56 Sparta Avenue • Newton, New Jersey 07860
(973) 300-3000 Sales • (973) 300-3600 Fax
www.thorlabs.com

THORLABS

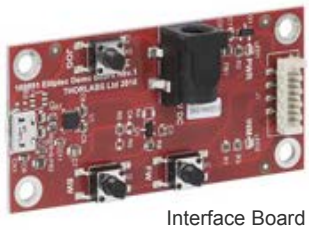
ELL7K/M - October 2, 2018

Item # ELL7K/M was discontinued on October 2, 2018. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

25 MM LINEAR STAGE WITH RESONANT PIEZOELECTRIC MOTORS

- **Linear Stage with Closed-Loop Positioning**
- **Open Frame Design for OEM Applications**
- **Control via Interface Board, GUI, or ASCII Message Calls**
- **Fully Integrated Drive Electronics**

Customization Available



Interface Board

Direction of Travel

ELL7K/M

Linear Stage

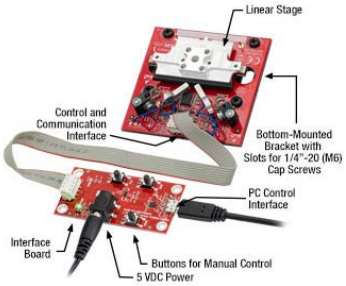
Application Idea
The ELL7K/M positions the slit to spatially filter incident light.

Hide Overview

OVERVIEW

Features

- Ideal for OEMs and Applications Requiring Rapid and Precise Positioning
- Micro-B USB and Picoflex® Connectors for Control Signals
- Multi-Drop Serial Communication Protocol Supported
- Linear Stage with One M4 and Four M3 Tapped Holes
- Magnetic Incremental Linear Encoder Used to Position Stage and Find Absolute Home Position



Click to Enlarge
The components of the ELL7K/M linear stage bundle are shown connected and with key features labeled.

Driven by Thorlabs' Elliptec™ piezoelectric resonant motor technology, this linear stage is designed to meet the needs of applications whose designs require multiple networked Elliptec resonant motor products. With a mass of 0.052 kg and maximum dimensions of 68.0 mm x 67.0 mm x 15.3 mm (without the mounting bracket), the stage is lightweight and compact. It is also designed for closed-loop operation, which allows the translating platform be positioned with an accuracy of 50 µm and a repeatability of 20 µm. When power is not applied to the motors, the stage is held in place by an approximately 1 N combined force exerted by the stationary arms of the motors. The assembled components of the ELL7K/M are shown in the image to the right, with key features labeled. The motor is highly dynamic and has no gearing. As the motor includes no magnets, it is compatible with EM-sensitive environments. Please see *The Elliptec™ Motor* tab for more information.

The open frame format, simplicity, and adaptability of this linear

Key Specifications[a]	
Travel[b]	25 mm (0.984")
Homing/Positioning Accuracy	50 µm
Repeatability (100 g Load)	20 µm
Velocity (Maximum, No Load)	180 mm/s
Minimum Incremental Motion (Measured, No Load)	8 µm
Maximum Total Load[c]	200 g (0.441 lbs)

stage makes it attractive for OEM applications, as it can be customized according to customer requirements and produced in high-volume quantities. Please contact us to discuss your specific requirements so that we may tailor a solution to meet the needs of your application.

DC Voltage Input	4.5 to 5.5 V
Weight of Stage and Bracket	0.168 lbs (0.076 kg)
Minimum Lifetime	100 km of Travel

a. See the *Specs* tab for complete specifications.
b. Not Intended for Continuous Operation
c. If an application requires collision with the end-stop pins, which are not contacted normal use, the load should not exceed 100 g.

Control

There are multiple options for powering, driving, and controlling this stage, which are detailed in the *Positioning the Linear Stage* section of the *Operation* tab. The stage possesses a 3.3 V serial bus and is designed to be operated with or without the interface board; the *Pin Diagram* tab provides pin assignments. Thorlabs offers software for our Elliptec products capable of providing full and independent control of the stage. When the interface board is used as an accessory to change the position of the stage, its status in the software is automatically updated. Please note that the linear stage is not designed for continuous operation. We recommend operation with duty cycles of 40% or less.

The multi-drop communications bus offers the option of connecting the stage to a hybrid network of up to 16 Elliptec resonant motor products and controlling the connected units with a device such as a microprocessor. When multiple units are connected to the same interface board, all can be controlled simultaneously using either the software or the buttons on the interface board.

Application Idea

The linear stage is well-suited for integration into a variety of applications. A single component may be attached directly to the stage using the center M4 tapped hole, or the four M3 tapped holes may be used to secure an adapter plate, such as MMP1/M or RB13P1/M, or other fixture. The setup pictured at the top of the page shows one implementation of the stage, which includes an adapter plate. Please see below for details.

Robert Capehorn
OEM Project Manager,
Elliptec Systems

Feedback?
Questions?
Product Suggestions?
Custom or OEM Applications?

Contact Me

Thorlabs' Elliptec Technology for OEM

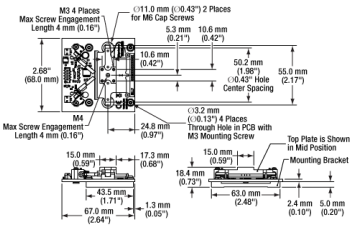
Elliptec Resonant Motor Products		
		
Multi-Position Sliders	25 mm Linear Stage	Rotation Stage

Hide Specs

SPECS

Click to Enlarge
Components of the ELL7K/M Bundle
(One Region-Specific Power Adapter Included with the Power Supply)

Specifications[a]	
Performance	
Travel	25.0 mm (0.984")
Homing/Positioning Accuracy	50 µm
Local Repeatability[b]	6 µm
Repeatability (With 100 g Load)	20 µm
Velocity (Maximum, No Load)	180 mm/s
Acceleration (Maximum, No Load)	6.0 m/s^2
Minimum Holding Force (Both Motors Engaged)	1 N
Vertical Straightness (Runout)[c]	6.3 µm
Horizontal Straightness (Runout)[c]	13.0 µm
Pitch (Over Full Travel Range)	2.40 mrad



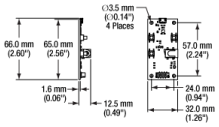
Click to Enlarge
Mechanical Drawings of the Linear Stage (With the Bracket Attached)

As shown in the drawing above, a mounting bracket included with the bundle fastens to the underside of the linear stage's PCB with the included four M3 screws. Two slots in the bracket align with the Ø11.0 mm (Ø0.43") holes at either side of the PCB, so that M6 cap screws can be inserted through the holes in the PCB to secure the linear stage board to optical tables and breadboards.

Yaw (Over Full Travel Range)	2.90 mrad
Full-Scale Nonlinearity Error	<120 µm
Encoder Resolution (Relative Magnetic Encoder)	0.5 µm
Minimum Incremental Motion (Measured, No Load)	8 µm
Velocity Compensation (No Load)[d]	60% to 100%
Maximum Total Load[e,f]	0.200 kg (0.441 lbs)
Minimum Lifetime[g]	100 km of Travel
Electrical	
Motor Type	Elliptec Resonant Piezo
DC Voltage Input	4.5 to 5.5 V
Typical Current Consumption, During Movement (No Load)	850 mA
Typical Current Consumption, During Standby	34 mA
Communications	
Bus[h]	Multi-Drop 3.3 V/5 V TTL RS232
Connector on Linear Stage Board	Picoflex®
Connectors on Interface Board	Picoflex® Micro-B USB 5 VDC Power: [For Plug with Ø5.5 mm OD (Ground) and Ø2.1 mm ID (+5 V)]
Speed	9600 baud
Data Length (1 Stop Bit, No Parity)	8 bit
Protocol Data Format	ASCII HEX
Module Address and Command Format	Mnemonic Character
8-Conductor Ribbon Cable Length (Supplied)	0.250 m
8-Conductor Ribbon Cable Length (Maximum)	3 m
Mechanical	
Mounting Threads (On Stage)	One M4, Four M3 Length: 4 mm (0.16")
Dimensions of the Linear Stage Board (Without Bracket)	68.0 x 67.0 x 15.3 mm (2.68" x 2.64" x 0.60")
Dimensions of the Linear Stage Board (With Bracket)	68.0 x 67.0 x 18.4 mm (2.68" x 2.64" x 0.73")
Dimensions of the Interface Board	32.0 mm x 66.0 mm x 12.5 mm (1.26" x 2.60" x 0.49")
Weight of the Linear Stage Board (Without Bracket)	0.052 kg (0.114 lbs)
Weight of the Linear Stage Board (With Bracket)	0.076 kg (0.168 lbs)
Environmental Operating Conditions	
Temperature Range	15 to 40 °C
Maximum Relative Humidity (Non-Condensing)	<80% at 31 °C
Maximum Altitude	2000 m

a. Performance specifications are given for the case when the linear stage is mounted as recommended in the *Operation* tab.
For Movements Between Two Positions up to 4 mm
b. Deviation from the Ideal Path, Referenced to a Theoretical Straight Line
c. The velocity of the stage can be adjusted to a value equal to or greater than 60% of the maximum velocity through use of the ASCII message calls described in the communications protocol manual.
d. Applies when the stage is mounted with the top surface in the horizontal plane, or when the stage is mounted vertically such that the load translates side to side. The stage is not designed to move a load up and down.
e. If an application requires collision with the end-stop pins, which are not contacted normal use, the load should not exceed 100 g.

f. The linear stage is not designed for continuous operation.
g. Use two 10 kΩ pull-up resistors in multi-drop mode for RX/TX.



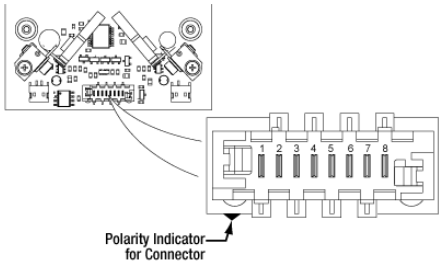
Click to Enlarge
Mechanical Drawings of the
Interface Board

Hide Pin Diagram

PIN DIAGRAM

Connector J1 Pinout[a,b]		
Pin	**Type**	**Function**
1	PWR	Ground
2	OUT	OTDX - Open Drain Transmit 3.3 V TTL RS232
3	IN	RX Receive - 3.3 V TTL RS232
4	OUT	In Motion, Open Drain Active Low Max 5 mA
5	IN	JOG/Mode, Active Low Max 5 V
6	IN	BW Backward, Active Low Max 5 V
7	IN	FW Forward, Active Low Max 5 V
8	PWR	VCC +5 V ±10%; 850 mA

a. Connector Model Number MOLEX 90814-0808;
Mating Connector Model Number MOLEX 90327-0308
b. A polarity indicator is engraved onto each PCB next to the Picoflex connector, as shown in the drawing to the left, to assist with properly connecting the interface board to the main unit. The red wire in the ribbon cable should be adjacent to this indicator. Not doing so can harm the unit.



Click to Enlarge
Pinout diagram of the Picoflex connector is shown referended to a cut-away diagram
of the Linear Stage Board. The polarity indicator on the connector
must be adjacent to the red wire on the supplied 8-connector cable.

Hide Operation

OPERATION

Operation Notes

This tab contains information on handling, mounting, and operating the ELL7K/M Linear Stage Bundle.

Contents

- Handling
- Mounting and Loading the Linear Stage
- Supplying Power

Operation of the Motors

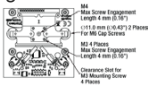
- Homing the Linear Stage
- Positioning the Linear Stage
- Resonant Frequencies

Handling

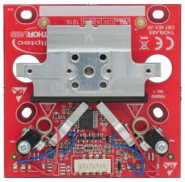
The linear stage and interface board included in the ELL7K/M bundle are robust to general handling. To ensure reliable operation, keep the surface of the plastic track contacted by the motors free of oils, dirt, and dust. It is not necessary to wear gloves while handling the linear stage, but avoid touching the track to keep it free of oils from fingerprints. If it is necessary to clean the track, it may be wiped with isopropyl alcohol or mineral spirits (white spirit). Do not use acetone, as this solvent will damage the plastic track.

Click to Enlarge
The Linear Stage Board with Adapter Plate RB13P1/M Mounted to the Top of the Stage and the Mounting Bracket Attached to the Bottom of the PCB Board

The open frame format of the ELL7K/M can tolerate up to 8 kV of static discharge. ESD precautions should be taken, as an electrostatic discharge can produce an electrical signal that may cause unintended movement of the stage. A bending load in excess of 500 g applied to the board may cause the PCB to deform, which will degrade the performance of the linear stage. As readings from a magnetic sensor are used during the homing and positioning of the stage, avoid subjecting the structural PCB to excessive loads or magnetic fields. Limit the strength of magnetic fields in proximity to the magnetic sensor to ±5 mT to avoid negatively affecting the homing and positioning operations.



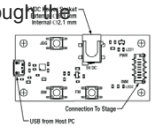
Click to Enlarge
Features of the Linear Stage



Click to Enlarge
The Linear Stage (Without the Bracket)

Mounting and Loading the Linear Stage

The linear stage can be operated with the top surface of the stage in the horizontal or the vertical plane. If the latter is chosen, orient the stage so that it moves side to side rather than up and down. A mounting bracket included with the ELL7K/M fastens to the underside of the linear stage's PCB with the included four M3 screws. Two slots in the bracket align with the Ø11.0 mm (Ø0.43") holes at either side of the PCB, so that M6 cap screws can be inserted through the holes in the PCB to secure the linear stage board to an optical table or breadboard. The image to the right shows the linear stage with the bracket attached. Alternately, the bracket can be omitted and the four slotted holes in the PCB used attach the stage to a custom fixture. Ensure that electrically conductive structures crossing the back of the board are not in contact with it, as this may cause electrical shorts detrimental to the operation of the stage. When mounting the stage, ensure that the installation does not bend the PCB.



Click to Enlarge
Features of the Interface Board

Click to Enlarge
The Interface Board

Loads may be mounted to the stage using the M4 or four M3 tapped holes at the center. The spacing of the M3 tapped holes is designed to be compatible with adapter plates such as the MMP1/M and RB13P1/M, which is illustrated in the image to the upper right and expands the functionality of the stage. The maximum allowed weight of the mounted components is 200 g. If an application requires collision with the end-stop pins, which are not contacted normal use, the load should not exceed 100 g. In all cases of mounting and loading, ensure that nothing interferes with the moving parts of the linear stage.

Supplying Power

When the setup includes the interface board, power may be supplied through the Micro-B USB connector and/or the 5 VDC power socket located on the board. The electronics on the interface board convert the applied DC signal to a sinusoidal signal oscillating at the required resonance frequency.

The ELL7K/M bundle include a 5 VDC power supply whose connector mates with the power socket on the interface board. Delivering power through this socket also leaves the Micro-B USB connector available to accept a USB cable connection to a computer, which can be used to control the stage remotely. The power supplied by the computer through the USB 2.0 connection is not sufficient to power the stage. If computer control is not necessary, another option for supplying power to the stage is a portable USB 5 V battery pack connected to the Micro-B USB connector on the interface board.

When the implementation does not include the interface board, the connection with the power source is made using the pins on the Picoflex connector that is included on the linear stage board. A pinout diagram of this connector is included in the *Pin Diagram* tab, and information on powering and addressing the linear stage is given in the manual and the communications protocol manual, respectively.

Operation of the Motors

The motion of the linear stage is controlled by forcing the piezoelectric elements to vibrate at specific ultrasonic frequencies. For each motor, there is an ultrasonic resonant frequency that will push the stage forward, and another that will pull the stage backward. Operating a motor at one of its resonance frequencies causes the tip of the motor to continuously cycle in a tight clockwise elliptical path. When the motor is driven at its other resonant frequency, the tip of the motor cycles through that same path in a counterclockwise direction. Both resonant frequencies are around 100 kHz. The total displacement at the tip of motor is a function of the mechanical load it is driving and the voltage supplied to the piezo element. In the case of no loading and a 5 V maximum driving voltage at a resonant frequency, the tip of the motor expands and contracts by no more than a few microns while tracing the elliptical path. Please see *The Elliptec™ Motor* tab for more informationand an animation illustrating the operational principle of the motors.

Homing the Linear Stage

To Home the stage, press the BW button on the interface board, click the Home button in the Elliptec™ software's graphical user interface (GUI), or send the appropriate ASCII message as is specified in the communications protocol manual. The stage uses a relative (incremental) magnetic sensor with an encoder resolution of 0.5 µm to home and position the stage. During the procedure to define the default Home position, the stage is translated forward and backward to index the limits of travel. The default Home position is located at one normal limit (the backward position) of the stage's range of motion. If desired, the user may redefine the position of Home to be offset from the default position. Being able to customize the Home position can be useful when synchronizing the orientations of two or more stages.

Positioning the Linear Stage

Note that the linear stage is not intended for continuous operation. We recommend operation with duty cycles of less than 40% during general use, while operation with duty cycles greater than 60% should be limited to a few seconds.

Before the stage may be positioned, the Home position of the stage must be found. Please see the previous section for details. The movement of the stage may be controlled by pressing buttons on the interface board, through computer control via the Elliptec software package that may be downloaded, or by sending simple signals to digital lines on the stage's board. The buttons on the interface board can be seen in the image of the interface board above. A link to download the software and accompanying documentation can be found in the *Software* tab. The interface board may be used as an accessory while interfacing with the stage through the Elliptec software; all changes in the position of the linear stage that occur as a result of pressing buttons on the interface board are registered by the software, and the software may independently control the linear stage while the interface board is connected. It is also possible to effect the simultaneous movement of a mixed network of up to 16 Elliptec piezoelectric resonant motor products by connecting all to the communications bus. When this is done, the software can send separate commands to each, while commands originating from buttons pressed on the handset will be sent to all connected devices. The communications protocol manual describes how to use the software to individually address each connected device.

The interface board can be used to move the stage forward and backward in increments by pressing and holding the JOG button while pressing and releasing the FW or BW button, respectively. The default increment is 2 mm, and a custom step size can be set using the Elliptec software or by sending the appropriate ASCII message(s) as specified in the communications protocol manual. The stage obtains its best repeatability and linear performance when incremental movement is ≤ 4 mm, as the pitch of the relative magnetic encoder is 4 mm. The Elliptec software can be used to move the stage to absolute and relative positions, in addition to jogging the stage forward or backward. The software is also used to set the jog step size, read the position of the stage, and adjust the position of Home, as is described in the previous section. The velocity of the stage can be adjusted to a value equal to or greater than 60% of the maximum velocity through use of the ASCII message calls described in the communications protocol manual.

The stage learns to efficiently position itself precisely using a position error compensation algorithm. After the stage moves into a new position, it detects the error between the requested and actual positions. The position of the stage is then corrected, and an error compensation value is calculated. The algorithm is then updated with the error compensation value, so that it is applied when the stage is move to its next position. Typically, an optimum error compensation value is found after between two and six movements.

Resonant Frequencies

On power-up, the factory default setting instructs each motor driving the linear stage to search for the resonant frequencies that will deliver the best performance. During this process, the linear stage will translate a forward and backward. If movement on start-up is undesirable, it is possible to disable this calibration procedure by using the serial port to initialize the frequencies on power-up. A new search for optimal resonant frequencies may be performed at any time; to maintain optimal performance, it is recommended that new searches be performed after changes in loading and/or ambient temperature. Please see the manual for details.

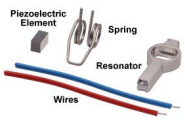
Hide The Elliptec™ Motor

THE ELLIPTEC™ MOTOR

The Elliptec™ Piezoelectric Resonant Motor

Thorlabs' Elliptec™ piezo resonant motor, shown at right, is lightweight, with a mass of 1.2 g, and compact: the dimensions of the resonator housing, excluding the spring, are 8 mm x 4 mm x 20 mm.

Click to Enlarge
The Elliptec Piezoelectric Resonant Motor



Click to Enlarge
The Components of the Elliptec Motor

Components of the Motor

The components that compose the motor are shown at far-right. The piezoelectric element is press fit into the aluminum resonator, which has been precisely designed and machined to produce the desired elliptical motion at the tip and to interface optimally with the driven module. The free ends of the spring are integrated with the resonator housing. The wires, which are soldered to the top and bottom of the piezoelectric element, deliver the voltage signal that induces the piezoelectric element to vibrate at ultrasonic frequencies.

When the motor is built into a system, the open loop of the spring is bolted to a sturdy surface that is stationary with respect to the item to be driven, and the

tip of the resonator is placed in contact with the item. The purpose of the spring is to maintain constant contact between the tip of the resonator and the driven item, and the direction of motion is determined by the resonance frequency at which the piezo element is driven.

Elliptical Motion and Comparison with Conventional Motors

Elliptec motors quickly and precisely position stages and mounts while never seeming to move. Their microscopic movements occur at ultrasonic frequencies and are invisible to the naked eye.

The motor is operated by driving it at one of its two resonance frequencies. A voltage signal oscillating at an ultrasonic frequency is applied to the piezoelectric chip, which responds by expanding less than a micron and then contracting back to its original dimensions at the frequency of the driving signal. This rapid-cycling change in the chip's dimensions causes a vibration in the aluminum resonator housing. When the vibration is at one of the housing's resonance frequencies, a pushing motion results at the tip of the motor. When the vibration is at the other resonance frequency a pulling motion results.

As illustrated in the video, the pulling and pushing motions result from the tip of the motor tracing an elliptical path in space when the motor operates at resonance. The selected resonance frequency controls the direction of the cyclical motion. The motor's tip traces one half of the ellipse as it expands and the other half as it contracts. When the motor pushes the driven item, the motor's tip is in contact with the item while the tip expands; the two are not in contact while the tip contracts. The converse is true when the motor pulls the driven item in the opposite direction. The total displacement at the tip of the motor is a function of both the mechanical load it is driving and the voltage supplied to the piezo element. The maximum displacement can be up to a few microns when the peak driving voltage is 5 V.

The motor behaves in many ways like a DC or electromagnetic stepper motor, but it does not suffer from many of the drawbacks of these conventional motors. Unlike conventional electromagnetic motors, which must overcome inertial delays to come to a stop, the highly dynamic Elliptec motor can stop within microseconds. As it has no gears, it does not exhibit backlash. Since it possesses no magnets, it is compatible with use in environments sensitive to electromagnetic interference. The motion of the driven element is continuous and smooth. As the tip of the motor must be in contact with the driven item to induce motion, the motor possesses the safety feature of an inherent friction brake. When in contact with a plastic surface, the motor operates virtually silently.

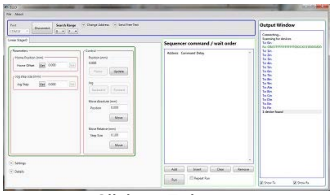
For OEM applications, the motor can be manufactured in volume at low cost, and it can be driven by inexpensive analog electronics. It does not require microprocessors or software; however it is compatible for use with them.

Hide Software

SOFTWARE

Software for Devices Driven by Elliptec™ Piezoelectric Resonant Motors

All devices based on the Elliptec™ resonant piezo motor may be controlled by the Elliptec system software, which features an intuitive graphical user interface (GUI). The source code, in C# format, is included in software bundle available for download, and custom applications can be created in any language. The image at right shows a screen capture of the GUI, and the button that follows links to the download page.



Click to Enlarge
The Elliptec Piezoelectric Resonant Motor Control Software GUI

Commands are entered in the *Sequencer command / wait order* section located at the center-left of the GUI. An example of a sequence of commands that might be sent to the device is "Agj" to get the jog step size of the stage at address "A," "Asj0000200" to set the jog step size as 0.25 mm, and "Abw" to jog the stage at address "A" backward by 0.25 mm. The command "As1" is used to perform the frequency search that will identify the optimal resonant frequencies, for the current operating conditions, for Motor 1 at adddress "A."

Software

Version 1.4.3

Includes the Elliptec System Software, with an easy-to-use GUI. Also available for download is the

Communications Protocol manual, which details the communication commands for the Elliptec software package.

Software

Hide Linear Stage Bundle

Linear Stage Bundle

- Ideal for OEM Evaluation Testing
- Easily Integrate into a Setup
- Operate using Manual and/or Computer Control
- Included Power Supply is Required for Powering the Stage

The Linear Stage Bundle is a complete package that includes a metric linear stage and an interface board, which facilitate quick integration into laboratory setups and other experimental applications. It also provides a convenient means to evaluate incorporating this technology into OEM applications.

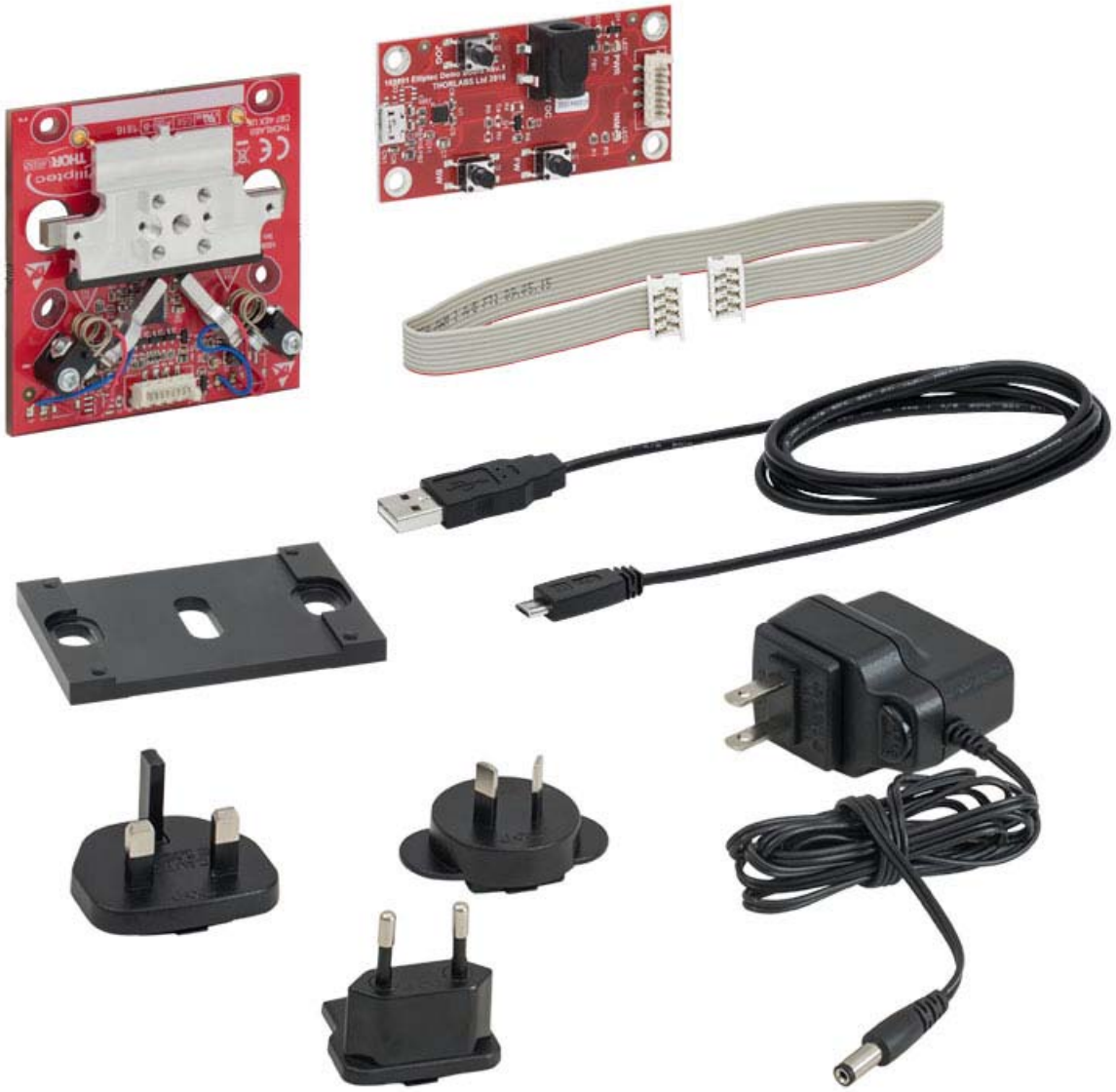
The tips of both motor housings are in firm contact with the rubber track at the base of stage, as can be seen in the image at the far-right. The motors are installed with opposite orientations and translation in both directions occurs when one motor pushes the track forward while the other pulls it backward.

Click to Enlarge
[APPLIST]
ELL7K/M Linear Stage Bundle used to Position a Variable Slit

Click to Enlarge
Red and blue wires deliver power to the motors, whose aluminum tips contact the black plastic strip at the edge of the linear stage.

Included in the ELL7K/M Bundle	
ELL7/M Linear Stage	5 V Power Supply
Interface Board	8-Conductor 28 AWG Ribbon Cable and USB Cable
Mounting Brackets	PC-Based Software for Download

Part Number	Description	Price	Availability
ELL7K/M	**Linear Stage Bundle: ELL7/M Stage, Interface Board, Power Supply, Bracket, Cables**	**$370.26**	**Lead Time**



One Region-Specific Power Adapter Included