apt™ Motion Control Electronics

Thorlabs' engineers have worked closely with customers, system integrators, and leading researchers to better understand their requirements for sophisticated yet easy-to-use motion control electronics and software. The result is the highly flexible apt™ (Advanced Positioning Technology) controller family. In addition to a stepper motor, DC motor, piezo controllers, a strain gauge reader, and a solenoid driver, we offer sophisticated feedback controllers (Nanotrak™) that fully optimize coupled optical powers automatically in a variety of alignment scenarios. There are three formats of controller to meet the performance requirements for a range of applications and budgets:

- Compact, Table-Mounted T-Cube™ apt™ Controllers (Pages 348-363)
- High-Power apt™ Benchtop Controllers (Pages 364-373)
- Modular Rack-Based apt™ Control Systems (Pages 374-379)

All the controllers are USB interfaced and supported by unified PC-based user and programming utilities (the apt™ software pages 380-382). This enables higher level custom applications to be constructed effectively and quickly using any combination of the apt™ controllers.

Features

- Highly Flexible and Easy to Use
- Manual and Software Control
- Common Software Interfaces
- Setup With Minimal Effort – Plug-and-Play
- 3 Formats Available: Tabletop T-Cubes™, High-Power Benchtop, and Rack-Based Systems
- Stepper Motor, DC Motor Controllers, Open- and Closed-Loop Piezo Drivers, Strain Gauge Reader, Shutter Controller, Auto-Alignment Controllers
- All USB Interfaced – All Software Included

The apt™ system software is described in more detail on page 380.

The following pages describe the range of apt™ controllers:

- **T-Cube™ Controllers – Pages 348-363**
- **Benchtop Controllers – Pages 364-373**
- **Rack-Based Controllers – Pages 374-379**

T-Cube™ apt™ USB Controllers

The T-Cube™ range of controllers provides a highly functional, flexible, and expandable electronics platform in a cost-effective and compact format. Their footprint measures just 60mm x 60mm x 47mm (2.4" x 2.4" x 1.8"), making them ideal for optomechanical applications where the controller is required to be in close proximity to the apparatus on the optical table. Each T-Cube™ is equipped with local controls to allow convenient manual operation, as well as a USB interface for automated PC control. The supplied apt™ software is easy to use and exposes the full motion control capabilities of the T-Cube™ controllers, including simultaneous command of multiple controllers. The optional T-Cube™ hub can provide both power distribution and USB communications for up to six controllers.

Stepper Motor Driver TST001
Page 350

DC Servo Driver TDC001
Page 352

Solenoid Controller TSC001
Page 354

Piezo Driver TPZ001
Page 356

Strain Gauge Reader TSG001
Page 358

NanoTrak™ Auto-Alignment Controller TNA001
Page 360

T-Cube™ USB Controller Hub TCH002
Page 362

T-Cube™ apt™ USB Stepper Motor Controller (Page 1 of 2)

TST001

RoHS COMPLIANT

Features

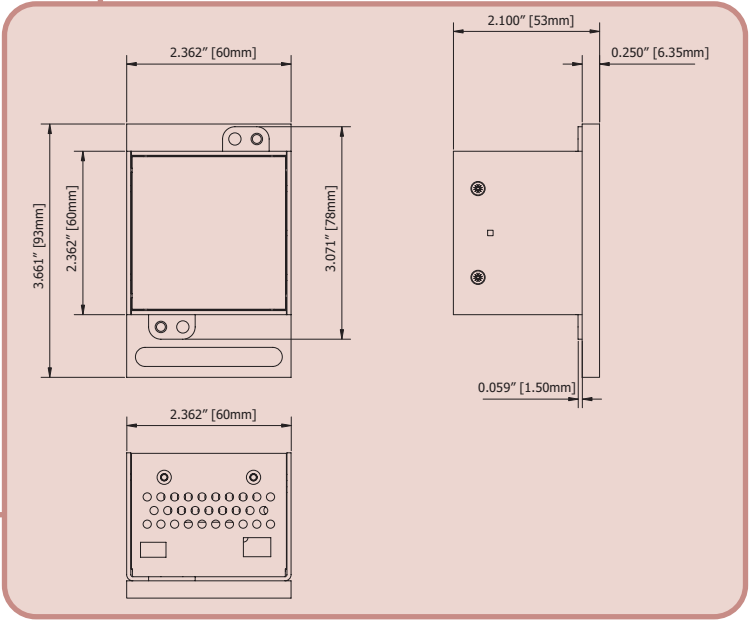
- High-Resolution Microstepping
- Supports 2-Phase, Bipolar, Low-Power Stepper Motors
- Compact Footprint
- Differential Encoder Feedback (QEP Inputs) for Closed-Loop Positioning
- Auto-Configure Function for Thorlabs' ZST Actuators
- USB Plug-and-Play PC-Controlled Operation
- Easy-to-Use Manual Controls With Velocity Slider and Jog Buttons
- Full Software Control Suite Supplied
- Extensive ActiveX® Programming Interfaces
- Fully Software Integrated With Other apt™ Family Controllers

The T-Cube™ USB apt™ Stepper Driver (TST001) is a very compact, single channel controller for easy manual and automated control of small, 2-phase, bipolar stepper motors. This driver has been designed to operate with a variety of lower-power motors (up to 15V/5W operation), equipped with or without encoder feedback. Although targeted at lower power operations, this product offers full control features with a highly flexible and powerful DSP controller providing a unique high resolution microstepping capability in a compact unit. The TST001 is optimized for "out of the box" operation with the Thorlabs range of ZST mini stepper motor actuators (see page 405); however, its highly flexible parameterization also supports operation with a wide range of third party stepper motors and associated stages and actuators.

USB connectivity provides easy plug-and-play PC controlled operation. Multiple units can be connected to a single PC via standard USB technology or by using the new T-Cube™ Controller Hub (TCH002) for multi-axis motion control applications – see page 362.

Specifications

- **Motor Drive Connector (15-Way, High-Density D-Type Female):**
  - Phase A and B Drive Outputs
  - Differential Quadrature Encoder (QEP) A and B Inputs
  - Forward, Reverse Limit Switch Inputs
  - 5V Encoder Supply
- **Stepping:**
  - 128 Microsteps per Full Step
  - 3072 Microsteps per Revolution (for 24 Full Step Motor – e.g. ZST Series)
- **Front Panel Controls:**
  - Potentiometer Slider
  - Bidirectional Velocity Control
  - Dual Buttons
  - Forward/Reverse Jogging or Position Presets
- **Motor Drive Voltage:** 15V (Supports 2-Phase, Bipolar Stepper Motors Up to 15V/5W)
- **Motor Drive Current:** 500mA (peak)
- **Motor Drive Type:** 10-Bit Sign/Magnitude PWM
- **Control Algorithm:** Open-Loop Microstepping (Closed-Loop using PC)
- **Position Feedback:** Quadrature Encoder (QEP) Input, 5V Differential
- **Encoder Feedback Bandwidth:** 500kHz
- **Position Counter:** 32-bit
- **Operating Modes:** Position, Velocity
- **Velocity Profile:** Trapezoidal
- **Input Power Requirements:** 15V Regulated DC, 500mA (Peak)
- **Housing Dimensions (W x D x H):** 60.3 x 60.3 x 47.5mm (2.37" x 2.37" x 1.8")
- **Weight:** 100g (3.5oz)



T-Cube™ apt™ USB Stepper Motor Controller (Page 2 of 2)

TST001 Stepper Motor Driver Applications

The TST001 Stepper Motor Driver T-Cube™ can be used to control our lower-power stepper motor-driven optomechanical products, such as the ZST series actuators. For 3-axis control, three stepper motor driver T-cubes can be used, either on the TCH002 controller hub (see page 362) or bolted to the optical table.

Power Supply Options

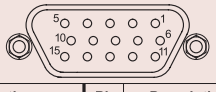
The TST001 T-Cube™ requires a 15V power supply. Thorlabs offers a compact, multi-way power supply unit (TPS008), allowing up to eight T-Cubes to be powered from a single main outlet. A single-way wall plug supply (TPS001) for powering a single T-Cube™ Driver is also available. The TCH002 USB Controller Hub provides power distribution for up to six T-Cubes. 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. For further information on the hub, see page 362.

Recommended Motor Requirements

- **Motor Type:** 2-Phase Bipolar Stepper
- **Peak Power:** 5W
- **Rated Phase Current:** 10 – 250mA
- **Step Angles:** 1.8° to 20°
- **Motor Drive Mode:** Current
- **Coil Resistance (nominal):** 5 – 20Ω
- **Coil Inductance:** 2 – 5.5mH
- **Position Control:** Open-Loop (Incremental Encoder Optional)

See pages 380-382 for more information on the apt™ software included with the TST001 Stepper Controller.

MOTOR DRIVE



Pin	Description	Pin	Description
1	Ground	9	Ident In
2	CCW Limit Switch	10	+5V
3	CW Limit Switch	11	Enc A +ve
4	Phase B -ve	12	Enc A -ve
5	Phase B +ve	13	Enc B +ve
6	Phase A -ve	14	Enc B -ve
7	Phase A +ve	15	Trigger In/Chan Enable
8	Trigger Out		

TST001

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ITEM#	$	£	€	RMB	DESCRIPTION
TST001	$ 637.50	£ 401.60	€ 592,90	¥ 6,088.10	T-Cube™ Single Channel USB Stepper Motor Controller/Driver
TPS001	$ 25.50	£ 16.10	€ 23,70	¥ 243.50	15V Power Supply Unit for a Single T-Cube
TPS008	$ 187.00	£ 117.80	€ 173,90	¥ 1,785.90	15V Power Supply Unit for up to 8 T-Cubes
TCH002	$ 765.00	£ 482.00	€ 711,50	¥ 7,305.80	T-Cube™ Controller Hub and Power Supply Unit

Single Axis Stages
Multi-Axis Stages
Flexure Stage Accessories
Motorized Mirror Mounts
Rotation Stages
Drive Electronics & Auto-Alignment
Actuators & Adjusters
Brief Tutorials

apt™ Control Software Overview – Page 1 of 3

Constructing automated custom alignment and positioning solutions in a speedy and efficient manner is becoming increasingly important in today's competitive environment. Often timescales are short and yet the nature of the solutions, particularly at the software level, are becoming more complex and demanding. We have worked very closely with a large number of system engineers and research specialists in order to gain a detailed understanding of the specific requirements for sophisticated yet easy-to-use electronics and software controller products.

Out-of-the-Box Operation

When faced with an automated alignment project, the system engineer or researcher will often face a steep learning curve, and when the end requirement involves programming automative alignment sequences, learning how to operate the equipment manually is an important first step. Every apt™ controller can be manually operated using the supplied 'APTUser' utility. This utility gives access to all settings, parameters, and operating modes. In this way most automated alignment sequences can be first tested and verified without writing a single line of custom software by first using APTUser.

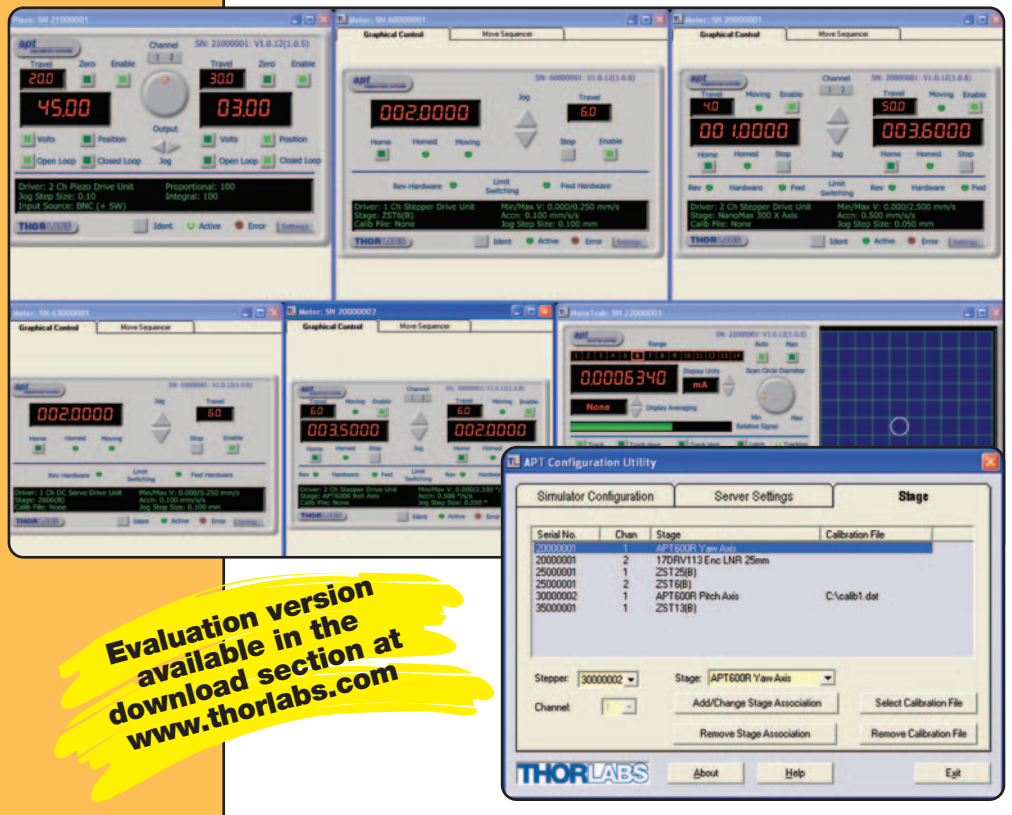
Time Saving Speedy Pre-Configuration

In order to further reduce the time required to configure our range of apt™ controllers, an offline pre-configuration utility, APTConfig, is supplied with all units.

As an example, this utility can be used to associate Thorlabs' stages and actuators with individual motor drive channels, thus allowing the system to set automatically a large number of system parameter defaults. This offline configuration eliminates the need to write the large amounts of initialization code often required when using other control systems, greatly reducing the time taken when developing custom applications. Many other preconfigured settings can be made by using the APTConfig utility.

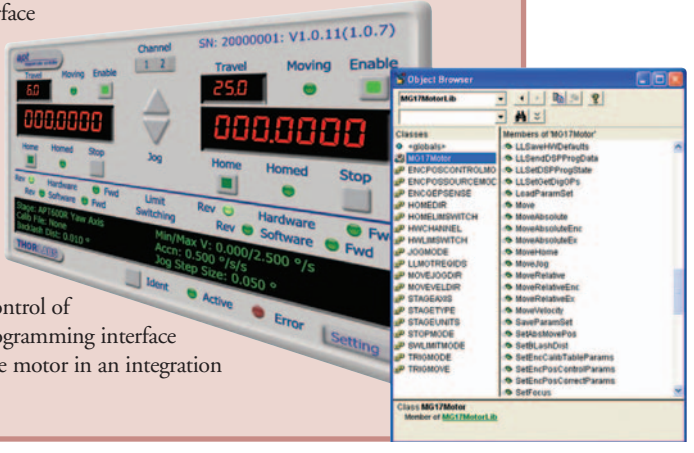
apt™ Server – The Engine for Integration Software Solutions

The apt™ Server lies at the heart of the apt™ system. This software engine sits underneath the operation of both APTUser and APTConfig and makes the functionality of both utilities easily accessible. The apt™ Server actually comprises a collection of cooperating ActiveX® Controls (see aside) and associated support libraries that provide a tool kit of graphical instrument panels and associated programming interfaces. It is this set of ActiveX® Controls that allow motion control and alignment functionality to be incorporated quickly and easily into custom applications.



Evaluation version available in the download section at www.thorlabs.com

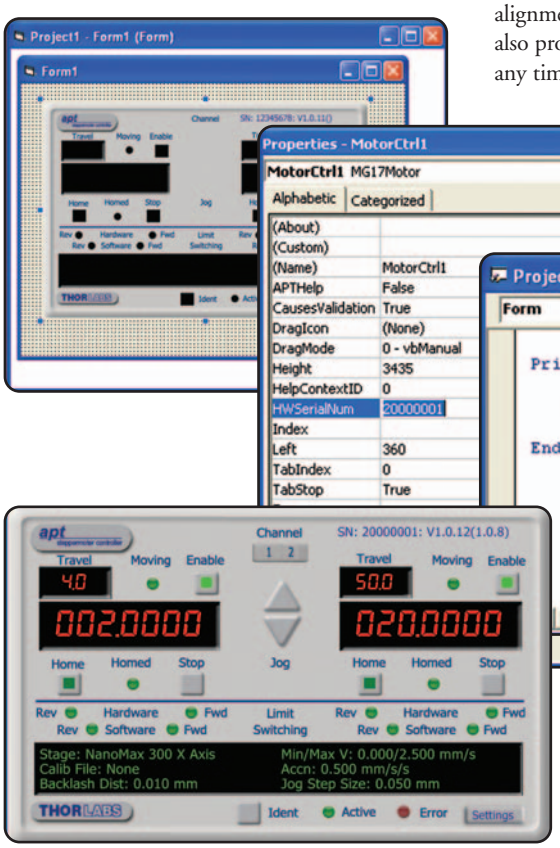
ActiveX® Controls allow apt™ motion control and alignment functionality to be incorporated quickly and easily into custom applications. ActiveX® Controls are pre-compiled software functional blocks (or components) that typically include both a graphical user interface (GUI) and programming (software function) interface. There are many such ActiveX® Controls available to the Windows software developer providing an enormous range of pre-compiled functionality for use in their own custom (or client) applications. The ActiveX® Controls supplied with the apt™ system provide all of the GUI and programmability required to operate and control the full range of apt™ controllers (T-Cube, benchtop, and rack-based variants). For example, the Motor ActiveX® Control provides a complete instrument panel allowing full manual control of our stepper motor driver units. In addition, the associated programming interface allows the software developer to automate the operation of the motor in an integration application.



apt™ Control Software Overview – Page 2 of 3

Multiple Development Environment Support – Your Choice

One of the first questions often posed by a system developer is that of language compatibility. We accept that our customers will want to use a wide variety of software development languages and tools when architecting their solutions, and it is for this very reason that we have engineered the apt™ Server to be ActiveX® compliant. ActiveX® is a language independent interfacing technology supported by a large number of Windows-based software development environments. Using our apt™ controllers, it is possible to create custom alignment applications with environments such as LabVIEW™, Visual Basic, Visual C++, Borland C++, HP VEE, Matlab, and even Microsoft Office via VBA (Visual Basic for Applications). Certain .NET environments (e.g. VB.NET, C#.NET) will also support ActiveX® through Microsoft interop technology.



Rapid Application Development – Drag and Drop

One of the key benefits using the apt™ ActiveX® Controls is the speed with which the associated motion control functionality can be incorporated into a custom alignment application. Taking Visual Basic for example, a fully functional apt™ motor control instrument panel can be incorporated into an end application literally within a minute with a single drag-and-drop operation, a single serial number setting, and a single line of code. Unlike many other motion control software libraries available, the apt™ system provides complete prewritten GUIs for use in custom applications. Consequently, a large amount of development time is saved by eliminating the need to write code to provide essential end user interface capability. These instrument panels can also be used during software development or when commissioning and configuring the system to alter essential settings. In the finished application, it is also very easy to hide these full parameter access graphical panels from the end user in order to prevent inadvertent changes to alignment parameters.

Comprehensive Programming Interfaces

We recognize that it is crucially important that the apt™ Server makes available all required parameters and operating modes through its programming interfaces.

We have taken every available system setting and command and exposed them to support the vast range of integrated software applications that can be built around the apt™ system. Hundreds of software commands and settings exist to ensure full flexibility and adaptability when automating the operation of our controllers.

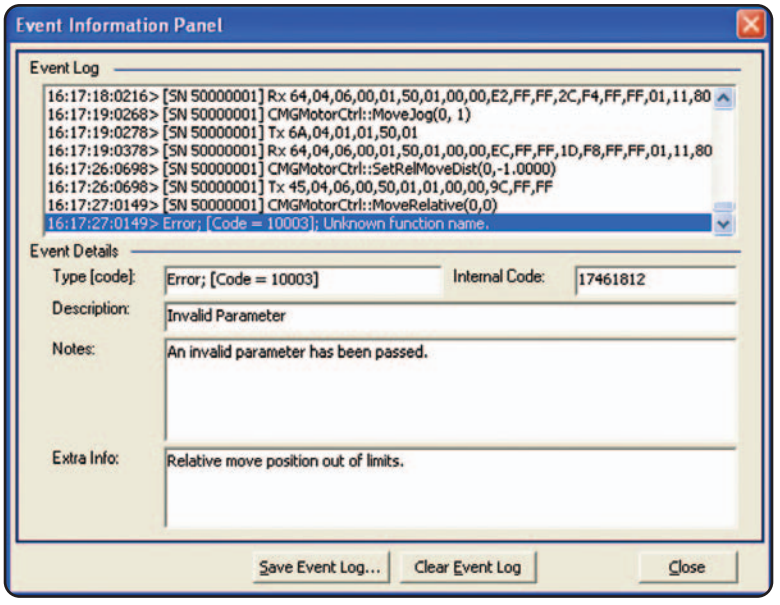
Multi-threading

When developing custom applications on a PC, it is important to ensure that the alignment process itself can execute without disruption (to maintain required alignment time for example). Additionally, a well-written client application will also provide feedback to the user via its GUI and allow operator intervention at any time should an error condition or other event occur. In many cases, a motion control application will also be required to interact with other system hardware such as device characterization and acquisition systems, laser sources, robotic units, and environment control units. The system engineer is faced with supporting all of the above within a single application while also overcoming the consequent issues of software latency from the end user's perspective (e.g. due to polling of equipment).

To address these fundamental application issues, we have built full multi-threading and event "firing" capability into the apt™ Server. Multi-threading is deployed to isolate operation of the apt™ hardware completely from that of the end application. In this way, an end client application can engage in intensive processing (such as data acquisition or number crunching) without affecting the operation of the apt™ controllers. Additionally, we have ensured that the graphical instrument panels are themselves executed in a separate processing thread. This unique approach taken in the apt™ Server ensures that the graphical panels remain fully responsive even when the end application is busy on some intensive processing activity. Always being able to access apt™ controller settings via their GUI panels is extremely useful when trying to optimise software routines, even if an alignment sequence is running. Event firing is the software mechanism by which an apt™ ActiveX® Control can inform the client application of some event or occurrence. In the apt™ system, this mechanism is effectively used to end motor movement and other lengthy operations. By responding to these events, a custom end application does not need to sit and poll for lengthy operations, which improves the overall system performance.

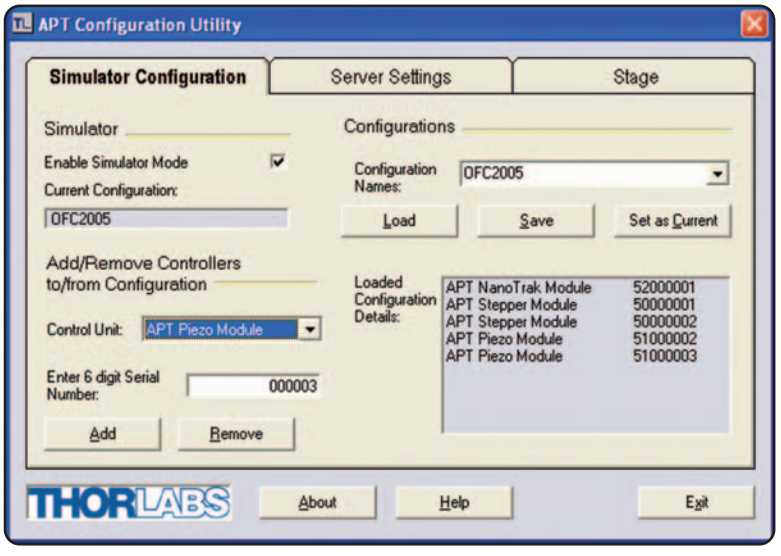
Single Axis Stages
Multi-Axis Stages
Flexure Stage Accessories
Motorized Mirror Mounts
Rotation Stages
Drive Electronics & Auto-Alignment
Actuators & Adjusters
Brief Tutorials

apt™ Control Software Overview – Page 3 of 3



apt™ Hardware Emulator – Offline Application Development
For total convenience, the apt™ Server can be placed into a full hardware emulation mode (using the APTConfig utility), giving the freedom to run the software without connecting actual physical units.

This emulation support is useful for many reasons, including learning how to use and program the apt™ software without necessarily tying up real apt™ hardware, which is useful if multiple person teams are working on the same integration project.



It also gives the option of developing custom applications off-line if, for example, the apt™ hardware is unavailable or already being used. Moreover, after an apt™-based custom application has been developed and released, the actual physical apt™ hardware may no longer be accessible for software support and maintenance purposes, and so a simulator mode proves invaluable.

Debugging – apt™ System Logger
Software development, particularly of complex alignment and positioning systems, is a process that inevitably involves debugging and process optimization. Often errors that occur during actual execution of the associated software (e.g. incorrectly calculated position parameter passed to the apt™ Server) are difficult to analyze after the event (and may not even occur when interactively debugging because of the difference in execution dynamics). To solve this issue, the apt™ software has a built-in system-wide event logging capability that records all function calls (and associated parameters). This chronological record of client application activity is invaluable in monitoring the sequence of events that lead up to a process failure, thereby helping the software developer to find and debug problems.

Developer Support CD
It is inevitable, even for relatively simple applications, that software programming support will be needed. Having recognized this and the wide range of software end applications that can be built around the apt™ system, we have brought together a comprehensive collection of programmer information and reference material and burned it onto a CD. A full set of sample applications written in Visual Basic and LabVIEW™ is included, together with various hints and tips. The programming samples themselves cover a varying degree of complexity, from basic to advanced examples. The advanced examples are working programs that can be used with the apt™ motion controllers and Thorlabs' positioning stages and actuators to perform optical alignments of real world multi-axis photonics. They form an excellent starting point for the system development and in many cases will provide the functionality required with only minor coding enhancements/changes.

Try the apt™ Software for Yourself
In the end, the best way to appreciate the power and flexibility of the apt™ system software is to try it yourself. You can obtain the latest shipping version of the apt™ software from the download section of the Thorlabs' website (www.thorlabs.com). After installation, it is possible to create a simulated configuration of apt™ controllers and then go on to explore all of the software commands and features described above, as well as experiment with writing custom motion control applications.

It is also useful to view the tutorial videos included. These cover all aspects of using the software, from overviews of the supplied user utilities to programming basics in Visual Basic, LabVIEW, and C++ environments.