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BNT001/IR
Benchtop NanoTrak® Controller

User Guide

Original Instructions

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Chapter 1   Overview

1.1   Description

The NanoTrak® Controller represents the latest developments in automated optical alignment technology. Its space-saving design combines an active-feedback optical alignment system and a two-channel piezoelectric controller in a single ergonomic unit, allowing the user to align optical fibers and optimize the coupling of light into and out of photonic devices.

Operator interaction is via an intuitive software interface and all connections are via the rear panel, which improves cable management and reduces the risk of entanglement or snagging.

1.2   Software

The controller is supplied with a full suite of software support tools. An intuitive graphical instrument panel allows immediate control and visualization of the operation of the NanoTrak controller, and any other controllers that are installed in the system. See Section 1.3. for a full description of the software.

The unit operation is fully configurable (parameterized) with key settings exposed through the associated graphical interface panel. Track or Latch operating modes can be selected 'on the fly', and in both modes the display can be changed to show drive voltage or position (in microns). In the closed loop operation mode, both the P & I (proportional and integral) components of the feedback control loop can be altered to adjust the servoloop response. For convenience and ease of use, adjustment of many key parameters is possible through direct interaction with the graphical panel. Note that all such settings and parameters are also accessible through the ActiveX programmable interfaces which allow the user to build automated alignment routines. See Section 1.3. for a full description of the Kinesis software.

The key innovation of the Thorlabs range of controllers and associated mechanical products is the ease and speed with which complete automated alignment systems can be engineered at both the hardware and software level. All controllers in the range are equipped with USB connectivity. The 'multi-drop' USB bus allows multiple units to be connected to a single controller PC using commerical USB hubs and cables. When planning an alignment application, simply add up the number and type of drive channels required and connect together the associated number of controllers.

1.3 PC Software Overview

1.3.1 Introduction

The BNT001 NanoTrak controllers feature 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 trouble shooting. 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.

1.3.2 Kinesis Server

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 controller. 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, Matlab, VB.NET, C#.NET and, via VBA, Microsoft Office applications such as Excel and Word.

Consider the control supplied for the BNT001 controller.
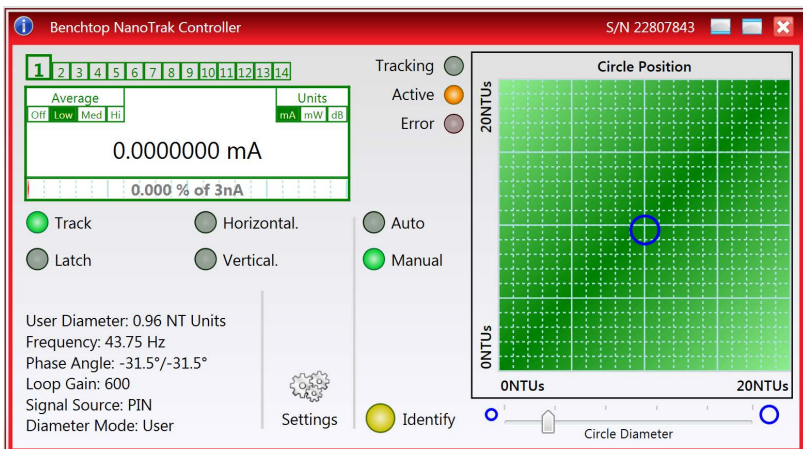
This Control provides a complete user graphical instrument panel to allow the NanoTrak unit to be manually operated, as well as a complete set of software functions to allow all parameters to be set and NanoTrak operations to be automated by a client application. The instrument panel reflects the current operating state of the controller unit to which it is associated (e.g. such as relative power). 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 NanoTrak Control to track the position of optimum power, progress is monitored automatically by changing position of the circle on the graphical interface, without the need for further programming intervention.

The Kinesis Controls collection provides a rich set of graphical user panels and programmable interfaces allowing users and client application developers to interact seamlessly with the Kinesis hardware. Each of the Kinesis controllers has an associated .Net Control and these are described fully in the handbooks associated with the controllers.
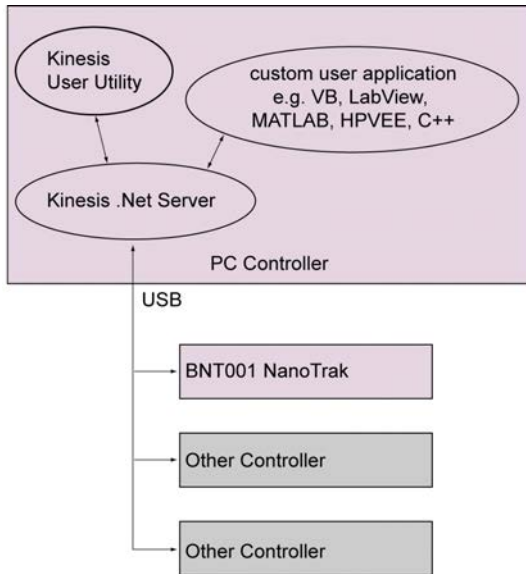
Fig. 1.1   System Architecture Diagram

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.

1.3.3   Software Upgrades
Thorlabs operate a policy of continuous product development and may issue software upgrades as necessary.

Chapter 2   Safety

2.1   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.

⚠	**Warning: Risk of Electrical Shock** 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.

2.2   General Warnings

⚠	**Warning** 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 absorbant tissue. Do not allow spilled fluid to enter the internal mechanism.

⚠	**Caution** If your PC becomes unresponsive (e.g due to an operating system problem, entering a sleep state condition, or screen saver operation) for a prolonged period, this will interrupt communication between the Kinesis Software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the software is run. Please consult your system administrator or contact Thorlabs technical support for more details.

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Chapter 3   Set Up And Operation

3.1   Introduction

The functionality required for a client application to control a number of NanoTrak units is provided by the NanoTrak Control Object within the APT server, with manual operation being facilitated via a GUI panel (see Section 3.7.1.). Instances of this ActiveX control can be dragged from the toolbox in the development software. Alternatively, the APT User utility allows multiple graphical instrument panels to be displayed so that multiple APT units can be controlled. All basic operating parameters can be set through this program, and all basic operations (such as setting circle diameter) can be initiated.

The APT Software Server System has been designed to allow custom nanopositioning applications to be developed in a Microsoft Windows environment. The use of ActiveX interfacing technology means that programming of the unit can be achieved in any compatible language (LabVIEW, Visual Basic etc.) without the need for an extensive library of language-specific functions.

Using the methods and properties described in the *APTServer helpfile*, the APT NanoTrak controller can be programmed as part of an automated alignment application.

> **Note**
>
> Before using the NanoTrak, ensure that the fibers can be aligned manually using the actuators on the positioning stage, and that the expected level of power can be transmitted between them. Set the NanoTrak to Latch and the range control to Auto, and observe the bar graphs on the front panel for an indication of power.
>
> If the positioning stage incorporates stepper motor actuators, ensure that the motors are disabled via the stepper motor controller GUI panel before performing any manual adjustment.

3.2   Front Panel Controls and Indicators

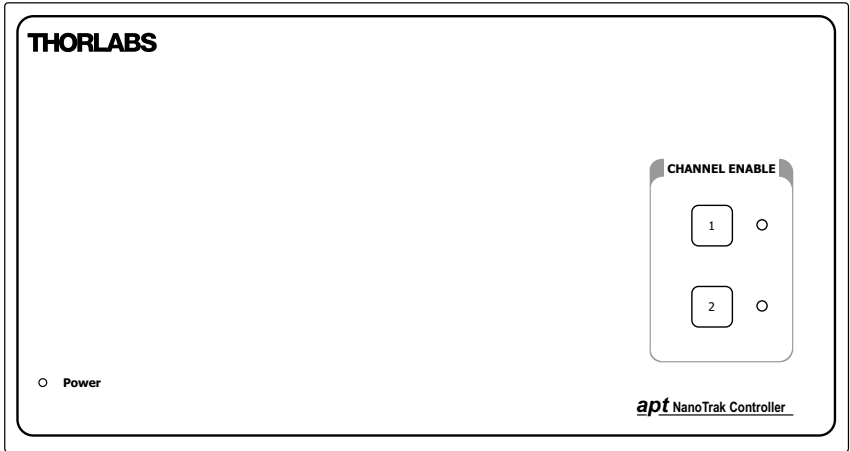**Fig. 3.1   Front panel controls and indicators**

Power LED – Indicates that power is applied to the unit.

Channel 1 and Channel 2 buttons – Used to enable/disable channel functionality. The associated LED is lit when the channel is enabled. Disabling channels on NanoTrak controllers sends their respective HV outputs to zero volts.
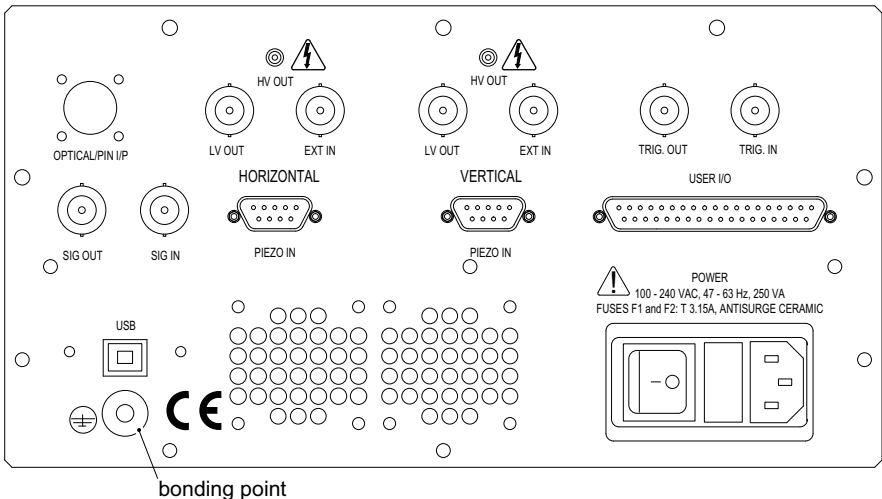
3.3   Rear Panel Connections

Fig. 3.2   Rear panel connections

**OPTICAL/PIN I/P - ** *SMB connector* – used to receive a signal from a PIN diode, as incorporated in external detector heads.

FC/PC connector – for use with detectors NTA007 and NTA009. Incorporates an internal detector and accepts a connectorized fiber.

SIG IN (BNC connector) – 0 to 10V, 100kΩ load. Used to receive a signal of optical power from an external power meter. Can be set to ±1V, ±2V, ±5V or ±10V full scale in the Settings panel (see Section 3.9.2.).

SIG OUT (BNC connector) – 0 to 10V, 2mA. Can be connected to an oscilloscope to monitor the power signal received on the OPTICAL IN connection. Also used in dual NanoTrak operation (see Section 3.10.3.).

HORIZONTAL Drive Channel

HV OUT (SMC connector) – 0 to 75V, 0 to 250mA. Provides the drive signal to the piezo actuator.

EXT IN (+) and **EXT IN (-)** (BNC connector) – Used to control the position of the piezo actuator from an external source. 0 to ±10V 100kΩ load. Polarity is selected in the Settings panel (see Section 3.9.2.) or in software by calling the appropriate function (see *Kinesis API helpfile*). The difference between the two signals is amplified internally before being routed to the HV OUT connector.

PIEZO IN – receives the signal from the position sensor (strain gauge) of the piezo actuator to provide the feedback for the control loop - see Section 4.2.6.

VERTICAL Drive Channel – as Horizontal Drive Channel.

CONTROL I/O

LV CH1/TRIG. OUT and LV CH2/TRIG. IN (BNC connector) – 0 to +10V. These outputs mirror the associated HV OUT, 10V being equivalent to 75V on the HV outputs, and can be connected to an oscilloscope to enable the drive signal of the piezo actuator to be monitored.

USER I/O- For use with digital, programmable I/O and serial ports - see Section 4.2.5.

COMMS – USB port for system communications.

Bonding point – used to electrically bond multiple units to eliminate circulating earth (ground) currents. Do not connect to the main power supply ground.

3.4 Detector Heads and Cables

The OPTICAL/PIN I/P connector on the rear panel of the NanoTrak controller has been designed to increase the interchangability of the optical input source. A range of connectors are available which simply plug into the connector on the rear panel.

The BNT001/IR NanoTrak is supplied with an Infra Red InGaAs photodiode, and a standard SMB connector for use with external detector heads which incorporate a PIN (p-type/intrinsic/n-type) diode.

A visible spectrum Si photodiode (NTA009) is available separately.

3.5 Installing the Software

Caution

IIf your PC becomes unresponsive (e.g due to an operating system problem, entering a sleep state condition, or screen saver operation) for a prolonged period, this will interrupt communication between the software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the software is run. Please consult your system administrator or contact Thorlabs technical support for more details.

Caution

Some PCs may have been configured to restrict the users ability to load software, and on these systems the software may not install/run. If you are in any doubt 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 on +44 (0)1353 654440 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.

3.6 System Setup

3.6.1 Initial Setup

1) Install the software as detailed in Section 3.5.

Connect the controller to the actuators (see Section 4.2.3.) and the PC, then switch ON. Wait approximately 5 seconds for the system to settle.

Caution

IIn applications requiring the highest level of accuracy and repeatability, it is recommended that the controller unit is powered up approximately 30 minutes before use, in order to allow the internal temperature to stabilize.

2) Run the software and check that the Graphical User Interface (GUI) panel appears and is active.
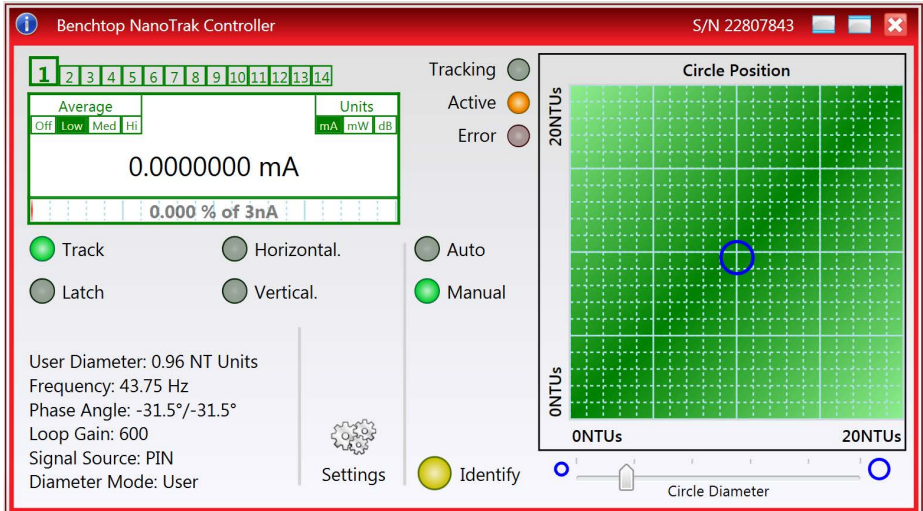
Fig. 3.3 Gui panel showing jog and ident buttons

3) Click the 'Identify' button. The digital display of the associated channel on the front panel of the controller flashes. This is useful in multi-channel systems for identifying which channel is associated with which GUI.

3.7   Manual Operation - NanoTrak

3.7.1   Description of GUI Panel Controls

Fig. 3.4   NanoTrak Software GUI

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> **Note**
>
> The serial number of the unit associated with the GUI control instance is displayed in the top right hand corner of the control.

Range indicator - displays the current range of the internal power meter. When operating in 'Manual' ranging mode, the range can be changed by clicking the required range number. Available ranges vary from 3 nanoam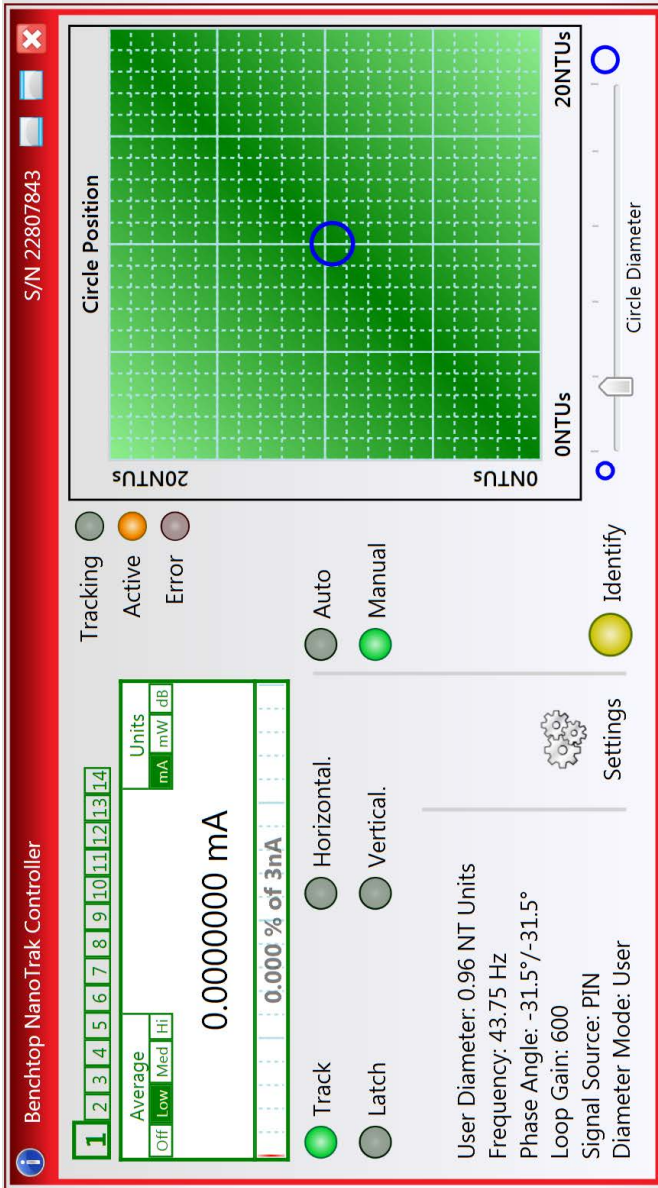ps (range 1) to 10milliamps (range 14) (when the display units are selected to mA - see below). Note that in many practical arrangements the lower ranges may be unusable with typical signal to noise ratios.

Digital Display - shows the feedback signal level being measured.

Display Units - show the measurement units associated with the display.

If a PIN (TIA) input signal is connected (input source is set to TIA mode in the Input/Output settings tab), the display can be configured to display mA, mW or dB.

If 'mA' is selected, readings are displayed or returned as the display shows the actual PIN current being detected by the PIN current amplifier.

If 'mW' is selected, readings are displayed or returned as power, generated using a Amp:Watt calibration factor specified either in the 'Settings' panel or by calling the associated software function.

> **Note**
>
> This is not intended to be a calibrated power reading, but rather a convenient mechanism for converting current to power. The conversion factor is typically wavelength specific.

If 'dB' is selected, readings are displayed or returned in dBs. The signal is first converted to Watts according to the calibration factor, and then into dB. Consequently, this conversion is also wavelength dependent.

If a BNC input is connected (input source is set to a BNC mode in the settings panel), the display can be configured to display 'V', '%' or 'User'.

If 'V' is selected, readings are displayed or returned in Volts, i.e. the raw input signal to the BNC connector.

If '%' is selected, readings are displayed or returned as a percentage of full scale input, e.g. a 1V signal into a 2V input range BNC will display a value of 50%.

If 'User' is selected, readings are displayed or returned as a calibrated value using a calibration factor set using the Voltage calibration parameter on the Input/Output tab of the Settings panel, e.g. if the calibration factor has been set to '20', a 1V signal into a 2V input range BNC will display a value of 10.

Average - displays the averaging level being applied to the power readings (and the relative display bar) displayed on the GUI. Settings of 'low', 'medium' and 'high' resulting in averaging numbers of 5, 10 and 20 repectively. At the default display update rate of 10Hz, this translates to 0.5, 1 and 2 second time constants

respectively. This setting is provided as a convenient way of smoothing readings displayed on the GUI only, and does not affect in any way those same readings when returned by software functions.

To change the setting, click the associated sector.

Relative Signal Power Bar - The max power located in the alignment. Bar display showing a convenient visual indication of the feedback signal level. When the input source is set to TIA (PIN), the bar display indicates the power level with respect to the currently applied range. E.g. if the TIA range is 1micro, then a bar displaying half length equates to a power level of 0.5micro. When the input source is set to BNC (voltage), then bar display indicates the voltage being measured. E.g. for an input voltage range of 2volts, a bar displaying half length equates to 1volt input signal.

Track - push button control used to set the NanoTrak to 'Track' mode, using both horizontal and vertical axes to set a circular scan pattern. When tracking, the NanoTrak detects any drop in signal strength resulting from misalignment of the input and output devices, and makes positional adjustments to maintain the maximum. The LED in the button is lit when selected.

Latch - push button control used to set the NanoTrak to latch mode, whereby scanning is disabled and the piezo drives are held at their present position. The LED in the button is lit when selected.

Horizontal - push button control used to set the NanoTrak to track using a horizontal line scan pattern. The LED in the button is lit when selected.

Vertical - push button control used to set the NanoTrak to track using a vertical line scan pattern. The LED in the button is lit when selected.

Auto and Manual - push button control used to toggle between auto and manual ranging. The LED in the button is lit when selected.

Tracking LED - lit when the NanoTrak is tracking and measuring feedback signal levels above a software threshold set in the Tracking settings tab.. This software threshold is set to reflect the signal levels at or above which the NanoTrak unit will be tracking at the position of the peak of the feedback signal. This threshold is typically set to lie above the 'noise floor' of the particular physical arrangement. Note that the tracking indicator does not apply when the input source is set to BNC (voltage) input.

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

Error LED - lit when a fault condition occurs, i.e. either a power supply voltage is out of range, or a channel has closed loop mode selected but the associated piezo is disconnected.

Circle Position display - shows the position of the scan circle which in turn, corresponds to the horizontal and vertical position of the piezo actuators. The width and height of the display is 20 NanoTrak (NT) units, each division being 1/20th of the max piezo travel, (e.g. for a 20µm piezo travel, 1 NT unit = 1µm). Right click in the display to show the Circle Position window - see section Chapter 3.8.

Circle Diameter control - used to adjust the diameter of the scan circle, when operating in 'Manual' adjustment mode. The current diameter is displayed in the

'Settings' list. Note. Use of this control will automatically switch the circle diameter adjustment mode to 'Manual'.

Settings list - shows user specified settings for the parameters listed below. Note. Some parameters can also be configured for automatic adjustment. When operating in the relevant 'Auto' mode, the user specified values displayed may be different to the actual values applied (and in some cases, displayed on the CRT).

User Diameter - displays the circle diameter (in NT units). The circle diameter can be set either by adjusting the manual control knob or by calling a software function.

Note

If the circle diameter adjustment mode is set to 'Auto', the actual circle diameter (displayed on the CRT) may be different to the diameter displayed in the Settings window. (see Section C.1.3. for further information).

Frequency - displays the scanning frequency (in Hz). The scanning frequency can be set either by entering a value in the 'Settings' panel, or by calling a software function.

Phase Angle - displays the phase compensation values (in degrees) for the horizontal and vertical components of the circle path. Values can be entered in the 'Tracking' settings panel. Note. If the phase compensation adjustment mode is set to 'Auto', the actual phase offset may be different to the diameter displayed. (see Section C.1.4. for further information).

Loop Gain - displays the gain setting for the NanoTrak control loop. The gain can be set either by entering a value in the 'Tracking' settings panel.

Signal Source - displays the type of input source connected. The input source is set by entering a value in the 'Input/Output' settings panel.

Diameter Mode - displays the mode of circle diameter adjustment as follows:

User	Diameter adjusted by the user
LUT	Diameter adjusted via Look Up Table (set via the Tracking tab).
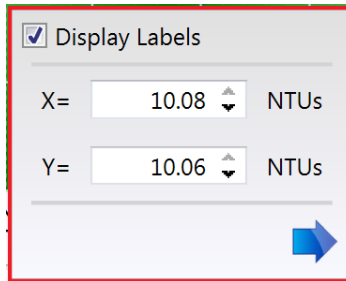
Settings button - Displays the 'Settings' panel, which allows the NanoTrak's operating parameters to be entered - see Section 3.9.

Identify - when this button is pressed, the channel LEDs on the I/O panel of the associated hardware module will flash for a short period.

3.8 Circle Position Window

Right click in the Circle Position Display, to show the position window.

This window shows the current circle position in whatever display units are selected, NanoTrak units or Microns. The circle can be positioned by entering a value into the X and/or Y fields and clicking the arrow.

3.9   Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed. This panel allows data such as scan circle frequency and diameter, and loop gain 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.

3.9.1   Tracking tab
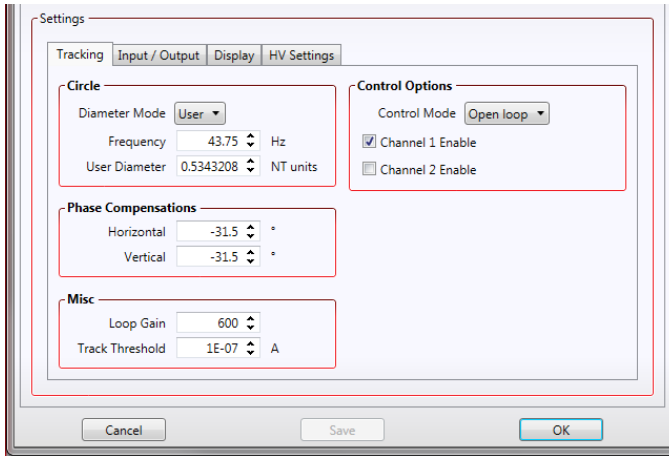
Fig. 3.5   NanoTrak Settings panel - Tracking Tab

Circle

Diameter Mode - this setting allows the different modes of circle diameter adjustment to be enabled and disabled.

If '*User*' is selected, the circle diameter remains at the value set by the user in the *User Diameter* parameter (in NanoTrak units). The circle diameter is measured on a scale such that 10 units is the width and height of the screen. If, for example, the NanoTrak is driving a 20 micron actuator, a circle diameter of 1 unit will result in a real diameter of 2 microns. The scanning circle diameter can have values in the range 0 to 5.0 with a value of 5.0 corresponding to one half the range of piezo motion.

If the Diameter Mode is set to '*LUT*', the circle diameter is adjusted automatically, using a table of range dependent circle diameter values (in NanoTrak units).
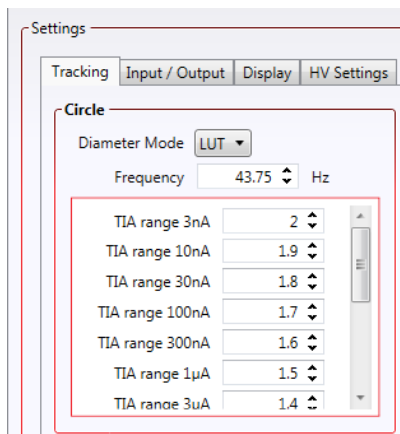
When automatic LUT diameter adjustment mode is enabled, the system uses values in this LUT to modify circle diameter in relation to the input range currently selected.

This LUT diameter adjustment mode allows appropriate circle diameters to be applied on an application specific basis. Typically, the circle diameter LUT will be configured to generate a reducing circle diameter for an increasing range setting. This fits an assumption that higher input signal readings correspond to a smaller FWHM of the feedback signal peak being tracked, and so a smaller circle diameter is required to prevent NanoTrak instability.

Enter a circle diameter (0 to 5 NT units) for each input range of the NanoTrak (1 to 14, corresponding to 3nA to 10mA respectively)

Frequency - the frequency of the scanning circle. The circle scanning frequency lies in the range 15 to 200Hz. The factory default setting for the scanning frequency is 43.75Hz. This means that a stage driven by the NanoTrak makes 43.75 circular movements per second. Different frequency settings allow more than one NanoTrak to be used in the same alignment scenario. Refer to Section 3.10.3. for more information

Control Options

Control Mode - Typically, the NanoTrak is operated in Open Loop mode because the piezo amplifiers have a higher bandwidth operation in open loop, thereby ensuring best bandwidth performance. If the NanoTrak is latched, the piezo actuator position is best maintained if the drift is minimized. This is achieved by placing the piezo channels into Closed Loop mode.

When in closed-loop mode, position is maintained by a feedback signal from the piezo actuator strain gauge or by a DC feedback signal derived externally. **Note**. This is only possible when using actuators equipped with position sensing.

Channel Outputs - these parameters allow the horizontal and vertical channels of the NanoTrak to be enabled/disabled.

Note

NanoTrak channels should not normally be disabled.

Phase Compensations

The feedback loop scenario in a typical NanoTrak application can involve the operation of various electronic and electromechanical components (e.g. power meters and piezo actuators) that could introduce phase shifts around the loop and thereby effect the system stability. These phase shifts can be cancelled by setting a 'Phase Compensation' factor.

Horizontal - the compensation for the horizontal component of the circle path.

*Vert*ical - the compensation for the vertical component of the circle path.

The values can be specified in the range -180.0 to 180.0 degrees and typically are set equal to each other.

Misc

Loop Gain - the gain setting is used to ensure that the DC level of the input (feedback loop) signal lies within the dynamic range of the input. Increasing this value can lead to a more responsive NanoTrak behaviour as the signal variation around the circular path is enhanced. However, for a particular set up, if this value is too high, then unstable NanoTrak operation (indicated by a fluctuating circle) can result.

The gain value can be specified in the range 100 to 10,000.

Track Threshold - the track threshold is set in Amps, and is dependent upon the application. Typically, the value is set to lie above the 'noise floor' of the particular physical arrangement. When the input signal level exceeds this value, the tracking LED is lit on the GUI panel. However, this is no guarantee that tracking is taking place. If the threshold value is set inappropriately, e.g. if the tracking threshold is set to below the noise floor, then the GUI will show a lit tracking LED even though no tracking is taking place.
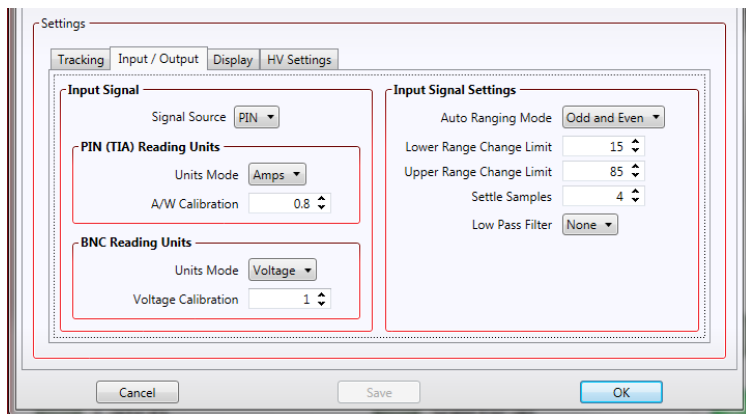
3.9.2 Input/Output tab

Fig. 3.6   NanoTrak Settings panel - Input/Output Tab

Input Signal

Signal Source - the input source can be set to PIN or a range of BNC voltage inputs.

The *PIN* Input option should be used when NanoTraking to optimise a PIN current feedback signal. The TIA (trans impedence amplifier) input source should be selected when using the rear panel Optical I/P connector or when an external detector head is connected to the optional SMB connector. This option uses the internal amplifier circuit and associated functionality (e.g. autoranging).

The BNC Input options should be used when NanoTraking to optimise a voltage feedback signal. Typically, these inputs are selected when using an external power meter which generates a voltage output. In this case the internal amplifier circuit is bypassed and ranging functionality (as displayed on the GUI) is inoperative. The input can be set to 1V, 2V 5V or 10V.

PIN (TIA) Reading Units

Units Mode - this parameter specifies the units relating to the input signal measured by the NanoTrak, and is applicable only if a PIN (TIA) input source has been specified.

If *Amps* is selected, readings are displayed or returned in mA, i.e. the raw PIN current input signal to the internal amplifier.

If *Watts* is selected, readings are displayed or returned in mW, using a Amp:Watt calibration factor specified in the A/W Calibration parameter.

Note

This is not intended to be a calibrated power reading, but rather a convenient mechanism for converting current to power. The calibration factor will usually be a wavelength dependent property.

If *dB* is selected, readings are displayed or returned in decibels. The signal is first converted to watts according to the calibration factor specified in the A/W Calibration parameter, and then into dB.

A/W Calibration - the Amp:Watt calibration factor used when Watts or dBs is specified in the PIN Units Mode parameter.

BNC Reading Units

Units Mode -.this parameter specifies the units relating to the input signal measured by the NanoTrak, and is applicable only if a BNC input source has been specified.

If *Voltage* is selected, readings are displayed or returned in Volts, i.e. the raw input signal to the BNC connector.

If *% Full Range* is selected, readings are displayed or returned as a percentage of full scale input, e.g. a 1V signal into a 2V input range BNC will display a value of 50%.

If *User Defined* is selected, readings are displayed or returned as a calibrated value using the Voltage Calibration parameter, e.g. if Voltage Calibration has been set to '20', a 1V signal into a 2V input range BNC will display a value of 10.

Voltage Calibration - the calibration factor used when User Defined is selected in the BNC Units Mode parameter.

This panel is used to modify the autoranging and output characteristics of the NanoTrak input amplifier circuit (Trans-impedance amplifier (TIA) circuit).

Input Signal Settings

Auto-ranging Mode - when auto-ranging mode is selected on the GUI panel, range changes occur whenever the input signal reaches the upper or lower end of the currently set range.

This parameter specifies how these range changes are implemented by the system.

If *Odd and Even* is selected, the unit visits all ranges when ranging between two input signal levels.

If *Odd Ranges* (or *Even Ranges*) is selected, only those odd (or even) numbered ranges between the two input signals levels will be visited. These latter two modes are useful when large rapid input signal fluctuations are anticipated. This is because the number of ranges visited is halved to give a more rapid response.

Auto Range Change Limits - When autoranging, the NanoTrak unit adjusts continually the TIA range as appropriate for the input signal level. When the relative signal on a particular range drifts below the limit set in the 'Lower' parameter, the NanoTrak unit decrements the range to the next lower setting. Similarly, when the relative signal

rises above the limit specified in the 'Upper' parameter, the unit increments the range to the next higher setting.

Settings are entered as a percentage of full range.

> **Note**
>
> The Upper limit must be higher than the Lower limit. If an attempt is made to enter a value for the Lower limit which is higher than the Upper limit, an error message is generated.

Settle Samples – This parameter determines the amount of averaging applied to the signal before autoranging takes place. Higher SettleSamples values improve the signal to noise ratio when dealing with noisy feedback signals. However, higher SettleSamples values also slow down the autoranging response. In a particular application, the SettleSamples value should be adjusted to obtain the best autoranging response combined with a noise free signal.

Values can be set from '2' to '32', with a default setting value of '4'.

Low Pass Filter - This setting specifies the cut off frequency of the digital low pass (LP) filter applied to output readings of the internal amplifier (TIA) circuitry. If the readings displayed or returned are unstable, this setting can be used to remove any unwanted high frequency components and improve input signal stability.

NONE - Low pass filter inactive   10HZ - Cut off all signals above 10Hz

1HZ - Cut off all signals above 1Hz   30HZ - Cut off all signals above 30Hz

3HZ - Cut off all signals above 3Hz   100HZ - Cut off all signals above 100Hz

> **Note**
>
> This low pass filter setting is different to the low pass filter specified using the HV Settings tab

3.9.3   Display tab
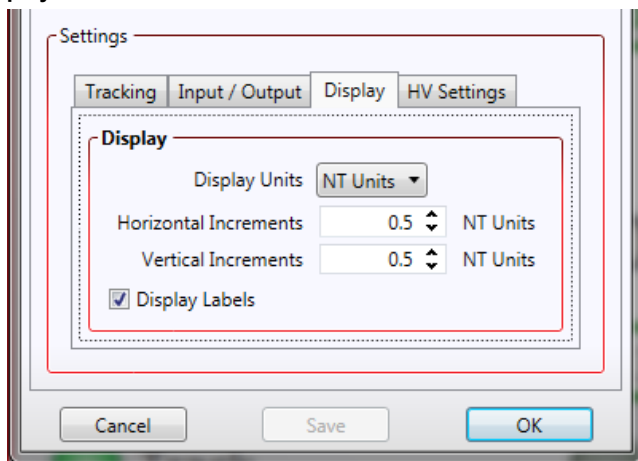
Fig. 3.7   NanoTrak Settings panel - NanoTrak Screen Tab

Sometimes, it may be useful to explore the area of interest by manually repositioning the two piezos driven by the NanoTrak. If desired, the NanoTrak circle can be positioned by using the mouse. This feature allows manual repositioning of the piezos, e.g. to enable investigation of the region of interest to look for side peaks, artifacts etc.

The circle can be moved either by click and drag, or by moving an incremental distances per mouse click.

Note. The circle can be moved in both Latch and Tracking modes.

Display Units - The circle position window (see Section 3.8.) is displayed by right clicking in the NanoTrak screen, and shows the current position of the circle, in NT Units or microns, whichever is selected.
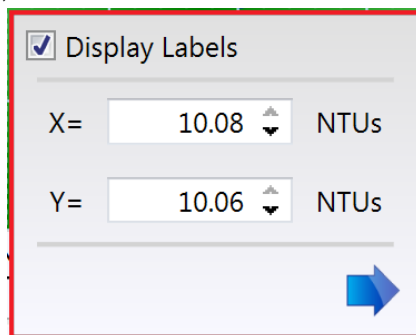
Fig. 3.8   Circle Position Window

> **Note**
>
> This setting affects only the NanoTrak screen and not the main 'Settings' display.
>
> If no piezo actuators are connected, then Microns cannot be selected and the display can only show NT units.

Horizontal and Vertical Increments - When the circle is positioned by a mouse click, the incremental distance can be set to NT units or microns. If set to NT Units, the increments can be set from 0.01 to 2 NT units.

If set to microns, the limits are dependent upon the travel of the piezo actuator, e.g. for a 20µm piezo travel, 1 NT unit = 1µm, therefore the limits are 0.01 to 2µm.

Display Labels - When this box is checked, the labels for the X and Y axes of the NanoTrak display are visible.

3.9.4   HV Settings Tab
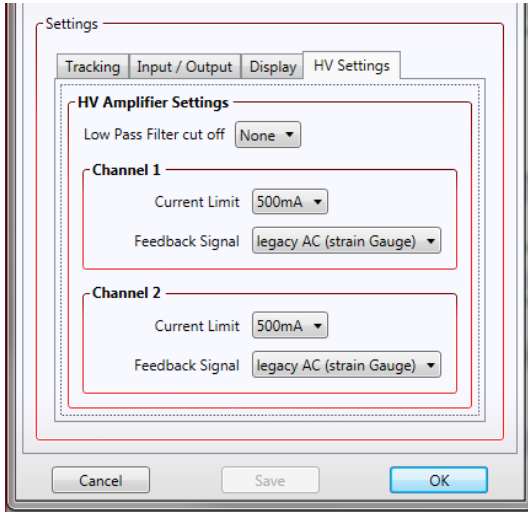
Fig. 3.9   NanoTrak Settings panel - HV Amps tab

This panel is used to set the output characteristics of the HV amplifier channels fitted to the NanoTrak unit. Both low pass filtering and current control settings can be made to tailor the piezo output drive to a particular application.

HV Amplifier Settings

Low Pass Filter – This parameter sets the cut off frequency of the hardware low pass filter, applied to the HV amplifier output channels. It applies to both channels simultaneously.

  10HZ - Cut off all signals above 10Hz

  100HZ - Cut off all signals above 100Hz

  5KHZ - Cut off all signals above 5KHz

  NONE - Low pass filter inactive

Note

This low pass filter setting is different to the low pass filter specified using the Input/Output tab.

Channel 1 and Channel 2

Current Limits - This parameter sets the maximum current output of the HV amplifier:

  100MA – Current output (piezo drive signal) limited at 100mA

  250MA – Current output (piezo drive signal) limited at 250mA

  500MA– Current output (piezo drive signal) limited at 500mA

Feedback Signal Type - This parameter sets the type of feedback signal used when operating the HV amplifier channels in closed loop operation.

Two types of feedback signal are supported:

Legacy AC (Strain Gauge) - The AC Strain Gauge mode refers to the use of AC excited strain gauge feedback signals as generated by the complete range of Thorlabs piezo actuators and piezo equipped multi axis stages.

Differential DC - It is possible to set the feedback signal type to DC 0 – 10V. This configures the feedback circuit to accept a differential 0-10V DC feedback signal in order to control position output. This latter feedback mode is available for use with third party piezo positioning systems capable of generating a standard voltage position feedback signal.

> **Note**
>
> On modular hardware (and later versions of benchtop hardware), the function of the pin connections on the 9-way D-type feedback connector is dependent on the feedback mode selected. Refer to the pin-out tables in Section 4.2.6. for details.

3.10 Programmed Operation - NanoTrak

> **Note**
>
> Familiarize yourself with NanoTrak operation from the GUI panel before attempting programmed operation from the Controller PC.

3.10.1 A Typical Alignment using the NanoTrak

1) In the NanoTrak GUI, set the 'Scan Circle Diameter' control to approximately mid-position.

2) Press the 'Latch' button to select Latch mode and check that the Latch indicator LED is lit.

3) Click and drag to centre the scan circle in the display.

4) Press the 'Auto' button to select 'Auto' mode. Ensure that the 'Auto' LED is lit.

5) Adjust the actuator on the positioning stage such that the fibers are spaced well apart, with zero power transmission between them. (Alternatively, switch off or obscure the optical power source). Make a note of the bar graph displays of relative power input and range. Since the optical source has been removed, only background noise is registered.

6) Use the actuators to bring the fiber tips together, until the display shows a significant increase indicating that the power has risen above the background level.

7) Press the 'Track' button to select Track mode. Check that the 'Tracking' indicator is lit and that the circle moves towards the position of maximum power (center screen). The NanoTrak has now positioned the fiber to give the maximum optical power transmission.

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Note

If the circle reaches the edge of the display, this means that the piezo actuators cannot move far enough to reach the position of maximum power. The horizontal and vertical actuators should be adjusted to bring the circle away from the edge of the screen – see Fig. 3.8.

If the circle tends to drift, increase the scan circle diameter, if the circle tends to oscillate, decrease the scan circle diameter.

Decrease horizontal actuator

Increase horizontal actuator

Decrease vertical actuator

Increase vertical actuator
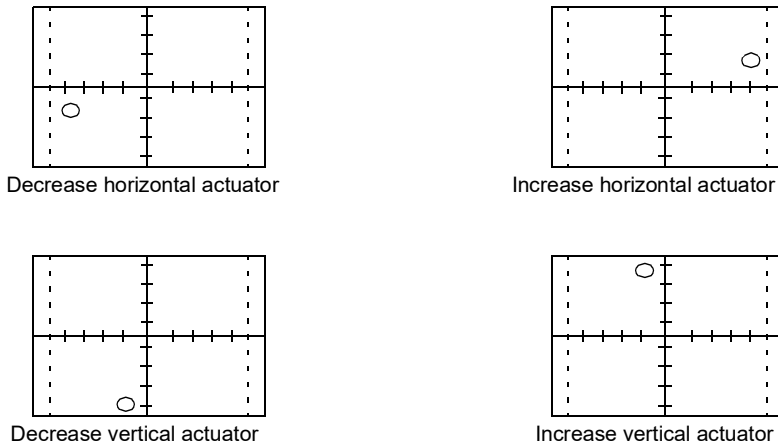
Fig. 3.10   CRT displays and actuator adjustments

3.10.2   Using an External Power Meter

Power meters are available that may give greater sensitivity and accuracy than the integral power meter of the NanoTrak. The output of the detector should be connected to the power meter, and the power meter O/P connected to the 'SIG IN' connector on the rear panel of the NanoTrak. The input defaults to a range of 1 V, although this can be changed to 2V, 5V or 10 V from the Settings panel – see Section 3.9.2.

Note

Use only an external power meter which gives a true analog output and does not introduce any phase shift into the system. Some power meters give a smoothed output only suitable for driving a chart recorder.

3.10.3 Using Two NanoTraks in the Same System

The NanoTrak scanning process uses a single frequency (and a highly selective discriminator similar to a radio receiver) and it is possible to use more than one NanoTrak controller in a single optical path (and with a single detector). For example, with two control units set to different scanning frequencies (e.g.30 Hz and 40 Hz) it is possible to couple fibers both into (master NanoTrak) and out of (slave NanoTrak) an integrated optical device such as a waveguide – see Fig. 3.11. The scan frequency and input source can be set either via the application software *(see Kinesis API Helpfile)* or directly via the Settings panel – see Section 3.9.1.

To set up a two NanoTrak system:

1) Make connections as shown in Fig. 3.11.
2) Power up the NanoTrak units.
3) Run the software.
4) In the master NanoTrak GUI, select 'Settings'.
5) Select the 'Tracking' tab, then set the Circle User Frequeny, e.g. 40 Hz.
6) Select the 'Input/Output' tab, then set the Input Signal Source to 'PIN (TIA)'.
7) In the slave NanoTrak GUI, select 'Settings'.
8) Select the 'Tracking' tab, then set the Circle User Frequency, e.g. 30 Hz.

> **Note**
>
> A difference of at least 10Hz is recommended between this frequency and that set at item (5). This is to ensure adequate frequency separation between the bandpass filters of the two NanoTraks.
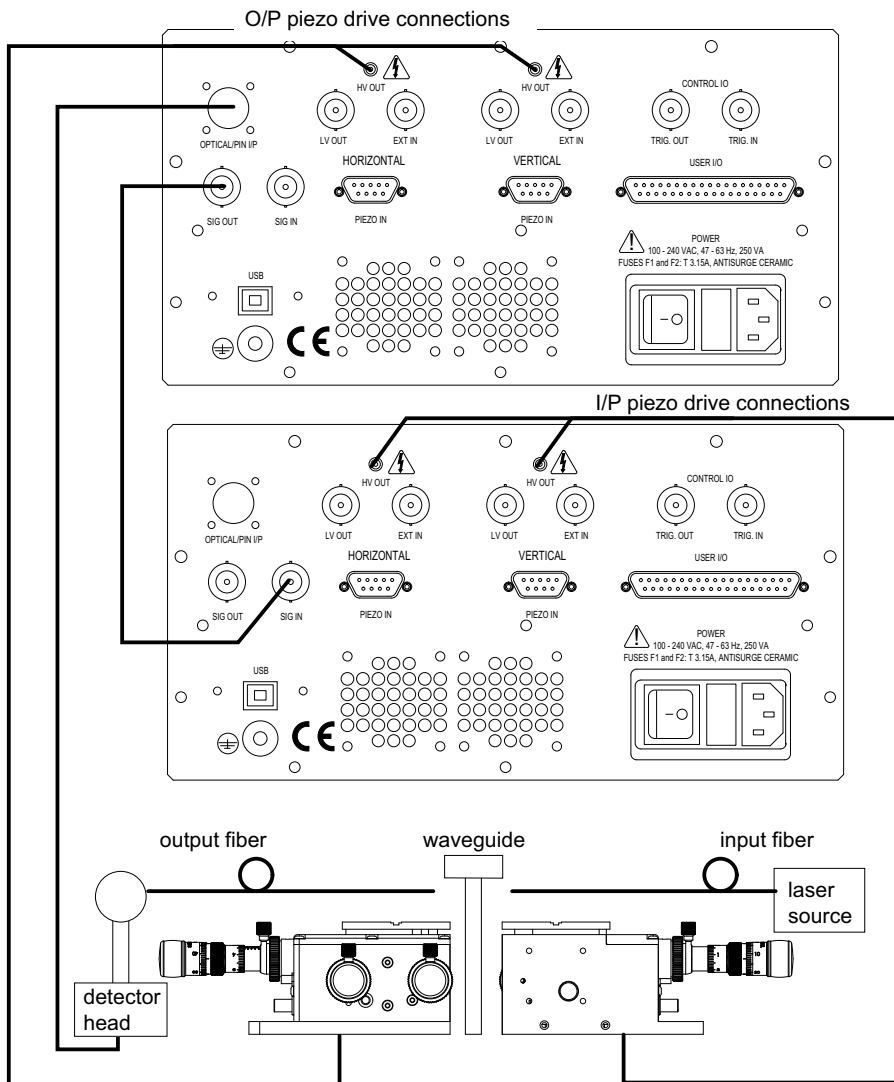
9) Select the 'Input/Output' tab, then set the Input Signal Source to 'BNC 10V'.

> **Note**
>
> With BNC input source is selected, the internal TIA circuit is bypassed and therefore autoranging is not required. Also, the Tracking Indicator on the GUI panel is inoperative.

10) Set both NanoTraks to 'Track'.
11) Once alignment is achieved, tracking can be verified. Move the axes of the stage(s) by a small amount. The circle of the NanoTrak associated with the stage should move accordingly to follow the signal.

If using the internal power meter, the detector output is connected to the OPTICAL/ PIN connector on the master unit and the signal to the slave NanoTrak must be routed from the master SIG OUT to the slave SIG IN. If using an external power meter, a T-splitter must be used on the SIG OUT connector of the master NanoTrak.

O/P piezo drive connections

HV OUT ⚡   HV OUT ⚡   CONTROL IO

OPTICAL/PIN I/P   LV OUT   EXT IN   LV OUT   EXT IN   TRIG. OUT   TRIG. IN

HORIZONTAL   VERTICAL   USER I/O

SIG OUT   SIG IN   PIEZO IN   PIEZO IN

POWER
100 - 240 VAC, 47 - 63 Hz, 250 VA
FUSES F1 and F2: T 3.15A, ANTISURGE CERAMIC

USB

CE

I/P piezo drive connections

HV OUT ⚡   HV OUT ⚡   CONTROL IO

OPTICAL/PIN I/P   LV OUT   EXT IN   LV OUT   EXT IN   TRIG. OUT   TRIG. IN

HORIZONTAL   VERTICAL   USER I/O

SIG OUT   SIG IN   PIEZO IN   PIEZO IN

POWER
100 - 240 VAC, 47 - 63 Hz, 250 VA
FUSES F1 and F2: T 3.15A, ANTISURGE CERAMIC

USB

CE

output fiber   waveguide   input fiber

laser
source

detector
head

Fig. 3.11   Dual NanoTrak connections

Chapter 4   Installation and Maintenance

4.1   Mechanical Installation

4.1.1   Siting

The NanoTrak controller is designed to be mounted free standing on a shelf, benchtop or similar surface.

> **⚠ Caution**
>
> When siting the unit, it should be positioned so as not to impede the operation of the rear panel power supply switch.
>
> Ensure that proper airflow is maintained to the rear of the unit.

4.1.2   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.

4.2 Electrical Installation

4.2.1 Connecting To The Supply

Warning

The unit must be connected only to an earthed fused supply of 100 to 240V.

Use only power supply cables supplied by Thorlabs, other cables may not be rated to the same current.

The unit is shipped to the UK, Europe and the USA, with the appropriate power plug already fitted to the power supply cable. When shipped to other territories the appropriate power plug must be fitted by the user. Cable identification is as follows:

Brown - Live

Blue - Neutral

Green/Yellow - Earth/Ground

4.2.2 Bonding

To eliminate circulating earth (ground) currents, units in the same system should be bonded using the rear panel terminal marked   .

Warning

Do not connect this terminal to the power supply ground.

4.2.3   Electrical Connections

Warning

High voltages may be present at the rear panel terminals. Ensure that the power is switched off before making or breaking any electrical connections. In particular, the piezo 'HV OUT' terminals can carry up to 75V
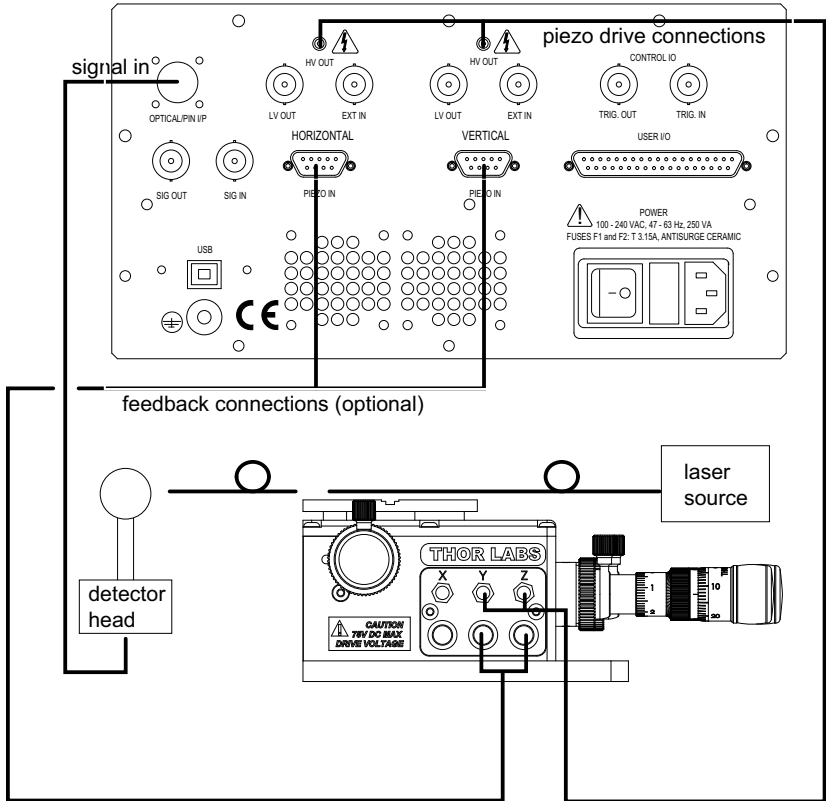
.

Fig. 4.1   Connecting the controller

Example Set Up of the NanoTrak with the Stage and Optical Fibers

Referring to Fig. 4.1:

1) Using SMC-terminated cables, connect the 'HV OUT' terminals to the inputs of the stage corresponding to horizontal and vertical motion.

2) Set up the optical fibers on the stage, using a V-groove holder or similar, such that the light can be transmitted between them. The incoming fiber carries light from a source such as a focussed HeNe laser or pigtailed laser diode. Ensure the fiber ends are clean and well cleaved.

3) If using the NanoTrak detector, connect the fiber to the OPTICAL I/P. If using an external detector head, connect the output fiber to the detector head. Using the SMB-terminated cable, connect the detector head to the 'OPTICAL/PIN I/P' connector of the NanoTrak.

4.2.4 Fuses

Two T 3A/250V a.c. antisurge ceramic fuses are located on the back panel, one for the live feed and one for the neutral as follows:

| Fuse	Rating	Type	Fused Line
F1	T 3A	ceramic; antisurge; 20mm	Live feed
F2	T 3A	ceramic; antisurge; 20mm	Neutral feed

When replacing fuses:

1) Switch off the power and disconnect the power cord before removing the fuse cover.

2) Always replace broken fuses with a fuse of the same rating and type.

4.2.5   Rear Panel User I/O Connector

The User I/O connector exposes a number of internal electrical signals. For convenience, a number of logic inputs and outputs are included, thereby negating the need for extra PC based IO hardware. These user programmable TTL logic lines can be deployed in applications requiring control of external devices such a relays, light sources and other auxiliary equipment. A 5V supply is required to power the digital outputs.

The pin functions are detailed in Fig. 4.2.
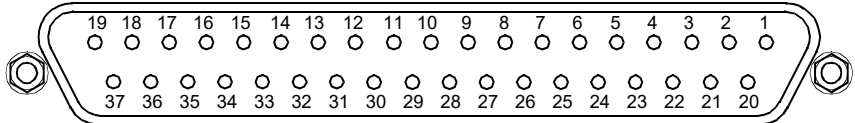
Pin	Description	Return	Pin	Description	Return
1	Ch 1 RS485 (-)	20	20	Ch 1 RS485 (+)	1
2	Ch 2 RS485 (-)	21	21	Ch 2 RS485 (+)	2
3	Not Used		22	Potentiometer Reference	23
4	Potentiometer Wiper Ch 1		23	Analog Ground	
5	Potentiometer Wiper Ch 2		23	† External Trigger O/P	
6	‡ Channel 1 10V O/P		25	† External Trigger I/P	
7	‡ Channel 2 10V O/P		26	5V User O/P (isolated)	27 to 37
8	* DIG O/P 1	27 to 37	27	** Isolated Ground	
9	* DIG O/P 2	27 to 37	28	** Isolated Ground	
10	* DIG O/P 3	27 to 37	29	** Isolated Ground	
11	* DIG O/P 4	27 to 37	30	** Isolated Ground	
12	* DIG I/P 1	27 to 37	31	** Isolated Ground	
13	* DIG I/P 2	27 to 37	32	** Isolated Ground	
14	* DIG I/P 3	27 to 37	33	** Isolated Ground	
15	* DIG I/P 4	27 to 37	34	** Isolated Ground	
16	* DIG I/P 5	27 to 37	34	** Isolated Ground	
17	* DIG I/P 6	27 to 37	36	** Isolated Ground	
18	* DIG I/P 7	27 to 37	37	** Isolated Ground	
19	* DIG I/P 8	27 to 37			

Notes.

*   Opto-isolated, TTL level signal.

**   For use with digital signals.

†   TTL signal.

‡   For use with external signal monitoring equipment.
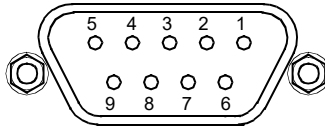
Fig. 4.2   USER I/O connector pin identification

4.2.6 .Rear Panel Piezo In Connector

Note

For use with piezo actuators with feedback capability.

The Piezo In connector provides the feedback connection from the piezo actuators (strain gauge).

The pin functions are detailed in Fig. 4.3.

Pin	Description	Return
1	Wheatstone bridge excitation	4 or 6
2	† +15V	4 or 6
3	† -15V	4 or 6
4	d.c.(+) or Equipment ground	
5	Feedback signal in	4 or 6
6	Equipment ground	
7	d.c.(-) or Actuator ID signal*	4 or 6
8	RS485(-)	9
9	RS485(+)	8

Notes.

† Power supply for the piezo actuator feedback circuit. It must not be used to drive any other circuits or devices.

* This signal is applicable only to Thorlabs actuators. It enables the system to identify the piezo extension associated with the actuator.

Fig. 4.3   Piezo In connector - pin identification

4.3 Preventive Maintenance

> **Warning**
>
> The equipment contains no user servicable parts. There is a risk of severe electrical shock if the equipment is operated with the covers removed. Only personnel authorized by Thorlabs Ltd and trained in the maintenance of this equipment should remove its covers or attempt any repairs or adjustments. Maintenance is limited to safety testing and cleaning as described in the following sections.

4.3.1 Safety Testing

PAT testing in accordance with local regulations, should be performed on a regular basis, (typically annually for an instrument in daily use).

> **Caution**
>
> The instrument contains a power supply filter. Insulation testing of the power supply connector should be performed using a DC voltage.

4.3.2 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 A   Troubleshooting

Question. Although the green 'TRACKING' LED is on, the circle appears to wander across the display screen.

Answer.

1) Increase the size of the scan circle diameter.
2) Increase the gain.
3) Adjust the phase offset.
4) Check the connections (see Section 4.2.3.). Check, using a dial gauge, that the stage moves in the horizontal and vertical axes (perpendicular to the fiber axis) when the manual control knobs on the Piezoelectric Controller GUI is adjusted.
5) An important point is that the 'TRACKING' LED is activated simply by an optical power threshold. If the power meter is set to a range that is too sensitive, it can be activated by noise. Increase the range, or adjust the micrometers to increase the optical power.

Question. Given the answer 5) above, how can I verify that the NanoTrak is really tracking?

Answer. If you make a small adjustment to one of the Micrometers, the circle will move slightly as the NanoTrak adjusts its drive outputs to track the maximum.

Question. Does the circle have to be precisely in the centre of the display?

Answer. No, the NanoTrak can track correctly as long as the circle is not at the edge of the display.

Question. The optical power transmitted from fiber to fiber is much less than I expected.

Answer. Check that the ends of the fibers are well cleaved and clean.

Appendix B   Specifications and Associated Parts

B.1   Specifications

Parameter	Value
Optical Power Measurement	
PIN Photo-Diode	FC/PC Fiber Input
Si or InGaAs Detector	1nA to 10mA Photocurrent
Optical Power Monitor (BNC)	Multiple Ranges
Signal Phase Compensation	-180° to 180°
NanoTraking	
Circle Scanning Frequency	1–300Hz
Circle Position Range	<1% to >99% MPE
Circle Dia Adjustment Modes	automatic and manual
Piezoelectric Input/Output:	
Two Output Connectors (SMC male)	Voltage Output: 0–75 VDC/Channel Voltage Stability: 100ppm over 24 Hours Noise: <3mVrms Output Current: 500 mA/Channel
Output Monitors (BNC)	0–10 VDC
Analog Inputs (BNC)	0–10 VDC
Strain Gauge Position Feedback	(Two 9 Pin D-type Female)
Other Input/Output:	
Optical Power Monitor (BNC)	0–10 VDC
User Control (37 Pin D-type female)	Isolated Digital I/O Trigger In/Out (BNC)
USB Port	USB Comms
Input Power Requirements	
Voltage	85-264 VAC
Power	200 W
Fuse	3.15 A
General	
Housing Dimensions (W x D x H)	245 x 130 x 330 mm (9.6 x 5.1 x 13 in.)
Instrument Weight	6 kg (13 lb)

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B.2   Associated Products

| Product Name	Part Number
InGaAs Detector	NTA007
Silicon Detector	NTA009
Drive Cable for Piezoelectric Actuators (3.0 m)	PAA100
Drive Cable for Piezoelectric Actuators (1.5 m)	PAA101
Piezoelectric Feedback Cable, Male D-type to Female LEMO converter (3.0 m)	PAA622

# Appendix C   Principles of Operation

C.1   The NanoTrak

C.1.1   Introduction

For simplicity, the following example refers to the alignment of two opposing butt coupled single mode fibers, however the principles of operation are equally valid for the physical alignment of any two opposing optically coupled faces or indeed any two objects that can provide a feedback signal (voltage) that varies as a function of their alignment with respect to each other. .
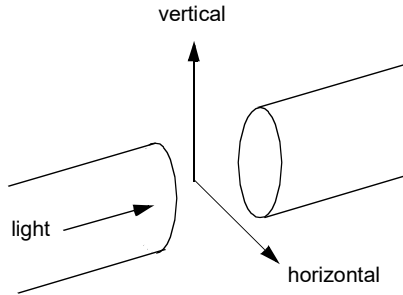
Fig. C.1 Alignment of optical fibers

In Fig. C.1, one of the fibers is fixed, the other is mounted on a piezo-actuated stage that moves the fiber in the horizontal and vertical axes. The NanoTrak must adjust the position of the moving fiber until the power transmitted between the two is maximized. Fig. C.2 shows a block diagram of the NanoTrak control loop. In many applications, a waveguide or similar device replaces one of the fibers, however this makes no difference to the principle of operation.
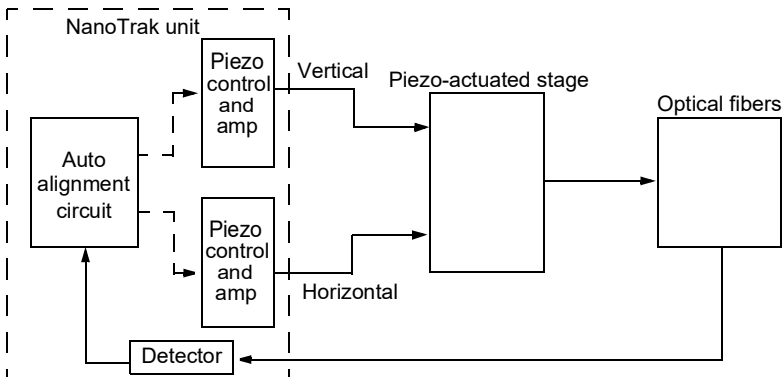
Fig. C.2 NanoTrak control loop

C.1.2   How the NanoTrak Maximizes Optical Power

To understand the principles involved in the alignment, consider the operation in a single axis. When two fibers are aligned, maximum power is transmitted between them, and if the fiber is moved a few microns to the left (Fig. C.3, position A), the power is reduced. Furthermore, oscillating the fiber by a few microns causes the detected power signal to assume an a.c. component whose amplitude is proportional to the amplitude of the mechanical oscillation (modulating signal).
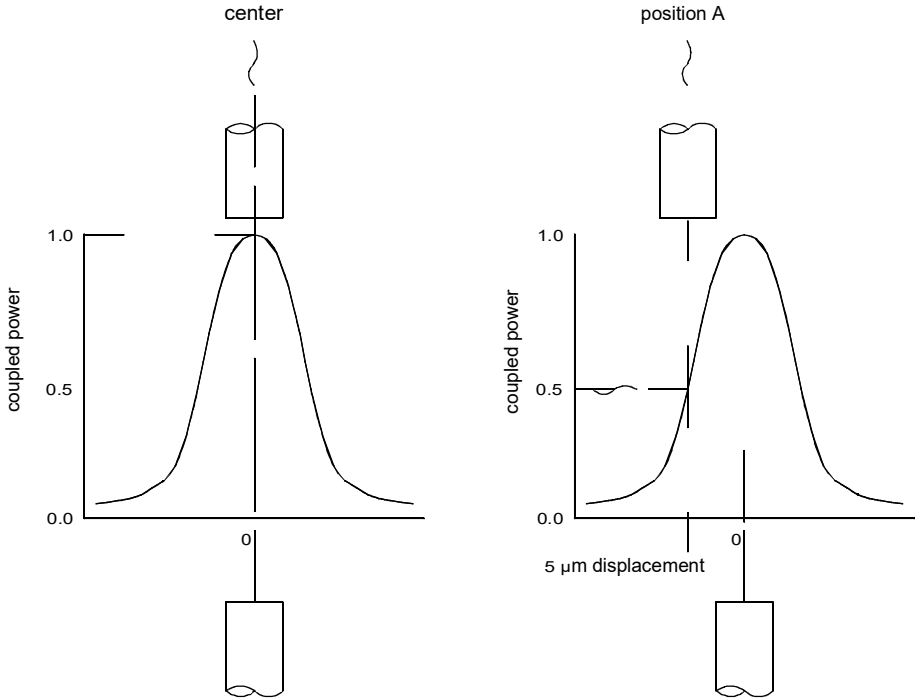
Fig. C.3 AC component of optical power

The received power signal contains a frequency component at the scanning frequency, and the phase of this (relative to the circle scan voltages) gives information on which direction to move.

When the circle is centred in the ideal position, the power signal contains no modulation at the scanning frequency. However, at position A, the signal has a phase difference with respect to the modulating signal. The power signal is Fourier analysed and the result of the computation is passed to an algorithm which drives the circle to the correct position.'

However, piezo transducers are unipolar and to achieve a positive and negative adjustment either side of center, the piezo must be at its center of travel when the error signal is zero. This is achieved by adding an offset voltage to the error signal.

Now, the range of the piezo is typically 20 to 30 µm, while the fiber is oscillated by 2 or 3 microns. Therefore, it can be seen, that by varying this offset voltage we can adjust the position at which the oscillation of the fiber takes place - see Fig. C.4 detail A.
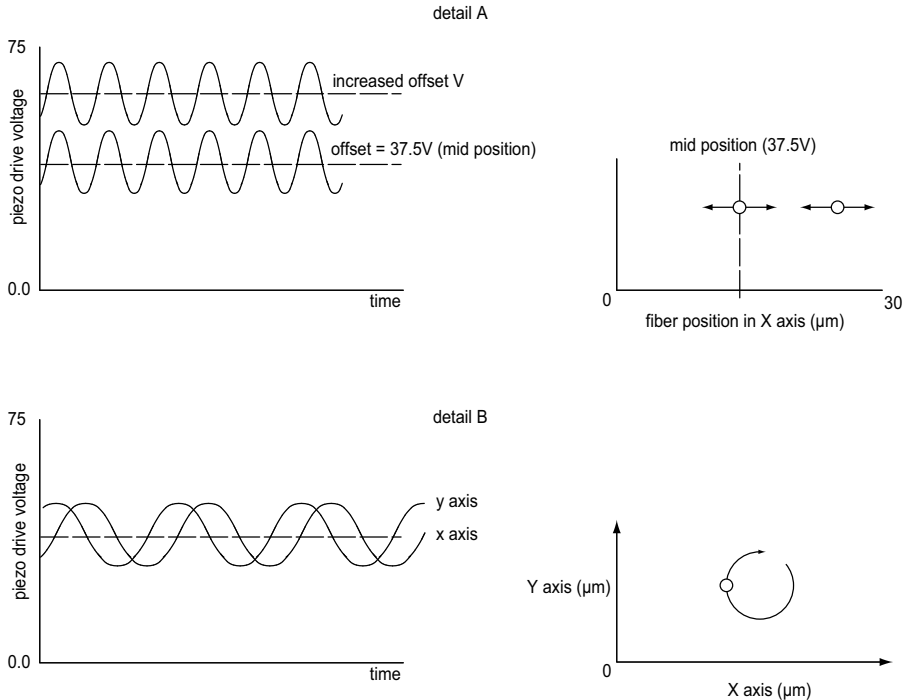
Fig. C.4 Offset voltage and fiber position

In reality, the fiber is oscillated both horizontally and vertically, with the modulating signal for Y phase shifted by 90° with respect to X - see Fig. C.4 detail B, which produces a circular oscillation. The detected signal is compared with both the horizontal and vertical phases of the modulating signal which results in both horizontal and vertical error signals.

As mentioned previously, the polarity of the error signals corresponds to the relative position of the two fibers and consequently, the signals can be used to drive the piezos until the fibers are aligned and the error voltages fall to zero.

Once the NanoTrak has found the position of maximum power, if one of the fibers is moved slightly (due to mechanical creepage or thermal drift), the NanoTrak detects the subsequent drop in power and corrects for the movement to maintain the maximum. This is called *tracking*.

C.1.3   Circle Size and Gain Control

Given that movement of two opposing fibers produces variations in the coupled power, the very act of automatically aligning the fibers to increase the coupled power may cause unwanted disturbances to the signal path.

Consider the optical profile in Fig. C.5. When the NanoTrak is tracking, the polarity of the resultant control voltage is determined by the position of the aligning fiber relative to the center line and the voltage amplitude is proportional to the amount of displacement from this center line.
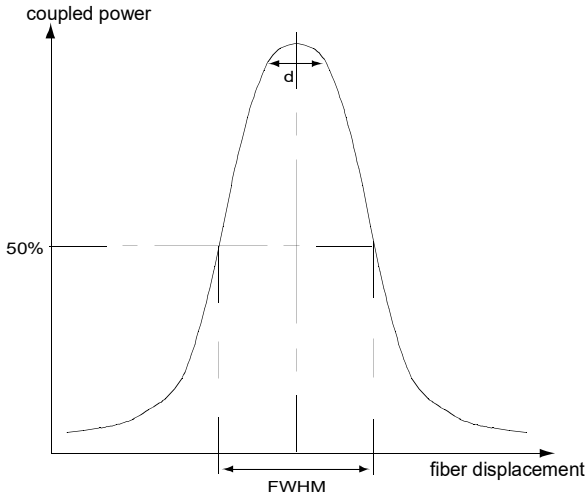
Fig. C.5 Circle diameter

If the scan circle diameter 'd' is such that the circle crosses the center line, the polarity of the control voltage is reversed and movement of the circle becomes erratic. The ideal circle size is dependant upon the shape and dimensions of the optical curve associated with a particular application, but should be between $^1/_{10}$ and $^1/_{20}$ FWHM (full width half maximum).

Under normal operation, the circle size should be reduced in proportion to the coupled signal, from a maximum of 3 µm to a value of less than 50nm. At the point of optimized alignment, this small modulating signal results in a small a.c. component, sufficient to maintain tracking but low enough to ensure that the resultant modulation does not interfere with the measurement being made.

The circle size can be set manually by entering a value in the Settings panel. Alternatively, if automatic LUT diameter adjustment mode is enabled, the system uses values in a LUT to modify circle diameter in relation to the input range currently selected.

This LUT diameter adjustment mode allows appropriate circle diameters to be applied on an application specific basis.

The loop gain can also effect system stability. If the gain is too high, the circle moves erratically, whereas too low a setting results in the circle 'floating' around the edge of the screen. Loop gain can be configured from the Controller GUI.

Both circle size and loop gain effect the system amplification. As a guide to manual settings, if the scan circle moves erratically round the screen, the amplification should be reduced, and conversely, if the scan circle movement is sluggish, the amplification should be increased. As with any phase locked control loop, it may be necessary to perform application-specific adjustments to optimize the speed of response and stability.

C.1.4   Phase Offset

Theoretically, if the NanoTrak were to read the power and respond by moving the fiber instantaneously, the power signal read in would be in phase with the modulating signal. In reality, the various electronic and electromechanical components (e.g. power meters, piezo actuators) within the control loop can introduce delays which means that the NanoTrak is always reacting to a power reading which was taken in the past. This, in turn, can cause a phase shift and in extreme cases can lead to instability.

A phase offset can be introduced to compensate for any phase shifts. In the system, a different phase offset can be specified for each axis of motion. This is particularly useful in those mechanical systems that exhibit different delays in different directions.

C.1.5   Latch, Track and Tracking modes

The purpose of the latch is to disable scanning and hold the drive outputs at the present position. With the latch released, the NanoTrak is in track mode. However, to minimise the risk of detecting a false peak, tracking should be activated only after a threshold power has been located, which is sufficiently above the background noise level. See the table below for details of the three modes of operation.

Mode	Description	Button LED	Tracking indicator
Latch	Drive outputs held in constant position	Latch ON	OFF
Track mode, not yet tracking	The drive outputs wander and the circle drifts around the display	Track ON	OFF (i.e. below threshold power)
Track mode and tracking	The drive outputs seek and maintain maximum power settings	Track ON	ON (i.e. above threshold power)

Appendix D   Regulatory

D.1   Declarations Of Conformity

D.1.1   For Customers in Europe
See Section D.2.

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

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

D.2 CE Certificate

THORLABS
www.thorlabs.com

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs Ltd.

Of: 1 St. Thomas Place, Ely, CB7 4EX, United Kingdom

in accordance with the following Directive(s):

2006/95/EC	Low Voltage Directive (LVD)
2004/108/EC	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: **BNT001/IR**

Equipment: **APT System Benchtop NanoTrak Controller-IR Detect**

is in conformity with the applicable requirements of the following documents:

EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013

and which, issued under the sole responsibility of Thorlabs, is in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8th June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:

does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive

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: On: 29 October 2015

CE 15

Name: Keith Dhese

Position: General Manager EDC - BNT001/IR -2015-10-29

Appendix E   Thorlabs Worldwide Contacts

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