Finger Lakes Instrumentation

Engineering Excellence

Because Your Image Depends On It

High Speed Filter Wheel

User's Guide

June 2018

WELCOME

Thank you for purchasing an FLI High Speed Filter Wheel. We know that this accessory will bring you years of excellent imaging results.

This User's Guide is intended as a reference tool for you to use with FLI High Speed Filter Wheel. Please read it and follow the procedures to ensure trouble-free installation of your hardware. For information on other FLI products, or to discuss your High Speed Filter Wheel, please contact:

sales@flicamera.com

If you have any questions about your purchase, please contact us.

CONTACT INFORMATION

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https://www.flicamera.com

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PRODUCT SAFETY

This FLI High Speed Filter Wheel is shipped with a 24V DC power supply. Do not use any other power supply with this FLI High Speed Filter Wheel, or use the power supply in a way other than described in this guide. Doing so may cause damage to the High Speed Filter Wheel that will not be covered under the warranty.

If you are concerned about lightning strikes in the area you use your High Speed Filter Wheel, you may want to take safety precautions as electrical surges can damage electrical equipment. We recommend that when your High Speed Filter Wheel is not in use that you unplug the High Speed Filter Wheel from power and any RS-232 cables.

HIGH SPEED FILTER WHEEL OVERVIEW

High Speed Filter Wheels (HSFW) use high-performance servo motors, which feature rare earth magnets coupled with backlash-free power transfer. This provides ultimate torque which translates to unparalleled speed. Filter exchange rates under 30 milliseconds are possible.

In addition to the servo motor's use of encoder feedback, which yields reliable operation, the High Speed Filter Wheel also features state-of-the-art semiconductor components, a high-performance Digital Signal Processor (DSP), and a sophisticated control algorithm.
The control system optimizes the trajectory to result in maximum speed with minimum vibration, and also adapts to the changes in load. When filters are added or removed, the controller parameters must be adjusted in order to maintain peak performance. A built-in adaptation mechanism takes care of these adjustments providing optimum performance under any operating conditions.

All of the drive and control electronics facilitating the functionality of the High Speed Filter Wheels are contained in the filter wheel housing. This convenient solution eliminates the need for an external controller and the associated wiring hassles. It is possible to operate multiple filter wheels through the same serial port by connecting up to three High Speed Filter Wheels in a linear series, or daisy-chain. Simply connect a computer to the input port and a second wheel to the output port to achieve functionality equivalent to a two-wheel system driven by a central control unit. Up to three filter wheels can be operated from the same serial port. Along side its motor drive and control circuitry, the High Speed Filter Wheel features an integrated circuit board including a shutter controller allowing for a direct connection of a shutter without the need of external drive electronics.

High Speed Filter Wheel Specifications

	HS-625	HS-632	HS-1025	HS-1032
Voltage	24V DC			
Power	120 W			
PC Connection	RS-232			
Filter Diameter	25 mm	32 mm	25 mm	32 mm
Adjacent Filter Transition	23 ms	30 ms	30 ms	30 ms
Longest Distance (5 Filter Positions or 180 Degree Wheel Turn)	90 ms			
Shutter Open Pulse	24 V			
Shutter Open Hold	4 V			

Note: Shutter information does not apply to the HS-632

Filter Information

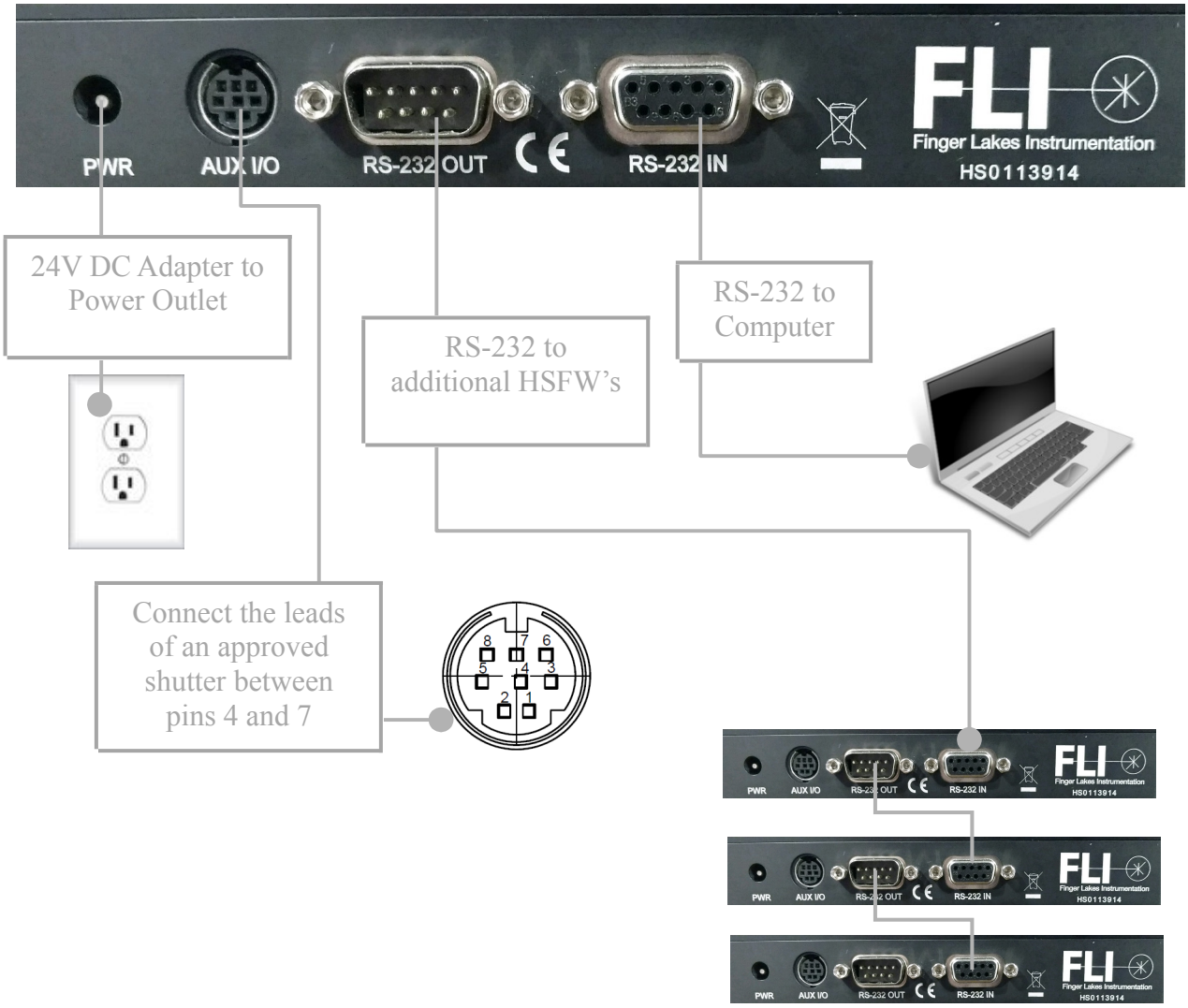
High Speed Filter Wheel	Filter Size	Filter Thickness
HS-625	25 ± 0.4 mm	1 mm – 9 mm
HS-632	32 ± 0.2 mm	1 mm – 9 mm
HS-1025	25 ± 0.1 mm	1 mm – 9 mm
HS-1032	32 ± 0.2 mm	1 mm – 9 mm
HS-1032 (With a 25 mm Filter Insert Adapter)	25 ± 0.1 mm	1 mm – 9 mm

RS-232 Settings

Baud	9600
Data Bits	8
Stop Bits	1
Parity	None
Flow Control	None

FILTER WHEEL CONNECTIONS

Connecting the HSFW to a Computer



INSTALLING FILTERS FOR HIGH SPEED FILTER WHEEL

1. Remove power supply connection from the High Speed Filter Wheel and remove the RS-232 cable from either the High Speed Filter Wheel or from the computer.

2. Carefully remove the High Speed Filter Wheel's filter port cover from the housing (if applicable).

3. Rotate the filter wheel to the position of the filter pocket to be populated.

   Note: On the HS-1025 and HS-1032 the filter pocket index is visible through the slot above the filter port. On the HS-625 and HS 632 models the filter pocket index is visible when replacing the filters through the filter port.

4. Remove the retainer ring from the filter pocket.

5. Place a circular filter into the filter pocket.

6. Replace the retainer ring, making sure not to over tighten the retainer ring.

7. Repeat steps 3 through 6 to install filters in remaining pockets.

8. Replace the filter port cover and fasten into housing (if applicable).

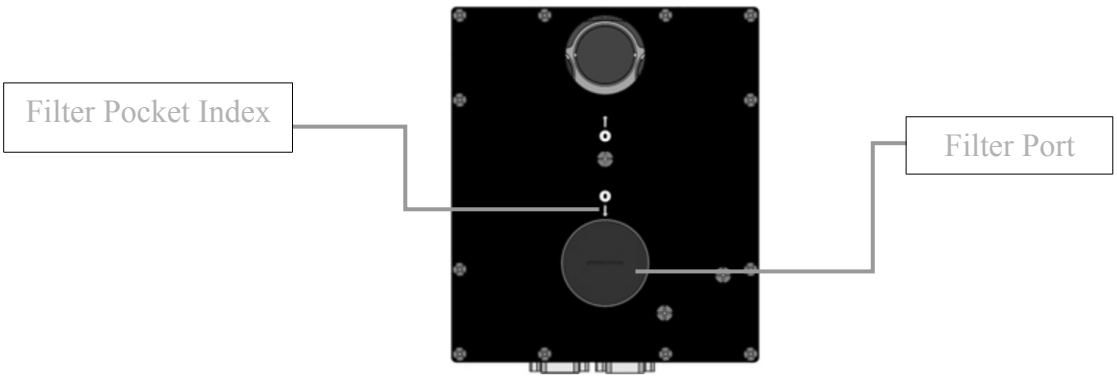


Fig. 1: HS-10xx

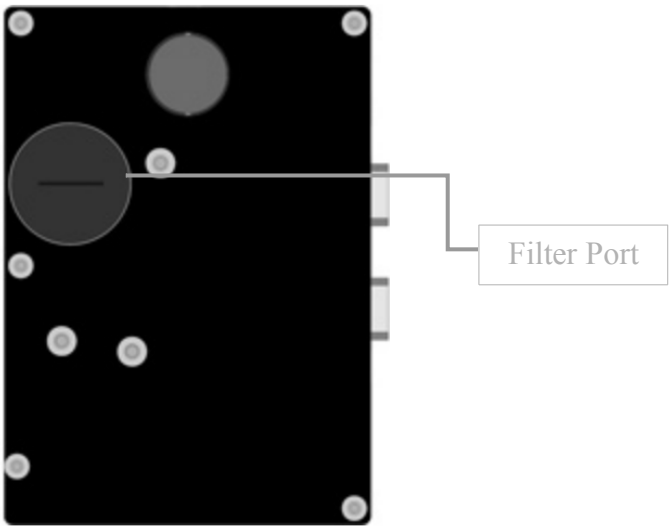


Fig. 2: HS-625

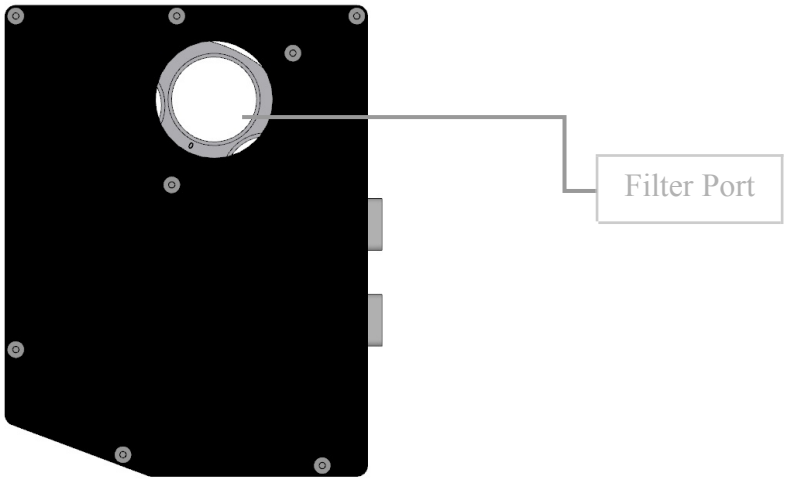


Fig. 3: HS-632

ACCESSORIES

For more information on any accessories that may be available for your High Speed Filter Wheel, please contact Finger Lakes Instrumentation, LLC by phone or email at:

585-624-3760
sales@flicamera.com

The spanner wrench is available for installing filters into the High Speed Filter Wheel more efficiently. The spanner wrench is designed to work for both 25mm and 32mm retainers.

Fig. 4: Spanner Wrench (Part# 24712)

COMMANDS

Get Filter Wheel Status

Byte 1: 0xCC							
7	6	5	4	3	2	1	0
1	1	0	0	1	1	0	0

Response: When requesting the wheel status, the device responds with the received command (CC hexadecimal) immediately and requests configuration information from a daisy-chained wheel.

Byte 1-11										
1	2	3	4	5	6	7	8	9	10	11
0xCC	WAST	WBST	-	WCST	SAST	SBST	SAMOD	-	SBMOD	0x0D

Byte 1: 0xCC								
Bit	7	6	5	4	3	2	1	0
Name	1	1	0	0	1	1	0	0

Byte 2: WAST (Wheel A Speed and Position)								
Bit	7	6	5	4	3	2	1	0
Name	0	SPD2	SPD1	SPD0	POS3	POS2	POS1	POS0

Wheel Speed	Wheel Position (0-9)
000 (0) Speed = 0	0000 (0) Position = 0
001 (1) Speed = 1	0001 (1) Position = 1
010 (2) Speed = 2	0010 (2) Position = 2
011 (3) Speed = 3	0011 (3) Position = 3
100 (4) Speed = 4	0100 (4) Position = 4
101 (5) Speed = 5	0101 (5) Position = 5
110 (6) Speed = 6	0110 (6) Position = 6
111 (7) Speed = 7	0111 (7) Position = 7
	1000 (8) Position = 8
	1001 (9) Position = 9

Byte 3: WBST (Wheel B Speed and Position)								
Bit	7	6	5	4	3	2	1	0
Name	1	SPD2	SPD1	SPD0	POS3	POS2	POS1	POS0

Wheel Speed	Wheel Position (0-9)
000 (0) Speed = 0	0000 (0) Position = 0
001 (1) Speed = 1	0001 (1) Position = 1
010 (2) Speed = 2	0010 (2) Position = 2
011 (3) Speed = 3	0011 (3) Position = 3
100 (4) Speed = 4	0100 (4) Position = 4
101 (5) Speed = 5	0101 (5) Position = 5
110 (6) Speed = 6	0110 (6) Position = 6
111 (7) Speed = 7	0111 (7) Position = 7
	1000 (8) Position = 8
	1001 (9) Position = 9

Byte 5: WCST (Wheel C Speed and Position)								
Bit	7	6	5	4	3	2	1	0
Name	1	SPD2	SPD1	SPD0	POS3	POS2	POS1	POS0

Wheel Speed	Wheel Position (0-9)
000 (0) Speed = 0	0000 (0) Position = 0
001 (1) Speed = 1	0001 (1) Position = 1
010 (2) Speed = 2	0010 (2) Position = 2
011 (3) Speed = 3	0011 (3) Position = 3
100 (4) Speed = 4	0100 (4) Position = 4
101 (5) Speed = 5	0101 (5) Position = 5
110 (6) Speed = 6	0110 (6) Position = 6
111 (7) Speed = 7	0111 (7) Position = 7
	1000 (8) Position = 8
	1001 (9) Position = 9

Byte 6: SAST (Shutter A State)								
Bit	7	6	5	4	3	2	1	0
Name	1	0	1	0	1	SHST2	SHST1	SHST0

Shutter State
010 (1) Open
011 (2) Open on ext. trigger
100 (3) Closed

Byte 7: SBST (Shutter B State)								
Bit	7	6	5	4	3	2	1	0
Name	1	0	1	1	1	SHST2	SHST1	SHST0

Shutter State
010 (1) Open
011 (2) Open on ext. trigger
100 (3) Closed

Byte 8: SAMOD (Shutter A Mode)								
Bit	7	6	5	4	3	2	1	0
Name	1	1	0	1	1	SHMOD2	SHMOD1	SHMOD0

Shutter Mode
011 (3) Not Connected
100 (4) Normal Operation

Byte 10: SBMOD (Shutter B Mode)								
Bit	7	6	5	4	3	2	1	0
Name	1	1	0	1	1	SHMOD2	SHMOD1	SHMOD0

Shutter Mode
011 (3) Not Connected
100 (4) Normal Operation

Get Filter Wheel Configuration

Byte 1: 0xFD							
7	6	5	4	3	2	1	0
1	1	1	1	1	1	0	1

Response: When requesting the wheel configuration, the device response with the received command (FD hexadecimal) immediately and requests the configuration information from a daisy chained wheel.

Bytes 1-5				
1	2	3	4	5
0xFD	'1'	'0'	'-'	'3'
Bytes:6-10				
6	7	8	9	10
'W'	'A'	':'	WHLACFG	
			Wheel A Configuration	
			'NC' Not Connected	
			'ER' Error	
			'25' 25 mm	
			'32' 32 mm	
Bytes 11-15				
11	12	13	14	15
'W'	'B'	':'	WHLBCFG	
			Wheel B Configuration	
			'NC' Not Connected	
			'ER' Error	
			'25' 25 mm	
			'32' 32 mm	
Bytes 16-20				
16	17	18	19	20
'W'	'C'	':'	WHLCCFG	
			Wheel C Configuration	
			'NC' Not Connected	
			'ER' Error	
			'25' 25 mm	
			'32' 32 mm	
Bytes 21-25				
21	22	23	24	25
'S'	'A'	':'	SHATYP	
			Shutter A Type	
			'VS' Vincent Shutter	
Bytes 26-30				
26	27	28	29	30
'S'	'B'	':'	SHBTYP	
			Shutter B Type	
			'VS' Vincent Shutter	

Byte 31
31
FRM
Firmware Revision

Set Wheel Position

Byte 1: 0xFC							
7	6	5	4	3	2	1	0
1	1	1	1	1	1	0	0

Note: Byte 1 only present for Wheel C configuration, omitted if Wheel A or B selected.

Byte 2								
Bit	7	6	5	4	3	2	1	0
Name	WHL	SPD2	SPD1	SPD0	POS3	POS2	POS1	POS0

Wheel Speed	Wheel Position (0-9)
000 (0) Speed = 0	0000 (0) Position = 0
001 (1) Speed = 1	0001 (1) Position = 1
010 (2) Speed = 2	0010 (2) Position = 2
011 (3) Speed = 3	0011 (3) Position = 3
100 (4) Speed = 4	0100 (4) Position = 4
101 (5) Speed = 5	0101 (5) Position = 5
110 (6) Speed = 6	0110 (6) Position = 6
111 (7) Speed = 7	0111 (7) Position = 7
	1000 (8) Position = 8
	1001 (9) Position = 9

WHL: 0: Command for directly connected device 1: Command for daisy chained device

Response: Byte 1: Command byte as received, returned immediately.
Byte 2: 0x0D after task completion

Set Shutter State

	Open	Open on Ext. Trig	Close
Wheel A	0xAA	0xAB	0xAC
Wheel B	0xBA	0xBB	0xBC

Byte 1								
Bit	7	6	5	4	3	2	1	0
Name	1	0	WHL1	WHL0	1	SHFUN2	SHFUN1	SHFUN0

Wheel Selection	Shutter State
10 (2) Wheel A	010 (2) Open
11 (3) Wheel B	011 (3) Open on ext. trigger
	100 (4) Close

Response: Byte 1: Command byte as received, returned immediately
Byte 2: 0x0D after task completion

Reset

Byte 1: 0xFB							
7	6	5	4	3	2	1	0
1	1	1	1	1	0	1	1

Response: 0x0D

Examples

Binary	Hexadecimal	Decimal	Functionality
00000000	00	0	Wheel A moves to position '0' at maximum speed
10000000	80	128	Wheel B moves to position '0' at maximum speed
11111100 00000000	FC 00	252 0	Wheel C moves to position '0' at maximum speed
00110110	36	54	Wheel A moves to position '6' at speed 3
10101010	AA	170	Shutter A opens
10101100	AC	172	Shutter A closes
10111010	BA	186	Shutter B opens

DIGITAL TRIGGERING FUNCTIONALITY

Sequence Programming

1. PC issues decimal command 189 (0xBD in hex) to enter sequence programming mode, the filter wheel responds with 0xBD

2. PC issues a series of motion commands, the filter wheel responds with the issued motion commands, the wheel does not move. The motion commands have the same structure as ones that make the wheel move and include desired filter position and speed.

3. If 50 motion commands are entered or decimal command 190 (0xBE in hex) is issued, the programming is complete and the sequence is stored in flash. The wheel responds with 0xBE if the 0xBE command was issued to end the sequence, followed by three instances of 0xBE (acknowledging successful completion of the flash erase, program, and verify functions). If the sequence programming mode is terminated by issuing 50 motion commands, the wheel responds with a sequence of three instances of 0xBE only. If any of the flash operations is not successful, the wheel responds with 0xBD instead of 0xBE for the given operation.

Sequence Playback

1. If a sequence is programmed into memory, a digital trigger executes the next command in the sequence.

2. The length of the sequence (number of commands) is defined during the sequence programming phase. After the last command in the sequence is executed, the next command in queue will be the one at the beginning of the sequence.

3. A transition from active (ON) to passive (OFF) trigger state is required in order to allow the next command in the programmed sequence to be executed. (The reason for this is to allow for manual advancement in the sequence using a push-button, otherwise it's next to impossible to manually advance by a single command at the highest speed.)

4. When the wheel is in motion, the digital trigger input (as well as any motion command issued over the RS-232 port) is ignored. A transition from active (ON) to passive (OFF) is registered even when the wheel is in motion. The wheel motion must be completed in order for the active (ON) trigger to be registered for the execution of the next command in the sequence.

5. When a motion command is issued over the serial port, the index in the programmed sequence is reset; the next digital trigger will activate the first motion command in the sequence.

6. Issuing of commands over the RS-232 port and digital triggering of motion commands in a sequence are not mutually exclusive, both function are accessible the same time without the need to switch the filter wheel into a particular operating mode.

Notes

1. 0xBE (end of sequence command) issued when not in programming mode is acknowledged (wheel responds with 0xBE) but ignored (nothing else happens).

2. The programmed sequence is retained after power down, the sequence is loaded from flash memory into RAM on power up.

3. The sequence can contain repeated consecutive commands.

4. The wheel motion (including triggering functionality) is suspended during sequence programming.

5. Pass through sequence programming functionality (programming of daisy chained wheel) is currently not supported. (The sequence programming functionality will only work with Wheel A.)

Electrical Interface

The digital motion trigger input is wired to pin 8 of the Auxiliary I/O connector. All connections on the AUX connector are wired through an optocoupler. Active trigger state (ON) corresponds to active optodiode state.

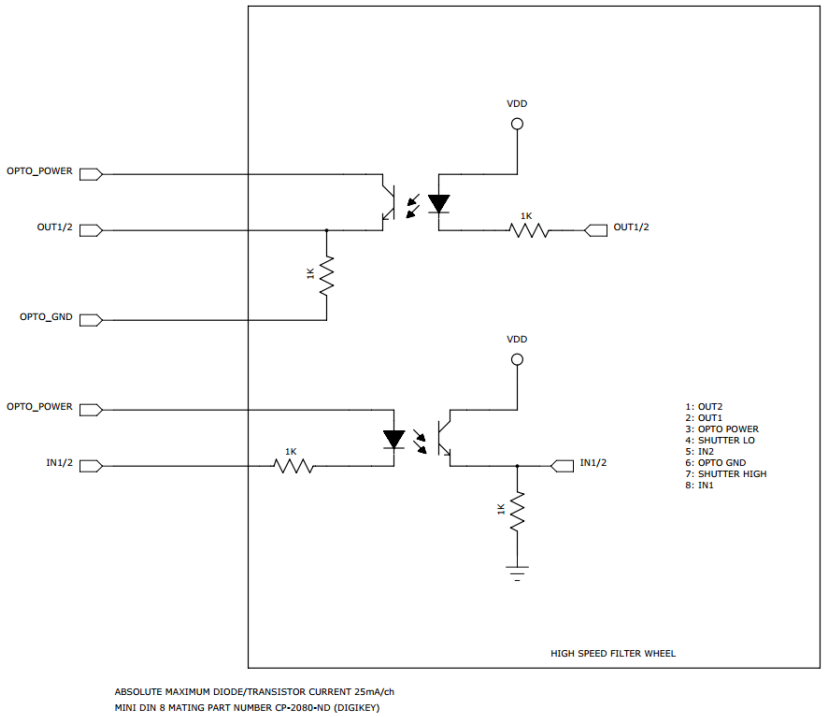


fig. 5: Optocoupler Connection Schematic

APPENDIX A – WARRANTY FOR FLI PRODUCTS

Limited Warranty Coverage

If your Product does not properly function because of a defect in its materials or workmanship, Finger Lakes Instrumentation, LLC ("FLI") will, at its sole option and for the length of the period indicated on the chart below, which period begins with the date of original purchase (the "Warranty Period"), either:

(a) repair your Product with new or refurbished parts;
or
(b) replace your Product with a new or refurbished product.

The decision to repair or replace, the parts used to repair, or the new or refurbished product used to replace your Product, as applicable, shall be made by FLI in its sole discretion. Without limiting its discretion, where FLI determines that your Product shall be replaced with a new or refurbished product that is different from your Product, FLI will use its commercially reasonable efforts to replace your Product with a new or refurbished product that is as close to equivalent to your Product as practicable.

This Limited Warranty is offered to the original purchaser of a new product from FLI, which was not sold on an "as-is" basis. A legible purchase receipt or other verifiable proof of purchase for your Product is required to receive Limited Warranty parts or service.

This Limited Warranty does not apply in special circumstances in which prior arrangements have been made and separate documentation has been supplied prior to, or with, your Product; in such cases, the warranty (if any) provided in such documentation shall supersede and replace this Limited Warranty for your Product.

Item or Part Name	Warranty Period
Your Product, except those items listed in this table below	One (1) Year
Your Product's Application Software (if included) and Batteries	None

Parts and Service

You must carry-in or mail-in your Product during the Warranty Period to receive the Limited Warranty parts or service. Prior to mailing or carrying-in your Product to FLI, you are required to contact FLI at the e-mail address or telephone number provided in the "Directory Information" Section of this Limited Warranty to receive a warranty service identifier code (and any other reasonably required identifiers, as directed by FLI) that you must provide in legible writing included within the package in which you mail FLI your Product.

The Limited Warranty does not include costs of shipping your Product, installation or re-installation of your Product, insurance relating to shipping your Product, or travel to carry your Product to FLI, except that FLI shall bear the costs of shipping your Product to and from FLI's service center (but not insurance or travel) for Product Internal Environment Limited Warranty service claims made within one (1) year from the date of original purchase when shipped within the continental United States.

All products and services are FCA FLI, Rochester NY USA.

Directory Information

Finger Lakes Instrumentation LLC
200 Tech Park Drive
Rochester NY 14623 USA
Tel USA 585-624-3760
https://www.flicamera.com

Product Software

As noted in the chart in the section of this Limited Warranty titled "Limited Warranty Coverage," the Limited Warranty does not apply to your Product software. Software supplied with your Product is for demonstration purposes only. FLI supplies the necessary information, drivers, and libraries, for users and third party vendors to develop software for their specific purposes. FLI seeks to maintain compatibility with many third party software vendors, but does not, and cannot, warrant or guarantee operation with non-FLI software. FLI is not responsible for changes, upgrades, or errors in third party programs.

Important Limited Warranty Information

This limited warranty ONLY COVERS failures due to defects in materials and workmanship, and DOES NOT COVER normal wear and tear or cosmetic damage. This limited warranty ALSO DOES NOT COVER damages which occurred in shipment, or failures which are caused by or to products not supplied by FLI, or failures which result from accidents, misuse, abuse, neglect, mishandling, misapplication, alteration, improper maintenance, power supplied to your Product (including, without limitation, over-voltage, mechanical shock, reverse polarity, or power surges), electrostatic discharge, modification, or commercial use, rental use of your Product, service to your Product by anyone other than FLI at an authorized service center, damage due to environmental conditions (including, without limitation, extreme temperatures, exposure to excessive moisture or humidity, radiation, or electromagnetic fields), damage occurring after condensation or moisture has appeared in the Product inner (sealed) chamber, or damage attributable to acts of God (including, without limitation, lightening).

- THERE ARE NO EXPRESS WARRANTIES EXCEPT AS LIMITED UNDER "LIMITED WARRANTY COVERAGE." FLI IS NOT LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM THE USE OF THIS PRODUCT, OR ARISING UNDER ANY BREACH OF THIS WARRANTY.

- ALL EXPRESS WARRANTIES MADE IN THIS LIMITED WARRANTY ARE LIMITED TO THE WARRANTY PERIOD OF THE LIMITED WARRANTY, AND ARE OTHERWISE HEREBY DISCLAIMED TO THE FULLEST EXTENT PROVIDED BY LAW.

- ALL IMPLIED WARRANTIES, INCLUDING THE WARRANTY OF MERCHANTABILITY, ARE HEREBY DISCLAIMED TO THE FULLEST EXTENT PROVIDED BYLAW.

- PARTS AND SERVICE WHICH ARE NOT COVERED BY THIS LIMITED WARRANTY ARE YOUR RESPONSIBILITY.

If your locality does not permit all or a portion of this Limited Warranty, this Limited Warranty may not apply to you. Please consult your local laws, rules, and regulations for any differences that may be present in your jurisdiction and apply to you. If you do not meet all of the criteria for this Limited Warranty or are outside of the Warranty Period, please be advised that you are not covered by this Limited Warranty and there may be a charge for any servicing and parts for your Product – please contact FLI using the directory information in this Limited Warranty for more information.

The Product is not authorized for use as critical components in life support or medical diagnostic applications where failure to perform could result in injury, faulty diagnosis, or other risk to patients or personnel.

The Product is not authorized for use in robotic control systems where malfunction or failure could cause system motions hazardous to personnel.

APPENDIX B – FLI RETURN PROCEDURE

If you need to return a product, please follow the instructions outlined below.

1. Contact FLI by phone or email to obtain a Return Material Authorization (RMA) number to return the camera/product and:

   a. If you are outside the United States, contact your Customs Authority to register the merchandise to be returned to the United States for warranty repair or refund. Use the Harmonized Code number 9801.00.1012 on your shipping documentation. The monetary value you place on the item should be stated for insurance purposes. Clearly state that the "Value is for Customs purposes ONLY." When FLI returns the repair item to you, we will use the same monetary value.

   b. If you are outside the United States, prepare a ProForma invoice to accompany the shipment with the following statement:

      For Equipment not covered under warranty: "American goods returned for repair only with NO Commercial Value. Temporary return only"

      For Equipment covered under warranty: "American goods returned for Warranty Repair only with NO Commercial Value. Temporary return only"

   c. For all customers, if you are requesting service under warranty or a return, a copy of your original receipt.

   d. For you records, make a copy of these documents.

   e. Prepare a large shipping label with the appropriate return address (FLI or distributor) and for shipments from outside the U.S., include the Harmonized Code number.

2. Locate the original shipping boxes in which your item(s) was packaged. These boxes are designed to protect the products.

   Notice: If you do not have the original shipping boxes, obtain a rigid box that is at least 3" (7.5 cm) larger in all dimensions than the items. A smaller box will not allow appropriate cushioning. Tape the side and bottom seams to secure the box.

3. If you have the original packing materials, place the item(s) in the original plastic bag(s) and place the bagged item in the appropriate foam cutout in the proper orientation. Insert other items into their appropriate compartments.

   Notice: If you do not have the original bag, place the item(s) in a plastic bag and seal it. Wrap the bagged item(s) with at least two layers of bubble wrap or two bubble wrap bags. Wrap other items in the same manner. At the bottom of the box, place two inches of packing material (Styrofoam peanuts or additional bubble wrap). Place the item(s) on the

bottom layer with space around each. Surround each item completely with additional packing material.

4. Write a letter that includes the following:

    a. Reason the item is being returned to FLI or distributor

    b. Your complete contact information (name, phone number(s), email address, return shipping address)

    c. If appropriate, payment method and information. On top of the item(s) in the box, add the required paperwork described in step 1 and the letter described in step 4. Seal the box with packing tape. Tape the top flaps and label the box with the shipping label prepared in step 1.

5. Contact a shipper for pickup or bring it to a reliable carrier. As noted in step 1, use the appropriate value on shipping forms. FLI is not responsible for damage to any item or items when they are in the possession of a carrier.