MPZ601
Piezo Control Module

Kinesis User Guide

Original Instructions

Contents

Chaper 1 Overview 1
1.1 Rack System Description 1
1.1.1 Introduction 1
1.1.2 Building Larger Scale Systems 1
1.1.3 Ease of Use 1
1.2 Software 2
1.3 PC Software Overview 3
1.3.1 Introduction 3
1.3.2 Kinesis Server 3
1.3.3 Software Upgrades 4

Chaper 2 Safety 5
2.1 Safety Information 5
2.2 General Warnings 5

Chaper 3 Description 6
3.1 Piezo Controller Description 6
3.1.1 Introduction 6
3.1.2 Easy to Use Software 6
3.1.3 Easily Configured Closed-Loop Operation 6
3.1.4 Open Architecture 7
3.1.5 A Complete Motion Control Solution 7
3.1.6 Software Upgrades 7

Chaper 4 Getting Started 8
4.1 Installing the Software 8
4.2 Mechanical Installation 8
4.2.1 Siting 8
4.2.2 Environmental Conditions 9
4.3 Rear Panel Connections 9
4.4 Electrical Installation 11
4.4.1 Electrical Connections 11
4.4.2 Rear Panel User I/O Connector 12
4.4.3 Rear Panel Piezo In Connector 13

continued...

Chaper 5 Operation Tutorial 14
5.1 Introduction 14
5.2 Using the Kinesis Software 14
5.3 Setting the Position Sensor Zero 15
5.4 Moving the Piezo 16
5.4.1 Entering the piezo position 16
5.4.2 Jogging the Piezos 17
5.5 Using the Controller as a Piezo Amplifier 17
5.6 Choice of Display Mode 18
5.7 Thermal Shutdown 18
5.8 Using the Controller with a Force Sensor 19

Chaper 6 Software Reference 20
6.1 GUI Panel 20
6.2 Settings Panel 21
6.2.1 Persisting Settings to the Hardware 21
6.2.2 Control tab. 22
6.2.3 Advanced Tab 24

Chaper 7 Preventive Maintenance 25
7.1 Safety Testing 25
7.2 Cleaning 25

Chaper 8 Specifications and Associated Products 26
8.1 Specifications 26
8.2 Associated Products 26

Chaper 9 Principles of Operation 27
9.1 Piezoelectric Controller 27
9.1.1 The Piezoelectric Effect 2 7
9.1.2 Hysteresis 28
9.1.3 Position Sensing and Feedback Control 28

Chaper 10 Regulatory 30
10.1 Declarations Of Conformity 30
10.1.1 For Customers in Europe 30
10.1.2 For Customers In The USA 30
10.2 CE Certificate 31

Chaper 11 Thorlabs Worldwide Contacts 32

Chapter 1 Overview

1.1 Rack System Description

1.1.1 Introduction

Thorlabs has an extensive range of one-, two- and three-axis controllers for stepper motor and piezo actuator control. Increasingly, production of optoelectronic components requires fully automated or semiautomated control of a large number of mechanical stages. In such applications, it is often more convenient to use a modular system of controllers to drive a modular system.

The Thorlabs Modular Motion Control System has been developed to meet the challenges of the modern optoelectronic production environment and provides unsurpassed ease of installation, reconfiguration, flexibility and upgrade.

The MMR601 modular rack provides a highly functional 12 channel platform within the 'footprint' of a 4U high, 19" wide enclosure. With a unified power supply and a USB communications interface, the rack system is easily incorporated into larger custom applications.

1.1.2 Building Larger Scale Systems

The unrestricted configuration flexibility offered by the rack allows any combination of the 2-channel stepper motor controller, piezoelectric driver and NanoTrak® control modules to be fitted for specific nanopositioning and alignment applications. For example, a system configured to operate our MAX683 6-axis nanopositioning stage, which has six stepper motors and six piezoelectric actuators with displacement sensors, would require 12 channels of motion control. Using three stepper motor modules, each with two channels, provides the motor control; using two piezoelectric controller modules and one NanoTrak controller module would power all 6 of the piezoelectric actuators while also taking advantage of the position sensors. Additionally, the NanoTrak module provides the full range of features offered by a fully operational auto-alignment system. All this functionality fits into the single MMR601 chassis that measures just 4U in height.

Please see the documentation supplied with the various module products for further details.

1.1.3 Ease of Use

The rack system architecture, hardware and software has been skilfully engineered to provide an efficient and effective solution to complex high channel count applications.

The rack presents a clean, uncluttered front panel, with six rear mounting bays for the plug-in modules. The backplane of the rack connects all modules and the control PC via a standard USB bus. This arrangement greatly simplifies the cable management issues that arise as the number of channels expands.

A flexible and energy efficient integral power supply powers all of the modules allowing for an adaptable, “mix-and-match” choice of module type, location and combination. These features greatly enhance ease-of-use, and provide an unparalleled flexibility for future system upgrades or reconfigurations. Each module is equipped with an on-board DSP embedded processor; as modules (channels of operation) are added, processing power is also added, hence the system is able to maintain maximum operating efficiency even when fully loaded.

Due to the inherent architecture of the system, additional racks can be added to the USB bus as required, thus allowing multiple, fully automated 6-axis positioning stages to be combined into a single unified motion control system.

The PC based software that is used to drive the MMR601 system operates from the same kernel of multi-threaded server code and associated suite of high level user applications used to drive our range of stand-alone bench top controllers. This makes it possible to offer effortless code-porting and concurrent control of bench top and rack controllers.

The Kinesis software is rigorously engineered using modern object oriented techniques, ensuring programming environment independence and compatibility with a large number of third party development tools. All key high level commands, settings and system parameters are exposed through a set of Drivers. These exposed objects allow the modular electronics system to be 'driven' from applications written by the user without the need to understand or alter the core system software.

1.2 Software

The controller is supplied with a full suite of software support tools. An intuitive graphical instrument panel allows immediate control and visualization of the operation of the piezo controller, and any other controllers that are installed in the system. See Section 1.3. for a full description of the software.

The unit operation is fully configurable (parameterized) with key settings exposed through the associated graphical interface panel. Track or Latch operating modes can be selected 'on the fly', and in both modes the display can be changed to show drive voltage or position (in microns). In the closed loop operation mode, both the P & I (proportional and integral) components of the feedback control loop can be altered to adjust the servo loop response. For convenience and ease of use, adjustment of many key parameters is possible through direct interaction with the graphical panel. Note that all such settings and parameters are also accessible through the software programmable interfaces which allow the user to build automated alignment routines. See Section 1.3. for a full description of the Kinesis software.

The key innovation of the Thorlabs range of controllers and associated mechanical products is the ease and speed with which complete automated alignment systems can be engineered at both the hardware and software level. All controllers in the range are equipped with USB connectivity. The 'multi-drop' USB bus allows multiple units to be connected to a single controller PC using commercial USB hubs and cables. When planning an alignment application, simply add up the number and type

of drive channels required and connect together the associated number of controllers.

1.3 PC Software Overview

1.3.1 Introduction

The MPZ601 piezo controllers feature 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.

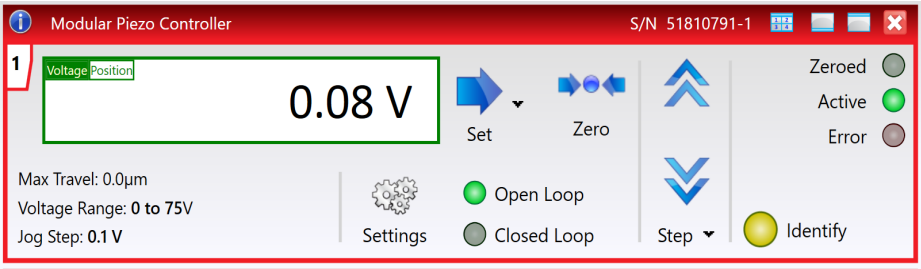
The Kinesis software suite provides a flexible and powerful PC based control system both for users of the equipment, and software programmers aiming to automate its operation.

The User Interface allows full control of all settings and operating modes enabling complete 'out-of-box' operation without the need to develop any further custom software. It provides all of 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 troubleshooting. The Kinesis server is also used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The server is described in more detail in the following section.

1.3.2 Kinesis Server

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 controller. 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, HPVEE, Matlab, VB.NET, C#.NET and, via VBA, Microsoft Office applications such as Excel and Word.

Consider the control supplied for the MPZ601 controller.



The system provides a separate control for each piezo drive channel to allow the piezo 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 driver unit to which it is associated (e.g. such as piezo drive voltage). 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 Control to move an actuator, the progress of that move is reflected automatically by changing position readouts 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.

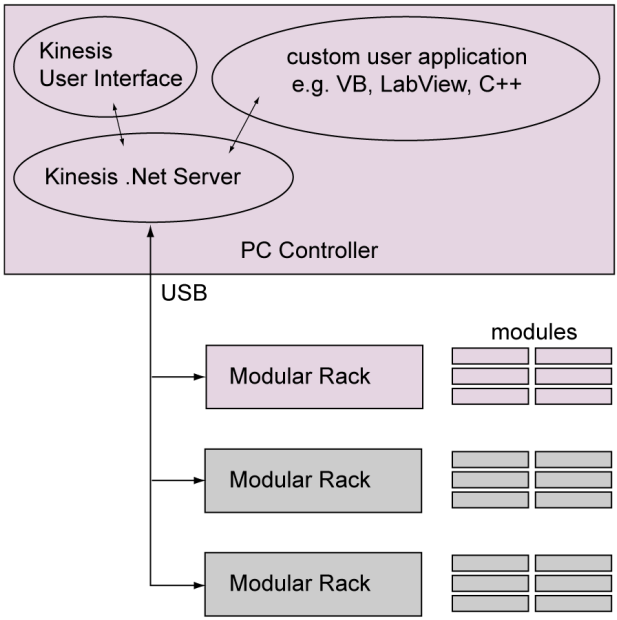


Fig. 1.1 System Architecture Diagram

Refer to the main Kinesis Software online help file, for a complete programmers 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.

1.3.3 Software Upgrades

Thorlabs operate a policy of continuous product development and may issue software upgrades as necessary.

Chapter 2 Safety

2.1 Safety Information

For the continuing safety of the operators of this equipment, and the protection of the equipment itself, the operator should take note of the **Warnings, Cautions** and **Notes** throughout this handbook and, where visible, on the product itself.

The following safety symbols may be used throughout the handbook and on the equipment itself.



Warning: Risk of Electrical Shock

Given when there is a risk of injury from electrical shock.



Warning

Given when there is a risk of injury to users.



Caution

Given when there is a risk of damage to the product.

Note

Clarification of an instruction or additional information.

2.2 General Warnings



Warning

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. In particular, 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.



Caution

If your PC becomes unresponsive (e.g due to an operating system problem, entering a sleep state condition, or screen saver operation) for a prolonged period, this will interrupt communication between the Software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the software is run. Please consult your system administrator or contact Thorlabs technical support for more details.

Chapter 3 Description

3.1 Piezo Controller Description

3.1.1 Introduction

The Modular Piezoelectric Controller is a component of the Thorlabs Modular Motion Control System, and is designed to be fully integrated into larger systems that also contain our stepper motor drive and NanoTrak® modules. It incorporates the latest high speed digital signal processing (DSP), low noise analog electronics and .Net software technology to provide two low noise, fully software controlled high voltage (0 - 75 V) output channels.

These modular controllers are designed for use in larger scale critical alignment applications where nanometer level motion control is required. The embedded software within the control unit itself is responsible for all actuator movement, and an intuitive desktop computer graphical user interface provides access to these routines. Any standard desktop computer with a USB port can be used. The advanced software includes functions to allow internal and external triggering, programmable search and scan routines, and external inputs. The embedded software can also be upgraded, thus offering a cost-effective route to enhancing the capabilities of the unit.

The piezo module inherits all of the functionality and drive specifications found in the equivalent bench top unit. Consequently, all software parameters and modes of operation first pioneered for the bench top controllers are now available in this 19" rack module format.

3.1.2 Easy to Use Software

The modular Piezo controller is supported by the full suite of Kinesis software tools. Once the software and associated USB drivers for the Rack are installed, immediate control and visualization of the operation of the piezo controller as well as any other plug-ins that are installed in the system, is achieved using the Kinesis software.

3.1.3 Easily Configured Closed-Loop Operation

The piezoelectric controller module's operation is fully configurable (parameterized) with key settings exposed through the associated graphical interface panel. Open or closed loop operating modes can be selected 'on the fly'. In both modes the display can be changed to show drive voltage or position (in microns). In the closed loop operation mode, both the P & I (proportional and integral) components of the feedback control loop can be altered to adjust the servo-loop response.

For convenience and ease of use, adjustment of many key parameters is possible through direct interaction with the graphical panel, or through the programmable interfaces that are included with the software. This allows the user to build automated alignment routines in almost any programming language. See Chapter 1 for a full description of the system software.

3.1.4 Open Architecture

A key benefit of the rack system's architecture is that the user interface software is able to unify the operation of a large number of modules, each performing its own set of functions in a true object-oriented fashion. By carefully ensuring compatibility in embedded design, the Piezo module is seemlessly supported by the same highly functional software suite developed for the bench top controllers. 'Out of the box' user operation is simply an issue of plugging the module into the USB equipped rack, connecting the rack to a PC and running the Kinesis software suite. All software learning need only be considered once, as all controls, features and concepts are fully portable. An additional benefit to this unified software approach is the ability to connect, using USB hub technology, multiple racks and bench top units together on a single host PC. This allows seemless mixing of both standalone and rack based systems in a single custom application with a single intuitive user interface.

3.1.5 A Complete Motion Control Solution

The key innovation of the Thorlabs range of controllers and associated mechanical products is the ease and speed with which complete automated alignment systems can be engineered at both the hardware and software level. All controllers in the range are equipped with USB connectivity. The 'multi-drop' USB bus allows multiple racks of modules to be connected to a single controller PC using commercial USB hubs and cables. When planning an alignment application, simply add up the number and type of drive channels required and connect together the associated number of controllers (modules or bench top units). It is important that the connection flexibility offered by the controllers is then matched by the associated software. To fulfill this requirement, all controllers are driven by the sophisticated Kinesis suite of control software routines. For additional details on the functionality of these software tools please see Chapter 1

3.1.6 Software Upgrades

Thorlabs operate a policy of continuous product development and may issue software upgrades as necessary.

Chapter 4 Getting Started

4.1 Installing the Software



Caution

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 technical support.



Caution

If your PC becomes unresponsive (e.g due to an operating system problem, entering a sleep state condition, or screen saver operation) for a prolonged period, this will interrupt communication between the software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the software is run. Please consult your system administrator or contact Thorlabs technical support for more details.

DO NOT CONNECT THE CONTROLLER TO YOUR PC YET

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

4.2 Mechanical Installation

4.2.1 Siting

The Piezoelectric Control Module is intended for installation in the Midi Rack as part of the Thorlabs Modular Motion Control System. Full installation instructions are contained in the handbook *Modular Rack* available from www.thorlabs.com.



Caution

When siting/mounting the rack, ensure there is adequate air flow. Do not obscure the ventilation holes on the left- and right-hand sides of the unit.

4.2.2 Environmental Conditions

Warning

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

Location	Indoor use only
Maximum altitude	2000 m
Temperature range	5 °C to 40 °C
Maximum humidity	Less than 80% RH (non-condensing) at 31 °C

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.

Caution

In applications requiring the highest level of accuracy and repeatability, it is recommended that the controller unit is powered up approximately 30 minutes before use, in order to allow the internal temperature to stabilize.

4.3 Rear Panel Connections

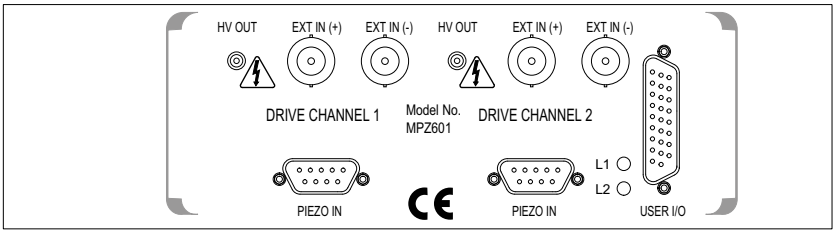


Fig. 4.1 Rear Panel Connections

Warning

Piezo actuators are driven by high voltages. Voltages up to 75 V may be present at the SMC connector. This is hazardous and can cause serious injury. Appropriate care should be taken when using this device.

Persons using the device must understand the hazards associated with using high voltages and the steps necessary to avoid risk of electrical shock.

The piezo controller must be switched OFF before the piezo actuator is plugged in or unplugged. Failure to switch the controller off may result in damage to either the controller, the stage or both.

DRIVE CHANNEL 1

HV OUT (SMC connector) – 0 to 75 V, 0 to 250 mA. Provides the drive signal to the piezo actuator.

EXT IN (+) and EXT IN (-) (BNC connector) – Differential Inputs used to control the position of the piezo actuator from an external source. The output from the HV amplifier circuit can be set to be controlled, in part, by the differential signal on these two inputs. These inputs allow a 0 V to 10 V input to drive the output to its full scale. This gives a gain of 7.5 on the 75 V range.The gain values are predefined with a tolerance of +/- 2%. The input impedance is 20 kΩ load.

Before they can be used, these inputs must be enabled in the Settings panel (see Section 6.2.) or in software by calling the Piezo SetIPSource method (see the *Kinesis helpfile* available from the Windows 'Start' menu).

PIEZO IN (9-pin D type connector) – For use with piezo actuators with feedback capability. Two types of feedback signal are supported, *AC Strain Gauge* and *DC 0 - 10 V.* The pin function is dependent on the feedback option, set in the Settings panel, see Section 6.2.2. and Section 4.4.3.

DRIVE CHANNEL 2 – As DRIVE CHANNEL 1.

L1 (Green) - Lit when power is applied to the unit.

L2 (Red) - Indicates a fault condition exists.

USER I/O (26-pin D type connector) - The User I/O connector exposes a number of internal electrical signals. For convenience, a number of logic inputs and outputs are included, thereby negating the need for extra PC based IO hardware. Using the support software, these user programmable logic lines can be deployed in applications requiring control of external devices such a relays, light sources and other auxiliary equipment.

4.4 Electrical Installation

4.4.1 Electrical Connections

Warning

High voltages may be present at the rear panel terminals. Ensure that the power is switched off before making or breaking any electrical connections. In particular, the piezo 'HV OUT' terminals can carry up to 85 V.

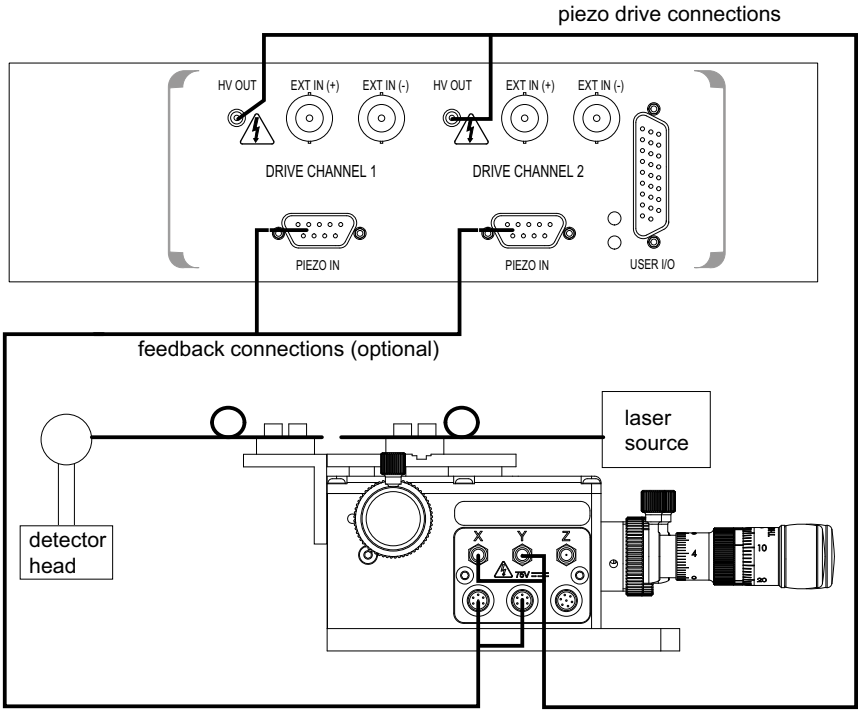


Fig. 4.2 Connecting the Control Module

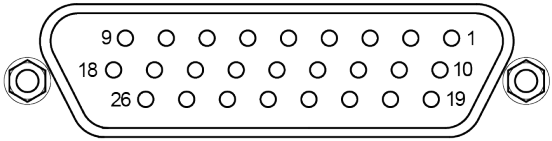
4.4.2 Rear Panel User I/O Connector

The User I/O connector exposes a number of internal electrical signals. For convenience, a number of logic inputs and outputs are included, thereby negating the need for extra PC based IO hardware. Using the Kinesis software, these user programmable TTL logic lines can be deployed in applications requiring control of external devices such a relays, light sources and other auxiliary equipment.

Note

A 5 V supply is required to power the digital outputs.

The pin functions are detailed in Fig. 4.3 and in each case must be referenced to the indicated return pin for the signal to be true.



Pin	Description	Return	Pin	Description	Return	Pin	Description	Return
1	* DIG I/P 1	19	10	* DIG O/P 1	19	19	** Isolated Ground	
2	* DIG I/P 2	19	11	* DIG O/P 2	19	20	Ext Trigger I/P	22
3	* DIG I/P 3	19	12	* DIG O/P 3	19	21	Ext Trigger O/P	22
4	* DIG I/P 4	19	13	* DIG O/P 4	19	22	Ground	
5	Channel 1 RS485 (+)		14	Channel 2 RS485 (+)		23	5 V User O/P (Isolated)	
6	Channel 1 RS485 (-)		15	Channel 2 RS485 (-)		24	Not Used	
7	Not Used		16	Not Used		25	Analog or Potentiometer Ground	
8	† Channel 2 10 V O/P	25	17	Potentiometer Wiper Ch 2		26	Potentiometer Reference	25
9	† Channel 1 10 V O/P	25	18	Potentiometer Wiper Ch 1				

Notes

* Opto-Isolated, TTL Level Signal

** For Use with Digital Signals

† For Use with External Signal Monitoring Equipment

Fig. 4.3 Piezo User I/O Connector Pin Identification

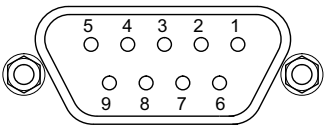
4.4.3 Rear Panel Piezo In Connector

Note

For use with piezo actuators with feedback capability.

The Piezo In connector provides the feedback connection from the piezo actuators (strain gauge).

The pin functions are detailed in Fig. 4.4.



Pin	Description	Return
1	Wheatstone Bridge Excitation	4 or 6
2	† +15 V	4 or 6
3	† -15 V	4 or 6
4	‡ D.C.(+) or Equipment Ground	
5	Feedback Signal In	4 or 6
6	Equipment Ground	
7	‡ D.C.(-) or Actuator ID Signal*	4 or 6
8	RS485(-)	9
9	RS485(+)	8

Notes

† Power supply for the piezo actuator feedback circuit. It must not be used to drive any other circuits or devices.

* This signal is applicable only to Thorlabs actuators. It enables the system to identify the piezo extension associated with the actuator.

‡ Software switchable signal for strain gauge or D.C. feedback

Fig. 4.4 Piezo In Connector - Pin Identification

Chapter 5 Operation Tutorial



Warning: Risk of Electrical Shock

Piezo actuators are driven by high voltages. Voltages up to 75 V may be present at the SMC connector. This is hazardous and can cause serious injury. Appropriate care should be taken when using this device.

Persons using the device must understand the hazards associated with using high voltages and the steps necessary to avoid risk of electrical shock.

The piezo controller must be switched OFF before the piezo actuator is plugged in or unplugged. Failure to switch the controller off may result in damage to either the controller, the stage or both.

5.1 Introduction

The following brief tutorial guides the user through a typical series of actions and parameter adjustments performed using the software. It assumes that the unit is electrically connected as shown in Section 4.4. and that the software is already installed - see Section 4.1. It also assumes that a piezo-actuated stage is connected to the 'HV OUT and PIEZO IN' connectors on the rear panel.



Caution

If your PC becomes unresponsive (e.g. due to an operating system problem, entering a sleep state condition, or screen saver operation) for a prolonged period, this will interrupt communication between the Kinesis Software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the software is run. Please consult your system administrator or contact Thorlabs technical support for more details.

5.2 Using the Kinesis Software

The Kinesis software 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.

1) Power up the hardware, and wait until the MPZ601 has finished booting up, then run the software - Start/All Programs/Thorlabs/Kinesis/Kinesis. The software registers automatically the units connected on the USB bus and displays the associated GUI panels as shown in Fig. 5.1.

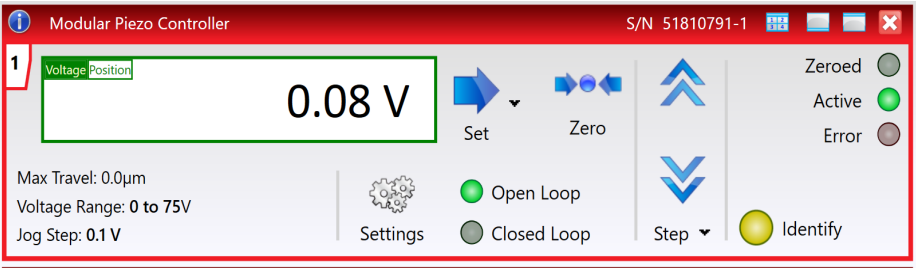


Fig. 5.1 Typical User Screen

Notice how the maximum travel for the associated piezo is displayed at the bottom left of the GUI display.

5.3 Setting the Position Sensor Zero

The position sensor is a strain gauge fitted to the piezo actuator. Due to limitations in manufacture, the strain gauge may give a small signal when the actuator is at zero position with zero volts applied. 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 actuator has a unique offset value. Therefore the offset should be adjusted whenever an actuator is replaced. Temperature and prolonged use can affect the performance of the strain gauge and therefore the offset value. It is good practice to adjust the offset value whenever the unit is powered up.

To adjust the offset zero:

1) In the GUI panel, click the 'Zero' button. Notice that the led in the button flashes to indicate that zeroing is in progress and the displayed position counts down towards zero (but may not reach zero).
2) When the zeroing move has been completed, the 'Zero' LED is lit.

5.4 Moving the Piezo

The piezo can be manually positioned in three ways: by entering a position, by using the 'CONTROL' potentiometer or by clicking the 'Jog' buttons.

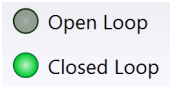
5.4.1 Entering the Piezo Position

Note

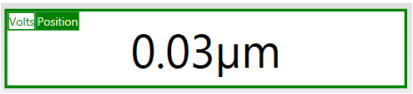
The piezo position can be entered only when operating in 'Closed Loop' mode.

The position of the actuator is relative to the minimum position set for the arrangement using the 'Zero' button. The extension of the actuator will be displayed as a position in microns.

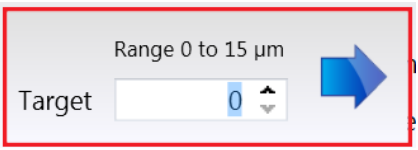
1) Click the 'Closed Loop' button.



2) Click the 'Position' button in the Main Display.



3) Click the Set Arrow  to display the Target window.



4) Enter a position. This can be entered directly into the field, or by clicking on the up/down arrows.
5) Click the arrow to save the change. Notice that the position display counts up to 10.00 to indicate a move to a position 10 µm from the Zero datum.

5.4.2 Jogging the Piezos

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

1) Click the Step Button 

to display the Step Size window.

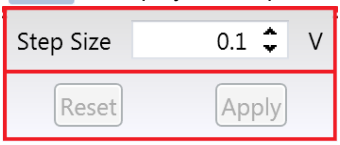


Fig. 5.2 Target Voltage Popup Window

2) In the 'Step Size' field, enter a step size in the range 0.1 V to 10 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.

The jog step size can also be set in th Setting panel, see Section 6.2.2.

5.5 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. 0 to 10 V output). To achieve this, the controller must handle the amplification from 10 V to 75 V.

The following procedure explains how to configure the unit as a piezo amplifier.

1) Connect a 0 - 10 V external source to the EXT IN (+) or EXT IN(-) connector on the rear panel.
2) In the GUI panel, click the 'Settings button to display the settings panel.

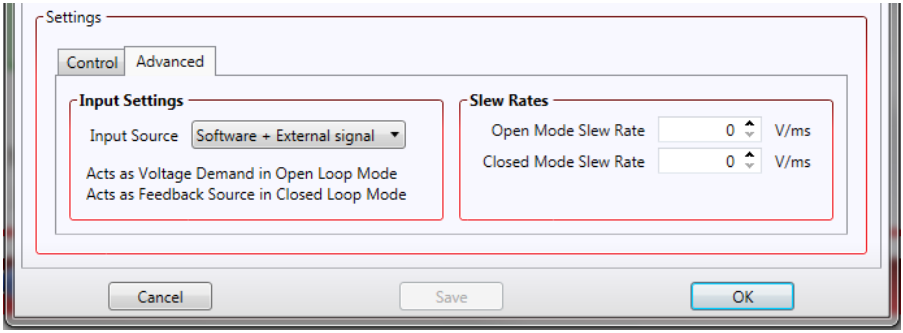


Fig. 5.3 Piezo Settings Panel

3) Select the 'General' tab.
4) In the 'Input Source' field, select '*Software + External Signal*'.
5) Click 'OK' to save the settings and close the window.

Any voltage on the rear panel BNC 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 0 - 10 V external source.

5.6 Choice of Display Mode

It is possible to set the GUI to display either the voltage applied to the actuator or the position measured by the sensor (in microns). Even if the module is in open-loop mode, the signal from the position sensor can still be displayed.

In the case of actuators with position feedback, there are 4 modes of operation in total;

1) Open-loop, display voltage applied to actuator
2) Closed-loop, display position (microns) measured by sensor
3) Closed-loop, display voltage applied to actuator
4) Open-loop, display position (microns) measured by sensor.

Note

These options can be selected through the GUI panel buttons, or by calling the appropriate function from the application software.

5.7 Thermal Shutdown

In order to protect the piezo driver card from overheating due to abnormal load conditions, the electronics contains thermal protection circuitry. When the protection is activated, the HV output is shut down, limiting the maximum output current to a few milliamps, and the 'Error' LED on the GUI panel lights up, warning the user of the fault condition. If the overtemp condition occurs, disconnect the load and allow 10 minutes for the unit to cool down.

5.8 Using the Controller with a Force Sensor

The controller unit can also be used to control a force sensor.

1) In the GUI panel, click the 'Settings' button to display the settings panel and select the Force Sensing tab.

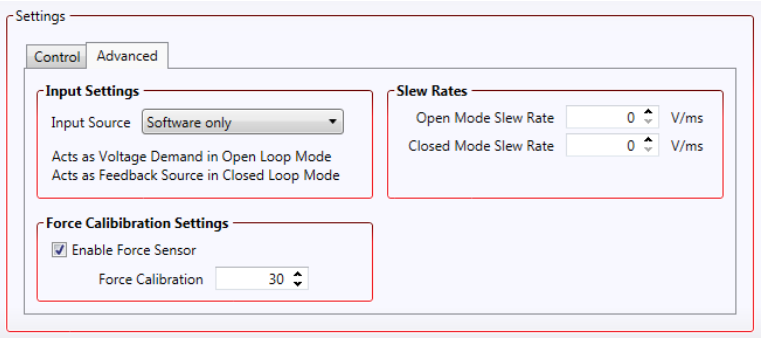


Fig. 5.4 Piezo Settings Panel

2) Check the *Enable Force Sense* box to select Force Sensing Mode.
3) Enter the calibration factor for the type of force sensor being used. For example, if set to 1, the GUI digital display shows a detected force of 0 to 1. The default setting for this parameter is 30, to be compatible with our FSC102 Force Sensor, which is specified to read forces up to 30 N.
4) Click OK.

The system defaults to Force display mode and the digital display shows the force detected by the sensor.

In Force Sensor mode, the jog arrows are hidden.

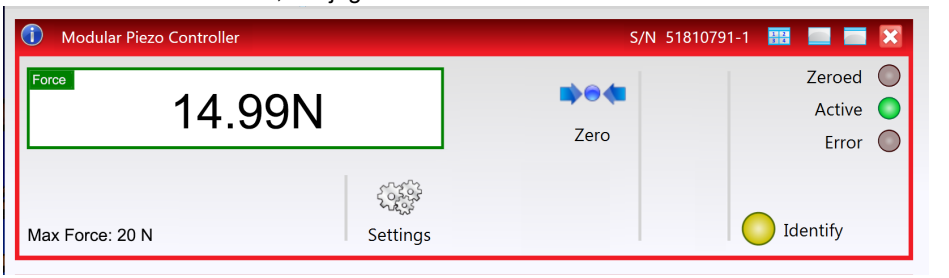


Fig. 5.5 GUI Display - Force Sensor Mode

5) The force sensor may display an offset when no contact is apparent. The *Zero* button is used to remove any latent offset, such that the sensor only detects a force when contact is experienced. When the sensor has been zeroed, the Zeroed LED is lit.

Chapter 6 Software Reference

6.1 GUI Panel

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

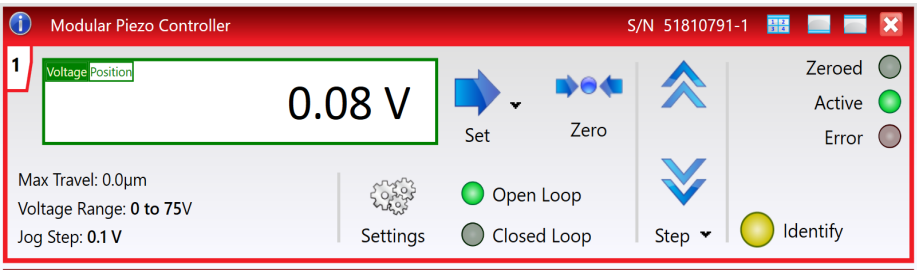
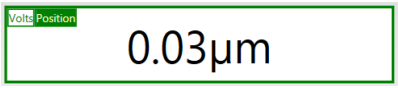


Fig. 6.1 Piezo Driver Software GUI

Note

The serial number of the driver card associated with the GUI panel is displayed in the top right hand corner. This information should always be provided when requesting customer support.

Main Display - Shows the voltage applied to the piezo, or the position (in microns), as determined by the feedback signal (if equipped). The display mode is set via the 'Volts' and 'Position' buttons in the top left corner of the display.



Set Arrow - Opens the settings window so that the target drive voltage or position can be entered - see Section 5.4.1.



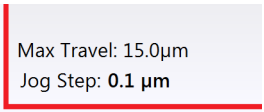
Zero - Sets the piezo drive voltage to zero, see Section 5.3.



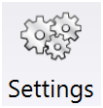
Step Arrows - Used to increment or decrement the output voltage or position. When the buttons are clicked, the piezo is driven in the selected direction, one step per click. The step size is set by clicking the Step Button 

- see Section 5.4.2.

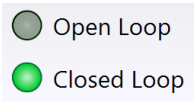




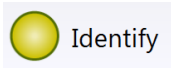
Parameters Display - Shows the maximum working voltage of the associated piezo actuator and the present setting for the step size



Settings - Displays the 'Settings' panel, which allows the operating parameters to be entered for the motor drive - see Section 6.2.



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



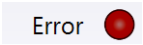
Identify - When this button is pressed, the main display on the front panel of the associated hardware unit will flash for a short period.



Zeroed - Lit when the associated piezo has been zeroed



Active - Lit when the unit is operating normally and no error condition exists.



Error - Lit when a fault condition occurs.

6.2 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 details.

6.2.1 Persisting Settings to the Hardware

Many of the parameters that can be set for the MPZ601 Piezo 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 controller is being used manually in the absence of a PC and USB link. The *Analogue Input Channel* and *Closed Loop Operation* 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.

Caution

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.

6.2.2 Control Tab

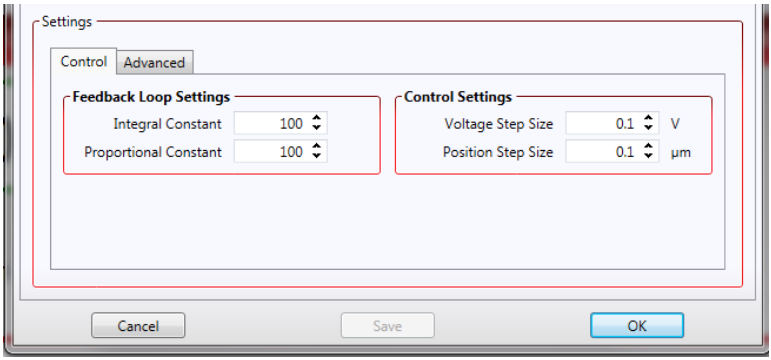


Fig. 6.1 Piezo Settings Panel - General Tab

Feedback Loop Settings

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 100 (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).

Control Settings

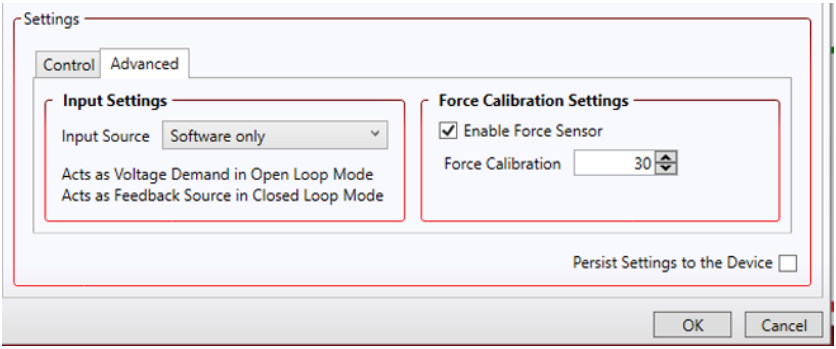
Voltage Step Size - Only applicable in open loop mode. This parameter specifies the amount by which the piezo drive voltage is incremented or decremented, each time the 'Step' button is clicked on the GUI panel.

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

Note

Legacy piezo stages (i.e. those fitted with an ident resistor) are driven by 75 V. The server will detect automatically if such a stage is fitted and in this case will limit the max voltage to 75 V.

6.2.3 Advanced Tab



Input Settings

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.

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 appropriate function (or the GUI panel 'Output' control).

If *Software + External Signal* is selected, the unit sums the signal on the rear panel 'EXT IN' SMC connector with the voltage set using the appropriate function.

If *Software + Potentiometer* is selected, the unit sums the voltage set using front panel CONTROL pot with the voltage set using the appropriate function.

Enable Force Sensor - Check this box to select Force Sensing Mode.

Force Calibration - The calibration factor for the type of force sensor being used. For example, if set to 1, the GUI digital display shows a detected force of 0 to 1. The default setting for this parameter is 30, to be compatible with our FSC102 Force Sensor, which is specified to read forces up to 30 N.

Chapter 7 Preventive Maintenance



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. Maintenance is limited to safety testing and cleaning as described in the following sections.

7.1 Safety Testing

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



Caution

The instrument contains a power supply filter. Insulation testing of the power supply connector should be performed using a DC voltage.

7.2 Cleaning



Warning

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 8 Specifications and Associated Products

8.1 Specifications

Dimensions (W x D x H)	190 x 270 x 50 mm (7.6" x 10.8" x 2.0")
Weight	1.5 kg (3.3 lb)
Piezo Drive	
Connector	SMC male connector
Voltage Output	0 to 75 V DC per channel
Voltage Stability	100 ppm over 24 hours
Output Current	500 mA per channel
Piezo In (feedback)	9 pin female D-type connector
User Control	26 pin female D-type connector

8.2 Associated Products

Product Name	Part Number
Modular Rack	MMR601
Drive Cable for Piezoelectric Actuators (3.0 m)	PAA100
Drive Cable for Piezoelectric Actuators (1.5 m)	PAA101
Piezoelectric Feedback Cable, Male D-type to Female LEMO converter (3.0 m)	PAA622

Chapter 9 Principles of Operation

9.1 Piezoelectric Controller

9.1.1 The Piezoelectric Effect

Piezoelectricity is the effect whereby 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 therefore form the basis of very high precision actuators. The resolution of these actuators is effectively only limited by the noise and stability of the drive electronics. Moreover, the force generated by the expanding piezo is very large, typically 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. This ability is used to advantage in the NanoTrak control system, for example.

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 – see Fig. 9.1. 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 Thorlabs actuators).

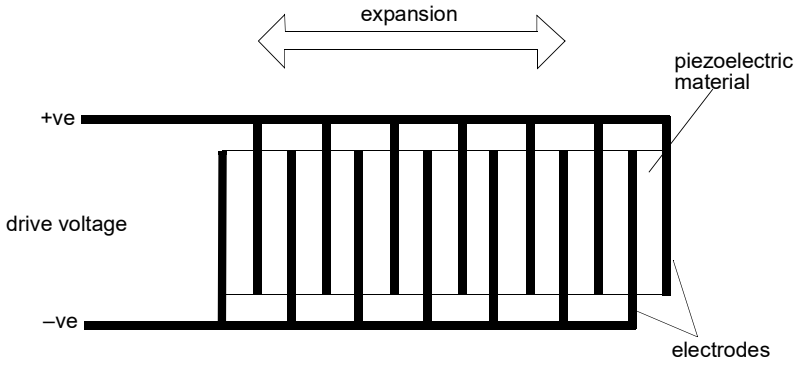


Fig. 9.1 Piezo-Electric Actuator Schematic Diagram

9.1.2 Hysteresis

Despite the very high resolution of piezoelectric actuators, an inherent problem is the significant amount of hysteresis they exhibit, (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 – see Fig. 9.2.

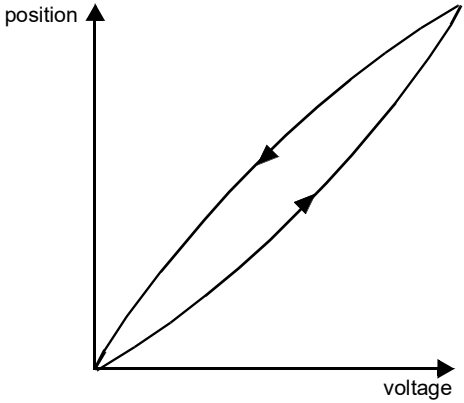


Fig. 9.2 Piezo-Electric Hysteresis

9.1.3 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 allows both types to be controlled.

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.

Note

An actuator with position sensing can also be driven in open-loop mode if desired, since the feedback part of the circuit can be switched off. An advantage of open-loop mode is the greater bandwidth of the system.

Block diagrams for both modes of operation are shown in Fig. 9.3.

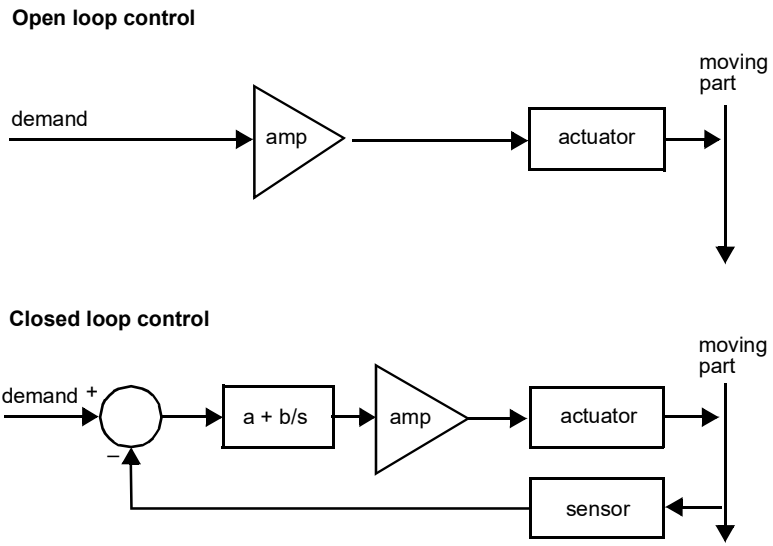


Fig. 9.3 Open Loop and Closed Loop Control

The result of using closed-loop control is a linear relationship between demand (voltage) and measured position – see Fig. 9.4, in contrast to open loop control – see Fig. 9.2.

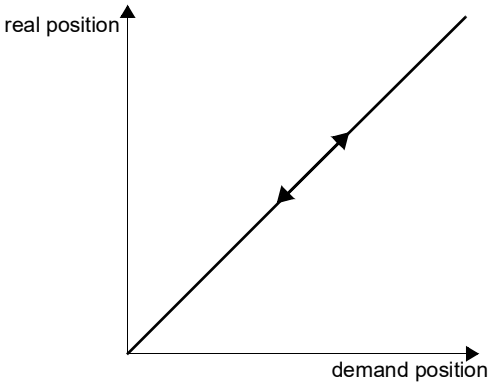


Fig. 9.4 Closed Loop Response

Chapter 10 Regulatory

10.1 Declarations Of Conformity

10.1.1 For Customers in Europe

See Section 10.2.

10.1.2 For Customers in the USA

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Changes or modifications not expressly approved by the company could void the user's authority to operate the equipment.

10.2 CE Certificate



EU Declaration of Conformity

Manufacturer: Thorlabs LTD

Address: 204 Lancaster Way, Ely, CB6 3NX

We hereby declare under our sole responsibility that:

Product: **MPZ601**

Product description: **Piezo Control Module**

is/are in conformity with the following directive(s):

2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2014/35/EU	Low Voltage Directive (LVD)
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS), including 2015/863

and (harmonized) standards / technical specifications :

EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010 + A1:2019 + AC:2019
EN IEC 63000	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	2018

I hereby declare that the equipment named has been designed to comply with the relevant sections of the above referenced specifications and complies with all applicable Essential Requirements of the Directives.

Signed: Keith Dhese

Name: Keith Dhese *On:* 12/10/2024

Position: General Manager

CE

Chapter 11 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.



USA, Canada, and South America
Thorlabs, Inc.
sales@thorlabs.com
techsupport@thorlabs.com

UK and Ireland
Thorlabs Ltd.
sales.uk@thorlabs.com
techsupport.uk@thorlabs.com

Europe
Thorlabs GmbH
europe@thorlabs.com

Scandinavia
Thorlabs Sweden AB
scandinavia@thorlabs.com

France
Thorlabs SAS
sales.fr@thorlabs.com

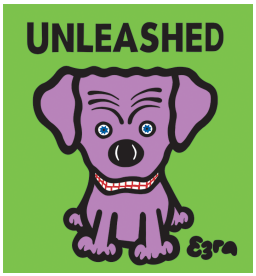
Brazil
Thorlabs Vendas de Fotônicos Ltda.
brasil@thorlabs.com

Japan
Thorlabs Japan, Inc.
sales@thorlabs.jp

China
Thorlabs China
chinasales@thorlabs.com

Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out "wheelie bin" logo (see right), were sold to and are currently owned by a company or institute within the EC, and are not dissembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. "End of life" units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site





THORLABS
www.thorlabs.com