STEPPER MOTOR MODULE

Model Number MST601

THORLABS

About the Company

Thorlabs has been an active member of the Photonics community for over 15 years.

We strive to be the ultimate resource for the photonics community-a place to find the products you need to enable your experiments, as well as the information you need to get your application working.

Thorlabs designs, develops, and manufactures building blocks for the photonics industry including equipment for opto-mechanics, motion control, nano-positioning, alignment, optical components, laser diodes, tunable lasers and vibration isolation systems. In addition to core photonics building blocks, we now provide system level solutions including complete OCT and imaging systems.

Trademarks

Windows is a trademark of Microsoft Corporation.

ActiveX is a trademark of Microsoft Corporation.

Visual Basic is a trademark of Microsoft Corporation.

LabVIEW is a trademark of National Instruments Corporation.

THORLABS is a registered trademark of Thorlabs Inc.

Revision History

Issue	Date	Summary
1	210907	Initial Issue
2	080908	14, 21, 34
3	060409	14
4	100809	36
5	080909	Method Summary

Product Warranty

Opto-Electronics, Control Electronics, Optics, and Nano-Positioning Product Lines.

Thorlabs offers a two year warranty on the above mentioned product lines, provided normal use and maintenance of the products and when properly handled and correctly installed.

Thorlabs shall repair or replace any defective or nonconforming product as detailed above. We ask that buyer contact Thorlabs for a Return Material Authorization number (RMA #) from our Customer Service/Returns department in order to most efficiently process the return and/or repair.

Products returned for repair that are not covered under warranty, a Thorlabs standard repair charge shall be applicable in addition to all shipping expenses. This repair charge will be quoted to the customer before the work is performed.

Contents

Continued...

For Your Safety

1.1   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 on the equipment:

Warning, risk of danger. Refer to the handbook for details on this hazard.

Warning, risk of electric shock. High voltages present.

Equipotentiality (bonding) terminal.

Functional (EMC) earth/ground terminal.

The following safety symbols may be used throughout the handbook:

Warning. An instruction which draws attention to the risk of injury or death.

Caution. An instruction which draws attention to the risks of damage to the product, process or surroundings.

Note. Clarification of an instruction or additional information.

1.2   Warnings

- The Equipment, as described herein, is designed for use by personnel properly trained in the use and handling of mains powered electrical equipment. Only personnel trained in the servicing and maintenance of this equipment should remove its covers or attempt any repairs or adjustments.
- If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Do not operate the instrument outside its rated supply voltages or environmental range. In particular, excessive moisture may impair safety.
- This unit is intended for operation from a normal, single phase supply, in the temperature range 5° to 40°C, 20% to 80% RH.

1.3   Declarations Of Conformity

1.3.1   For Customers in Europe

This equipment has been tested and found to comply with the EC Directives 89/336/EEC 'EMC Directive' and 73/23/EEC 'Low Voltage Directive' as amended by 93/68/EEC.

Compliance was demonstrated by conformance to the following specifications which have been listed in the Official Journal of the European Communities:

Safety   EN61010: 2001 Installation Category II, Polution Degree II.

EMC   EN61326: 1997

1.3.2   For Customers In The USA

This equipment has been tested and found to comply with the limits for a Class A digital device, persuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Changes or modifications not expressly approved by the company could void the user's authority to operate the equipment.

1.4 Waste Electrical and Electronic Equipment (WEEE) Directive

1.4.1 Compliance

As required by the Waste Electrical and Electronic Equipment (WEEE) Directive of the European Community and the corresponding national laws, we offer all end users in the EC the possibility to return "end of life" units without incurring disposal charges.

This offer is valid for electrical and electronic equipment

• sold after August 13th 2005
• marked correspondingly with the crossed out "wheelie bin" logo (see Fig. 1)
• sold to a company or institute within the EC
• currently owned by a company or institute within the EC
• still complete, not disassembled and not contaminated
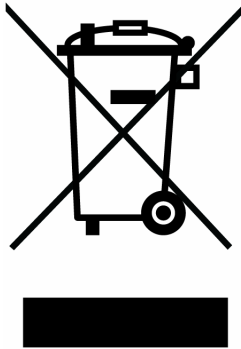
Fig. 1.1 Crossed out "wheelie bin" symbol

As the WEEE directive applies to self contained operational electrical and electronic products, this "end of life" take back service does not refer to other products, such as

• pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
• components
• mechanics and optics
• left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

1.4.2   Waste treatment on your own responsibility

If you do not return an "end of life" unit to the company, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

1.4.3   Ecological background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

Overview

2.1 APT Rack System Description

2.1.1 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.

2.1.2 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.

2.1.3   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.

2.2   Software

2.2.1   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.

2.2.2   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 stepper controller unit.

This Control provides a complete user graphical instrument panel to allow the motor 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 motor 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 motor position). 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 stepper motor Control to move a motor, the progress of that move is reflected automatically by changing position readouts 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).
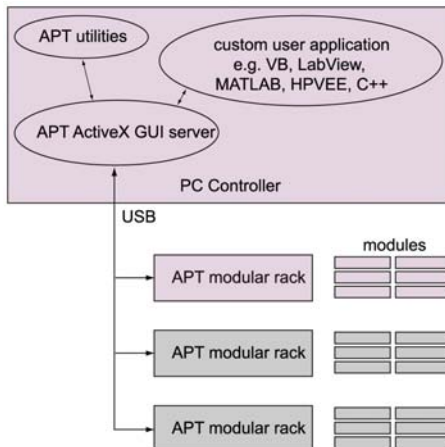
2.2.3 APT User.exe

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.
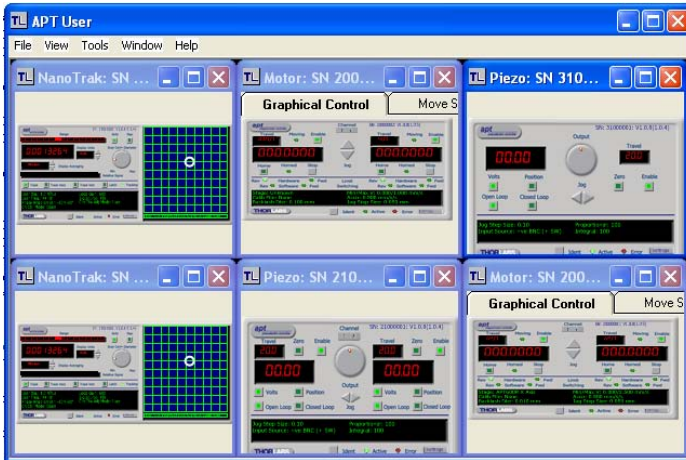

All basic operating parameters can be altered and, similarly, all operations (such as motor moves) can be initiated. For many users, the APTUser application provides all of the functionality necessary to operate the APT hardware without the need to develop any further custom software. For those who do 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

2.2.4 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.
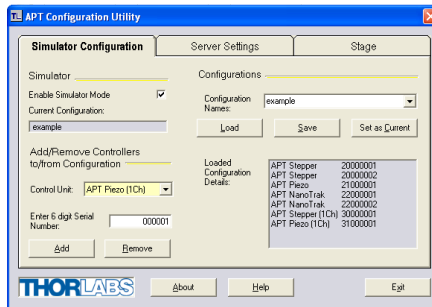
The APTConfig utility is provided as a convenient means for making these system wide settings and adjustments. Full details on using APTConfig are provided in the online help supplied with the utility.

2.3   Stepper Motor Controller Description

2.3.1   Introduction

The two channel modular APT stepper motor module provides a scalable motion control solution, which allows the independent control of up to 12 stepper motors within a single APT 19" rack enclosure. The USB interface and advanced application software, allow multiple channel systems to be seamlessly integrated into a single large scale solution. Additionally, it is possible to combine the APT rack systems with one or more bench top units. The plug-in modules have all the same performance and ease of use features as our bench top controllers. They combine the latest high-speed digital signal processors (DSP), low-noise analog electronics, and ActiveX software technology.

The modular APT stepper 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 - see Section 2.2.3.

2.3.2   Driver Functionality

A wide range of 2-phase bipolar stepper motors and associated actuators is commerically available and each has its own characteristics such as step resolution, peak phase current or voltage, and lead screw pitch. For this reason we have chosen to make the operation of the APT stepper motor controller fully configurable (parameterized). All of the key settings are accessable through a number of graphical interface panels. For example, the motor step resolution and lead screw pitch can be set for a particular motor/actuator combination, phase currents can be limited to suitable peak powers as required, and limit switch configuration is accommodated through a flexible set of limit switch logic settings. Moreover, relative and absolute moves can be initiated with move profiles set using velocity profile parameters. Similarly, home sequences have a full set of associated parameters that can be adjusted for a particular stage or actuator. For simplicity of operation, the APT software incorporates pre-configured settings for each of the Thorlabs stages and actuators, while highlighting and making available all operating parameters for use with other manufacturers stepper motor systems.

For convenience and ease of use, adjustment of many key operating parameters is also accessible through the software generated control panels. For example the next "move to" command can be initiated by clicking directly on the position display and entering a new value. Note that all such settings and parameters are also accessible through the ActiveX programmable interfaces for automated alignment sequences. See Section 2.2. for a full description of the APT system software.
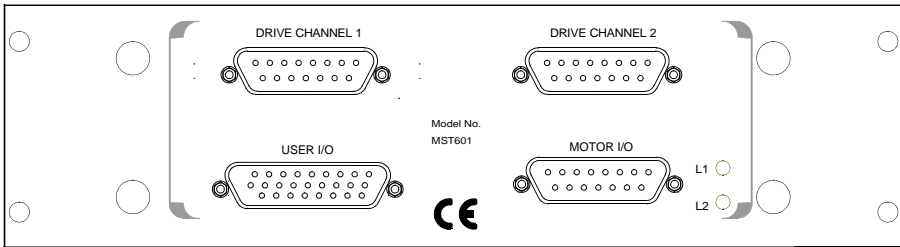
2.4   Rear Panel Connections

Fig. 2.1 Rear panel connections

DRIVE CHANNEL 1 - Provides connection to the actuator associated with channel 1.

DRIVE CHANNEL 2 - Provides connection to the actuator associated with channel 2. These two connectors provide all phase current drive and encoder feedback connections to drive a range of encoded and non-encoded stepper motors - see "Specifications" on page 36 and "Rear Panel Drive Channel Connectors" on page 34 for more information - see Section 5.2.4.

USER I/O - 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 APT support software, these user programmable logic lines can be deployed in applications requireing control of external devices such a relays, light sources and other auxillairy equipment - see Section 5.2.3.

MOTOR I/O - The 'Motor I/O' connector exposes a number of electrical signals useful for external control. Interlock enable lines are used to enable/disable the motor drive outputs and are a useful mechanism for implementing an external emergency stop feature. Motor jogging lines can be used to jog the motor in both forward and reverse directions. Jogging parameters (e.g. jog distance) are set via the GUI panel - see Section 5.2.2.

⚠ **Caution**. If a remote handset is not used, the terminator supplied must be fitted to the MOTOR I/O connector inoredr for the unit to function.

The terminator must fitted ONLY to the MOTOR I/O connector. If the unit is powered up with the terminator fitted to the DRIVE CHANNEL connectors, the unit will be damaged.

Principle of Operation

3.1 How A Stepper Motor Works

3.1.1 General Principle

Thorlabs' actuators use a stepper motor to drive a precision lead screw.

Stepper motors operate using the principle of magnetic attraction and repulsion to convert digital pulses into mechanical shaft rotation. The amount of rotation achieved is directly proportional to the number of input pulses generated and the speed is proportional to the frequency of these pulses. A basic stepper motor has a permanent magnet and/or an iron rotor, together with a stator. The torque required to rotate the stepper motor is generated by switching (commutating) the current in the stator coils as illustrated in Fig. 3.1.
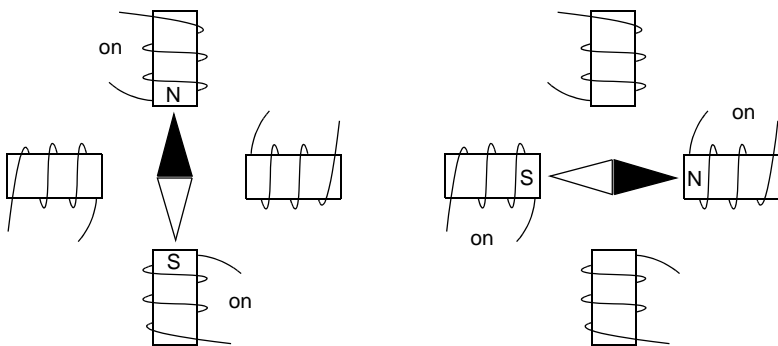
Fig. 3.1 Simplified concept of stepper motor operation

Although only 4 stator poles are shown above, in reality there are numerous tooth-like poles on both the rotor and stator. The result is that positional increments (steps) of 1.8 degrees can be achieved by switching the coils. If the current through one coil is increased as it is decreased in another, the new rotor position is somewhere between the two coils and the step size is a defined fraction of a full step (microstep).

The size of the microstep depends on the resolution of the driver electronics. When used with the Thorlabs APT motor controller, the smallest angular adjustment is 0.014 degrees, resulting in a resolution of 25,600 microsteps per revolution. The mechanical resolution achieved by the system may be coarser than a single microstep, primarily because there may be a small difference between the orientation of the magnetic field generated by the stator and the orientation in which the rotor comes to rest.

3.1.2 Positive and Negative Moves

Positive and *negative* are used to describe the direction of a move. A positive move means a move from a smaller absolute position to a larger one, a negative move means the opposite.

In the case of a linear actuator, a positive move takes the platform of the stage further away from the motor.

In a rotational stage, a positive move turns the platform clockwise when viewed from above.

3.1.3 Velocity Profiles

To prevent the motor from stalling, it must be ramped up gradually to its maximum velocity. Certain limits to velocity and acceleration result from the torque and speed limits of the motor, and the inertia and friction of the parts it drives.

The motion employed is described by a trapezoidal velocity profile, reflecting the shape of the velocity *vs.* time graph (see Fig. 3.2.), thereby driving the stage to its destination as quickly as possible, without causing it to stall or lose steps.

The stage is ramped at acceleration '*a*' to a maximum velocity '*v*'. As the destination is approached, the stage is decelerated at '*a*' so that the final position is approached slowly in a controlled manner.
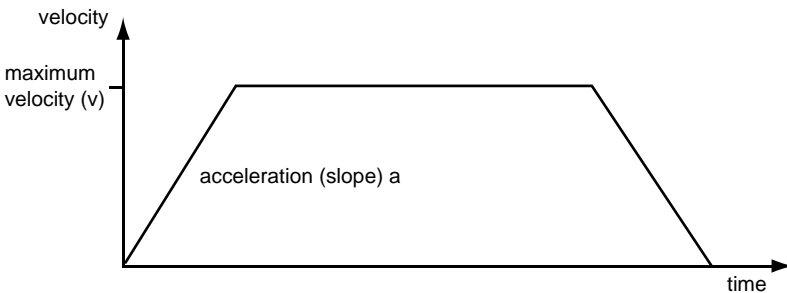
Fig. 3.2 Graph of a trapezoidal velocity profile

3.2   Positioning the Stage

3.2.1   General

Whenever a command to move a stage is received, the Control PC converts the movement specified in motion units, (e.g., mm) to a number of microsteps. It then sends a signal to the stage to move by this number of microsteps.

Each motor in the system has an associated electronic counter in the Control PC, which keeps a record of the net number of microsteps moved. If the Control PC is requested to report the position, the value of this counter is converted back into motion units.

✱ **Note**. During a manual move, (i.e. if the motor shaft is turned by hand) no signal is sent to the motor, the counter is not updated and any subsequent position reporting will be false until the motor is 'Homed'.

3.2.2   Home position

When the system is powered up, the counters in the controller are all set to zero and consequently, the system has no way of knowing the position of the stage in relation to any physical datum.

A datum can be established by sending all the motors to their 'Home' positions. The 'Home' position is set during manufacture and is determined by driving the motor until the negative limit switch is reached and then driving positively a fixed distance (zero offset).

When at the Home position, and the counters are reset to zero thereby establishing a fixed datum that can be found even after the system has been switched off.

3.2.3   Limit Switches

A linear stage moves between two stops, and movement outside these limits is physically impossible. Linear stages can include stages that control the angle of a platform within a certain range, although the movement of the platform is not really linear but angular. Rotary stages can rotate indefinitely, like a wheel.

Linear and rotary stages both contain microswitches that detect certain positions of the stage, but they differ in the way these switches are used.

All linear stages have a –ve limit switch, to prevent the stage from accidentally being moved too far in the –ve direction. Once this switch is activated, movement stops. The switch also provides a physical datum used to find the Home position. Some linear stages have a +ve limit switch also, whereas others rely on a physical stop to halt the motion in the positive direction. A rotary stage has only one switch, used to provide a datum so that the Home position can be found. Movement is allowed right through the switch position in either direction.
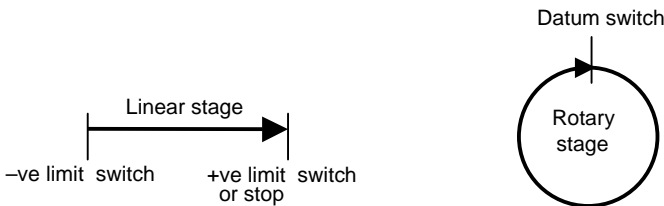
Fig. 3.3 Stage limit switches

3.2.4   Minimum and Maximum Positions

These positions are dependent upon the stage to which the motors are fitted, and are defined as the minimum and maximum useful positions of the stage relative to the 'Home' position - see Fig. 3.4.

The distance from the Minimum position to the Maximum position is the 'useful travel' of the stage. It is often the case that the Minimum position is zero. The Home and Minimum positions then coincide, with movement always occurring on the positive side of the Home position.

Rotary stages have effectively no limits of travel. The Minimum and Maximum positions are conventionally set to 0 and 360 degrees respectively. When the position of a rotary stage is requested, the answer will be reported as a number between 0 and 360 degrees, measured in the positive direction from the Home position.
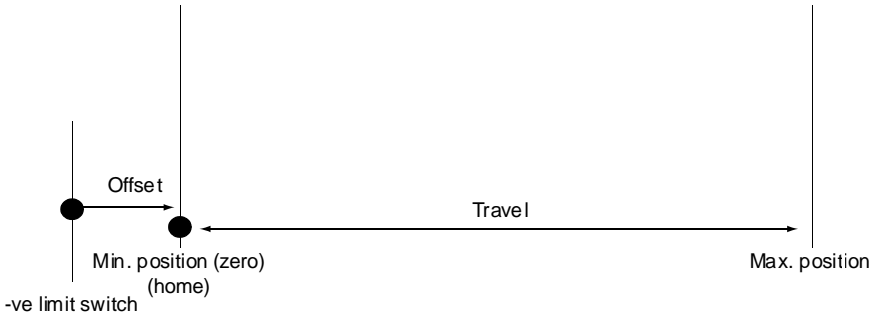
Fig. 3.4 Minimum and Maximum Positions

3.2.5   Power Saving

The current needed to hold a motor in a fixed position is much smaller than the current needed to move it, and it is advantageous to reduce the current through a stationary motor in order to reduce heating. Although this heating does not harm the motor or stage, it is often undesirable because it can cause thermal movements through expansion of the metal of the stage.

For this reason, power saving is implemented by default from the software drivers.

3.3 Error Correction

3.3.1 Backlash correction

The term *backlash* refers to the tendency of the stage to reach a different position depending on the direction of approach.

Backlash can be overcome by always making the last portion of a move in the same direction, conventionally the positive direction. Consider the situation in Fig. 3.5, a *positive* move, from 10 to 20 mm, is carried out as one simple move, whereas a *negative* move, from 20 to 10 mm, first causes the stage to overshoot the target position and then move positively through a small amount.
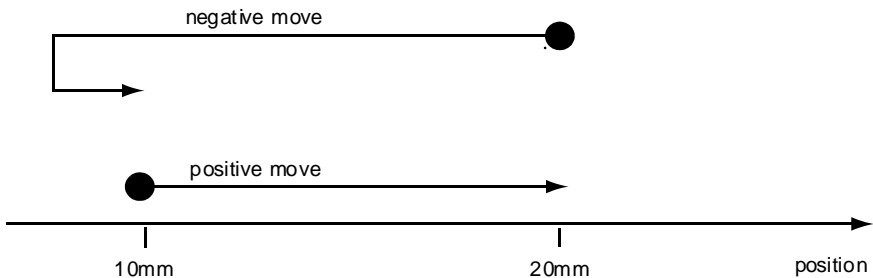
Fig. 3.5 Backlash correction

The controller has this type of 'backlash correction' enabled as its default mode of operation, but it can be overridden (i.e. set to zero) if the overshoot part of the move is unacceptable for a particular application.

If this is the case, backlash correction can be achieved through software. The controller calculates the number of pulses required to complete a move and then if a negative move is executed issues additional pulses to correct for the backlash. However, for this method to be successful, the precise amount of backlash must be known.

Operation

4.1 System Setup

1) Install the APT Software - see the Installation Guide supplied on the software CD.

2) Install the electronic hardware and connect the modules to the relevent axes of the associated stages (see Chapter 5 of this handbook, and also the handbooks supplied with other control modules).

3) For each Stepper Motor Controller in your system, fit the interlock plug (supplied) to the MOTOR CONTROL connector on the rear panel.

4) To ensure that a particular stage is driven properly by the system, a number of parameters must first be set. These parameters relate to the physical characteristics of the stage being driven (e.g. min and max positions, leadscrew pitch, homing direction etc.).

   To assist in setting these parameters correctly, it is possible, using the APT Config utility, to associate a specific stage type and axis with the motor controller channel. Once this association has been made, the APT server applies automatically, suitable default parameter values on boot up of the software.

   Run the APTConfig utility, then associate each motor channel with its stage and axis - see the *APTConfig* helpfile for detailed instructions.

5) **Note.** The 'APT Config' utility can be used to set up simulated hardware configurations and place the APT Server into simulator mode. In this way it is possible to create any number and type of simulated (virtual) hardware units in order to emulate a set of real hardware. This is a particularly useful feature, designed as an aid to application program development and testing. Any number of 'virtual' control units are combined to build a model of the real system, which can then be used to test the application software, without the need for expensive hardware system production.

   If using real hardware, ensure that Simulator Mode is disabled. If using a simulated setup, enable Simulator Mode and set up a 'Simulated Configuration' - see the *APTConfig* helpfile for detailed instructuions.

   Run APTUser.exe and begin using the APT hardware - see the APTUser helpfile for further details.

4.2   Manual Operation
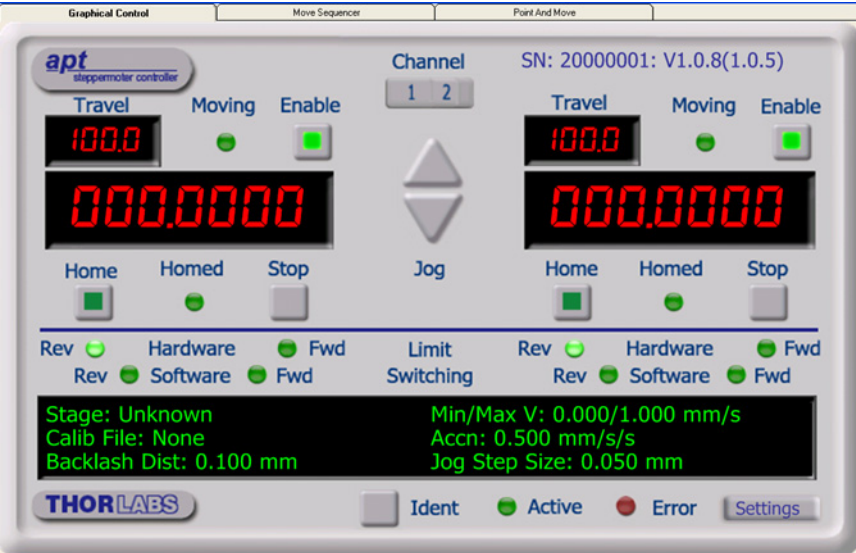
4.2.1   Operation from the GUI Panel

Fig. 4.2 Motor controller software GUI (dual channel version)

The software drivers consist of several 'objects', which in turn contain 'Methods' and 'Properties'. The 'Motor' object contains the methods which facilitate the programmed operation of the controller.

The methods apply to single axes and are called using a channel ID parameter, with moves being specified in motion units, conventionally millimetres or degrees.

An overview of the methods and properties for the Motor object, can be found in Chapter 7.

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 - dual channel version only. Used to select the applicable channel, when operating the 'Jog' controls. Also selects the channel data displayed in the 'Settings' window.

Jog - used to increment or decrement the motor position. When the button is clicked, the motor is driven in the selected direction at the initial velocity one step per click. The step size and jog velocity parameters can be set in the 'Settings' panel or by using the SetJogVelParams method. While the button is clicked, positioning commands from the control PC are not executed and an appropriate error message is returned.

Travel - displays the range of travel (in μm) of the motor.

Moving - lit when the motor is in motion.

Enabled - applies power to the motor. With the motor enabled, the LED in the button is lit. Note. The motor cannot be positioned using the knob on the motor shaft if the drive is 'Enabled'.

Digital display - shows the position (in millimetres or degrees) of the motor. The motor must be 'Homed' before the display will show a meaningful value.

Home - sends the motor to its 'Home' position - see 'Principle of Operation, Home Position'. The LED in the button is lit while the motor is homing.

Homed - lit when the motor has previously been 'Homed' (since power up).

Stop - halts the movement of the motor.

Limit switches - the LEDs are lit when the associated limit switch has been activated - see 'Principle of Operation, Limit Switches.

Settings display - shows the following user specified settings:

Stage - the stage type and axis associated with the specified channel.

Calib File - the calibration file associated with the specified channel.

See the Config utility helpfile for more details on assigning and using calibration files.

Backlash Dist - the backlash distance in mm or degrees. The backlash can be set either via the Settings panel or by calling the SetBLashDist method.

Min/Max V - the minimum velocity at which a move is initiated, and the maximum velocity at which the move is performed. Values are displayed in real world units (mm/s or degrees/s), and can be set either via the Settings panel or by calling the SetVelParams method.

Accn - the rate at which the velocity climbs to, and slows from, maximum velocity, displayed in real world units (mm/s/s or degrees/s/s). The acceleration can be set either via the Settings panel or by calling the SetVelParams method and is used in conjunction with the Min/Max velocity settings to determine the velocity profile of a motor move.

Jog Step Size - the size of step (in mm or degrees) taken when the jog signal is initiated. The step size can be set either via the Settings panel or by calling the SetJogStepSize method.

Settings button - Displays the 'Settings' panel, which allows the motor drive's operating parameters to be entered - see Section 4.2.2. **Note**. The channel settings shown when the Settings panel is displayed is determined by the channel rocker switch on the main panel.

Ident - when this button is pressed, the Channel LEDs 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 conditions occur:

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.

4.2.2   Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed for the selected channel. This panel allows motor operation parameters such as move/jog velocities, and stage/axis information to be modified. Note that all of these parameters have programmable equivalents accessible through the ActiveX methods and properties on this Control (refer to the *Programming Guide* in the *MG17Base helpfile* for further details). The various parameters are described below:

Moves/Jogs tab
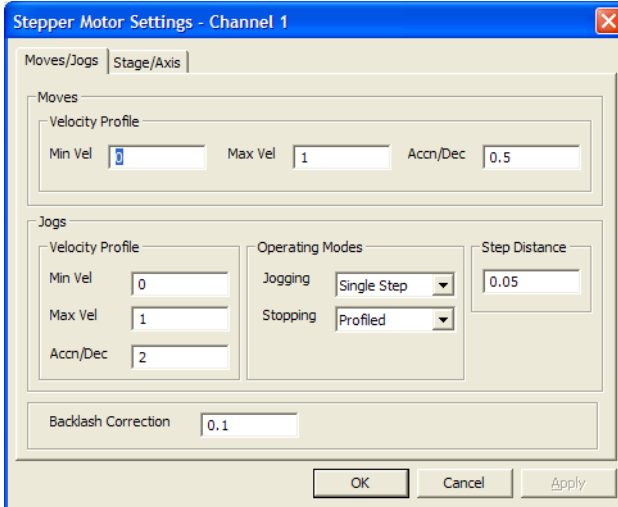
Fig. 4.1 Stepper motor controller - Move/Jog settings

Moves

Moves can be initiated by calling the various move methods, or via the graphical panel, either by using the jog buttons or by entering a position value after clicking on the position display box). These settings determine the move profile.

Velocity Profile (specified in real world units, millimetres or degrees)

MinVel - the minimum velocity at which to start and end a move.

MaxVel - the maximum velocity at which to perform a move.

Accn/Dec - the rate at which the velocity climbs from minimum to maximum, and slows from maximum to minimum.

Note. Under certain velocity parameter and move distance conditions, the maximum velocity may never be reached (i.e. the move comprises an acceleration and deceleration phase only),

Jogs

Jogs are initiated by using the 'Jog' keys on the GUI panel or by using the optional jog handset unit.

Velocity Profile (specified in real world units, millimetres or degrees)

MinVel - the minimum velocity at which to start and end a jog

MaxVel - the maximum velocity at which to perform a jog

Accn/Dec - the rate at which the velocity climbs from minimum to maximum, and slows from maximum to minimum

Note. Under certain velocity parameter and jog distance conditions the maximum velocity may never be reached (i.e. the move comprises an acceleration and deceleration phase only).

Operating Modes

Jogging - The way in which the motor moves when a jog command is received (i.e. handset button pressed or GUI panel button clicked).

Single Step - the motor moves by the step size specified in the Step Distance parameter.

Continuous - the motor continues to move until the jog signal is removed (i.e. jog button is released). Note. Continuous mode is not applicable to moves initiated via the GUI panel.

Stopping - the way in which the jog motion stops when the demand is removed.

Immediate - the motor stops abruptly, in a non-profiled manner

Profiled - the motor stops in a profiled manner using the jog Velocity Profile parameters set above.

Step Distance - The distance to move when a jog command is initiated. The step size is specified in real world units (mm or degrees dependent upon the stage).

Backlash Correction - The system compensates for lead screw backlash during reverse direction moves, by moving passed the demanded position by a specified amount, and then reversing. This ensures that positions are always approached in a forward direction. The Backlash Correction Distance is specified in real world units (millimeters or degrees). To remove backlash correction, this value should be set to zero.

Stage/Axis tab

Fig. 4.2 Stepper motor controller - Stage/Axis settings

✳ **Note**. This tab contains a number of parameters which are related to the physical characteristics of the particular stage being driven. They need to be set accordingly such that a particular stage is driven properly by the system.

For Thorlabs stages, the APT Config utility can be used to associate a specific stage and axis type with the motor channel (refer to the APT Config helpfile for further details on how to associate a stage and axis). Once this association has been made, the APT server will automatically apply suitable defaults for the parameters on this tab during boot up of the software. These parameters should not be altered for pre-defined Thorlabs stages selected using APT Config, as it may adversely affect the performance of the stage.

For custom stage types not available using the APT Config utility, the stage details must be entered manually. Individual parameters are described in the following paragraphs.

Stage and Axis Type - For Thorlabs stages, the stage type is displayed automatically once the axis has been associated using the APTConfig utility. For third party stages, the display shows '*Unknown*'.

⚠ **Caution**. Extreme care must be taken when modifying the stage related settings which follow. Some settings are self consistent with respect to each other, and illegal combinations of settings can result in incorrect operation of the physical motor/stage combination being driven. Consult Thorlabs for advice on settings for stage/actuator types not covered in this documentation.

Min Pos - the position of the minimum limit (typically zero).

Max Pos - the position of the maximum limit.

Pitch - the pitch (in mm) of the motor lead screw (i.e. the distance to travel per revolution of the motor).

Units - the units of measure (mm or degrees).

Homing

When homing, a stage typically moves in the reverse direction, (i.e. towards the reverse limit switch). These settings allow increased flexibility for stages with both Forward and Reverse limits.

Direction - the direction sense to move when homing, either *Forward* or *Reverse*.

Limit Switch - The hardware limit switch associated with the home position, either *Forward HW or Reverse HW*.

Zero Offset - the distance (in mm or degrees) of the minimum limit from the Home position.

Velocity - the maximum velocity at which the motors should move when Homing.

For further information on the home position, see Section 3.2.2.

Hardware Limit Switches

★ **Note.** The minimum velocity and acceleration/deceleration parameters for a home move, are taken from the existing move velocity profile parameters.

Rev Switch - The action of the reverse limit switch when contact is made, either *Ignore/Absent, Switch Makes or Switch Breaks.*

Fwd Switch - The action of the forward limit switch when contact is made, either *Ignore/Absent, Switch Makes or Switch Breaks.*

Motor

These parameters are used to set the 'resolution' characteristics of the stepper motor connected to the selected channel. The resolution of the motor, combined with other characteristics (such as lead screw pitch) of the associated actuator or stage, determines the overall resolution.

Steps Per Rev - The number of full steps per revolution of the stepper motor (minimum '1', maximum '1000').

✱ **Note**. The *Gearbox Ratio* parameter is applicable only to motors fitted with a gearbox.

Gearbox Ratio - The ratio of the gearbox. For example, if the gearbox has a reduction ratio of X:1 (i.e. every 1 turn at the output of the gearbox requires X turns of the motor shaft) then the Gearbox Ratio value is set to X. (minimum '1', maximum '1000').

✱ **Notes**.

- The stepper motors used on the majority of Thorlabs stages/actuators have 200 full steps per rev and no gearbox fitted. For these motors the Steps Per Rev and Gearbox Ratio parameters have values of 200 and 1 respectively. As an exception to this, the ZST family of actuators use 24 steps per rev stepper motors fitted with a 76:1 reduction gearbox. In this case, the Steps Per Rev and Gearbox Ratio should be set to '24' and '76' respectively.

- The correct default values for Steps Per Rev and Gearbox Ratio are applied automatically when the APTConfig.exe utility is used to associate a specific stage or actuator type with a motor channel. See the APTConfig helpfile for more details.

⚠ **Caution**. Extreme care must be taken when modifying the stage related settings above. Some settings are self consistent with respect to each other, and illegal combinations of settings can result in incorrect operation of the physical motor/stage combination being driven. Consult Thorlabs for advice on settings for stage/actuator types not covered in this documentation.

Installation And Maintenance

5.1   Mechanical Installation

5.1.1   Siting

The Stepper Motor control module is intended for installation in the Midi Rack as part of the Thorlabs APT Modular Motion Control System. Full installation instructions are contained in the handbook *ha 0117 APT Modular Rack*.

⚠ **Caution**.
When mounting the unit in the rack, ensure that proper airflow is maintained to the rear of the unit.

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^oC to 40^oC
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.

5.1.2   Identifying Unsafe Equipment

Whenever it is suspected that the safety of the product has been impaired, it is recommended that an appropriate label, recognized by your company, be attached and that the unit be removed to a place of repair.

5.2   Electrical Installation
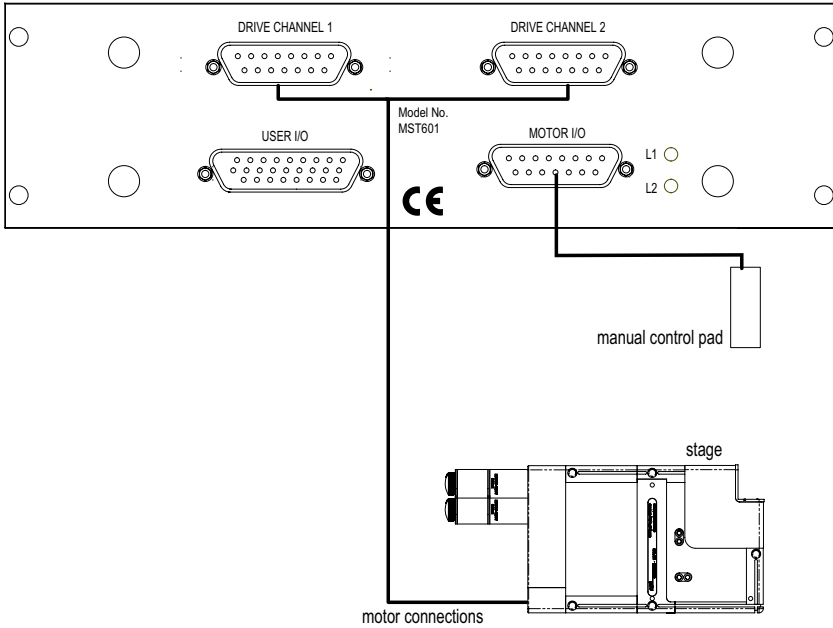
5.2.1   Electrical Connections

**Fig. 5.1 Connecting the motor control module**

5.2.2   Rear Panel Motor I/O Connector

✳ | **Note**. If the motor control connector is not used, the terminator supplied must be fitted.

The 'Motor I/O' connector exposes a number of electrical signals useful for external control. Interlock enable lines are used to enable/disable the motor drive outputs and are a useful mechanism for implementing an external emergency stop feature. Motor jogging lines can be used to jog the motor in both forward and reverse directions. Jogging parameters (e.g. jog distance) are set via the GUI panel.

The pin functions are detailed in Fig. 5.2 and in each case must be referenced to the indicated return pin for the signal to be true.
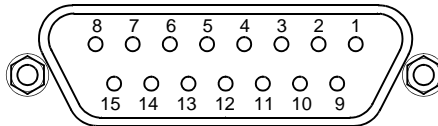
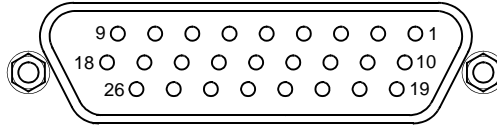| Pin	Description	Return
1	User 5V I/O	9
2	* Channel 1 jog forwards	9
3	* Channel 2 jog forwards	9
4	** Channel 1 emergency stop daisy chain link return	12
5	** Channel 1 enable return	13
6	** Channel 2 emergency stop daisy chain link return	14
7	** Channel 2 enable return	15
8	Not Used	–
9	User 0V	–
10	* Channel 1 Jog backwards	9
11	* † Channel 2 Jog backwards	9
12	** Channel 1 emergency stop daisy chain link	4
13	** Channel 1 enable	5
14	** Channel 2 emergency stop daisy chain link	6
15	** Channel 2 enable	7

Notes.

* Jog inputs are opto-coupled and must be short circuit to User 0V (pin 9) in order to function.

** Channel enable inputs and daisy chain links are non-driveable and require a closed contact to the associated return pin in order to function.

Fig. 5.2 MOTOR I/O connector pin identification

5.2.3   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 APT support software, these user programmable logic lines can be deployed in applications requiring control of external devices such a relays, light sources and other auxilliary equipment.

The pin functions are detailed in Fig. 5.3.

| Pin	Description	Return	Pin	Description	Return	Pin	Description	Return
1	Digital I/P 1	19	10	Digital O/P 1	19	19	‡ Dig Ground 1 (0V)	
2	Digital I/P 2	19	11	Digital O/P 2	19	20	External Trigger I/P	22
3	Digital I/P 3	19	12	Digital O/P 3	19	21	External Trigger O/P	22
4	Digital I/P 4	19	13	Digital O/P 4	19	22	‡ Dig Ground 2 (0V)	
5	Channel 1 RS232 TX		14	Channel 2 RS232 TX		23	5V User O/P (50mA Max.)	
6	Channel 1 RS232 RX		15	Channel 2 RS232 RX		24	Reserved for Future Use	
7	Not Used		16	Reserved for Future Use		25	Reserved for Future Use	
8	† Channel 2 Analog I/P(+)	17	17	† 0 V (Analog Rtn)	8	26	* ‡ Analog Ground (0 V)	
9	† Channel 1 Analog I/P(+)	18	18	† 0 V (Analog Rtn)	9			

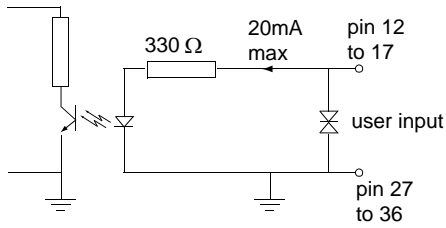**Notes.**

*   For use with analog inputs

†   0 to 10 V d.c. between I/P +ve and I/P -ve (e.g. pins 8 and 17).

‡   Ground pins are common to the equipment ground

Fig. 5.3 USER I/O connector pin identification
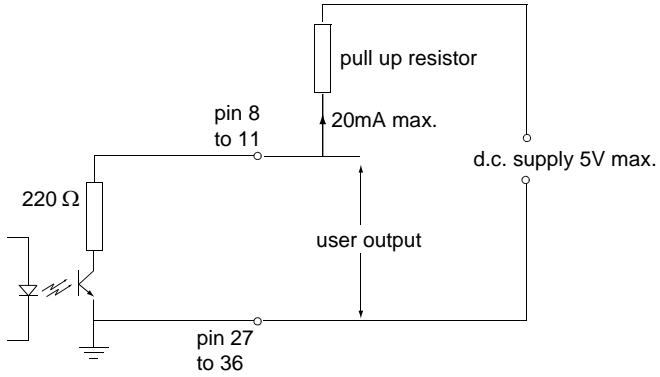
Fig. 5.4 Open collector output details

Fig. 5.5 Opto-coupled input details

5.2.4   Rear Panel Drive Channel Connectors

The 'DRIVE CHANNEL' connectors provide connection to the motors. The pin functions are the same for each channel and are detailed in Fig. 5.6. In each case the signal must be referenced to the indicated return pin in order to be true.
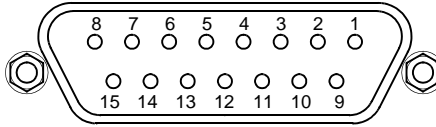
Pin	Description	Return	Pin	Description	Return
1	Encoder A +ve		9	CW Limit Switch	
2	Encoder A -ve		10	CCW Limit Switch	
3	Encoder B +ve		11	0V User	
4	Encoder B -ve		12	Reserved for Future Use	
5	5v User		13	Reserved for Future Use	
6	Not used		14	Phase B +	
7	Phase B -		15	Phase A +	
8	Phase A -				

Fig. 5.6 DRIVE CHANNEL connector pin identification

5.3   Preventive Maintenance

⚠ **Warning**. The equipment contains no user servicable parts. There is a risk of severe 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.

5.3.1   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.

5.3.2   Cleaning

⚠ **Warnings**.
• 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.

Specifications and Associated Products

6.1 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)
Microstep capability	25,600 steps per revolution
(assuming 200 step motor)	Max 128 microsteps per full step
Motor Control	15 pin female D-type connector
Motor Drive	15 pin female D-type connector
User Control	26 pin female D-type connector

Compatible Motors
   Peak Powers   2 to 50W
   Average Power   25W Maximum
   Step Angle Range   20° to 1.8°
   Coil Resistance   4 to 15Ω
   Coil Inductance   4 to 15mH
   Rated Phase Currents 100mA to 1A

6.2 Associated Products

Product Name	Part Number
APT Rack	MMR601
APT System Stepper Motor Drive	DRV 601
APT Stepper Motor Drive Cable (3.0 m)	PAA 613
Stepper Motor Drive Cable Male D-type to Female LEMO converter (3.0 m)	PAA 620
Stepper Motor Drive Cable Female D-type to Male LEMO converter (3.0 m)	PAA 621

Motor Control Method Summary

The 'Motor' ActiveX Control provides the functionality required for a client application to control one or more of the APT series of motor controller units.

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 Motor ActiveX Control can be used to perform activities such as homing stages, absolute and relative moves, and changing velocity profile settings. A brief summary of ech method and property is given below, for more detailed information and individual parameter descriptiond please see the on-line help file supplied with the APT server.

Methods

CalibrateEnc	Calibrates encoder equipped stage.
DeleteParamSet	Deletes stored settings for specific controller.
DisableHWChannel	Disables the drive output.
DoEvents	Allows client application to process other activity.
EnableHWChannel	Enables the drive output.
GetAbsMovePos	Gets the absolute move position.
GetAbsMovePos_AbsPos	Gets the absolute move position (returned by value).
GetBLashDist	Gets the backlash distance.
GetBLashDist_BLashDist	Gets the backlash distance (returned by value).
GetCtrlStarted	Gets the ActiveX Control started flag.
GetDispMode	Gets the GUI display mode.
GetEncCalibTableParams	Gets the encoder calibration table parameters for encoder equipped stages.
GetEncPosControlParams	Gets the encoder position control parameters for encoder equipped stages.
GetEncPosCorrectParams	Gets the encoder position correction parameters for encoder equipped stages.

GetHomeParams	Gets the homing sequence parameters.
GetHomeParams_HomeVel	Gets the homing velocity parameter (returned by value).
GetHomeParams_ZeroOffset	Gets the homing zero offset parameter (returned by value).
GetHWCommsOK	Gets the hardware communications OK flag.
GetHWLimSwitches	Gets the limit switch configuration settings.
GetJogMode	Gets the jogging button operating modes.
GetJogMode_Mode	Get the jogging button operating mode (returned by value).
GetJogMode_StopMode	Gets the jogging button stopping mode (returned by value).
GetJogStepSize	Gets the jogging step size.
GetJogStepSize_StepSize	Gets the jogging step size (returned by value).
GetJogVelParams	Gets the jogging velocity profile parameters.
GetJogVelParams_Accn	Gets the jogging acceleration parameter (returned by value).
GetJogVelParams_MaxVel	Gets the jogging maximum velocity parameter (returned by value).
GetMotorParams	Gets the motor gearing parameters.
GetParentHWInfo	Gets the identification information of the host controller.
GetPhaseCurrents	Gets the coil phase currents.
GetPosition	Gets the current motor position.
GetPosition_Position	Gets the current motor position (returned by value).
GetPositionEx	Gets the current motor position.
GetPositionEx_UncalibPosition	Gets the current uncalibrated motor position (returned by value).
GetPositionOffset	Gets the motor position offset.
GetRelMoveDist	Gets the relative move distance.
GetRelMoveDist_RelDist	Gets the relative move distance (returned by reference).
GetStageAxis	Gets the stage type information associated with the motor under control.
GetStageAxisInfo	Gets the stage axis parameters.
GetStageAxisInfo_MaxPos	Gets the stage maximum position (returned by value).
GetStageAxisInfo_MinPos	Gets the stage minimum position (returned by value).

GetStatusBits_Bits	Gets the controller status bits encoded in 32 bit integer (returned by value).
GetTriggerParams	Gets the move triggering parameters.
GetVelParamLimits	Gets the maximum velocity profile parameter limits.
GetVelParams	Gets the velocity profile parameters.
GetVelParams_Accn	Gets the move acceleration (returned by value).
GetVelParams_MaxVel	Gets the move maximum velocity (returned by value).
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.
LLSetGetDigOPs	Sets or Gets the user digital output bits encoded in 32 bit integer.
LoadParamSet	Loads stored settings for specific controller.
MoveAbsolute	Initiates an absolute move.
MoveAbsoluteEnc	Initiates an absolute move with specified positions for encoder equipped stages.
MoveAbsoluteEx	Initiates an absoloute move with specified positions.
MoveAbsoluteRot	Initiates an absolute move with specified positions for rotary stages.
MoveHome	Initiates a homing sequence.
MoveJog	Initiates a jog move.
MoveRelative	Initiates a relative move.
MoveRelativeEnc	Initiates a relative move with specified distances for encoder equipped stages.
MoveRelativeEx	Initiates a relative move with specified distances.
MoveVelocity	Initiates a move at constant velocity with no end point.
SaveParamSet	Saves settings for a specific controller.
SetAbsMovePos	Sets the absolute move position.
SetBLashDist	Sets the backlash distance.
SetChannelSwitch	Sets the GUI channel switch position.
SetDispMode	Sets the GUI display mode.
SetEncCalibTableParams	Sets the encoder calibration table parameters for encoder equipped stages.
SetEncPosControlParams	Sets the encoder position control parameters for encoder equipped stages.

SetEncPosCorrectParams	Sets the encoder position correction parameters for encoder equipped stages.
SetHomeParams	Sets the homing sequence parameters.
SetHWLimSwitches	Sets the limit switch configuration settings.
SetJogMode	Sets the jogging button operating modes.
SetJogStepSize	Sets the jogging step size.
SetJogVelParams	Sets the jogging velocity profile parameters.
SetMotorParams	Sets the motor gearing parameters.
SetPhaseCurrents	Sets the coil phase currents.
SetPositionOffset	Sets the motor position offset.
SetPotParams	Sets the velocity control potentiometer parameters (Cube drivers).
SetRelMoveDist	Sets the relative move distance.
SetStageAxisInfo	Sets the stage axis parameters.
SetTriggerParams	Sets the move triggering parameters.
SetVelParams	Sets the velocity profile parameters.
ShowSettingsDlg	Display the GUI Settings panel.
StartCtrl	Starts the ActiveX Control (starts communication with controller)
StopCtrl	Stops the ActiveX Control (stops communication with controller)
StopImmediate	Stops a motor move immediately.
StopProfiled	Stops a motor move in a profiled (decelleration) manner.

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.
DisplayMode	Allows the display mode of the virtual display panel to be set/read.
HWSerialNum	specifies the serial number of the hardware unit to be associated with an ActiveX control instance.

Products and Customer Support

Optical and Opto-mechanical Components

Optical mounts and rails

Lenses, prisms and filters

Polarization-optics

Laser diodes

Standard and specialized optical fibers

Optics, laser & fiber accessories

Test- and Measurement Systems

High precision current and TEC controllers for laser diodes

Highly stable, tunable laser diodes with integrated electronics

Optical powermeters

Fabry-Perot interferometer and spectrum analyzers

Polarization analyzer and controller systems

Optical Tables and Vibration Control

Optical tables and protection systems

Vibration damping systems

Optical breadboards and vibration isolated workstations

Nanopositioning Systems

Manual, motor- and piezo-driven translators, stages and mounts

Electronic stepper motor and piezo controllers

Integrated multi-axis positioning systems at sub-micron to nanometer scale

Laser Systems

External cavity laser sources

Ultra broadband laser sources

Femtosecond laser sources

Optical amplifiers

HeNe lasers

THORLABS

Technical Support

Thorlabs provide a comprehensive after sales service. Contact us through your local representative, or at the address below:

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Fax: +44 (0) 1353 654444

email: techsupport.uk@thorlabs.com

Customer Feedback

It is always helpful to have detailed and accurate information about any problems encountered by customers

We welcome comments or suggestions about any aspect of the equipment and instruction handbooks.

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