index to be inserted must be within the list that is already set up. That is, it cannot be used to specify an index which is out of the range of the current list, in contrast to the `ss` command. Again, the time interval `n3` is optional and if it is not given, default value of 50 ms or as defined by `TI` command is applied. `n4` is optional and if it is not given, default value is 2 (WIDE).

**NOTE:** When inserting sequence entries, the length of the sequence automatically increments by 1 and the entries from the current index to the end of list is shifted downward. For example, if the current list has 5 entries, inserting into the 3<sup>rd</sup> entry (`n1=3`) will update the wavelength and time interval values in index 3. The original values from index 3 to 5 will move to index 4 to 6.

If `n1` is out of the current list range, the controller returns `CMD_ARG_RANGE_ERR`.

### **DS=n – Delete Sequence Entry**

The `DS` command is used to delete an entry in the existing sequence list. The value of `n` must be within the length of the current list; otherwise, the controller returns `CMD_ARG_RANGE_ERR`. After an entry is deleted, the remaining entries after the current index are automatically shifted upward. If value `n=0`, the command deletes all sequences.

### **WD=n; WD? – Default Wavelength for all Elements in Sequences**

The `WD` command is used to set or query the default Wavelength for all elements in sequence.

#### **WD=n**

Sets the default Wavelength value `n`, in nm. Valid values of `n` ranges from 420 to 730 for VIS tunable filter and 650 to 1100 for NIR tunable filter, in nm. When a sequence list already exists, it resets the Wavelength of all elements in the current list to the value specified by `n`. If `n` is out of the allowable range, the controller returns `CMD_ARG_RANGE_ERR`.

#### **WD?**

Queries the current default Wavelength value in sequence, in nm.

Return:

`WD=n`

where `n` is the default Wavelength. If it is never specified from power on, then `n` is defined as 550 nm for VIS tunable filter and 850 nm for NIR tunable filter.

### **BD=n; BD? – Default Bandwidth Mode for all Elements in Sequences**

The `BD` command is used to set or query the default Bandwidth Mode for all elements in sequence. This command is only available for K2VB1(/M). The default Bandwidth Mode for K2WL1(/M) and K2WB1(/M) is WIDE. The default Bandwidth Mode for K2XE2(/M) and K2XL1(/M) is NARROW.

#### **BD=n**

Sets the default Bandwidth Mode. Valid values of `n` are:

`n=2` : WIDE mode

`n=4` : MEDIUM mode

`n=8` : NARROW mode

When a sequence list already exists, it resets the Bandwidth Mode of all elements in the current list to the value specified by `n`. If `n` is out of the allowable range, the controller returns `CMD_ARG_RANGE_ERR`.



**TI=n; TI? – Default Time Interval**

The **TI** command is used to set or query the default time interval for sequence list entries if they are not specified when using the **SS** and **IS** commands.

**TI=n**

Sets the default time interval value *n*, in ms. Valid values of *n* ranges from 1 to 60000. When a sequence list already exists, it also resets the time interval of all elements in the current list to the value specified by *n*. If *n* is out of the allowable range, the controller returns **CMD\_ARG\_RANGE\_ERR**.

**TI?**

Queries the current default time interval value, in ms.

Return:

TI=*n*

where *n* is the default time interval. If it is never specified from power on, then *n* is defined as 50 (or 50 ms).

**SL? – Sequence Length**

The **SL?** command queries the current length of the sequence list.

Return:

SL=*n*

where *n* is the number of entries in the current list.

**ST? – Filter Status**

Queries the current status of the optical filter head.

Return:

ST=*n*

where *n* can be one of the following:

*n*=0: Initialization. The filter is in an initialization stage to transit from idle to operation state. This initialization period takes 120 sec from power up.

*n*=1: Warm up. The internal heater is providing heat to the optical elements in order to reach a target of 40 °C, which is the optimal operating temperature of the filter. While warming up, the filter is fully operational, except that the center wavelength might be shifted, and the switching speed may be slower.

*n*=2: Ready. The temperature of the optical elements has reached 40 °C and the filter is fully operational and performs as specified.

**TP? – Filter Temperature**

The **TP?** command queries the internal temperature of the K2VB1 optical filter head. The filter is designed to operate at 40 °C and there is a heating element within the optical filter head. This temperature can be monitored in real time.

Return:

TP=*n*

where *n* is the current temperature in °C.

**TO=n; TO? – Trigger Output Setting**

The `TO` command sets or queries the trigger output operation mode. When  $n=0$ , the trigger output is in normal operation mode (low during idle, high during wavelength switch). When  $n=1$ , the trigger output is flipped (high during idle, low during wavelength switch).

**TO=n**

Sets the trigger output operation mode. Valid values of  $n$  is 0 (normal) or 1 (flipped).

**TO?**

Query the current trigger output operation mode.

Return:

`TO=n`

where  $n=0$  (normal) or  $n=1$  (flipped).

**ET=1; Enforce Trigger Out**

Supported in firmware version 2.1 or above, while filter is in external triggered sequence mode, issuing `ET=1` causes the filter to advance one step ahead, regardless of the current trigger in signal. This can be regarded as a software trigger when hardware trigger is not available.

**HL=n; HL? – LED Indicator Setting**

The `HL` command sets or queries the LED status. When  $n=0$ , the LED is OFF. When  $n=1$ , the LED is ON.

**HL=n**

Sets the LED Indicator. Valid values of  $n$  is 0 (off) or 1 (on).

**HL?**

Query the current LED status.

Return:

`HL=n`

where  $n=0$  (off) or  $n=1$  (on).

**TE=n; TE? – Trigger In Setting**

The `TE` command sets or queries the trigger in operation mode. When  $n=0$ , the trigger in is in rising edge operation mode. When  $n=1$ , the trigger in is falling edge.

**TE=n**

Sets the trigger in operation mode. Valid values of  $n$  are 0 (rising edge) or 1 (falling edge).

**TE?**

Query the current trigger in operation mode.

Return:

`TE=n`

where  $n=0$  (rising edge) or  $n=1$  (falling edge).

**DK=n; DK? – Dark Mode Setting**

The **DK** command sets or queries the Dark Mode status. When  $n=0$ , the Dark Mode is OFF. When  $n=1$ , the Dark Mode is ON.

**DK=n**

Sets the Dark Mode. Valid values of  $n$  are 0 (off) or 1 (on).

**DK?**

Query the current Dark Mode status.

Return:

DK= $n$

where  $n=0$  (off) or  $n=1$  (on).

**BN=n; BN? – Brightness Setting**

The **BN** command is used to set or query the brightness value.

**BN=n**

Sets the brightness value  $n$ . Valid values of  $n$  ranges from 10 to 100. When  $n=10$ , the brightness is min. When  $n=100$ , the brightness is max. If  $n$  is out of the allowable range, the controller returns **CMD\_ARG\_RANGE\_ERR**.

**BN?**

Queries the current brightness value.

Return:

BN= $n$

where  $n$  is the brightness value.

## Chapter 7 Troubleshooting

Below are a few checks to help in troubleshooting problems that may arise. Please contact your local Thorlabs Technical Support office with any questions.

If the unit does not appear to turn on correctly, please check the following items:

- Ensure that the main AC receptacle is powered.
- Ensure that main power cable is fully seated at both ends.
- Ensure that Kurios® filter head is connected to the controller.
- Ensure that front power switch is in the “Press” position.
- Ensure that the KURIOS2 controller displays “STABLE”.

## Chapter 8 Disposal

Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return “end of life” Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out “wheelie bin” logo (see right), were sold to and are currently owned by a company or institute within the EC and are not disassembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own



responsibility. “End of life” units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site. It is the user’s responsibility to delete all private data stored on the device prior to disposal.

## Chapter 9 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at [www.thorlabs.com/contact](http://www.thorlabs.com/contact) for our most up-to-date contact information.



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