



# FW102C, FW102CNEB, FW212C, FW212CNEB Motorized Filter Wheel

## User Guide



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## Chapter 1 Warning Symbol Definitions

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or Chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution: Risk of Electric Shock
	Caution: Hot Surface
	Caution: Risk of Danger
	Warning: Laser Radiation
	Caution: Spinning Blades May Cause Harm

## 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.



### ATTENTION



**Do not use the filter wheel in explosive environments.**



### ATTENTION



**Filter wheel is not intended for use in an outdoor environment.**



### WARNING



**Prior to opening, troubleshooting, changing filters or maintaining the unit, ensure that the power is off and the unit is disconnected from the DC source.**

### Original Instructions Written in English

**These instructions were drafted in English. Thorlabs is not responsible for the content of any manual translated into another language.**

## Chapter 3 Description

The FW102C, FW102CNEB, FW212C, and FW212CNEB are high-precision, motor-driven filter wheels used for a host of applications, including color CCD photography, fluorescence microscopy, and photometry. The FW102CNEB and FW212CNEB are the same as the FW102C and FW212C, respectively, with preloaded filters. (See which filters on page 7)

All units consists of a control unit, filter wheel housing, and a removable Ø4" filter wheel. The FW102C Filter Wheel accommodates up to six Ø1" optical filters, while the FW212C can accommodate up to twelve Ø1/2" optical filters.

**Note: The FW102CNEB and FW212CNEB Filters Wheels come with preloaded filters.**

Filter selection can be made manually from the push button controls on the display panel or remotely from a USB 2.0 interface, a serial port, or a TTL level active low (BNC) input. Both filter wheels contain an active display to indicate the selected filter: two separate aperture openings exist, the first opening at the top of unit 12 o'clock position or 0° and the second opening at the 7 o'clock position or 210° degrees. (see drawing on page 14)

All units are designed to ensure an accuracy of greater than  $\pm 1^\circ$ . The FW102C filter wheel housing easily mounts to our Ø1" lens tube systems and optical instruments via two SM1 (1.035"-40) threaded mounts. The FW212C housing includes four SM1A6FW SM1 to SM05 (0.535"-40) adapters for mounting our Ø1/2" lense tube systems. Other adapters are available to interface to other popular camera, microscope, and telescope thread sizes. All units are also compatible with Thorlabs' 30 mm cage systems; each port has the required four 4-40 tapped holes to mount the cage rods. They also also feature #8 and M6 tapped holes for mounting to steel posts. Two 1/4"-20 and M6 tapped holes allow the filter wheel to be mounted to a plate (See Drawing on Page 7). The flexible mounting system makes these filter wheels ideal for both instrument and laboratory applications.

All units come with a CD-ROM that contains a Windows™ -based, standalone application program. Sample code is provided for LabVIEW™ and C++ code development. The filter wheels can also be controlled via a set of command line prompts using terminal server software, allowing users to create scripts in their own programs. The unit is powered via a 12 VDC input (converter supplied with unit).

### 3.1. Features

- Automated Computer Control Capability (Application Software Provided)
- Wheel Size: Ø4"
- Filter Wheel Options:
  - FW102C: 6-Position for Ø1" Filters
  - FW102CNEB: 6-Position with Preloaded Ø1" filters (See Page 8 for Included Filters)
  - FW212C: 12-Position for Ø1/2" Filters
  - FW212CNEB: 12-Position with Preloaded Ø1/2" Filters (See Page 8 for Included Filters)
- External Trigger In (Increment Control)
- External Trigger Out (Provisioned from Software)
- Bidirectional Controls
- Selectable Aperture Openings at 0° (12 o'clock position) and 210° (7 o'clock position)
- Dimmable Display

### 3.2. New Design

The FW102C and FW212C lines feature a new, more robust design compared to the older FW102B. The filter wheel is turned using a powerful and reliable stepper motor and worm gear. This design will provide millions of wheel changes over its life time.



#### ATTENTION



**Due to play in the gears, some noise can be heard during operation and when moving or shaking the device. There are virtually no small parts that can come loose inside the device. This noise is normal and not indicative of a problem.**

### 3.3. Shipping Inventory

The FW102C, FW102CNEB, FW212C and FW212CNEB are shipped with the following components respectively:

Part Description	Qty.	FW102C	FW212C	FW102CNEB	FW212CNEB
Controller with Filter Housing	1	✓	✓	✓	✓
6-Position Wheel, Ø1" Optics	1	✓	✗	✓	✗
12-Position Wheel, Ø1/2" Optics	1	✗	✓	✗	✓
SM1A6FW SM1 to SM05 Adapter	4	✗	✓	✗	✓
12 V DC Converter	1	✓	✓	✓	✓
Power Cord	1	✓	✓	✓	✓
USB Cable	1	✓	✓	✓	✓
SM1CP2 End Cap, SM1 Thread	2	✓	✗	✓	✗
SM05CP2 End Cap, SM05 Thread	2	✗	✓	✗	✓
SM1RR Retaining Ring	6	✓	✗	✓	✗
SM05RR Retaining Ring	12	✗	✓	✗	✓
NE501B Absorptive ND Filter	1	✗	✗	✗	✓
NE502B Absorptive ND Filter	1	✗	✗	✗	✓
NE503B Absorptive ND Filter	1	✗	✗	✗	✓
NE504B Absorptive ND Filter	1	✗	✗	✗	✓
NE505B Absorptive ND Filter	1	✗	✗	✗	✓
NE506B Absorptive ND Filter	1	✗	✗	✗	✓
NE510B Absorptive ND Filter	1	✗	✗	✗	✓
NE513B Absorptive ND Filter	1	✗	✗	✗	✓
NE520B Absorptive ND Filter	1	✗	✗	✗	✓
NE530B Absorptive ND Filter	1	✗	✗	✗	✓
NE540B Absorptive ND Filter	1	✗	✗	✗	✓
NE550B Absorptive ND Filter	1	✗	✗	✗	✓
NE05B Absorptive ND Filter	1	✗	✗	✓	✗
NE10B Absorptive ND Filter	1	✗	✗	✓	✗
NE20B Absorptive ND Filter	1	✗	✗	✓	✗
NE30B Absorptive ND Filter	1	✗	✗	✓	✗
NE40B Absorptive ND Filter	1	✗	✗	✓	✗



Figure 1 FW102C Filter Wheel System

## Chapter 4 Basic Operation

The following sections describe the basic operation of the motorized filter wheels and application software.

### 4.1. Changing and Removing the Filters



#### WARNING



**Prior to changing filters, ensure that the power is off and the unit is disconnected from the DC source.**

The filters can be changed by first removing the filter wheel cover, which is held in place with a single thumbscrew. Filters can then be inserted into the desired locations for either a six- or twelve-position wheel. The filters for the six-position wheels are secured via SM1RR retaining rings, while the filters for the twelve-position wheel are secured using SM05RR retaining rings, all which are included with the specified unit. For easy access, the entire filter wheel can be lifted out of the filter wheel housing. Please note that the rear edge of the threaded filter holes contain a retaining lip that secures the edge of the filter (see figure 2). Some smaller filters may need to be mounted between two retaining rings to be properly secured.



**Figure 2 Rear Retaining Lip**

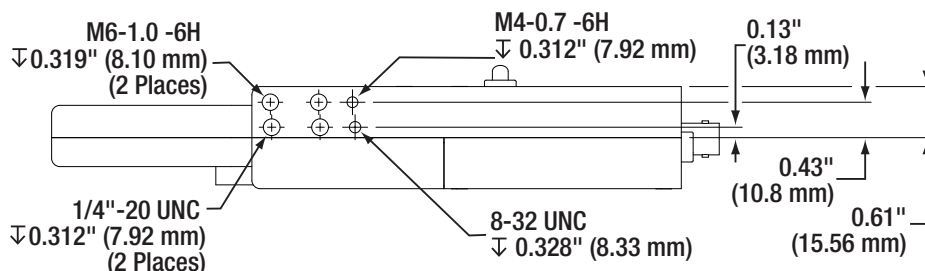
Thorlabs offers preloaded filter wheels if that is desired. The table below outlines which filters are included with each system, their optical density, and the position they are mounted in.

FW102CNEB			FW212CNEB		
Filter Item #	Optical Density	Position	Filter Item #	Optical Density	Position
Blank	N/A	1	Blank	N/A	1
NE05B	0.5	2	NE501B	0.1	2
NE10B	1.0	3	NE502B	0.2	3
NE20B	2.0	4	NE503B	0.3	4
NE30B	3.0	5	NE504B	0.4	5
NE40B	4.0	6	NE505B	0.5	6
-	-	-	NE506B	0.6	7
-	-	-	NE510B	1.0	8
-	-	-	NE513B	1.3	9
-	-	-	NE520B	2.0	10
-	-	-	NE530B	3.0	11
-	-	-	NE540B	4.0	12

Once the filter wheel has been populated with filters and properly installed, the process of reassembling the filter wheel goes as follows: slip the wheel over the shaft and turn slightly to allow the gears to mesh, replace the cover and tighten the thumb screw. It is not necessary to return the wheel to any particular orientation; the unit will reorient automatically when the power is turned on.

## 4.2. Mounting

The base of the unit contains an array of mounting holes for attaching to steel posts or directly to other mounting plates. See Figure 3 below for whole sizes and locations.



**Figure 3 Filter Wheel Mounting Holes**

The filter wheel cover contains SM1 threads for attaching lens tubes or for mounting the unit directly to cameras, microscopes, and telescopes. The filter wheel can be attached directly to Thorlabs' 30 mm cage systems via four 4-40 tapped holes that surround each port.

## 4.3. Power

The unit comes with an AC wall adapter to supply 12 VDC to the unit. Plug the 2.1 mm plug from the AC adapter into the DC input jack on the unit. The ON/OFF (0/1) switch is located on the side of the unit. Upon power up, the unit will display the filter number that is located at the selected aperture. If the wheel is not located at a valid location, it will rotate to the closest valid position.

**Power Supply**  
Thorlabs Filter Wheel

**Input Voltage Rating:** 90-264 VAC, 47-63 Hz

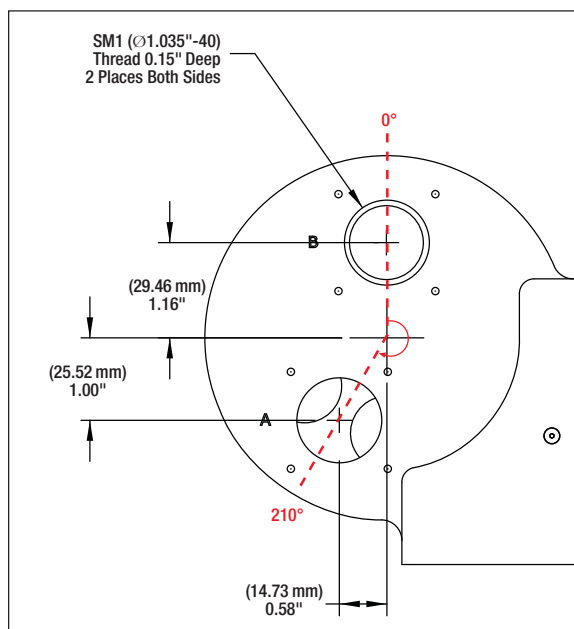
**Max Voltage Input:** 12.6 V DC

**Max Current Input:** 2.08 A



## 4.4. Aperture

The unit has two aperture locations labeled “A” and “B” for the 0° (12 o'clock position) and 210° (7 o'clock position), respectively (see Figure 3 below). The A/B switch on the side of the unit selects the aperture.



**Figure 4** Filter Wheel Apertures

## 4.5. Manual Control

Pushing the ▲ / ▼ arrow buttons on the top of the unit will adjust the filter location. The arrows indicate the direction of the wheel's rotation, and the display will indicate the filter selection. The display brightness can be adjusted using a small screwdriver at the hole marked DIM (see figure 5).



**Figure 5** DIM Display Brightness

## 4.6. External Trigger

The unit may be remotely triggered to advance to the next position. This is done by applying an active low pulse to the BNC trigger input. The input is TTL compatible and should not exceed 5 V. Because the input is internally pulled up, the trigger will operate with a passive connection to ground. The trigger mode defaults on power up to an input mode. Software provisioning can, however, change the trigger mode to an output mode. In the output mode, the unit generates an active high 10 ms pulse (TTL level) to indicate that the wheel has completed its rotation to the selected position. This pulse may be used to activate other equipment. The trigger can be changed to the output mode from the application software or by sending the command “Trig=1” over the USB interface.

## Chapter 5 Software Control

### 5.1. Application Software Operation

The FW102C(NEB) and FW212C(NEB) come with a CD-ROM that contains application software to control the unit using USB 2.0, or RS232, from a PC. (See Thorlabs Motorized Filter Wheel Software Manual).

#### **Minimum PC Requirements**

The application program requires a minimum of a Pentium-class machine running Windows XP or newer.

### 5.2. Command Line Interface

The FW102C can also be controlled by a command line language through the USB or RS232 ports. This is offered to enable operation through a terminal interface or for those who may want to write their own program to control the wheel. Prior to running the command line interface, the unit should be powered, and a USB or RS232 cable should be connected between the FW102C and the host. The terminal emulator should be configured as follows:

Parameter	Setting
Baud Rate	115.2 K Bits per Second
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

If the connection is correct, you will see the following message after pushing the *Enter* key:

*Command error CMD\_NOT\_DEFINED*

This message will be followed immediately by the prompt:

>

The basic structure of the interface is a keyword followed by either an equals sign “=” or a question mark “?”. The “=” or “?” will determine if the string is a command or a query. All strings (commands and queries) must be terminated by a carriage return (CR) or pressing the ENTER key on the computer.

#### 5.2.1. Command Structure

*Keyword = argument (CR)*

Here, *keyword* defines the function, and *argument* is a numerical value followed by a carriage return (CR).

#### 5.2.2. Query Structure

*Keyword? (CR)*

*Keyword* defines the function, and the question mark (?) indicates a query. The string is terminated with a carriage return (CR). Exceptions to this and unique shortcut keys are given in the table on page 11.

The prompt symbol “>” will appear on power-up and after a command is accepted by the FW102C and indicates that the FW102C is ready to receive another command line.

### 5.2.3. Keywords (Commands and Queries)

The following table describes all of the available commands and queries:

Command	Syntax	Description
Get ID	*idn?	Returns the model number and firmware version
Set Position	pos=n	Moves the wheel to filter position n
Get Position	pos?	Position Query
Set Position Count	pcount=n	Sets the wheel type where n is 6 or 12
Get Position Count	pcount?	Returns the wheel type
Set Trigger Mode	trig=0	Sets the external trigger to the input mode
	trig=1	Sets the external trigger to the output mode
Get Trigger Mode	Trig?	Returns the trigger mode
Set Speed Mode	speed=0	Sets the move profile to slow speed
	speed=1	Sets the move profile to high speed
Get Speed Mode	speed?	Returns the move profile mode
Set Sensor Mode	sensors=0	Sensors turn off when wheel is idle to eliminate stray light
	sensors=1	Sensors remain active
Get Sensor Mode	sensors?	Returns the sensor mode
Set Baud Rate	baud=0	Sets the baud rate to 9600
	baud=1	Sets the baud rate to 115200
Get Baud Rate	baud?	Returns the baud rate where 0 = 9600 and 1 = 115200
Save Settings	save	This will save all the settings as default on power up

<sup>a</sup>All commands and queries are in lower case letters.

If the keyword, format, or argument are incorrect or out of range, the unit will return an error string.

In addition to the commands given above, there is also special functionality added to the arrow keys of the computer's keyboard:

Key	Description
Up Arrow	Increments the filter position by 1
Down Arrow	Decrements the filter position by 1

## Chapter 6 Troubleshooting and Maintenance



### WARNING



Prior to troubleshooting or maintaining the unit, ensure that the power is off and the unit is disconnected from the DC source.

Dust or debris can sometimes get into the filter wheel housing and block the sensors. This will result in the filter wheel failing to move to the desired position. To prevent this, periodically remove the filter wheel and use compressed air to clear away any contaminants. Externally the unit can be cleaned with a damp cloth to remove dust or debris.

### 6.1. Removing the Filter Holder

The filter holder may be tight and difficult to remove. To make the wheel release with the minimal of force, grab it on the right side (by filter position 5 in image below) and pull the wheel out and to the left as depicted by the large red arrow.

When reinserting the wheel, push the filter holder onto the post jiggling the holder clockwise and counterclockwise to help align the gears.

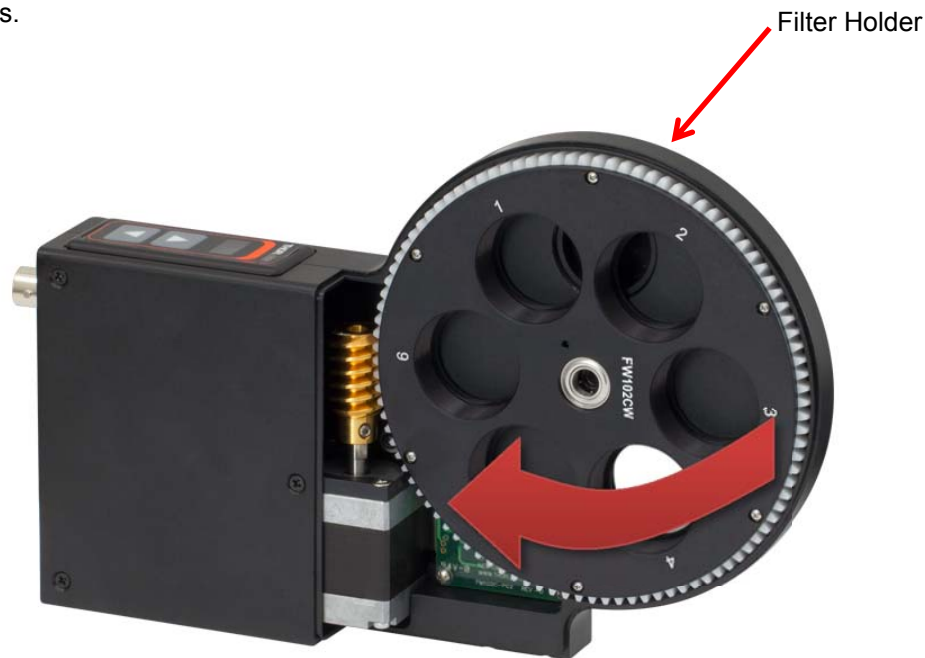


Figure 6 Open Filter Wheel

## 6.2. Changing Filter Wheel Types

When changing filter wheel types (i.e. from a 6- to 12-position wheel), the unit will need to be set to a mode that will correctly interpret the correct position of the wheel. To convert the unit from 6-position wheel operation to 12-position wheel operation, follow the steps below (process is similar for the other way around):

1. Unplug the power from the unit
2. Unscrew the thumbscrew and remove housing
3. Remove the 6-position wheel and insert the 12-position wheel
4. Reinstall the housing and secure with the thumbscrew
5. Plug the power cable back into the unit
6. Turn on the unit and select a position for the wheel other than 6 or 12
7. Hold down both arrow buttons until the display shown 6 or 12. This means that the unit is in the mode select menu.
8. The down arrow will then select the 6-position and the up arrow will select the 12-position. Press the up arrow button and make sure the display shows 12.
9. Hold down both arrow buttons until the display shows a different number (~3 s)
10. The unit is now able to operate a 12-position wheel

## 6.3. Error Codes & Troubleshooting

The following table describes some typical problems that may be encountered while using the FW102C or FW212C and possible solutions to these problems.

Problem	Solution
<b>Unit does not turn on when switching the power switch to the ON position.</b>	<ol style="list-style-type: none"> <li>1. Make sure the AC line cord is fully inserted into the AC input receptacle and plugged into an outlet providing 100 to 240 VAC.</li> </ol>
<b>I can't connect to the FW102C/FW212C over the USB port.</b>	<ol style="list-style-type: none"> <li>1. Make sure the unit is turned on prior to connecting the USB.</li> <li>2. Power off unit, remove AC cord, remove the USB cable, reattach AC cord, power on unit and reattach the USB cable.</li> <li>3. Make sure USB drivers are installed.</li> </ol>
<b>Error Code "E#"</b>	<ol style="list-style-type: none"> <li>1. Make sure the filter wheel is installed correctly, that the housing is seated correctly, and the thumbscrew is secure.</li> <li>2. Remove the housing cover and filter wheel use compressed air to clear any dust or debris from the inside of the housing and green circuit board. If dust or debris blocks the sensors, this will result in erroneous filter wheel position movements or may cause the unit to seize.</li> <li>3. Remove and inspect the blunt crenulated patterns cut into the inner rim of the wheel (opposite side of engraving). If one or more are bent or broken off, the sensors will be unable to read the correct position and the wheel will need to be replaced.</li> </ol>

## Chapter 7 Specifications

### 7.1. Performance

Parameter	Min	Typical	Max
<b>Access Time (Adjacent Locations)</b>			
FW102C, FW102CNEB	-	<1 s	-
FW212C, FW212CNEB	-	<0.5 s	-
<b>Access Time (Other Locations)</b>			
FW102C, FW102CNEB	-	2.5 s	-
FW212C, FW212CNEB	-	2.5 s	-
<b>Accuracy / Repeatability</b>	-	$\pm 2^\circ$	-
<b>Expected Cycles</b>	$1.5 \times 10^6$	-	-

### 7.2. Electrical

Parameter	Min	Typical	Max
<b>BNC Input Trigger</b>			
<b>Max Rate</b>	-	-	0.5 pulses/sec
<b>Minimum Pulse Width</b>	1.0 ms	-	-
<b>BNC Input Trigger<sup>1</sup></b>			
<b>Input High</b>	3.3 V	4.5 V	5.3 V
<b>Input Low</b>	-0.3 V	0.0 V	1.0 V
<b>BNC Output Trigger</b>			
<b>Output Pulse Width</b>	9.0 ms	10.0 ms	11.0 ms
<b>Output High<sup>2</sup></b>	2.5 V (1 k $\Omega$ )	3.3 V (1.95 k $\Omega$ )	5.0 V (Hi Z)
<b>Output Low<sup>2</sup></b>	0.0 V	0.0 V	1.0 V
<b>Power (DC Input, 1 A)</b>	11.75 VDC	12 VDC	12.25 VDC
<b>Operating Temperature</b>	0 °C	-	60 °C

<sup>1</sup> The BNC input trigger is an active low input. The input has an internal 1 k $\Omega$  input resistor. Grounding the center conductor of the jack will activate the trigger.

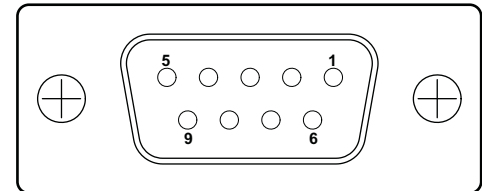
<sup>2</sup> When operating as an output, the unit output driver is configured in series with a 1 k $\Omega$  resistor.

### 7.3. Physical characteristics and Interface

Parameter	FW102C(NEB)	FW212C(NEB)
Trigger Jack	BNC Female	
Power Jack	Male 2.1 MM	
USB Connector	Mini B	
Mounting	(2) 1/4"-20, 8-32, (2) M6, M4, (2) SM1 Thread	
Max Planar Filter Width	0.25" (6.35 mm)	
Dimensions (L x W x H)	5.44" x 1.85" x 4.39" (138 mm x 47 mm x 112 mm)	
Weight (Without Power Supply)	1.65 lbs. (0.75 kg)	

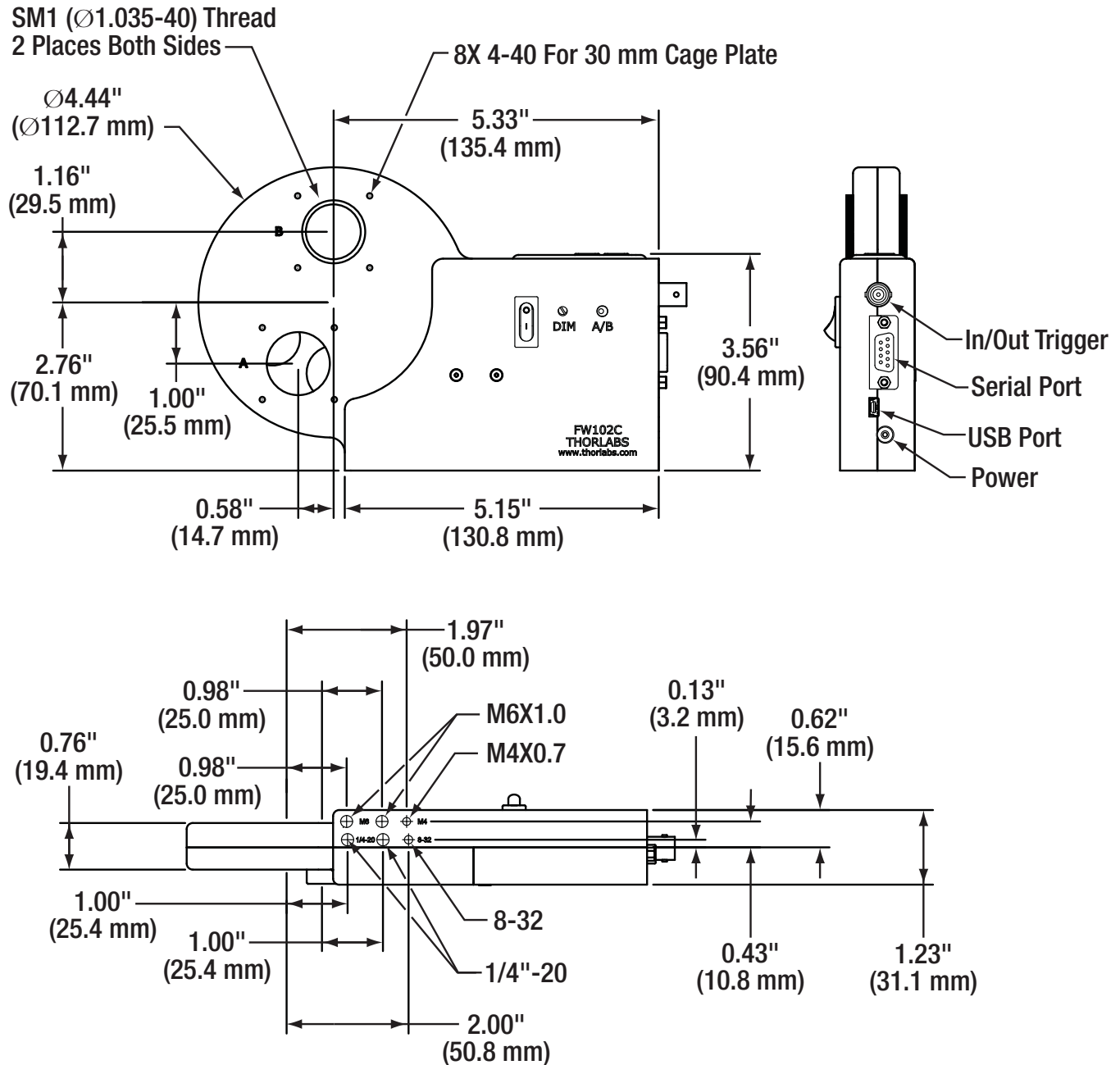
### 7.4. Pin Diagram

Pin	Connector	Pin	Connector
1	N.C.	6	N.C.
2	TR2 (From Housing)	7	Connected to Pin 8
3	RX2 (To Housing)	8	Connected to Pin 7
4	N.C.	9	N.C.
5	Signal Ground		



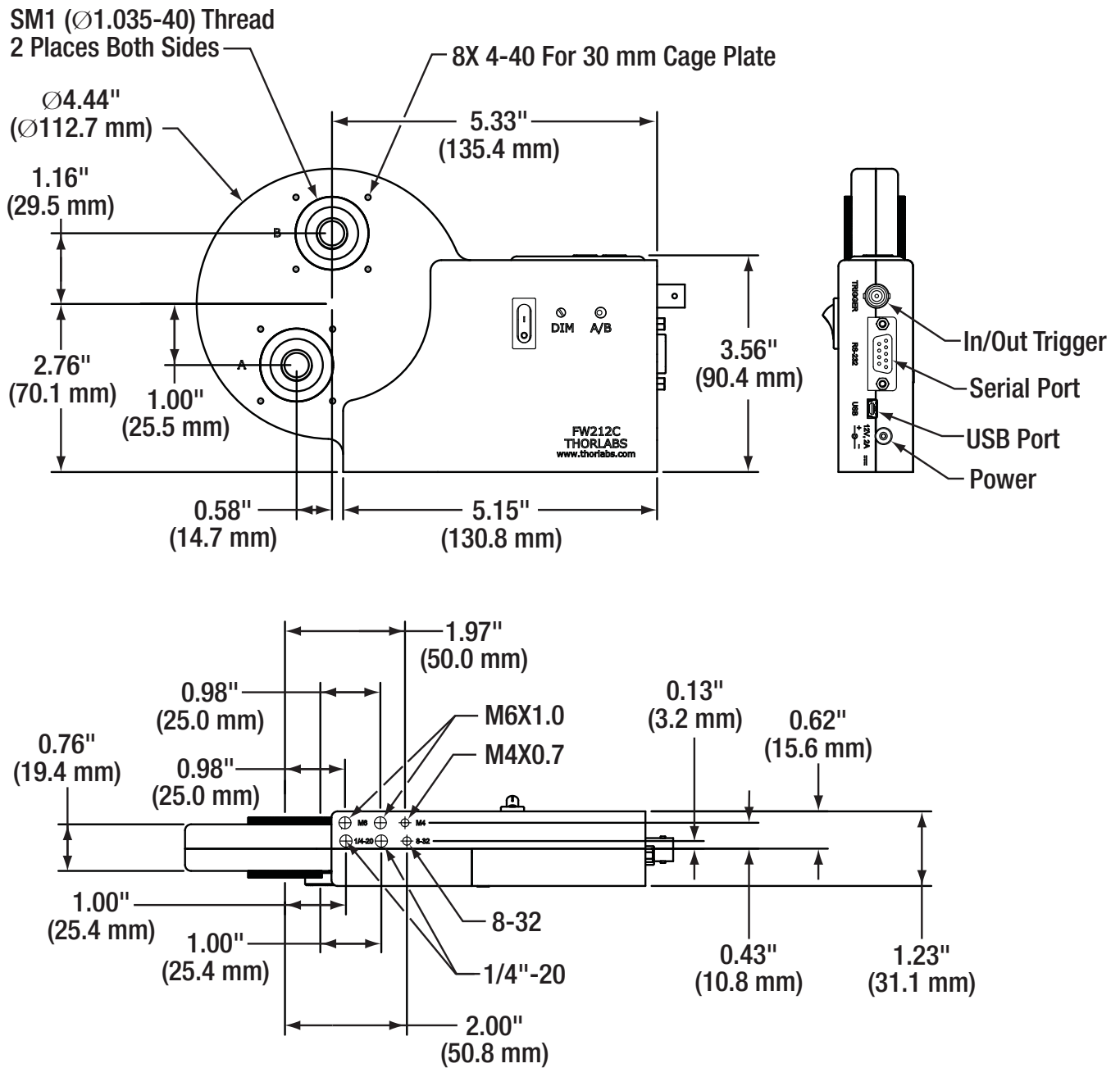
## Chapter 8 Mechanical Drawings

### 8.1. FW102C, FW102CNEB





## 8.2. FW212C, FW212CNEB



## Chapter 9 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



**Wheelie Bin Logo**

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

### Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

### Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

### FCC Rules

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 10 Thorlabs Worldwide Contacts

### USA, Canada, and South America

Thorlabs, Inc.  
56 Sparta Avenue  
Newton, NJ 07860  
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Tel: 973-300-3000  
Fax: 973-300-3600  
www.thorlabs.com  
www.thorlabs.us (West Coast)  
Email: sales@thorlabs.com  
Support: techsupport@thorlabs.com

### Europe

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Hans-Böckler-Str. 6  
85221 Dachau / Munich  
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Tel: +49-(0) 8131-5956-0  
Fax: +49-(0) 8131-5956-99  
www.thorlabs.de  
Email: europe@thorlabs.com

### France

Thorlabs SAS  
109, rue des Côtes  
78600 Maisons-Laffitte  
France  
Tel: +33 (0) 970 444 844  
Fax: +33 (0) 825 744 800  
www.thorlabs.com  
Email: sales.fr@thorlabs.com

### Japan

Thorlabs Japan, Inc.  
3-6-3 Kitamachi,  
Nerima-ku, Tokyo 179-0081  
Japan  
Tel: +81-3-6915-7701  
Fax: +81-3-6915-7716  
www.thorlabs.co.jp  
Email: sales@thorlabs.jp

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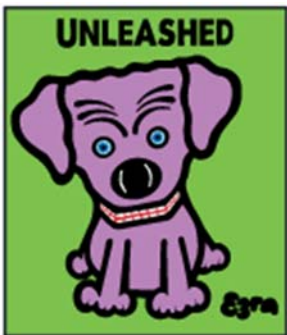
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