BPC301
Benchtop Piezo Controller

User Guide



Original Instructions

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Chapter 1 Overview

1.1 Introduction

This controller is designed for use in critical alignment applications where nanometer level motion control is required. These high power units deliver up to 150V/500mA per channel and are compatible with all piezo-actuated nanopositioning actuators & stages in the Thorlabs range.

The unit combines the latest highspeed digital signal processors (DSP) with low-noise analog electronics for effortless single-axis motion. Additional axes can be driven by connecting one or more benchtop units via a standard USB hub.

Manual controls are located on the front face of the unit to allow manual adjustment of the piezo position using the digitally encoded adjustment pot. The display is easy to read and can be set to show either applied voltage or position in microns. Open or closed loop control , maximum drive voltage, and zeroing of the piezo can also be selected from the front panel.



Fig. 1.1 Single Channel Piezo Controller (BPC301)

The piezo 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 1.2. for a full description of the system software.

The piezo unit 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', 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 servoloop response. For convenience and ease of use, adjustment of many key parameters is possible through direct interaction with the graphical panel. For example, the output drive voltage or position can be adjusted by entering a value in the display window (see the tutorial in Chapter 4 for further details). Note that all such settings and parameters are also accessible through the programmable interfaces which allow the user to build automated alignment routines. See Section 1.2. 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 commerical 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. In the remainder of this handbook, the Tutorial section (Chapter 4) provides a good initial understanding on using the unit, and the reference section (Chapter 5) covers all operating modes and parameters in detail.

1.2 PC Software Overview

1.2.1 Introduction

The BPC303 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.

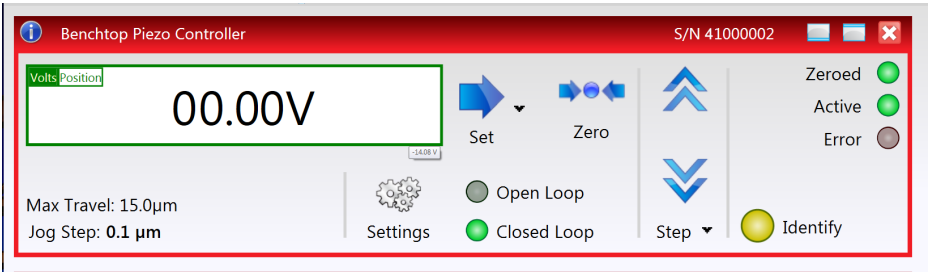
The Kinesis software suite provides a flexible and powerful PC based control system both for users of the equipment, and software programmers aiming to automate its operation.

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 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. The server is described in more detail in the following section.

1.2.2 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 BPC301 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.

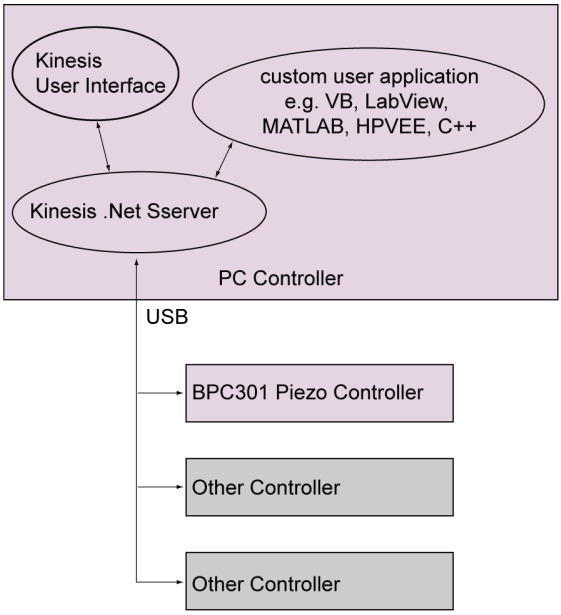


Fig. 1.2 System Architecture Diagram

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.

1.2.3 Software Upgrades

Thorlabs often releases updated firmware for bug fixes and support for new features. We recommend all users to download the latest version of Kinesis software and use the included firmware update utility.

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 absorbant tissue. Do not allow spilled fluid to enter the internal mechanism.

The equipment is for indoor use only.

The equipment is not designed for use in an explosive atmosphere.

Chapter 3 Setup

3.1 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 on +44 (0)1353 654440 and ask for 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 APT 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.

3.2 Mechanical Installation

3.2.1 Siting

The unit is designed to be mounted free standing on a shelf, benchtop or similar surface.



Caution

When siting the unit, it should be positioned so as not to impede the operation of the rear panel power supply switch.

Ensure that proper airflow is maintained to the rear of the unit.

3.2.2 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.

3.3 Electrical Installation

3.3.1 Connecting To The Supply



Warning: Risk of Electrical Shock

The unit must be connected only to an earthed fused supply of 85V to 264V.

Use only power supply cables supplied by Thorlabs, other cables may not be rated to the same current. The unit is shipped with appropriate power cables for use in the UK, Europe and the USA. When shipped to other territories the appropriate power plug must be fitted by the user. Cable identification is as follows:

Brown Live

Blue Neutral

Green/Yellow Earth/Ground



Warning

Piezo actuators are driven by high voltages. Voltages up to 150V 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.

3.3.2 Fuses

Two T 3.15A/250V a.c. antisurge ceramic fuses are located on the back panel, one for the live feed and one for the neutral.

When replacing fuses:

1) Switch off the power and disconnect the power cord before removing the fuse cover.
2) Always replace broken fuses with a fuse of the same rating and type.

3.3.3 Powering Down The Unit



Warning

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.

3.3.4 Rear Panel Connections

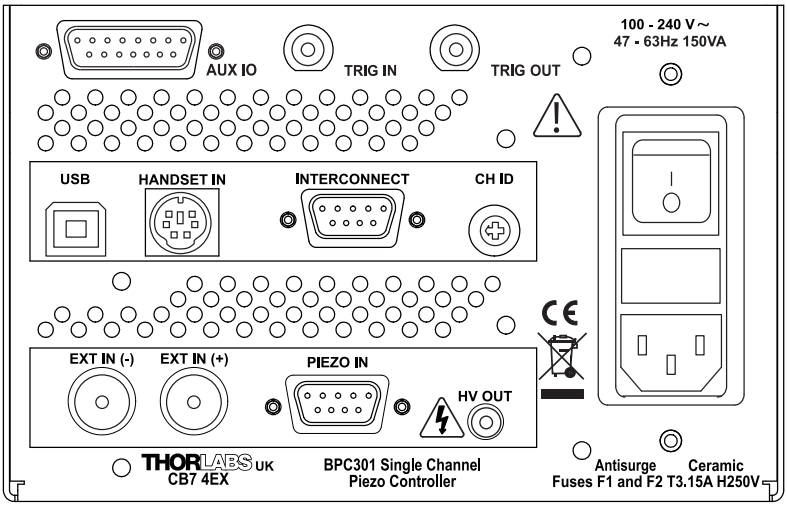


Fig. 3.1 Rear panel connections

AUX IO - This female 15-Pin D-type connector exposes a number of internal electrical signals. For convenience, a number of logic inputs and outputs are included, thereby eliminating the need for extra PC based IO hardware. These user programmable logic lines can be deployed in applications requiring control of external devices such a relays, light sources and other auxilliary equipment - see Section A.2. for further details.

TRIG IN – Reserved for future use, not implemented at this time.

TRIG OUT – Reserved for future use, not implemented at this time.

USB - USB port for system communications.

Note

The USB cable length should be no more than 3 metres unless a powered USB hub is being used.

HANDSET IN - Provides connection for the MZF001 Jopystick - see Section 4.9. and Section A.4.

INTERCONNECT - For Future Use.

CH ID - For channel selection when using the MZF001 joystick - see Section 4.9.

EXT IN (+) and EXT IN (-) (BNC connector) – Used to control the output voltage (open loop) or position of the piezo actuator(closed loop) from an external source. These inputs allow a 0V to 10V input to drive the output to its full scale. This gives a gain of 7.5 on the 75V range, 10 on the 100V range and 15 on the 150V range. The

gain values are predefined with a tolerance of +/- 2%. The input impedence is 20kΩ load.

The exact bandwidth achievable is dependent on a variety of factors, such as the load capacitance but in general is a few kHz in open loop mode and about 200 Hz in closed loop.

Before they can be used, these inputs must be enabled in the Settings panel (see Section 5.2.) or in software by calling the appropriate function (see the *Online helpfile* available from the Windows 'Start' menu).

The difference between the two signals is amplified internally before being routed to the HV OUT connector. The high voltage amplifier output will be 0V when the positive input is equal to the negative input, and will be at full scale (75V, 100V or 150V depending on the voltage range selected) when the positive input minus the negative input equals 10V. If either input is unconnected, it contributes 0V. The differential nature of these inputs can be useful in some applications, as they reject unwanted common mode signals. Although they are differential, these inputs can also be used in single-ended mode. In this configuration, the +ve input can be considered as non-inverting and the -ve input as inverting. The unused input can simply be left unconnected.

PIEZO IN – This Female 9-Pin D-type connector receives the signal from the position sensor (strain gauge) of the piezo actuator to provide the feedback for the control loop - see Section A.1. for pin out details.

HV OUT (SMC connector) – 0 to 150V, 0 to 500mA. Provides the drive signal to the piezo actuator.



Caution

It is recommended that only cables supplied by Thorlabs are used to connect the piezo drive outputs. Other cables may not be rated to the same specification. If using third party cables for the high voltage output, the HV cable used must have insulation able to withstand 200V DC / 150V AC.

3.4 Front Panel Controls and Indicators

The front panel controls of the BPC301 piezo controller allow the unit to be operated as a standalone unit, without the need to connect to a PC.

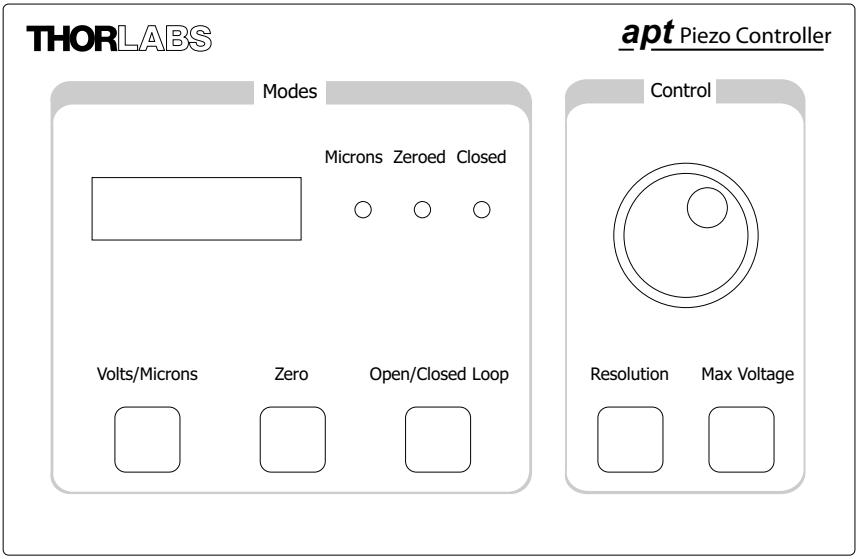


Fig. 3.2 Front panel controls and indicators

Digital Display – Shows the voltage applied to the piezo actuator/stack or the position (in microns).

Note

The main digital display will flash when the 'Ident' button is clicked on the GUI panel - see Section 5.1. for further details.

Microns LED – Indicates that the display is showing the piezo position in microns. If the LED is not lit, the display is showing the output voltage in Volts.

Zeroed LED – Indicates that the piezo has been zeroed. This LED flashes during the zeroing operation.

Closed LED – Indicates that the unit is operating in Closed Loop mode. If the LED is not lit, the unit is operating in open loop.

Volts/Microns Button – Selects either Volts or Microns to be displayed.

Open/Closed Loop Button – Selects Open or Closed Loop mode.

Zero Button – Initiates the zeroing routine - see Section 3.5.2.

Note

The 'Zero' and 'Open/Closed Loop' buttons perform the same function as their respective equivalents on the software GUI panel. If a control PC is connected, pressing these buttons has the same effect as pressing the correspondingGUI button. Similarly, the 'Zeroed' and 'Closed' LEDs correspond to the virtual button lights on the GUI.

The 'Volts/Microns' button is similar in function to the 'Volts' button on the GUI but it operates independently. For example, it is possible to display microns on the GUI but volts on the front panel.

Control Potentiometer – Used to adjust the voltage applied to the piezo actuator/ stack.

Resolution Button – Toggles the 'Control' potentiometer between 'Coarse' and 'Fine' adjustment and 'Parked' mode - see Section 3.5.1.

Max Voltage Button – Used to adjust the maximum drive voltage output - see Section 3.5.3.

3.5 Button Operation

3.5.1 Resolution Button

The resolution button cycles the behaviour of the Control potentiometer between 'Coarse' and 'Fine' adjustment, and 'Parked' mode.

In 'Coarse' mode, one revolution of the pot varies the output by a factor of 10 greater than in 'Fine' mode. In 'Open loop' mode, the full voltage range corresponds to about 12 turns of the pot in 'Coarse' mode. In 'Parked' mode, the 'Control' potentiometer is disabled, and turning it has no effect.

At power up, the resolution defaults to 'Coarse'.

3.5.2 Zero Button

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) Click the 'Zero' button. Notice that the 'Zeroed' led flashes to indicate that zeroing is in progress.

2) When the zeroing move has been completed, the ‘Zeroed’ LED is lit and the controller switches to closed loop mode.

3.5.3 Max Voltage Button

The Max Voltage button sets the max limit of the drive output voltage. When the button is pressed and released, the present limit flahes on the main display. The voltage may be cycled through 75 V, 100 V and 150 V by turning the control potentiometer. The new limit is saved by pressing and releasing the Max Voltage button again..

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.

3.6 Control Potentiometer Operation

The ‘Control’ potentiometer is an infinite turn encoder, used to adjust and set the voltage or position output as displayed in the main digital display. To increase the drive voltage, turn the potentiometer clockwise - once the maximum voltage (75V) is attained, subsequent clockwise turns do not effect the output, however the voltage decreases immediately the control is turned anticlockwise. Similarly, once the voltage has been decreased to 0V, subsequent anticlockwise turns do not effect the output, but the voltage increases immediately the control is turned clockwise.

If the channel is in closed loop mode (set using the 'closed loop' button on the panel) then this control can be used to adjust position output. If open loop mode is selected (using the 'open loop' button) then the control is used to adjust the voltage output.

3.6.1 Moving the Piezo using the ‘Control’ Potentiometer

1) Press the ‘Open/Closed Loop’ button until the ‘Closed’ LED is lit. The unit is now in Closed Loop mode.
2) Press the ‘Volts/Microns’ button until the ‘Microns’ LED is lit. The display now shows the piezo position in microns.
3) Rotate the ‘Control‘ potentiometer clockwise. Notice how the position display increments to show the increasing piezo position.
4) Rotate the ‘Control’ anticlockwise. Notice how the position display decrements to show the decreasing piezo position.
5) Press the ‘Volts/Microns’ button until the ‘Microns’ LED is extinguished. Notice how the display changes to show the voltage associated with the current piezo position.

3.7 Adjusting the Display Brightness

The display brightness can be adjusted in relation to the ambient light conditions.

To adjust the brightness:

1) Press and hold the Resolution button and turn the Control potentiometer.

3.8 Connecting The Hardware

1) Connect the piezo actuator to the Controller unit.
2) Connect the Controller unit to the power supply and switch 'ON'.
3) Connect the Controller unit to your PC.

Note

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) Windows™ should detect the new hardware. Wait while Windows™ installs the drivers for the new hardware - see the Getting Started guide for more information
5) Run the Kinesis software
   Start/Programs/Thorlabs/Kinesis/Kinesis.
6) Your Piezo Controller is now ready for use.
   See Chapter 4 of this manual, for a brief tutorial on operation of the unit.

3.9 Verifying Software Operation

3.9.1 Initial Setup

1) Install the software as detailed in Section 3.1.

Connect the controller to the actuators (see Section 3.3.4.) and the PC, then switch ON. Wait approximately 5 seconds for the system to settle.

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.

2) Run the software and check that the Graphical User Interface (GUI) panel appears and is active.

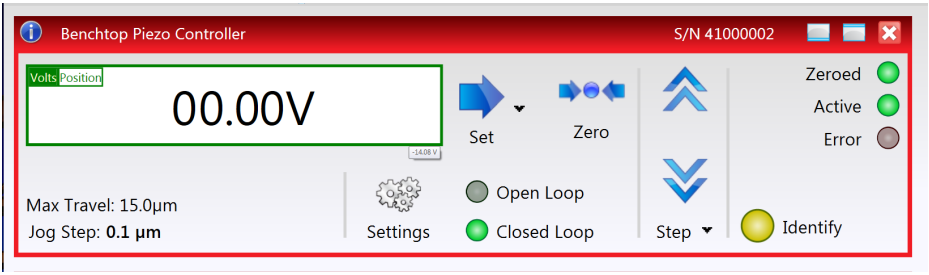


Fig. 3.3 Gui panel showing jog and ident buttons

3) Click the 'Identify' button. The digital display of the associated channel on the front panel of the controller flashes. This is useful in multi-channel systems for identifying which channel is associated with which GUI.
4) Click the 'Step' buttons on the GUI panel to move the piezo or axis connected to the controller. The position display for the associated GUI should increment and decrement accordingly.

Follow the tutorial described in Chapter 4 for further guidance on basic operation.

Chapter 4 PC Operation - Tutorial



Warning: Risk of Electrical Shock

Piezo actuators are driven by high voltages. Voltages up to 150V 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.



Caution

Thorlabs often releases updated firmware for bug fixes and support for new features. We recommend all users to download the latest version of Kinesis software and use the included firmware update utility. Failure to do this could result in stages not being recognized by the latest controllers.

4.1 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 3.3.4. and that the software is already installed - see Section 3.1. 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.

4.2 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 BPC301 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. 4.1.

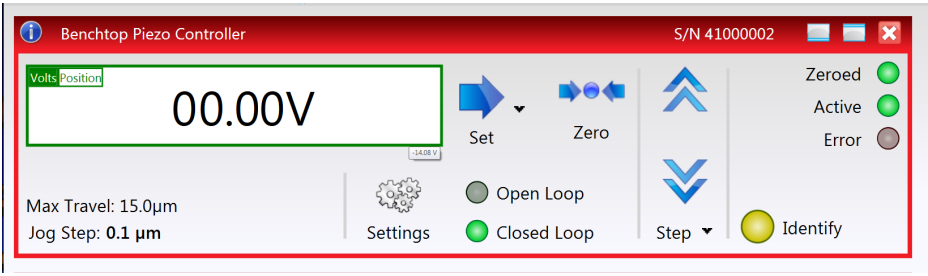


Fig. 4.1 Typical User Screen

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

4.3 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.

4.4 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.

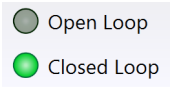
4.4.1 Entering the piezo position

Note

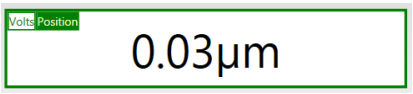
The piezo position can be entered only when operating in 'Closed Loop' mode.

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.

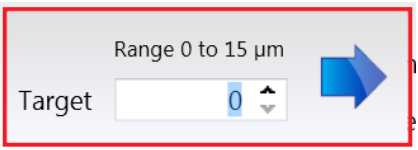
1) Click the 'Closed Loop' button.



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 10µm from the Zero datum.

4.4.2 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..

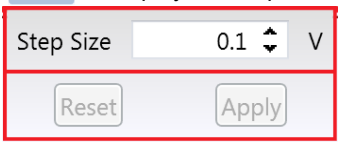


Fig. 4.2 Target Voltage Popup Window

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 5.2.2.

4.5 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 10V output). To achieve this, the controller must handle the amplification from 10V to 75V.

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

1) Connect a 0 - 10V 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.

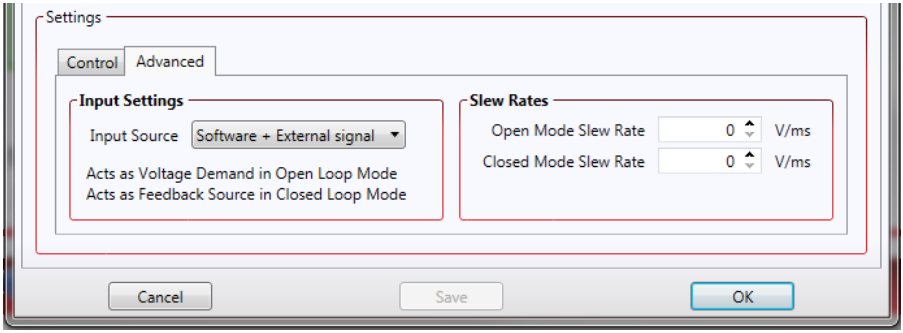


Fig. 4.3 Piezo settings panel

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 0-10V external source.

4.6 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.

4.7 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 its shut down, limiting the maximum output current to a few milliamps, and the 'Error' LED on the GUI panel lights, 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.

4.8 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.

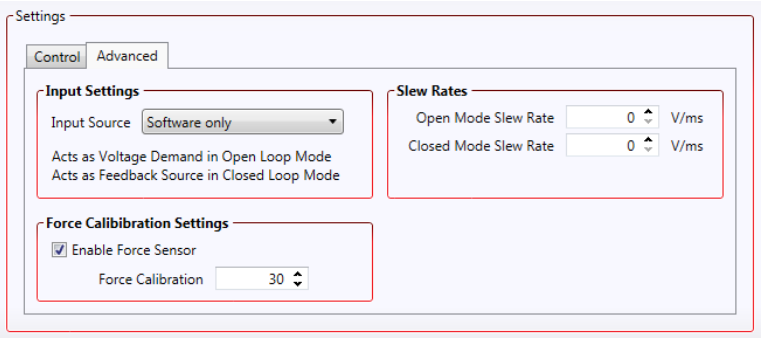


Fig. 4.4 Piezo settings panel

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 30N.
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.

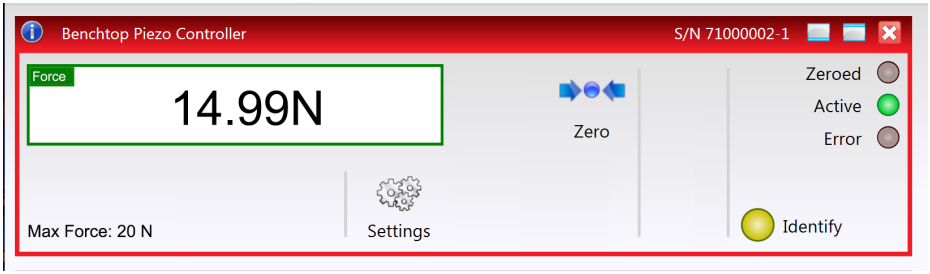


Fig. 4.5 GUI Display - Force Sensor Mode

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.

4.9 Using the MZF001 Joystick

The MZF001 joystick console has been designed for microscope users, to provide intuitive, tactile, manual positioning of the MZS500 stage. It is used in conjunction with a BPC30X series piezo controllers. Up to 3 joysticks can be connected to each other, interfacing neatly into a multi-channel control application. Furthermore, if the parameter settings are saved (persisted) to the controller, the controller need not be connected to a host PC, thereby allowing remote operation.

1) Connect the stage to the controller as detailed in the handbook supplied with the stage and controller unit.
2) Using the lead supplied, connect the CONTROLLER/EXT IN terminal on the joystick console to the HANDSET IN connector on the rear panel of the Controller unit.



Fig. 4.1 Connections

In order to establish control over a particular axis, the joystick axes must be associated with the corresponding channels of the related controller. This is achieved by setting the joystick ID switch, located on the underside of the joystick console, and the channel ident switches on the rear panel of the BPC controller to the same number.

For example, if the joystick switch is set to '1', then the channel ID switch on the controller must also be set to ‘1’ as shown in Fig. 4.2.



Fig. 4.2 ID switch setings

3) Using a small, flathead screwdriver, set the joystick console ID switch and the controller channel ID switch as described in the preceding paragraph.

Caution

Do not set the switches to 'E' or 'F' as this is reserved for factory use and testing.

4) Switch ON the controller.
5) Wait until the red warning LED on the joystick console stop flashing (~3s). This indicates that initialisation is complete.
6) Press and hold the 'High/Low' button for 2 seconds, then release to zero the stage. When zeroing is complete, the green LED stops flashing.
7) The stage can now be moved using the joystick, GUI panel, or by setting commands to move by relative and absolute amounts – see the helpfile supplied with the server for more information.

4.10 Load Response

The response of the BPC301 to varying load and frequencies is shown below.

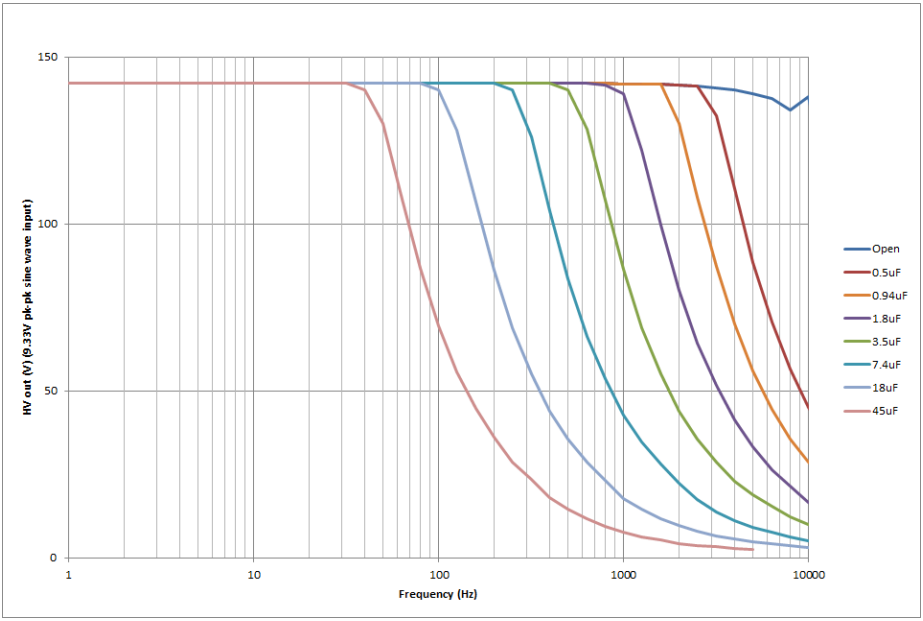


Fig. 4.6 Response of BPC301 to Varying Loads and Frequencies

Chapter 5 Software Reference

5.1 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.

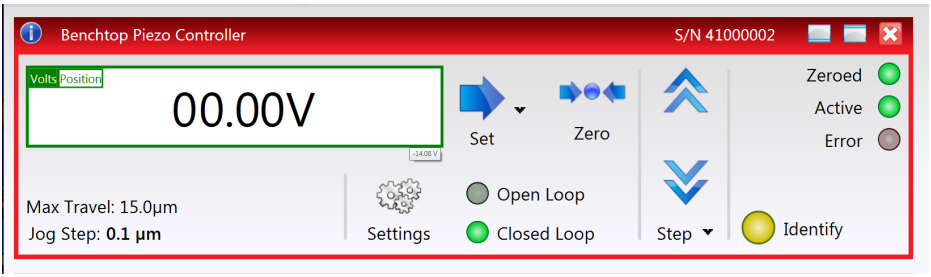
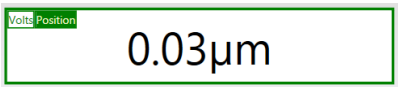


Fig. 5.1 Piezo Driver Software GUI

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 4.4.1.



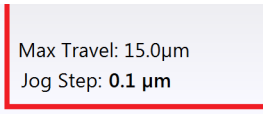
Zero - Sets the piezo drive voltage to zero, see Section 4.3.



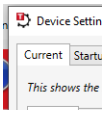
Step Arrows - used to increment or decrement the output voltage or position. When the buttons are clicked, the piezo is driven in the selected direction, one step per click. The step size is set by clicking the Step Button 

- see Section 4.4.2.

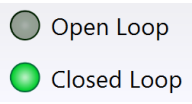




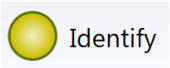
Parameters Display - shows the maximum working voltage of the associated piezo actuator and the present setting for the step size



Settings - Displays the 'Settings' panel, which allows the operating parameters to be entered for the motor drive - see Section 5.2.



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



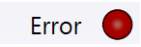
Identify - when this button is pressed, the main display on the front panel of the associated hardware unit will flash for a short period.



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.

5.2 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.

5.2.1 Persisting Settings to the Hardware

Many of the parameters that can be set for the BPC303 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.

5.2.2 Control tab.

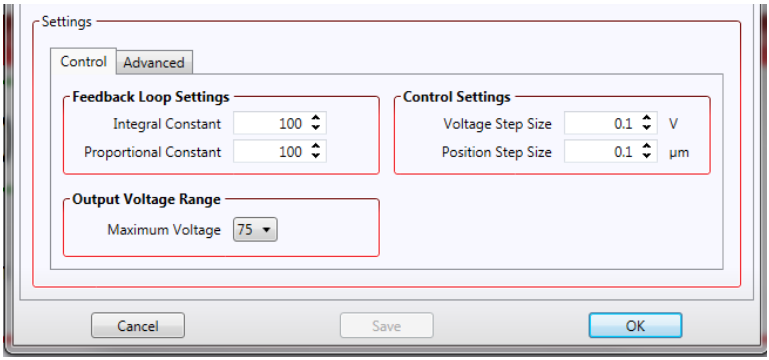


Fig. 5.3 Piezo Settings panel - General tab

Feedback Loop Settings

Loop Constants - When operating in Closed Loop mode, the proportional and integral (PI) constants can be used to fine tune the behaviour 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 optimised 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.

Output Voltage Range

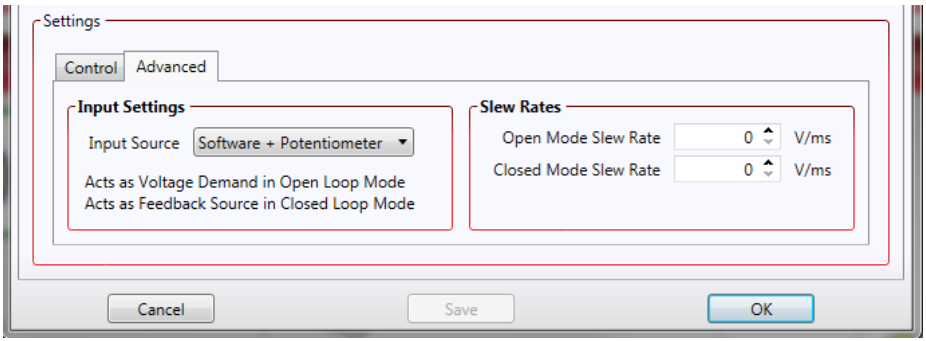
Maximum Voltage - used to set the maximum output voltage of the piezo controller. This must be set up to suit the maximum specified operating voltage of the piezo actuator connected to the unit. Most Thorlabs piezo actuators are specified for either 75V or 150V maximum operation. In general, the maximum voltage should not be exceeded because it can cause damage to the piezo actuator.

The output voltage range can be selected from 75V, 100V or 150V. Of these 3 settings, 75V and 150V are hardware limits: the piezo unit contains an internal clamping circuit that limits the output voltage to approximately 10% above these values. (Piezo actuators can tolerate a 10% overvoltage without damage.) The 100V limit is a software limit: under software control it is not possible to exceed this limit but using the external inputs the limit can be exceeded. Therefore exercise care when 100V piezo actuators are driven under external input control.

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.

5.2.3 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.

Slew Rates

When stages with delicate internal mechanisms are being driven, it is possible that sudden large changes to the drive voltage could cause damage. These parameters set the limits for the rate of change of the drive voltage in V/ms. Different limits may be set for open loop and closed loop operating modes.

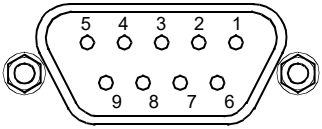
Note

The controller is loaded at the factory with default values suitable for driving legacy piezo stages. For newer generation stages (e.g. MZS500 Z-Axis Stage), the slew rate is read in automatically. Consequently, these parameters should not require adjustment under normal operating conditions.

Appendix A Rear Panel Connector Pinout Detail

A.1 Rear Panel PIEZO IN Connectors

This Female 9-Pin D-Type connector receives the signal from the position sensor (strain gauge) of the piezo actuator to provide the feedback for the control loop. The pin functions are detailed in Fig. A.1.



Pin	Description
1	Strain Gauge excitation
2	† +15V out
3	† -15V out
4	Ground
5	AC Feedback IN
6	Ground
7	* Actuator ID signal
8	Reserved for future use
9	Reserved for future use

Note

† 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.

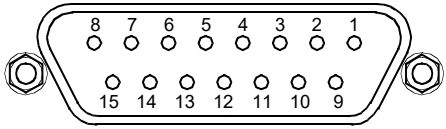
Fig. A.1 PIEZO IN Connector Pin Identification

A.2 Rear Panel AUX I/O Connector

A.2.1 Pin Identification

This female 15-pin D-Type connector exposes a number of internal electrical signals. For convenience, a number of logic inputs and outputs are included, thereby eliminating the need for extra PC based IO hardware. These user programmable logic lines can be deployed in applications requiring control of external devices such a relays, light sources and other auxilliary equipment.

The pin functions are detailed in in Fig. A.2 .



Pin	Description	Return	Pin	Description	Return
1	Digital O/P 1	5, 9, 10	9	Digital Ground	
2	Digital O/P 2	5, 9, 10	10	Digital Ground	
3	Digital O/P 3	5, 9, 10	11	For Future Use (Trigger Out)	5, 9, 10
4	Digital O/P 4	5, 9, 10	12	For Future Use (Trigger IN)	5, 9, 10
5	Digital Ground		13	Digital I/P 4	5, 9, 10
6	Digital I/P 1	5, 9, 10	14	5V Supply Output	5, 9, 10
7	Digital I/P 2	5, 9, 10	15	5V Supply Output	5, 9, 10
8	Digital I/P 3	5, 9, 10			

Warning

Do not, under any circumstances attempt to connect the digital I/O to any external equipment that is not galvanically isolated from the mains or is connected to a voltage higher than the limits specified in Section A.2.2. to Section A.2.6.. In addition to the damage that may occur to the controller there is a risk of serious injury and fire hazard.

Fig. A.2 USER Connector Pin Identification

A.2.2 Digital Outputs

All digital outputs are of the open-collector type, with a 330 Ohm series resistor. When the output is set to a logic zero (which is also the default state), it behaves as open circuit. When it is a logic one, it behaves as a 330 Ohm resistor connected to ground.

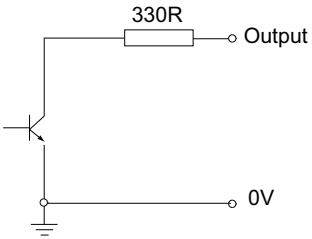


Fig. A.3 Digital Output Schematic

In some applications, the digital outputs may be required to control external equipment that has optocoupler type inputs (such as PLCs). The digital outputs used here can be used to directly drive most optocouplers and the +5V supply available on pins 14 and 15 can be used to provide power for the optocouplers.

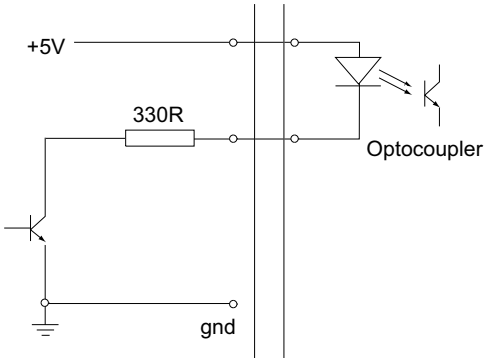


Fig. A.4 Application Example: Connection to Optocoupler Inputs

The digital outputs can also be used to interface to external logic circuitry (a pull-up resistor may be needed if the external logic does not contain it) or control other types of inputs.

Caution

The voltage that external equipment applies to the digital outputs must be within the range 0 V and +5 V DC, or damage to the outputs may occur.

Please see the Online helpfile for details on software calls used to control these logic IO.

A.2.3 Digital Inputs

The digital inputs used in the controller are of the standard CMOS logic gate type with TTL compatible input levels and a built-in pull-up resistor (10 kOhm to +5V). They can be connected directly to mechanical switches, open-collector type outputs or most type of logic outputs.

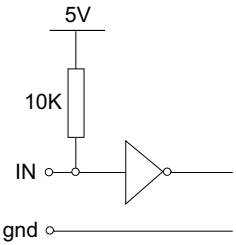


Fig. A.5 Digital Input Schematic (protection circuitry not shown)

When connected to a switch, the inputs will read as logic LOW if the switch is open circuit and HIGH if the switch is closed. When connected to a logic output, or any other voltage source, the input is guaranteed to read LOW if the voltage is above 2.4V and HIGH when the output is below 0.8 V. Please see the Online helpfile for details on software calls used to control these logic IO.

Caution

The voltage applied to the digital inputs must be within the range 0 V to +7V DC, or damage to the inputs may occur.

A.2.4 +5 Volt Supply

A +5 V, 250 mA supply is provided for interfacing to external circuits that require a power source.

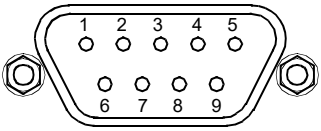
Caution

Do not exceed the 250 mA maximum output current. For applications requiring higher currents an external power supply must be used.

A.3 Rear Panel INTERCONNECT Connector

Although this Male 9-Pin D-type connector exposes internal electrical signals for use with serial communications or an external remote control handset, no firmware support is available at present.

The pin functions are detailed in in Fig. A.6 .

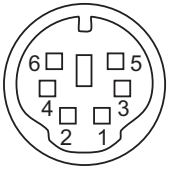


Pin	Description
1	Not Connected
2	RX (controller input)
3	TX (controller output)
4	Not Connected
5	Ground
6	Not Connected
7	Not Connected
8	Not Connected
9	Not Connected

Fig. A.6 iNTERCONNECT Connector Pin Identification

A.4 Rear Panel HANDSET Connector

Provides connection to the MZF001 joystick. The pin functions are detailed in in Fig. A.7



Pin	Description
1	RX (controller input)
2	Ground
3	Ground
4	+5V , 100 mA Supply for Joystick
5	TX (controller output)
6	Ground

Fig. A.7 HANDSET Connector Pin Identification

Appendix B Preventive Maintenance



Warning: Risk of Electrical Shock

The equipment contains no user servicable 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.

B.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.

B.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.

Appendix C Specifications and Associated Parts

C.1 Specifications

Parameter	Value
Piezoelectric Output (SMC Male)	
Voltage Output	75 V, 100 V, and 150 V DC/channel
Output Current	500 mA
Voltage Stability	100ppm over 24 hours (after 30 mins warm up time)
Noise	<3m V RMS
Typical Piezo Capacitance	1 to 10 µF
Bandwidth	10 kHz (1 µF Load, 1 V_{p-p})
External Input (BNC)	
Input Type	Differential or Single Ended
Input Voltage for Full Range (i.e. 75 V, 100 V or 150 V)	10 V ±2%
Max Output	75 V Range: -10V to 90 V DC 100 V Range: -10V to 115 V DC 150 V Range: -10 V to 159 V DC
Position Feedback (9-Pin D-Type Female)	
Feedback Transducer Type	Strain Gauge or Capacitive Sensor
Detection Method	AC Bridge (18 kHz Excitation)
Typical Resolution	5 nm (for 20 µm Actuator e.g. PAZ005)
Auto-Configure	Ident Resistance or Stage ID EEPROM in Actuator
User Input/Output (D-type 15 Pin Female)	
4 Digital Inputs	TTL Levels
4 Digital Outputs	Open Collector
Trigger Input/Output	TTL
Trigger Input Functionality	Triggered Voltage Ramps/Waveforms
Trigger Output Functionality	Trigger Generation during Voltage Ramps Output
User 5V (with Ground)	250 mA Max
Input Power Requirements (IEC Connector)	
Voltage	85-264 VAC
Power	150 VA
Fuse	3.15 A
USB Port	Version 2.0 Full Speed Compatible
General Data	

Parameter	Value
Housing Dimensions (W x D x H)	152 x 244 x 104 mm (6 x 9.6 x 4.1 in.)
Weight:	3.18 kg (7 lbs)

C.2 Associated Products

Product Name	Part Number
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
Z Focus Joystick	MZF001

Appendix D Piezo Operation - Background

D.1 Piezoelectric Controller

D.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. D.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).

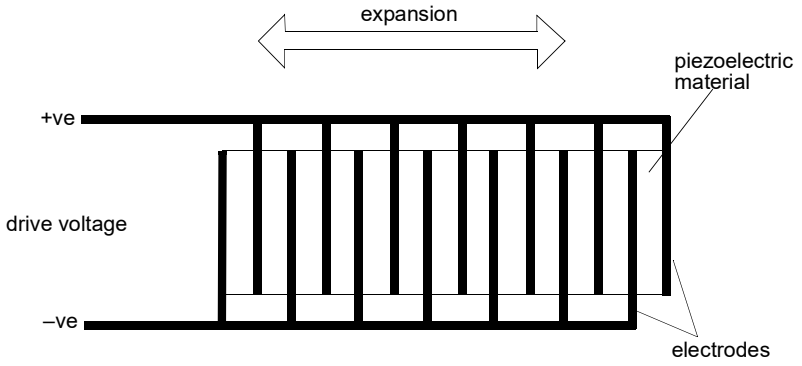


Fig. D.1 Piezo-electric actuator schematic diagram

D.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. D.2.

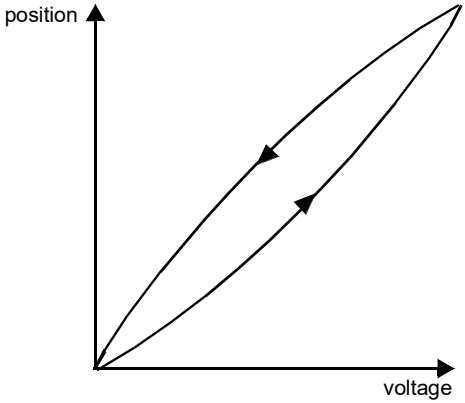


Fig. D.2 Piezo-electric hysteresis

D.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. D.1.

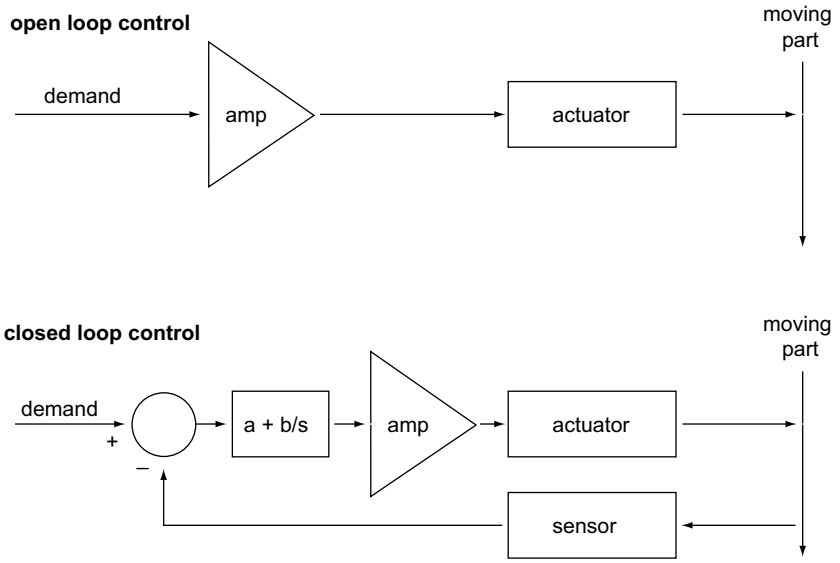


Fig. D.3 Open loop and closed loop control

The result of using closed-loop control is a linear relationship between demand (voltage) and measured position – see Fig. D.4, in contrast to open loop control – see Fig. D.2.

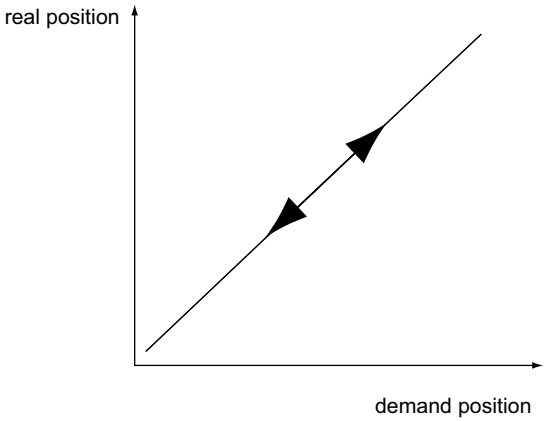


Fig. D.4 Closed loop response

Appendix E Regulatory

E.1 Declarations Of Conformity

E.1.1 For Customers in Europe

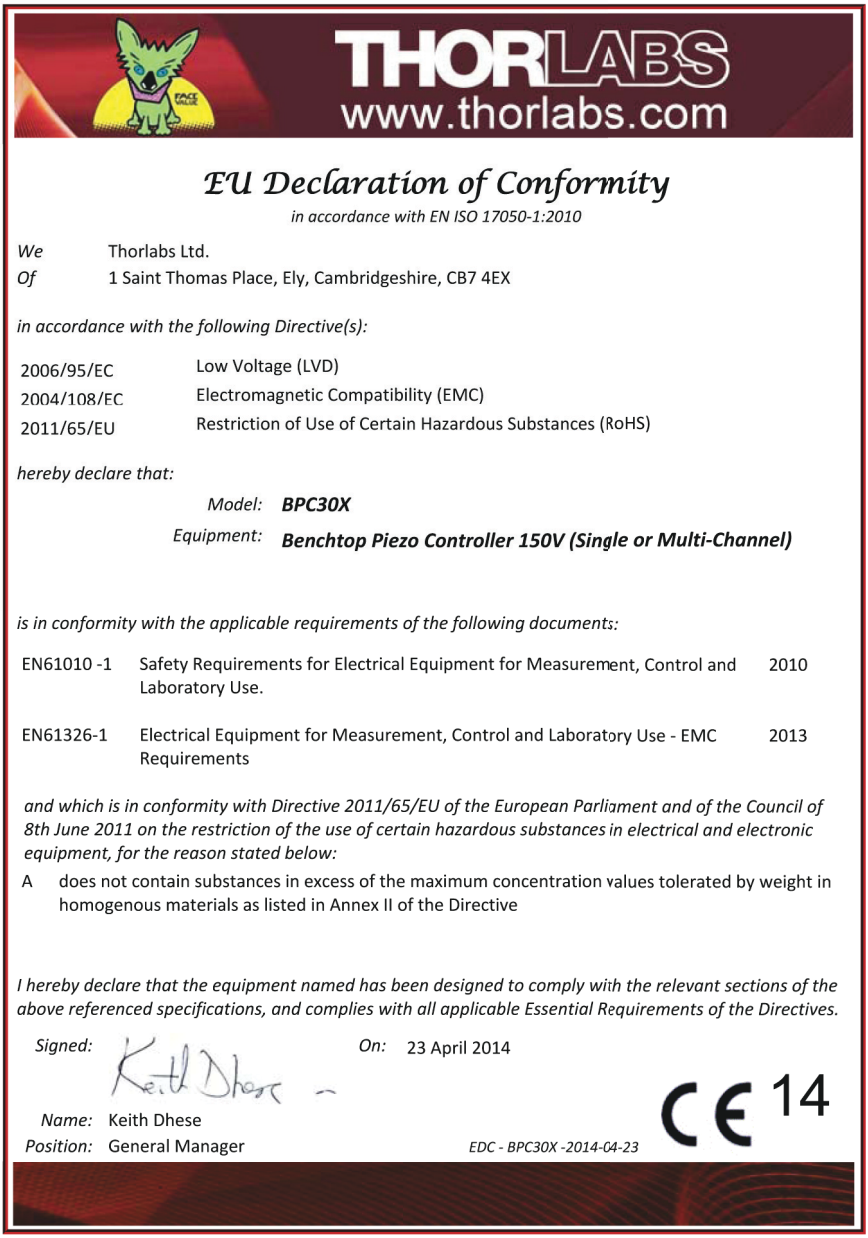
See Section E.2.

E.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, persuant 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.

E.2 CE Certificate



THORLABS
www.thorlabs.com

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We Thorlabs Ltd.
Of 1 Saint Thomas Place, Ely, Cambridgeshire, CB7 4EX

in accordance with the following Directive(s):

2006/95/EC	Low Voltage (LVD)
2004/108/EC	Electromagnetic Compatibility (EMC)
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***BPC30X***

Equipment: ***Benchtop Piezo Controller 150V (Single or Multi-Channel)***

is in conformity with the applicable requirements of the following documents:

EN61010 -1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010
EN61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013

and which is in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8th June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:

A does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive

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 *On:* 23 April 2014

Name: Keith Dhese
Position: General Manager

EDC - BPC30X -2014-04-23

CE 14

Appendix F 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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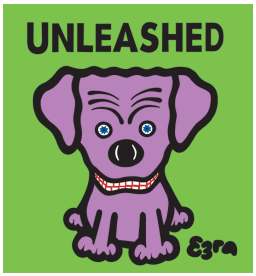
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Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical 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.



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