KPC101
Combined Piezo Controller and Strain Gauge Reader

User Guide



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Chapter 1 Introduction

1.1 Intended Use

KPC101 Closed Loop Piezo controller is compatible with all Thorlabs open and closed loop piezo actuators. It is to be used in an indoor laboratory environment only, to be operated with the ambient temperature range of 5 °C to 40 °C and in an environment with maximum humidity below 80% RH (non-condensing) at 31 °C. Proper working is not guaranteed outside this temperature range. To ensure reliable operation the unit should not be exposed to corrosive agents or excessive moisture, heat or dust. If the unit has been stored at a low temperature or in an environment of high humidity, it must be allowed to reach ambient conditions before being powered up.

The 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.


Warning


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 KPC101 is a compact and versatile closed-loop piezo controller that combines the functionality of a high-voltage piezo amplifier and a strain gauge reader, which allows both open-loop (voltage mode) and closed-loop (position mode) control of piezo stages. In open loop mode the customer can control the output voltage range from -10 to +150 V and in closed loop it can reach -12 V. The internal power supply voltage of the KPC101 limits the maximum negative voltage to about -14 V. This controller merges the features of the previous Thorlabs KPZ101 and KSG101 controllers into a single-width cube without externally connecting two separate units, while offering a unified software interface, simultaneous voltage and position display, reduced heat dissipation and lower output noise.

1.4 Technical Data

The KPC101 controller requires a single 15 V, 2 Amp power supply for operation. KPS201 is recommended for powering the unit. Thorlabs also offers the 3-channel (KEH3 or KCH301*) and 6-channel (KEH6 or KCH601*) K-Cube Controller Hubs. These products have been designed specifically with multiple K-Cube operations in mind to simplify issues such as cable management, power supply routing, multiple USB device communications and

different optical table mounting scenarios. The K-Cube Controller Hub comprises a slim base-plate type carrier with electrical connections located on the upper surface to accept the K-Cubes.

* The KCH301/601 are previous generation items and are no longer sold individually.

1.4.1 Specifications

Item #	Value
Piezoelectric Output	
Control Mode	Open Loop (Voltage) or Closed Loop (Position)
Piezo Drive Voltage[a]	–10 to +150 V Max (SMC Connector)
Piezo Drive Current	±12 mA Continuous
Output Noise	< 1 mV rms
Typical Piezo Load Capacitance	1 µF to 10 µF
Unit Internal Capacitance	100 nF
Output Impedance	15 Ω
Drive Bandwidth	1 kHz (1 µF Load, 1 V pp)
Drive Input (EXT IN)	±10 V (SMA Connector)
Monitor Output (MONITOR)	–1 to +10 V (SMA Connector)
K-Cube Controller Hub Connector	26-Way ERNI
Input Power Requirements	
Supply Voltage	15 VDC
Supply Current	130 mA at Output Current = 0 mA 250 mA at Output Current = 13 mA (typical)
Power Supply	KPS201
General Data	
Housing Dimensions (Excluding Buttons and Baseplate)	60.0 mm x 60.0 mm x 47.0 mm (2.36" x 2.36" x 1.85")
Weight (Including the K-Cube and Baseplate)	0.21 kg
USB Connector Type	USB 3.0
USB Connection Speed	USB 1.1 Full Speed (12 Mbps)
Display Type	128 x 32 Pixel LCD

a. The output voltage is limited to -10 V by software in the negative region and it can reach -12 V in closed loop.

1.4.2 Graph

The graph below illustrates the KPC101 controller operating with a 9.33 V peak-to-peak sine wave across different capacitive loads.

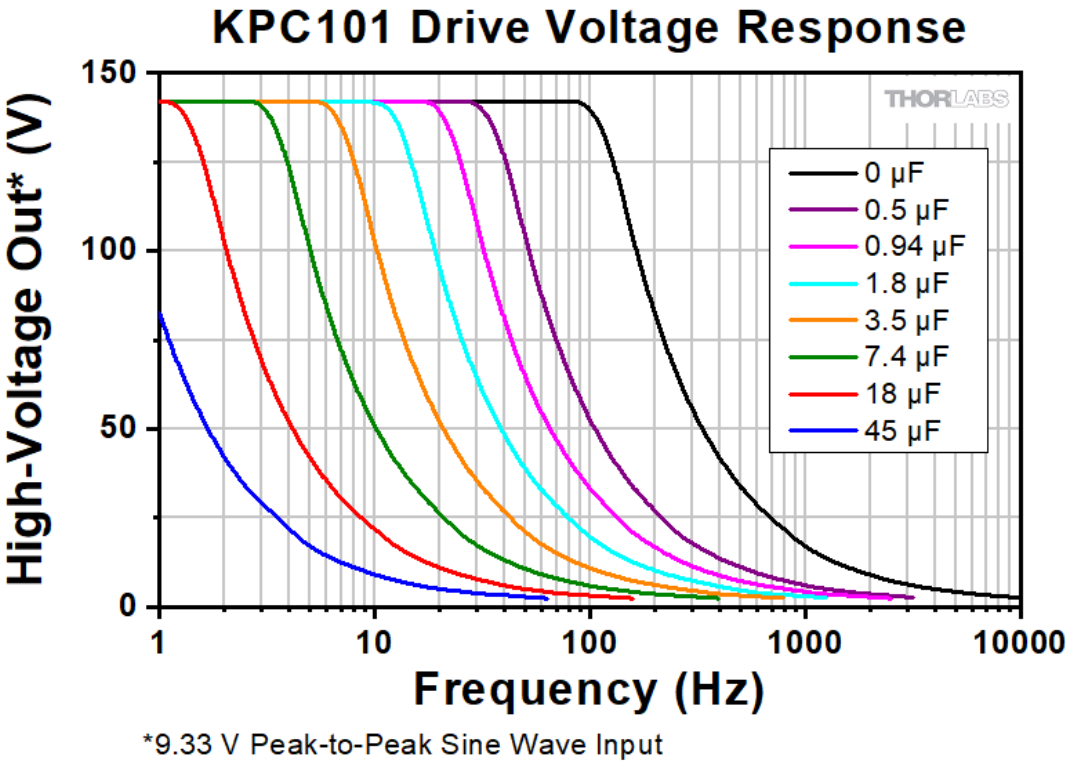


Figure 1 Representative Voltage Response Curves for Selected Capacitive Loads

1.4.3 Mechanical Drawings

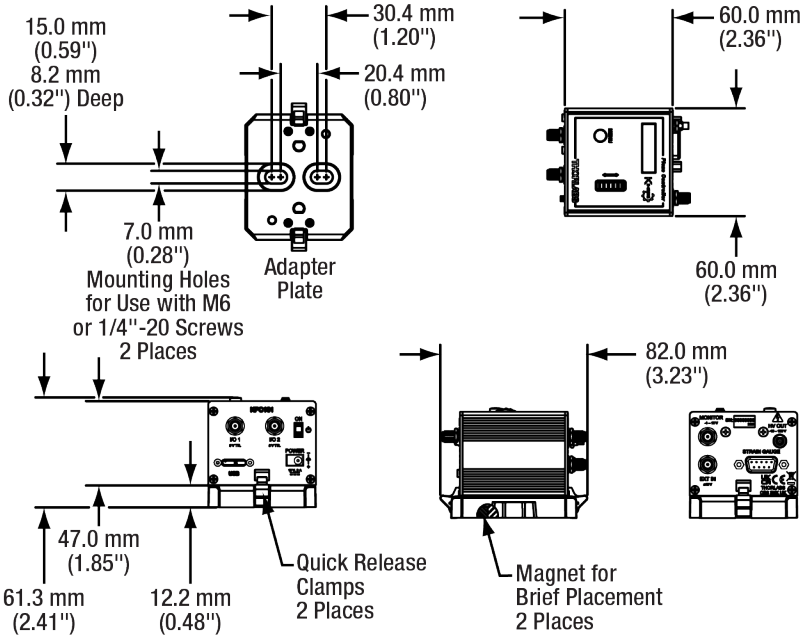


Figure 2 Mechanical Drawing

1.5 Connector Pinout Details

Strain Gauge Input (I/P) Connector receives the signal from the position sensor (strain gauge) to provide feedback for the control loop.

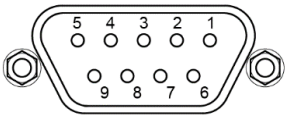


Figure 3 Strain Gauge Connector Pin Diagram

Pin	Description
1[a]	Wheatstone Bridge Excitation (output)
2	+15 V out
3	-15 V out
4	Ground
5	AC Feedback IN (Input)
6	Ground
7	Actuator ID Signal
8	Reserved for Future Use
9	Reserved for Future Use

Table 1 Pin Identification

a. The strain gauge bridge excitation voltage parameters are as follows

Frequency: 18.029 kHz

Amplitude: 2.75 V pp when loaded with a 350 Ω strain gauge

NOTICE

Pins 2 and 3: Power supply for the piezo actuator feedback circuit must not be used to drive any other circuits or devices. Pin 7: This signal is applicable to Thorlabs piezo actuators fitted with an ID resistor. It enables the system to identify the piezo extension associated with the actuator.

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=16405

Chapter 2 Safety

⚠WARNING Operation outside the following environmental limits may adversely affect operator safety.

NOTICE

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Excessive moisture may impair operation.
Spillage of fluid, such as sample solutions, should be avoided. If spillage does occur, clean up immediately using absorbent tissue. Do not allow spilled fluid to enter the internal mechanism.

Chapter 3 Software Applications

This controller is fully compatible with Thorlabs' Kinesis® and XA software applications. This manual describes use of the KPC101 controller with Thorlabs' Kinesis software. For information about operation using Thorlabs' XA software, refer to the XA User Guide.

3.1 Introduction

The K-Cube range of controllers share many benefits which include USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development. The Kinesis software suite provides a flexible and powerful PC based control system both for users of the equipment, and software programmers aiming to automate its operation. The User Interface allows full control of all settings and operating modes enabling complete operation without the need to develop any further custom software. It provides all the necessary system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. The Kinesis server is also used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease.

3.2 Kinesis Server

Kinesis controls are re-usable compiled software components that supply both a graphical user interface and a programmable interface. Many such Controls are available for Windows applications development, providing a large range of re-usable functionality. For example, there are Controls available that can be used to manipulate image files, connect to the internet or simply provide user interface components such as buttons and list boxes.

With the Kinesis system, .Net Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the Piezo K-Cube. Software applications that use .Net Controls are often referred to as 'client applications'. A .Net Control is a language independent software component. Consequently, the controls can be incorporated into a wide range of software development environments for use by client application developers. Development environments supported include Visual Basic©, LabVIEW©, Visual C++©, C++ Builder©, C API©, HPVEE©, MATLAB©, VB.NET©, C#.NET© and, via VBA©, Microsoft Office applications such as Excel and Word.

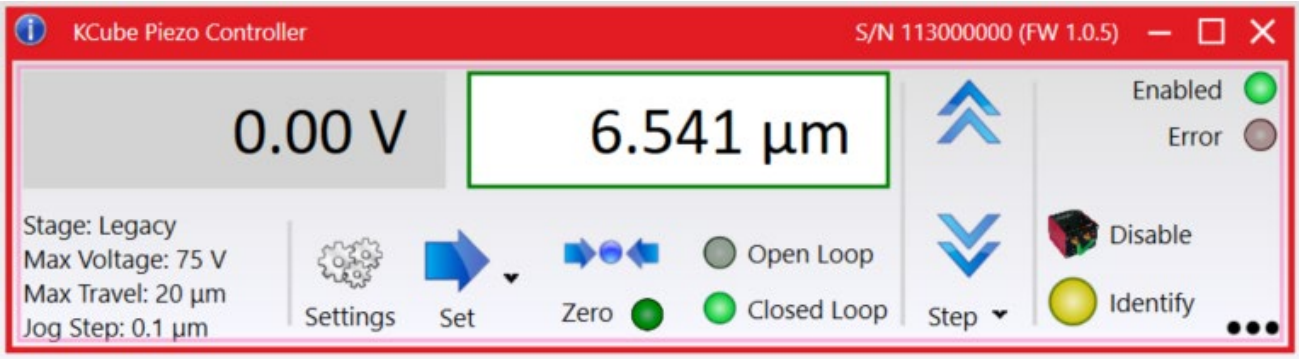


Figure 4 Kinesis Server

This Control provides a complete user graphical instrument panel to allow the Piezo Strain Gauge unit to be manually operated, as well as a complete set of software functions to allow all parameters to be set and operations to be automated by a client application. The instrument panel reflects the current operating state of the controller unit to which it is associated (e.g., such as Piezo Strain Gauge reading). Updates to the panel take place automatically when a user (client) application is making software calls into the same Control. For example, if a client application instructs the associated Piezo Strain Gauge Controller to zero the position sensor, progress is monitored automatically by changing position readout on the graphical interface, without the need for further programming intervention.

The Kinesis Controls collection provides a rich set of graphical user panels and programmable interfaces allowing users and client application developers to interact seamlessly with the Kinesis hardware. Each of the Kinesis controllers has an associated .Net Control and these are described fully in the handbooks associated with the controllers.

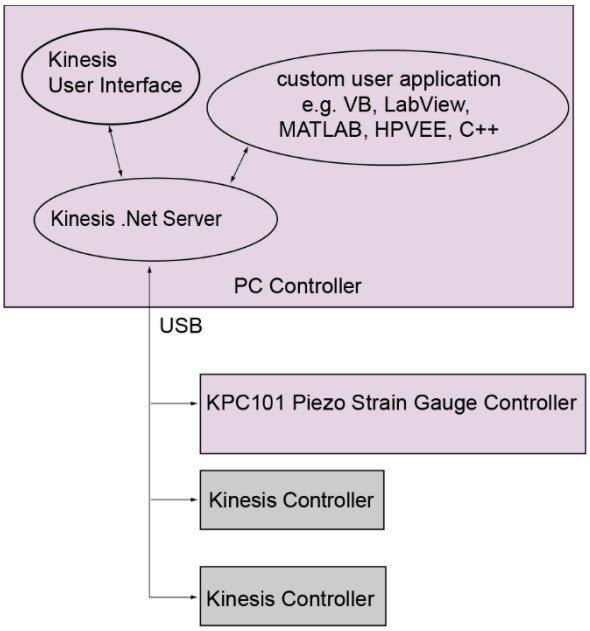


Figure 5 System Architecture Diagram

Refer to the main Kinesis Software online help file, for a complete programmer's guide. This is available either by pressing the F1 key when running the Kinesis server, or via the Start menu, Start\Programs\Thorlabs\Kinesis\Kinesis Help.

3.3 Software Updates

Thorlabs operate a policy of continuous product development and may issue software upgrades as necessary. We recommend all users to download the latest version of Kinesis software and use the included firmware update utility. The latest software can be downloaded from the 'services' section of www.thorlabs.com.

Chapter 4 Installation

4.1 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. Refer servicing to qualified personnel.

4.2 Packing List/Special Tools Required for Installation

Items are listed below:

- KPC Cube Base Unit
- K- Cube Single Adapter
- USB 3.0 A/M-Micro B/M Cable, 1.5 m Black

4.3 Installation

4.3.1 Mechanical Installation

Mounting

The Piezo-Strain Gauge Controller is shipped with a baseplate, for use when fitting the unit to a breadboard, optical table or similar surface. For multiple cube systems, a 3-channel (KEH3 or KCH301*) and 6-channel (KEH6 or KCH601*) K-Cube Controller Hub are also available.

NOTICE

When siting the unit, it should be positioned so as not to impede the operation of the control panel buttons. Ensure that proper airflow is maintained to the rear of the unit.

* The KCH301/601 are previous generation items and are no longer sold individually.

Using the Baseplate

The baseplate must be bolted to the worksurface before the K-Cube is fitted, as shown below. The K-cube is then located on two dowels in the baseplate and secured by two clips.

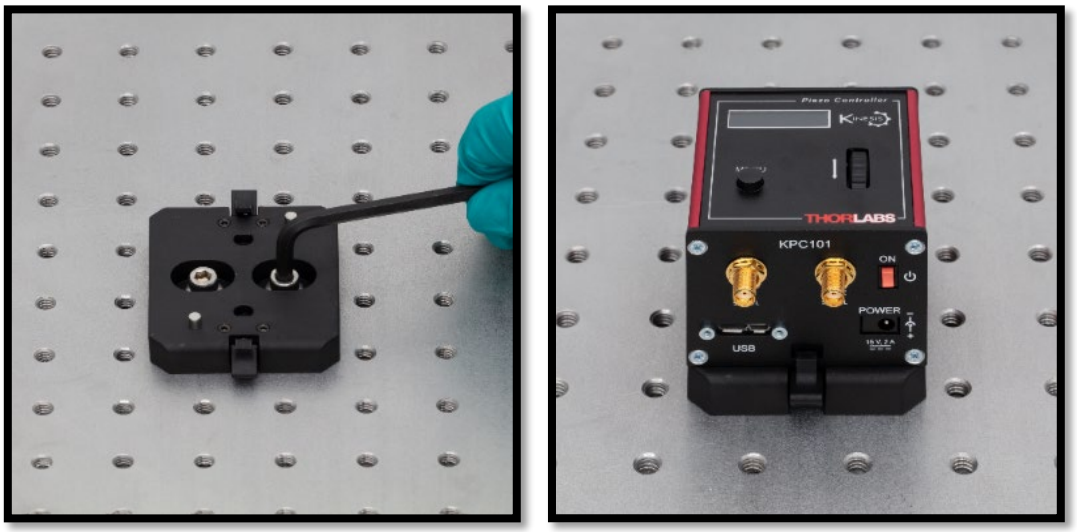


Figure 6 Using the Baseplate

4.3.2 Electrical Installation

Front Panel

⚠CAUTION

The unit must be connected only to a DC supply. Connection to a supply of a different rating may cause damage to the unit and could result in injury to the operator.

NOTICE

Ensure the power switch on the front panel of the unit is switched off before connecting power to the K-Cube. Always power up the K-Cube unit by its ON switch. Do not connect the K-Cube unit to a 'live' external power supply. Doing so (i.e., “hot plugging”) carries the risk of permanent damage to the unit. Similarly, to power down the unit, turn the power switch off before disconnecting the power supply.

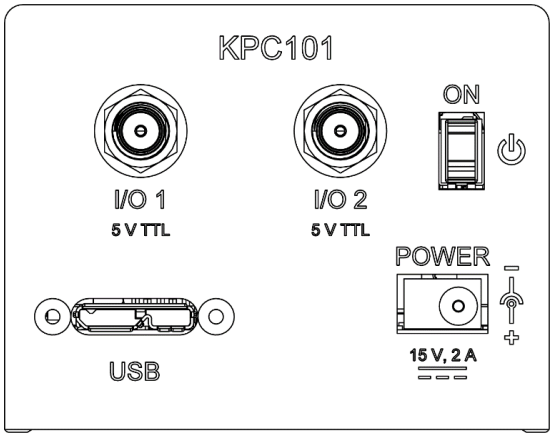


Figure 7 Front Panel

POWER – A standard 3.5 mm front panel jack connector for connecting the unit to a regulated DC power supply of 15 V, 1 A-2.66 A. KPS201 is used.

USB – USB port for system communications. The USB cable length should be no more than 3 meters unless a powered USB hub is being used.

ON - Power ON/Standby switch.

I/O 1 and I/O 2 - SMA connectors for use with external trigger input and output signals (5V TTL levels). The function is set to trigger IN or OUT via the settings panel.

Rear Panel

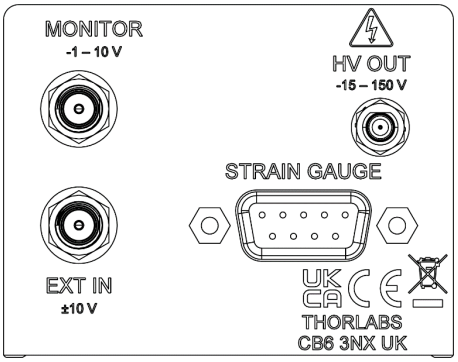


Figure 8 Rear Panel

HV OUT - (SMC connector) – -15 to +150V, ±13 mA (typical) maximum output current. Provides the drive signal to the piezo actuator. The maximum voltage can be selected via the Kinesis GUI.

NOTICE

The output voltage is limited to -10 V by software in the negative region.

EXT IN (SMA connector) – Used to connect an external analogue signal source to control the operation of the cube. The input voltage range is ±10 V and the input impedance is 32 kΩ. The way the signal driving the EXT

IN input controls the unit depends on the operating mode. In open loop mode, the voltage on the EXT IN can be used to drive the high voltage amplifier directly and the output voltage is proportional to the driving voltage. In closed loop mode, EXT IN can be used to control position. The voltage present on EXT IN is added to the contribution of the software defined voltage or position irrespective of the operating mode. The contribution can be positive or negative.

NOTICE

The KPC101 controller has two distinct hardware output voltage ranges: 75 V and 150 V. Most of the Thorlabs piezo actuators have a maximum of 75 V limit and exceeding this voltage can damage these devices. However, the controller can also be switched to output a maximum of 150 V, for third-party piezo stacks that require a higher voltage. It changes various internal amplification factors to optimize accuracy and resolution in both operating ranges.

In addition to the two distinct hardware ranges, the output voltage can also be limited to a lower maximum voltage within the range. For example, in 150 V mode the output voltage can be limited to 100 V maximum. This is a software limitation implemented in firmware only.
Digital Signal Processor
It is highly recommended to use the 75 V range with 75 V piezo actuators rather than using the 150 V range and software limiting the output voltage. The 75 V range offers increased accuracy and also reduces the dissipation generated by the controller.

MONITOR (SMA connector) – This low-voltage (-1 to +10 V), output can be used to monitor the signal at the HV OUT high voltage output or the position. To monitor the output voltage, the 0 V to +10 V output voltage range corresponds to the 0 V to 75 V or 0 to 150 V output voltage range, depending on the selected voltage range. To monitor position, the 0 V to +10 V output voltage range corresponds to 0 to maximum travel. In accordance with the output voltage and position also having a small negative range, the monitor voltage can also swing slightly negative. Most commonly it can be connected directly to an oscilloscope to observe the waveforms or voltage levels present at the high voltage output.

NOTICE

The KPC101 has two main, selectable output voltage ranges of 0 to 75 V or 0 to 150 V, to allow driving piezo actuators with different drive requirements. Regardless of which range is selected, output voltage range on the MONITOR connectors is always -1 to +10 V full scale and the EXT IN input voltage range is -10 V to +10 V. Thorlabs supply a variety of SMA to BNC and SMC to BNC adaptor and extension cables. Please see our catalog or visit www.Thorlabs.com for further details.

STRAIN GAUGE (9 way D-Type female connector) – This connector receives the signal from the strain gauge to provide the feedback for the control loop – refer to section 1.5 for pin out details. Thorlabs supply cabling to connect from this D-type connector to the full range of strain gauge equipped piezo actuators and force sensors. Thorlabs supply Strain Gauge Pre-Amp Circuit (AMP002) to connect with closed loop piezo actuator's bare strain gauge wires to this D-type connector, please refer AMP002 manual for more information.

Supply Voltage and Current Requirements

Supply	Minimum	Maximum	Maximum Operating Current
15 V	**14.5 V**	**15.5 V**	**0.3 A Continuous 2.0 A Peak**

Connecting To a Power Supply

⚠CAUTION

The unit must be connected only to a DC supply. Connection to a supply of a different rating may cause damage to the unit and could result in injury to the operator.

NOTICE

Ensure the power switch on the front panel of the unit is switched off before connecting power to the K-Cube. Always power up the K-Cube unit by its ON switch. Do not connect the K-Cube unit to a 'live' external power supply. Doing so (i.e., “hot plugging”) carries the risk of permanent damage to the unit. Similarly, to power down the unit, turn the power switch off before disconnecting the power supply.

1. Connect the unit to a regulated DC power supply of the rating using the front panel.
2. Switch on the Power Supply unit and then switch on the KPC101.
3. The Version number of the embedded software is displayed for a few seconds. Thorlabs offers a compact one-way power supply unit (KPS201), allowing one K-Cubes to be powered from a single mains outlet.

Powering Down the Unit

The controller may cause drive voltage spikes on power down. In applications requiring the highest sensitivity, the piezo drive voltage should be set to zero, and the HV cable disconnected before the unit is powered down. Always use the front panel ON switch to power down the unit. When in the ON position, the unit is fully powered up. When the switch is turned to the Standby position, the unit initiates a controlled power down sequence, saving all user adjustable parameters to non-volatile memory before turning off the power. For the first few seconds, the shutdown can be cancelled by turning the switch on again, in which case the unit will save the parameters but will remain powered up. In a powered down (Standby) state, the logic circuits are powered off and the unit will draw only a small quiescent current.

Connect the Hardware

Perform the following:

1. Perform the mechanical installation as detailed in section 4.3.1.
2. Install the Kinesis Software.

NOTICE

During items (3) to (6) the instructions should be followed strictly in the order stated. Problems may occur if the process is not performed in the correct sequence.

3. Connect the controller unit to the PC.

NOTICE

The USB cable should be no more than 3 metres in length. Communication lengths in excess of 3 metres can be achieved by using a powered USB hub.

4. Connect the piezo actuator to the Controller Unit. Ensure the power supply unit is isolated from the mains before connecting to the K-Cube unit. Always power up the K-Cube unit by connecting its power

supply to the mains. DO NOT connect the K-Cube unit to a 'live' external power supply. Doing so (i.e., “hot plugging”) carries the risk of PERMANENT damage to the unit. Similarly, to power down the unit, disconnect the power supply from the mains before disconnecting the K-Cube unit.

5. Connect the controller unit to the power supply.
6. Connect the PSU to the main supply.
7. Switch “ON” the unit using the switch on the front panel. The unit takes about 5 seconds from power application until warm up is finished, during which time the software revision is displayed. Windows® should detect the new hardware. Wait while Windows® installs the drivers for the new hardware.
8. The unit starts up with the HV output displayed. This must be displayed before any further settings can be adjusted. If any issues are encountered during the connection and power up process, power cycle the unit, which should clear the error.

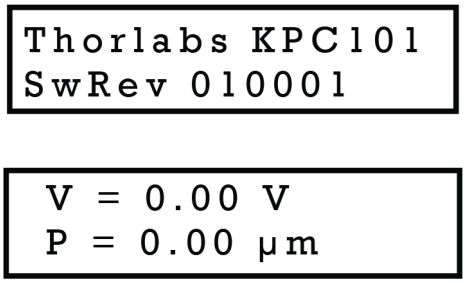


Figure 9 Start Up

4.3.3 Software Installation

Some PCs may have been configured to restrict the users’ ability to load software, and on these systems the software may not install/run. If you are in any doubt about your rights to install/run software, please consult your system administrator before attempting to install. If you experience any problems when installing software, contact Thorlabs on +44 (0)1353 654440 and ask for Technical Support.

This section is applicable only if the K-Cube is to be used with a PC. If your application consists only of local operation via the K-Cube front face, refer to section 4.3.2. When operating via a PC, direct user interaction with the Piezo driver is accomplished through intuitive graphical user interface panels (GUIs), which expose all key operating parameters and modes. The user can select multiple panel views displaying different information about a particular hardware unit. The multitasking architecture ensures that the graphical control panels always remain live, showing all current hardware activity.

Perform the following before connecting the controller to the PC.

1. Go to Services/Downloads at www.thorlabs.com and download the software.
2. Run the .exe file and follow the on-screen instructions.

Chapter 5 Piezo Strain Gauge Operation

5.1 Introduction

The Piezo Strain Gauge Controller has been designed specifically to operate with the extensive range of Thorlabs piezo-actuated feedback equipped opto-mechanical products. It is also compatible with Thorlabs force sensor products, FSC102 and FSC103 providing high-sensitivity force and touch probe sensing. For non-PC use the unit is equipped with an LCD Display to indicate position, together with a settings menu to change

the display units and set the zero-position point. These parameters can also be set via the Kinesis Server software. The unit offers a fully featured open loop control capability, including piezo drive voltage adjustment and input source selection. High precision closed loop positioning is possible using the complete range of feedback equipped piezo actuators available from Thorlabs. The following brief overview explains how the front panel controls can be used to perform a typical series of operations. In conjunction with this chapter, it also may be useful to read the background on piezo operation contained in **Chapter 9**.

Warning: Risk of Electrical Shock
Persons using the KPC101 controller must understand the hazards associated with using high voltages and the steps necessary to avoid risk of electrical shock. If the KPC101 is used in a manner not specified by Thorlabs, the protective features provided by the product may be impaired.

5.2 Control Panel

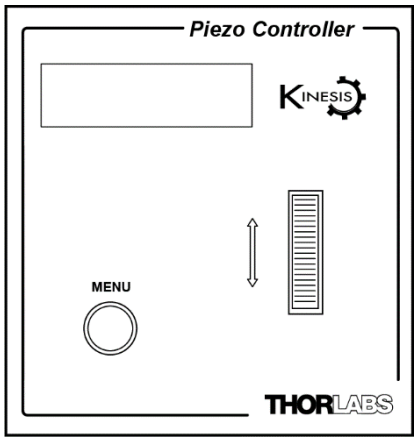


Figure 10 Panel Control and Indicators

Controls- These controls allow all motor moves to be initiated.

Wheel - The wheel/joystick is an infinite turn potentiometer, which is used to select different parameters and values in the settings menu.

Digital Display - The display shows the menu options and settings, accessed via the menu button. When the Ident button on the associated GUI panel is clicked, the display will flash for a short period.

MENU - used to access the settings menu.

5.2.1 Digital Display- Operating Mode

During normal operation, the top line of the digital display shows the current drive voltage applied and the bottom line shows the position in µm.

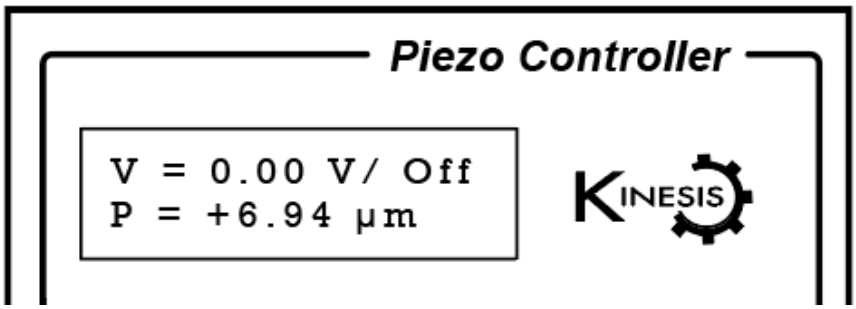


Figure 11 Digital Display – Normal Operation

5.3 Joystick Wheel Operation

The joystick wheel is an infinite turn potentiometer, which is used to initiate different types of adjustments depending on its mode setting. The mode can be set either via the Kinesis GUI Settings panel (refer to section 7.1) or via the top panel display menu, refer to section 5.4.

In open loop, the adjustment, jog and preset functions described below are used to control the output voltage whereas in closed loop they control the position.

5.3.1 Adjustment Mode

In adjustment mode, the wheel can be used to increase and decrease the drive voltage (open loop) or position (closed loop). The voltage/position change is proportional to the deflection of the wheel, refer to section 5.4.6. The rate of change is adjusted in the Joystick Menu parameter – refer to section 5.4.7.

5.3.2 Go To Mode

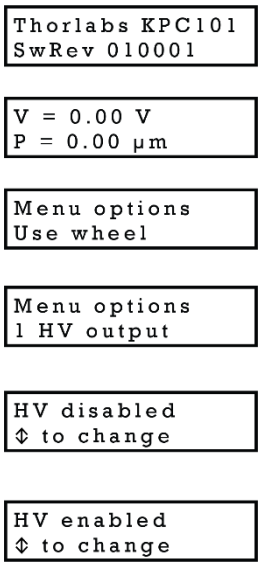
In ‘Go To’ mode, two preset voltage/position values can be specified, such that the drive voltage/position is set to preset value 1 when the wheel is moved down, and to preset value 2 when it is moved up. These ‘taught’ voltages can be set through the software GUI or via the display menu. This mode of operation is enabled by setting the ‘Wheel Mode’ to ‘Go to’ through the software GUI or via the display menu.

5.3.3 Jog Mode

The top panel wheel can also be configured to ‘jog’ the drive voltage/position. This mode of operation is enabled by setting the ‘Wheel Mode’ parameter to ‘Jog’ through the software GUI or via the display menu.

5.4 Settings Menu

The settings menu can be accessed, as follows:



Press the MENU button.

Use the wheel to scroll to the 1 HV output option.

Press the MENU button to enter the option.

Use the wheel to scroll to the HV enabled option.

Press the MENU button to save and exit.

5.4.1 Menu Overview

Press the MENU button.

Use the wheel to scroll through the menu options.

Press the MENU button to enter a particular option.

Enable/disable the drive output.

Zeroing the Position Sensor.

Set open loop or closed loop mode.

Set the analogue input source.

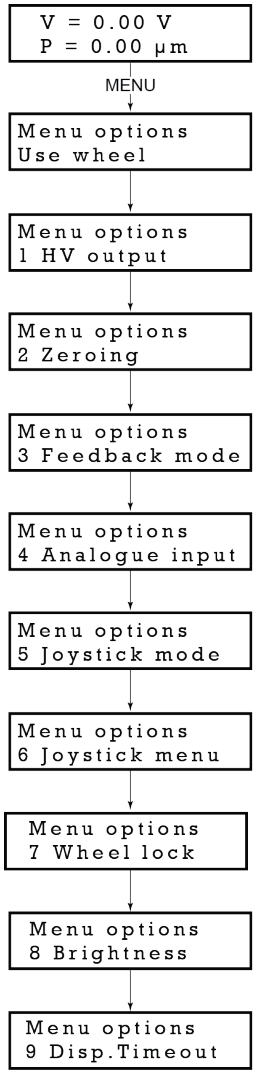
Set the wheel/joystick mode.

Set the wheel/joystick parameters.

Disable the wheel.

Set the display brightness.

Set the display timeout period.



5.4.2 Menu Option- HV output

This mode is to enable or disable the drive output.

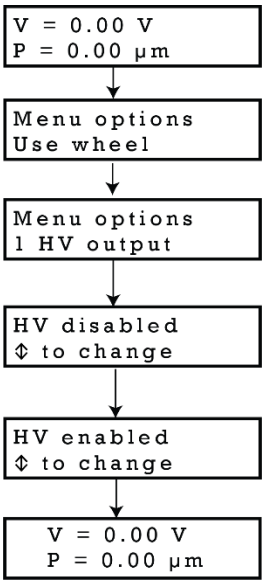
Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the 1 HV output option.

The display shows the current setting.

Use the wheel to enable/disable the output.

Press the MENU button to store the selection and return to the operating screen.



5.4.3 Menu Option Zeroing

The piezo strain gauge connected to the K-Cube may give a small signal when the device is at zero position with zero volts applied (due to limitations in manufacture, or temperature fluctuations). This 'offset' signal must be removed before the position attained by a specific applied voltage and the position attained by a corresponding specified distance can be rationalized.

Each device has a unique offset value. Therefore, the offset should be adjusted whenever a device is replaced. Temperature and prolonged use can affect the performance of the device and therefore the offset value. Initially, after the unit is powered up, the display will show the position reading with the piezo-stage specific and temperature dependent offset and the device should be zeroed to eliminate this offset.

To zero the position sensor.

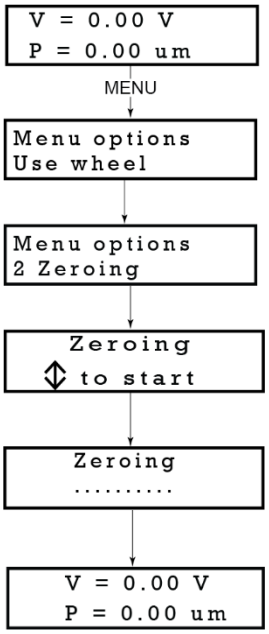
Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the 2 Zeroing option.

Press Menu button again.

The unit will start the zeroing procedure automatically.

When zeroing is complete, the unit reverts to the normal operating display and both V and P will show 0.



5.4.4 Menu Option Feedback mode

When the piezo strain gauge controller is used high precision closed loop operation is possible using the complete range of feedback equipped piezo actuators available from Thorlabs for schematic diagrams of open and closed loop operation.

This mode is used to set the feedback mode.

Press the MENU button, then use the wheel to scroll through the menu options.

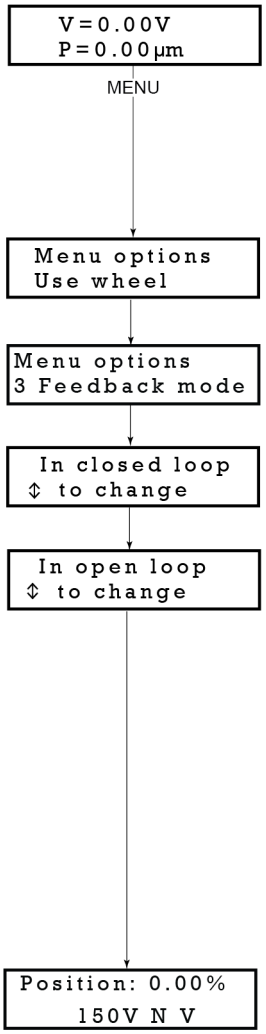
Press the MENU button to enter the 3 Feedback mode option. The display shows the current setting.

Use the wheel to change to the required mode, e.g., in closed loop.

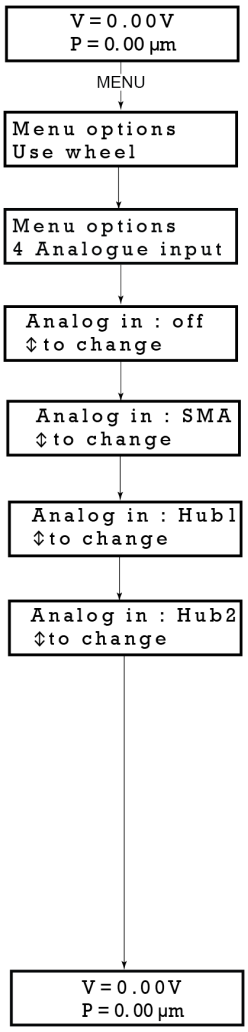
Note- This setting cannot be saved (persisted), i.e., at subsequent power-up cycles the unit always defaults to open loop mode.

Caution- If the Piezo Strain Gauge controller is switched to closed loop mode without being connected to a Strain Gauge Reader, the piezo driver will expect a feedback signal and the piezo drive voltage will ramp up to the to the current maximum voltage limit.

Press the MENU button to save the setting and return to the operating screen.



5.4.5 Menu Option Analogue input



The K-Cube piezo strain gauge controller has 3 external inputs whose function depends on whether the cube is used in open or closed loop mode.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the 4 Analogue input option. The display shows the current input setting.

If Analog in off is selected, the analogue input is disabled. In open loop mode, the external input (Ch1, Ch2 or SMA) is used to control the high voltage amplifier.

If Analog in SMA is selected, the signal is routed via the Ext IN SMA connector on the rear panel.

If Analog in hub (Ch1) is selected, the feedback signal runs through all the bays. This setting is useful in applications where a master cube is controlling several slave cubes.

If Analog in hub (Ch2) is selected, the feedback signals run between adjacent pairs of K-Cube bays (i.e., 1 and 2, 3 and 4, 5 and 6). This setting is useful when several pairs of cubes are being used on the same hub.

Use the wheel to change to the required input mode. Press the MENU button to save the setting and return to the operating screen.

5.4.6 Menu Option Joystick mode

This mode is used to set the operating mode of the joystick wheel.

Press the MENU button, then use the wheel to scroll through the menu options.

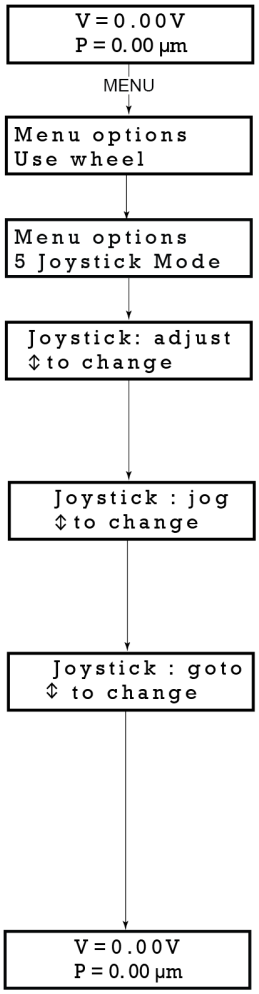
Press the MENU button to enter the 5 Joystick mode option. Use the wheel to scroll through the options. The display shows the current setting.

In Adjust mode, the wheel can be used to increase and decrease the drive voltage(open loop) or position (closed loop). The voltage/position change is proportional to the deflection of the wheel according to the setting in the Speed parameter in the 6 Joystick menu option.

In Jog mode, deflecting the wheel initiates a change in the drive voltage (open loop) or position (closed loop), using the parameters specified by the step parameter in the 6 Joystick menu option. The voltage/position is increased or decreased by one step per click of the wheel.

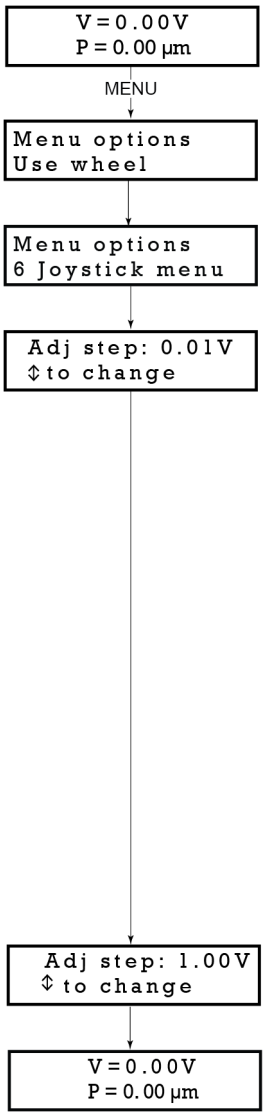
In Go To mode, deflecting the wheel changes the voltage/position from the current value to one of the two predefined “preset” values.

Use the wheel to display the required option, then press MENU to store the selection and return to the main display.



All the above settings, together with their corresponding parameters, are also available via the GUI Settings -> Advanced -> On-Device Controls panel.

5.4.7 Menu Option Joystick menu



This mode is used to set various parameters depending on the Joystick mode setting.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the 6 Joystick menu option. The display shows the current setting.

If Jog Joystick mode is selected in the previous section, deflecting the wheel initiates a change in the drive voltage/position, using the parameters specified by the Step parameter. To change the step size, click the MENU button when this option is displayed, then turn the wheel to adjust the step size.

Press MENU to store the selection and return to the main display.

If Adjust Joystick mode is selected in the previous section, the wheel can be used to increase and decrease the drive voltage/position. The voltage/position change is proportional to the deflection of the wheel according to the setting in the Speed parameter as follows:

Speed: High
Voltage adjusts at a high rate, i.e., 1 V per detent/click.
Position adjusts at 1 µm.

Speed: medium –
Voltage adjusts at a medium rate, i.e., 100 mV per detent/click.
Position adjusts at 0.1 µm.

Speed: low –
Voltage adjusts at a low rate, i.e., 10 mV per detent/click.
Position adjusts at 0.01 µm.

The size of the step is as set in the Step parameter above.

To change the adjustment rate, click the MENU button when the Speed: option is displayed, then turn the wheel to adjust the step size.

Press MENU to store the selection and return to the main display.

5.4.8 Menu Option Wheel lock

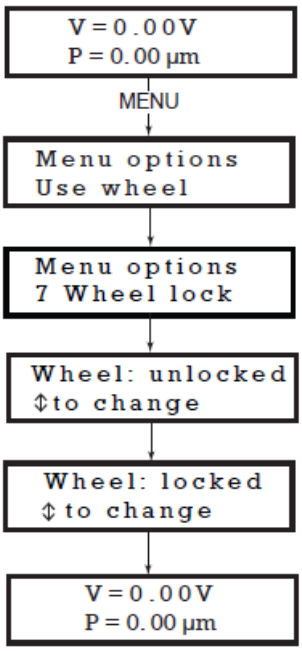
In certain applications, it may be advantageous to disable the wheel to remove the possibility of unwanted motion due to accidental movement of the wheel.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the 7 Wheel lock option.

The display shows the current setting. Use the wheel to select 'Wheel locked' or 'Wheel unlocked' as required.

Press the MENU button to store the selection and return to the main display.



5.4.9 Menu Option Brightness

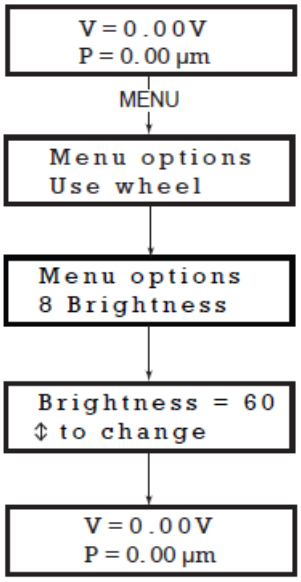
In certain applications, it may be necessary to adjust the brightness of the LED display. The brightness is set as a value from 0 (Off) to 100 (brightest). The display can be turned off completely by entering a setting of zero, however, pressing the MENU button on the top panel will temporarily illuminate the display at its lowest brightness setting to allow adjustments. When the display returns to its default operating display mode, it will turn off again.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the 8 Brightness option.

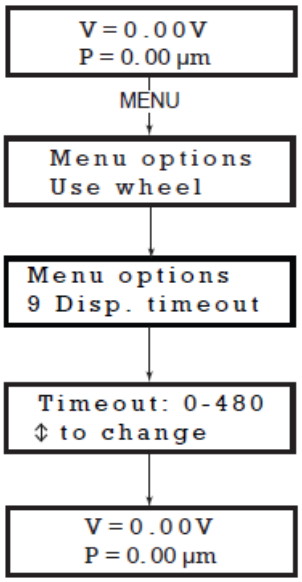
Use the wheel to adjust the brightness.

Press the MENU button to store the selection and return to the main display.



5.4.10 Menu Option Disp timeout

'Burn In' of the display can occur if it remains static for a long time. To prevent this, the display is automatically dimmed after a specified time interval.



Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Disp. timeout option.

The time out interval is specified in minutes in the range 1 to 480. The adjustment is done in steps of 1 minute if the timeout is between 1 to 10 minutes, 10-minute steps between 10 minutes and 1 hour, and 30 minute steps above, up to a maximum of 480 minutes. After 480 minutes there is an option for Never. The dim level can only be adjusted via the Settings panel.

Press the MENU button to store the selection and return to the main display.

Chapter 6 PC Operation – Tutorial

6.1 Introduction

The following brief tutorial guides the user through a typical series of actions and parameter adjustments performed using the Kinesis software. It assumes that the unit is electrically connected as shown in Section 4.3.2 and that the software is already installed - see Section 4.3.3. It also assumes that a piezo strain gauge controller is connected to the 'HV OUT connector on the rear panel.

6.2 Kinesis Software

The Kinesis application allows the user to interact with any number of hardware control units connected to the PC USB Bus. This program allows multiple graphical instrument panels to be displayed so that multiple units can be controlled. All basic operating parameters can be set through this program, and all basic operations (such as piezo moves) can be initiated.

This tutorial shows how the Kinesis application provides all of the functionality necessary to operate the hardware.

Power up the hardware, and wait until the KPC101 has finished booting up, then run the Kinesis software - Start/All Programs/Thorlabs/Kinesis/Kinesis.

NOTICE

For maximum accuracy, wait approximately 30 mins for the unit to thermally stabilize to the environment.

The server registers automatically the units connected on the USB bus and displays the associated GUI panels as shown below.

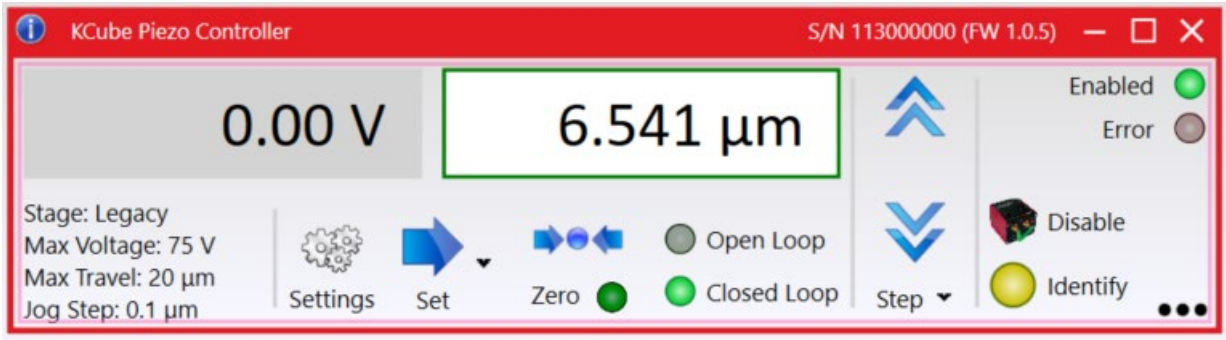


Figure 12 Piezo Strain Gauge Controller Software GUI

6.3 Open and Closed Loop Piezo Operation

The KPC101 Piezo Strain Gauge Controller has two distinct modes of operation: open and closed loop mode. In open loop mode, the output voltage is controlled directly, using the potentiometer, one of the external inputs, the GUI or a combination of these three. The output voltage is proportional to the controlling source. This voltage controls the expansion of the piezo actuator, turning the voltage into a certain amount of displacement.

The need for a closed loop mode of operation arises from the fact that the displacement produced by the piezo actuator is not a linear function of the driving voltage. All piezo actuators show a certain amount of nonlinearity, hysteresis, temperature dependence and aging – refer to **Chapter 9** for more details.

In precision positioning applications this can seriously limit the accuracy and repeatability of the system. This problem can however be eliminated when closed loop control is used. Closed loop mode assumes that the piezo actuator is fitted with a position sensor, usually a strain gauge, that is capable of reading the actual

position and this signal is fed back to the piezo controller. Rather than outputting a constant voltage, the piezo controller continuously monitors the position signal and, if necessary, adjusts the output voltage to maintain the required position.

6.3.1 Open Loop

Below diagram shows a simplified block diagram of the piezo controller in open loop mode.

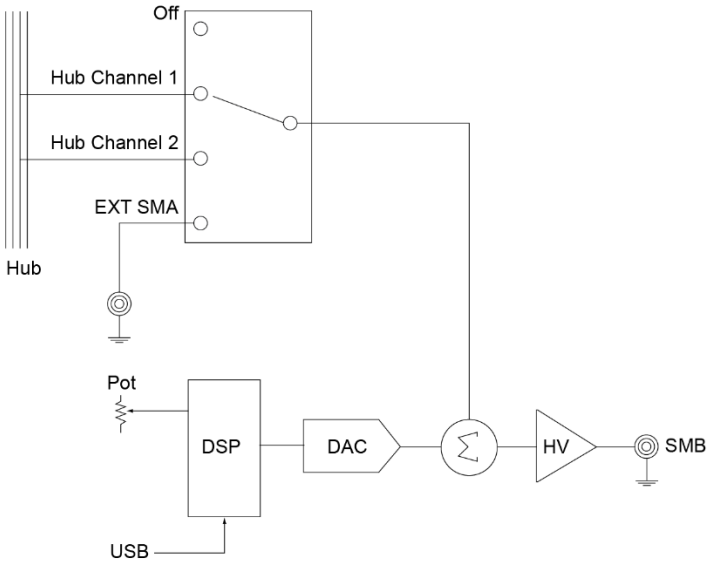


Figure 13 Open Loop Schematic Diagram

The output voltage is controlled by the Digital Signal Processor (DSP), allowing the Kinesis server to set the output voltage. The output voltage can also be controlled by the top panel potentiometer. In addition, one of the 3 possible external inputs (SMA input, Hub Channel 1 or Hub Channel 2) can also be added to the signal that controls the output voltage.

The following procedures explain how the piezo strain gauge controller is driven. In open loop mode, the piezo can be positioned in three ways: by entering a voltage, by using the 'Output' potentiometer or by clicking the 'Jog' buttons.

Entering the Piezo unit

1. Click the Set Arrow 

to display the Target window.

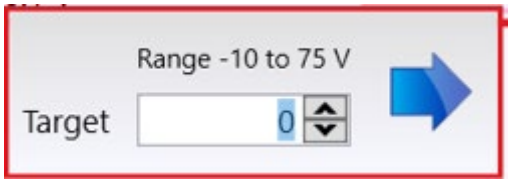
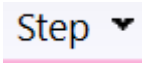


Figure 14 Target Voltage Pop-up Window

2. Enter a voltage into the pop-up window. This can be entered directly into the field or by clicking on the up/down access.
3. When finished, click the Set Target Output arrow to the right of the window. The main GUI display counts up to the value entered.

Jogging the Piezos

When the jog buttons are pressed, the piezo moves by the voltage step specified in the Jog Step Size parameter.

1. Click the Step Button 

to display the Step Size Window.

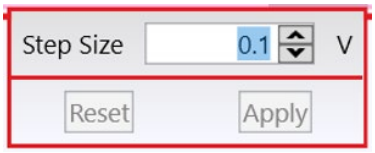


Figure 15 Target Voltage Pop-up window

2. In the 'Step Size' field, enter a step size in the range 0.1 V to 150 V. This can be entered directly into the field, or by clicking on the up/down arrows.
3. Click 'Apply' to save the settings and close the window. To cancel the change click Reset.
4. Click the upper Jog arrow on the GUI panel to jog the piezo. Notice that the voltage display increments by the value entered every time the button is clicked.
5. Click the lower Jog arrow on the GUI panel. Notice that the voltage display decrements by the value entered every time the button is clicked.

Using the Controller as a Piezo Amplifier

Certain applications may require the piezo to be driven by a voltage generated from an external source (e.g., a signal generator). The piezo K-Cube is designed to accept an external -10 to +10 V signal and handle the amplification from 10 V to 75 or 150 V.

As an example, the following procedure explains how to configure the unit as a piezo amplifier.

1. Connect a +/- 10 V external source to the EXT IN connector on the rear panel.
2. In the GUI panel, click the 'Settings button to display the settings panel, then select the 'Advanced' tab.

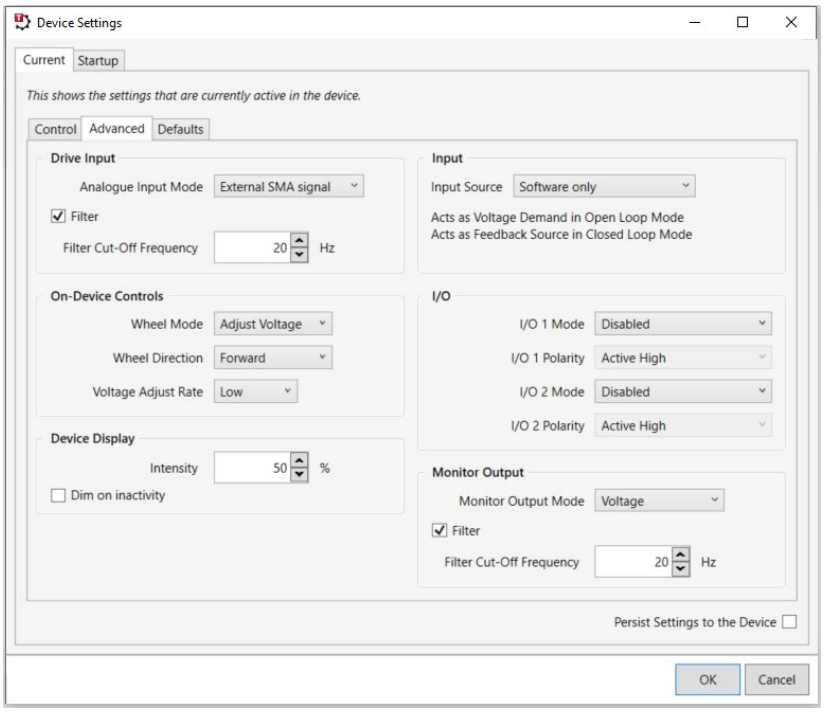


Figure 16 Piezo Advanced Tab

3. In the ‘Input Source’ field, select Software + External signal.
4. In the ‘Analogue Input Mode’ field, select External SMA signal.
5. Click ‘OK’ to save the settings and close the window.

Any voltage on the rear panel SMA connector is now amplified by the unit and presented at the HV OUT (piezo drive) connector and the position of the piezo actuator can be controlled by varying the -1 to 10V external source. If required, the contribution of the potentiometer on the top panel of the unit can also be added by selecting the appropriate option in the ‘Input Source’ field. In this way it is possible to adjust the DC level on the output whilst adding an AC signal to this DC level via the external SMA terminal.

6.3.2 Closed Loop

The diagram below shows a simplified block diagram of the piezo controller in closed loop mode.

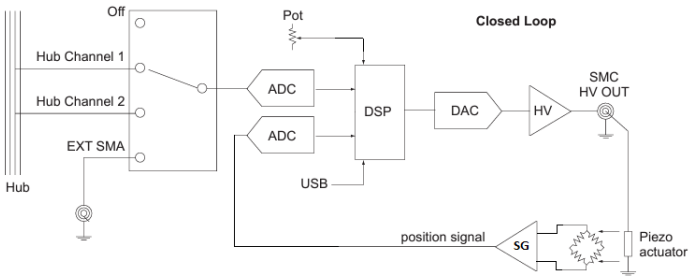


Figure 17 Closed Loop Schematic Diagram

In closed loop, the role of the external input changes, and the selected input receives the position signal from the external position reader. The DSP now implements a digital PI (proportional-integral) control feedback loop. This control loop monitors the actual position reading and adjusts the high voltage output to maintain a constant position (set point). This set point can be varied by adjusting the OUTPUT pot on the top panel or the Output control on the GUI.

Chapter 7 Software Reference

The following screen shot shows the graphical user interface (GUI) displayed when accessing the controller using the Kinesis software.

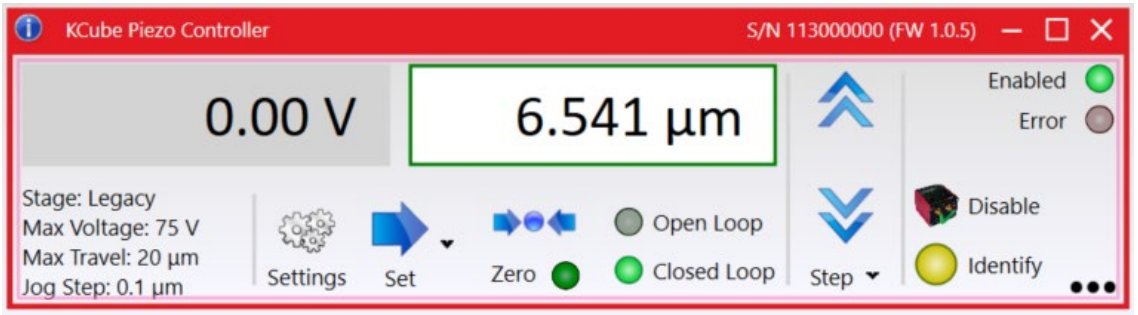


Figure 18 KPC101 Piezo Strain Gauge Controller

NOTICE

The serial number of the KPC101 unit associated with the GUI panel, is displayed in the top right-hand corner. This information should always be provided when requesting customer support along with the firmware.

Main Display - The display shows the voltage and the travel applied to the piezo and the travel. Grey colour of the display indicates if KPC101 works in closed or open loop mode. If the actuator driven by KPC101 is not fitted with a position fedback sensor, the position displayed as zero.



Set Arrow- Opens the settings window, so that the target drive voltage or position can be entered.



If the controller is used in open loop mode, the output voltage is controlled, whereas in closed loop the position.

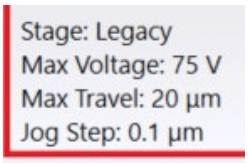
Zero- Sets the piezo drive voltage to zero.



Step Arrows- - Used to increment or decrement the output voltage or position. When the buttons are clicked, the piezo is driven in the selected direction, one step per click. The step size is set by clicking the Step Button.



Parameters Display- Shows the maximum working voltage and travel of the associated piezo strain gauge controller and the present setting for the step size.



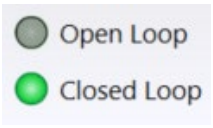
Settings- Displays the 'Settings' panel, which shows the operating parameters for the motor drive.



Enabled- It is lit during normal operation.

Error- it is lit when a fault occurs.

Open and Closed Loop LEDs- When Open Loop or Closed Loop mode is selected, the corresponding LED is lit.



Identify- When this button is pressed, the POWER LED and the main display on the front panel of the associated hardware unit will flash for a short period.



7.1 Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed. This panel allows data such as jog step size and input sources to be entered. Note that all of these parameters have programmable equivalents accessible through the functions on this Control (refer to the Kinesis API helpfile for further detail.

7.1.1 Persist Settings to the Hardware

Many of the parameters that can be set for the Piezo Strain Gauge Controller can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually in the absence of a PC and USB link. The Analogue Input Channel and Display Mode parameters are good examples of settings that can be altered and then persisted in the driver for use in absence of a PC. To save the settings to hardware, check the 'Persist Settings to Hardware' checkbox before clicking the 'OK button.

NOTICE

The 'Persist Settings' functionality is provided to simplify use of the unit in the absence of a PC. When the unit is connected to a PC and is operated via the Kinesis software, the default settings will be loaded at boot up, even if the 'Persist Settings' option has been checked.

7.1.2 Control Tab

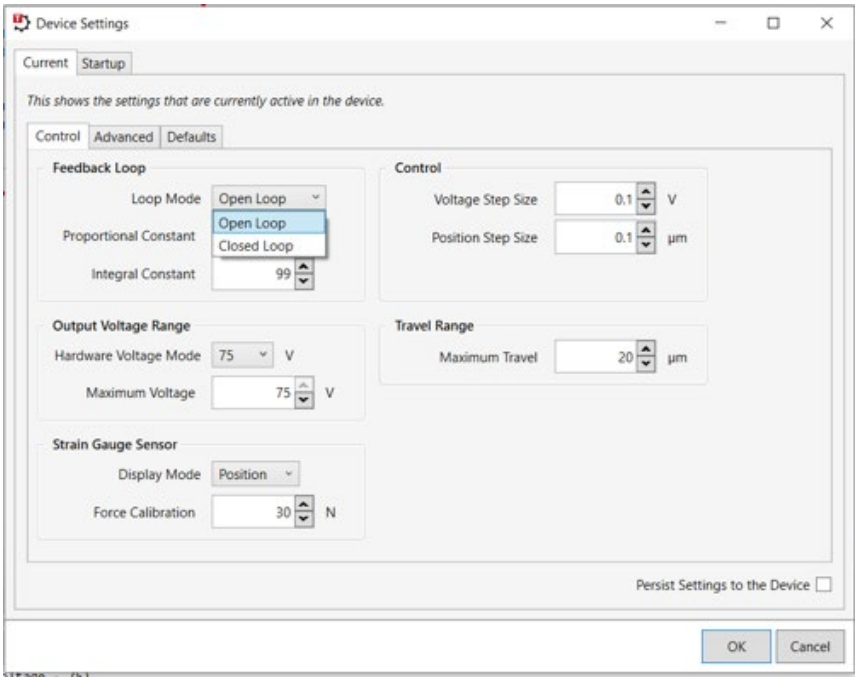


Figure 19 Control Tab

Feedback Loop Settings Loop mode

This panel can be used to select between the two distinct operating modes: open loop and closed loop.

Select Open Loop or Closed Loop as required.

Loop Constants - When operating in Closed Loop mode, the proportional and integral (PI) constants can be used to fine tune the behavior of the feedback loop to changes in the output voltage or position. While closed loop operation allows more precise control of the output position, feedback loops need to be adjusted to suit the different types of piezo actuator that can be connected to the system. The default values of 10 (proportional) and 100 (integral) have been optimized to work with most Thorlabs piezo actuators, so usually these values can be left unchanged.

Integral Constant - sets the integral feedback loop constant for the selected channel (0 to 255).

Proportional Constant - sets the proportional feedback loop constant for the selected channel (0 to 255).

Controls

Voltage Step Size - Applicable in open loop. This parameter specifies the amount by which the piezo drive voltage is incremented or decremented, each time the 'Step' button is clicked on the GUI panel.

Position Step Size - Applicable in closed loop. This parameter specifies the distance to move, each time the 'Step' button is clicked on the GUI panel.

Output Voltage Range

Hardware Voltage Mode- The KPC101 controller has two distinct voltage ranges: 75 V and 150 V. The 75 V is used with 75 V piezo actuators, reducing the output voltage of the internal high voltage boost regulator and the high voltage amplifier's gain. This range is recommended with 75 V piezo actuators as it increases the accuracy of the output voltage, reduces thermal drift and also minimizes the dissipation produces by the unit. The 150 V range can be used for piezo actuators that require a higher voltage for full extension.

Maximum Voltage – In addition to the hardware voltage range, the maximum output voltage can be limited to a user-selectable lower voltage using this parameter. For example, in the 150 V hardware range the maximum output voltage can be limited to 100 V. This limit is applied regardless of the operating mode.

In the 150 V hardware range the maximum voltage can be limited to below 75 V which is preferable to use as it offers reduced drift, dissipation and higher accuracy.

Travel Range

The KPC101 controller identifies the travel range of Thorlabs piezo stages after power-up and the maximum travel is the factory-defined value for the piezo actuator.

For custom piezo actuators that are not equipped with an identification device the KPC101 is unable to do this automatically and for these the travel range is displayed initially as 0 µm. Customers can use this parameter to enter the piezo travel range and persist the setting. On the next power up the KPC101 will check if a user-persisted maximum travel range has been defined and it will use this value if automatic identification is not possible.

Thorlabs offers the AMP002 strain-gauge preamplifier for custom devices; the KPC101 can be used with the AMP002 and the travel range can be redefined using this setting.

The other use for the Maximum Travel setting is to make a small correction to the nominal maximum travel value read on power-up. If the actual measured maximum travel is slightly different, the user can enter a more precise (for example calibrated) value and the controller will use this value for calculating the actual travel. The value can be persisted, and the controller will overload the nominal travel read from the stage as long as the persisted value is within 20% of the nominal value.

Strain Gauge Sensor

Piezo actuators are most frequently controlled by the KPC101 controller, either in open or closed loop mode. Nevertheless, KPC101 can also be utilized as a force sensor since it works with the axial force sensors from Thorlabs, like FSC102 and FSC103.

Choose "Force" as the Display Mode to use this option.

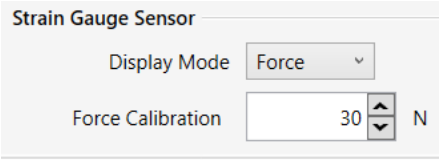


Figure 20 Strain Gauge Sensor

Force sensors work similarly to closed loop piezo actuators and uses strain gauge bridges to measure the mechanical force applied to them instead of detecting the expansion of the piezo stack.

These force sensors lack an actuator in force sensing mode which is why KPC101 only works as a readout device; the functionality for adjusting the output voltage and position is not relevant. Accordingly, the Set and Step voltage/position control arrows on the main GUI panel are disabled when the device is in force sensing mode. Both the GUI and LCD displays switch from position measurements in µm to force readings in N when the device is in force sense mode.

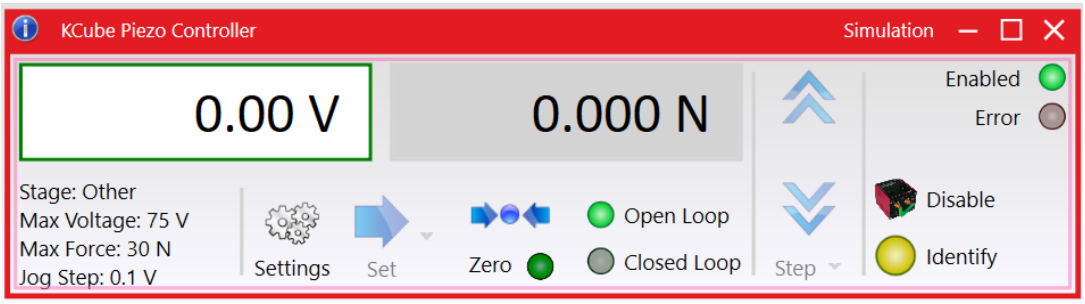


Figure 21 Kinesis GUI

Choose the Force Calibration option to set the force that corresponds to the maximum strain gauge output. The FSC102 and FSC103 sensors' nominal value is 30 N, however a more precise or user-calibrated value may also be utilized.

The Strain Gauge Sensor settings can be persisted and loaded automatically by the controller upon powerup just like other parameters.

7.1.3 Advanced Tab

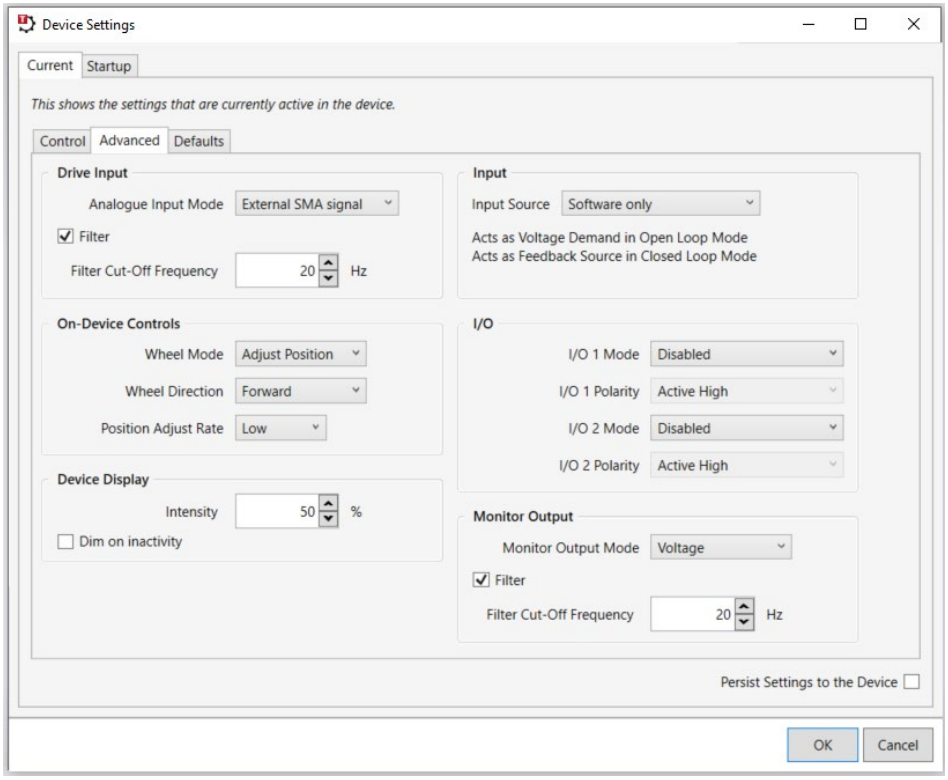


Figure 22 Advanced Tab

Drive Input

Analogue Input Mode - This field allows the user to select the analogue input source, which can be one of 3 inputs:

If Analogue Channel 1 is selected, the feedback signal runs through all the bays – refer to Figure 23. This setting is useful in applications where a master cube is controlling several slave cubes.

If Analogue Channel 2 is selected, the feedback signals run between adjacent pairs of K-Cube bays (i.e., 1 and 2, 3 and 4, 5 and 6) – refer to Figure 23. This setting is useful when several pairs of cubes are being used on the same hub.

If External SMA signal is selected, the signal runs through external connections via the rear panel EXT IN SMA terminal. This option is useful if a hub is not available, or the controlling signal source is not a member of the K-Cube family of products.

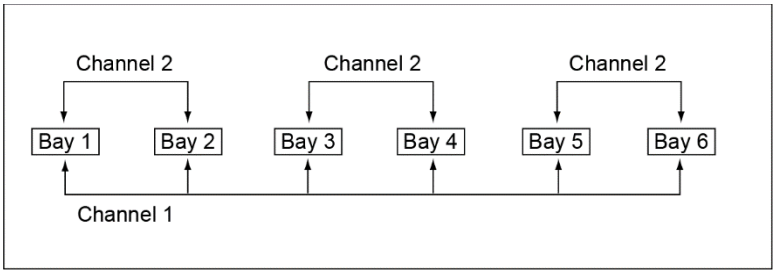


Figure 23 Controller Hub Feedback Channels

Input

Input Source - the voltage output of the unit is a sum of up to 3 contributing sources: the software (GUI) 'Output Voltage' setting, the front panel potentiometer and the external input source, which in turn can be set to Hub Channel 1, Hub Channel 2 or 'EXT IN' SMA connector - see Analogue Input Source parameter.

In open loop mode the selected input(s) control the output voltage, whereas in closed loop they control position.

Of these 3 contributing sources, software control is always on (since whenever the GUI panel is displayed, the software is controlling the piezo cube), whilst the contribution of the front panel pot and the external input can be individually enabled or disabled as follows:

If Software only is selected, the unit responds only to software inputs and the HV amp output is that set using the SetVoltageSource method (or the GUI panel ‘Output’ control).

If Software + External Signal is selected, the unit sums the signal on the rear panel ‘EXT IN’ SMA connector with the voltage set using the SetVoltageSource method (or the GUI panel ‘Output’ control).

If Software + Wheel is selected, the unit sums the voltage set using the top panel joystick wheel with the voltage set using the SetVoltageSource method (or the GUI panel ‘Output’ control).

On - Device Controls

The joystick wheel is an infinite turn potentiometer, which is used to initiate different types of move depending on its mode setting. The mode can be set either via the GUI Settings panel as follows or via the top panel display menu.

Wheel Mode

The parameters displayed are dependent upon the Feedback Loop Settings selected on the Control tab. If Open Loop is selected, the parameters are displayed in Voltage, if Closed Loop is selected the parameters are displayed in Position.

Adjust Voltage/Position - The wheel can be used to increase and decrease the drive voltage/position. The voltage change is proportional to the deflection of the wheel according to the setting in the Voltage Adjust Rate parameter as follows:

High - Voltage adjusts at a high rate, i.e., 1 V per click /1 µm per click.

Medium - Voltage adjusts at a medium rate, i.e., 100 mV per click/0.1 µm per click.

Low - Voltage adjusts at a low rate, i.e., 10 mV per click/0.01 µm per click.

Jog - Deflecting the wheel initiates a change in the drive voltage, using the parameters specified by the Voltage Step parameter. The voltage changes by one step for each click of the wheel.

Set - Deflecting the wheel changes the drive voltage to one of the two predefined "teach" voltages or positions. The teach voltages are specified in the Preset Volts/Position 1 and Preset Volts/Position 2 parameters.

Wheel Direction- The direction of a voltage change initiated by the joystick wheel is specified as follows: Forward - Upwards rotation of the wheel results in a positive change (i.e., increased voltage).

Reverse - Upwards rotation of the wheel results in a negative change (i.e., decreased voltage).

Device Display

Intensity- In certain applications, it may be necessary to adjust the brightness of the LED display on the top of the unit. The brightness is set in the Display Intensity parameter, as a value from 0 (Off) to 100 (brightest). The display can be turned off completely by entering a setting of zero, however, pressing the MENU button on the top panel will temporarily illuminate the display at its lowest brightness setting to allow adjustments. When the display returns to its default position display mode, it will turn off again.

'Burn In' of the display can occur if it remains static for a long time. To prevent this, the display is automatically dimmed after the time interval specified in the Display Timeout parameter has elapsed. The time interval is specified in minutes in the range 1 to 480. The dim level is set in the Dimmed Intensity parameter, as a percentage of full brightness from 0 (Off) to 10 (brightest) but is also limited by the Display Intensity parameter if this is lower. These settings are only visible and active if the Dim on inactivity box is ticked.

I/O

When configured as an input, the I/O ports can be used as a general purpose digital input, or for triggering voltage or position jog step changes. When used for triggering changes, the port is edge sensitive. In other words, it has to see a transition from the inactive to the active logic state (Low->High or High->Low) for the trigger input to be recognized. For the same reason a sustained logic level will not result in another trigger step . The trigger input has to return to its inactive state first in order to start the next trigger. The mode is set in the Trigger 1 Mode and Trigger 2 Mode parameters as follows:

Disabled - The trigger IO is disabled.

Digital Input - General purpose logic input (read through status bits using the GetStatusBits method).

Trigger Input Jog Up - Input trigger for voltage/position jog step up. On receipt of the trigger, the drive voltage/position increases by the value set in the Voltage/Position Step parameter.

Trigger Input Jog Down - Input trigger for voltage/position jog step down. On receipt of the trigger, the drive voltage/position decreases by the value set in the Voltage/Position Step parameter.

When the Trig 1 Mode and Trig 2 Mode parameters are configured as outputs, the TRIG ports can be used as a general-purpose digital output as follows:

Digital Output - General purpose logic output (set using the `SetDigitalOutputs` method).

Less than lower limit - The output trigger is active when the strain gauge input is less than the lower limit.
More than lower limit - The output trigger is active when the strain gauge input is greater than the lower limit.
Less than upper limit - The output trigger is active when the strain gauge input is less than the upper limit.

More than upper limit - The output trigger is active when the strain gauge input is greater than the upper limit.
Between Limits - The output trigger is active when the strain gauge input is between the two limits.
Outside Limits - The output trigger is active when the strain gauge input is outside either of the two limits

Triggering Polarity

The polarity of the trigger pulse is specified in the Trig. 1 Polarity and Trig 2 Polarity parameters as follows:
Active High - The active state of the trigger port is logic HIGH 5 V (trigger input and output on a rising edge).
Active Low - The active state of the trigger port is logic LOW 0 V (trigger input and output on a falling edge).

Monitor Output

The analogue MONITOR output is provided to monitor the controller operation. In open loop mode it produces a 0 to +10V voltage that corresponds to 0 to 75 V or 0 to 150 V maximum high voltage output. In closed loop mode the output voltage corresponds to 0 V to the maximum travel range of the controller.

As both the output voltage and the output position can reach small negative values, the MONITOR output can also output a proportional small negative voltage, down to approximately -1 V. It can also be switched to software control mode. In this mode the output voltage can be set independently of the high voltage output and position via a software command.

7.1.4 Defaults

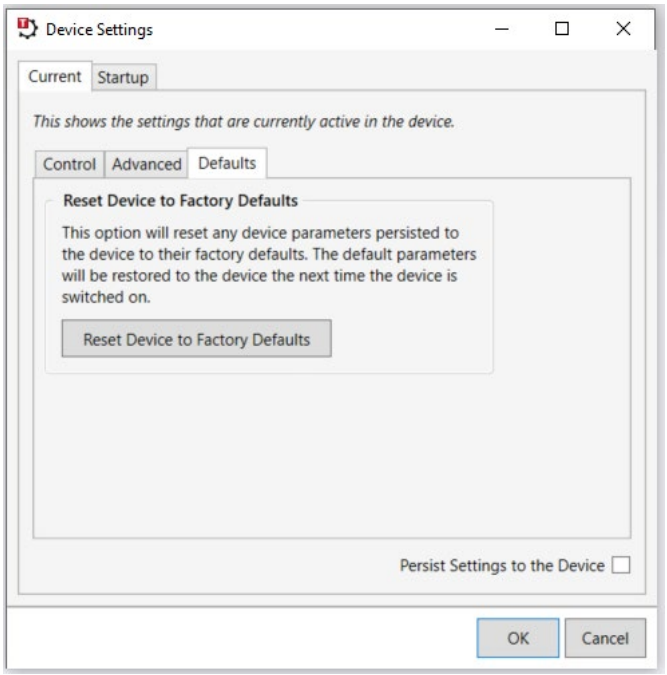


Figure 24 Defaults Tab

This option will reset any device parameters persisted to the device to their factory defaults. The default parameters will be restored to the device the next time the device is switched on.

Chapter 8 Maintenance and Cleaning

Warning: Risk of Electrical Shock
The equipment contains no user serviceable parts. There is a risk of electrical shock if the equipment is operated with the covers removed. Only personnel authorized by Thorlabs Ltd and trained in the maintenance of this equipment should remove its covers or attempt any repairs or adjustments.

PAT testing in accordance with local regulations, should be performed on a regular basis, (typically annually for an instrument in daily use).

Cleaning

Disconnect the power supply before cleaning the unit. Never allow water to get inside the case. Do not saturate the unit. Do not use any type of abrasive pad, scouring powder or solvent, e.g., alcohol or benzene. The fascia may be cleaned with a soft cloth, lightly dampened with water or a mild detergent.

Chapter 9 Piezo Operation

9.1 The Piezoelectric Effect

Piezoelectricity occurs when certain types of crystal expand reversibly when subjected to an electric field. Although the amount of expansion is usually very small (corresponding to less than 1% strain in the material) it can be controlled extremely finely by varying the strength of the electric field. Piezoelectric materials form the basis of very high precision actuators. The resolution of these actuators is only limited by the noise and stability of the drive electronics. The force generated by the expanding piezo is very large, usually hundreds of newtons. Perhaps the most useful property of these actuators is their ability to produce oscillating motion at considerable frequencies, usually limited by the mechanical system driven rather than by the piezo actuator itself. The ability is helpful for the NanoTrak control system. The electric field gradient needed to produce a useful amount of expansion is quite large. Thus, to avoid excessive drive voltages, the actuator is constructed as a stack, consisting of lamina of active material sandwiched among electrodes - refer to Figure 25. In this way, the distance from positive to negative electrodes is very small. A large field gradient can therefore be obtained with a modest drive voltage (75 V in the case of most Thorlabs actuators).

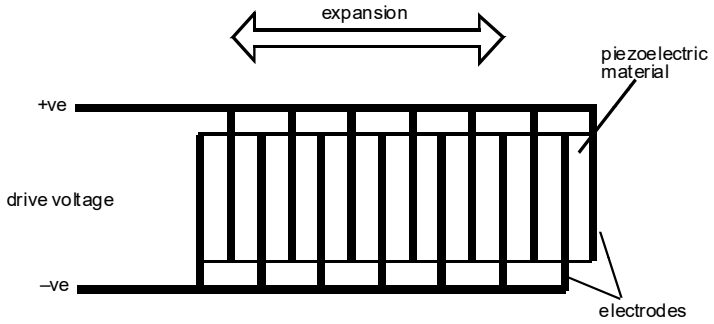


Figure 25 Piezo-electric Actuator Schematic Diagram

9.2 Hysteresis

Though the piezoelectric actuators have very high resolution still they experience a significant amount of hysteresis (i.e., the tendency of the actuator to reach a final position that lags behind the demand position). If a cyclic voltage is applied to the actuator the positions reached on the upward sweep are smaller than those achieved on the downward sweep. If position is plotted against voltage, the graph describes a hysteresis loop - refer to Figure 26.

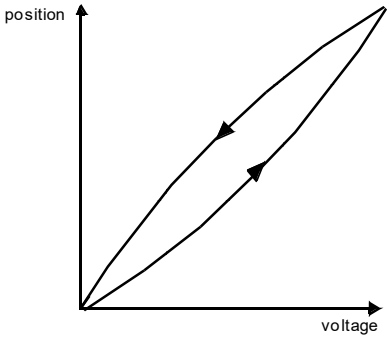


Figure 26 Piezo-electric Hysteresis

9.3 Position Sensing and Feedback Control

Hysteresis can be eliminated by using a position sensor and feedback loop, i.e., the sensor measures the position, the circuit subtracts the measured position from the demand position to get the error, and a proportional-integral feedback loop adjusts the voltage to the actuator until the error is virtually zero. Some Thorlabs nanopositioning actuators have position sensing, others do not. The Piezoelectric control module controls both types. To control an actuator with position sensing, the Piezoelectric control module should be set to closed loop mode. To control an actuator without position sensing, the Piezoelectric Control module should be set to open loop mode.

A position sensing actuator can also be driven in open-loop mode if required, since the feedback part of the circuit can be switched off. Open-loop mode has an advantage of greater bandwidth in the system.

Block diagrams for both modes of operation are shown in Figure 27.

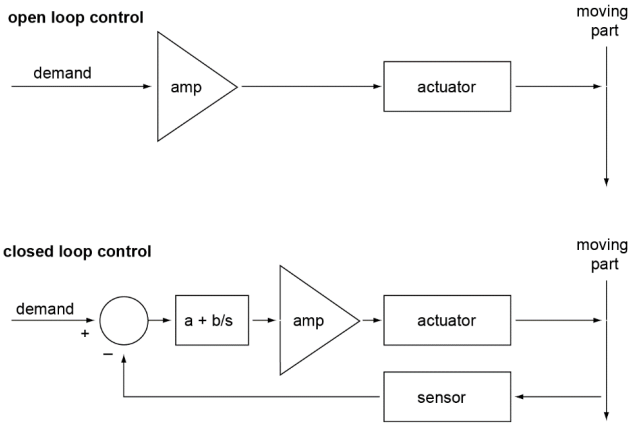


Figure 27 Open Loop and Closed Loop Control

The result of using closed-loop control is a linear relationship between demand (voltage) and measured position – refer to Figure 28.

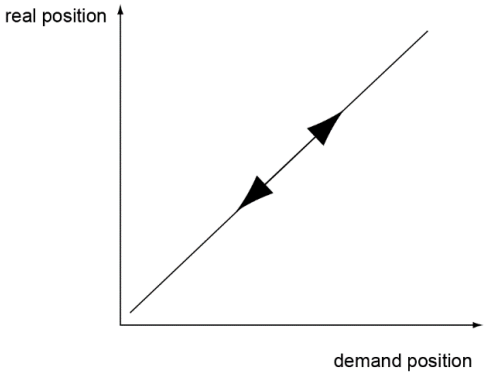


Figure 28 Closed Loop Response

Chapter 10 Thorlabs Worldwide Contacts

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



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