KPZ101 - June 10, 2024

Item # KPZ101 was discontinued on June 10, 2024. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

KINESIS® K-CUBE™ PIEZO CONTROLLER

- ► **Open-Loop Piezo Driver Supplies up to 150 V**
- ► **Seamless Operation with Thorlabs' Piezo Actuators**
- ► **Operation via Local Panel Controls or Remote PC via USB**

KPZ101
Power Supply
Sold Separately

Table Mounting Plate
(Included with the KPZ101)

Application Idea
The KPZ101 Piezo Controller can be powered by the KCH301 USB Controller Hub (sold separately) along with two additional K- or T-Cubes.

OVERVIEW

Features

- Compact Footprint: 60.0 mm x 60.0 mm x 49.2 mm
- Selectable High-Voltage Output Range: 75 V, 100 V, or 150 V
- Digital Potentiometer Provides High-Voltage Control with Adjustable Resolution
- 0 to 10 V Analog Input (SMA Female, See *Pin Diagrams* Tab for Details)
- Monitor Output (SMA Female, See *Pin Diagrams* Tab for Details)
- Easy-to-Use Manual Controls
    - Velocity Wheel: Variable Speed Bidirectional Control
    - Digital Display Menu: Jogging Functionality with Position Presets
- Voltage Ramp/Waveform Generation Capability and Input and Output Triggers for Piezo Scanning Applications
- Full Kinesis® or APT™ Software Control Suite (See *Motion Control Software* Tab for Details)
- Software Compatible with other Kinesis and APT Controllers for Integrated Systems Development
- Single- and Multi-Channel PSU Options Available Separately
- Multi-Axis Expansion Using USB Controller Hubs (Sold Separately)
- Magnetic, Clip-On Optical Table Mounting Adapter Included

Click to Enlarge
Back and Top Views of the KPZ101 K-Cube (See the *Pin Diagrams* Tab for More Information)

K-Cube™ Motion Control Modules
Brushed DC Servo Motor Controller
Brushless DC Servo Motor Controller
Fiber Alignment Controllers
Four-Channel Piezo Inertia Actuator Controller
PSD Auto Aligner
Single-Channel Piezo Controller
Single-Channel Combined Piezo Controller and Strain Gauge Reader
Solenoid Controller
Stepper Motor Controller

The KPZ101 K-Cube Piezo Controller is a part of Thorlabs' growing Kinesis® line of high-end, compact motion controllers. Designed to provide easy manual or automatic control of piezo elements, this single-channel 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). It is compatible with Thorlabs' bare piezo stacks, piezo-equipped actuators, and piezo-driven mirror mounts, as well as piezo-driven single- and multi-axis flexure stages. For mounts with BNC connectors, a BNC to SMC adapter is required. Note that actuators and mounts with piezo inertia motors are not compatible with the KPZ101 controller and should be driven with a Piezo Inertia Motor Controller.

The unit has a highly compact 60.0 mm x 60.0 mm x 49.2 mm footprint, allowing it 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. Each unit contains a front-located power switch that, when turned off, saves all user-adjustable settings. Please note that this switch should always be used to power down the unit. For convenience, a 1.5 m long Type A to Type Micro B USB 3.0 cable is included with the KPZ101 cube.


Click to Enlarge
[APPLIST]
[APPLIST]
KCH601 USB Controller Hub (Sold Separately) with Installed K-Cube and T-Cube Modules (T-Cubes Require the KAP101 Adapter)

Thorlabs designed this K-Cube to encapsulate full piezo control capability in an extremely small package. 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 0 - 10 V analog input connector, while the low-voltage output connector allows for easy monitoring of the high-voltage output (e.g., when using an oscilloscope). Programmable waveform generation capability combined with triggering inputs and outputs makes this unit particularly well suited for use in piezo scanning applications.

USB connectivity provides easy 'Plug-and-Play' PC-controlled operation with two available software platforms: our new Kinesis software package or our legacy APT (Advanced Positioning Technology) software package. 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. Our legacy APT software allows the user to quickly set up complex move sequences with advanced controls made possible via the ActiveX® programming environment. For example, all relevant operating parameters are set automatically by the software for Thorlabs stage and actuator products. For more details on both software packages, please see the *Motion Control Software* and *APT Tutorials* tabs.

Optical Table Mounting Plate
Each unit comes with a mounting plate that clips onto the base of the controller. The plate contains two magnets for temporary placement on an optical table and two counterbores for 1/4"-20 (M6) cap screws for a more permanent placement on the tabletop. Please see the *Specs* for a mechanical drawing of the table mounting plate and the *Mounting Options* tab for how to mount the plate.

Power Supply Options

The preferred power supply (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.

Multiple units can be connected to a single PC by using the KCH301 or KCH601 USB Controller Hubs, available below, for multi-axis motion control applications. The KCH301 allows up to three T- or K-Cube controllers to be used while the KCH601, shown to the right, allows up to six controllers to be used.

All power supply options compatible with the KPZ101 Motor Controller can be found below.

Other Piezo Driver Controllers				
K-Cube Controller Single Channel	K-Cube Combined Piezo Controller and Strain Gauge Reader Single Channel	Open Loop Benchtop Controller 1 and 3 Channel	Closed Loop Benchtop Controller 1 and 3 Channel	Rack System Module 2 Channel

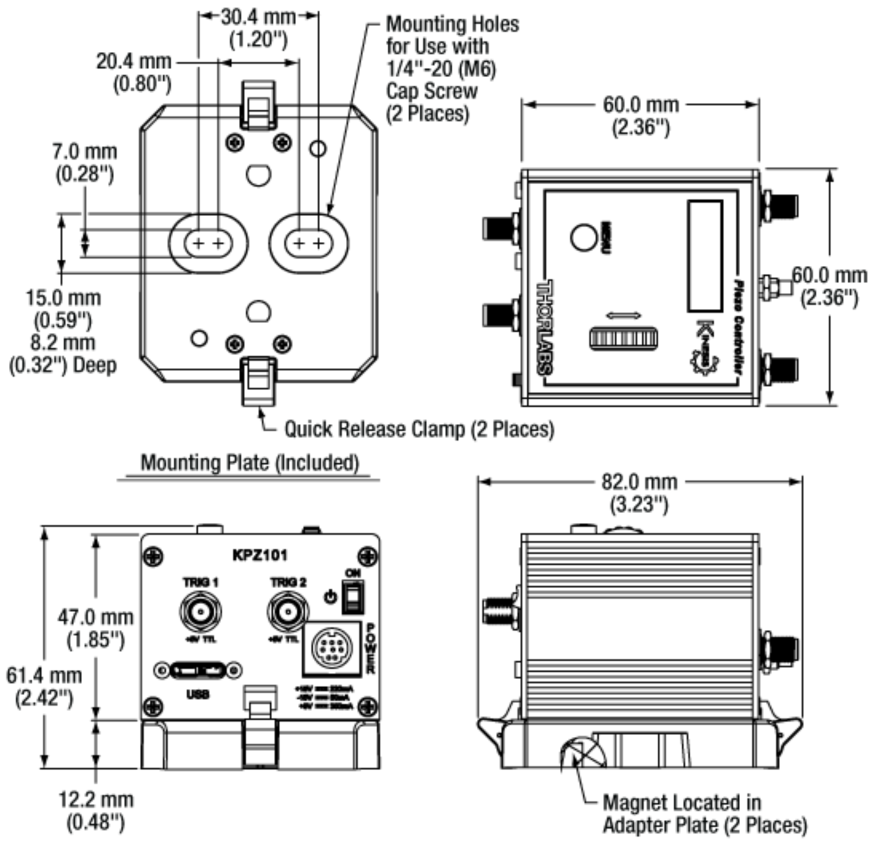
SPECS

KPZ101 Specifications	
Piezoelectric Output	
Drive Voltage (SMC Male)	0 - 150 V (SMC Male Connector)
Maximum Drive Current (Continuous)	7.5 mA
User Voltage Control	Digital Potentiometer (Resolution Selectable)
Stability	100 ppm Over 24 hrs (After 30 min Warm-Up)
Output Noise	No Load: <5 mV_{RMS} 3.6 µF Load: <3 mV_{RMS}
Typical Piezo Capacitance	1 - 10 µF
Drive Bandwidth	1 kHz (1 µF Load, 1 V_{p-p})
Drive Input (SMA Female)	0 - 10 V
Output Monitor (SMA Female)	0 - 10 V
T-Cube Controller Hub Connector	26-Way ERNI
General	
Input Power Requirements	+15 V @ 220 mA -15 V @ 50 mA +5 V @ 350 mA
USB Connector Type	USB 3.0
USB Connection Speed	USB 1.1 Full Speed (12 Mbps)
Housing Dimensions[a] (W x D x H)	60.0 mm x 60.0 mm x 49.2 mm (2.36" x 2.36" x 1.94")

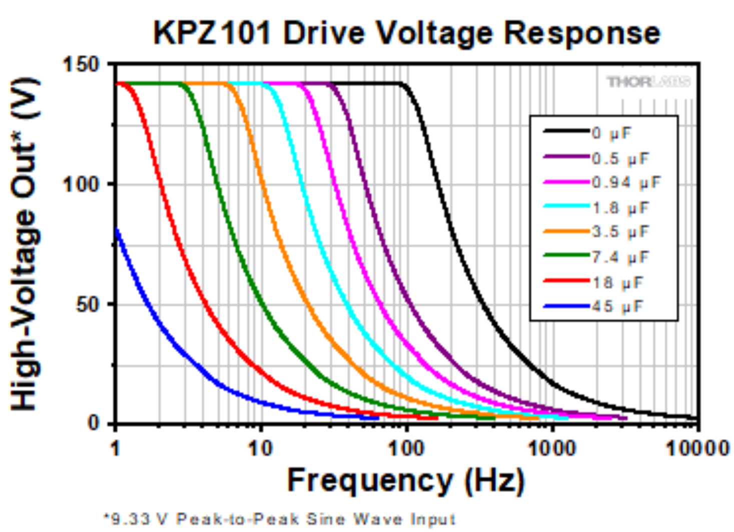
a. Including Top Panel Controls

Compatible Thorlabs Stages and Actuators	
Translation Stages	3-Axis and 6-Axis Nanopositioners, NF15AP25, NFL5DP20, NFL5DP20S
Piezo Controlled Mounts[a]	KC1-P, KC1-PZ, POLARIS-K05P2, POLARIS-K1S3P, POLARIS-K1S2P, POLARIS-K2S2P
Bare Piezos	Piezo Chips and Stacks with Drive Voltages up to 150 V
Actuators	DRV120, PE4[a], DRV517, PK2FSF1, PK2FVF1, PAS005, PAS009, PAZ005, PAZ009

a. Requires a T4292 BNC female to SMC female adapter.



Click to Enlarge
Mechanical Drawing of the KPZ101 and Included Optical Table Adapter

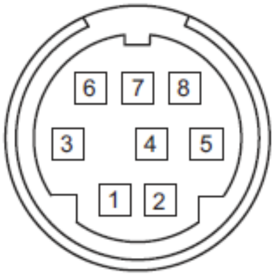


Click to Enlarge
Click Here for Raw Data
Drive Voltage/Frequency Response at Different Capacitive Loads for the KPZ101

PIN DIAGRAMS

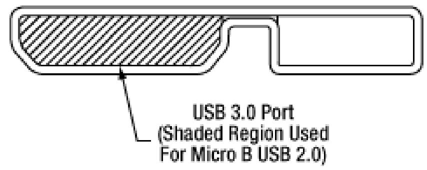
Power Connector

Mini-DIN Female



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		

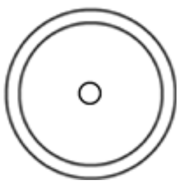
Computer Connection*



*The USB 3.0 port is compatible with a USB 2.0 Micro B connector if the Micro B connector is plugged into the shaded region in the photo above. A USB 3.0 type A to type Micro B cable is included with the KPZ101.

Monitor

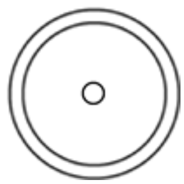
SMA Female



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.

EXT IN

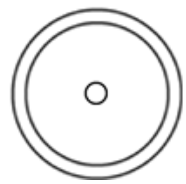
SMA Female



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.

HV OUT

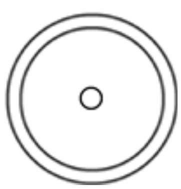
SMC Male



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.

TRIG 1

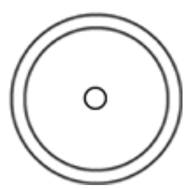
SMA Female



+5 V TTL

TRIG 2

SMA Female



+5 V TTL

These connectors provide a 5 V logic level input and output that can be configured to support triggering into and out of external devices. Each port can be independently configured to control the logic level or to set the trigger as an input or output.

MOUNTING OPTIONS

K-Cube Mounting Options

Two options are available to securely mount our K-Cube controllers onto an optical table. An optical table mounting plate, provided with every K-Cube, allows for a single controller to be attached to an optical table. Alternatively, three- and six-port USB controller hubs are offered (sold separately) that can mount and power our K-Cube controllers. These options are described in further detail below.

Optical Table Mounting Plate

Each K-Cube unit comes with a mounting plate that clips onto the base of the controller, as shown in the animation to the right. The plate contains two magnets for temporary placement on an optical table and two counterbores for 1/4"-20 (M6) cap screws for a more permanent placement on the tabletop. Please see the *Specs tab* for a mechanical drawing of the table mounting plate.

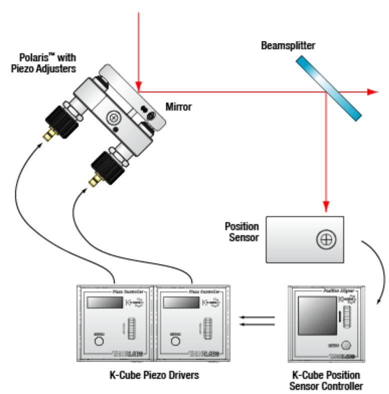
Kinesis USB Controller Hubs

Multiple units can be mounted and connected to a single PC by using the KCH301 or KCH601 USB Controller Hubs. They each consist of two parts: the hub, which can support up to three (KCH301) or six (KCH601) K-Cubes or T-Cubes, and a power supply that plugs into a standard wall outlet. K-Cubes simply clip into place using the provided on-unit clips, while current- and previous-generation T-Cubes require the KAP101 Adapter Plate, shown in the animation above. The hub vastly reduces the number of USB and power cables required when operating multiple controllers.

K-Cube Table Mounting Plate

Kinesis USB Controller Hubs

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	KPZ101 T-Cube Piezo Controller[a]
Mirror Mount with Piezo Adjusters (Choose One)	POLARIS-K1S3P Polaris® Mirror Mount with 3 Adjusters, POLARIS-K1S2P Polaris® Mirror Mount with 2 Adjusters, KC1-PZ (KC1-PZ/M) Mirror Mount, or KC1-T-PZ (KC1-T-PZ/M) Mirror Mount with SM1-Threaded Bore
Position Detector	PDP90A (320 - 1100 nm), PDQ80A (400 - 1050 nm), or PDQ30C (1000 - 1700 nm)
K-Cube Position Sensor Controller	KPA101

a. One controller is required per independently controlled axis.

K-CUBES VS. T-CUBES

Introducing Thorlabs' Kinesis® Motion Controllers

A major upgrade to the former-generation T-Cubes™, the growing K-Cube™ line of high-end controllers provides increased versatility not only through the new Kinesis software, but through an overhaul and updating of their physical design and firmware.

Every K-Cube controller includes a digital display. In addition to basic input and output readouts, this display hosts a number of menu options that include go-to-position commands, homing, velocity control, and jogging. The on-unit velocity wheel and menu button are used to scroll through the available options. Each unit contains a front-located power switch that, when turned off, saves all user-adjustable settings as well as two bidirectional SMA trigger ports that accept or output a 5 V TTL logic signal.

Please see the table to the right for a full comparison of the features offered by our new KPZ101 K-Cube and previous-generation TPZ001 T-Cube motion controllers.

Click to Enlarge
KPZ101 K-Cube Kinesis Piezo Controller

K-Cube vs. T-Cube Feature Comparison		
Feature	**KPZ101 K-Cube**	**TPZ001 T-Cube**
Kinesis Software Compatibility	✔	✔
APT Software Compatibility	✔	✔
Kinesis USB Controller Hubs Compatibility	✔	Requires KAP101 Adapter
TCH002 T-Cube USB Controller Hubs Compatibility	N/A	✔
Power Switch	✔	N/A
Bidirectional SMA Trigger Port[a]	2	N/A
SMA Monitor Output[a]	✔	✔
SMA External Analog Input[a]	✔	✔
Computer Connection[a]	USB 3.0 Micro B (USB 2.0 Compliant)	USB 2.0 Micro B (USB 2.0 Compliant)
Included Mounting Plate	✔	✔
Size (L x W x H)	60.0 mm x 60.0 mm x 49.2 mm (2.36" x 2.36" x 1.94")	60.0 mm x 60.0 mm x 49.2 mm (2.36" x 2.36" x 1.94")
On-Unit Digital Display Menu	✔	✔
Set Open/Closed Loop	✔	✔
Go To Voltage	✔	Only via Software
Voltage Range and Control	✔	✔
Joystick Mode	✔	Only via Software
Jog Voltage Step Size	✔	Only via Software
Teach Voltage	✔	Only via Software
Screen Brightness	✔	✔
Disable Movement	✔	N/A
Stage Select	✔	Only via Software

a. Please see the *Pin Diagrams* tab for details.

Kinesis USB Controller Hubs

Complementing our K-Cubes are our Kinesis USB 2.0 controller hubs. With two versions available for three or six K- or T-Cubes, these USB hubs are designed specifically for communication between multiple controllers and the host control PC. These hubs are backward compatible with our T-Cubes.

K-Cubes simply clip into place using the provided on-unit clips, while current- and previous-generation T-Cubes require the KAP101 Adapter Plate, shown in the animation to the below right. The hub vastly reduces the number of USB and power cables required when operating multiple controllers.

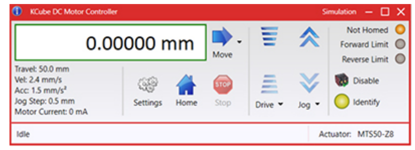
K-Cube Table Mounting Plate

Kinesis USB Controller Hubs

MOTION CONTROL SOFTWARE

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

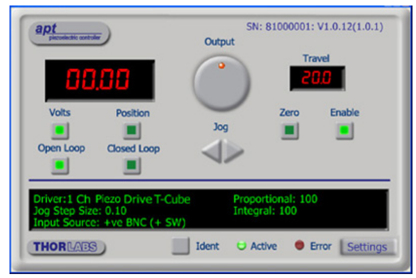
The Kinesis Software features .NET controls which can be used by 3rd party developers working in the latest C#, Visual Basic, LabVIEW™, or any .NET compatible languages to create custom applications. Low-level DLL libraries are included for applications not expected to use the .NET framework. A Central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



Kinesis GUI Screen

Our legacy APT System Software platform offers 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.

By providing these common software platforms, Thorlabs has ensured that users can easily mix and match any of the Kinesis and 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 single-axis to multi-axis systems and control all from a single, PC-based unified software interface.



APT GUI Screen

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 is 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.

Software

Kinesis Version 1.14.47

The Kinesis Software Package, which includes a GUI for control of Thorlabs' Kinesis and APT™ system controllers.

Also Available:

- Communications Protocol

Software

Software

APT Version 3.21.6

The APT Software Package, which includes a GUI for control of Thorlabs' APT™ and Kinesis system controllers.

Also Available:

- Communications Protocol

Software

KINESIS TUTORIALS

Thorlabs' Kinesis® software features new .NET controls which can be used by third-party developers working in the latest C#, Visual Basic, LabVIEW™, or any .NET compatible languages to create custom applications.

C#

This programming language is designed to allow multiple programming paradigms, or languages, to be used, thus allowing for complex problems to be solved in an easy or efficient manner. It encompasses typing, imperative, declarative, functional, generic, object-oriented, and component-oriented programming. By providing functionality with this common software platform, Thorlabs has ensured that users can easily mix and match any of the Kinesis 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 Kinesis System Software allows two methods of usage: graphical user interface (GUI) utilities for direct interaction 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.

For a collection of example projects that can be compiled and run to demonstrate the different ways in which developers can build on the Kinesis motion control libraries, click on the links below. Please note that a separate integrated development environment (IDE) (e.g., Microsoft Visual Studio) will be required to execute the Quick Start examples. The C# example projects can be executed using the included .NET controls in the Kinesis software package (see the Kinesis Software tab for details).

Click Here for the Kinesis with C# Quick Start Guide
Click Here for C# Example Projects
Click Here for Quick Start Device Control Examples

LabVIEW

LabVIEW can be used to communicate with any Kinesis- or APT-based controller via .NET controls. In LabVIEW, you build a user interface, known as a front panel, with a set of tools and objects and then add code using graphical representations of functions to control the front panel objects. The LabVIEW tutorial, provided below, provides some information on using the .NET controls to create control GUIs for Kinesis- and APT-driven devices within LabVIEW. It includes an overview with basic information about using controllers in LabVIEW and explains the setup procedure that needs to be completed before using a LabVIEW GUI to operate a device.

Click Here to View the LabVIEW Guide
Click Here to View the Kinesis with LabVIEW Overview Page

APT TUTORIALS

The APT video tutorials available here fall into two main groups - one group covers using the supplied APT utilities and the second group covers programming the APT System using a selection of different programming environments.

Disclaimer: The videos below were originally produced in Adobe Flash. Following the discontinuation of Flash after 2020, these tutorials were re-recorded for future use. The Flash Player controls still appear in the bottom of each video, but they are not functional.

Every APT controller is supplied with the utilities APTUser and APTConfig. APTUser provides a quick and easy way of interacting with the APT control hardware using intuitive graphical control panels. APTConfig is an 'off-line' utility that allows various system wide settings to be made such as pre-selecting mechanical stage types and associating them with specific motion controllers.

APT User Utility

The first video below gives an overview of using the APTUser Utility. The OptoDriver single channel controller products can be operated via their front panel controls in the absence of a control PC. The stored settings relating to the operation of these front panel controls can be changed using the APTUser utility. The second video illustrates this process.

APT User - Overview   APT User - OptoDriver Settings

APT Config Utility

There are various APT system-wide settings that can be made using the APT Config utility, including setting up a simulated hardware configuration and associating mechanical stages with specific motor drive channels. The first video presents a brief overview of the APT Config application. More details on creating a simulated hardware configuration and making stage associations are present in the next two videos.

APT Config - Overview   APT Config - Simulator Setup   APT Config - Stage Association

APT Programming

The APT Software System is implemented as a collection of ActiveX Controls. ActiveX Controls are language-independant software modules that provide both a graphical user interface and a programming interface. There is an ActiveX Control type for each type of hardware unit, e.g. a Motor ActiveX Control covers operation with any type of APT motor controller (DC or stepper). Many Windows software development environments and languages directly support ActiveX Controls, and, once such a Control is embedded into a custom application, all of the functionality it contains is immediately available to the application for automated operation. The videos below illustrate the basics of using the APT ActiveX Controls with LabVIEW, Visual Basic, and Visual C++. Note that many other languages support ActiveX including LabWindows CVI, C++ Builder, VB.NET, C#.NET, Office VBA, Matlab, HPVEE etc. Although these environments are not covered specifically by the tutorial videos, many of the ideas shown will still be relevant to using these other languages.

Visual Basic

Part 1 illustrates how to get an APT ActiveX Control running within Visual Basic, and Part 2 goes on to show how to program a custom positioning sequence.

APT Programming Using Visual Basic - Part 1   APT Programming Using Visual Basic - Part 2

LabVIEW

Full Active support is provided by LabVIEW and the series of tutorial videos below illustrate the basic building blocks in creating a custom APT motion control sequence. We start by showing how to call up the Thorlabs-supplied online help during software development. Part 2 illustrates how to create an APT ActiveX Control. ActiveX Controls provide both Methods (i.e. Functions) and Properties (i.e. Value Settings). Parts 3 and 4 show how to create and wire up both the methods and properties exposed by an ActiveX Control. Finally, in Part 5, we pull everything together and show a completed LabVIEW example program that demonstrates a custom move sequence.

APT Programming Using LabVIEW - Part 1: Accessing Online Help   APT Programming Using LabVIEW - Part 2: Creating an ActiveX Control   APT Programming Using LabVIEW - Part 3: Create an ActiveX Method

APT Programming Using LabVIEW - Part 4: Create an ActiveX Property   APT Programming Using LabVIEW - Part 5: How to Start an ActiveX Control

The following tutorial videos illustrate alternative ways of creating Method and Property nodes:

APT Programming Using LabVIEW - Create an ActiveX Method (Alternative)   APT Programming Using LabVIEW - Create an ActiveX Property (Alternative)

Visual C++

Part 1 illustrates how to get an APT ActiveX Control running within Visual C++, and Part 2 goes on to show how to program a custom positioning sequence.

APT Programming with Visual C++ - Part 1 APT Programming with Visual C++ - Part 2

MATLAB

For assistance when using MATLAB and ActiveX controls with the Thorlabs APT positioners, click here.

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

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:

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

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

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

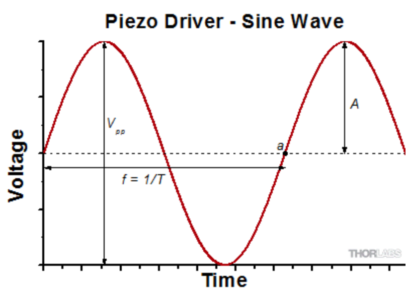
Hence, for an instantaneous voltage change from 0 V to 75 V, it would take 3 ms for the output voltage to reach 75 V.

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:

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



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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:

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

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.

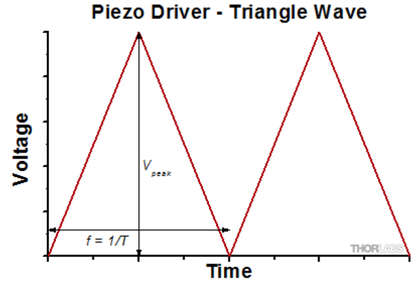
Triangle Wave Signal

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:

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

Or, since $f = 1/T$:

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



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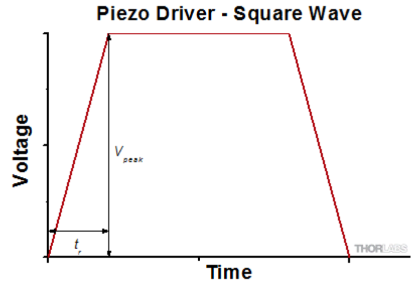
Square Wave Signal

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

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

or

$$t_r = \frac{CV_{peak}}{I_{max}}.$$



Click to Enlarge

For additional information about piezo theory and operation, see the Piezoelectric Tutorials page.

K-Cube™ Piezo Controller


KPZ101
Shown with Included Mounting Plate

- Front Panel Velocity Wheel and Digital Display for Controlling Piezo Elements
- Two Bidirectional Trigger Ports to Read or Control External Equipment
- Interfaces with Computer Using Included USB Cable
- Fully Compatible with Kinesis® or APT™ Software Packages
- Compact Footprint: 60.0 mm x 60.0 mm x 49.2 mm (2.36" x 2.36" x 1.94")
- Power Supply Not Included (See Below)

Thorlabs' KPZ101 K-Cube Piezo Controller provides local and computerized control of a single axis. It features a top-mounted control panel with a velocity wheel that supports four-speed bidirectional control with forward and reverse jogging as well as position presets. The digital display on the top panel includes a backlight that can be dimmed or turned off using the top panel menu options. The front of the unit contains two bidirectional trigger ports that can be used to read a 5 V external logic signal or output a 5 V logic signal to control external equipment. Each port can be independently configured to control the logic level or to set the trigger as an input or output.

The unit is fully compatible with our Kinesis software package and our legacy APT control software. Please see the *Motion Control Software* tab for more information.

Please note that this controller does not ship with a power supply. Compatible power supplies are listed below.

Part Number	Description	Price	Availability
KPZ101	**K-Cube Piezo Controller (Power Supply Sold Separately)**	**$772.66**	**Lead Time**

Compatible Power Supplies

- Individual ±15 V/5 V Power Supply
  - TPS002: For up to Two K-Cubes™ or T-Cubes™ with Mini-DIN Input*
- USB Controller Hubs Provide Power and Communications
  - KCH301: For up to Three K-Cubes or T-Cubes
  - KCH601: For up to Six K-Cubes or T-Cubes

The TPS002 supplies power for up to two K-Cubes* or T-Cubes. The cubes still require individual computer connection via USB cable.

The KCH301 and KCH601 USB Controller Hubs each consist of two parts: the hub, which can support up to three (KCH301) or six (KCH601) K-Cubes or T-Cubes, and a power supply that plugs into a standard wall outlet. The hub draws a maximum current of 10 A; please verify that the cubes being used do not require a total current of more than 10 A. In addition, the hub provides USB connectivity to any docked K-Cube or T-Cube through a single USB connection.

For more information on the USB Controller Hubs, see the full web presentation.

*The TPS002 can only support one KNA-VIS or KNA-IR controller or one KLD101 driver and should not be used to power any additional units as that may exceed current limitations.

Part Number	Description	Price	Availability
TPS002	**±15 V/5 V Power Supply Unit with Mini-DIN Connectors for up to Two K- or T-Cubes**	**$128.29**	**Today**
KCH301	**USB Controller Hub and Power Supply for Three K-Cubes or T-Cubes**	**$598.63**	**7-10 Days**
KCH601	**USB Controller Hub and Power Supply for Six K-Cubes or T-Cubes**	**$724.52**	**Today**