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THORLABS

TPZ001 - February 3, 2016

Item # TPZ001 was discontinued on February 3, 2016. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

T-CUBE PIEZO CONTROLLER

▶ **Open Loop Piezo Driver up to 150 V**

▶ **Seamless Operation with Throlabs' Piezo Actuators**

▶ **Operation via Local Panel Controls or Remote PC via USB**

▶ **Optional T-Cube Hub for Multi-Channel Applications**

Application Idea

TPZ001
Power Supply
Sold Separately

USB ⇌

NF15AP25 Stage Controlled by TPZ001 Plezo Driver

OVERVIEW

Features

- Compact T-Cube Footprint
- Selectable High Voltage Output Range: 75 V, 100 V, or 150 V
- Digital Potentiometer High Voltage Control (Adjustable Resolution)
- Low Voltage Driver Input and Monitor Output (SMA)
- Closed-Loop Operation with T-Cube Strain Gauge Reader Unit
- Voltage Ramp/Waveform Generation Capability (Scanning Applications)
- Standalone or PC Controller Operation via USB Plug and Play
- Software Control Suite Included
- Extensive ActiveX® Programming Interfaces
- Software Compatible with other APT™ Controllers (Integrated Systems Development)

T-Cube Motion Control Modules
Brushed DC Servo Motor Controller
Brushless DC Servo Motor Controller
Stepper Motor Controller
Single-Channel Piezo Controller
Single-Channel Strain Gauge Reader
Dual-Channel NanoTrak Auto-Aligner
Quadrant Detector
Solenoid Controller

Click to Enlarge
Back View of the TPZ001 T-Cube
(See the *Pin Diagrams* Tab for More Information)

The T-Cube Piezo Controller (TPZ001) is a compact single-channel controller/driver for easy manual and automatic control of a wide range of piezo stacks and actuators. This driver is capable of delivering up to 150 V of drive voltage at 7.5 mA, thereby allowing operating bandwidths up to 1 kHz (see *Specs* tab). The TPZ001 is compatible with Thorlabs' complete range of bare piezo stacks, piezo-equipped actuators, and piezo-driven mirror mounts with SMC connectors using the cables included with each piezo component. For mounts with BNC connectors, an adapter is required. Furthermore, when operated together with the T-Cube Strain Gauge Reader unit (TSG001), high-precision closed-loop operation is possible using the complete range of feedback-

equipped piezo actuators available from Thorlabs. If used on the T-Cube Controller Hub (TCH002), the two units can be mounted together and all power and USB requirements are provided in a convenient package.

The unit has a very small footprint (60 mm x 60 mm x 47 mm) [2.4" x 2.4" x 1.8"] and may be mounted directly to the optical table using the 1/4" (M6) clearance slot in the base plate. This compact size allows the controller to be positioned close to the motorized system for added convenience when manually adjusting motor positions using the top panel controls. Tabletop operation also allows minimal drive cable lengths for easier cable management. For convenience, a Type A to Type Mini B USB cable is included with the TPZ001 T-Cube.

Although compact in footprint, this unit offers a full piezo control capability. To support a wide variety of piezo devices, the output range can be user selected to 75 V, 100 V or 150 V. The resolution of the digitally encoded adjustment pot is easily altered to provide very accurate positioning control. Direct hardware control of the high voltage output can be facilitated using the low voltage input connector. A low voltage output connector allows for easy monitoring of the HV output (for example, using an oscilloscope). As a useful feature, a programmable waveform generation capability makes this unit particularly well suited for use in piezo scanning applications.

USB connectivity provides easy plug and play PC controlled operation. The TPZ001 also includes the very user friendly APT software which allows the user to quickly set up complex control sequences. For example, all relevant operating parameters are set automatically by the software for Thorlabs stage and actuator products. Advanced custom motion control applications and sequences are also possible using the extensive ActiveX® programming environment described in more detail on the *Motion Control Software* and *APT Tutorials* tabs.

Furthermore, multiple units can be connected to a single PC via standard USB hub technology or by using the T-Cube Controller Hub (TCH002) for multi-axis motion control applications.

Click to Enlarge
TCH002 USB Controller Hub (Power Supply not Shown)
with Installed T-Cube Modules

Power Supply Options

The preferred power supply (i.e., single channel, multi-channel, or hub-based) depends on the end user's application and whether you already own compatible power supplies. To that end and in keeping with Thorlabs' green initiative, we do not ship these units bundled with a power supply. This avoids the cost and inconvenience of receiving an unwanted single channel supply if a multi-channel or hub-based system would be more appropriate. The power supply options compatible with the TPZ001 Piezo Controller are listed in the table below.

Other Piezo Driver Controllers			
T-Cube[TM] Controller Single-Channel	Open Loop Benchtop Controller 1- and 3-Channel	Closed Loop Benchtop Controller 1- and 3-Channel	Rack System Module 2-Channel

SPECS

| Specification	Value
Piezoelectric Output (SMC Male)	
Drive Voltage	0 - 150 V
Drive Current, Max, Continuous	7.5 mA
Stability	100 ppm Over 24 hrs (After 30 min Warm-Up)
Noise	<2 mV$_{RMS}$
Typical Piezo Capacitance	1 - 10 µF
Bandwidth	1 kHz (1 µF Load, 1 V$_{p-p}$)
External Input (SMA Female)	0 - 10 V
Output Monitor (SMA Female)	0 - 10 V
USB Port[a]	Version 1.1 mini
T-Cube Controller Hub Connector	26-Way ERNI
General	
Input Power	+15 V @ 220 mA, -15 V @ 50 mA, +5 V @ 350 mA
Housing Dimensions (W x D x H)	60 mm x 60 mm x 47 mm (2.4" x 2.4" x 1.8")
Weight	160 g (5.5 oz)

- A USB cable with a Type A connector on one end and a Type Mini B connector on the other end is included.

The graph below shows the drive voltage/frequency response at different capacitive loads for the TPZ001.
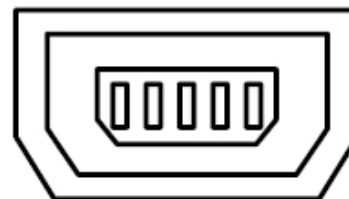
TPZ001

*9.33 V peak-to-peak sine wave input

Click to Enlarge

Click Here for Raw Data
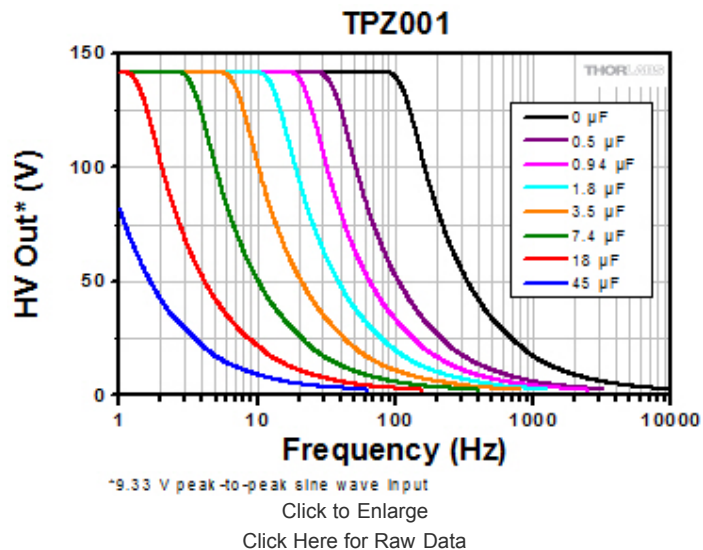
PIN DIAGRAMS

Power Connector

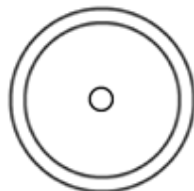**Mini-DIN Female**
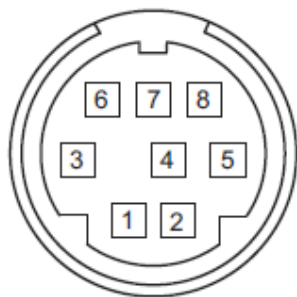
Computer Connection

USB Mini-B*

*Type A to Mini-B cable included

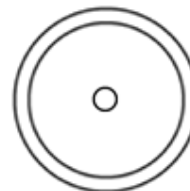| Pin	Description	Pin	Description
1	+5 V	6	Common Ground
2	+5 V	7	Common Ground
3	-15 V	8	Common Ground
4	+15 V	Shield	Common Ground
5	+5 V		

Monitor

SMA Female

HV OUT

**SMC Male**

EXT IN

SMA Female

This low-voltage (0 to +10 V), output can be used to monitor the signal at the HV OUT high voltage output. In its most common use, it can be connected directly to an oscilloscope to observe the waveforms or voltage levels present at the high voltage output.

0 to 150 V, 0 to 7.5 mA. Provides the drive signal to the piezo actuator. The maximum voltage (75 V, 100 V, or 150 V) is set via the front panel.

Used to connect an external analogue signal source to control the operation of the cube. The input voltage range is 0 to +10 V and the input impedance is 12 kΩ.

APPLICATION
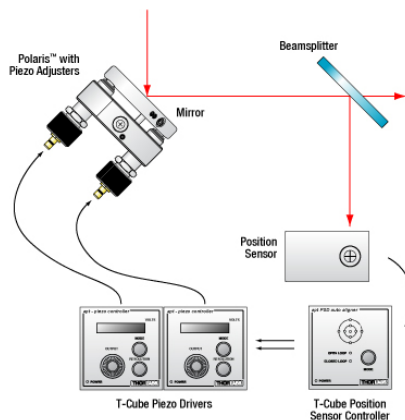
Click for Details
Piezo Controller as Part of a Closed-Loop System

Piezo Controller in a Beam Stabilization Setup

Active beam stabilization is often used to compensate for beam drift (unintended beam pointing deviations) in experimental setups. Drift can be caused by insecurely mounted optics, laser source instabilities, and thermal fluctuations within an optomechanical setup. In addition to correcting for setup errors, active stabilization is frequently used in laser cavities to maintain a high output power or used on an optical table to ensure that long measurements will take place under constant illumination conditions. Setups with long beam paths also benefit from active stabilization, since small angular deviations in a long path will lead to significant displacements downstream.

An example of a beam stabilization setup is shown in the schematic to the left. A beamsplitter inserted in the optical path sends a sample of the beam to a quadrant position sensor that monitors the displacement of the beam relative to the detector's center. (For optimal stabilization, the beamsplitter should be as close as possible to the measurement.) The quadrant detector outputs an error signal in X and Y that is proportional to the beam's position. Each error signal is fed into a channel of a piezoelectric controller that steers the beam back to the center of the quadrant sensor.

The setup illustrated here stabilizes the beam to a point in space. In order to stabilize the beam over a beam path, four independent output channels are required (i.e., at least two piezoelectric controllers), as are two mirror mounts with piezo adjusters, two position sensors, and two position sensor controllers. Suggested electronics for a beam stabilization setup are given in the table below.

Suggested Components	
Description	**Item #**
Piezoelectric Controller	TPZ001 T-Cube Piezo Controller[a]
Mirror Mount with Piezo Adjusters (Choose One)	POLARIS-K1PZ Polaris™ Mirror Mount with 3 Adjusters, POLARIS-K1PZ2 Polaris™ Mirror Mount with 2 Adjusters, KC1-PZ (KC1-PZ/M) Mirror Mount, KC1-T-PZ (KC1-T-PZ/M) Mirror Mount with SM1-Threaded Bore, or ASM003 Ø7.0 mm Mirror Mount
Quadrant Position Detector	PDP90A (320 - 1100 nm), PDQ80A (400 - 1050 nm), or PDQ30C (1000 - 1700 nm)
T-Cube Position Sensor Controller	TPA101

- One controller is required per independently controlled axis.

FURTHER INFO

Introduction

The T-Cube Piezo Driver (TPZ001) is a compact single channel controller for use in alignment applications where manual or automated nanometer level motion control is required. It has been designed to operate with all open loop piezo-actuated nanopositioning actuators & stages in the Thorlabs range. Furthermore, when the unit is operated together with the T-Cube Strain Gauge Reader unit (TSG001) on the T-Cube Controller Hub(TCH002), high precision closed loop operation is possible using our complete range of feedback equipped piezo actuators.

Although compact in footprint, this unit offers fully featured piezo control capability. To support a wide variety of piezo devices, the output range can be user selected to 75 V, 100 V or 150 V. The resolution of the digitally encoded adjustment pot is easily altered to provide very accurate positioning control. Direct hardware control of the high voltage output can be facilitated using the low voltage input connector. A low voltage output connector allows for easy monitoring of the HV output (using a scope for example). Open or closed loop* operation is a simple button click. As a useful feature, a programmable waveform generation capability makes this unit particularly well suited for use in piezo scanning applications.

*Closed loop operation requires TSG001 and TCH002.

TPZ001 Piezo Driver T-Cube

As an open loop piezo controller the TPZ001 Piezo Driver T-Cube is compatible with our complete range of non-feedback piezo actuators and stages including the PAS series actuators, the PE4 actuatorand our bare piezo stacks. Furthermore, many of our flexure based, high precision positioning stages can be equipped with open loop piezo control, including the 1 axis NanoFlex stages, 3 axis NanoMax 300 and 6 axis NanoMax 600.

When used in combination with the TSG001 Strain Gauge Reader T-Cube (and T-Cube Controller Hub), full and precise closed loop piezo positioning control is possible. This T-Cube controller combination is then compatible with all of our closed loop piezo solutions including the PAZ series actuators, the DRV120 actuator, and other actuators such as the DRV517. Closed loop control on many of our flexure based products is also possible, including the 1-axis NanoFlex stages, 3-axis NanoMax 300 and 6-axis NanoMax 600.

See the 'Related Items' for links to a range of piezo equipped products that can be operated using the Piezo T-Cube Driver.

A Range of Piezo Actuated Products

Joining the apt™ Family
Thorlabs' T-Cube drivers are members of the apt™ family of controllers, which includes a range of high specification motor and piezo controllers (both in benchtop and rack-based formats) specifically aimed at high resolution positioning applications. By inheriting much of the functionality developed for these high end variants, the T-Cube drivers are built on a flexible and powerful motion control capability with full and complete software support. It is perfectly feasible to mix operation of the TPZ001 T-Cube unit with any other member of the apt™ controller family through the same unified software interfaces, both graphical and

programmable. For the first time, positioning and motion control applications deploying any of the complete range of Thorlabs motorized/piezo actuated nano-positioning and opto-mechanical hardware is easily achieved in minimum time via a common PC software platform.

TPZ001 Rear Panel

Deployment

Designed as a low power, yet fully featured equivalent to the BPC301/3 benchtop controller series (see Related Items tab), the TPZ001 Piezo Driver T-Cube is contained in a very compact 60 mm x 60 mm x 47 mm (2.4" x 2.4" x 1.8") housing incorporating easily accessible local controls for manual piezo control and positioning. We have taken care to keep the footprint to a minimum allowing the possibility, in many opto-mechanical applications, of locating this driver on the optical table in close proximity to the piezo actuated apparatus being driven. A base plate option allows easy mounting to optical tables in a stacked side by side configuration for control of multiple piezo channels. Use of this driver solution within the photonics R&D environment is further considered by an overall black finish and by elimination of any stray light generation associated with the front panel LEDs, which can be disabled by using a software command.
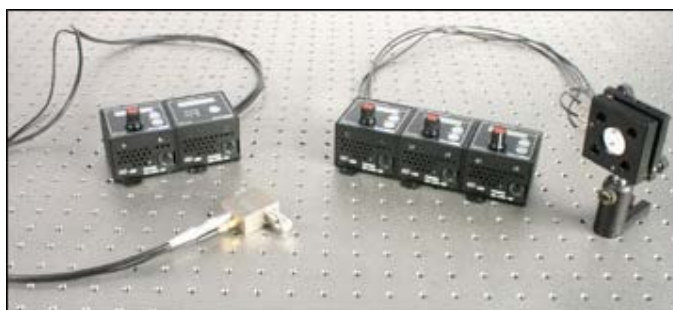
Typical Applications

Note that the TPZ001 unit is equipped with SMA connectors for LV input and output and an SMC connector for the high voltage output. For convenience, Thorlabs supplies a range of SMC to BNC and SMA to BNC adapters for those applications where BNC connections are required.

SMC to BNC and SMA to BNC Adapters

T-Cube Controller Hub

As a further level of convenience when using the T-Cube Controllers, Thorlabs also offers the T-Cube Controller Hub. This product has been designed specifically with multiple T-Cube operation in mind, in order to simplify issues such as cable management, power supply routing, multiple USB device communications and different optical table mounting scenarios. The T-Cube Controller Hub comprises a slim base-plate type carrier [375 mm x 86 mm x 21.5 mm (14.75" x 3.4" x 0.85")] with electrical connections located on the upper surface to accept up to six T-Cubes. Internally, the Controller Hub contains a fully compliant USB 2.0 hub circuit to provide communications for all six T-Cubes - a single USB connection to the Controller Hub is all that is required for PC control. The Controller Hub also provides power distribution for up to six T-Cubes. In addition, the Hub routes digital and analog signals between T-Cubes allowing deterministic inter-Cube operation in certain applications. For example, the TPZ001 Piezo Driver can pick up (via the Hub) an analog feedback voltage generated from a neighboring TSG001 Strain Gauge Reader to facilitate closed loop piezo control.

Vertical and Horizontal Mounting Options for the TCH002

Note: When operating the TPZ001 T-Cube standalone (in absence of the TCH002 Hub) a separate power supply is required. A compact multi-way power supply unit (TPS002) is available from Thorlabs, allowing up to 2 individual TPZ001 Drivers to be powered from a single mains outlet (see picture below).

TPS002 Power Supply

Manual Operation

For quick "out of the box" manual operation, the TPZ001 Piezo controller can simply be connected to one of the range of Thorlabs piezo equipped, nano-positioning actuators, stages or bare piezo stacks and then powered-up by connecting to the individual Thorlabs power supply option (TPS002) or by using the T-Cube Controller Hub (TCH002). Piezo positioning control is then facilitated using the digital potentiometer located on the top face of the unit; the resolution of the potentiometer can be altered with a single button press. A clear, easy to read, 5 digit readout displays the output voltage being generated by the driver. To cover the wide range of piezo equipped products offered by Thorlabs, the maximum output voltage can be set to 75 V, 100 V or 150 V using the 'Mode' button also located on the top face. The 'Mode' button, and theassociated menu displayed on the readout, can also be used to select open or closed loop - note that closed loop operation is only possible when the Piezo Drive T-Cube is used in conjunction with the Strain Gauge Reader T-Cube (TSG001) and T-Cube Controller Hub (TCH002). It is also possible to use the potentiometer to adjust display brightness as required. For full flexibility, the supplied PC software can be used to alter all default parameters - saving any changes to the memory within the driver unit,such that they are applied whenever the unit is powered

up.

Automated (PC) Control

For automated remote operation, the TPZ001 is fitted with a USB port for connection to a host control PC. One or more drivers can be connected together easily via standard USB hubs or the T-Cube Controller Hub (TCH002) for control from a single computer. To enable easy and flexible simultaneous control of multiple units, a full software control suite (the apt™ System Software) is supplied by Thorlabs. This motion control software was originally developed to provide sophisticated PC control of the full range of apt™ bench top motion controllers and has now been fully updated to provide support for the T-Cube drivers. Using this feature rich apt™ system software, the full piezo control capabilities of the TPZ001 are exposed through very intuitive graphical user control panels, allowing piezo position to be set and monitored very easily. All operating parameters can be easily accessed and changed to fine tune operation as required. Multiple graphical panels displayed within the software allow control of multiple T-Cube Drivers simultaneously, in an easy and intuitive way.

As a very useful feature it is possible to upload a Voltage Look Up Table (LUT) into the unit and then activate the output of this voltage sequence at different rates. In this way, high voltage output waveforms can be programmed to facilitate piezo scanning experiments, for example.

TPZ001 Software GUI

Full Software GUI Control Suite & ActiveX® Controls Included

A full and sophisticated software suite is supplied with the TPZ001. It comprises a number of 'out of the box' user utilities to allow immediate operation of the unit without any detailed pre-configuration. All operating modes can be accessed manually and all operating parameters changed and saved for next time use. For more advanced 'custom' motion control applications, a fully featured ActiveX® programming environment is also included to facilitate custom application development in a wide range of programming environments. Note that all such settings and parameters described above are also accessible through these ActiveX® programmable interfaces. For further information on the apt™ software support for the T-Cube drivers, please refer to the Software tab. Demonstration videos illustrating how to program the apt™ software are also available for viewing from the Video Tutorial tab.

Typical ActiveX Control View

The ActiveX® apt™ system software shipped with the TPZ001 is also compatible with other apt™ family controllers including our multi-channel rack-based system and the higher power benchtop controllers. This single unified software offering allows seamless mixing of any apt™ benchtop, table top and/or rack based units in any single positioning application.

The APT Family

The key innovation of the apt™ range of controllers and associated mechanical products is the ease and speed with which complete automated alignment/positioning 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™ units to be connected to a single controller PC using commercial USB hubs and cables. When planning a multi-channel application, simply add up the number and type of drive channels required and connect together the associated number of APT controllers.

Software Developers Support CD
A developers' kit is shipped with all of our apt™ series controllers. This additional software support is intended for use by software developers working on large, system integration projects that incorporate apt™ products. The kit contains an extensive selection of useful code samples as well as a library of Video Tutorials.

MOTION CONTROL SOFTWARE

Thorlabs offers two platforms to drive our wide range of motion controllers: our legacy APT™ (Advanced Positioning Technology) software package or the new Kinesis software package. Either package can be used to control devices in the APT family, which covers a wide range of motion controllers ranging from small, low-powered, single-channel drivers (such as the T-Cubes) to high-power, multi-channel, modular 19" rack nanopositioning systems (the APT Rack System).

Our legacy APT System Software platform is available by clicking on the link below. It features ActiveX-based controls which can be used by 3rd party developers working on C#, Visual Basic, LabVIEW or any Active-X compatible languages to create custom applications, and includes a simulator mode to assist in developing custom applications without requiring hardware.

The Kinesis Software features new .NET controls which can be used by 3rd party developers working in the latest C#, Visual Basic, LabVIEW or any .NET compatible languages to create custom applications. Low level DLL libraries are included for applications not expected to use the .NET framework. A Central Sequence Manager supports integration and synchronization of all Thorlabs motion control hardware.

APT GUI Screen

By providing these common software platforms, Thorlabs has ensured that users can easily mix and match any of the APT controllers in a single application, while only having to learn a single set of software tools. In this way, it is perfectly feasible to combine any of the controllers from the low-powered, single-axis to the high-powered, multi-axis systems and control all from a single, PC-based unified software interface.
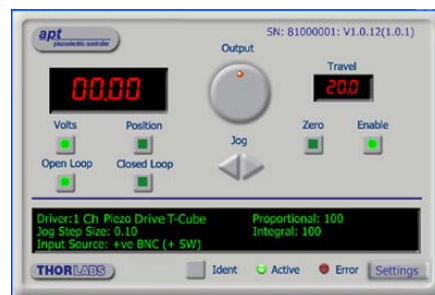
The software packages allow two methods of usage: graphical user interface (GUI) utilities for direct interaction with and control of the controllers 'out of the box', and a set of programming interfaces that allow custom-integrated positioning and alignment solutions to be easily programmed in the development language of choice.

A range of video tutorials are available to help explain our APT system software. These tutorials provide an overview of the software and the APT Config utility. Additionally, a tutorial video is available to explain how to select simulator mode within the software, which allows the user to experiment with the software without a controller connected. Please select the *APT Tutorials* tab above to view these videos, which are also available on the software CD included with the controllers.

included
with the controllers.

Software
APT Version 3.10.0
The APT Software Package, which includes a GUI

Software
Kinesis Version 1.1.0
The Kinesis
 GUI for control of Thorlabs' APT™ system
 controllers.

Also Available:

- Comminications Protocol

  Software ⬇

- Communications Protocol

  Software ⬇

Kinesis GUI Screen

APT TUTORIALS

These videos illustrate some of the basics of using the APT System Software from both a non-programming and a programming point of view. There are videos that illustrate usage of the supplied APT utilities that allow immediate control of the APT controllers out of the box. There are also a number of videos that explain the basics of programming custom software applications using Visual Basic, LabView and Visual C++. Watch the videos now to see what we mean.

Click here to view the video tutorial

To further assist programmers, a guide to programming the APT software in LabView is also available.

Click here to view the LabView guide

PIEZO BANDWIDTH

Piezo Driver Bandwidth Tutorial

Knowing the rate at which a piezo is capable of changing lengths is essential in many high-speed applications. The bandwidth of a piezo controller and stack can be estimated if the following is known:

1. The maximum amount of current the controllers can produce. This is 0.5 A for our BPC Series Piezo Controllers, which is the driver used in the examples below.
2. The load capacitance of the piezo. The higher the capacitance, the slower the system.
3. The desired signal amplitude (V), which determines the length that the piezo extends.
4. The absolute maximum bandwidth of the driver, which is independent of the load being driven.

To drive the output capacitor, current is needed to charge it and to discharge it. The change in charge, *dV/dt*, is called the slew rate. The larger the capacitance, the more current needed:

$$slew\ rate = \frac{dV}{dt} = \frac{I_{max}}{C}$$

So, for example, for a 100 μm stack, having a capacitance of 20 μF, being driven by a BPC Series piezo controller with a maximum current of 0.5 A, the slew rate is given by

$$slew\ rate = \frac{0.5\,A}{20\,\mu F} = 25\,V/ms$$

Hence, for an instantaneous voltage change from 0 V to 75 V, it would take 3 ms for the output voltage to reach 75 V.

Note: For these calculations, it is assumed that the absolute maximum bandwidth of the driver is much higher than the bandwidths calculated, and thus, driver bandwidth is not a limiting factor. Also please note that these calculations only apply for open-loop systems. In closed-loop mode, the slow response of the feedback loop puts another limit on the bandwidth.

Sinusoidal Signal

The bandwidth of the system usually refers to the system's response to a sinusoidal signal of a given amplitude. For a piezo element driven by a sinusoidal signal of peak amplitude A, peak-to-peak voltage V_{pp}, and frequency f, we have:

Click to Enlarge

$$V(t) = A sin(2\pi ft) + A$$

A diagram of voltage as a function of time is shown to the right. The maximum slew rate, or voltage change, is reached at $t = 2n\pi$, $(n=0, 1, 2,...)$ at point a in the diagram to the right:

$$\left. \frac{dV}{dt} \right|_{t = 2n\pi} = 2\pi A f_{max}$$

From the first equation, above:

$$\frac{dV}{dt} = \frac{I_{max}}{C}$$

Thus,

$$f_{max} = \frac{I_{max}}{2\pi AC} = \frac{I_{max}}{\pi V_{pp}C}$$

For the example above, the maximum full-range (75 V) bandwidth would be

$$f_{max} = \frac{I_{max}}{\pi V_{pp}C} = \frac{0.5\,A}{\pi(20\,\mu F)(75\,V)} \approx 106\,Hz$$

.

For a smaller piezo stack with 10 times lower capacitance, the results would be 10 times better, or about 1060 Hz. Or, if the peak-to-peak signal is reduced to 7.5 V (10% max amplitude) with the 100 µm stack, again, the result would be 10 times better at about 1060 Hz.

Triangle Wave Signal

For a piezo actuator driven by a triangle wave of max voltage V_{peak} and minimum voltage of 0, the slew rate is equal to the slope:
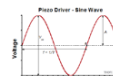

Click to Enlarge

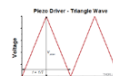$$\frac{I_{max}}{C} = \frac{2V_{peak}}{T}$$

.

Or, since $f = 1/T$:

$$f_{max} = \frac{I_{max}}{2V_{peak}C} = \frac{0.5\,A}{2(20\,\mu F)(75\,V)} \approx 167\,Hz$$
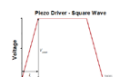
Square Wave Signal

For a piezo actuator driven by a square wave of maximum voltage V_{peak} and minimum voltage 0, the slew rate limits the minimum rise and fall times. In this case, the slew rate is equal to the slope while the signal is rising or falling. If t_r is the minimum rise time, then

Click to Enlarge

$$\frac{I_{max}}{C} = \frac{V_{peak}}{t_r}$$

or

$$t_r = \frac{C V_{peak}}{I_{max}} .$$

T-Cube Piezo Controller

TPZ001

Two T-Cube Piezo drivers are required for use with the NanoTrak T-cube, one driver for each channel. The piezo drivers amplify the signal from the NanoTrak sensor, for use by the piezo actuated nanopositioning stage.

Note: Power Supplies sold separately; please see options below.

Part Number	Description	Price	Availability
TPZ001	T-Cube 150 V Piezo Driver (Power Supply Not Included)	$613.00	Lead Time

Compatible Power Supplies

TPS002

TCH002

▶ Power Supplies for Single- and Multi-Channel Use
▶ Integrated, Compact T-Cube Design
▶ Compatible with all T-Cube Modules

Power Supply Options for T-Cube Readers and Controllers	
T-Cube Operation	**Power Supply**
Single- or Dual-Channel Operation	TPS002 Power Supply
System or Multi-Channel Operation	TCH002 USB Controller Hub

Please note that our KPS101 Single T-Cube Power Supply is not compatible with this T-Cube Controller since it does not offer reversible polarity.

Part Number	Description	Price	Availability
TPS002	±15 V/5 V Power Supply Unit for up to Two T-Cubes	$105.00	Today
TCH002	T-Cube Controller Hub and Power Supply Unit	$749.00	3-5 Days