THORLABS

KPA101
Beam Position Aligner

Kinesis® User Guide



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Chapter 1 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 throughout the handbook and on the equipment itself.

Shock Warning

Given when there is a risk of injury from electrical shock.

Warning

Given when there is a risk of injury to users.

Caution

Given when there is a risk of damage to the product.

Note

Clarification of an instruction or additional information.

1.2 General Warnings

Warnings

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. In particular, excessive moisture may impair operation.

Spillage of fluid, such as sample solutions, should be avoided. If spillage does occur, clean up immediately using absorbent tissue. Do not allow spilled fluid to enter the internal mechanism.

Stable, closed loop operation can only be achieved with continuous wave (CW) lasers. This product is not recommended for use with Pulsed Lasers.

Chapter 2 Overview and Setup

2.1 Introduction

The KPA101 beam position aligner K-Cube is designed to work with the Thorlabs PDP and PDQ series detector heads. As a member of the K-Cube family of controllers this unit benefits from a unified software interface, USB connectivity, very compact footprint and compatibility with the K-Cube Hub System. It is particularly useful in laser beam alignment, position monitoring and beam stabilization applications.

The detector head outputs signals that sense the position and intensity of the light beam hitting the photo detector array. The KPA101 allows monitoring of these signals and gives a visual indication of the position of the beam, both via the top panel display and the software Graphical User Interface (GUI).

The unit features three main operating modes - Monitor, Open loop and Closed loop. In Monitor mode, the unit outputs the XDiff, YDiff and Sum signals from the detector array for use in a monitoring application. In open loop mode the XOut and YOut position demand output signals can be turned off, to allow the mirrors to be positioned manually.

This position aligner K-Cube also benefits from a closed loop mode. In closed loop operation the unit can be configured to drive out a pair of position demand analog signals. In typical applications these signals can be used to control the positioning of a motorized or piezo driven turning mirror in an optical system. The DSP processor within the unit runs two independent feedback loops, one for each axis of the detector head. These feedback loops attempt to zero out the X and Y difference signals by manipulating the position of the turning mirror to center the beam on the quad detector head. Full PID parameterisation of these feedback loops allow the system to be tuned to a wide variety of beam alignment applications.



Fig. 2.1 K-Cube Position Aligner (Shown Without Base Plate Fitted)

For convenience the footprint of this unit has been kept to a minimum, measuring only 60 mm x 60 mm x 47 mm (2.4" x 2.4" x 1.8") and with the ability to directly mount to the optical table close to the device under control. Table top operation also allows minimal drive cable lengths for easier cable management. All controls are located on the top face of the unit – very useful when manually adjusting devices and monitoring the positions via the easy to interpret 'Target' display.

USB connectivity provides easy 'Plug and Play' PC controlled operation - multiple units can be connected to a single PC via standard USB hub technology or by using the K-Cube Controller Hub for multi-axis motion control applications. Coupling this with the user friendly Kinesis® software (supplied) allows the user to get up and running in a short period of time. Advanced custom motion control applications and sequences are also possible using the extensive programming environment also supplied. This programming library is compatible with many development tools such as Python, LabView, Visual Basic, Visual C++, C++ Builder, LabWindows/CVI and Delphi.

Important Note

For convenience and consistency, all system descriptions and examples throughout this manual assume that the KPA101 is used with a pair of KPC101 K-Cube Piezo Controllers. It is also possible to use the MDT693B or BPC303 controllers, or a 3rd party piezo amplifier, or even a non-piezo actuated positioning element, as long as they have suitable low voltage external control inputs and a manual adjustment facility.

2.2 Power Options

For power, a compact two-way power supply unit (TPS002) is available from Thorlabs allowing up to two K-Cube Piezo Drivers to be powered from a single mains outlet. This power supply unit is also designed to take up minimal space and can be mounted to the optical table in close proximity to the driver units, connected via short power leads. For multiple cube systems, a 3-channel (KEH3) or 6-channel (KEH6) K-Cube Controller Hub are offered. Previous generation 3- and 6-channel controllers (KCH301 and KCH601, respectively) may also be used, but are no longer available for individual purchase. These products have been designed specifically with multiple K-Cube operation in mind in order to simplify issues such as cable management, power supply routing, multiple USB device communications and different optical table mounting scenarios.

The K-Cube Controller Hub comprises a slim base-plate type carrier with electrical connections located on the upper surface to accept the K-Cubes.

Internally the Controller Hub contains a fully compliant USB 2.0 hub circuit to provide communications for all K-Cubes – a single USB connection to the Controller Hub is all that is required for PC control. The Controller Hub also provides power distribution for the K-Cubes, requiring only a single power connection.

2.3 Kinesis Software Overview

2.3.1 Introduction

The K-Cube range of controllers share many of the benefits including USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development.

The Kinesis software suite provides a flexible and powerful PC based control system both for users of the equipment and software programmers aiming to automate its operation.

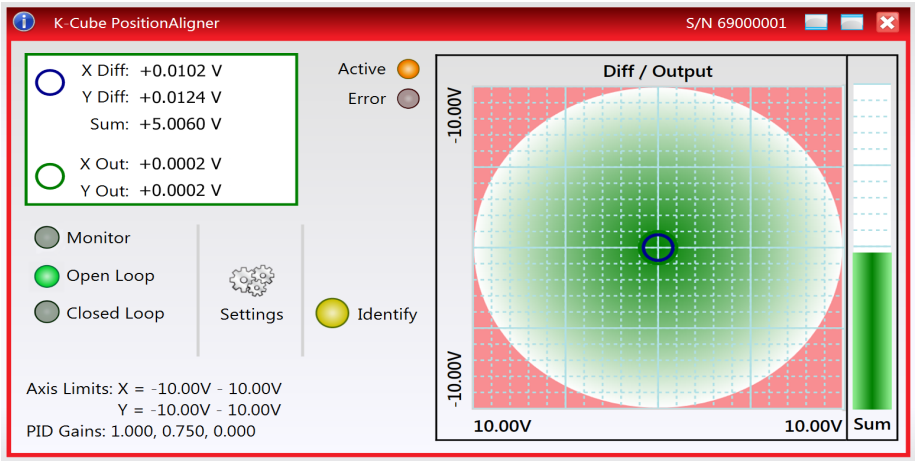
The User Interface allows full control of all settings and operating modes enabling complete 'out-of-box' operation without the need to develop any further custom software. It provides all of the necessary system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware troubleshooting. The Kinesis server is also used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The server is described in more detail in the following section.

2.3.2 Kinesis Server

Kinesis 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 Kinesis system, .Net Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the Piezo K-Cube. Software applications that use .Net Controls are often referred to as 'client applications'. A .Net Control is a language independent software component. Consequently the 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, VB.NET, C#.NET and, via VBA, Microsoft Office applications such as Excel and Word.

Consider the Control supplied for a KPA101 position aligner (one panel is displayed for each controller).



This Control provides a complete user graphical instrument panel to allow the 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 control operations to be automated by a client application. The instrument panel reflects the current operating state of the position aligner unit to which it is associated (beam position and SUM value). 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 Quad Detector Control to centralize the laser beam within the quad detector photodiode array, progress is monitored automatically by changing position on the spot display without the need for further programming intervention.

The Kinesis software provides a rich set of graphical user panels and programmable interfaces allowing users and client application developers to interact seamlessly with the hardware. Each of the controllers has an associated GUI Control and these are described fully in the manual for the associated controller.

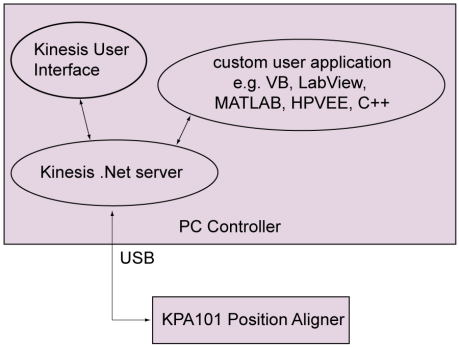


Fig. 2.2 System Architecture Diagram

Refer to the main Kinesis Software online help file for a complete programmers guide. This is available either by pressing the F1 key when running the Kinesis server or via the Start menu, Start\Programs\Thorlabs\Kinesis\Kinesis Help.

2.3.3 Software Upgrades

Thorlabs maintains a policy of continuous product development and may issue software upgrades as necessary. The latest software can be downloaded from the 'Software Downloads' section of www.thorlabs.com.

Chapter 3 Initial Installation

3.1 Install The Software

Note

This section is applicable only if the K-Cube is to be used with a PC. If your application consists only of local operation via the K-Cube front face, proceed to Section 3.2

When operating via a PC, direct user interaction with the unit is accomplished through intuitive graphical user interface panels (GUIs), which expose all key operating parameters and modes. The user can select multiple panel views displaying different information about a particular hardware unit. The multitasking architecture ensures that the graphical control panels always remain live, showing all current hardware activity.



Caution



Some PCs may have been configured to restrict the user's ability to load software, and on these systems the software may not install/run. If you are unsure about your rights to install/run software, please consult your system administrator before attempting to install.

If you experience any problems when installing software, contact Thorlabs and ask for Technical Support.

DO NOT CONNECT THE CONTROLLER TO YOUR PC YET

1) Go to Services/Downloads at www.thorlabs.com and download the Kinesis software.
2) Run the .exe file and follow the on-screen instructions.

3.2 Mechanical Installation

3.2.1 Environmental Conditions

Warning

Operation outside the following environmental limits may adversely affect operator safety.

Location	Indoor use only
Maximum altitude	2000 m
Temperature range	5 °C to 40 °C
Maximum Humidity	Less than 80% RH (non-condensing) at 31 °C

To ensure reliable operation the unit should not be exposed to corrosive agents or excessive moisture, heat or dust.

If the unit has been stored at a low temperature or in an environment of high humidity, it must be allowed to reach ambient conditions before being powered up.

3.2.2 Mounting Options

The K-Cube Position Aligner is shipped with a baseplate for use when fitting the unit to a breadboard, optical table or similar surface - see Section 3.2.3

For multiple cube systems, a 3-channel (KEH3) or 6-channel (KEH6) K-Cube Controller Hub are offered. Previous generation 3- and 6-channel controllers (KCH301 and KCH601, respectively) may also be used, but are no longer available for individual purchase. See Section 2.2 for further details. Full instructions on the fitting and use of the controller hub are contained in the manual for the units, available at www.thorlabs.com.

Caution

When siting the unit, it should be positioned so as not to impede the operation of the control panel.
Ensure that proper airflow is maintained to the unit.

3.2.3 Using the Baseplate

The baseplate is supplied with magnets for quick positioning on an optical work surface. For more secure positioning, it can be bolted to the work surface before the K-Cube is fitted, as shown below. The K-cube is then located on two dowels in the baseplate and secured by two clips.

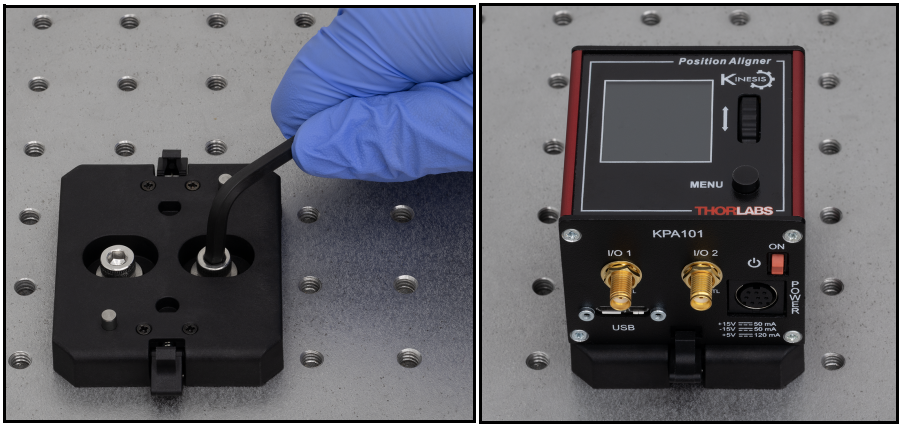


Fig. 3.1 Using The Baseplate

3.3 Electrical Installation

3.3.1 Rear Panel

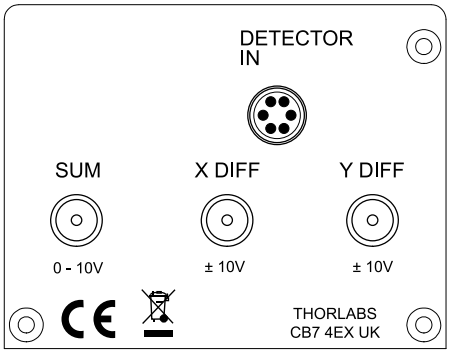


Fig. 3.2 Rear Panel Connections

DETECTOR IN – used to connect the detector (compatible with Thorlabs PDQ and PDP series detectors) - see Section A.2 for pin out details.

SUM, X DIFF and **Y DIFF** (Female SMA connectors) – Used to output the signals from the detector to the rest of the system. Typically, the sensor head is a quad photodiode

array that provides top-minus-bottom (Y-Axis alignment) and left-minus-right (X-Axis alignment) difference signals (-10 V to +10 V). These two difference signals are voltage analogs of the light intensity difference sensed by the pairs of photodiode elements in the array. Additionally, the sensor provides a signal that is the sum of signals (total beam power) from all four quadrants (0 to 10 V).

The signal present on the X DIFF and Y DIFF terminals depends on the operating mode selected (Monitor, Open Loop or Closed Loop - see Section 4.5).

Note

Throughout this document, references to the XDIFF and YDIFF signals follow the general mathematical convention of drawing graphs, so the positive values are on the right hand side and upper half of the X-Y plane. However, as a voltage coming from the sensor (and measured on the rear panel SMA output connectors in monitor mode), XDIFF is inverted, so the voltage becomes more negative as the beam is moving from left to right. The equations describing the detector heads also show this fact.

The SUM signal from the detector is always present on the rear panel SUM SMA connector irrespective of the operating mode selected. This signal is proportional to the total amount of light hitting the detector.

Note

Thorlabs supply a variety of SMA to BNC and SMC to BNC adaptor and extension cables. Please visit www.thorlabs.com for further details.

3.3.2 Supply Voltage and Current Requirements

Supply	Minimum	Maximum	Max Operating Current
+5 V	+4.9 V	+5.1 V	120 mA
+15 V	+14.5 V	+15.5 V	50 mA
-15 V	-14.5 V	-15.5 V	50 mA

3.3.3 Front Panel

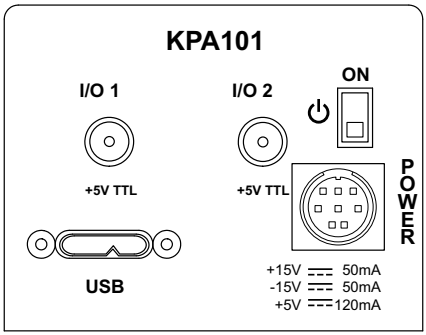


Fig. 3.3 Front Panel Power Supply Connections

Shock Warning

The unit must be connected only to a DC supply as detailed in Section 3.3.2 Connection to a supply of a different rating may cause damage to the unit and could result in injury to the operator.

POWER - Eight pin connector for connecting the unit to a regulated DC power supply of the rating detailed in Section 3.3.2

Thorlabs offers a compact power supply unit (TPS002), allowing up to two K-Cubes to be powered from a single mains outlet.

USB - USB port for system communications.

Note

The USB cable length should be no more than 3 meters unless a powered USB hub is being used.

ON - Power ON/Standby switch. When in the ON position, the unit is fully powered up. When the switch is turned to the Standby position, the unit initiates a controlled power down sequence, saving all user-adjustable parameters to non-volatile memory before turning off the power. For the first few seconds, the shutdown can be cancelled by turning the switch on again, in which case the unit will save the parameters but will remain powered up. In a powered down (Standby) state, the logic circuits are powered off and the unit will draw only a small quiescent current. The switch should always be used to power down the unit.

I/O 1 and I/O 2 - SMA connectors for use with external trigger input and output signals (5 V TTL levels). The function is set to trigger IN or OUT via the settings panel - see Section 6.2.4

3.3.4 Connecting To A Standalone Power Supply

Warning

The unit must be connected only to a DC supply as detailed in Section 3.3.2 Connection to a supply of a different rating may cause damage to the unit and could result in injury to the operator.

Caution

Do not connect the K-Cube unit to a 'live' external power supply. Doing so (i.e. "hot plugging") carries the risk of PERMANENT damage to the unit. Always ensure the DC power supply unit is isolated from the mains before connecting to the K-Cube unit. Always power up the units by connecting their power supply to the mains. Similarly, to power down the unit, disconnect the power supply from the mains before disconnecting the K-Cube.

1) Using the front panel connector as shown above, connect the unit to a regulated DC power supply of the rating detailed in Section 3.3.2
2) Switch on the Power Supply unit.

Thorlabs offers a compact, two-way power supply unit (TPS002), allowing up to two position aligner or Piezo driver K-Cubes to be powered from a single mains outlet. However, if an external supply is to be used, see Appendix A.1 for power supply connector pin out details.

Caution

If an external power supply is used, ensure that the 3 supply voltages are turned on and off simultaneously. Applying the supply voltages with a large (more than 1 second) time delay between them can result in the position aligner cube showing an incorrect reading.

Chapter 4 Getting Started - Basic Operation

4.1 Introduction

The KPA101 K-Cube position aligner interfaces with the Detector Sensor Head and can be used either to measure the position of the beam on the sensor or to generate a signal that can be used as the feedback input for an automated beam steering element. The signal generated can be used to steer the beam to the center of the position aligner sensor. This active feedback system is particularly useful in beam stabilization applications.

Throughout this section, the sensor described is a PDQ80A quad detector. However, the KPA101 unit is also compatible with other Thorlabs detectors, such as the PDQ30C IR detector head or the PDP90A Lateral Effect Detector.

4.1.1 Overview - Typical System Example

The system comprises a KPA101 position aligner K-Cube, a Sensor Head and two KPC101 Piezo Drivers, together with the associated piezo-actuated stage, turning mirror and laser source (see Fig. 4.1). The objective of the system is to position and hold the laser beam centrally within the detector array.

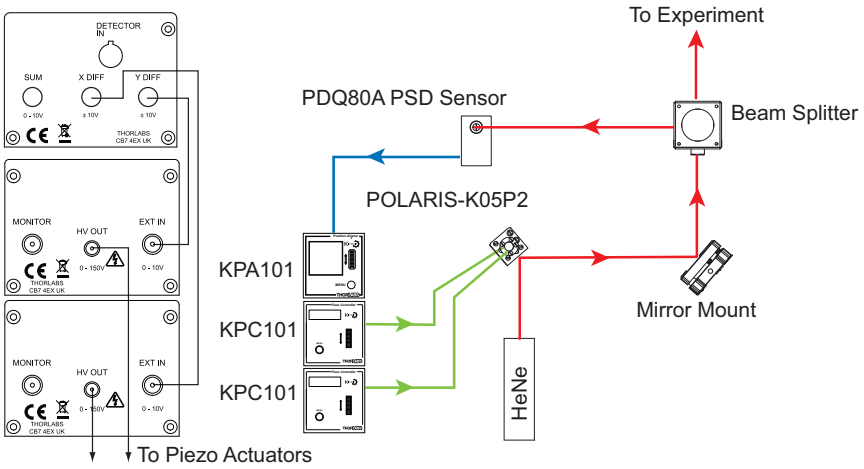


Fig. 4.1 Typical Stand Alone Set Up

The unit is first set to open loop mode. The turning mirror is adjusted manually to position the laser beam within the detector array. The position aligner unit reads the signal from the PDQ80A photodiode sensor to indicate the position of the beam on the target display. When set to closed loop mode, the quadrant reader K-Cube sends a pair of position demand signals to the piezo drivers, which control the position of the piezo turning mirror.

In order for the system to operate correctly in different applications, various software settings (explained in Section 6.2) may need to be adjusted. However, the default settings should allow the position aligner to be operated, in most cases, straight out of the box without the need for a PC.

4.2 Detector Head Descriptions

The KPA101 unit is compatible with quadrant detector heads and lateral effect sensors. Quadrant detectors are used primarily for beam alignment whereas lateral effect sensors are normally used for position measurement. However, the KPA101 can be used with either type of sensor for both auto-alignment and position measurement. Both types of sensor output three voltages (XDiff, YDiff and SUM) that are proportional to the position of the beam and the total optical power, however, lateral effect sensors like the PDP90A have a defined accurate relationship between these three voltages. Furthermore, if the user selects the PDP90A sensor type in the settings panel (see Section 6.2) the display shows the XPos and YPos values in millimeters, whereas if the PDQ80A or PDQ30C sensor type is selected, the display shows the XDiff and YDiff values that the sensor outputs in Volts. The KPA101 reads the voltages for both sensor types, but for the PDP90A sensor it can actually calculate the X and Y positions from these voltages.

4.2.1 PDQ80A and PDQ30C Quadrant Detector Heads

The PDQ80A and PDQ30C are quad photodiode arrays that provide top-minus-bottom (Y-Axis alignment) and left-minus-right (X-Axis alignment) difference signals. Additionally, the sensors provide a signal that is the sum of signals (total beam power) from all four quadrants. The two difference signals are voltage analogs of the light intensity difference sensed by the pairs of photodiode elements in the array. These three signals are sent in analog form to the KPA101 position aligner via its rear panel DETECTOR IN (6-pin HRS) connector.

X-axis sensor: (Q2 + Q3) - (Q1 + Q4)
Y-axis sensor: (Q1 + Q2) - (Q3 + Q4)
SUM: (Q1 +Q2 + Q3 + Q4)

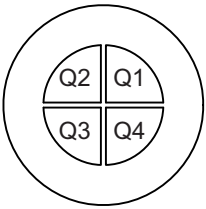


Fig. 4.2 Photodiode Array Details

4.2.2 PDP90A Lateral Effect Sensor

The PD90A lateral effect position sensor is sensitive to the position of the beam independent of the power density or beam shape. The sensing element has four anode electrodes bonded to the surface (A, B, C & D below).

One cathode electrode is connected to the back surface, which is covered with resistive material. When radiation is incident upon the sensor, a photocurrent is generated at that position and it is proportional to the incident light energy. The photocurrent is proportionally distributed between the four electrodes on the front surface relative to the position of the light spot on the sensor. A transimpedance amplifier is used to create measurable voltages. These values are used to calculate the position using the equations below.

$$X\,Diff = (B+C) - (A+D)$$
$$Y\,Diff = (A+B) - (C+D)$$
$$SUM = A+B+C+D$$

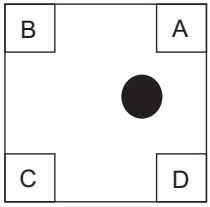


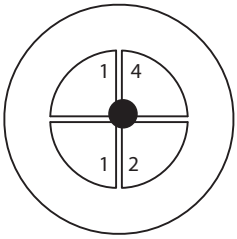
Fig. 4.3 Lateral Effect Sensor

4.2.3 Use of the Sum and Difference Signals for Alignment

Note

In the general mathematical convention of drawing graphs, the positive values are on the right hand side and upper half of the X-Y plane. However, as a voltage coming from the sensor (and measured on the rear panel SMA output connectors in monitor mode), XDIFF is inverted, so the voltage becomes more negative as the beam is moving from left to right. The equations describing the detector heads also show this fact.

As previously described, the difference signals indicate the beam position on the detector in the X and Y axes. The sum signal is used to 'normalize' the difference signals in relation to beam power. For example, consider the situation below, where the beam is positioned in the upper right hand quadrant of the detector. In this case, the XDiff and YDiff signals may be '-4' and '2' respectively, with a sum value of '8'.



X-axis sensor: (Q2 + Q3) - (Q1 + Q4), so XDIFF = (1 + 1) - (4 + 2)
Y-axis sensor: (Q1 + Q2) - (Q3 + Q4), so YDIFF = (4 + 1) - (1 + 2)

SUM: (Q1 +Q2 + Q3 + Q4) = 8

If the beam power were to be reduced by half, due perhaps to the fitting of a filter, the XDiff and YDiff values would then be '-2' and '1' respectively. Viewed in isolation, these values indicate that the spot has moved nearer to the center. It is only when the values are 'normalized' and considered together with the sum value, now '4', that the true picture becomes apparent.

The sum output signal may be used to provide preliminary alignment of the sensor to the source light beam. First, the beam position is adjusted for maximum sum output signal. Second, the beam position is adjusted until the X-Axis (XDIFF) and Y-Axis (YDIFF) difference signals are at minimum. This procedure results in the beam being centered on the quad photodiode array. See Section 4.6.3 for a description of how this procedure is implemented using the KPA101 position aligner cube.

4.2.4 A Note About Bipolar Voltage Outputs

The KPA101 has a ±10 V bi-polar output and is generally used with a KPC101 piezo driver which has 0+10 V.

The specified 0..+10 V input range for the KPC101 analogue (SMA) input means that, if there is no other contribution from the other two controlling sources (i.e. the software controlled DAC and the potentiometer), then a 0 to +10 Volt input will result in a 0… full range output voltage. So, assuming that the KPC101 is used in the 150 Volt range, the 0.. +10 V input corresponds to 0…150 Volt output.

However in the KPC101 unit, there are three input sources (SMA, DAC and potentiometer) that are added together to generate an output voltage. So for example, if the input contribution of the DAC is +5 Volt and you drive the SMA input with -5 Volt, then the effect of this is zero output. In other words, from an electrical point of view the input accepts both positive and negative voltages and, as long as their sum is a positive voltage, the KPC101 will work correctly.

In a closed loop system, the KPA101 acts like the controller and can output a positive voltage to increase the output voltage of the KPC101 (make it more positive), or output a negative voltage to decrease it. Normally the output of the KPC101 is offset in open loop to about mid-range and the KPA101 controls the position by increasing or decreasing the KPC101 output to maintain a fixed position. This requires a bipolar output voltage, like that produced by the KPA101.

4.2.5 Beam Size Considerations

The light spot applied to the sensor must be smaller than the diameter of the sensor photodiode array, and the recommended beam diameters are as follows:

PDQ80A - 1 to 3.9 mm, PDP90A - 0.2 to 7 mm, PDQ30C - <0.5 mm.

A decrease in output signal strength is observed as the light spot crosses the separation boundary of the sensor arrays, usually referred to as 'the gap'. This effect is more pronounced as the diameter of the light spot decreases since a larger percentage of the light spot's power falls within the non-active gap. For this reason, it is recommended that a lens be used to adjust the size of the beam to fall between the min and max dimensions quoted above.

4.2.6 Sensor Data Precision

The precision of the beam alignment data for a sensor is dependent on the beam size, beam geometry, and beam power density characteristics. Given a beam size and geometry that fits within the recommended diameter of the sensor, a zero value for both the X and Y difference signals indicates the beam is centered with respect to power density (i.e. the center of power) which may not be the geometric center of the beam.

Apart from beam alignment, the actual beam position relative to true alignment can only be determined if the beam size, beam geometry, and beam power density gradient are well understood. Beam alignment is best achieved for a stable circular beam with a diameter as stated above, and a uniform power density over the beam area.

4.2.7 Temperature Considerations

The operating temperature must be between 10 to 40 °C. For best resolution, the temperature should be kept at or below 25 °C. Thermal gradients across the detector will cause position errors and should be avoided.

4.3 Control Panel Buttons and Indicators

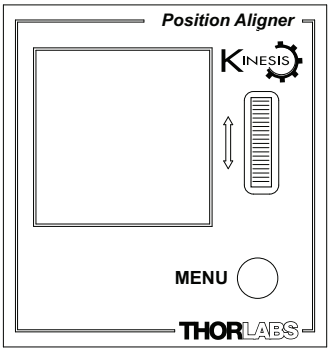


Fig. 4.4 Panel Controls and Indicators

These controls allow all operations to be initiated.

Wheel - Used to move through the various set up menu options - see Section 4.5

Digital Display - Under normal operation, the display shows the horizontal and vertical position of the laser beam within the detector sensor array, together with the X-Diff and Y-Diff values, see Section 4.3.1 It also shows the menu options and settings, accessed via the menu button - see Section 4.4 When the Ident button on the associated GUI panel is clicked, the display will flash for a short period.

MENU - used to access the settings menu - see Section 4.4

4.3.1 Digital Display - Operating Mode

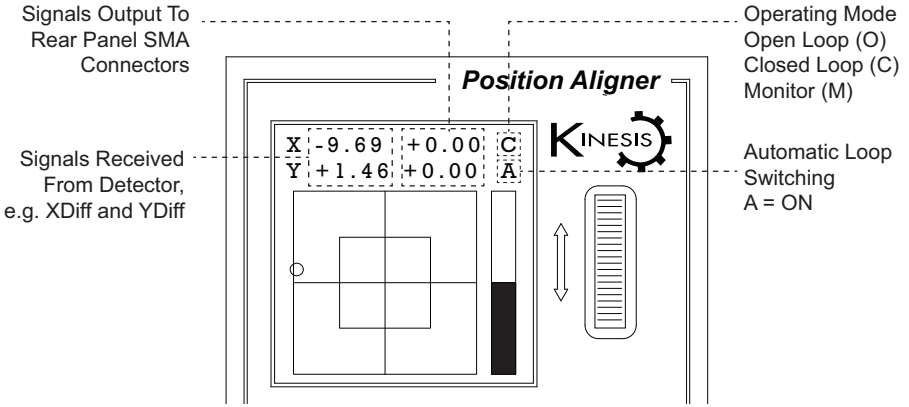


Fig. 4.5 Digital Display - Normal Operation

During normal operation, the top two lines of the digital display show the X-axis and Y-axis I/O values. The left hand side shows the signals being received from the detector. If a PDQ series position aligner head is connected, the display shows the XDiff and YDiff values in Volts. If a PDP series Lateral Effect sensor is connected, the display shows the XPos and YPos values in mm - see Section 4.2 The values are relative to the center of the screen (0 V). These signals represent the output from the rear panel the XDIFF and YDIFF SMA connectors when operating in Monitor mode.

The right hand side shows X and Y axis position demand output values (XOut & YOut), which are applicable only in open loop and closed loop modes. These values represent the signals sent to the rear panel SMA connectors, which are then used by positioning elements (e.g. piezo drivers) to drive the mirror in order to keep the beam centered on the detector.

The last digit on the top line denotes the operating mode; C (Closed loop), O (Open Loop) or M (Monitor). The last digit on the second line shows ‘A’ if automatic switching from Closed to Open loop is selected - see section Section 6.2.4

The lower ‘target’ area shows the horizontal and vertical position of the laser beam within the detector sensor array.

The detector head provides top-minus-bottom (Y-Axis alignment) and left-minus-right (X-Axis alignment) difference signals, together with a signal that is the sum of signals (total beam power) from all four sensors of the internal photodiode array. The two difference signals are voltage analogs of the light intensity difference sensed by the pairs of photodiode elements in the array, and therefore indicate the beam position on the detector in the X and Y axes - see Section 4.2.3 for more details.

The display also shows a bar graph, which represents the SUM value from the detector, in the range 0 to 10.

4.4 Settings Menu

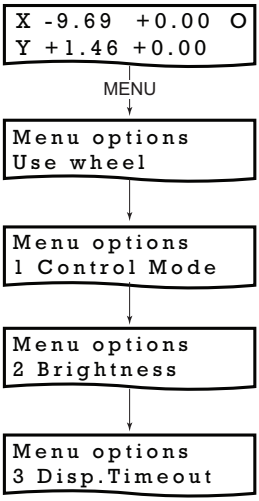
4.4.1 Menu Overview

Press the MENU button.

Use the wheel to scroll through the menu options.
Press the MENU button to enter a particular option.

Set open loop or closed loop mode.

Set the display brightness - see Section 4.4.3.



4.4.2 Menu Option - Control Mode

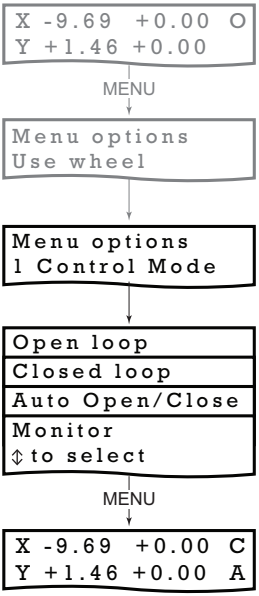
When the K-Cube Auto Aligner is used in conjunction with a positioning unit, high precision closed loop operation is possible.

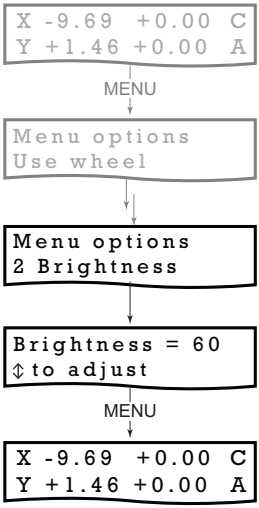
Press the MENU button.

Use the wheel to scroll through the menu options.

Press the MENU button to enter the 1 Control Mode option.

Use the wheel to scroll through the options - see Section 4.5 for more details, then press the MENU button to store the selection and return to the main display.





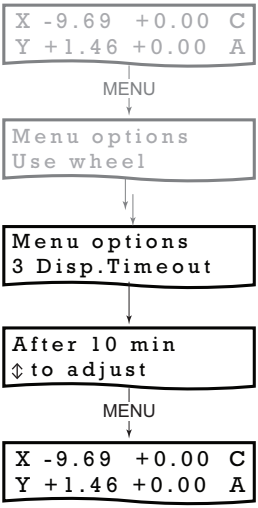
4.4.3 Menu Option - Brightness

In certain applications, it may be necessary to adjust the brightness of the LED display. The brightness is set as a value from 0 (Off) to 100 (brightest). The display can be turned off completely by entering a setting of zero, however, pressing the MENU button on the top panel will temporarily illuminate the display at its lowest brightness setting to allow adjustments. When the display returns to its default operating display mode, it will turn off again.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Brightness option.

Use the wheel to adjust the brightness, then press the MENU button to store the selection and return to the main display.



4.4.4 Menu Option - Disp.Timeout

'Burn In' of the display can occur if it remains static for a long time. To prevent this, the display is automatically dimmed after a specified time interval.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Disp.Timeout option.

The time out interval is specified in minutes in the range 1 to 480. The adjustment is done in steps of 1 minute if the timeout is between 1 to 10 minutes, 10 minute steps between 10 minutes and 1 hour, and 30 minute steps above, up to a maximum of 480 minutes. After 480 minutes there is an option for Never.

The dim level can only be adjusted via the Settings panel - see Section 6.2.2

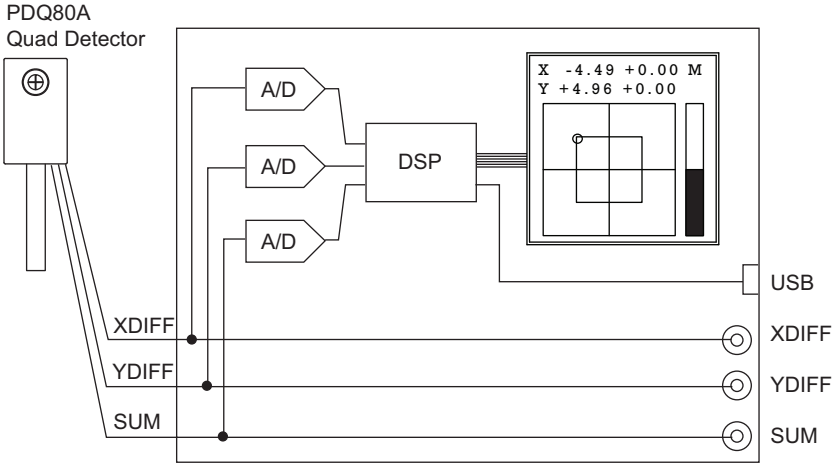
Press the MENU button to store the selection and return to the main display.

4.5 Operating Modes

The operating mode can be set via the Settings menu (see Section 4.4), or by via the GUI panel (see Section 6.1).

4.5.1 Monitor Mode

When operating in 'Monitor' mode, the X axis (XDIFF) and Y axis (YDIFF) difference signals from the detector are fed through to the rear panel SMA connectors for use in a monitoring application - see Fig. 4.6.



MONITOR MODE: The XDIFF, YDIFF and SUM signals are routed to the corresponding SMA connectors.
The DSP *monitors* the position of the light beam and measures the XDIFF, YDIFF and SUM signals.

Fig. 4.6 MONITOR Mode Schematic Diagram

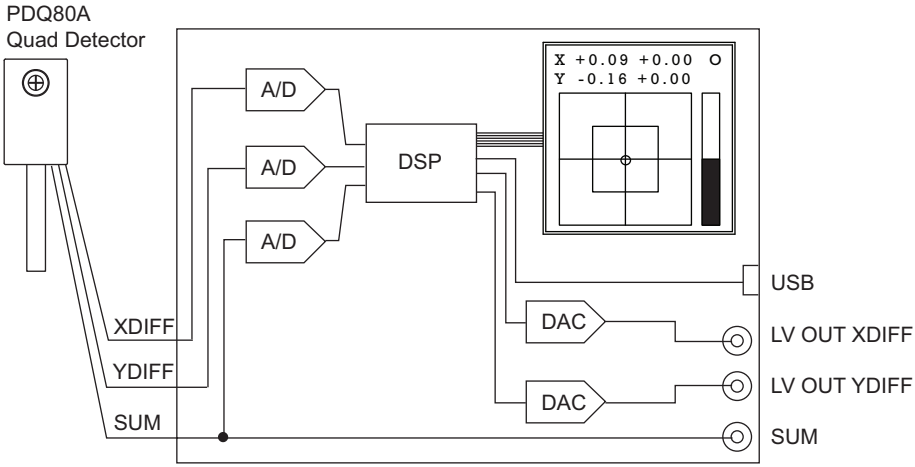
Note

In Monitor mode, the XDIFF and YDIFF outputs are not normalized with SUM. Instead, they output the corresponding signals coming from the position sensitive detector but there is no further signal processing. Normalization is only used for display purposes, to calculate where the light beam hits the sensor.

Background: the position sensitive detector heads (PDP90A, PDQ80A) output three analogue signals: XDIFF and YDIFF and SUM. Due to the physics of the photodiodes used in these position sensors, the magnitude of the XDIFF and YDIFF signals are not only proportional to the position of the light beam (in x and y directions, respectively) but to the optical power as well. To calculate the actual real position of the beam, the XDIFF and YDIFF signals are divided by SUM and this is what the GUI displays as the beam position.

4.5.2 Open Loop Mode

When in 'Open Loop' mode, the signals on the rear panel XDIFF and YDIFF connectors now represent the XOut and YOut position demand signals, used to position the beam steering element. These signals are either fixed at zero (0 V), or held at the last Closed Loop value (depending on the '*Position Demands In Open Loop Mode*' parameter in the Settings panel - see Section 6.2) - see Fig. 4.7. This is useful when the system is being adjusted manually, to position the light beam within the detector array.



OPEN LOOP MODE: The XDIFF and YDIFF signals are routed to the DSP. The DSP either sets the outputs to zero, or holds them at their last closed loop voltage (dependent on the setting of the '*Position Demand In Open Loop Mode*' parameter in the Settings panel).

CLOSED LOOP MODE: The XDIFF and YDIFF signals are routed to the DSP. The DSP implements a PID control loop for each axis. The resulting position demand signals (XPos YPos) are routed, via the rear panel SMA connectors, to the positioning elements to drive the spot to the center of the detector.

Fig. 4.7 OPEN LOOP and CLOSED LOOP Schematic Diagram

4.5.3 Closed Loop Mode

In 'Closed Loop' mode, the signal from the detector is interpreted by the unit, and the feedback circuit sends position demand signals (XOut and YOut) to the rear panel XDIFF and YDIFF connectors, which can be used to drive a pair of positioning elements (e.g. piezo controllers) in order to position the light beam within the center of the detector array, see Fig. 4.7. For a detailed diagram of the PID loop, see Fig. 4.8.

When the beam is central, the spot will be in the center of the Target display.

Note

In closed loop mode, with the beam central, the X and Y axis difference outputs from the photodiode array are zero. However, the position demand signals on the rear panel XDIFF and YDIFF SMA connectors are whatever value is necessary to drive the positioning elements to center the beam.

Stable, closed loop operation can only be achieved with continuous wave (CW) lasers. This product is not recommended for use with Pulsed Lasers.

4.5.4 Automatic Open Loop/Closed Loop Switching

The controller is capable of switching automatically between open loop and closed loop operating modes, depending on whether there is sufficient optical power required for closed loop operation. Automatic Switching mode can be selected from the top panel settings menu (Closed Loop with Auto - see Section 4.5.2) or by clicking the Enable Auto Open Loop checkbox on the Control Settings panel - see Section 6.2.2

If during closed loop operation the SUM signal falls below the minimum specified in the Trig1 Sum Min parameter, the controller will switch back to open loop mode. If subsequently the SUM signal rises above the limit again, the controller will switch back to closed loop mode.

The automatic switchover works in conjunction with the "Position Demands In Open Loop Mode" option that defines whether the controller will hold (freeze) the XPOS and YPOS outputs when switching over to open loop or set them to zero.

Automatic switchover might be advantageous in scenarios where the beam might be temporarily blocked, for example during experiments involving manual manipulation of optical components, particularly when the beam path is quite long and the beam steering actuator can deflect the beam so far that it falls outside the sensor area. In setups like this and with the controller in closed loop, blocking the beam can result in the feedback loop ramping the XPOS and/or YPOS outputs to saturation and steering the beam completely outside the sensor area. When this happens, restoring the beam will not normally restore the beam alignment as at this point the feedback algorithm does not even see the beam. However, with automatic switchover the loss of light will stop the closed loop operation, optionally freeze the last valid beam position and prevent the outputs ramping up as an unintentional consequence of the loss of feedback signals. Later when the beam is restored, closed loop operation will resume and continue control starting from the last valid beam position.

Note that because automatic switchover assumes the knowledge of the last valid closed loop beam position that is lost when the controller is powered down, this option cannot be persisted. For a similar reason, the controller will always power up in open loop mode.

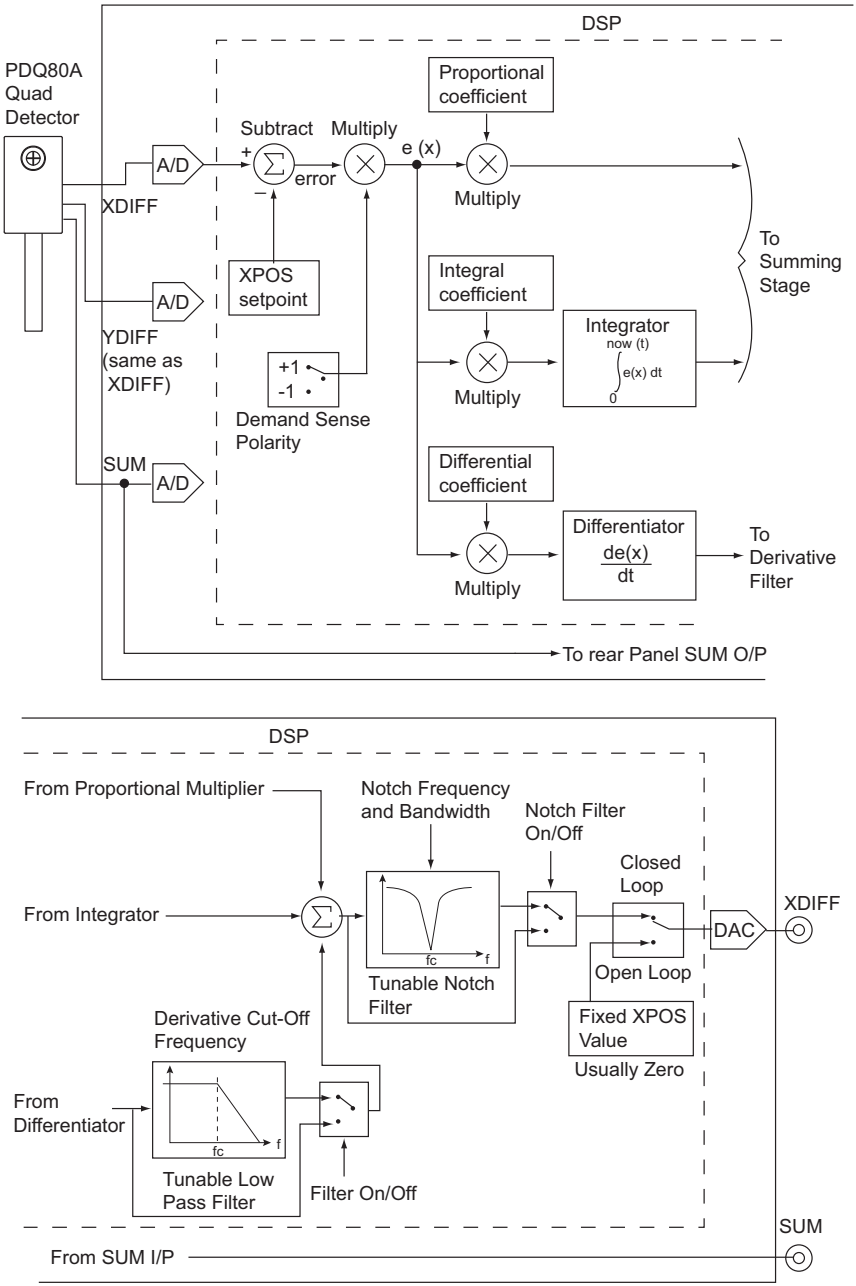


Fig. 4.8 Single Axis PID Control Schematic Diagram

4.6 Basic Application Example

4.6.1 Introduction

It is likely that the KPA101 position aligner will be used as a closed loop controller in a potentially complicated opto-mechanical system. This section illustrates its deployment in a beam stabilization application, and describes the main steps required to build a working closed loop system. The example describes the correct settings for working closed loop operation and can be used as a reference point for more complex practical applications.

4.6.2 Wiring and Initial Set Up

The following procedure describes a typical set up, with the KPA101 position aligner cube being used with a pair of KPC101 piezo driver cubes - see Fig. 4.9 for a typical system schematic diagram.

1) Perform the mechanical installation as detailed in Section 3.2 of this manual and also in the manual supplied with the K-Cube piezo drivers.
2) Connect the X DIFF and Y DIFF terminals on the rear of the position aligner to the associated EXT IN terminals on the rear of the piezo drivers.

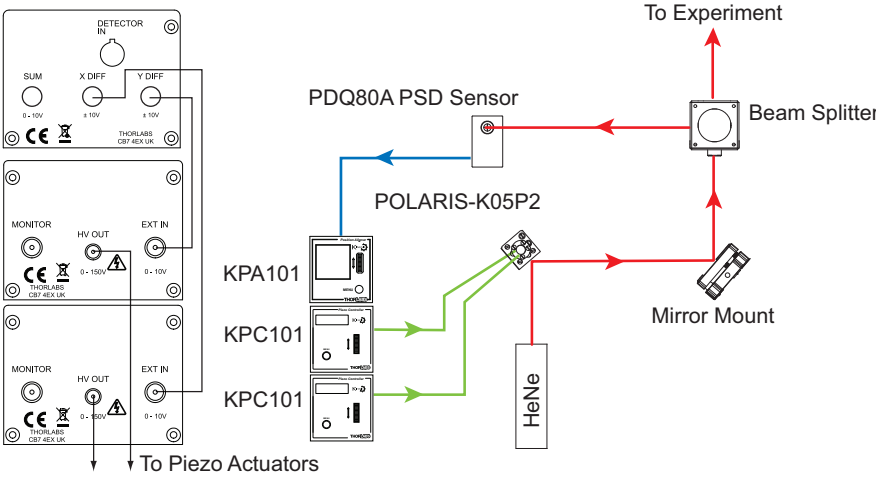


Fig. 4.9 Typical Stand Alone Set Up

3) Connect the HV OUT terminals on the rear of the piezo drivers to the associated piezo actuators.
4) Connect the laser to the laser driver.
5) Install any mechanical components such as mirror holders etc. which may be required in the beam path - see Fig. 4.9 for a typical set up.

Caution

During item (6) ensure the power switch on the front panel of the unit is turned OFF before connecting to the K-Cube units. DO NOT connect the K-Cube units to a 'live' power supply. Doing so (i.e. "hot plugging") carries the risk of PERMANENT damage to the unit. Similarly, to power down the unit, turn the power switch OFF before disconnecting the K-Cube.

6) Connect the position aligner and the piezo units to the power supply - see Section 3.3.2
7) Connect the PSU (Power Supply Unit) to the main supply and switch 'ON'. The version number of the embedded software is displayed on each piezo unit during boot up. The software version is useful when requesting technical support.

4.6.3 Basic Operation

The general procedure involves setting the position aligner to 'Open Loop' and using the manual actuators on the mirror mount to adjust the beam position until the laser beam is within the detector quadrant sensors. Once this initial position is achieved, the position aligner is switched to 'Closed Loop' and the unit controls the piezo drivers which move the piezo mirror to focus the beam in the center of the detector.

1) Power up the system. The unit will boot up in OPEN LOOP mode.
2) Adjust the KPC101 output voltages to mid range (e.g. 37.5 V for a 75 V piezo).
3) Using the manual actuators on the mirror mount, position the laser beam such that it is directed at the center of the detector sensor array, and the spot is in the center of the Target display.
4) Check that the piezo controller connected to the X DIFF connector is driving the X-axis piezo actuator. Turn the control knob on the piezo controller to increase the piezo drive voltage. The laser beam should move along the X-axis with very little Y-axis movement. If the beam moves in the Y-axis, or diagonally, the piezo controller is connected to the wrong actuator.
5) To ensure correct closed loop operation, the Position Demand Sense of the optical system must be checked. An incorrect setting will cause the system to drive to its limit of travel when switched to closed loop.
   When the X-axis piezo voltage is increased, if the spot moves to the left, the

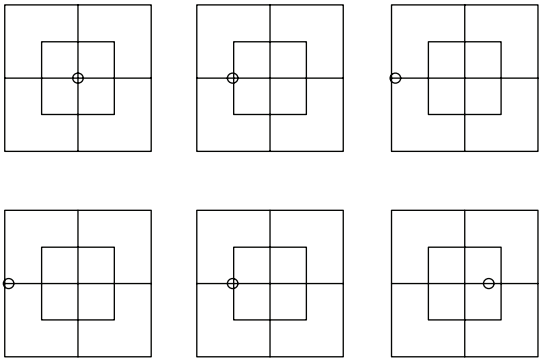
demand sense is positive - see Fig. 4.10. If it moves to the right, the demand sense is negative.

Note

The default settings for the Position Demand Sense is 'Positive', which is correct for the setup shown in Fig. 4.9. If the check described at item (5) shows a negative demand sense, then it will be necessary to connect a PC to change the *Position Demand Sense* parameter in the Settings panel - see Section 6.2

Positive Position Demand Sense Response

Gradually increasing the piezo voltage moves the spot to the left



Gradually decreasing the piezo voltage moves the spot to the right

Fig. 4.10 X-Axis Position Demand Sense Check

6) Check that the piezo controller connected to the Y DIFF connector, is driving the Y-axis piezo actuator. Turn the control knob on the piezo controller to increase the piezo drive voltage. The laser beam should move along the Y-axis with very little X-axis movement. If the beam moves in the X-axis (or diagonally), the piezo controller is connected to the wrong mirror mount axis.
7) When the Y-axis piezo voltage is increased, if the spot moves towards the top, the demand sense is positive. If the spot moves towards the bottom, the demand sense is negative.

Note

The default settings for the Position Demand Sense is 'Positive', which is correct for the setup shown in Fig. 4.9. If the check described at item (7) shows a negative demand sense, then it will be necessary to connect a PC to change the *Position Demand Sense* parameter in the Settings panel - see Section 6.2

8) Press the MODE button on the position aligner to select 'Closed Loop' mode, i.e. the CLOSED LOOP LED is lit.
   The position aligner unit now takes over the alignment and controls the piezo units to drive the piezo mirror to direct the laser beam to the central position. The beam position within the sensor array is indicated by the target display on the top panel.
9) Depending on the position of other components in the system, it is possible that the travel range of the piezo actuators driving the mirror is not sufficient to position the beam on the detector array. In this case, the piezos should be centered and the actuators on the other turning mirrors should be adjusted to reposition the beam - see Section 4.6.6

4.6.4 Signs of Instability

The control loop PID settings allow the system response to be tuned to a particular application. Higher proportional and integral coefficients decrease the residual error in the system and also allow the system to respond more quickly to a disturbance (i.e. the system is able to dampen vibrations at a higher frequency range). However, above a certain level, the system becomes unstable and the integral and proportional coefficients will need to be decreased until the system stabilizes.

Instability in the system may be recognized by the following symptoms:

- Whistling, buzzing or similar noises from the piezo actuators.
- Unstable XOut and YOut values (only visible on the GUI panel).
- Spot not stable in the center of the detector.

Note

The default settings for the PID parameters are correct for the set up shown in Fig. 4.9. If any of the above signs are apparent, it will be necessary to connect a PC to adjust the PID settings in the Settings panel - see Section 6.2

Once the PID parameters have been adjusted, check that the system is unconditionally stable. Tap the work surface to check that the system cannot be provoked into instability by vibration.

4.6.5 Troubleshooting

In summary, the four most common reasons why the system will not operate correctly are:

- A piezo controller is connected to the wrong axis - see Section 4.6.3 Item 4 or 6, or the axes are swapped.
- X-axis or Y-axis Position Demand Sense is set incorrectly - see Section 6.2
- PID constants need adjustment - see Section 6.2
- The 'Drive Input Source' parameter for the piezo unit is set incorrectly - see Section 6.2

4.6.6 Using the Target Display

The 'target' display shows the horizontal and vertical position of the laser beam within the detector sensor array. When used in conjunction with the display on the piezo cubes, it can also be used to show when the piezo actuators are near the ends of their travel and need re-centering. This will require manual adjustments to the turning mirror actuators.

For example, consider the situation shown below, when the unit is in open loop mode and the spot is in the upper right side of the display. This indicates that the laser beam is in the upper right hand quadrant of the detector array. Let's also assume that the piezo drivers controlling the piezo mirror show approximately 10 V.

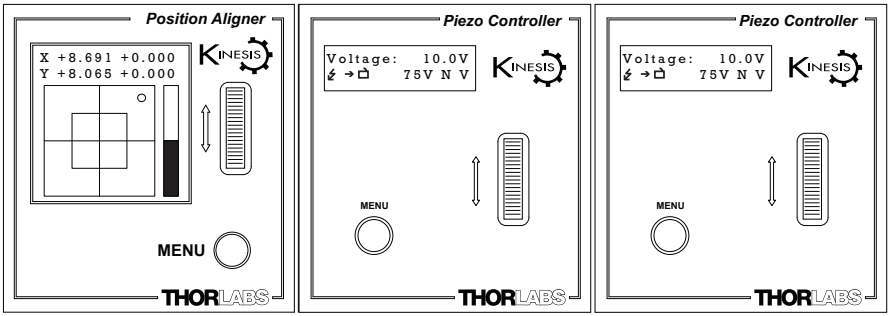


Fig. 4.11 TARGET and VOLTS Displays Showing Values Near Travel Limit

When the unit is switched to closed loop mode, the spot moves towards the center of the display, as the piezo units drive the piezo mirror to reposition the laser beam.

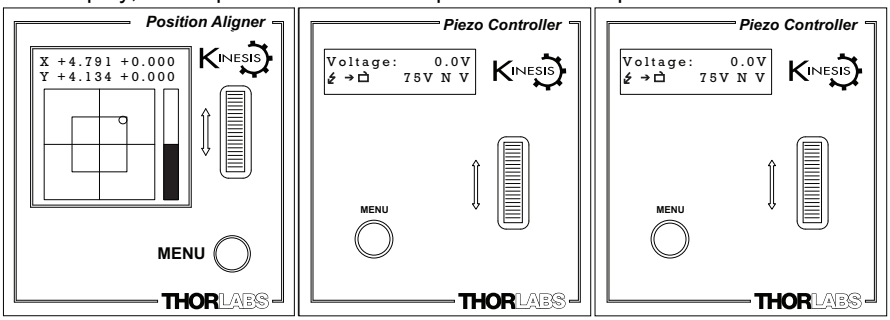


Fig. 4.12 Repositioning the Laser Beam

But the piezo units now show 0 V which means that the piezos are at the limit of their travel and cannot drive the piezo mirror further. The piezo actuators must be recentered (i.e. OUTPUT pot adjusted for 37.5 V display), and the position error taken up by manual adjustment.

1) Press the MENU button on the position aligner and select ‘Open Loop’ mode.
2) Adjust the voltage on the piezo drivers until both displays read 37.5 V.
3) Adjust the manual actuators on the turning mirror as necessary to position the laser beam in the detector array.
4) Press the MENU button on the position aligner and select ‘Closed Loop’ mode.
5) The piezos drivers will position the piezo mirror such that the laser beam is held central within the detector array, i.e. for a 75 V piezo, the piezo driver displays 37.5 V and the TARGET display shows the spot in the center - see Fig. 4.13.

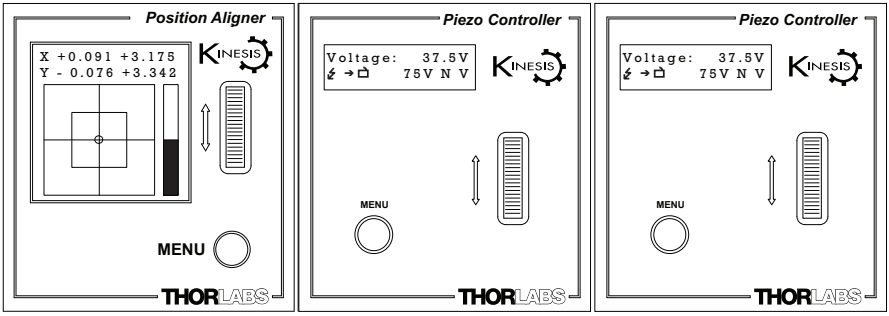


Fig. 4.13 TARGET and VOLTS Displays Showing Values At Mid Position

6) If any positional changes occur, due perhaps to thermal drift, the position aligner sends a signal to the piezo drivers to reposition the beam such that it is maintanined in a central position.

Chapter 5 PC Operation - Tutorial

5.1 Introduction

Note

Familiarize yourself with operation and set up of the basic system detailed in Chapter 4 before attempting operation from the GUI panel.

The following brief tutorial guides the user through a typical series of actions and parameter adjustments performed using the Kinesis software. It assumes that the unit is electrically connected as shown in Section 3.3 and that the Kinesis Software is already installed - see Section 3.1

5.2 Using the Kinesis Software

The Kinesis application allows the user to interact with any number of hardware control units connected to the PC USB Bus. This program allows multiple graphical instrument panels to be displayed so that multiple units can be controlled. All basic operating parameters can be set through this program, and all basic operations (such as piezo moves) can be initiated.

This tutorial shows how the Kinesis application provides all of the functionality necessary to operate the hardware.

Power up the hardware, and wait until the KPA101 has finished booting up, then run the Kinesis software - Start/All Programs/Thorlabs/Kinesis/Kinesis.

Note

For maximum accuracy, wait approximately 30 mins for the unit to thermally stabilize to the environment.

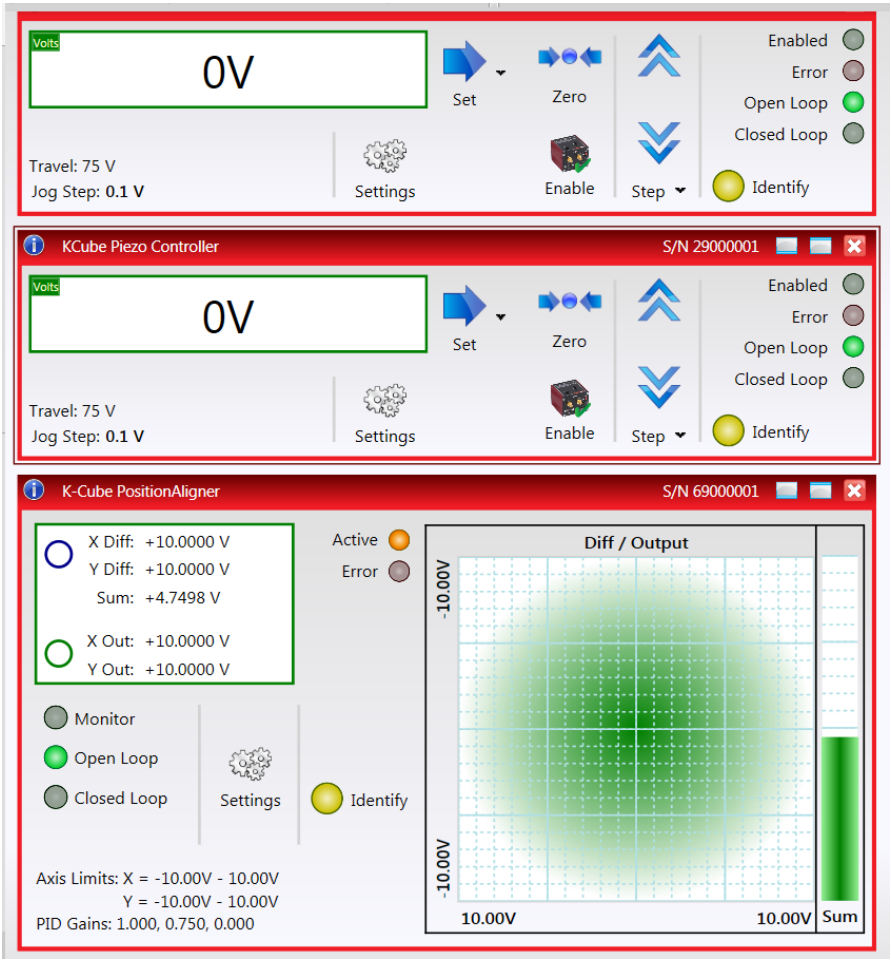


Fig. 5.1 Typical Kinesis User Screen

The Kinesis software will be used throughout the rest of this tutorial to interface with the position aligner.

Throughout this section, the sensor described is a PDQ80A quad detector. However, the KPA101 unit is also compatible with other Thorlabs detectors, such as the PDQ30C IR detector head or the PDP90A Lateral Effect Detector.

5.3 Building An Auto-Alignment System - PC Operation

5.3.1 Introduction

The following sections describe the electrical connections and software settings necessary when the KPA101 position aligner is used with two KPC101 piezo K-Cubes, to provide the drive signals to the piezo actuators in the system.

Note

There are only enough hub lines to facilitate comms between one KPA101 unit and a pair of KPC101 units. If a second KPA101 unit is used with 2 KPC101 units, then SMA to SMA connections are required.

These configurations are by no means the only possible options, and indeed any piezo controller (MDT693B, BPC series, etc.) could be used to provide the drive voltage amplification.

5.3.2 Wiring and Software Settings for Hub Operation

Using the KCH601 hub greatly simplifies system wiring because the hub provides all the necessary power, signal and USB comms connections to all controller cubes.

The following procedure describes a typical set up, with the KPA101 position aligner cube being used with a pair of KPC101 piezo driver cubes on the KCH601 controller hub - see Fig. 5.2 for a general system schematic diagram. The K-Cube positions on the hub and associated parameter settings described are by no means the only possible options. For further information, see Section 5.3.3

1) Perform the mechanical installation as detailed in Section 3.2 of this manual and also in the manual supplied with the K-Cube piezo drivers.
2) Install the K-Cube units onto the controller hub. Fit a piezo unit in bay 1, the position aligner in bay 2 and the other piezo unit in bay 3, as shown in Fig. 5.2.
3) Connect the HV OUT terminals on the rear of the piezo drivers to the associated piezo actuators, Bay 1 to X-axis and Bay 3 to Y-axis.
4) Connect the laser to the laser driver.
5) Install any mechanical components such as turning mirrors etc. which may be required in the beam path. - see Fig. 5.2 for a typical set up.

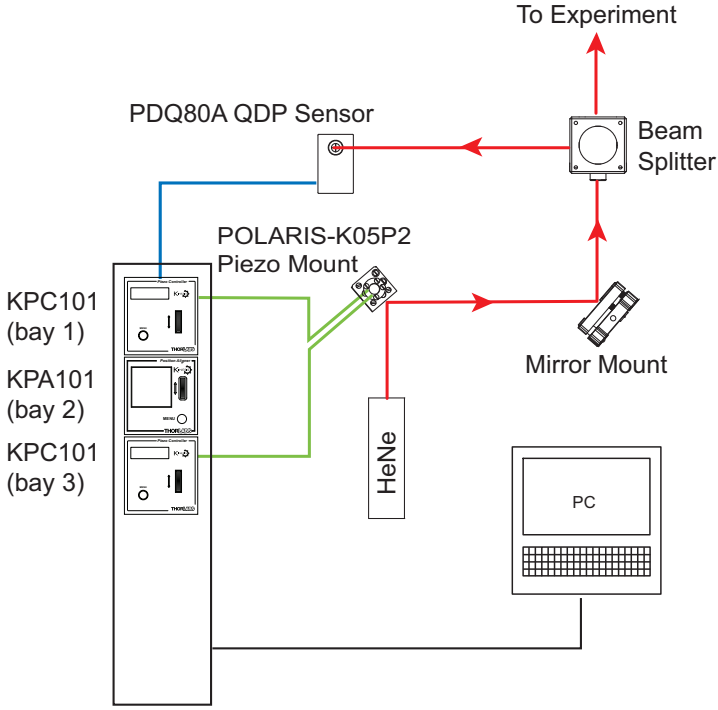


Fig. 5.2 Typical Set Up

6) Connect the controller hub to the power supply.
7) Connect the PSU to the main supply and switch 'ON'. The version number of the embedded software is displayed on each piezo unit during boot up. The software version is useful when requesting technical support. The ident number of the associated K-Cube bay on the hub is also displayed.
8) Connect the controller hub to your PC.

Note

The USB cable should be no more than 3 meters in length. Communication lengths in excess of 3 meters can be achieved by using a powered USB hub).

9) Windows® should detect the new hardware. Wait while Windows® installs the drivers for the new hardware.
10) Run the Kinesis software.
Start/All Programs/Thorlabs/Kinesis/Kinesis.
11) Click the 'Settings' button on GUI of the piezo driver fitted in bay 1. The Settings panel is displayed.

Note

To identify the piezo unit associated with a GUI panel, click the 'Ident' button; the Power LED on the panel of the associated controller flashes for a short period.

12) Make the following parameter settings, as shown in Fig. 5.3
Feedback Loop Mode - Select *Open Loop*
Output Voltage Range - For the POLARIS-K05P2 mirror shown in Fig. 5.2, set 75 V, (other piezo mirrors, set 75 V, 100 V or 150 V whichever is applicable).
Input Source - Select *Software + External Signal*
Analogue Input Mode - Select *Analogue Channel 2*
It is advisable to click the 'Persist Settings To Hardware' box. These settings will then be loaded on each power up cycle.

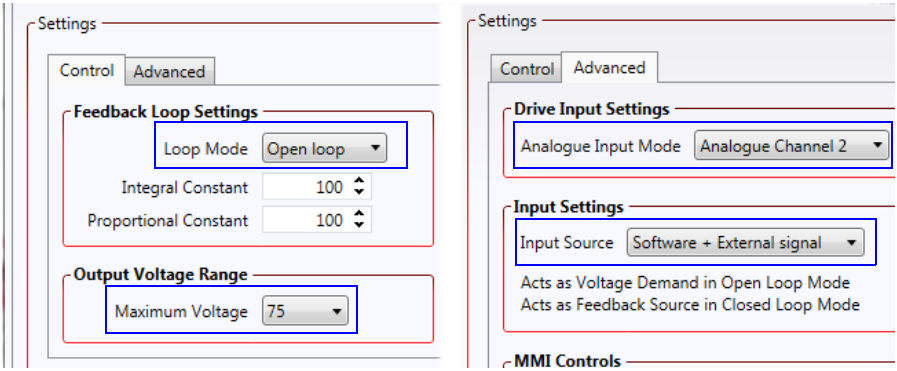


Fig. 5.3 Piezo Driver Settings

13) Click ‘OK to save the settings.
14) On the GUI panel, turn the ‘Output’ control to give a reading of 0 V on the display.
15) Click the ‘Settings’ button on GUI of the piezo driver fitted in bay 3. The Settings panel is displayed
16) Make the following parameter settings, as shown in Fig. 5.3
    Feedback Loop Mode - Select *Open Loop*
    Output Voltage Range - For the POLARIS-K05P2 mirror shown in Fig. 5.2. Other piezo mirrors, set 75 V, 100 V or 150 V whichever is applicable)
    Input Source - Select *Software + External Signal*
    Analogue Input Mode - Select *Analogue Channel 1*

17) It is advisable to click the ‘Persist Settings To Hardware’ box. These settings will then be loaded on each power up cycle
18) On the position aligner GUI, click the ‘Settings’ button to display the Settings panel.
19) Click the Control tab and set the *X & Y Feedback Sense* to *Forward* as shown in Fig. 5.4.
20) Click the Display tab and set the *LV Signal Routing* parameter to *Position Aligner Hub and SMA*, as shown in Fig. 5.4.

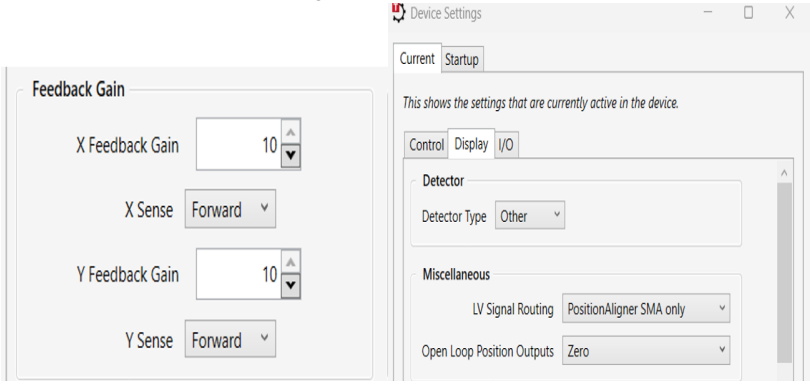


Fig. 5.4 KPA101 Settings Panel - Hub Operation

Note

When signals are routed via the hub, the YDIFF signal is routed via Channel 1 and XDIFF is routed via channel 2. It is important to set correctly the hub channels for the associated piezo controllers and to make correct connections to the X-axis and Y-axis piezo actuators.

21) It is advisable to click the ‘Persist Settings To Hardware’ box. These settings will then be loaded on each power up cycle
22) Click ‘OK’ to save the settings.

5.3.3 Hub Mounting Options

When the K-Cube position aligner and two piezo drivers are used together on the hub, signals can be routed via dedicated internal communication channels. These channels are selected via the GUI Settings panel.

If Channel 2 is selected, the feedback signals run between adjacent pairs of K-Cube bays (i.e. 1 and 2, 3 and 4, 5 and 6). If Channel 1 is selected, the feedback signal runs through all the bays - see Fig. 5.5.

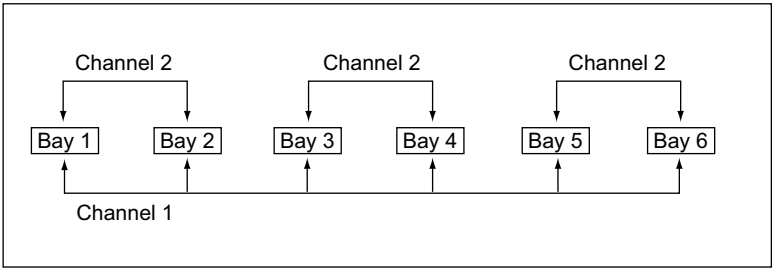


Fig. 5.5 Hub Analog Input Channels

Only certain position aligner and piezo cube arrangements allow the system to function correctly. Furthermore, the setting for the *Analogue Input Mode* parameter in the piezo settings panel depends on the bays in which the piezo and position aligner units are fitted. The various bay options, and their associated *Analogue Input Source* settings are described in Fig. 5.6.

Note

When the XDIFF and YDIFF signals are routed via the hub, the YDIFF signal is routed via Channel 1 and XDIFF is routed via channel 2. It is important to set correctly the hub channels for the associated piezo controllers and to make correct connections to the X-axis and Y-axis piezo actuators.

5.3.4 Wiring and Software Settings - Off Hub Operation

Using the KCH601 hub greatly simplifies system wiring because the hub provides all the necessary power, signal and USB comms connections to all controller cubes.

However, for certain applications it may be convenient to set up the system without using a KCH601 hub, with hard wired electrical connections via the rear panel terminals and power supply and USB connections for each individual unit.

In this case, the procedure is as detailed in Section 4.6.2 but the '*Analogue Input Mode*' parameter in the piezo settings panel should be set to *'External SMA Signal*'.

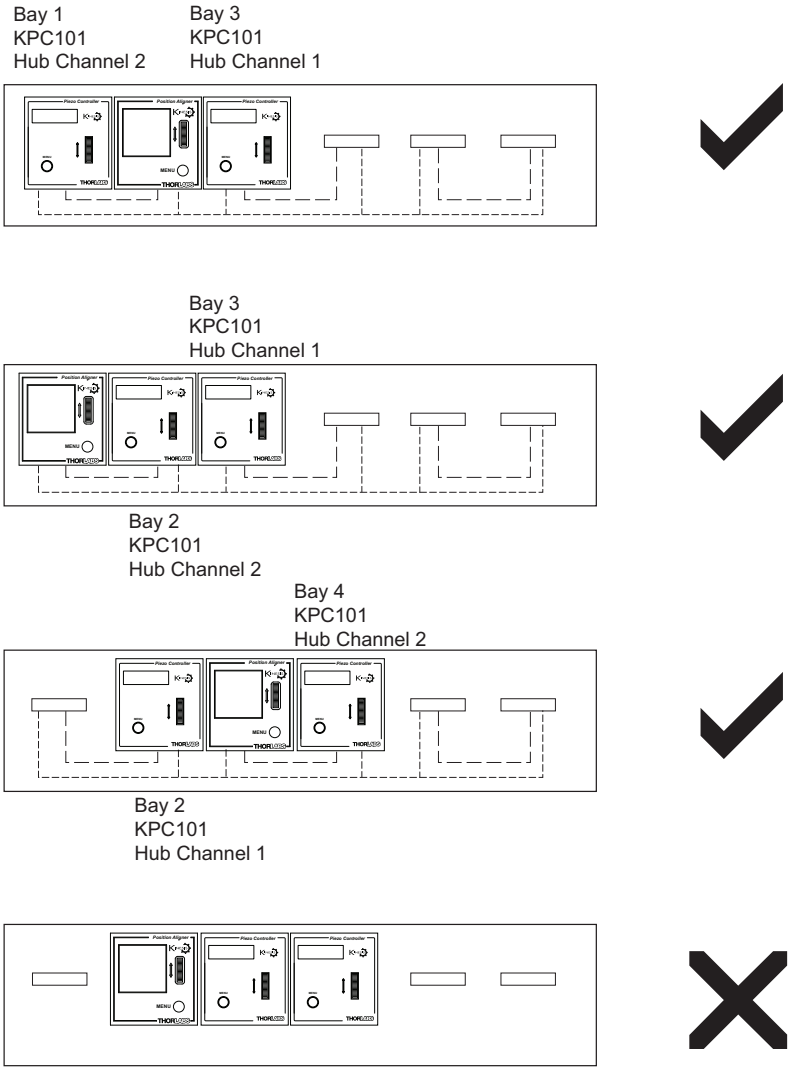


Fig. 5.6 Bay Options and Associated Analog Input Source Settings

5.3.5 Basic Operation

The general procedure involves setting the position aligner to 'Open Loop' and using the turning mirror actuators to adjust the beam position until the laser beam is within the detector quadrant sensors. Once this initial position is achieved, the position aligner is switched to 'Closed Loop' and the unit controls the piezo drivers which move the piezo mirror to focus the beam in the center of the detector.

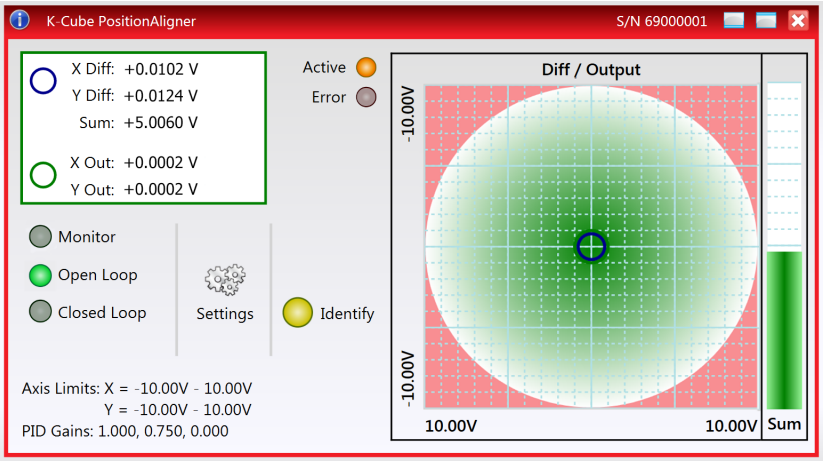


Fig. 5.7 Position Aligner Software GUI

1) Power up the system. The unit will boot up in OPEN LOOP mode.
2) Adjust the KPC101 output voltages to mid range (e.g. 37.5 V for a 75 V piezo).
3) Using the turning mirror actuators, position the laser beam such that it is directed at the center of the detector sensor array, and the center LED on the Target display is lit.
4) Check that the piezo controller connected to the X DIFF connector is driving the X-axis piezo actuator. Turn the control knob on the piezo GUI to increase the piezo drive voltage. The spot in the main display of the KPA101 GUI should move along the X-axis with very little Y-axis movement. If the beam moves in the Y-axis, or diagonally, the piezo controller is connected to the wrong actuator.
5) To ensure correct closed loop operation, the Position Demand Sense of the optical system must be checked. An incorrect setting will cause the system to drive to its limit of travel when switched to closed loop.
   When the X-axis piezo voltage is increased, if the spot moves to the left, the demand sense is positive. If it moves to the right, the demand sense is negative.

Note

The default setting for the Position Demand Sense is 'Forward', which is correct for the set up shown in Fig. 5.2. If the check described at item (5) shows a negative demand sense, then it will be necessary to change the *Position Demand Sense* parameter in the Settings panel - see Section 6.2

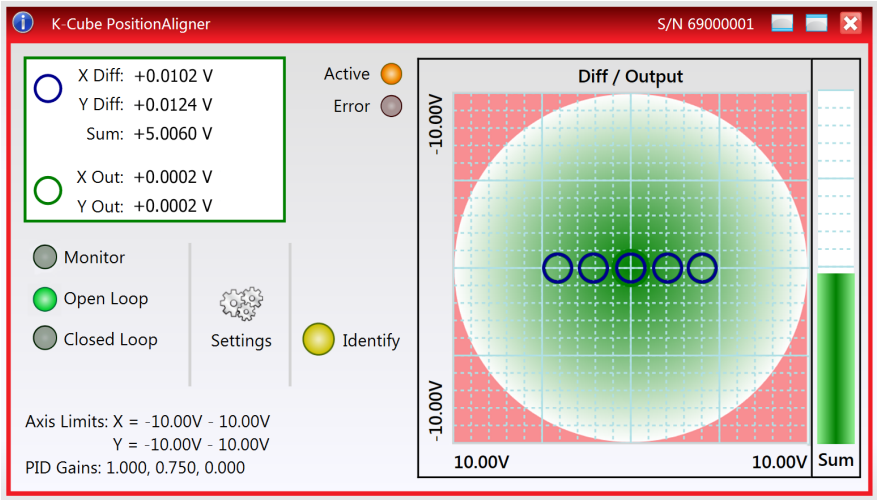


Fig. 5.8 X-axis Position Demand Sense Check

6) Check that the piezo controller connected to the Y DIFF connector, is driving the Y-axis piezo actuator. Turn the control knob on the piezo controller to increase the piezo drive voltage. The laser beam should move along the Y-axis with very little X-axis movement. If the beam moves in the X-axis (or diagonally), the piezo controller is connected to the wrong actuator.
7) When the Y-axis piezo voltage is increased, if the spot moves towards the top, the demand sense is positive. If the spot moves towards the bottom, the demand sense is negative.

Note

The default setting for the Position Demand Sense is 'Positive', which is correct for the set up shown in Fig. 5.2. If the check described at item (7) shows a negative demand sense, then it will be necessary to change the *Position Demand Sense* parameter in the Settings panel - see Section 6.2

8) Press the CLOSED LOOP button on the GUI panel to select 'Closed Loop' mode, i.e. the CLOSED LOOP LED is lit.
   The position aligner unit now takes over the alignment, and controls the piezo units to drive the piezo mirror to direct the laser beam to the central position. The beam position within the sensor array is indicated by the 'Grid' display.
9) Depending on the position of other components in the system, it is possible that the travel range of the piezo actuators driving the mirror is not sufficient to position the beam on the detector array. In this case, the piezos should be centered and the actuators on the other turning mirrors should be adjusted to reposition the beam as follows:

Using the GUI Displays

The small left hand display shows the detector XDiff, YDiff and Sum signal values in Volts. Also shown are the XOut and YOutvalues, which are applicable in 'closed loop' mode only. These values show the low voltage position demand signals applied to the piezos in order to keep the beam central in the detector.

The right hand display shows either a representation of the XDIFF and YDIFF values or the XOut and YOut position demand signals applied to the piezos, depending on the XY Display Mode selected. The display also shows a bar graph, which represents the Sum value from the detector.

Viewed together, these displays are useful in deciding when to center the piezo actuators and make manual adjustments to the turning mirror actuators.

For example, consider the situation shown below, when the unit is in open loop mode and the display shows the beam in the upper right hand quadrant of the detector array. Let's also assume that the output to the piezo drivers is around 1 V as indicated by the X Out and Y Out values. This means that the actual piezo drive voltages for a 75 V piezo will be about 7.5 V (15 V for a 150 V piezo).

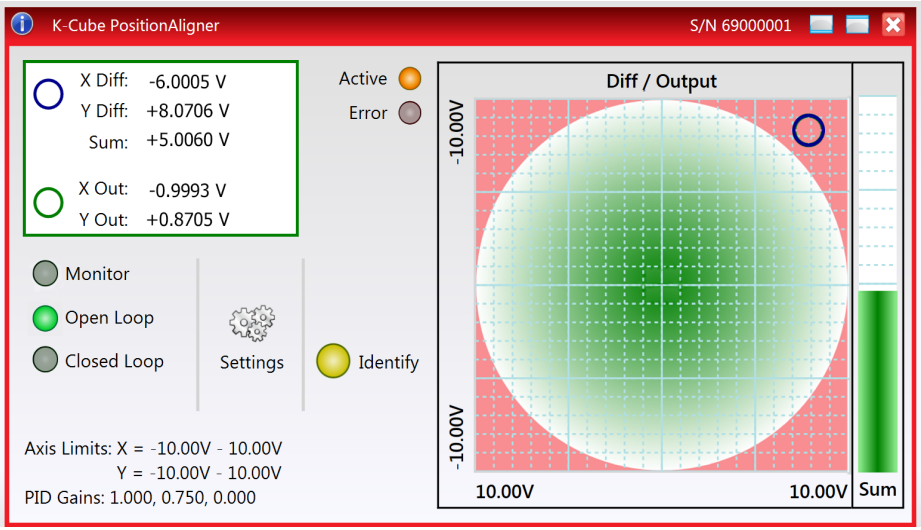


Fig. 5.9 Displays Showing Values Near Travel Limit

When the unit is switched to closed loop mode, the spot moves towards the center of the display as the piezo units drive the piezo mirror to reposition the laser beam.

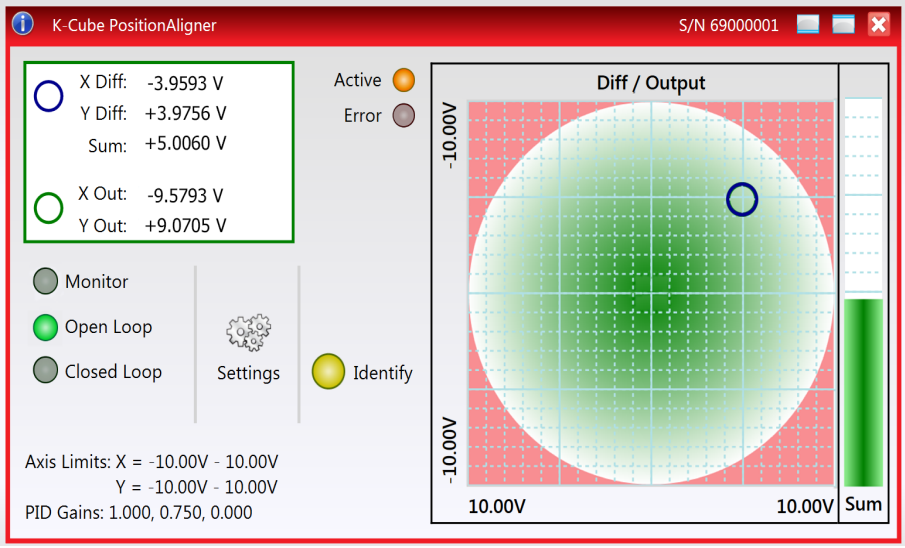


Fig. 5.10 Repositioning the Laser Beam

But the X Out and Y Out values are nearly 10 V, which means that the piezos are near the limit of their travel. The system cannot drive the piezo mirror further and has not managed to move the laser spot to the center of the detector. The piezo actuators must be recentered (i.e. OUTPUT pot adjusted for 37.5 V display), and the position error taken up by manual adjustment.

10) Press the OPEN LOOP button on the GUI panel to select 'Open Loop' mode.
11) Adjust the OUTPUT pot on the piezo drivers GUI until both displays read 37.5 V.
12) Adjust the manual actuators on the turning mirror as necessary to position the laser beam in the detector array.
13) Press the MODE button on the position aligner to select 'Closed Loop' mode.

14) The piezos drivers will position the piezo mirror such that the laser beam is held central within the detector array, i.e. for a 75 V piezo, the X Out and Y Out values show around 0 V (37.5 V piezo drive) and the spot is central within the display as shown below.

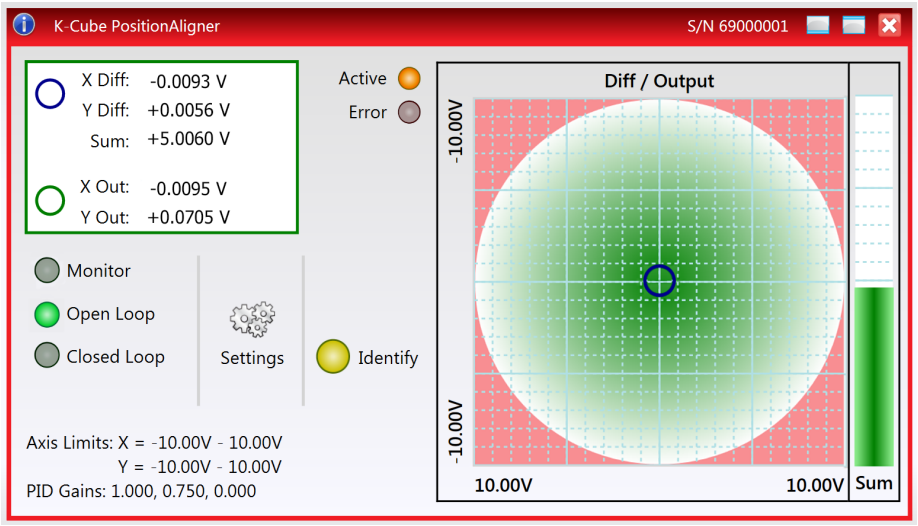


Fig. 5.11 TARGET and VOLTS Displays Showing Values at Mid Position

15) If any positional changes occur, due perhaps to thermal drift, the position aligner sends a signal to the piezo drivers to reposition the beam such that it is maintained in a central position.

5.3.6 Signs Of Instability

The control loop PID settings allow the system response to be tuned to a particular application. Higher proportional and integral coefficients decrease the residual error in the system and also allow the system to respond more quickly to a disturbance (i.e. the system is able to dampen vibrations at a higher frequency range). However, above a certain level, the system becomes unstable and the integral and proportional coefficients will need to be decreased until the system stabilizes.

Instability in the system may be recognized by the following symptoms:

- Whistling, buzzing or similar noises from the piezo actuators.
- Unstable XOut and YOut values visible on the GUI panel.
- Spot not stable in the center of the detector (i.e. spot not stable in center of Target).

Note

The default settings for the PID parameters are correct for the set up shown in Fig. 5.2. If any of the above signs are apparent, it will be necessary to adjust the PID settings in the Settings panel - see Section 6.2

Once the PID parameters have been adjusted, check that the system is unconditionally stable. Tap the work surface to check that the system cannot be provoked into instablity by vibration.

Note

Stable, closed loop operation can only be achieved with continuous wave (CW) lasers. This product is not recommended for use with Pulsed Lasers.

5.3.7 Troubleshooting

In summary, the 4 most common reasons why the system will not operate correctly are:

- A piezo controller is connected to the wrong axis - see Section 5.3.5 Item 4 or 6, or the axes are swapped.
- X-axis or Y-axis Position Demand Sense is set incorrectly - see Section 6.2
- PID constants need adjustment - see Section 6.2
- The 'Drive Input Source' parameter for the Piezo unit is set incorrectly - see Section 6.2

5.4 Setting Sequences

The Kinesis software allows sequences to be programmed, allowing several operations to be performed without user intervention. For more details and instructions on setting sequences, please see the *Kinesis Helpfile*.

5.5 Changing and Saving Parameter Settings

During operation, certain settings (e.g. operating mode, etc) can be changed as required and saved to the device for use in the absence of a PC. However, when the device is next connected to a PC and the Kinesis Server is run up, these settings will be overwritten by the default settings. These values have been chosen to provide safe performance in the majority of applications. For applications where these settings need to be changed, a new set of Device Start Up settings must be created which can then be applied and/or uploaded on subsequent start up. See the *Kinesis Helpfile* for more details.

Chapter 6 Software Reference

6.1 GUI Panel

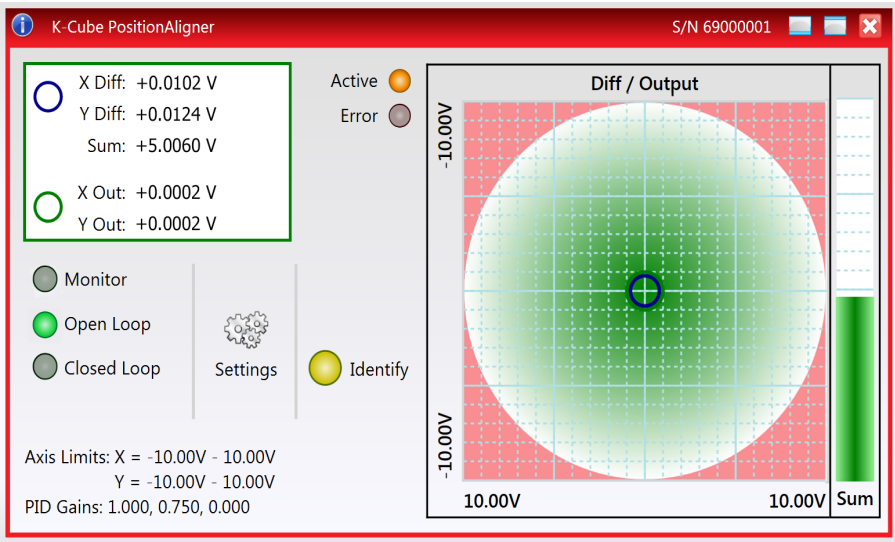
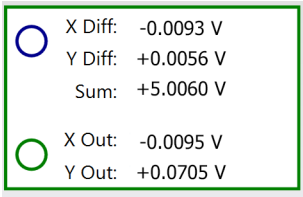


Fig. 6.1 Position Aligner Software GUI

Note

The serial number of the KPA101 position aligner associated with the GUI panel, is displayed in the top right hand corner. This information should always be provided when requesting customer support.

Digital Display - Shows the X axis (XDiff) and Y axis (YDiff) difference signals and the Sum signal values from the detector array.



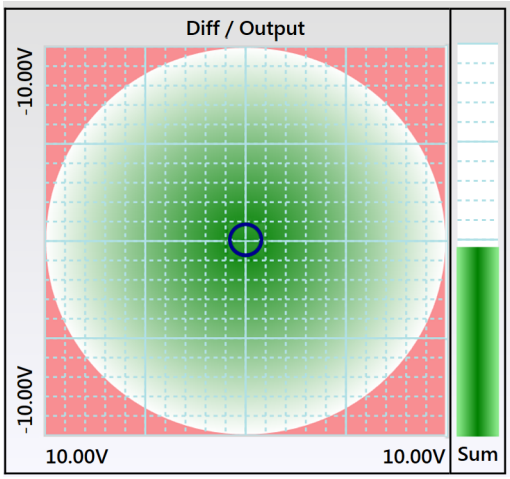
If a PDQ series position aligner head is connected, the display shows the XDiff and YDiff values in Volts.

If a PDP series Lateral Effect sensor is connected, the display shows the XPos and YPos values in mm - see Section 4.2 The values are relative to the center of the screen (0 V).

These signals represent the output from the rear panel the X DIFF and Y DIFF SMA connectors when operating in Monitor mode.

Also shown are the X and Y axis position demand output values (XOut & YOut), which are applicable only in open loop and closed loop modes. These values represent the signals sent to the rear panel SMA connectors, then used by positioning elements (e.g. piezo drivers) to drive the mirror in order to keep the beam centered on the detector.

Grid Display - The detector head provides top-minus-bottom (Y-Axis alignment) and left-minus-right (X-Axis alignment) difference signals, together with a signal that is the sum of signals (total beam power) from all four sensors of the internal photodiode array. The two difference signals are voltage analogs of the light intensity difference sensed by the pairs of photodiode elements in the array. The Main Grid Display plots the XDiff and YDiff signals from the array and shows the resulting signal as a blue circle ◯.

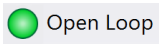


The Main Grid Display also plots a graphical representation of the XOut and YOut values described above (e.g. the piezo positions if a piezo mirror is being used) and shows these signals as a green circle ◯. See Section 4.2 for more details.

The display also shows a bar graph, which represents the SUM value from the detector.

Note

When a PDP series detector head is being used, the accuracy of the position measurements is affected by the SUM signal level. If SUM is too low, the measurement error increases due to system offset and gain errors. If SUM is too high, the sensor and electronics might operate close to their saturation limits. To warn of this, the SUM bar display turns red when the SUM value is either below 5% or above 99% of its full range.

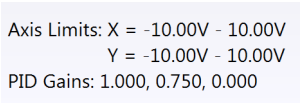


Monitor, Open Loop and Closed Loop - These three buttons are used to toggle between Monitor, Open Loop and Closed Loop modes. The LED in the button is lit when a particular mode is selected - see Section 4.5 for more details.

When operating in '*Monitor*' mode, the X axis (XDIFF) and Y axis (YDIFF) difference signals from the detector, are fed through to the rear panel SMA connectors for use in a monitoring application.

When in '*Open Loop*' mode, the signals at the rear panel are fixed at zero (0 V), or held at the last closed loop value, depending on the setting of the '*Position Demands In Open Loop*' parameter in the settings panel (see Section 6.2). This is useful when the system is being adjusted manually, to position the light beam within the detector array.

In '*Closed Loop*' mode, the feedback circuit sends position demand signals (XOut & YOut) to the rear panel XDIFF and YDIFF connectors, which can be used to drive a pair of positioning elements (e.g. piezo drivers) in order to position the light beam within the center of the detector array.



Limits Display - shows user specified settings for the parameters listed below.

Axis Limits: - shows the values of the Minimum and Maximum limits for the XOut and YOut values, between -10 V and +10 V. The XOut and YOut values are the signals sent to the X DIFF and Y DIFF connectors in closed loop mode, which are then used by the position element to drive the piezo mirror in order to keep the beam central in the detector. Under normal operating conditions, these values are between -10 V and +10 V however, some applications may require the limits to be less than this.

PID Gains - the value of the proportional, integral and derivative constants for the feedback loop. This term provides the force used to drive the piezo to the demand position, reducing the positional error. They accept values in the range 0 to 1 and are set in the Control Settings tab, see section Section 6.2.2

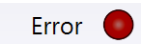


Settings button - Displays the 'Settings' panel, which allows the position aligner operating parameters to be entered - see Section 6.2

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



Error - lit when a fault condition occurs, e.g. the KPC101 unit is powered up without a feedback input connected.



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



6.2 Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed. This panel allows data such as output modes and operating modes to be entered. Note that all of these parameters have programmable equivalents accessible through the functions on this Control (refer to the *Kinesis API helpfile* for further details).

6.2.1 Persisting Settings to the Hardware

Many of the parameters that can be set for the KPC101 Cube can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually in the absence of a PC and USB link. The *Analogue Input Channel* and *Display Mode* parameters are good examples of settings that can be altered and then persisted in the driver for use in absence of a PC.

To save the settings to hardware, check the ‘Persist Settings to Hardware’ checkbox before clicking the ‘OK’ button.

Caution

The ‘Persist Settings’ functionality is provided to simplify use of the unit in the absence of a PC. When the unit is connected to a PC and is operated via the Kinesis software, the default settings will be loaded at boot up, even if the ‘Persist Settings’ option has been checked.

6.2.2 Control Settings Tab

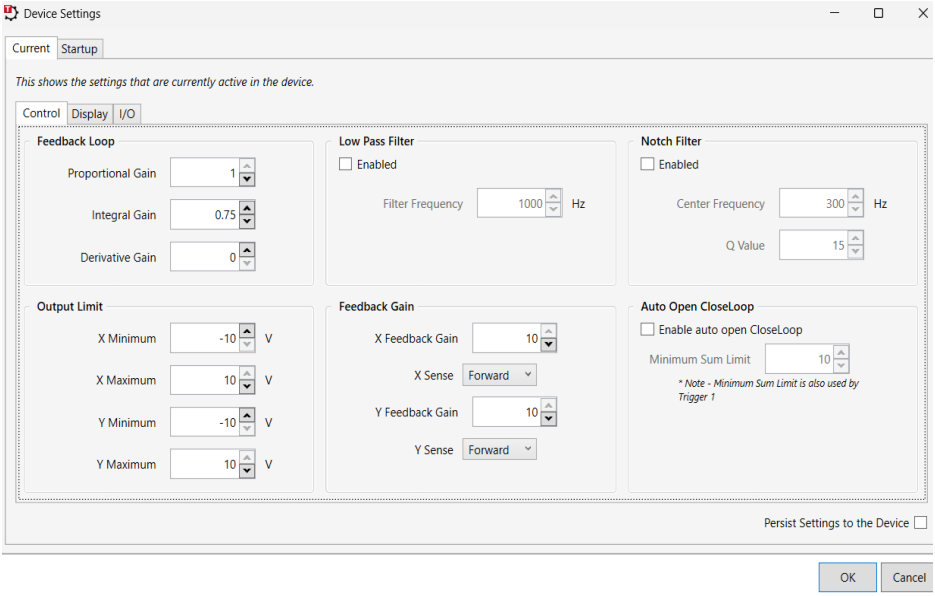


Fig. 6.2 Position Aligner Control Settings Panel

Feedback Loop Settings - When operating in Closed Loop mode, the proportional, integral and differential (PID) constants can be used to fine tune the behaviour of the feedback loop to changes in the output voltage or position. While closed loop operation allows more precise control of the beam position, feedback loops need to be adjusted to suit the different types of sensor that can be connected to the system.

The default values have been optimised to work with the sensor, in the opto-mechanical set up shown in Fig. 5.2.

Proportional - This parameter makes a change to the output which is proportional to the current error value. A high proportional gain results in a large change in the output for a given error. If set too high, the system can become unstable.

It accepts values in the range 0 to 1.

Integral - This parameter accelerates the process towards the demanded set point value, ensuring that the positional error is eventually reduced to zero. If set too high, the output can overshoot the demand value.

It accepts values in the range 0 to 1.

Derivative - This parameter damps the rate of change of the output, thereby decreasing the overshoot which may be caused by the integral term. However, the differential term also slows down system response. If set too high, it could lead to instability due to signal noise amplification.

It accepts values in the range 0 to 1.

For more details on setting the PID parameters, see Appendix B .

Low Pass Filter - The output of the derivative (differential) part of the PID controller can be passed through a tunable low pass filter. Whilst the derivative component of the PID loop often improves stability (as it acts as a retaining force against abrupt changes in the system), it is prone to amplifying noise present in the system, as the derivative component is sensitive to changes between adjacent samples. To reduce this effect, a low pass filter can be applied to the samples. As noise often tends to contain predominantly high frequency components, the low pass filter can significantly decrease their contribution, often without diminishing the beneficial, stabilizing effect of the derivative action. In some applications enabling this filter can improve the overall closed loop performance.

Click the Enable checkbox to enable the filter.

The *Cut Off Frequency* is specified in Hz in the range 0 to 10000.

Output Limit Settings - These parameters are applicable only when operating in closed loop mode. The XOut and YOut values are the low voltage signals sent to the X DIFF and Y DIFF connectors, which are then used by the piezo K-Cubes to drive the piezo mirror in order to keep the beam central in the detector. (See the next topic for a typical application).

Under normal operating conditions, these values are between -10 V and +10 V however, some applications may require the limits to be less than this. The *Output Limits* can be used to set the limits for the XOut and YOut values, between -10 V and +10 V.

Feedback Gain Settings - These parameters are applicable only when operating in closed loop mode, and set the sense and gain of the feedback signals from the detector array.

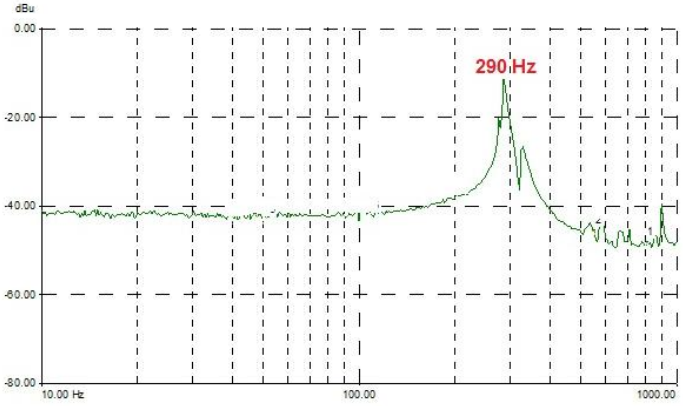
Feedback Sense - The default setting for these parameters is Forward, i.e. the signals are +ve when the beam is in the top and left hand quadrants and -ve when in the bottom and right hand quadrants. If Backward is selected, then the sense is reversed.

Notes

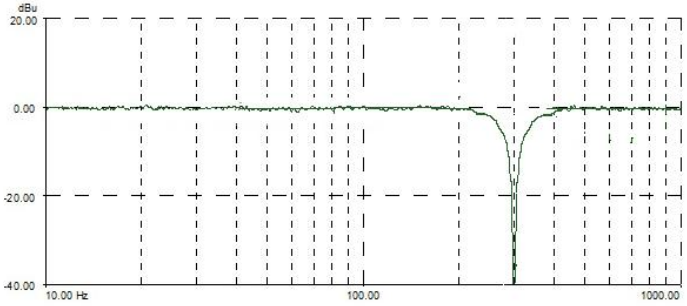
See Section 4.6 or Section 5.3 for more information on the Position Demand Feedback Sense.

Notch Filter Settings - Due to their construction, most actuators are prone to mechanical resonance at well-defined frequencies. The underlying reason is that all spring-mass systems are natural harmonic oscillators. This proneness to resonance can be a problem in closed loop systems because, coupled with the effect of the feedback, it can result in oscillations. With some actuators the resonance peak is either weak enough or at a high enough frequency for the resonance not to be troublesome. With other actuators the resonance peak is very significant and needs to be eliminated for operation in a stable closed loop system. The notch filter is an

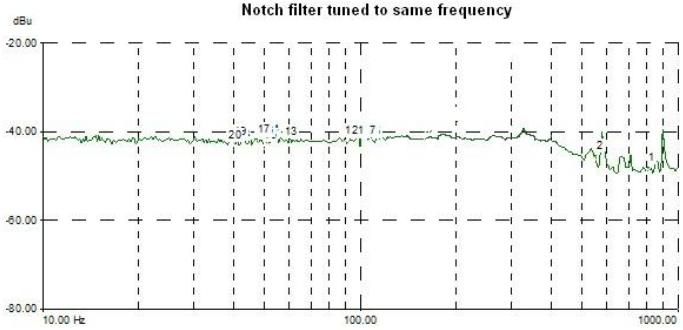
adjustable electronic anti-resonance that can be used to counteract the natural resonance of the mechanical system.



Frequency response of actuator showing resonance at 290 Hz



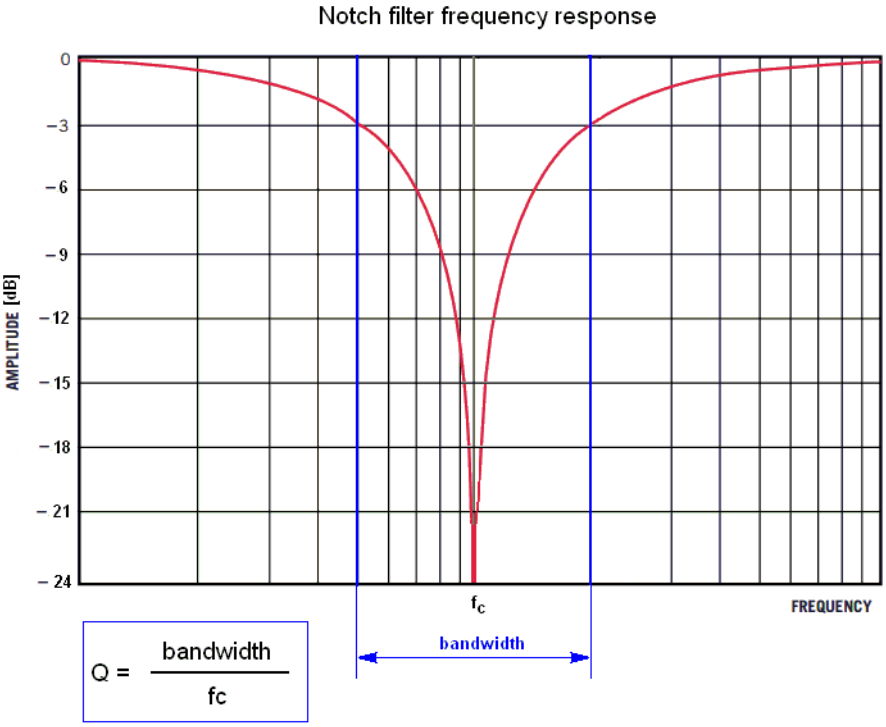
Notch filter tuned to same frequency



The resonance is largely eliminated

As the resonance frequency of actuators varies with load in addition to the minor variations from product to product, the notch filter is tunable so that its characteristics can be adjusted to match those of the actuator. In addition to its center frequency, the bandwidth

of the notch (or the equivalent quality factor, often referred to as the Q-factor) can also be adjusted. In simple terms, the Q factor is the center frequency/bandwidth, and defines how wide the notch is, a higher Q factor defining a narrower ("higher quality") notch.



Optimizing the Q factor requires some experimentation but in general a value of 5 to 10 is in most cases a good starting point.

The *Center Frequency* is specified in Hz in the range 0 to 10000.

The *Q Factor* is specified in the rage 0.1 to 100.

Enable Auto Open Close Loop - If this box is checked, the unit will automatically switch from closed loop mode to open loop when the SUM value falls below the limit set in the *Minimum Sum Limit* parameter, specified as a percentage of full scale in the range 1% to 99%.

The unit will revert back to closed loop when the minimum limit is exceeded once again.

6.2.3 Display Tab

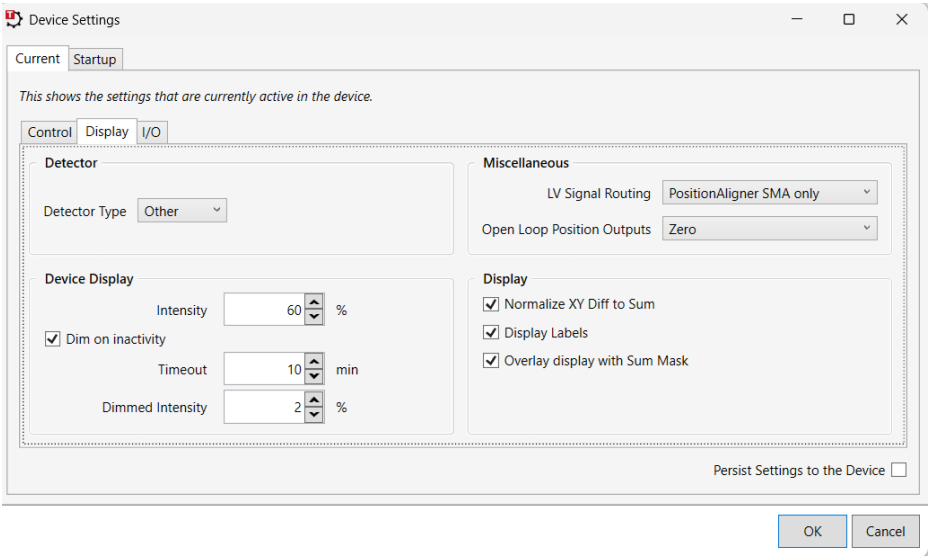


Fig. 6.3 Display Tab

Detector

The unit can be configured for use with a number of sensor/detector heads. This parameter allows the user to set the type of detector head being used as follows:

PDQ80A	PDQ80A Quadrant Detector Head
PDQ30C	PDQ30C Quadrant Detector Head
PDP90A	PDP90A Lateral Effect Detector Head
OTHER	Third Party Detector Head

Miscellaneous Settings

LV Signal Routing - when operating in closed loop mode, the position aligner position control signals are always output on the external SMA connectors (X DIFF and Y DIFF). In addition, they can also be routed to the KCHx01 hub, which eliminates the need for external SMA to SMA cables when the position aligner is used with KPC101 piezo cubes - see Section 5.3.3

For use with piezo K-Cubes, select '*PositionAligner Hub and SMA*' to use the internal comms lines or '*PositionAligner SMA Only*' to use just the external SMA connectors - see Section 5.3.3 for more details.

Open Loop Position Outputs - This parameter sets the value of the drive signal from the XDiff and YDiff connectors when the unit is switched to from closed loop to open loop mode.

If set to Last Closed Loop value, the outputs are fixed at the values present when the unit is switched to open loop.

If set to Zero, the output is set to zero (0 V).

Device Display Settings

In certain applications, it may be necessary to adjust the brightness of the LED display on the top of the unit. The brightness is set in the *Display Intensity* parameter, as a value from 0 (Off) to 100 (brightest). The display can be turned off completely by entering a setting of zero, however, pressing the MENU button on the top panel will temporarily illuminate the display at its lowest brightness setting to allow adjustments. When the display returns to its default position display mode, it will turn off again.

Furthermore, 'Burn In' of the display can occur if it remains static for a long time. To prevent this, the display is automatically dimmed after the time interval specified in the *Display Timeout* parameter has elapsed. The time interval is specified in minutes in the range 1 to 480. The dim level is set in the *Dimmed Intensity* parameter, as a percentage of full brightness from 0 (Off) to 10 (brightest) but is also limited by the *Display Intensity* parameter if this is lower. These settings are only visible and active if the *Dim device display on inactivity* box is checked.

UI Settings

As previously described, the difference signals indicate the beam position on the detector in the X and Y axes. The SUM signal can be used to 'normalize' the difference signals in relation to beam power - see Section 4.2.3 for more details.

Click the *'Normalize X, Y Difference Signals to Sum Signal'* checkbox if normalization is required.

Click the *'Display Labels* checkbox' to show captions on the axes of the GUI graphical display.

If the *'Overlay display with Sum Mask* checkbox' is checked, the areas of the display where the sum signal is out of limits are shaded pink. This gives a visual indication of when the system is near its limits of travel.

To save the settings to hardware, check the '*Persist Settings to Hardware*' checkbox before clicking the 'OK' button.

6.2.4 I/O Tab

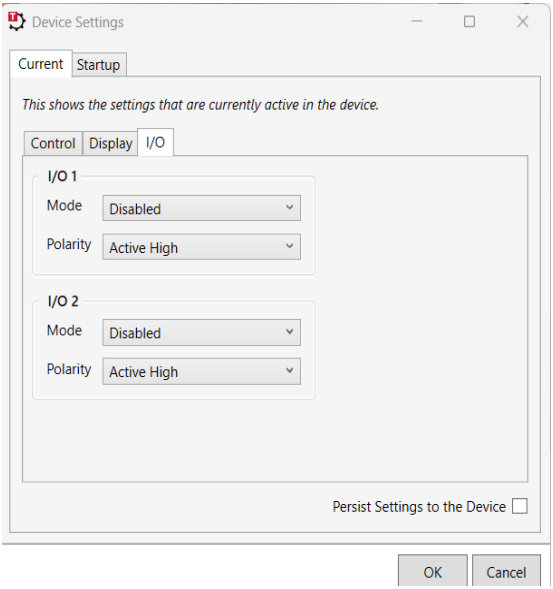


Fig. 6.4 I/O Tab

Triggering Introduction

The K-Cube position aligner has two bidirectional trigger ports (I/O1 and I/O 2) that can be independently configured either as an input or an output and assigned a function from the list of options described in the following section. The polarity (logic HIGH / LOW or rising / falling edge) can also be configured to suit the requirements of the equipment connected to these ports.

In the input operating modes the port is electrically configured as a TTL compatible logic input. When the port is driven with a voltage level below +0.8 V, it will read a logic LOW and when driven above +2.4 V, it will read a logic HIGH. The ports have an internal weak pull-up resistor ensuring that a stable logic level is present on the inputs even when there is no driving source connected to it. This means that when unconnected the ports will read a logic HIGH. The internal pull-up also allows the direct connection of mechanical switches or other unpowered control devices.

In the output modes the port is electrically configured as a logic output using 5 Volt logic levels. The port is connected to the output driver logic with a 620 Ohm resistor in series; this resistor limits the maximum output current to approximately 8 mA and provides protection against the output being accidentally short circuited to ground. The output can be used to drive the majority of digital inputs used on external equipment without any additional circuitry.

Warning

Do not drive the I/O ports from any voltage source that can produce an output in excess of the normal 0 to 5 Volt logic level range. In any case the voltage at the I/O ports must be limited to -0.25 to +5.25 Volts.

I/O Settings

The mode for each I/O port is set in the appropriate *I/O Mode* parameters as follows:

Disabled - The trigger I/O is disabled. Selecting this option effectively results in the port returning to its default digital input configuration.

Trig In - GPI - General purpose logic input. Other than being able to read the logic state of port there is no other functionality associated with it. The state of the port is returned in the periodic status update messages, or can be read by using the GetStatusBits method. In this mode the *Triggering Polarity* setting has no effect; the logic state of the input is returned as it is present on the port without inversion.

Trig In - Loop Open/Close: In this mode the port can be used to toggle the operating mode of the controller between open loop and closed loop modes. If the trigger polarity is selected to be "Active High", the operating mode toggles on the rising edge (LOW to HIGH transition) of the signal present on the TRIG input. Conversely, with "Active Low", the toggle takes place on the falling edge (HIGH to LOW transition).

Trig Out - GPO - In this operating mode the TRIG port functions as a simple digital output. The logic state of the output can be set using the SetGetDigOPs method. Other than being able to read the logic state of port there is no other functionality associated with it. The logic state of the output can be inverted by setting the Triggering *Polarity* parameter to "Low"; with this option selected the state of the output will be the opposite of the corresponding bit setting in the software call. The default state of the output in this mode is also the opposite of the option selected as the Triggering *Polarity*.

Trig Out - SUM - The state of the TRIG port is asserted depending on whether the SUM signal coming from the position sensor is inside the limits specified in the *Trig Sum Min* and *Trig Sum Max* parameters. If SUM is within the limits, the state will be the logic state selected in *Triggering Polarity* and conversely if it falls outside these limits, it will assume the opposite logic state. This mode can be used to detect the presence or absence of light falling on the position sensor; or that the optical power is within the expected limits. This option might be useful to signal a condition required for normal operation as under normal operating conditions the optical power is often expected to remain fairly constant. The *Sum Minimum* and *Sum Maximum* parameters are specified as a percentage of full scale, in the range 1% to 99%.

Trig Out - Diff - The state of the TRIG port is asserted depending on whether both the XDIFF and the YDIFF signals coming from the position sensor are below the

Trig Diff Threshold parameter. If both XDIFF and YDIFF are below the limit, the state will be the logic state selected in *Triggering Polarity* and conversely if either of them falls outside these limits, it will assume the opposite logic state. This mode can be used to signal whether or not the beam is close to the center (beam aligned) position within a certain margin. In closed loop mode it also indicates that the controller is capable of tracking the changes in the beam position and maintaining beam alignment. The *Diff Threshold* parameter is specified as a percentage of full scale, in the range 1% to 99%.

Trig Out - SUM/Diff - This output mode is a 'logic AND' combination of the "Inside SUM range" and "Below Diff Threshold" conditions described above. Having to meet both conditions provides a more reliable indication of the normal closed loop operation when the beam is aligned and in the center of the position sensor. In this scenario the SUM signal is within the expected limits (there is sufficient amount of light hitting the sensor) and both XDIFF and YDIFF are below a certain threshold (the beam is centralized). The second part of the condition, XDIFF and YDIFF below the threshold can also occur if the beam is blocked.

Polarity

The polarity of the trigger pulse is specified in the appropriate *Polarity* parameters as follows:

Active is High - The active state of the I/O port is logic HIGH 5 V (trigger output on a rising edge).

Active is Low - The active state of the I/O port is logic LOW 0 V (trigger output on a falling edge).

Appendix A Connector Pinout Details

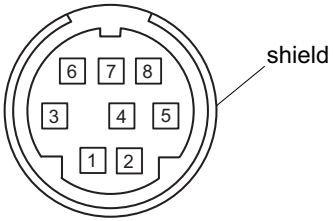
A.1 Power Connector

Thorlabs recommends that the position aligner cube is operated with Thorlabs power supply TPS002, as it was specifically designed for use with this product. However, to enable customers to use the cube in installations where a ±15 V and 5 V power is already available, the piezo cube can be operated with a different external power supply, such as a bench or lab supply.

In this case however, extreme care must be taken to ensure that it meets the specifications and is connected to the cube correctly. Out of tolerance supply voltages or incorrect connection, applied even momentarily, can result in the sensitive electronic components inside the cube getting damaged, invalidating warranty.

The cube uses a standard “mini-DIN” type of input connector, the corresponding plug is available from most standard electronics suppliers.

Fig. A.1 shows the mini-DIN socket as viewed by looking at the rear panel of the cube. The pin numbering follows the standard for mini-DIN connectors.



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		

Warning

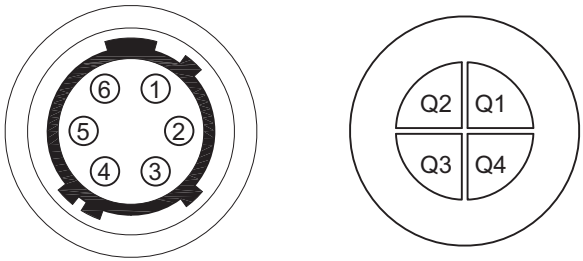
When wiring the mini-DIN plug, ensure that all the ground pins are used and the shield is connected to common ground. This provides a level of protection against overvoltages due to loss of ground. A “loss of ground” condition can seriously damage the electronics inside the cube.

Fig. A.1 POWER Connector Pin Identification

A.2 DETECTOR IN Connector

The DETECTOR IN connector on the rear panel is a HIROSE HR10A-7R-6S connector, which mates with the connector on the sensor cable.

Fig. A.2 shows the pin configuration as viewed by looking at the rear panel of the cube.



DETECTOR IN Photodiode Detail

Pin 1 - X-axis [Q2 + Q3] - [Q1 + Q4] (-10 to +10 V)
Pin 2 - Y-axis [Q1 + Q2] - [Q3 + Q4] (-10 to +10 V)
Pin 3 - SUM [Q1 +Q2 + Q3 + Q4] (0 to +10 V)
Pin 4 - +V (+15 V,15 mA Max)
Pin 5 - Common
Pin 6 -V (-15 V,15 mA Max)

Fig. A.2 DETECTOR IN Connector Pin Identification

Appendix B PID Tutorial

The KPA101 implements a PID control loop for closed loop control. A PID (Proportional-Integral-Derivative) controller is a widely used feedback mechanism that is relatively easy to tune.

The reason why tuning is required in most cases is because individual setups can be very different. Different systems, consisting of complex electrical and opto-mechanical components will respond to external stimuli in different ways. For example, opto-mechanical components such as turning mirrors usually have mechanical resonance points due to their inertial mass and elasticity; in addition electrical controllers cannot force them to move instantaneously. One practical way of dealing with widely varying systems parameters is by making the control loop tunable so that the loop can be optimized for a given system and application.

The aim of closed loop control is to ensure that the beam is always centered in the middle of the detector; tuning the closed loop parameters will determine how the system responds to any disturbance that attempts to move the beam out of the center position. Tuning the controller involves finding a set of values that results in a system that is stable and responds to any disturbance as quickly as possible, restoring the center position of the beam.

In general, start with a low values for Proportional (P) and Integral (I). The default values for these is 10 and 5 which normally result in an unconditionally stable system. Usually, with low P and I values, the system is very stable but responds to disturbances quite slowly. Low P and I values tend to dampen the internal mechanical resonance of the system as well. As the P and I values are increased, the system becomes quicker, which can be advantageous because it rejects external disturbance, such as mechanical vibrations, more efficiently. If the P and I values are increased further, at some point the system will become unstable and oscillate. In this case increasing the Differential (D) parameter can help, together with reducing the PI parameters. The drawback of adding and increasing the Differential parameter is that it also tends to accentuate noise in the system.

With some PID parameters, the opto-mechanical actuators used in typical setups can sometimes show conditional stability as well. This means that while the system is stable and in some cases appears relatively good at rejecting low-level disturbances, such as small mechanical vibrations, large disturbances can provoke instability. This can happen because opto-mechanical systems can exhibit non-linearity over large excursions. In some cases this behaviour can be useful, especially when maximum vibration rejection is needed and large disturbances are not likely to occur.

Appendix C Preventive Maintenance

Shock Warning

The equipment contains no user serviceable parts. There is a risk of electrical shock if the equipment is operated with the covers removed. Only personnel authorized by Thorlabs 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.

C.1 Cleaning

Warning

Disconnect the power supply before cleaning the unit.

Never allow water to get inside the case.

Do not saturate the unit.

Do not use any type of abrasive pad, scouring powder or solvent, e.g. alcohol or benzene.

The fascia may be cleaned with a soft cloth, lightly dampened with water or a mild detergent.

Appendix D Specifications and Associated Parts

D.1 Specifications

Parameter	Value
Connector Type **DETECTOR I/P** **X DIFF, Y DIFF and SUM**	 Hirose HR10A-7R-6S SMA Female
Voltage Range **DETECTOR I/P** **X DIFF, Y DIFF** **SUM**	 -10 V to 10 V -10 V to 10 V 0 to 10 V
ADC Resolution **DETECTOR I/P** **SUM**	 16 Bits 12 Bits
DAC Resolution **X DIFF, Y DIFF**	 16 Bits
Closed Loop X & Y Position Control	Type: PID with Notch Filter Servo Update Frequency: 20 kHz Arithmetic: 32-Bit Floating Point
Input Voltage Requirements	+15 V (50 mA), -15 V (50 mA), +5 V (120 mA)
USB Connector Type	USB 3.0
USB Connection Speed	USB 1.1 Full Speed (12 Mbps)
Housing Dimensions (W x D x H)	60 x 60 x 47 mm (2.4" x 2.4" x 1.8")
Weight	160 g (5.5 oz.)

D.2 Associated Products

Product Name	Part Number
Quad Detector (Visible)	PDQ80A
Quad Detector (Infra Red)	PDQ30C
Lateral Effect Sensor	PDP90A
K-Cube Piezo Driver	KPC101
2-Way Power Supply Unit	TPS002
K-Cube Controller Hub and Power Supply	KCH601/KEH6
SMA Male to SMA Male Cable 12”	CA2912
SMA to BNC Converter Cable 12”	CA2812
SMA Female to BNC Male Converter	T4289
SMA Male to BNC Female Converter	T4290

Other cables and lengths are also available, please see www.thorlabs.com.

Appendix E Regulatory

E.1 Declarations Of Conformity

E.1.1 For Customers in Europe

E.1.2 For Customers In The USA

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

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

CE Certificate



EU Declaration of Conformity

Manufacturer: Thorlabs LTD

Address: 204 Lancaster Way, Ely, CB6 3NX, UK

We hereby declare under our sole responsibility that:

Product: **KPA101**

Product description: **K-Cube Beam Position Aligner**

is/are in conformity with the following directive(s):

2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS), including 2015/863
2014/35/EU	Low Voltage Directive (LVD)

and (harmonized) standards / technical specifications :

EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
EN IEC 63000	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	2018
EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010 + A1:2019 + AC:2019

I hereby declare that the equipment named has been designed to comply with the relevant sections of the above referenced specifications and complies with all applicable Essential Requirements of the Directives.

Signed: Keith Dhese

Name: Keith Dhese *On:* 3/16/2026

Position: General Manager

CE

Appendix F Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at www.thorlabs.com/contact for our most up-to-date contact information.



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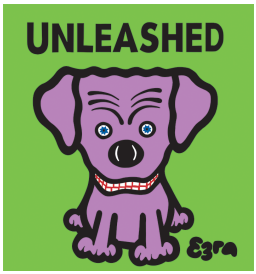
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