THORLABS

MPZ601
Piezo Control Module

APT User Guide

Original Instructions

Contents

continued...

Chapter 1 Overview

1.1 APT 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 upgradability.

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 APT rack system is easily incorporated into larger custom applications.

1.1.2 Building Larger Scale Systems

The unrestricted configuration flexibility offered by the APT rack allows any combination of the 2-channel APT 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 APT606 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 APT 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 ActiveX multithreaded server code and associated suite of high level user applications used to drive our range of APT stand-alone bench top controllers. This makes it possible to offer effortless code-porting and concurrent control of bench top and rack controllers.

The APT 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 ActiveX 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.

In addition, ActiveX technology is language independent, allowing custom application development to be undertaken using any language or development system that supports ActiveX.

1.2 Software

1.2.1 Background

A common requirement in many optoelectronic alignment and characterization applications concerns the implementation of automated positioning sequences. Typically, such positioning sequences require a series of descrete movements and measurements to implement an overall solution

The mechanical stage options and drive electronics offered by Thorlabs are ideally suited to performing all of these individual steps in a variety of different ways.

The key to the APT range of controllers (and associated mechanical products) concerns the ease and speed with which complete automated alignment systems can be engineered at the software level. All controllers in the APT range are equipped with USB connectivity. The 'multi-drop' USB bus allows multiple APT units to be connected to a single controller PC using simple USB hubs and cables.

The USB connection flexibility offered by the APT controllers is matched by the associated product software. All APT controllers are shipped with a sophisticated multithreaded ActiveX based software control suite. This suite comprises the main ActiveX based APT Server with a number of utilities including APTUser and

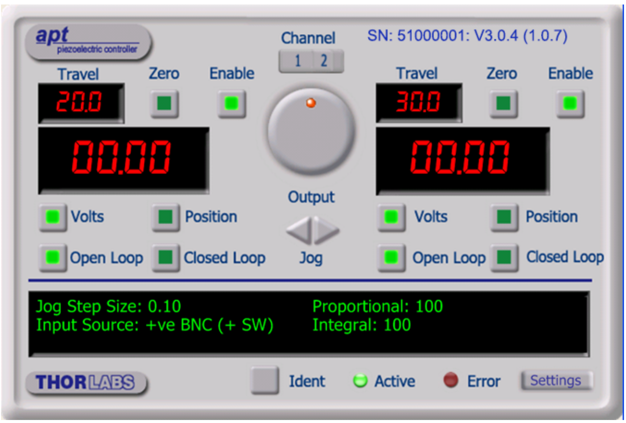
APTConfig. APT Server is the main software 'engine' that runs on the host PC to provide all necessary APT services such as generation of sophisticated graphical instrument panels, multiple unit USB communications and multithreaded execution to enhance system operation and prevent GUI deadlock. Rather than a single monolithic entity, the APT Server is actually an interoperating collection of ActiveX Controls (or simply Controls) together with associated support files and libraries. These ActiveX Controls, developed using leading edge object oriented coding techniques, are the key to the powerful, flexible and yet extremely easy to use APT control software.

1.2.2 APT Server (ActiveX Controls)

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

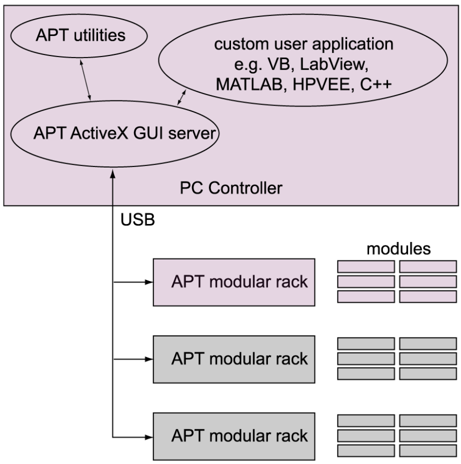
With the APT system, ActiveX Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units. Software applications that use ActiveX Controls are often referred to as 'client applications'. Based on ActiveX interfacing technology, an ActiveX Control is a language independent software component. Consequently ActiveX 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 ActiveX Control supplied for the APT Piezo control module.



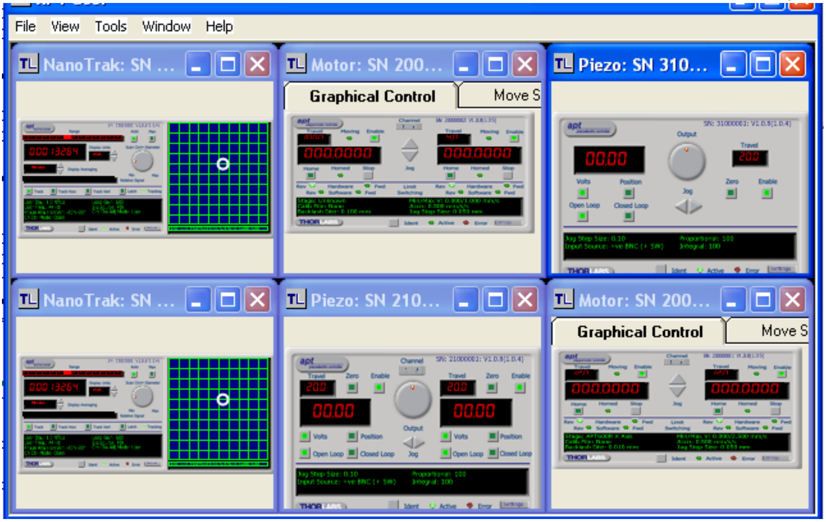
This Control provides a complete user graphical instrument panel to allow the Piezo unit to be manually operated, as well as a complete set of software functions (often called methods) to allow all parameters to be set and Piezo control operations to be automated by a client application. The instrument panel reflects the current operating state of the controller unit to which it is associated (e.g. such as piezo travel). 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 to a particular position, progress is monitored automatically by changing position readout on the graphical interface, without the need for further programming intervention.

The APT ActiveX Controls collection provides a rich set of graphical user panels and programmable interfaces allowing users and client application developers to interact seamlessly with the APT hardware. Each of the APT controller modules has an associated ActiveX Control and these are described fully in system online help or the handbooks associated with the controllers. In addition to the main ActiveX Server, a number of other utilities are supplied with the APT system, most notably APTUser and APTConfig. Note that these utilities themselves take advantage of and are built on top of the powerful functionality provided by the APT ActiveX Server (as illustrated in the system architecture diagram below).



1.2.3 APT User.exe

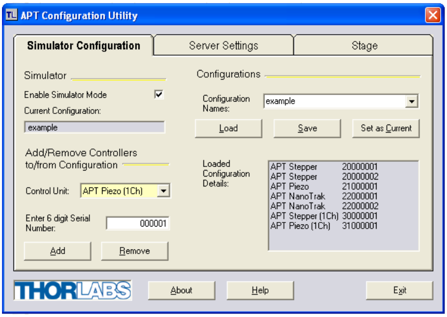
The APTUser application allows the user to interact with a number of APT hardware control units connected to the host PC. This program displays multiple graphical instrument panels to allow multiple APT units to be controlled simultaneously.



All basic operating parameters can be altered and, similarly, all operations (such as motor moves) can be initiated. For many users, the APTUser application provides all of the functionality necessary to operate the APT hardware without the need to develop any further custom software. For those who do need to further customise and automate usage of the APT modules (e.g. to implement an alignment algorithm), this application illustrates clearly how the rich functionality provided by the APT ActiveX Controls are used by a client application. The complete Visual Basic source project is provided as a useful aid to software developers.

1.2.4 APT Config Utility

There are many system parameters and configuration settings associated with the operation of the APT Server (ActiveX Controls). Most can be directly accessed using the various graphical panels and their associated programmable interfaces. However there are several system wide settings that can be made 'off-line' before running the APT software. These settings have global effect; such as switching between simulator and real operating mode, associating mechanical stages to specific motor actuators and incorporation of calibration data.



The APTConfig utility is provided as a convenient means for making these system wide settings and adjustments. Full details on using APTConfig are provided in the online help supplied with the 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.

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 APT Modular Piezoelectric Controller is a component of the Thorlabs APT 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 ActiveX software technology to provide two low noise, fully software controlled high voltage (0-75V) 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 APT 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 APT Piezo controller is supported by the full suite of APTsoftware tools. Once the software and associated USB drivers for the APT Rack are installed, immediate control and visualization of the operation of the stepper motor controllers as well as any other plug-ins that are installed in the system, is achieved using the APTUser.exe utility

3.1.3 Easily Configured Closed-Loop Operation

The APT 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 ActiveX™ programmable interfaces that are included with each instrument. This allows the user to build automated alignment routines in almost any programming language. See

Section 1.2. for a full description of the APT system software and background on the advantages of the ActiveX Control technology.

3.1.4 Open Architecture

A key benefit of the APT 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 APT Piezo module is seamlessly supported by the same highly functional multithreaded ActiveX 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 APT rack, connecting the rack to a PC and running the existing APT 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 APT racks and bench top units together on a single host PC. This allows seamless 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 APT 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 APT range are equipped with USB connectivity. The ‘multi-drop’ USB bus allows multiple APT racks of modules 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 APT controllers (modules or bench top units). It is important that the connection flexibility offered by the APT controllers is then matched by the associated software. To fulfill this requirement, all APT controllers are shipped with a sophisticated multithreaded ActiveX based suite of control software routines. This suite is comprised of the main ActiveX based APT Server along with the *APTUser* and *APTConfig* utilities. For additional details on the functionality of these software tools please see Section 1.2.

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 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 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 *ha 0117 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

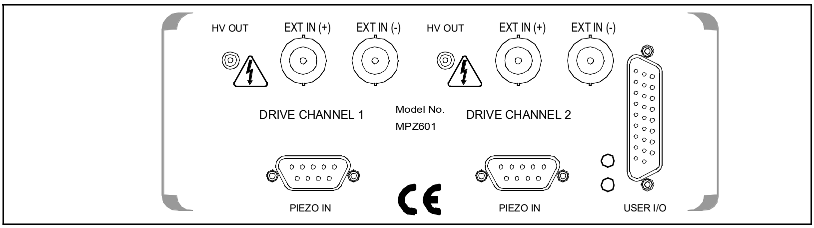


Fig. 4.1 Rear panel connections

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 75V, 0 to 250mA. 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 0V to 10V input to drive the output to its full scale. This gives a gain of 7.5 on the 75V range. The gain values are predefined with a tolerance of +/- 2%. The input impedence is 20kΩ 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 *APTServer 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 0-10V.* The pin function is dependent on the feedback option, set in the Settings panel, see Section 6.2. 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 auxillairy 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 85V.

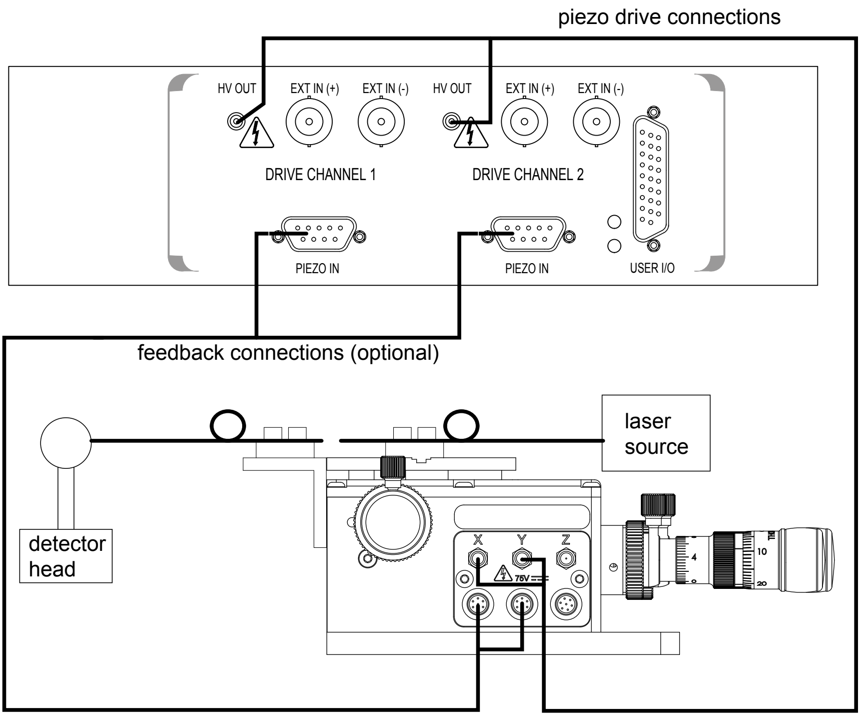


Fig. 4.2 Connecting the control module

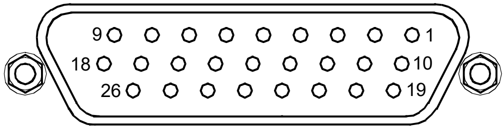
4.4.2 Rear Panel User I/O Connector

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 5V 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	5V 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 10V O/P	25	17	Potentiometer wiper Ch 2		26	Potentiometer Reference	25
9	† Channel 1 10V 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

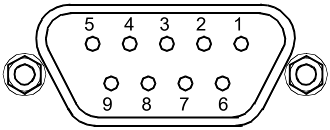
4.4.3 Rear Panel Piezo In Connector

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	† +15V	4 or 6
3	† -15V	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 identificationl

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 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.

5.2 Using the APT Software

The APT 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 APT application provides all of the functionality necessary to operate the hardware.

1) Run the APT User program - Start/All Programs/Thorlabs/APT User/APT User. The APT server registers automatically the units connected on the USB bus and displays the associated GUI panels as shown in Fig. 5.1..

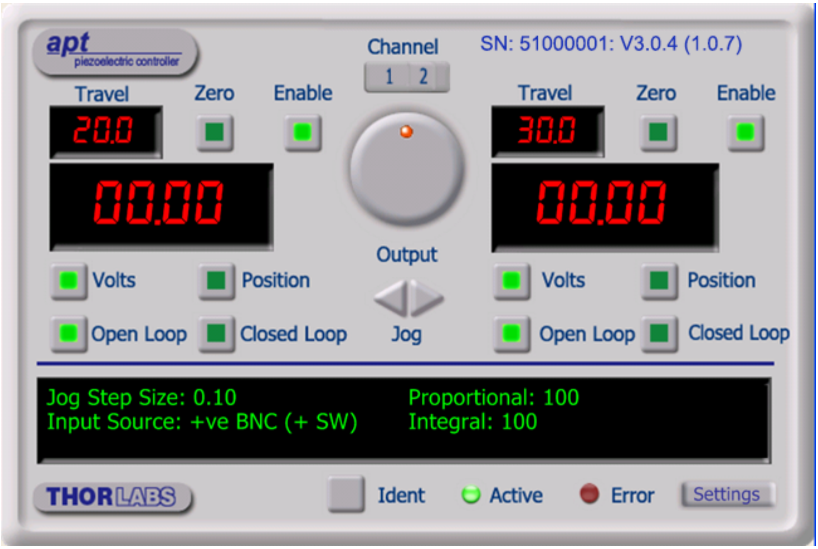


Fig. 5.1 MPZ601 GYUI Panel

Notice how the maximum travel for the associated piezo is displayed in the Travel window - see Section 5.2.2.

5.2.1 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 ‘Settings’ panel or by calling the SetVoltPosDispMode method from the application software.

5.2.2 Detection of Range of Travel

In the case of actuators with position feedback, the Piezoelectric driver can detect the range of travel of the actuator, since this information is programmed in the electronic circuit inside the actuator.

It is possible to get the range of travel of the actuator from the application software by calling the *GetMaxTravel* method – *see Help File - MG17Base*.

This feature is not present in actuators without position sensing.

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.

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

5.4 Moving the Piezo

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.
3) Click the position display.

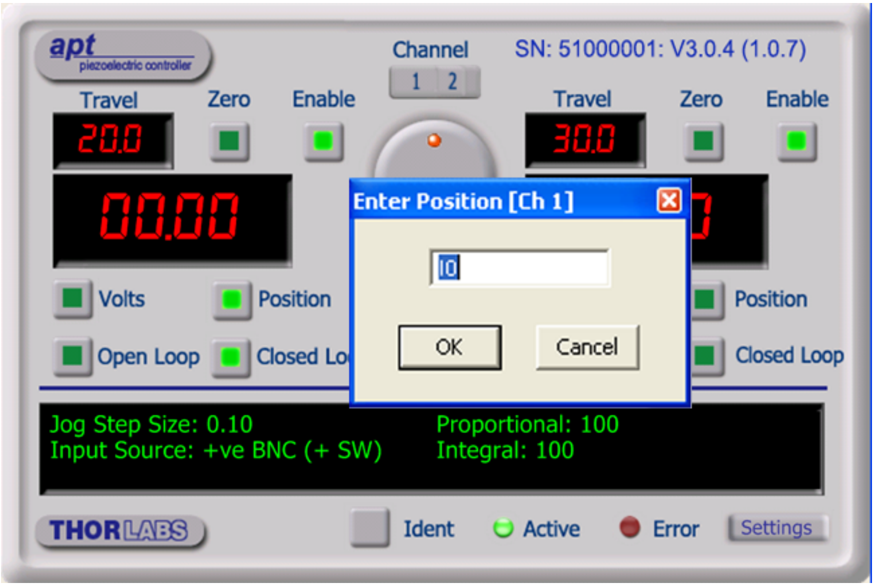


Fig. 5.2 Position Popup Window

4) Enter 10.0 into the pop up window
5) Click ‘OK’. Notice that the position display counts up to 10.00 to indicate a move to a position 10µm from the Zero datum.

5.4.2 Moving the Piezo using the ‘Output’ control

The ‘Output’ control is used to adjust and set the voltage or position output as displayed in the main digital display. 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.

1) Click the ‘Closed Loop’ button.
2) Click the ‘Position’ button.
3) Rotate the ‘Output‘ control clockwise. Notice how the position display increments to show the increasing piezo position.
4) Rotate the ‘Output’ control anticlockwise. Notice how the position display decrements to show the decreasing piezo position.
5) Click the ‘Voltage’ button. Notice how the display changes to show the voltage associated with the current piezo position.

Note

The read out in the main digital display is independent of the operating mode (open or closed loop) selected for the particular channel. If the 'Volts' button is selected, then the read out is in volts, even if the channel is in closed loop mode and the Output control is being used to adjust position. Similarly, if the 'position' button is selected, the read out is in microns, derived from the strain gauge feedback signal, even if the channel is operating in open loop.

5.4.3 Jogging the Piezos

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

1) Click the ‘Settings’ button to display the Settings panel.

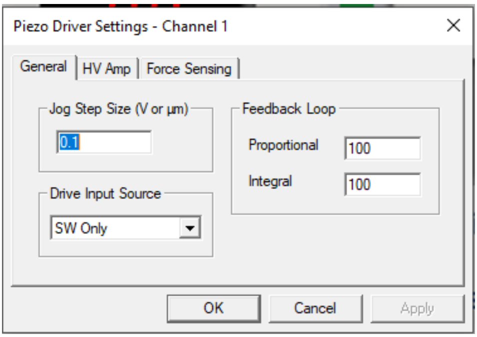


Fig. 5.3 Piezo settings panel

2) Select the General tab as shown in above.
3) In the ‘Jog Step Size’ field, enter 0.1
4) Click ‘OK’ to save the settings and close the window.
5) Click the RH Jog arrow on the GUI panel to jog the piezo. Notice that the position display increments 0.1µm every time the button is clicked.
6) Click the LH Jog arrow on the GUI panel. Notice that the position display decrements 0.1µm every time the button is clicked.

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

As an example, 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 front panel.
2) In the GUI panel, click the 'Settings button to display the settings panel.

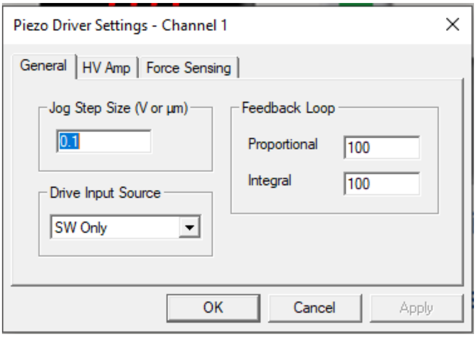


Fig. 5.4 Piezo settings panel

3) Select the 'General' tab.
4) In the 'Drive Input Source' field, select '+ve *BNC (+SW)*'.
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.

5.6 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.

5.7 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.

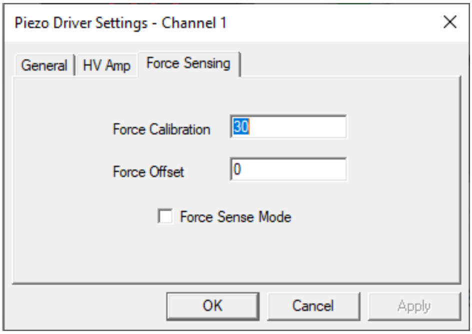


Fig. 5.5 Piezo settings panel

2) Check the *Force Sense Mode* 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) The force sensor may display an offset when no contact is apparent. The *Force Offset* parameter is used to remove any latent offset, such that the sensor only detects a force when contact is experienced. Enter the required value to remove any offset from the force sensor output.

In Force Sensor mode, an 'F' is displayed next to the digital display on the GUI panel.

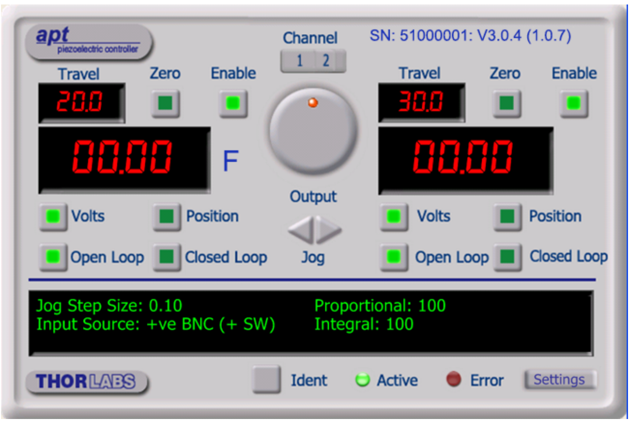


Fig. 5.6 GUI Display - Force Sensor Mode

Chapter 6 Software Reference

6.1 GUI Panel

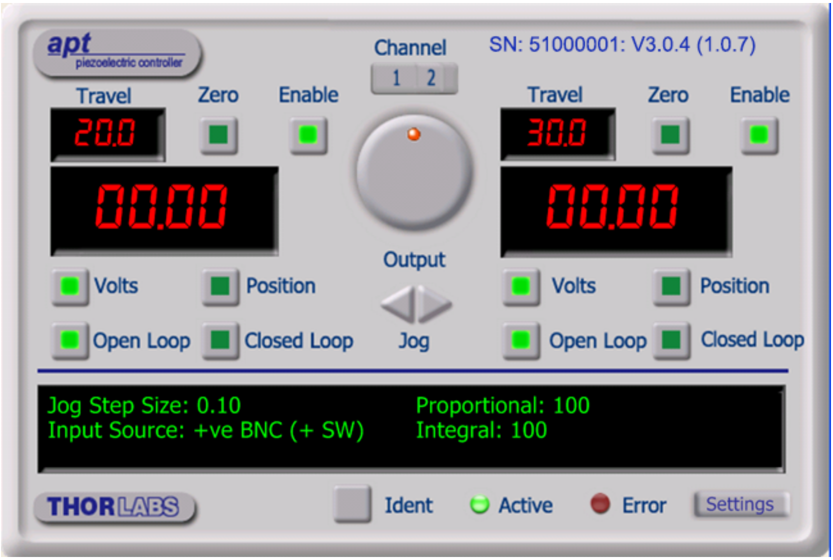


Fig. 6.1 Piezo Controller GUI panel

The software drivers consist of several ‘Objects’, which in turn contain ‘Methods’ and ‘Properties’. The ‘Piezo’ object contains the methods which facilitate the programmed operation of the module.

The methods are used to perform such tasks as setting Volts or Position display, setting Open or Closed loop operation, and adjusting the position of the piezo actuator.

More detailed information on objects, methods and parameters, including a full description of the Piezo objects, can be found in the *MG17Base Helpfile*.

Programmed operation of the Piezo controller allows a wider range of functions to be used than operation from the GUI panel alone. Other units such as the APT Stepper Motor controller can also be controlled with the Piezo controller.

Note. The serial number of the APT unit associated with the ActiveX control instance (allocated using the HWSerialNum property), the APT server version number, and the version number (in brackets) of the embedded software running on the APT unit, are displayed in the top right hand corner of the control.

Channel - Used to select the applicable channel, when operating the 'Jog' and 'Output' controls. Also selects the channel data displayed in the 'Settings' window.

Output Control - used to adjust and set the voltage or position output as displayed in the main digital display. 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. Note that the read out in the main digital display is independent of the operating mode (open or closed loop) selected for the particular channel. If the 'Volts' button is selected, then the read out is in volts, even if the channel is in closed loop mode and the Output control is being used to adjust position. Similarly, if the 'position' button is selected, the read out is in microns, derived from the strain gauge feedback signal, even if the channel is operating in open loop.

Jog - used to increment or decrement the piezo position. When the button is clicked, the piezo is driven in the selected direction, one step per click. The step size can be set in the 'Settings' panel or by using the SetJogStepSize method.

Travel - the range of travel (in µm) of the piezo actuator.

Zero - used to zero the position sensor (strain gauge) when operating in 'Closed Loop mode' - see see Section 5.3. Setting The Position Sensor Zero.

Enable - enables or disables the HV channel's output voltage. With the piezo enabled, the LED in the button is lit. When disabled, the LED is unlit and the output voltage on the HV amp channel is set to zero volts.

Digital 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 either via the 'Volts' and 'Position buttons, or by calling the SetVoltPosDispMode method.

Volts and Position - push button controls used to toggle the display between volts and position modes - see Display Modes. The LED in the button is lit when selected.

Open Loop and Closed Loop - push button control used to toggle between open loop and closed loop modes. The LED in the button is lit when selected.

Settings display - shows the following user specified settings:

Jog Step Size - the distance to move when a jog command is initiated. If in closed loop mode, the step size is measured in microns; if in open loop mode, the step size is measured in Volts. The step size can be set either via the Settings panel or by calling the SetJogStepSize method.

Input Source - displays the input source associated with the selected channel. The input source can be set either via the 'Settings' panel or by calling the SetIPSource method.

If *SW Only* is dispayed, the unit responds only to software inputs and the output to the piezo actuator is that set using the SetVoltOutput method.

If *+ ve BNC (+SW)* is displayed, the unit sums a positive analog signal on the rear panel BNC connector with the voltage set using the SetVoltOutput method.

If *- ve BNC (+SW)* is selected, the unit sums a negative analog signal on the rear panel BNC connector with the voltage set using the SetVoltOutput method.

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

Integral - displays the integration feedback loop constant for the selected channel (0 to 255).

Settings button - Displays the 'Settings' panel, which allows the tuning parameters to be entered - see Section 6.2.

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

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

Error - lit when one of the following fault condition occurs:

1) One or more power supply voltages are out of range.
2) Channel 1 or channel 2 has closed loop mode selected but the associated piezo is disconnected.

6.2 Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed for the selected channel. This panel allows data such as jog step size and input sources to be entered. The various parameters are described below.

6.2.1 General tab.

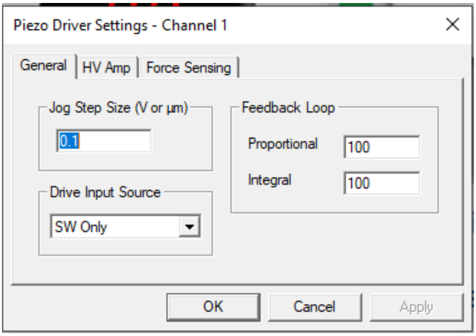


Fig. 6.2 Piezo Settings panel - General tab

Jog Step Size - the distance to move when a jog command is initiated. If in closed loop mode, the step size is measured in microns; if in open loop mode, the step size is measured in Volts.

Feedback Loop - these parameters determine the response characteristics when operating in closed loop mode.

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

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

Input Source - determines the input source(s) which controls the output from the HV amplifier circuit (i.e. the drive to the piezo actuators).

SW Only - the unit responds only to software inputs and the HV amp output is that set using the SetVoltOutput method (or the GUI panel 'Output' control).

BNC (+ SW) - the unit sums the differential signal on the rear panel EXT IN (+) and EXT IN (-) BNC connectors with the voltage set using the SetVoltOutput method (or the GUI panel 'Output' control).

POT (+ SW) - the HV amp output is controlled by a potentiometer input (connected to the rear panel User I/O D-type connector) summed with the voltage set using the SetVoltOutput method (or the GUI panel 'Output' control).

BNC + POT (+ SW) - the HV amp output is controlled by the sum of all three input sources (potentiometer, BNC's and software).

6.2.2 HV Amp Tab

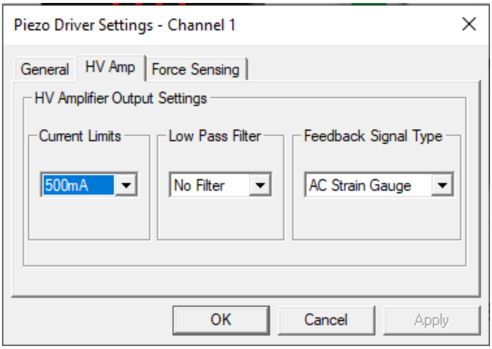


Fig. 6.3 Piezo Settings panel - HV Amp tab

This panel is used to set the output characteristics of the HV amplifier channels fitted to the Piezo unit. Both low pass filtering and current control settings can be made to tailor the piezo output drive to a particular application.

Current Limits - This parameter sets the maximum current output of the HV amplifier:

100MA – Current output (piezo drive signal) limited at 100mA

250MA – Current output (piezo drive signal) limited at 250mA

500MA– Current output (piezo drive signal) limited at 500mA

Low Pass Filter – This parameter sets the cut off frequency of the hardware low pass filter, applied to the HV amplifier output channels. It applies to both channels simultaneously.

10HZ - Cut off all signals above 10Hz

100HZ - Cut off all signals above 100Hz

5KHZ - Cut off all signals above 5KHz

No Filter - Low pass filter inactive

Feedback Signal Type - This parameter sets the type of feedback signal used when operating the HV amplifier channels in closed loop operation.

Two types of feedback signal are supported:

AC Strain Gauge - The AC Strain Gauge mode refers to the use of AC excited strain gauge feedback signals as generated by the complete range of Thorlabs piezo actuators and piezo equipped multi axis stages. All versions of the APT Piezo electronics support this feedback mode.

DC 0-10V - On APT modular hardware (and build 2 versions of benchtop APT hardware) it is possible to set the feedback signal type to DC 0 – 10V. This configures the feedback circuit to accept a differential 0-10V DC feedback signal in order to control position output. This latter feedback mode is available for use with third party piezo positioning systems capable of generating a standard voltage position feedback signal.

Note. On APT modular hardware (and build 2 versions of benchtop APT hardware), the function of the pin connections on the 9-way D-type feedback connector is dependent on the feedback mode selected. Refer to the pin-out tables in Section 4.4.3. for details.

6.2.3 Force Sensing Tab

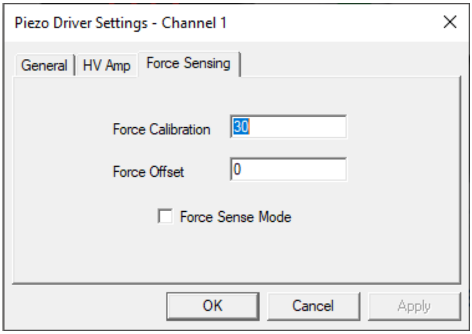


Fig. 6.4 Piezo settings panel

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 30N.

Force Offset - The force sensor may display an offset when no contact is apparent. This parameter is used to remove any latent offset, such that the sensor only detects a force when contact is experienced. Enter the required value to remove any offset from the force sensor output.

Force Sense Mode - Check this box to select Force Sensing Mode.

Chapter 7 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.

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 in.)
Weight	1.5 kg (3.3 lb)
Piezo Drive	
Connector	SMC male connector
Voltage Output	0 to 75V d.c. per channel
Voltage Stability	100ppm over 24 hours
Output Current	500mA 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
APT Modular Rack	MMR601
Drive Cable for Piezoelectric Actuators (3.0 m)	PAA100
Drive Cable for Piezoelectric Actuators (1.5 m)	PAA101
Feedback Cable for Piezoelectric Actuators (1.0 m)	PAA605
Feedback Cable for Piezoelectric Actuators (3.0 m)	PAA606
Piezoelectric Feedback Cable, Male D-type to Female LEMO converter (3.0 m)	PAA622
Piezoelectric Feedback Cable, Female D-type to Male LEMO converter (3.0 m)	PAA623

Chapter 9 Piezo Control Method Summary

The 'Piezo' ActiveX Control provides the functionality required for a client application to control one or more of the APT series of piezo controller units. This range of controllers covers both open and closed loop piezo control in a variety of formats including compact Cube type controllers, benchtop units and 19" rack based modular drivers. Note one additional product, the TSG001 T-Cube Strain Gauge reader is another member of the APT controller range - and can also be accessed using the Piezo ActiveX Control.

To specify the particular controller being addressed, every unit is factory programmed with a unique 8-digit serial number. This serial number is key to the operation of the APT Server software and is used by the Server to enumerate and communicate independently with multiple hardware units connected on the same USB bus. The serial number must be specified using the HWSerialNum property before an ActiveX control instance can communicate with the hardware unit. This can be done at design time or at run time. Note that the appearance of the ActiveX Control GUI (graphical user interface) will change to the required format when the serial number has been entered.

The Methods and Properties of the Piezo ActiveX Control can be used to perform activities such as selecting output voltages, reading the strain gauge position feedback, operating open and closed loop modes and enabling force sensing mode. A brief summary of the methods and propertys applicable to the BPC201 unit is given below, for more detailed information and individual parameter descriptiond please see the on-line help file supplied with the APT server.

Methods

DeleteParamSet	Deletes stored settings for specific controller.
DisableHWChannel	Disables the drive output.
DoEvents	Allows client application to process other activity.
EnableEventDlg	Enables or disables the event dialog box.
EnableHWChannel	Enables the drive output.
GetAmpFeedbackSig	Gets the feedback signal type (AC or DC).
GetAmpOutputParams	Gets the HV amplifier output parameters.
GetControlMode	Gets the loop operating mode (open/closed).
GetForceSenseParams	Gets the force sensing mode parameters.
GetIPSource	Gets the HV amplifier input source.
GetJogStepSize	Gets the jogging step size.
GetMaxTravel	Gets the maximum travel of a strain gauge equipped piezo actuator

GetOutputLUTParams	Gets the output voltage waveform (LUT) operating parameters.
GetOutputLUTTrigParams	Gets the output voltage waveform (LUT) triggering parameters.
GetOutputLUTValue	Gets a specific voltage output value in the voltage waveform (LUT) table.
GetParentHWInfo	Gets the identification information of the host controller.
GetPIConsts	Gets the closed loop operating (proportional, integration) parameters.
GetPosOutput	Gets the piezo actuator extension in closed loop mode.
GetVoltOutput	Gets the HV output voltage.
GetVoltPosDispMode	Gets the GUI display mode (voltage or position).
Identify	Identifies the controller by flashing unit LEDs.
LLGetDigIPs	Gets digital input states encoded in 32 bit integer.
LLGetStatusBits	Gets the controller status bits encoded in 32 bit integer.
LLSaveHWDefaults	Allows the current settings of the operation parameters to be saved into the onboard 'Flash' memory of the hardware unit.
LLSetGetDigOPs	Sets or Gets the user digital output bits encoded in 32 bit integer.
LoadParamSet	Loads stored settings for specific controller.
SaveParamSet	Saves settings for a specific controller.
SetAmpFeedbackSig	Sets the feedback signal type (AC or DC).
SetAmpOutputParams	Sets the HV amplifier output parameters.
SetControlMode	Sets the loop operating mode (open/closed).
SetForceSenseParams	Sets the force sensing mode parameters.
SetHWMode	Sets Piezo Amp or NanoTrak operating mode.
SetIPSource	Sets the HV amplifier input source.
SetJogStepSize	Sets the jogging step size.
SetOutputLUTParams	Sets the output voltage waveform (LUT) operating parameters.
SetOutputLUTTrigParams	Sets the output voltage waveform (LUT) triggering parameters.
SetOutputLUTValue	Sets a specific voltage output value in the voltage waveform (LUT) table.

SetOutputLUTValueTypes	Specifies whether the samples output from the LUT are voltage or position values.
SetPIConsts	Sets the closed loop operating (proportional, integration) parameters.
SetPosOutput	Sets the piezo actuator extension in closed loop mode.
SetVoltOutput	Sets the HV output voltage.
SetVoltPosDispMode	Sets the GUI display mode (voltage or position).
ShowEventDialog	Shows the event dialog when it has previously been disabled using the EnableEventDlg method
StartCtrl	Starts the ActiveX Control (starts communication with controller)
StartOutputLUT	Starts outputting the voltage waveform (LUT).
StopCtrl	Stops the ActiveX Control (stops communication with controller)
StopOutputLUT	Stops outputting the voltage waveform (LUT).
ZeroPosition	Nulls the strain gauge reading to take out offset errors.

Properties

APTHelp	Specifies the help file that will be accessed when the user presses the F1 key. If APTHelp is set to 'True', the main server helpfile MG17Base will be launched.
HWSerialNum	specifies the serial number of the hardware unit to be associated with an ActiveX control instance.

Chapter 10 Principles of Operation

10.1 Piezoelectric Controller

10.1.1 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. 10.1. 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).

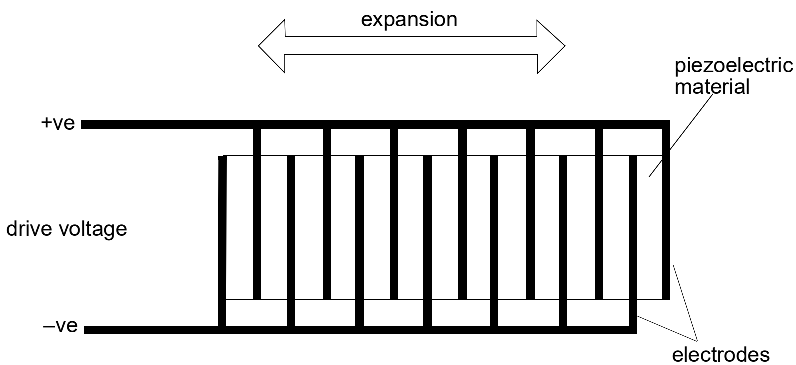


Fig. 10.1 Piezo-electric actuator schematic diagram

10.1.2 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. 10.2.

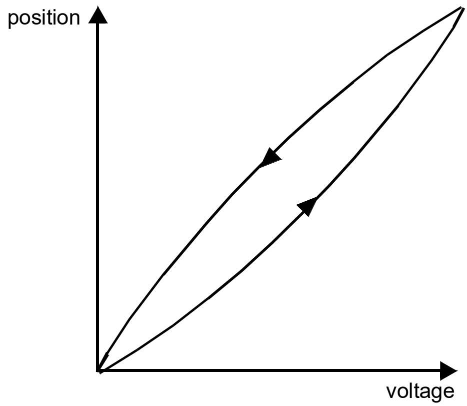


Fig. 10.2 Piezo-electric hysteresis

10.1.3 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. 10.3.

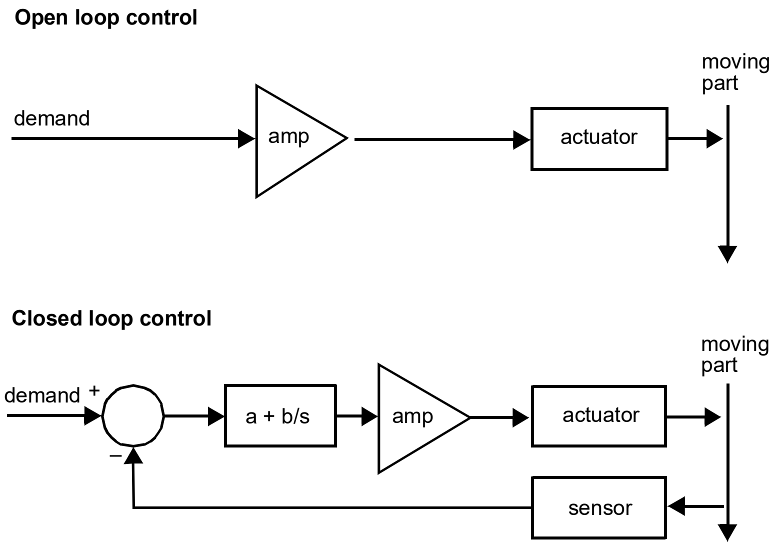


Fig. 10.3 Open loop and closed loop control

The result of using closed-loop control is a linear relationship between demand (voltage) and measured position – see Fig. 10.4, in contrast to open loop control – see Fig. 10.2.

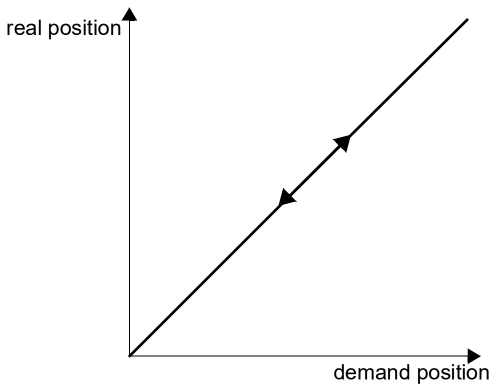


Fig. 10.4 Closed loop response

Chapter 11 Regulatory

11.1 Declarations Of Conformity

11.1.1 For Customers in Europe

See Section 11.2.

11.1.2 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.

11.2 CE Certificate

Chapter 12 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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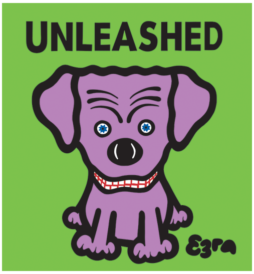
chinasales@thorlabs.com

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



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