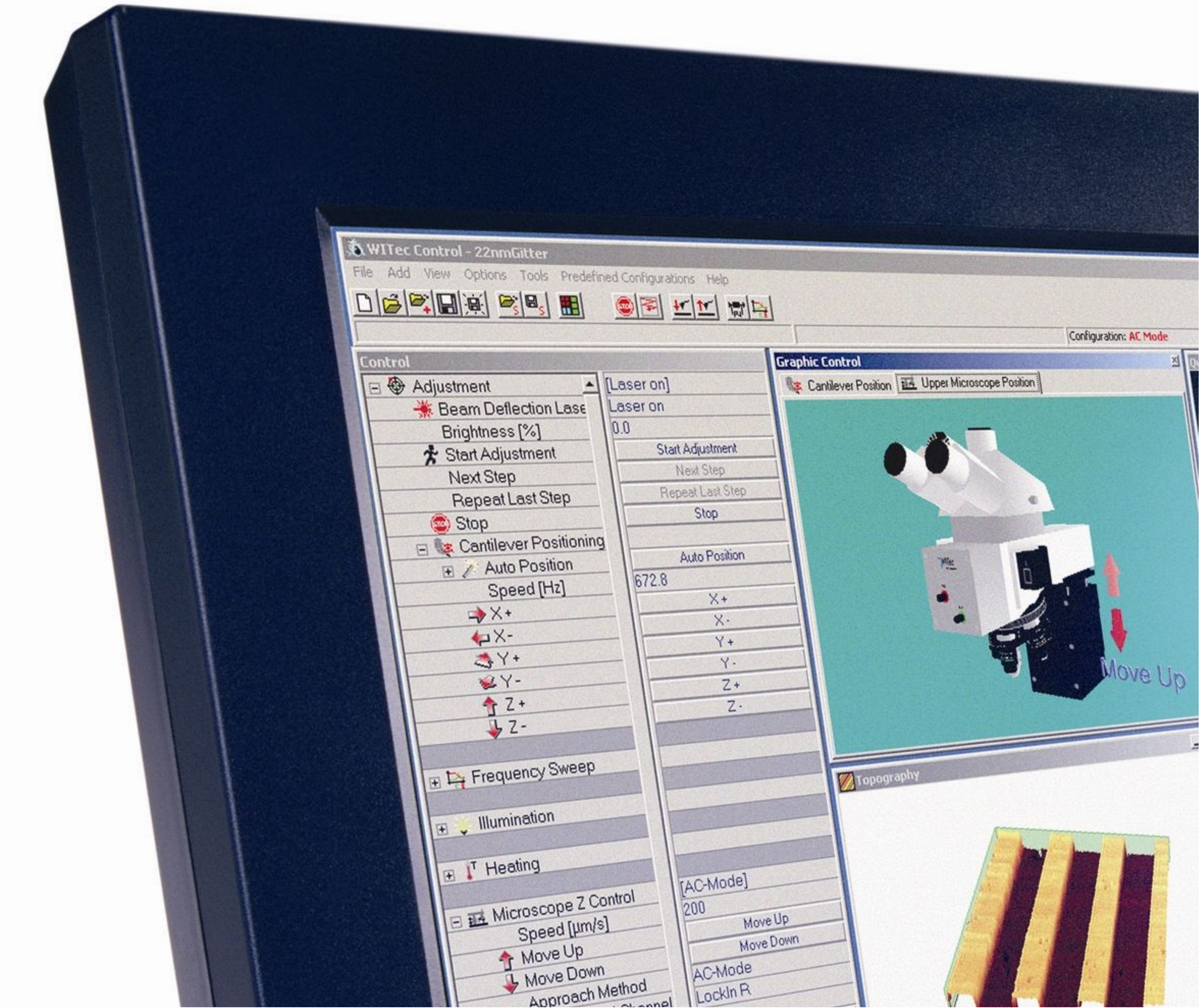
WITec Control

Scanning and Data Acquisition Software

User Manual

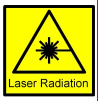
WITec focus innovations



About this manual

This manual describes the WITec Control scanning and data acquisition software. WITec Control is based on the WITec Project software. It uses the structure and all the components of the WITec Project software with additional functionalities for measuring modes such as Confocal Raman Microscopy, SNOM, and AFM. Only these functionalities and their corresponding spectroscopy options are described in this manual.
For information about all other features, the user is referred to the WITec Project manual.

Warnings are marked with a red bar. Please read these warnings carefully to avoid problems that may otherwise occur.



If extra care should be taken by the operator due to the presence of intense laser radiation, this warning sign will be present.

HINT Throughout the manual, you will find text blocks with a blue **HINT** on the left–hand side of the text. These text blocks contain additional, useful information.

Text marked with a shaded rectangle such as Menu Item Name refer to a menu item in the software.

Text marked with a rectangle such as Button Name refer to a button or checkbox in the software.

Keyboard keys are highlighted as Key.

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Safety Information

Please read this manual carefully before using the software.

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Chapter 1

Opening and closing WITec Control

The WITec Control software is designed to manage the acquisition of data using WITec microscopes in conjunction with the alphaControl. Therefore, the software should only be started if the computer is already connected to the controller and the controller is switched ON.

1.1 Open WITec Control

After double-clicking the WITec Control symbol  on the desktop of the computer, the main menu of the software is displayed (Section 2.1). Additionally, the software checks for the presence of various hardware components, the system configuration, and whether or not the software was shut down properly after the last usage.
After these initial checks, a start-up sequence is activated. In this procedure several operations such as: calibrating the scan table, initializing the spectrometer, cooling the CCD camera, etc, are performed to ensure the optimal performance of the alpha300 / alpha500 / alpha700 system. The performed operations are listed in the message window (Chapter 6).

Interrupting this start-up sequence might lead to malfunctions.

1.2 Close WITec Control

When closing the WITec Control software, a shut-down sequence is initiated. This sequence includes:

- An increase of the distance between the sample and the objective by 500μm.
- The reset of all voltages to default values, which avoids potential damage to the system components.

- The deactivation of the white light illumination.
- The controlled heating of the CCD camera (if present) to room temperature.

The performed operations are listed in the message window (Chapter 6).
Shutting down the computer without completing the shut-down sequence may harm the CCD camera due to excessive thermal stress.

Chapter 2

Appearance

After opening the WITec Control software, the main window is displayed. While almost identical to the WITec Project software, this software offers additional features related to measurement control and the acquisition of data. Descriptions of these features are included in this manual. For a detailed description of all other functions, the user is referred to the WITec Project manual.

2.1 Main Menu

The main menu of the WITec Control software provides access to all functions and menus. All functions can be selected using either the mouse or via HotKeys using the Alt - key on your keyboard in combination with the appropriate letter for the desired menu.

2.1.1 Hardware Control

All hardware controls, visual displays and message windows are listed in this menu. By activating the checkbox, the desired window is displayed at its designated location.

Control

The control window provides access to all functions and parameters of the controller. Based on their functionality, the parameters are grouped in a tree-like structure, allowing quick and intuitive access to all parameters. The functions listed in the control window depend on the configuration of the system and may vary from one data acquisition method to another. A detailed description of the functions and the appropriate parameters can be found in Chapter 3.

Video Control

The video images acquired by the alpha300 / alpha500 / alpha700 system are displayed in the video control window. All functions required for proper video imaging are contained within this window. A detailed description of its functions is given in Chapter 4.

Status

The status window contains a 2 column chart which lists the actual values of important parameters. The displayed parameters vary from one data acquisition method to another (see Chapter 5).

Message Window

The message window provides information about the status of an operation and the remaining time required to fulfill the given task. Hints and warnings for the user are also displayed in this window. A detailed description of the various messages and their symbols can be found in Chapter 6.

Quadrant

The quadrant window is a visual representation of the beam deflection laser detector. This window is useful for AFM and SNOM measurements. A detailed description of the display is given in Chapter 7.

Graphic Control

This function opens the graphic control window. In this window some of the controls are displayed in extended visual interfaces. These are accessible via tab sheets and a detailed description of each extended visual interface can be found in Chapter 8.

Point Viewer

The point viewer is used for the definition of sample rasters. Using these it is possible to automatically move to up to several thousand predefined points on the sample and execute automated script functions. A detailed description of the point viewer is given in Chapter 9.

2.1.2 Configurations

In this menu, the microscope's mode of operation can be selected. The software will list only the microscope operation modes corresponding to the system configuration. When selecting a predefined measuring configuration, the control, status, and quadrant windows will change accordingly. The current measuring mode is displayed in the status bar of the main menu (Section 2.3).

Save current Parameters

This function allows the current parameter settings displayed in the right column of the control window to be saved. The name the parameters are saved under is the same as the operation mode displayed in the status bar of the main menu. The next time this operation mode is selected the saved parameters will be loaded automatically.

Save current Configuration

This function saves the current configuration displayed in the left column of the control window. The name the configuration is saved under is the same as the operation mode displayed in the status bar of the main menu. The next time this operation mode is selected the saved configuration will be loaded automatically. For a more detailed discussion of parameters and configurations see Chapter 3.

Save as

This function is similar to the save current configuration function, while offering the possibility to change the filename using the Windows® standard save-dialog.

2.2 Speed Buttons

The main menu contains several groups of speed buttons, which allow quick access to different functionalities of the software.
The first group of speed buttons  refers to file management, project settings, and the reset of viewers. A detailed description of these buttons can be found in the WITec Project manual.

The remaining speed buttons allow quick access to microscope and controller functions. The speed buttons displayed vary with the selected microscopy method and are therefore described in separate documents corresponding to the individual configuration of the system purchased.

2.3 Status Bar

The status bar provides, in addition to the information about the available computer memory (similar to WITec Project), information about the current configuration of the alpha300 / alpha500 / alpha700 system and the functionality of the remote control.

Chapter 3

Control Window

The Control Window provides access to the full functionality of the alphaControl. Due to the large number of available parameters, the concept of the Control Window is based on a highly flexible tree structure. Sections 3.1, 3.2 and 3.3 will cover the functionality, appearance and operation of the Control Window. While only the parameters necessary for the selected measurement mode will generally be displayed, all relevant parameters will be described in in Section 3.4, Section 3.5 and Section 3.6.

In the default setting the Control Window will open upon starting WITec Control. Alternatively the Control Window can be opened through the hardware control in the menu bar.

3.1 Basic Functional Principles

The representation of the values needed for a certain measurement is individually adjustable using WITec Control. The following basic distinctions illustrate the underlying philosophy of the controls.

Parameters

Parameters are a set of values which are needed to perform a certain task. They are predefined for all standard measurement methods and define the state of the instrument before, during and after each task. Some parameters will depend on other parameters or will automatically be changed during the execution of a certain task.

Styles

A style is a visual representation of a set of parameters. Styles are used in WITec Control to group the parameters in logical categories. These are either devices or sequencers (see below) and will vary from one measurement modus to another. Additional speed buttons appearing in the main window are also defined within the styles.

Configurations

A configuration combines a style with the numerical values of all parameters. However, only the parameters relevant for the chosen measurement mode are displayed. Therefore, the configuration must be changed when changing the measurement modus (eg. from AFM to SNOM).

Devices

A device is a logical collection of parameters relevant for a physical apparatus such as the scan table or the microscope illumination. The assemblies of parameters are defined in the style and may vary from one measurement mode to another.

Sequencers

Sequencers are, similar to devices, sets of parameters defined by the styles as groups of parameters. In contrast to devices however, sequencers perform certain tasks such as the oscilloscope function or a scan. Sequencers use some of the devices to perform their tasks and automatically change some of the parameters of the devices used.

3.2 Visual Representation

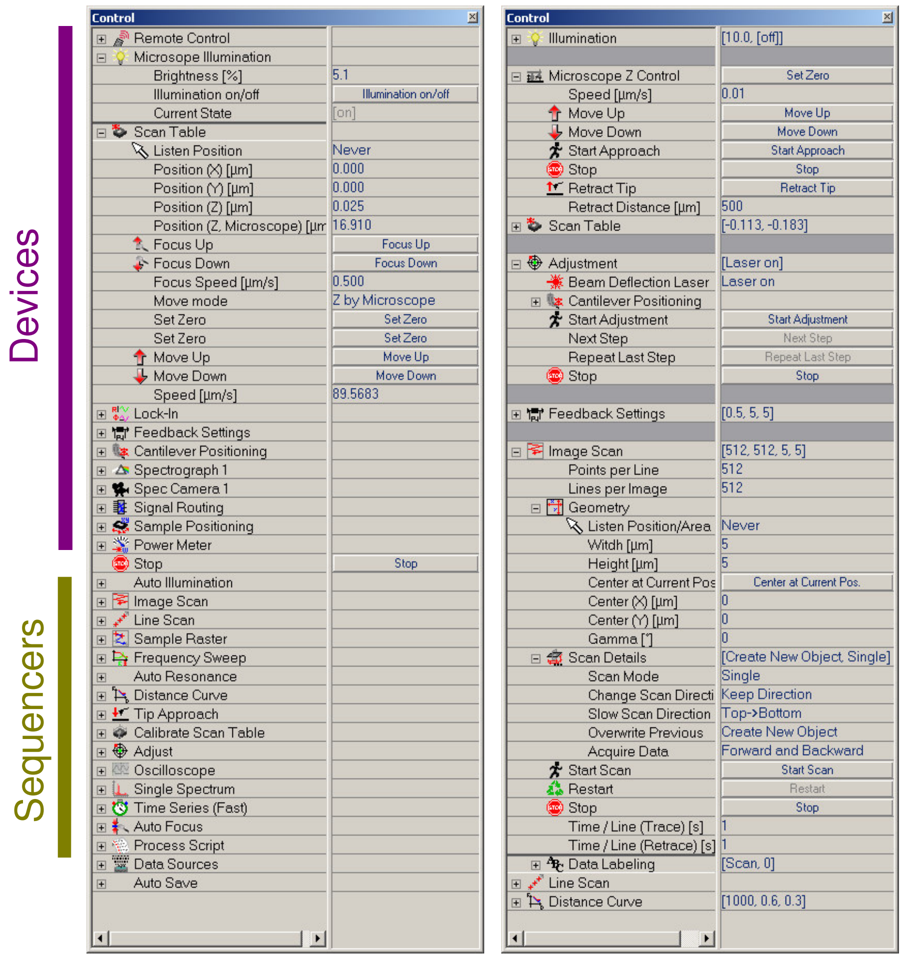
Fig. 3.1 shows two examples of how the Control Window may appear. Fig. 3.1(a) shows the default tree which can be opened through the context menu of the Control Window. The context menu can be accessed by right-clicking on the Control Window.

Only very advanced users should use the default tree for their measurements. The default tree will allow access to all parameters of the alphaControl and entering wrong parameter values may lead to malfunctioning of the alphaControl or false measurement results. The user will generally only need to access the default tree when in contact with a WITec service representative.

Fig. 3.1(b) shows the Control Window in the AFM contact configuration. In this example some of the logical categories are expanded and others collapsed (as can be seen from the - and + symbols to the left of the category names).

Some devices display a ... button in the cell to the right of the category name when activated. Clicking this button will open the corresponding extended visual interface (see Chapter 8).

The Control Window is split in two columns where the left column shows either the category name or the parameter description and the physical unit of the parameter, which is given in square brackets. If the left cell contains a category name, the right cell will -where applicable- contain a summary of the most important information within the category in square brackets. Where the left cell contains a parameter description, the right cell will contain the corresponding value of the parameter. These



(a) (b)

Fig. 3.1: Examples of the Control Window using the default tree (a) and the AFM Contact configuration (b). In (a) the devices and the sequencers are identified.

parameters are either numerical values, strings, items selectable from a drop down menu or buttons. Regarding buttons, two types can be distinguished. First, the so called trigger buttons, which trigger a corresponding action upon clicking (eg. the Stop button) and second, the continuous-action buttons (eg. the Move Up button). The latter will continue to have an effect on the system as long as they are pressed (eg. while the Move Up button is pressed, the Z-Microscope will continue to move up).

As mentioned above, all functions available though the alphaControl are accessible via the Control Window. The parameters displayed will depend on the hardware present as well as the configuration chosen. Upon shipment of the system, the software will be configured according to the hardware specific to your individual system. As mentioned in Chapter 1, WITec Control will search for the presence of the hardware upon start up. If any part of the hardware the software is configured for is not found, a warning will be issued and the parameters related to the missing hardware will not be available.

Upon installation of WITec Control (which will generally not be necessary for the user) the configurations appropriate for the individual hardware will be saved in

`[`*`Install_Dir`*`]\WITec\WITecControl_`*`VersionNumber`*`\UserDefaults\Configurations`

where *`Install_Dir`* is the chosen installation directory (typically `C:\Program Files`) and *`VersionNumber`* is the actual version number of the installed software. Every time a new user uses the software, these default configurations will be copied to

`C:\Documents and Settings\`*`UserName`*`\WITecControl_`*`VersionNumber`*`\Configurations`

where *`UserName`* is the Windows™ user name.

HINT Should problems with the configuration occur, the default configurations can simply be copied again into the corresponding directory. Similarly, if a user wants to use the exact same configuration as saved by another user, these configurations can also be copied as required.

3.3 Navigation

Most functions are accessible through both the mouse and keyboard. The control using the mouse is similar to the standard Windows™ usage and the control using the keyboard is described below for each of the columns. Using the Tab key it is possible to switch between the left and right columns.

Left Column

In the left column, the ↑ and ↓ keys can be used to move up and down the list. When pressing the → key while sitting on an entry with a +, the category will expand. Similarly, pressing the ← key while a field with a - is highlighted, will collapse the category. If one of the lines within an expanded category is highlighted and the ← key is pressed, the field corresponding to higher level category will be activated.

Right Column

Similar to the left column, the ↑ and ↓ keys can be used to move up and down the list and if a collapsible or expandable field (indicated by the - and + in the left column) is highlighted, the functionality of the ← and → is again to collapse or expand the category.

If a numerical value is activated, a new value can be entered or the value changed by holding the Control key and pressing the ↑ key to increase and the ↓ key to decrease the value. Larger increments for increasing or decreasing a value using this method can be selected by simultaneously pressing the Shift key.

If a drop down menu is highlighted, pressing the ← and → allows browsing through the possible entries.

A button can be activated by pressing either the Enter or the Space key. If the button is a continuous-action button, the action will be executed while the key is pressed.

3.4 Devices

In this section all devices accessible through the default tree configuration (see Fig. 3.1a) and their respective parameters will be explained. The specific configuration selected for the individual measurement mode will contain a subset of the devices described in the following. Some of the devices will -for specific configurations- be included as a subset of another parameter group and not all parameters set in the specific configuration will be displayed through the style selected. A detailed description of the configurations of your individual system are provided in separate documents.

3.4.1 Remote Control

The remote control device determines the behavior of the remote control which is supplied with the alphaControl. The following parameters can be adjusted:

Active Duration [s]

This parameter identifies the time the remote control will remain active after one of the buttons or the rotation knob were last operated. Upon expiration of this time, the remote control is set to the *NONE* device, its idle state.

Controlled Device

The controlled device is selectable from a drop down menu which contains all devices that may be remote controlled plus the idle state *NONE*. However, only the devices permitted for remote control (see below) will be selectable from the drop down menu.

None

The idle state of the remote control. It is always permitted and cannot be changed.

Scan Table

This parameter controls whether the Scan Table can be moved using the remote control (setting *YES*) or not (setting *NO*).

Microscope Z

This parameter controls whether the microscope Z stage can be moved using the remote control (setting *YES*) or not (setting *NO*).

Cantilever Position

This parameter controls whether the cantilever position can be moved via the inertial drive using the remote control (setting *YES*) or not (setting *NO*).

Inverted Microscope

This parameter controls whether the inverted microscope can be moved using the remote control (setting *YES*) or not (setting *NO*).

Sample Positioning

This parameter controls whether the sample positioning via the motorized XY stage can be accessed using the remote control (setting *YES*) or not (setting *NO*).

3.4.2 Microscope Illumination

The parameters for the control of the microscope illumination are

Brightness [%]

Using this parameter, the percentage of the maximum illumination power can be selected.

Illumination on/off

This button toggles the illumination on and off where the brightness set using the parameter described above is used as the ON state.

Current State

This field informs the user whether the illumination is [on] or [off].

3.4.3 Scan Table

The scan table parameter group provides access not only to the position and the behavior of the X, Y, and Z axes of the scan table, but also to the microscope Z stage. The microscope Z stage is either moving the microscope body up and down for *alpha300* systems or, for industrial applications using the *alpha500* or *alpha700* systems, the Z stage can be located underneath the scan table providing up and down movement of the scan table. The control in both cases is identical and the value given as the Z position is always the relative objective↔sample distance (ie the larger the number the bigger this distance).

WITec Control allows the use of various reference positions which are helpful during the scanning operations. These reference positions and their relationships to one another are outlined in the following before the individual parameters of the scan table parameter group will be described.

Coordinate Systems

WITec Control uses an external and an internal coordinate system for the control of the scan and the microscope Z stage as illustrated in figure Fig. 3.2.

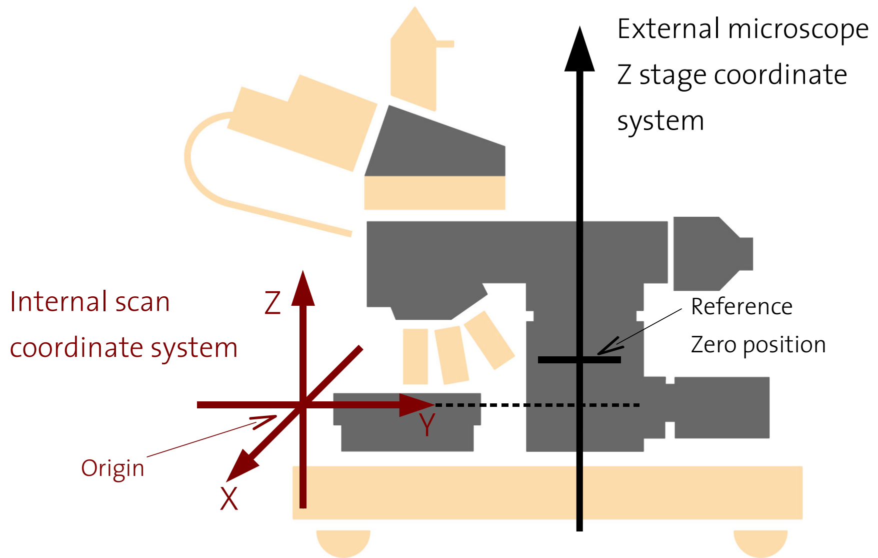


Fig. 3.2: Internal and external coordinate systems in WITec Control.

Scans will always be performed in the internal coordinate system. The Z axis of the external coordinate system is always the direction of movement of the microscope Z stage. The Z axis of the internal coordinate system can, however, be either the Z axis of the scan table or the microscope Z stage. This allows depth scans with up to 200μm depth while the scan table would only be capable of a 20μm movement. The zero point or origin in the Z direction can be freely set in both coordinate systems to allow the logical referencing of relevant positions and it also facilitates returning to those positions after performing various operations. The zero point in the external coordinate system might be, for example, the position at which the sample surface is in focus in confocal mode. Therefore entering 0 as the desired Z microscope position at any time will refocus the image (if the sample Z position has not changed).

The parameters

Position(X)[μm]

Shows the X position of the scan table and can be increased or decreased up to the limits of the scan table ($\pm$50 or $\pm$100μm depending on the scan table purchased). If an out of range value is entered, the scan table will move to its maximum position which will then also be displayed as the parameter value.

Position(Y)[μm]

Shows the Y position of the scan table and can be increased or decreased up to the limits of the scan table ($\pm$50 or $\pm$100μm depending on the scan table purchased). If an out of range value is entered, the scan table will move to its maximum position which will then also be displayed as the parameter value.

Position(Z)[μm]

Shows the Z position of the scan table and can be increased or decreased up to the limits of the scan table ($\pm$10μm). If an out of range value is entered, the scan table will move to its maximum position which will then also be displayed as the parameter value.

Position(Z, Microscope)[μm]

This parameter represents the relative distance between the objective and the sample and can be increased or decreased.

Upon start up, the software cannot recognize the position of the microscope Z stage. Therefore it is possible to drive the objective into the sample and destroy the objective and/or the sample while decreasing this distance. Care must therefore be taken when approaching the sample with the microscope Z stage. When increasing this distance the microscope Z stage can potentially be driven into its limit which will be audible by a clicking noise from the table. This must also be avoided.

Move mode

Using this drop down menu, the behavior of the Z axis can be controlled with the following options:

- **Z for Feedback**
  This mode is typically used for SNOM or AFM measurements. Here the Z axis of the scan table is controlled through the PI controller using the feedback laser as a reference. If this mode is selected, the position of the Z axis of the scan table cannot be changed manually.

- **Z by Microscope**
  This is the typical mode of operation when performing confocal or confocal

Raman measurements, in which the microscope Z stage is used as the Z axis of the internal coordinate system. This allows depth scans of up to 200μm. However, only scans in the X-Y or X-Z plane are possible (ie no tilted scans) with the Z position changing from line to line or image to image if applicable.

- **Z by Scan Table**
  This mode is not yet implemented in the standard configurations provided to date but will in the future allow tilted scans. Here the Z axis of the scan table is the Z axis of the internal coordinate system. Additionally, using the Z axis of the scan table only allows for depth scans with a maximum range of 20μm.

Move Up

Using this continuous action button, the distance between the objective and the sample can be increased using the speed entered (see below).

Move Down

Using this continuous action button, the distance between the objective and the sample can be decreased using the speed entered (see below).

Speed [μm/s]

Here a numerical value for the speed used to move the microscope Z stage can be selected from between the limits of 0.01 and 500$\mu m/s$. This speed can also be changed using the potentiometer on the remote control or the graphical representation of the potentiometer in the graphic Control Window. The numerical value displayed in the graphic Control Window is the same as displayed here. Entering out of range values will result in the use and display of the maximum or minimum value.

Focus Up

Using this continuous action button, the Z value of the axis (which is NOT the Z axis of the internal coordinate system) can be increased using the focus speed entered (see below).

Focus Down

Using this continuous action button, the Z value of the axis which is NOT the Z axis of the internal coordinate system can be decreased using the focus speed entered (see below).

Focus Speed [μm/s]

Here, a numerical value for the speed used to move along the Z axis which is not the Z axis of the internal coordinate system can be entered. The minimum and maximum speeds are 0.001 and 10$\mu m/s$ respectively and entering out of range values will result in the use and display of the maximum or minimum value.

Listen Position

The listen position parameter allows the selection of coordinates for the positioning of the scan table and/or the microscope Z stage using any graph or image linked to a spatial cursor. See the WITec Project manual for a more detailed description of spatial cursors. In the drop down list of this menu item the options *Never*, *Once* or *Multiple* can be selected to identify how many times the coordinates will be adjusted if a corresponding position is selected via a mouse click. Upon clicking on, for example, the video image, the scan table will automatically move to the X and Y coordinates of the point clicked on in the video image if the listen position option is activated. The X and Y coordinates can be changed through this action using any image captured in the X-Y plane such as a 2D scan, video image or a bitmap so long as this bitmap is linked to the corresponding cursor. The Z axis of the internal coordinate system can be altered using this action by clicking on a depth scan for example. Additionally, positioning using this feature is also allowed using graphs from cross sections or line scans.

3.4.4 Lock-In

Lock-in amplifiers are used to measure very small AC signals, especially when the signals are obscured by noise. They use a technique known as phase-sensitive detection to single out the component of the signal at a specific reference frequency. Noise signals at frequencies other than the reference frequency are rejected and do not affect the measurement.

Lock-in measurements require a reference signal d which typically is of the form

$$d = Dsin(\omega_d t + \phi_d). \tag{3.1}$$

Here D is the amplitude, ω_d the frequency and ϕ_d the phase of the reference signal. Typically, parts of an experimental setup are excited at a fixed frequency and the lock-in detects the response from the setup at the reference frequency.
The lock-in amplifier of the alphaControl is represented schematically in Fig. 3.3. It generates its own reference signal d, which is also typically used as the dither-signal to excite the cantilever during AFM AC Mode measurements.

The input signal (e.g. the T-B signal in AC mode), which can be represented as

$$s = Ssin(\omega_s t + \phi_s), \tag{3.2}$$

is amplified and multiplied with the lock-in reference (Equ. 3.1) using a phase sensitive multiplier. Here S is the amplitude, ω_s the frequency and ϕ_s the phase of the detected signal. The output of the phase sensitive detectors are the products of

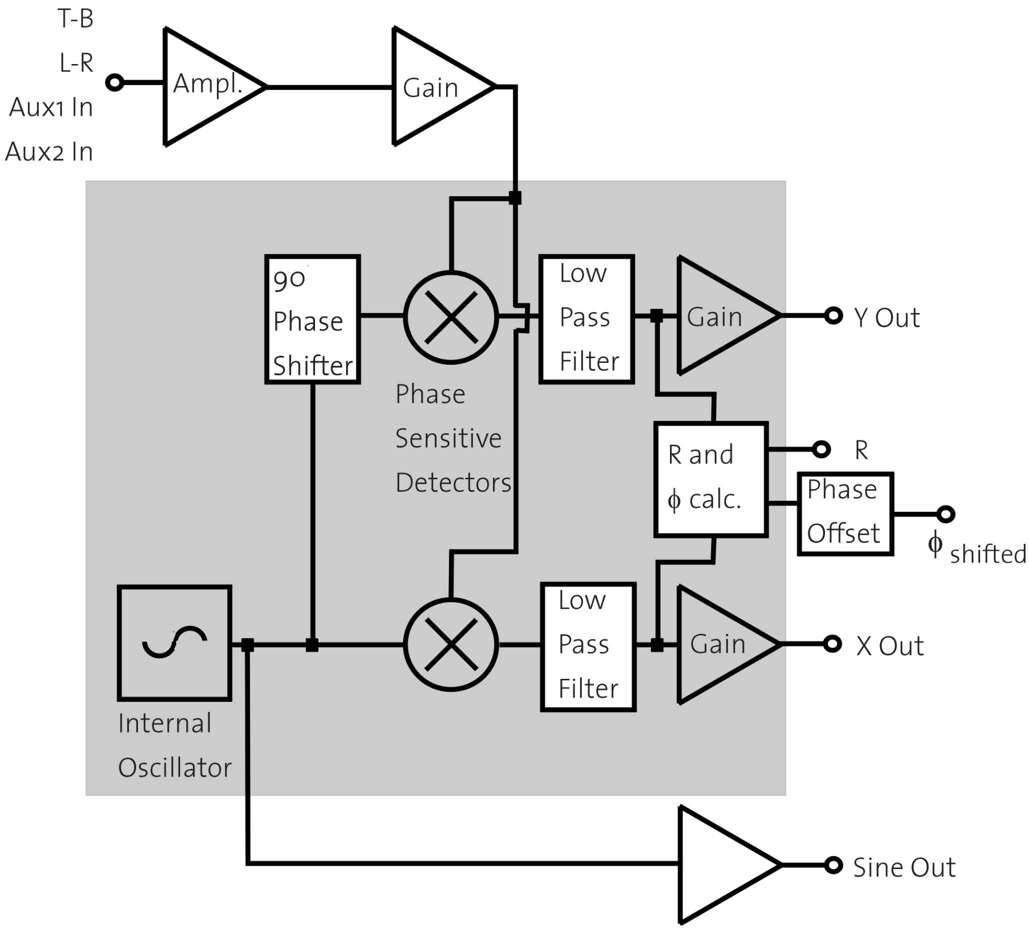


Fig. 3.3: Schematic representation of the dual-phase lock-in of the alphaControl.

two sine waves (Equ. 3.3) which can also be represented as the sum of two AC signals, one at the difference frequency ($\omega_s - \omega_d$) and the other at the sum frequency ($\omega_s + \omega_d$) as shown in Equ. 3.4.

$$PSD_X = DSsin(\omega_d t + \phi_d)sin(\omega_s t + \phi_s) \tag{3.3}$$

$$= \frac{1}{2}DScos[(\omega_s - \omega_d)t + \phi_s - \phi_d] - \frac{1}{2}DScos[(\omega_s + \omega_d)t + \phi_s + \phi_d] \tag{3.4}$$

If $\omega_s = \omega_d$, the difference frequency component (term one of Equ. 3.4) will be a DC offset proportional to the signal amplitude. Therefore, if this PSD output is passed through a low pass filter with which the AC signal is removed (the second term of Equ. 3.4), the resulting signal can be described by the following equation:

$$PSD_X = \frac{1}{2}DScos\phi \tag{3.5}$$

with

$$\phi = \phi_s - \phi_d. \tag{3.6}$$

The time dependence of the phase ϕ_s is eliminated by multiplying the signal s (Equ. 3.2) by the reference signal shifted by 90^o. The second low pass filtered PSD signal is therefore

$$PSD_Y = \frac{1}{2} DS sin\phi. \tag{3.7}$$

The signal defined by Equ. 3.5 is proportional to $cos\phi$ and the second signal defined by Equ. 3.7 is proportional to $sin\phi$. If the two signals are called X and Y,

$$X = \frac{1}{2} DS cos\phi \tag{3.8}$$
$$Y = \frac{1}{2} DS sin\phi \tag{3.9}$$

these two quantities represent the signal as a vector relative to the lock-in reference oscillator. X is called the in-phase component and Y the quadrature component.

By computing the magnitude R of the signal vector, the phase dependency is removed.

$$R = \sqrt{X^2 + Y^2} = \frac{1}{2} DS \tag{3.10}$$

The magnitude R measures the signal amplitude and does not depend on the phase between the signal and lock-in reference. The phase ϕ between the signal and lock-in reference can be measured according to

$$\phi = \arctan \frac{X}{Y}. \tag{3.11}$$

The parameters used for the operation of the lock-in are listed below.

Driving Amp. pk-pk [V]

This parameter is used to set the output of the internal oscillator of the lock-in amplifier. This amplitude can be varied from $0 - 20$ V and is used as the drive amplitude for the cantilever oscillation.

Listen Frequency 

With this parameter the frequency cursor can be activated. The status of the cursor is displayed in the right column. Clicking with the mouse on this field opens a drop down window in which the duration of the active time of the frequency cursor can be selected.
With the frequency cursor, the driving frequency can be set by clicking on any graph viewer linked to a corresponding cursor.

Driving Frequency [Hz]

This parameter is used to set the driving frequency of the reference oscillator (e.g. for the cantilever oscillation).

Filter Frequency [Hz]

This parameter sets the low pass filter for the PSD outputs of the lock-in amplifier. This filter is implemented as a 3^{rd} order IIR filter[1].
For AFM AC Mode measurements the default setting of this filter is $\frac{1}{10}^{th}$ of the driving frequency.

Phase Offset [$^\circ$]

The measured phase ϕ (Equ. 3.11) can be shifted with this parameter.

Auto Phase

This button sets the phase offset in a way that $\phi_{shifted}$ (see Fig. 3.3) becomes zero.

3.4.5 Feedback Settings

The feedback settings allow access to the parameters used in conjunction with the PI control of the scan table Z axis.

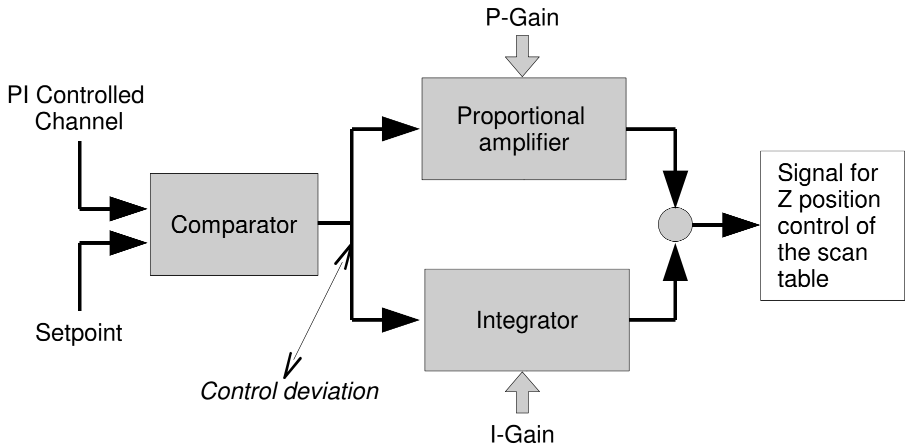


Fig. 3.4: Schematic illustration of the PI controller

Fig. 3.4 illustrates schematically the functional principle of this digital controller. An adjustable setpoint is first compared to a selectable PI controlled channel. The resulting control deviation is used in conjunction with a proportional amplifier and an integrator to calculate the control signal for the Z axis of the scan table in order to minimize the control deviation. Of the parameters described in the following, only the first four may need to be adjusted by the user during normal operation of the instrument. The others are set automatically and should not be altered.

Beam Deflection Laser

This parameter controls whether the laser is *On* or *Off*.

Setpoint [V]

The setpoint voltage can be adjusted from -10V to +10V and is compared to the voltage measured from the *PI Controlled Channel* (see below).

P-Gain [%]

This parameter allows the increase or decrease of the proportional gain of the PI controller from 0 to 100%. It might be necessary to adjust this value to avoid oscillations due to the natural frequency of the cantilever or oscillations induced by the sample.

I-Gain [%]

This parameter allows the increase or decrease of the integral gain of the PI controller from 0 to 100%. It might be necessary to adjust this value to avoid oscillations due to the natural frequency of the cantilever or oscillations induced by the sample.

PI Controlled Channel

With this parameter, the channel which is compared to the setpoint can be selected. The following options are available for selection:

- **Top-Bottom**
  This signal is the difference between the electrical signal received from the top and the bottom halves of the four quadrant diode. This is the typical setting for AFM and SNOM contact measurements.

- **LockIn R**
  LockIn R is the amplitude recorded through the Lock-In amplifier. This channel is typically selected if the measurement mode is AFM AC or SNOM AC.

- **Fmax**
  In this selection the maximum force, as determined from the peak of the force distance curve in PFM or DPFM mode, is used as the controlled variable.

- **off**
  No channel is used as an input and the PI controller is off.

- **Aux1**
  The signal read from the Aux1 input is used as the controlled variable.

▶ **Aux2**
The signal read from the Aux2 input is used as the controlled variable.

▶ **Z-sensor**
Using this signal, the capacitive sensor in Z direction of the scan table is used as an input and the system then acts as an active feedback controller for the Z position of the scan table.

Inverted

This variable allows the inversion of the control deviation signal (see Fig. 3.4). This is due to the fact that in AFM contact mode the scan table should retract if the signal is too high whereas it should move up in AFM AC mode.

HV Amp Active

During AFM measurements, the regulation of the bending of the cantilever can be achieved in two different ways. Either the Z axis of the scan table is used or a cantilever arm with a piezo positioning element. If such a cantilever arm is used, a high voltage signal needs to be provided to the piezo. The HV Amp Active can therefore be activated (setting *YES*) or not (setting *NO*). The signal is then automatically amplified and directed to the respective hardware.

HINT If the regulation using the cantilever with the positioning element is used, the topography readout of the scan table will not show the topography since the Z position of the table will be held constant during those measurements. Instead the feedback signal recorded can be used to derive the topography from it.

Output Limitation Active

This parameter is generally set to *Yes* to protect the controlling card of the scan table. This is necessary because the output of the alphaControl is ±10V which exceeds the maximum range of the controlling card of the scan table.

Output Limitation Range

Here a multiplicative factor is entered (typically 0.65) which if multiplied with the voltage output range of the alphaControl (20V) results in the correct range of the controlling card of the scan table (13V). The minimum and maximum values are 0 and 1 respectively.

Output Limitation Offset

A multiplicative factor for the offset of the signal in the range from -1 to +1 can be entered as the output limitation offset. Multiplying this factor with the positive voltage range of the controller (+10V) results in the offset necessary for the electronics of the scan table.

3.4.6 Heating

The heating stage can be mounted directly onto the scan stage and is driven through the alphaControl controller via the WITec Control data acquisition software. Its temperature range is from room temperature to 200°C, which it typically (depending on the volume of the sample) reaches within less than 2 minutes.

Upon start of the software, the heating stage is calibrated using the PT100 element within the stage. Information about this process is displayed in the message window. The state of the heating stage (*enabled, disabled, stabilized,...*) as well as the current temperature while heating is also displayed in the message window.

If the heating stage is present, the temperature determined at the start and the end of a measurement (such as an image scan) is saved in the automatically created text object describing the scan.

The following parameters allow control over the the heating stage.

Enable Temp. Control

Using this parameter the temperature control can be enabled (*Yes*) or disabled (*No*). If the temperature control is disabled, all other parameters in this group will be inactive and the target temperature is set automatically 20°C.

Target Temp. [°C]

Here the target temperature of the stage can be entered. If it is changed, the stage will try to reach the new target temperature using the P, I and D parameters for the Proportional(P) Integral(I) Differential(D) regulating loop.

Temperature Ramp

Using this group it is possible to ramp the temperature linear to a certain target temperature. The following parameters allow this control:

- ▶ **End Temp. [°C]**
  The temperature the stage should reach at the end of the ramp.
- ▶ **Temp. Gradient [°C/min]**
  The slope of the temperature ramp in °C per minute.
- ▶ **Start Gradient**
  Starts the temperature ramp.
- ▶ **Stop Gradient**
  Stops the temperature ramp.

P-Gain

The P-gain for the PID regulating loop.

I-Gain

The I-gain for the PID regulating loop.

D-Gain

The D-gain for the PID regulating loop.

Calibrate

This button triggers the automatic calibration of the heating stage using the PT100 element inside the stage. This procedure is automatically executed upon starting the WITec Control software.

Get Temperature Interval [s]

This parameter determines in which time intervals the temperature is measured.

3.4.7 Cantilever Positioning 

Cantilever positioning is facilitated by a piezoelectrically driven inertial drive. The position of the cantilever (in X, Y and Z) can be altered in three different ways: the remote control, the graphic control and through the parameter set described here. In the following, the parameters will be described as well as their connection to the settings on the remote and graphic control interfaces. When driving any of the axes by using the remote control or the parameter list, the arrows in the graphic Control Window will indicate the active axis and the direction of movement.

X+ 

This continuous action button causes the cantilever to move in the positive X direction.

X- 

This continuous action button causes the cantilever to move in the negative X direction.

Y+ 

This continuous action button causes the cantilever to move in the positive Y direction.

Y- 

This continuous action button causes the cantilever to move in the negative Y direction.

Z+ 

This continuous action button causes the cantilever to move in the positive Z direction (upward).

Z- 

This continuous action button causes the cantilever to move in the negative Z direction (downward).

Care must be taken when moving the cantilever in the negative Z direction because this could potentially allow the cantilever to be driven into the sample. This could result in damage to the cantilever and/or sample. In general, the inertial drive should generally not be used if the tip is in contact with the sample.

Speed [Hz]

The value entered here is the repetition rate with which the piezos push the axes in their respective directions. This value is identical for all three axes. The minimum and maximum values are 1 and 1500Hz respectively. By using the potentiometer on the remote control as well as through the graphical representation of the potentiometer in the graphic control, this value can also be altered. The numerical value displayed in the graphic Control Window is another representation of this value.

StepSizeX (StepSizeY, StepSizeZ)

This parameter is a measure of the distance the piezo is pushing the X (Y,Z) axis during each cycle. It can be adjusted between 0 and 100 and will in combination with the speed (see above) be a measure of the velocity with which the axis moves.

BalanceX (BalanceY, BalanceZ)

Due to the nature of the inertial drive, it is possible that the velocity in +X (+Y,+Z) will vary from the velocity in -X (-Y,-Z). The balance setting which is adjustable from -100 to +100 can be used to compensate for this effect.

3.4.8 Filter Wheel 

Using the drop down menu, which is the only parameter in this group, the filter placed in the transmitted beam (e.g. during transmission SNOM measurements) can be selected. The drop down menu contains the entries *Filter 1*, *Filter 2*, *Filter 3* and *Filter 4*. Fig. 3.5 indicates the positions of filters within the filter wheel. The filter wheel itself is situated in the housing for transmission SNOM measurements.

3.4.9 Inverted Microscope 

The inverted microscope can be moved in the X, Y and Z directions with stepper motors. The position can, as with the cantilever, be entered by the remote control,

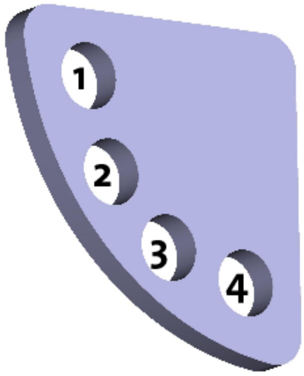


Fig. 3.5: Schematic illustration of the filter wheel indicating the positions of the individual filters.

the graphic control and through the parameter set described here. In the following, the parameters will be described as well as their connection to the settings on the remote and graphic control interfaces. When driving any of the axes though the remote control or the parameter list, the arrows in the graphic Control Window will indicate the active axis and direction of movement. Of the following parameters only the first 8 may be altered whereas the others should not be modified.

HINT If used within the measurement mode, the position of the inverted microscope is displayed in the status window (see Section 5).

X+ 

This continuous action button causes the inverted microscope to move in the positive X direction.

X- 

This continuous action button causes the inverted microscope to move in the negative X direction.

Y+ 

This continuous action button causes the inverted microscope to move in the positive Y direction.

Y- 

This continuous action button causes the inverted microscope to move in the negative Y direction.

Z+ 

This continuous action button causes the inverted microscope to move in the positive Z direction (upward).

Care must be taken when moving the inverted microscope upward because this could potentially allow the objective of the inverted microscope to be driven into the sample. This could result in damage to the objective and/or sample as well as the cantilever if in contact.

Z-

This continuous action button causes the inverted microscope to move in the negative Z direction (downward).

Speed [μm/s]

The value entered here is the speed with which the stepper motors drive the inverted microscope. This value is identical for all three axes. The minimum and maximum values are 0.1 and 200$\mu m/s$. By using the potentiometer on the remote control as well as through the graphical representation of the potentiometer in the graphic control, this value can also be altered. The numerical value displayed in the graphic Control Window is another representation of this value.

Set Zero (XYZ)

Using this button, the X, Y, and Z positions of the inverted microscope can be set to 0 for referencing purposes. This position in combination with the maximum travel (see below), will also limit the positions within the range of the inverted microscope.

MaximumTravelX (MaximumTravelY, MaximumTravelZ)

The values displayed here cannot be changed and are for informative purposes only. They indicate the maximum travel in steps in the positive and negative directions relative to the last zero position. Multiplied with the internally defined factor for the conversion of steps to micrometers, this results in a range of approximately $\pm$1.5mm for each axis.

HINT Should the inverted microscope not respond to a move request, the status window should be checked to see if the limits of the axis of the inverted microscope have been reached.

3.4.10 PFM Control

Pulsed Force Mode (PFM) is a non-resonant, intermittent contact mode imaging technique for AFM/SNOM. A detailed description of the technique is given in the PFM Configuration manual.

The PFM control parameter group contains the additional control parameter required for the acquisition of pulsed force mode images.

Modulation

This binary variable either turns the modulation of the cantilever *On* or *Off*.

Driving Amp. pk-pk [V]

The peak to peak voltage of the sinusoidal modulation of the cantilever can be entered as a value between 0 and 20V.

Driving Frequency [Hz]

The frequency of the cantilever oscillation can be entered as a value between 1 and 10000Hz.

Excitation Phase [°]

The excitation phase can be adjusted in order to ensure that the pulsed force curve will be displayed in the graph window in the standard way with the snap-in near the left hand side of the window, then the force increasing to the maximum force, followed by the decrease of the force up to the maximum adhesion and the free oscillation after the snap-out as shown in Fig. 3.6.

Reference Modulation Phase [°]

The reference modulation phase can be adjusted to ensure that the sinusoidal reference modulation signal displays a minimum where the PFM curve displays a maximum. This is necessary for the proper representation of the pulsed force curves as force↔distance curves.

Fmax Window Start [°]

The start of the region in the PFM curve where the hardware will search for the maximum force can be defined from 0 to 360° using this parameter.

Fmax Window Width [°]

The width of the region in the PFM curve where the hardware will search for the maximum force can be defined from 0 to 360° using this parameter.

Listen (F max) 

The listen (F max) parameter allows the selection of the angular range for the determination of the maximum force from the displayed PFM curve. In the drop down list of this menu item the options *Never*, *Once* or *Multiple* can be selected to identify how many times the entries in the *Fmax Window Start* and *Fmax Window Width* will be adjusted if a corresponding area is selected. The selection is done by activating the  button in the graph tool window after the PFM window was activated. The angular range of interest can then be selected and will be marked in the PFM window. If the selection is still active, the color of the marked area will be dark purple and if it is not active anymore it will be red (Fig. 3.6).

Adhesion Window Start [°]

The start of the region in the PFM curve from which the hardware will determine the adhesion can be defined from 0 to 360° using this parameter.

Adhesion Window Width [°]

The width of the region in the PFM curve from which the hardware will determine the adhesion can be defined from 0 to 360° using this parameter.

Listen (Adhesion)

The listen (Adhesion) parameter allows the selection of the angular range for the determination of the adhesion from the displayed PFM curve. In the drop down list of this menu item the options *Never*, *Once* or *Multiple* can be selected to identify how many times the entries in the *Adhesion Window Start* and *Adhesion Window Width* will be adjusted if a corresponding area is selected. The selection is done by activating the button in the graph tool window after the PFM window was activated. The angular range of interest can then be selected and will be marked in the PFM window. If the selection is still active, the color of the marked area will be dark blue and if it is not active anymore it will be light blue (Fig. 3.6).

Stiffness Window Start [°]

The start of the region in the PFM curve from which the hardware will determine the stiffness can be defined from 0 to 360° using this parameter.

Stiffness Window Width [°]

The width of the region in the PFM curve from which the hardware will determine the stiffness can be defined from 0 to 360° using this parameter.

Listen (Stiffness)

The listen (Stiffness) parameter allows the selection of the angular range for the determination of the stiffness from the displayed PFM curve. In the drop down list of this menu item the options *Never*, *Once* or *Multiple* can be selected to identify how many times the entries in the *Stiffness Window Start* and *Stiffness Window Width* will be adjusted if a corresponding area is selected. The selection is done by activating the button in the graph tool window after the PFM window was activated. The angular range of interest can then be selected and will be marked in the PFM window. If the selection is still active, the color of the marked area will be dark blue and if it is not active anymore it will be green (Fig. 3.6).

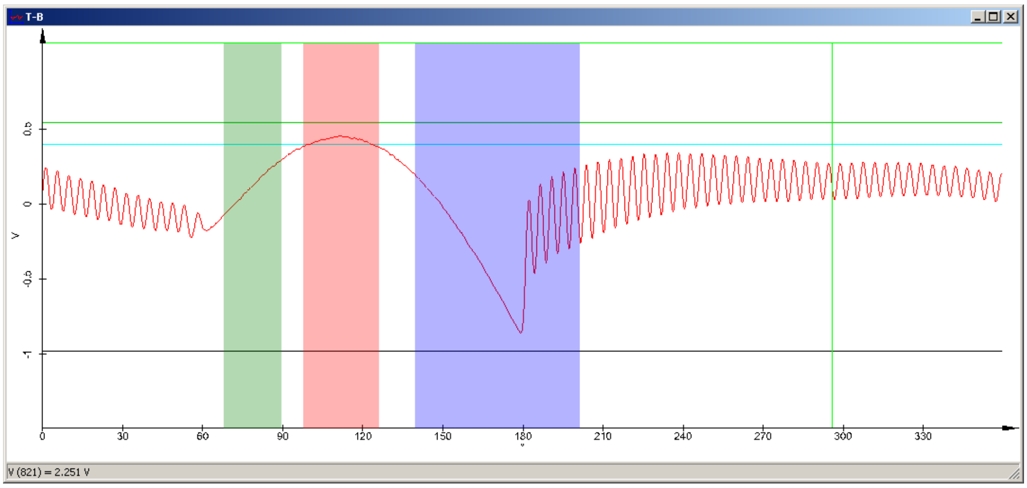


Fig. 3.6: The typical PFM curve with the search regions marked. (Green = Stiffness; Red = Fmax; Blue = Adhesion)

3.4.11 Spectrograph

For each spectrometer connected to the alphaControl one spectrograph parameter group will be present in the default configuration tree. The parameters described in the following provide access to the full functionality of the spectrometer including its calibration.

Grating

The grating parameter allows the selection of the gating used for spectrometry. The gratings listed in the the pull down menu depend on the individual configuration but generally have the form

$$\left[\textit{Turret number} : \textit{Groove density Blaze wavelength} \right]$$

and an example typical for the UHTS would be

T1 : 600 g/mm BLZ=500nm.

Laser Wavelength [nm]

This parameter should contain the wavelength of the laser used for the spectral measurements.

Center Wavelength [nm]

The wavelength hitting the center of the CCD chip can be adjusted using this parameter. This wavelength will then also be the central wavelength in the spectra displayed in the software. To change the central wavelength, the software calculates the necessary rotation of the grating selected.

Spectral Center

The spectral center is identical to the center wavelength. The only difference is that the units this central position is described by are variable and adjustable using the *Spectral Unit* parameter (see below). It may, for example, be desirable to enter 2050 rel. 1/cm which is a good starting point for the 600 g/mm grating if a 532 nm laser is used for excitation. The laser wavelength will then be displayed on the left hand side of the spectra with virtually the entire spectrum visible to its right. The central wavelength (λ_c) and the relative wave number in the center (ν_c) are related as follows.

$$\nu_c = \frac{1}{\lambda_{ex}} - \frac{1}{\lambda_c}, \tag{3.12}$$

where λ_{ex} is the excitation wavelength.

Spectral Unit

The spectral unit controls the display of the numerical value in the *spectral center* parameter field. If the spectral unit is changed, the entry in the *spectral center* parameter field will be changed accordingly. Additionally any change in the spectral unit will also change the X axis and thus the display of the hardware spectrum currently recorded. Any measurement started after changing this parameter will also use the units set with this parameter. The units available are:

- **nm**
- **μm**
- **1/cm**
- **rel. 1/cm**
- **eV**
- **meV**
- **rel. eV**
- **rel. meV**

Listen 

The Listen parameter allows the selection of a new spectral center using any graph linked to a spectral cursor. See the WITec Project manual for a more detailed description of spectral cursors. In the drop down list of this menu item the options *Never*, *Once* or *Multiple* can be selected. This identifies how many times the coordinates will be adjusted if a corresponding position is selected via a mouse click. If this option is activated, the grating will be moved so that a position clicked on in a recorded spectrum, for instance, will be the new central wavelength.

Exit Mirror

This parameter is only present if the corresponding spectrometer with an integrated flip mirror is included with the spectrometer. It then allows to set the exit mirror position to *Front* which typically directs the light towards the CCD camera and *Side* allowing the detection of the signal using an APD (if included with the system).

Options

Clicking the Options button opens the options dialog which contains two tab sheets: Startup and Information. The detailed appearance of these tab sheets will depend on the spectrograph used and therefore the following descriptions can only be seen as examples for the most common spectrometers. The startup tab sheet allows the startup configuration of the spectrometer to be programmed. The adjustable parameters are the grating and the center wavelength and their description is identical to that or their respective parameters above. The information tab contains information about, for example, the hardware version or the serial number of the spectrometer.

Start Calibration 

Using this button, the spectrometer can be calibrated or the calibration can be verified. Upon clicking this button the standard Windows™ open file dialog is activated. This dialog opens per default in the directory
`C:\Documents and Settings\All Users\WITecControl_`*`VersionNumber`*`\Options`
and *`VersionNumber`* is the actual version number of the installed software. The files necessary for calibration and verification of the calibration can be found in this directory. They generally have the form

`SpectrometerName _ Action _ AdditionalInformation.WHD`

where the `SpectrometerName` identifies the spectrometer. `Action` identifies if the file is used for calibration or verification of the calibration and `AdditionalInformation` offers information about such considerations as which spectral range the routine is intended for.

▶ **Calibration**

The calibration file contains the definitions necessary for the software to perform the calibration of the spectrometer. These include a set of calibration lines (typically a subset of the lines emitted from an Ar/Hg spectral lamp) which will be measured at various off-axis positions on the CCD chip.

HINT | Please contact WITec if another calibration lamp is intended to be used for calibration purposes.

From the positions determined, the calibration parameters are calculated and a text data object containing this information will be added to the project. This text data object will contain the following three major sections:

General

General information concerning the date and time as well as the operator is displayed in this section.

New Calibration Parameter

The calculated calibration parameters are displayed as in the example below:

```
Focus:          298.88
Gamma:          24.7247
Delta:          2.71003
CCDCenter:      512
Offset:         -1.22493E-04
Amplitude:      3.46354E-05
Phase:          9.67982E-01
```

Calibration Data

The calibration data is displayed in the following form:

```
Average Error [Pixel]:  0.647
Average Error [nm]:     0.087
Maximum Error [Pixel]:  2.246
Maximum Error [nm]:     0.306

Emission Line[nm] Position[Pixel] Error[nm] Error[Pixel] Peak...
435.833           510.170         -0.306    -2.246       1.355
546.074           373.790         +0.185    +1.376       0.415
435.833           231.081         -0.179    -1.307       1.308
                                      ⋮
```

The values displayed here are the measured values on whose basis the calibration values are calculated and are NOT the errors the spectrometer will display following calibration.

▶ **Verification**

Following the calibration a verification of the calibration should be performed. This verification will be performed automatically by simply choosing the appropriate file. The measured off-axis positions of the individual spectral lines are compared to the calculated values. The deviations are presented as the errors in a text data object which will be added to the project. This data object will contain general information similar to the one described above followed by the verification data which is of the same format as the calibration data described above. The verification data reported in this file is a realistic estimate for the maximum error of the spectrometer.

3.4.12 Spec Camera

For each spectral camera connected to the alphaControl , one Spec Camera parameter group will be present in the default configuration tree. The parameters described in the following provide access to the full functionality of the spectral cameras.

Temperature[°C]

This parameter determines the setpoint for the temperature of the spectral camera. Upon changing this parameter the camera will be heated or cooled accordingly. The message window (see Chapter 6) then displays the temperature during the heating/cooling until the set temperature is reached.

HINT If a measurement is started during the heating or cooling of the camera, the display of the temperature change will be disabled.

Oscilloscope Type

This parameter determines if the oscilloscope (see Section 3.5.11) will display the spectrum when engaged or the full two dimensional image recorded by the CCD camera.

Description

This parameter cannot be changed and contains information about the spectral camera.

Options

The Options button opens the options dialog for the spectral camera. This dialog contains tab sheets of which one will contain general information about the camera. An additional one allows control over the read-out speed and a third the selection of the active binning area. All of these tab sheets will vary depending on the camera used. However, the parameters for the most commonly used cameras on the tab sheets are:

- **The Speed tab sheet**

AD Converter

The respective AD converter can be selected here. For most cameras only one will be selectable. However, some cameras will allow the selection of a fast and a slow converter.

Output Amplifier

This field will only be visible if a Newton^{EM} CCD camera is present. It then allows the change between *conventional* and *EMCCD*. The EMCCD is a electron multiplying output amplifier allowing the camera to be operated with only few ms integration times.

Vertical Shift Speed
The vertical shift speed is the speed used for vertical binning of the CCD chip within the camera. The minimum and maximum values which can be entered here will depend on the individual camera and/or its mode of operation.

Horizontal Shift Speed
The horizontal shift speed is the speed used for horizontal binning of the CCD chip within the camera. The minimum and maximum values which can be entered here will depend on the individual camera and/or its mode of operation.

Preamplifier Gain
The Gain used for pre-amplification before AD conversion can be adjusted using this parameter. The minimum and maximum values which can be entered here will depend on the individual camera and/or its mode of operation.

EMCCD Gain
This field will only be visible if a Newton^{EM} CCD camera is present. Here a value between 0 and 255 can be entered as a measure for the electron multiplication gain.

Preset Selection
This field will only be visible if a Newton^{EM} CCD camera is present. Here certain presets can be selected where all the parameters above are set according to the requirements. The selectable presets are: *High Intensity low noise*, *High Intensity High Speed*, *Low Intensity* and *No Preset*.

▶ **The Binning tab sheet**

The binning tab sheet allows the selection of the active binning area. Typically the detectors consist of 1024×127 or 1600×200 pixels while only the central 10-20 rows are illuminated. Depending on the mode of operation of the CCD camera, it can be beneficial to use only these central rows for the readout since this will eliminate the signal originating from the thermal noise of the non-illuminated pixels. This is especially useful if the camera is operated in EM-CCD mode. In conventional mode it is generally only useful for single spectra. For both the *Continuous Spectrum* and the *Single Spectrum* mode, the following parameters can be adjusted:

FVB
Full Vertical Binning. If this check box is selected, the entire height of the chip is binned (ie each column is added up from top to bottom).

Start/Stop Row
These parameters defines the start and stop row for the binning if not the entire chip is used.

Single Data

Using this parameter group, an active spectral range can be defined from which a single value is calculated as the sum of the pixels covered by the area. This function is similar to the Σ-filter function (see WITec Project manual). It is mainly used for the automatic focusing function as described in Section 3.5.14. The following parameters can be accessed for the definition of the active range.

▶ **Listen**

This feature is similar to the *Listen* parameter described in Section 3.4.11. The difference is that upon clicking onto a position, the spectrometer will not move to this spectral position but the area marked will be used as the start and end points of the spectral range from which the single data is evaluated. To select such an spectral area the following steps should be followed:

1. Set the *Listen* parameter to *Once* or *Multiple*.
2. Activate an graph marker through the corresponding button in the graph tool window. This function is also available through the context menu (*Mouse Mode*⇒*Marker*) in any graph window.
3. The new single data range can then be defined by marking the area of interest in any graph window linked to a spectral cursor. Simply hold down the left mouse button while moving the mouse over the area of interest to mark it. The new start and stop values will then automatically be enterer in the single data parameter group.

▶ **Start / Stop**

These two values identify the start and the stop of the evaluated area. They will automatically be entered if the *Listen* option (see above) is used. The values are given in the unit as displayed in the spectral unit field as described below.

▶ **Spectral Unit**

This field is for information purposes only and shows the unit the *Start* and *Stop* values are given in. It will automatically change to the unit selected in the window from which the *Start* and *Stop* values are selected.

3.4.13 Signal Routing

This section allows the setting of the Dither DAC output. The signal can either be the lock in excitation signal (in AC mode) or the PFM modulation curve (in PFM mode).

This setting is for internal and automated use only. Do not change the settings manually.

3.4.14 Sample Positioning

The *Sample Positioning* menu allows the control of an additional, motorized XY stage. This stage is driven by stepper motors and allows an expansion of the scanning range of the instrument. Using the standard, piezo-driven scan table (see Section 3.4.3) the maximum scan range is 200×200 μm². With the sample positioning stage the scan range can be expanded to 150 mm in X and 80 mm in Y direction using the alpha300 system. Switching to the industrial size setup, the alpha500 achieves scan ranges of 150×150 mm² and the alpha700 of up to 300×300 mm². These scan ranges are achieved while maintaining a positioning accuracy better than 10 μm.

The use of the inverted microscope (as for example needed for SNOM measurements) is not possible using these sample positioning stages.

The sample positioning stage is located underneath the piezo driven scan table. It is calibrated at WITec using a second order positioning correction before shipment. The sample positioning stage therefore needs to be driven to a calibrated position in X and Y in order to activate this calibrated hardware positioning correction. Otherwise the positioning is performed using the nominal (non-calibrated) step width of the stepper motors. See also the *Go To Calibration Pos.* parameter description below.

HINT The sample positioning stage is especially useful in combination with the *Sample Raster* (Section 3.5.4) and the *Process Script* sequencer (Section 3.5.15). Using these, various (up to several thousand) points on a large sample (or a sample array) can be approached automatically and predefined scripting functions can be executed at each of these positions.

A separate, independent coordinate system can be defined for the sample positioning stage to suit the current sample or sample array. This coordinate system is independent of the coordinate systems introduced in Section 3.4.3.

Upon startup of the system, the current position of the sample positioning stage is assumed as the origin of the coordinate system (coordinate 0/0) with 0° rotation. Several methods to define the coordinate system thereafter are available for the stage as can be seen below.

The following parameters are available for the control of the sample positioning stage.

Reset Coord. Sys.

Using this trigger button, the current position is set to the origin of the sample coordinate system (0/0) and the rotation is set to 0.

Coord. Learn Meth.

The sample coordinate system can be defined using various methods. The method can be selected here and the software will, upon starting the procedure, guide the user through the respective procedure. This guidance is similar to the one described in Section 3.5.10. The selectable methods are:

- **Coord. Syst. by 3 Points**
  In this method three points are used to calculate the offset and the rotational angle of the sample coordinate system.

  Once this method is started through the Establish Coord. Sys. button, the user is asked to drive the sample positioning stage manually to three different positions. The movement can be achieved through the *Absolute X/Y* or the *X*± / *Y*± functions described below, or the remote control. Once a position is reached the user is asked to enter the actual coordinates of the current position. Upon completion of the last point, the new coordinate system is evaluated and used from there on.

- **Circular Center by 3 Points**
  Using this method, three points are used to evaluate their circular center. For this point the coordinates can then be entered and from this the new offset is calculated. The rotational angle of the sample coordinate system is not changed through this procedure.

  Once this method is started through the Establish Coord. Sys. button, the user is asked to drive the sample positioning stage manually to three different positions. The movement can be achieved through the *Absolute X/Y* or the *X*± / *Y*± functions described below, or the remote control. Once a position is reached the user is asked to enter the actual coordinates of the center position. Upon completion of the last point, the new coordinate system is evaluated and used from there on.

- **Offset by one Point**
  Using this method, a single point is used to evaluate the new offset of the coordinate system. The rotational angle of the sample coordinate system is not changed through this procedure.

- **Rotation and Offset by 2 Points**
  Using this method the coordinate calibration is based on an orthogonal coordinate system with identical scaling on both axis. Then two points are used to calculate the offset and the rotation of the new coordinate system.

Establish Coord. Sys.

Pressing this trigger button causes the system to start the coordinate learning method selected (see above). The user will be guided step by step though the respective method. If necessary, the sequencer requests user inputs and/or manual adjustments from the user via the status window (see Chapter 5) where information about the progress of the procedure is also displayed. The procedure can be stopped at any time by pressing any stop button within the software.

Next Step

When executing a coordinate learning method, this trigger button will become active. After finishing a task given to the user by the sequencer via the message window, this trigger button should be pressed to continue the procedure.

Abs. Pos. X/Y [μm]

These fields show the actual position of the sample positioning system within the actually valid coordinate system. New target positions can also be entered here and by pressing the Go to Abs. Position button the sample positioning stage moves to the entered coordinates. During movement of the sample positioning stage, the fields are blocked and only upon arrival of the stage at the final position will the display be updated again.

Go to Abs. Position

This trigger button causes the sample positioning stage to move to the coordinates entered as Abs. Pos. X [μm] and Abs. Pos. Y [μm] within the current coordinate system.

X+ 

This continuous action button causes the sample positioning stage to move in the positive X direction along the X-axis of the XY stage. Since this movement is along the axis of the XY table, this way show a movement in X and Y of the currently defined coordinate system.

X- 

This continuous action button causes the sample positioning stage to move in the negative X direction along the X-axis of the XY stage. Since this movement is along the axis of the XY table, this way show a movement in X and Y of the currently defined coordinate system.

Y+ 

This continuous action button causes the sample positioning stage to move in the positive Y direction along the Y-axis of the XY stage. Since this movement is along the axis of the XY table, this way show a movement in X and Y of the currently defined coordinate system.

Y- 

This continuous action button causes the sample positioning stage to move in the negative Y direction along the Y-axis of the XY stage. Since this movement is along the axis of the XY table, this way show a movement in X and Y of the currently defined coordinate system.

Speed [%]

The relative speed of the sample positioning stage can be entered in % here.

Go To Cal. Pos. X/Y

These trigger buttons causes the sample positioning stage to drive to the calibrated position of the respective axis. Once these positions are reached, the calibrated hardware positioning correction as determined at WITec before shipment becomes active. Without driving the sample positioning stage to these points, the positioning is performed using the nominal (non-calibrated) step width of the stepper motors.

Go To Calibration Pos.

These trigger buttons causes the sample positioning stage to drive to the calibrated position of *both* axis. Once this position is reached, the calibrated hardware positioning correction as determined at WITec before shipment becomes active. Without driving the sample positioning stage to these points, the positioning is performed using the nominal (non-calibrated) step width of the stepper motors.

HW Cal. X/Y Axis

These buttons are intended for the hardware calibration of the axis. This requires an interferometer and is done at WITec. The user should not use these functions unless specifically instructed by WITec personnel.

Stop X-/Y-Axis

Using these stop buttons, the axes can be stopped individually.

3.4.15 Power Meter 

The *Power Meter* device allows the calibrated measurement of the power of excitation lasers. The measured value can be displayed in the status window (see Chapter 5). The calibration data for the measurement of up to ten different wavelengths can be stored and accessed by the user. To calibrate the power meter for a certain wavelength an external, calibrated power meter is needed. Through the determination of the reading of the two devices a linear calibration curve for the internal power meter is calculated. This procedure needs to be performed for each wavelength used.

The following parameters are accessible within the power meter device:

Available Wavelengths

In this drop down list, the wavelengths for which the power meter has already been calibrated are listed. If no calibration data is available, the list will be empty. Selecting the appropriate wavelength will load the calibration data and convert the raw sensor reading into a calibrated power value which can be displayed in the status window.

Read Laser Power

This trigger button causes the system to read the current reading of the power meter and to display the calibrated value in the status window.

Calibrate Laser Intensity

This parameter group allows the computer guided calibration of the power meter for different wavelengths. Since the response of the detector will be wavelength dependent, a calibration for each wavelength used needs to be performed. The way this calibration should be performed is that a high laser intensity is set for the laser and the power out of the fiber should then be measured using the external, calibrated laser power meter. This should be done once with the laser shutter open and once with the laser shutter closed. Ensure that the room light will not interfere with the measurement. The fiber should then be connected to the instrument WITHOUT changing the laser intensity. The signal determined by the internal power meter for the two respective cases (shutter open and closed) will then allow the determination of a linear regression curve for the calculation of the laser power from the sensor reading.

To perform the calibration the following parameters are available:

- **Storage Position**

  In this drop down list the available storage positions are listed. This list may look like:

1.	488 nm
2.	514 nm
3.	---
4.	---
⋮	
10.	---

  "---" denotes a free entry in this list.

  From this list the user should choose the storage position for the calibration. If a used storage position is chosen the user is prompted if the existing entry should be overwritten.

▶ **Start Calibration**
This trigger button starts the calibration procedure. The user will be asked to perform certain tasks through the message window. First the user is asked to enter the power measured by the external power meter for case 1 (for example shutter closed). The laser power measured should then be entered in the field *Current Laser Intensity[μW]* and the same laser power should be applied to the system at this point (eg if the power entered is the one when the shutter is closed, the fiber should now be connected to the microscope and the shutter closed as well). Pressing the Next Step button triggers the readout of the internal power meter. Then the user is asked to enter the second value measured with the external power meter. This power again should at this point be present within the microscope. Pressing the Next Step button again triggers the next readout of the internal power meter. Following this the user is asked to verify the wavelength of the radiation currently measured (which should be entered under *Laser Wavelength [nm]*) before the calibration data is calculated and stored at the selected storage position.

▶ **Next Step**
This trigger button moves to the next step of the computer guided calibration procedure.

▶ **Delete Calibration**
This trigger button deletes the currently selected calibration after confirmation through the user.

▶ **Laser Wavelength [nm]**
The laser wavelength for which the current calibration is performed should be entered in this field.

▶ **Current Intensity [μW]**
In this field, the laser power as determined using the external power meter should be entered when prompted by the computer guided calibration procedure.

3.5 Sequencers

This section describes all sequencers accessible through the default tree configuration and their respective parameters (see Fig. 3.1a). Since the parameter group *Data Labeling* is used by a variety of sequencers while its functionality does not change, this parameter group is described first.

Data Labeling

Data labeling groups belong to certain sequencers which are used for data recording. Using this parameter group, the data recorded can be labeled with a name (*Sample Name*) and a number for the data recorded (*Number*). The number will automatically increase with each recorded data set thus facilitating the identification of the data. The name and number entered can be saved through *Configurations*⇒*Save current Parameters*.

3.5.1 Auto Illumination

The auto illumination parameter group allows the automatic adjustment of the microscope illumination based on the currently displayed video image (see Chapter 4).

If the iris is closed too much, the auto illumination may not deliver satisfying results because the entire video image is used for the calculations.

The following parameters are contained within this parameter group:

Max. Brightness

This value, which is adjustable between 0 and 255, is a comparison value for the adjustment of the brightness.

Auto Brightness

This trigger button prompts the sequencer to adjust the microscope illumination.

3.5.2 Image Scan

In the image scan parameter group, all parameters necessary for the capture of a two or three dimensional data set can be defined. While the data sources recorded are defined within the individual data sources parameter groups (see Section 3.6), all other parameters such as the geometry of the scan or the scan speed can be adjusted in this parameter group. The adjustable parameters in detail are:

Start

Pressing this button starts the scan and the data acquisition using the parameters currently entered.

Restart

This trigger button causes the scan to restart using the parameters currently entered.

HINT WITec Control allows most parameters within the image scan parameter group to be changed during the scan. This allows optimization of the scan parameters while scanning.

The data of the currently collected data set will be lost

Pre Measurement State

This parameter group is identical to the one which can be found with some data sources (see Section 3.6).

Post Measurement State

This parameter group is identical to the one which can be found with some data sources (see Section 3.6).

If any of the pre or post measurement states of the recorded channels and/or the values set in the image scan parameter group are in conflict, the states in question will not be changed before or after the measurement (see Section 3.6).

Points per Line

This parameter allows the user to change the number of pixels, data points or spectra per line.

Lines per Image

Lines per image allows the user to select the number of lines scanned inside the selected scan area (see below).

Layers per Scan

This parameter defines how many layers are recorded in a stack scan (confocal mode only). It does not have an effect on other modes.

Geometry

The *geometry* parameter group allows the selection of the desired scan area where the coordinates are given in the internal coordinate system (see Fig. 3.2). Since the scan table performs the movement, the selectable geometry is limited by the scan range of the scan table. The following parameters can be adjusted:

- **Listen Position/Area** 

  This feature is similar to the *Listen Position* parameter described in Section 3.4.3. The difference is that upon clicking onto a position, the scan table will not move to this position but the position clicked upon will be marked as the new center position for the scan. It also allows the selection of the desired scan area from any image linked to a spatial cursor. To select such an area the following steps should be followed:

  1. Set the *Listen Position/Area* parameter to *Once* or *Multiple*.
  2. Activate an image marker  through the corresponding buttons in the video image or the image tool window. This function is also avail-

able through the context menu (*Mouse Mode⇒Marker*) in any image linked to a spatial cursor.

3. The new scan area can then be defined by clicking the mouse on one of the corners of the desired area and pulling a rectangle of the desired size over the image. The new center of the scan as well as the scan dimensions will be automatically entered in their respective fields. If the selected scan area lies outside the maximum scan range, the geometry parameters will be displayed in red indicating this fault.

- **Width [μm]**
  The *width* sets the size of the box scan. It is always the size of the fast scan direction (length of one line).

- **Height [μm]**
  The *height* is always the size of the slow scan direction (height of the rectangular) of the box scan. This parameter will not have any effect if a depth scan is performed.

- **Depth [μm]**
  The *depth* parameter is used not only in conjunction with the width for depth scans, but also in conjunction with both width and height for stack scans. In depth scans, it is the dimension of the slow scan direction and in stack scans, the distance from the uppermost to the lowest stack scanned.

- **Center at Current Pos.**
  Clicking this trigger button causes the current coordinates within the internal coordinate system to be copied into the respective fields for the center position of the scan.

- **Center (X) [μm]**
  The X coordinate of the central position about which the scan will be performed.

- **Center (Y) [μm]**
  The Y coordinate of the central position about which the scan will be performed.

- **Center (Z) [μm]**
  The Z coordinate of the central position about which the scan will be performed.

- **Alpha [$^\circ$]**
  Alpha identifies the rotation of the scan area about the X axis and is measured relative to the Y axis.

- **Beta [$^\circ$]**
  Beta identifies the rotation of the scan area about the Y axis and is measured relative to the X axis.

- **Gamma [$^\circ$]**

Gamma identifies the rotation of the scan area about the Z axis and is measured relative to the X axis.

HINT Entering a positive value for one of the angles will rotate the scan in the mathematically positive direction. Since, however, the recording device (e.g. AFM tip) remains stationary, the resulting image will appear rotated in the mathematically negative direction.
For the determination of the position of the scan area when using a rotated scan, the rotation about the X axis is applied first. Then the rotation about the Y axis is performed relative to the rotated plane. Last, the rotation about Z is applied which is again performed within the rotated/tilted plane.

Scan Mode

Using this parameter, the scan mode can be selected from the following options.

- **Single**
  Using this selection a single scan is performed on the plane defined through the angles *Alpha*, *Beta* and *Gamma* (typically the X-Y plane if $Alpha = Beta = 0°$) using the width and height entered. The scan table will remain in the final position of the scan upon completion.

- **Continuous**
  In this mode the scan will be performed as in the *single* setting. However, it will automatically be repeated upon completion using the exact same settings. *Change Scan Direction* and *Overwrite Previous* (see below) are additional parameters defining the behavior of this scan mode.

- **Depth**
  Using this selection, a single depth scan is performed perpendicular to the plane defined through the angles *Alpha*, *Beta* and *Gamma* (typically the X-Z plane if $Alpha = Gamma = 0°$) using the width and depth entered. The scan table will remain in the final position of the scan upon completion.

- **Continuous Depth**
  In this mode the scan will be performed as in the *depth* setting. However, it will automatically be repeated upon completion using the exact same settings. *Change Scan Direction* and *Overwrite Previous* (see below) are additional parameters defining the behavior of this scan mode.

- **Stack**
  A stack scan is a collection of single scans which are performed at different depths (typical for confocal mode). The number of scans performed depends on the *Layers per Scan* parameter and the different depth levels on the combination of *Layers per Scan* and the *Depth* parameters. The individual scans are labeled automatically with incremented numbers.

Change Scan Direction

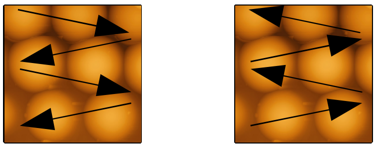
This parameter takes effect for continuous or stack scans and has the following options:

▶ **Keep Direction**
In this setting each scan will start in the direction defined by the *Slow Scan Direction*.

▶ **Alternate**
This setting will cause the *Slow Scan Direction* to alternate with each scan. Therefore if a scan, which had started at the upper left hand corner of the scan area, has finished, the next scan will start at the bottom left hand corner.

Slow Scan Direction

This parameter sets the scan direction as illustrated in Fig. 3.7.



(a) Top→Bottom (b) Bottom→Top

Fig. 3.7: Schematic illustration of the slow scan direction.

Overwrite Previous

This parameter takes effect for continuous or stack scans and can be set to *Create New Object* and *Overwrite*. If *Create New Object* is selected a new data object will be created for each scan. If the option *Overwrite* is selected the second scan will overwrite the first one.

Speed Defined By

This parameter can be set to *Integration Time* or *Time per Line*. Both of these parameters can be entered and are described as

$$[Time\ per\ Line] = [Integration\ Time] * [Points\ per\ Line] \qquad (3.13)$$

Speed Defined By determines which variable will remain unchanged if the $[Points\ per\ Line]$ parameter is changed.

Int. Time (Trace) [s]

The integration time in the forward scan direction defines the time for one pixel, data point or spectrum. Changing this time will automatically change the *Time / Line (Trace) [s]* parameter.

Int. Time (Retrace) [s]

The integration time in the backward scan direction also defines the time for one pixel, data point or spectrum. If no data is recorded in this scan direction this time basically defines the backward motion speed of the scan table. Changing this time will automatically change the *Time / Line (Retrace) [s]* parameter.

Time / Line (Trace) [s]

The time required for one line of the scan in the forward direction can be altered here. Changing this parameter will automatically change the *Int. Time (Trace) [s]* parameter.

Time / Line (Retrace) [s]

The time required for one line of the scan in the backward direction can be altered here. Changing this parameter will automatically change the *Int. Time (Retrace) [s]* parameter.

If no data is recorded in the backward direction this time can be shortened significantly. However, if the time is selected too short, the sample might move due to the impact upon turnaround if the sample is not fixed properly.

Acquire Data

This parameter determines whether or not data is recorded in only the *Forward* scan direction or in both the *Forward and Backward* scan directions.

Pre/Post Pixels

This parameter defines how many pixel triggers will be output before and after each line. This might be necessary if certain external devices are triggered through the alphaControl.

Slow Turnaround [%]

The slow turnaround reduces the impact caused by the change of direction of the scan table. If the slow turnaround is activated the scan table will be accelerated to the final scan speed and slowed down from the final scan speed upon turnaround. The distance taken for this acceleration can be altered with this parameter. The reference used with this percentage is the scan width and half of this distance will be used on each side of the line scanned. WITec Control sets this parameter automatically and it is dependent on the mode of measurement.

Linear Overscan [%]

The linear overscan is an extension of the scan width which is used in combination with the TrueScan™ mode implemented within the alphaControl. The reference used with this percentage is the scan width and half of this distance will be used on each side of the line scanned. WITec Control sets this parameter automatically and it is dependent on the mode of measurement.

Data Labeling

Data labeling (see page 41 for a more detailed description) is available for these scans with the keyword *Scan* being the default name.

3.5.3 Line Scan

The line scan parameter group allows the adjustment of all parameters necessary for the collection of data along a definable straight line. Currently WITec Control only allows the collection of spectra and/or distance curves along the line. However in future versions all single data channels will be available for recording. The behavior of the line scan can be defined using the following parameters.

Start Line Scan

Pressing this trigger button starts the line scan and the data acquisition using the parameters currently entered.

Nr. of Points

This parameter defines the number of equidistant points at which measurements will be performed along the line.

Listen Line

This feature is similar to the *Listen Position/Area* parameter described in Section 3.5.2. The difference is that instead of choosing the marker ( ) from the video window, the image window or the context menu, the line marker ( ) must be selected. With this a line can be drawn on the images and the start and end points of this line are then used as the start and end points of the line scan. The respective coordinates will automatically be entered as the corresponding position parameters.

Start Point

This parameter group contains the parameters for the three coordinates X, Y and Z (in μm) of the starting point for the line scan. Note that the scan table performs the line scan.

End Point

This parameter group contains the parameters for the three coordinates X, Y and Z (in μm) of the end point for the line scan.

At Every Point

Here the user can define which actions should be performed at every point. Currently only *Distance Curve* and *Single Spectrum* can be selected (*Yes* or *No* selection). If any of these are selected, the parameter values set in the corresponding parameter groups (see Section 3.5.7 and Section 3.5.12) are used for the respective task. If both of the tasks are selected they will be performed sequentially.

Data Labeling

Data labeling (see page 41 for a more detailed description) is available for these scans with the keyword *Line* being the default name.

3.5.4 Sample Raster

This parameter group is used in combination with the *Point Viewer* (see Chapter 9). In the *Point Viewer* up to several thousand points on the sample can be defined where automated measurements can be performed. The *Sample Raster* parameter group is used to define the state of the instrument before and after the execution of the raster of the defined points. Also, the execution of the raster is started from this parameter group and the *Point Viewer* can be opened.

Start Raster

This trigger button starts the execution of the currently defined raster (= the point list as defined in the *Point Viewer*).

Pre Measurement State

This parameter group is identical to the one which can be found with some data sources (see Section 3.6).

Post Measurement State

This parameter group is identical to the one which can be found with some data sources (see Section 3.6).

If any of the pre or post measurement states of the recorded channels and/or the values set in the *Sample Raster* parameter group here are in conflict, the states in question will not be changed before or after the measurement (see Section 3.6).

Point List Editor

This trigger button openes the *Point Viewer* window described in Chapter 9. In this window the points of which the raster consists can be defined.

3.5.5 Frequency Sweep

The frequency sweep varies the frequency of the output signal of the lock-in amplifier (Section 3.4.4) in order to determine the response in amplitude and phase of the detected signal as a function of the excitation frequency. E.g. in AC mode this is used to find the resonance frequency of the cantilever. Amplitude and phase are represented in a graph viewer. (see also WITecProject Manual). The parameters used to perform a frequency sweep are listed below.

Start Sweep

This parameter starts the frequency sweep.

Listen Range

The frequency cursor can be activated with this parameter. Clicking with the mouse on this field opens a drop down window in which the duration of the active time of the frequency cursor can be selected. From the graph which displays the frequency sweep, a frequency range can be selected and the corresponding values will automatically be entered as the initial and final frequency.

Initial Frequency [Hz]

This parameter defines the initial frequency of the frequency sweep.

Final Frequency [Hz]

This parameter defines the end frequency of the frequency sweep.

Divisions

This parameter defines the number of steps between the initial and final frequency.

Create Data

This parameter allows the user to either only view the frequency sweep or to save the frequency sweep as a graph data object in the project manager.

Data Labeling

Data labeling (see page 41 for a more detailed description) is available for these scans with the keyword *FrequencySweep* being the default name.

3.5.6 Auto Resonance

This sequencer is used to automatically determine the resonance frequency of the cantilever when the alphaControl is operated in AFM AC Mode. Similar to the fre-

quency sweep (Section 3.5.5), the frequency of the output signal of the lock-in amplifier is varied and the amplitude of the cantilever is measured at every frequency. In this procedure a coarse frequency sweep is performed over a large frequency range (typically from 10 kHz up to 500 kHz). As the maximum amplitude of the cantilever is approached, a second fine frequency sweep is performed to determine the exact resonance frequency.
The graph represented in the graph viewer displays the amplitude and phase variations close to the resonance frequency. The resonance frequency is automatically set as the drive frequency of the reference signal in the lock-in amplifier and the phase offset is adjusted to zero (Section 3.4.4).

Auto Resonance
This parameter starts the auto resonance procedure.

Initial Start Frequency [Hz]
This parameter sets the initial start frequency for the auto resonance procedure.

Initial End Frequency [Hz]
This parameter sets the initial end frequency for the auto resonance procedure.

3.5.7 Distance Curve

Distance curves are used to study phenomena which occur at a defined sample position if a probe is approached to and retracted from the sample by using the z-scan of the scan table. The probe can be for instance a cantilever tip in AFM and SNOM measurements, where the tip↔sample interactions are examined. In these experiments the cantilever tip is approached to and retracted from the sample. The recorded signals as a function of distance are:

- the T-B signal of the beam deflection system if the AFM is operated in contact mode. The resulting curve displayed in the graph viewer is a force - distance curve.
- the variation of the amplitude as described by Equ. 3.10 if the AFM is operated in AC mode. The resulting curve displayed in the graph viewer is an amplitude - distance curve.

Typically, distance curves are recorded when the tip is already in contact with the sample and its position is controlled by the feedback loop.
In addition to studies of tip↔sample interactions, the probe can also be a light source, in which case the light intensity is recorded as a function of distance from the sample.

The parameters required to measure a force distance curve are listed below.

Start
This parameter starts the distance curve.

Sample Points
This parameter defines the number of points recorded in a distance curve.

Pull [μm]
This parameter defines the distance the probe will be lifted off the sample before and after recording a distance curve.

Push [μm]
This parameter defines the distance the probe will be moved downwards into the sample. As reference for the downwards movement is the start position (see below).

Speed [μm/s]
This parameter defines the speed of movement in the z-direction of the scan table during the complete distance curve.

Start Position
This parameter defines the reference point within the internal coordinate system for the pull and push parameters described above. This parameter can either be set to *current* or *absolute*. If absolute is chosen, the *Absolute Start Position* parameter (see below) is used as the start position.

Absolute Start Position [μm]
This parameter defines the start position in terms of the absolute position along the z-axis of the scan table.

Data Labeling
Data labeling (see page 41 for a more detailed description) is available for these scans with the keyword *FDC* being the default name.

3.5.8 Tip Approach

This sequencer is used for the tip approach for AFM and SNOM measurements with the alphaControl. The following parameters are used to control and perform a tip approach.

Start Approach
This button starts the tip approach procedure.

Out of Contact Speed [μm/s]

This parameter defines the speed of the microscope Z stage during an approach before the feedback setpoint is reached (see Section 3.4.5).

In Contact Speed [μm/s]

This parameter defines the speed of the microscope Z stage during an approach after the feedback setpoint is reached (see Section 3.4.5). As the scan table (Section 3.4.3) is completely extended in the Z-direction, the microscope Z stage travels at the *in contact speed* downwards, while the feedback loop retracts the scan table to its *final Z position* (see below).

Final Position Z [μm]

This parameter sets the z-position of the scan table at which the approach is completed.

Approach Method

The tip approach depends on the selected feedback settings as described in Section 3.4.5. This function allows the selection of the proper approach method for the following modes:

Contact Mode

During the approach in contact mode, the tip is in contact with the surface as soon as the setpoint is reached. At this point the cantilever is bent and a force, defined by the setpoint and the spring constant of the cantilever, is acting between tip and sample. Following this the scan table retracts to its middle position while the microscope Z stage simultaneously compensated for this movement in order to keep the bending of the cantilever constant.

AC Mode

During the approach in AC mode, the cantilever is oscillating at a defined free amplitude before the sample is reached. As the tip reaches contact with the sample this amplitude is damped and the tip is in its designated position once the setpoint defined by the feedback has been reached. Due to long range forces however, the amplitude damping can begin before the tip is in physical contact with the sample. Therefore, the indication that the tip is in contact during AC approach is the change of phase shift ϕ (see Section 3.4.4) when the setpoint is decreased slightly. To determine the phase shift reliably, ϕ is sampled continuously during the tip approach. As soon as the final Z position is reached, the setpoint is decreased further and the standard deviation $\sigma(\phi)$ is determined. If $\sigma(\phi) < \sigma_{max}$ (the maximum deviation of ϕ) the setpoint is decreased further while the final Z position is corrected using the microscope Z stage. The tip approach is stopped when the standard deviation $\sigma(\phi) \geq \sigma_{max}$.

For safety reasons, the AC mode tip approach is also stopped if the current setpoint is smaller than half of the initial setpoint.

PFM Mode

The approach in PFM mode is similar to the approach in contact mode with the difference the the signal used for regulation is not the T-B signal (ie the signal of the constant bending of the cantilever). The signal used here is the F_{max} signal determined from the PFM curve. This ensures a constant maximum force on the cantilever. See also Section 3.4.10.

HINT | The approach in PFM mode will only be successful if the F_{max} window is selected properly.

Tip Regulated Contact Mode

In this mode, the tip positioning in Z direction is regulated by the positioning piezo located in the cantilever arm instead of the Z axis of the scan table. Therefore the retracting of the tip is done to the middle position of this piezo and not of the scan table.

PhiStdDevAccums

To calculate the standard deviation $\sigma(\phi)$, n samples of ϕ are utilized. The parameter *PhiStdDevAccums* defines the number n of the ϕ samples.

Stop@PhiStdDev

This parameter defines the maximum deviation σ_{max} at which the AC approach is stopped.

Retract Distance [μm]

This parameter defines the upward travel distance of the microscope z stage during tip retraction.

Retract Tip 

This button retracts the tip using the microscope z stage by the defined retract distance.

3.5.9 Calibrate Scan Table 

This sequencer is executed upon each startup of WITec Control but generally remains hidden from the user.

Only advanced users should alter the settings herein.

When executed, the scan table will be driven to two different positions per axis at which the output of the capacitive sensors are measured. Using these values a lead and an offset error are calculated for each axis. These values are then used to correct the stationary positioning of the scan table during its use. A text data object named *Calibration Information* is added to the project tree for information purposes.

HINT This file should also be checked if the calibration of the scan table fails. This may occur if the offset potentiometers for the scan table on the alphaControl are not set to their minimum positions.

The following parameters are available to set the calibration routine:

Start Calibration

This trigger button starts the calibration sequencer.

CalibrateXAxis (CalibrateYAxis, CalibrateZAxis)

This parameter determines if the X (Y,Z) axis is calibrated (*Yes*) or not (*No*).

XAxisPos1/2 (YAxisPos1/2 ZAxisPos1/2) [μm]

Using these parameters the two target positions for the calibration of the X (Y,Z) axis can be entered. Entering an out of range value will cause the software to automatically enter the maximum/minimum value possible.

Calibrate Relative To Current Position

If this option is selected (*Yes*), the scan table will move not to the position entered in e.g. XAxisPos1 but to ([Current X-Axis Position] + XAxisPos1). Similarly it will move to ([Current X-Axis Position] + XAxisPos2) instead of XAxisPos2.

3.5.10 Adjust

The *adjust* sequencer offers software assisted step by step alignment procedures for certain measurement modes. It automatically changes the parameters required for the adjustments. If necessary, the sequencer requests user inputs and/or manual adjustments from the user via the status window (see Chapter 5) where information about the progress of the adjustment is also displayed. The adjustment can be stopped at any time by pressing any stop button within the software. The following parameters are available within this parameter group:

Start Adjustment

Pressing this trigger button will start the adjustment procedure using the current set of parameters.

Next Step

When executing an adjustment this trigger button will become active. After finishing a task given to the user by the sequencer via the message window, this trigger button should be pressed to continue the adjustment.

Repeat Last Step

This trigger button allows repetition of the last task performed during the adjustment.

Adjust Method

This parameter defines for which method the adjustment will be performed.

3.5.11 Oscilloscope

The *oscilloscope* sequencer allows the user to display measured values in a similar way as is done through an oscilloscope. The measured values which are displayed are set by the configurations and defined by WITec.

HINT If other values are required to be displayed in the oscilloscope window, contact WITec for assistance.

If single value signals such as the counter output of a photomultiplier are displayed, the signal will be integrated for the set time and the recorded value will then be displayed. The currently displayed values will shift to the left in the oscilloscope window with each new value recorded and the total time displayed is adjustable as well. If the recorded signal is a spectrum, the CCD camera will integrate the signal for the set amount of time and then refresh the entire oscilloscope window using the new spectrum. The following parameters are adjustable within the *oscilloscope* parameter group.

Start Oscilloscope

Pressing this trigger button will start the oscilloscope using the current set of parameters.

Pre Measurement State

This parameter group is identical to the one which can be found with some data sources (see Section 3.6).

Post Measurement State

This parameter group is identical to the one which can be found with some data sources (see Section 3.6).

If any of the pre or post measurement states of the recorded channels and/or the values set in the oscilloscope parameter group here are in conflict, the states in question will not be changed before or after the measurement (see Section 3.6).

Displayed Time [s]

This parameter sets the total time displayed within the oscilloscope window.

Integration Time [s]

This parameter sets the integration time per point measured. This is the counting time for a photon counting device or the integration time in the cases where spectra are recorded.

3.5.12 Single Spectrum

This parameter group allows (if applicable) recording of single spectra using the CCD camera connected to the system. A single spectrum acquisition stores only one spectrum. This spectrum can be an accumulation of several spectra, which can either be added or the average spectrum can be calculated. The single spectrum acquisition is controlled by the following parameters:

Acc. Single Spectrum

Pressing this trigger button, will start the acquisition using the current set of parameters.

Pre Measurement State

This parameter group is identical to the one which can be found with some data sources (see Section 3.6).

Post Measurement State

This parameter group is identical to the one which can be found with some data sources (see Section 3.6).

If any of the pre or post measurement states of the recorded channels and/or the values set in the single spectrum parameter group here are in conflict, the states in question will not be changed before or after the measurement (see Section 3.6).

Accumulations

This parameter describes how many spectra will be accumulated using the *integration time* for each of them.

Integration Time [s]

This parameter defines the integration time for one spectrum. The minimum and maximum integration times depend on the CCD camera used.

Infinite Accumulation

If this option is selected (*Yes*) the CCD camera will continuously record spectra using the *integration time* and the software will accumulate them until the measurement is interrupted by the user by pressing any of the stop trigger buttons.

Accumulation Mode

Here the mode of accumulation can be switched between *accumulate* and *average*. If average is selected, only the average spectra will be displayed whereas if accumulate is selected, the spectra are added and displayed as the sum of all spectra recorded.

3.5.13 Time Series (Fast)

The *time series (fast)* sequencer allows the acquisition of data sources (e.g. spectra or count rates) at a fixed scan table position as a function of time. In this mode changes to the sample over time can for example be observed. The fast time series was developed for maximum speed and therefore does not allow pauses between the measurements. The following parameters can be adjusted to control the time series:

Start Time Series

Pressing this trigger button will start the time series using the current set of parameters.

Measurements

This parameter determines how many measurements will be performed. It can be adjusted between 1 and 2^{17}(=131072).

Integration Time [s]

Using this parameter, the integration time per measurement can be set between 0.1 ms and 10 s. Changes to this parameter will automatically also change the frequency parameter. If the integration time entered is shorter than the fastest possible by the device (e.g. the CCD camera), the time will automatically set to the fastest possible by the device.

Frequency [Hz]

Using this parameter, the frequency of the measurements can be set between 0.1 Hz and 10 kHz. Changes to this parameter will automatically also change the integration time parameter. If the frequency entered is higher than the highest possible by the device (e.g. the CCD camera), the frequency will automatically set to the highest possible by the device.

3.5.14 Auto Focus

The auto focus function allows the automatic focusing of the microscope based on either a counter output (typically PMT or APD) or the integrated intensity of certain parts of the spectrum as recorded by the spectral camera. If a spectral camera is used, the single data function as described in Section 3.4.12 is used. In this case the currently entered values in the *Spectrograph* and *Spec Camera* parameter groups are used for the evaluation of the numerical data.

The auto focus procedure works as follows:

1. The intensity is measured from the counter selected or the spectrometer in 50 equidistant points within the *Search Range*. The starting position is in the middle of the *Search Range*.
2. The maximum of the points measured is determined.
3. Around the position where the maximum was found the new search range is determined as
$[Search\ Range] = \frac{4}{50} \times [Old\ Search\ Range]$
4. Points 1 to 3 are repeated until the step width is smaller than an internally defined threshold.
5. The microscope Z stage is driven to the maximum found.

The following parameters are available within the *Auto Focus* parameter group:

Start Auto Focus
: This trigger button starts the auto focus procedure.

Max Search Range [μm]
: In this field the initial search range can be entered.

Min. Integration Time [μm]
: The integration time of the photon counting device / the spectral camera can be entered here. The CCD camera may add read-out time to this value if used.

The auto focus procedure either finds the maximum or aborts, if no definite maximum in terms of signal to noise ratio is found.

3.5.15 Process Script

The *Process Script* parameter group allows the definition of script based command lines for the automatic execution of several consecutive tasks. Each task that can be included in the script is shown in this parameter group. Tasks, which are fully defined in their respective parameter groups (such as *Image Scan* or *Auto Focus*) use the parameters set in their respective parameter groups. These tasks will nevertheless be shown in the *Process Script* parameter group, but without any parameters. Some additional tasks are included in the *Process Script* parameter group and their

Task Name	Command Line	Parameter	Parameter Description
Pause	pause	Duration [ms]	The duration of the pause at this point
Snapshot	snapshot	Color	Color video snapshot (YES) or black and white (NO)
		Brightness [%]	Brightness of the while light illumination for the snapshot
Move Z Microscope	movezmicroscope	Distance [μm]	The distance the microscope Z stage should move (+ = increase; - = decrease in objective↔ sample distance)
		Speed [μm/s]	The speed of the microscope Z stage during the movement
Auto-Illumination	autoillumination	Uses the parameters described in Section 3.5.1.	
Auto-Focus	autofocus	Uses the parameters described in Section 3.5.14.	
Tip-Approach	tipapproach	Uses the parameters described in Section 3.5.8.	
Single Spectrum	singlespectrum	Uses the parameters described in Section 3.5.12.	
Image Scan	imagescan	Uses the parameters described in Section 3.5.2.	
Save Project	saveproject	Uses the parameters described in Section 3.7.	

Table 3.1: The tasks usable in the *Process Script* sequencer. New parameters are described and the location of the parameters defined in other parameter groups are indicated.

parameters can be adjusted herein. Table 3.1 shows the tasks available and their parameters.

During the execution of one scrip, the parameters remain constant. If, for example, several *Move Z Microscope* commands are included in the script, all of them will be executed with the same speed and distance.

The script itself can contain the various commands separated by semicolons. An example for a script is given below:

$$pause\,;\ autofocus\,;\ singlespectrum\,;\ imagescan\,;\ saveproject\,;\ movezmicroscope$$

In this example, the microscope will first pause for the defined duration before performing the auto focus function. Then a single spectrum will be recorded before an image scan is performed. Following the completion of this image scan, the project will be saved and the microscope will move the defined distance in Z.

Scripts can be executed by pressing the Start Script trigger button (see below) or through a raster as defined in the point editor (see Chapter 9).

Once the execution of a script is triggered, it is first checked for syntax errors. Should the script contain any error, the execution will not be started and a corresponding message identifying the number of the command where the error occurs will be displayed in the message window (see Chapter 6). The erroneous command will also be displayed.

Apart from the executable commands the following entries can be found in the *Process Script* parameter group:

Start Script

Using this trigger button the execution of the script can be started.

Cancel Current Cmd.

This trigger button cancels the current command. The next command in the command line will automatically be executed. In the example of the command line shown above, pressing the Cancel Current Cmd. button while the image scan is executed will cancel this execution and the *saveproject* function will automatically be executed.

Command Line

The command for the script function as shown in an example above can be entered here.

Command Parameters

This group contains all tasks which can be executed through the script and which have been explained in Table 3.1.

HINT Using the *Save As* function which can be found in the *Configurations* menu, the current script as well as all parameters set in the individual parameter groups can be saved for later usage. This would essentially then represent another configuration, based on a standard one, but with the predefined parameters for the script execution.

3.6 Data Sources

The alpha Controller fulfills a wide variety of functions, during which data are measured and communicated continuously among various devices and sequencers.

In most cases the users interest lies in the output of a sequencer and not in all the intermediate measured data. Therefore, WITec Control provides access to this data via channels, fast stream channels and spectral channels. However, the data sources tree-structure also contains some internal controller management parameters (Section 3.6.4), which are for internal use only and should not be modified by any user.

The tree-structure of the data sources lists a large number of available channels. However, some of these channels are for internal use only and will not be described in this manual.

3.6.1 Channels

The channels provide access to controller outputs where each measuring point describes one measured data. This data may be single values or sets of values as is the case for e.g. distance curves or a spectra. The listed output channels are characterized by a set of parameters followed by the sequencers which are able to record this channel.

Common Channel Parameters

The parameters listed below are available for all channels.

- **Channel Nr**
  This parameter cannot be modified by the user and is for internal reference only.
- **Caption**
  This caption is stored with the name of every data object created through the output of this channel.
- **Unit**
  This parameter describes the physical unit of the measured channel. It will be stored with every data object created through the output of this channel.
- **Offset (Unit)**
  This parameter is used in conjunction with the *scale* (see below) to calculate the physical value from the measured signal.
- **Scale**
  This parameter is used in conjunction with the *offset* (see above) to calculate the physical value from the measured signal.
- **Show Status**
  The output of the channel can be displayed as a numerical value in the status window (see Chapter 5). The caption is used as the parameter name

followed by its unit. The displayed numerical value is calculated based on the unit offset and scaling parameter.

Pre Measurement State

These parameter groups define the state of various devices before the measurement of a specific data channel is started. Each group hereby consists of two entries where one parameter can be set to either *Change State* or *Do Not Change State*. If the *Change State* is selected, the corresponding device will change into the defined state whereas if *Do Not Change State* is selected no action will be performed. The other parameter defines the state the device will change into if applicable and the only choices available for this parameter are described in the following.

- **Microscope Illumination (State)**
  The white light can be turned off (*Light Off*) or on (*Light On*) before the measurement of the specific channel.

- **Flip Mirror (State)**
  Up to two mirrors can be added to an alpha300 system. Each mirror can be switched between its two states (e.g. for the alpha300 S the standard mirror has the states *CCD Camera* and *Photo Multiplier*).

- **Counter (State)**
  An alpha300 / alpha500 / alpha700 system can be equipped with up to three counters. Each counter can be switched *On* or *Off* before a measurement.

- **Filter Wheel (Filter Number)**
  If the filter wheel is included, the position of the filter wheel (ie which filter will intersect the beam path) can be set to *Filter 1, ... , Filter 4*.

Post Measurement State

The Post Measurement State contains the same parameters as the Pre Measurement State. These parameters however, define the state of the devices after measuring the specific channel.

Sequencers

The sequencers which are able to record channels are listed below.

- **Image Scan**
  The parameters required to record and display an image scan are:

  Capture

  This parameter allows the selection of *Yes* - the data set is captured in an image data object and listed in the project manager, or *No* - the image is not captured.

Show
If an image is captured, it can be automatically displayed in an image viewer if *Yes* is selected.

Show Retrace
The retrace of a captured image is automatically displayed in an image viewer if *Yes* is selected.

Show Line Graph
If *Yes* is selected, a graph viewer is automatically opened. It displays the value of the channel recorded along the current line of an image scan.

Image Line Correction
The image displayed in the image viewer can be line corrected. This line correction does not affect the saved data. It refers only to the display of the image in the image viewer (see also WITec Project Manual - Image Viewer).

Graph Line Correction
The graph displayed in the graph viewer can be line corrected. This line correction does not affect the captured data. It refers only to the display of the line in the graph viewer (see also WITec Project Manual - Graph Viewer).

▶ **Line Scan**

Capture
This parameter allows the selection of *Yes* - the data set is captured in a data object and listed in the project manager, or *No* - the data is not captured.

Show
If the data is captured, it can be automatically displayed in an graph viewer if *Yes* is selected.

▶ **Frequency Sweep**
The parameters required to record, display and store a frequency sweep are listed below.

Capture
If this parameter is set to *Yes*, the frequency sweep is captured. However, a graph data object is created only if the *Create Data* parameter is set to *Yes* in the frequency sweep sequencer (see Section 3.5.5).

Show
If this parameter is set to *Yes*, the frequency sweep is opened automatically in a graph viewer.

▶ **Distance Curve**
The parameters required to record, display and store a distance curve are listed below.

Capture
Distance curves are captured and stored in graph data objects if *Yes* is selected.

Show
If *Yes* is selected, the distance curves are automatically opened in a graph viewer.

▶ **Oscilloscope**
The parameters required to record and display the channel output in the oscilloscope mode are listed below.

HINT Oscilloscope displays do not create a data object and can not be stored.

Capture
If *Yes* is selected, the channel output is captured without creating a graph data object.

Show
The data captured in the oscilloscope mode are displayed in a graph viewer if *Yes* is selected.

▶ **Time Series (Fast)**
The parameters required to record, display and store a fast time series are listed below.

Capture
This parameter allows the selection of *Yes* - the data set is captured in a data object and listed in the project manager, or *No* - the data is not captured.

Show
The data captured in the time series is displayed in a graph viewer if *Yes* is selected.

▶ **Auto Focus**
The parameters required to allow the usage of the channel for the auto focusing procedure as described in Section 3.5.14, are shown below.

Capture
If *Yes* is selected, the single data created by this channel is used for the auto focusing function. Only one channel at a time may be set to *Yes*, otherwise the auto focus routine will not start.

Show
If *Yes* is selected, the data collected in each cycle of the auto focusing procedure is displayed in a graph window.

The Output Channels

In Tab. 3.2 the available output channels are listed in combination with the sequencers which are able to record the channels. The positions of the ✓ indicate valid combinations in Tab. 3.2. Additionally, the individual channels are described below.

- **T-B**
  The T-B output is the difference in the electrical signals collected from the top and the bottom halves of the four quadrant photo diode of the beam deflection system. Its unit is V. This output is used to monitor the feedback during contact mode measurements.

- **Lock-In R**
  The Lock-In R output signal of the lock-in amplifier (see Section 3.4.4) is the signal amplitude defined by Equ. 3.10. Its unit is V and it is used to monitor the feedback during AC mode measurements.

- **Lock-In Phi**
  The Lock-In Phi output signal of the lock-in amplifier (see Section 3.4.4) is the phase ϕ defined by Equ. 3.11. Its unit is $^\circ$ and it is used to monitor the phase shift during AC mode measurements.

- **F max.**
  The F max. output is the maximum of the PFM curve as evaluated by the controller hardware (see Section 3.4.10). Its unit is V and it is mainly used as the PI controlled channel in PFM measurements.

- **Adhesion**
  The adhesion is measured in V and is determined by the controller based on the adhesion search window from the PFM curve (see Section 3.4.10). Variations in the adhesion of a sample can be determined using this signal.

- **Stiffness**
  The stiffness is measured in V and is evaluated by the controller based on the stiffness search window from the PFM curve (see Section 3.4.10). Variations in the stiffness of a sample can be determined using this signal.

- **Viscosity**
  The viscosity is measured in $^\circ$ and is determined by the controller based on the viscosity search window from the PFM curve (see Section 3.4.10). Variations in the viscosity of a sample can be determined using this signal. This, however, is not yet implemented.

- **L-R**
  The L-R output is the difference in the electrical signals collected from the left and right halves of the four quadrant photo diode of the beam deflection system. Its unit is V. This output is used to monitor the torsion of the cantilever during contact mode measurements.

- **Aux 1 and Aux 2**
  Aux 1 and Aux 2 are the auxiliary channels of the alphaControl system. The unit of these signals is V.

Channel	Image Scan	Line Scan	Freq. Sweep	Dist. Curve	Oscillos-cope	Display in Stat. Win.	Time Series	Auto Focus
T-B	✓	✓		✓	✓	✓		
Lock-In R	✓	✓	✓	✓	✓	✓		
Lock-In Phi	✓	✓	✓	✓	✓	✓		
F max.	✓	✓			✓	✓		
Adhesion	✓	✓			✓	✓		
Stiffness	✓	✓			✓	✓		
Viscosity	✓	✓			✓	✓		
L-R	✓	✓		✓	✓	✓		
Aux 1	✓	✓		✓	✓	✓	✓	
Aux 2	✓	✓		✓	✓	✓	✓	
Sum						✓		
X-Sensor	✓				✓	✓	✓	
Y-Sensor	✓				✓	✓	✓	
Z-Sensor	✓	✓			✓	✓	✓	
Feedback	✓	✓		✓	✓	✓		
Photon Cnt.	✓	✓		✓	✓	✓	✓	✓
Counter Rate	✓	✓		✓	✓	✓	✓	✓
Microscope Z						✓		✓
Inv. Mic. X						✓		
Inv. Mic. Y						✓		
Inv. Mic. Z						✓		
Sample Pos. X						✓		
Sample Pos. Y						✓		
Opt. Laser Pow.						✓		

Table 3.2: Output channels and their sequencer. The ✓indicate valid combinations of channels and sequencers.

- **Sum**
  The Sum output is the total electrical signal collected from the four quadrant photo diode of the beam deflection system. Its unit is V.

- **X-Sensor**
  The X-sensor output is the signal collected from the capacitive sensor measuring the X-axis position of the scan table (Section 3.4.3). Its unit is μm. This signal is used to determine the precise position of the scan table.

- **Y-Sensor**
  The Y-sensor output is the signal collected from the capacitive sensor measuring the Y-axis position of the scan table (Section 3.4.3). Its unit is μm. This signal is used to determine the precise position of the scan table.

- **Z-Sensor**
  The Z-sensor output is the signal collected from the capacitive sensor measuring the Z-axis position of the scan table (Section 3.4.3). Its unit is typically μm. This signal is used to represent the topography of a surface during

AFM and SNOM measurements. For confocal measurements the z-sensor output reads the precise z position of the scan table.

- **Feedback**
  The feedback output is the setpoint position of the z-axis of the scan table. Its unit is typically μm^* (proportional to μm), but without the linear corrections induced by the sensor. This signal is used in AFM and SNOM measurements especially if the surface topography varies by less than $1\ nm$.

- **PMT, APD and other photon counting devices**
  Several photon counting devices can be added to an alpha system. Typically, the first photon counter is a PMT and the second counter an APD. The output of the counters is the actual counter reading of how many photons were counted during the last pixel. Its unit is cts (counts).

- **Count Rate of photon counting devices**
  The Count Rate output is the counter reading divided by the time required to record the pixel. Its unit is Hz (counts /second).

- **Microscope Z**
  The microscope Z output is the relative position of the microscope z-stage. Its unit is μm.

- **Inv. Mic. X**
  The inverted microscope X output is the relative position of the inverted microscope in the X-direction. Its unit is μm.

- **Inv. Mic. Y**
  The inverted microscope Y output is the relative position of the inverted microscope in the Y-direction. Its unit is μm.

- **Inv. Mic. Z**
  The inverted microscope Z output is the relative position of the inverted microscope in the Z-direction. Its unit is μm.

- **Sample Pos. X**
  The Sample Pos. X is the X position of the sample positioning stage in the currently active coordinate system. Its unit is μm.

- **Sample Pos. Y**
  The Sample Pos. Y is the Y position of the sample positioning stage in the currently active coordinate system. Its unit is μm.

- **Optical Laser Power**
  The optical laser power parameter contains the power as read from the photo-detector and converted by the calibrated conversion. Its unit is μW.

- **Heating Stage Temperature**
  The heating stage temperature contains the temperature as determined through the calibrated PT100 element in the heating stage.

3.6.2 Fast Stream Channels

Fast stream channels can be transferred with higher speed (5 MHz) from the controller to the PC. There is a limited number of channels available for this fast transfer (T-B, L-R, Aux1 and Aux2) and their description is similar to how they were described in Section 3.6.1. At this point the T-B is the only signal used in fast streaming mode and this is implemented during PFM measurements.

3.6.3 Spectral Channels

This category of data sources contains the outputs of the spectral cameras connected to the alpha300 / alpha500 / alpha700 system. Up to three spectral cameras can be added to an alpha300 / alpha500 / alpha700 system. In this case, one measuring point describes a set of measured data (e.g. a full spectrum).

Each spectral camera delivers a set of data to the software. The parameters which describe each camera are listed below.

General Parameters

- **Spectral Camera**
  This parameter defines the internal code for a spectral camera and is not accessible to users.
- **Caption**
  The caption is stored with the name of every data object created using the output of the spectral camera
- **Unit**
  This parameter describes the physical unit of the spectral camera (e.g. CCD cts).

Spectral channels can also have defined pre- and post measurement states which are similar to the ones described in Section 3.6.1.

The sequencers, which are able to record the data of a spectral camera, are listed below.

Image Scan

This image scan sequencer records a 2D data array (see Section 3.5.2). The parameters listed below are used to capture, store, and display a 2D data array image scan.

- **Capture**
  This parameter allows the selection of *Yes* - the spectral data are captured

in a multi-graph data object and listed in the project manager, or *No* - the spectral data are not captured.
All spectra read from the spectral camera are displayed in a graph viewer labeled *Hardware Spectrum*. This viewer opens automatically upon starting a measurement.

▶ **Show**
If *Yes* is selected, an additional graph viewer is opened. This graph viewer displays one spectrum of the multi-graph data object captured during the trace movement of the scan table.

▶ **Show Retrace**
If *Yes* is selected, the graph viewer displays one spectrum of the multi-graph data objet which contains the data recorded during the retrace movement of the scan table.

▶ **Create Filt.Man. Trace**
If a multi-graph data object is created, the filter manager can be used to calculate specific spectral features by using predefined filters and summarize these features in an image data object. A filter manager can be created automatically and displayed. If this parameter is set to *Yes*, the filter manager is created for all data measured during the trace movement of the scanner.

▶ **Create Filt.Man. Retrace**
If Yes is selected for this parameter, a filter manager is created for all data measured during a retrace movement of the scanner.

Line Scan

The parameters required to record a multi-graph line scan are listed below.

▶ **Capture**
If *Yes* is selected, a one dimensional multi-graph data object is created and listed in the project manager. All spectra read from the spectral camera are displayed in a graph viewer labeled *Hardware Spectrum*. This viewer opens automatically when the measurement is started.

▶ **Show**
If *Yes* is selected, an additional graph viewer is opened. This graph viewer displays the captured multi-graph data object.

Oscilloscope Mode

▶ **Capture**
If *Yes* is selected, all spectra read from the spectral camera are displayed automatically in a graph viewer. Storage of the spectra is not possible in the oscilloscope mode.

Single Spectrum

The parameters required to record a single spectrum are listed below.

- **Capture**
  If *Yes* is selected, a one dimensional graph data object is created and listed in the project manager. The single spectrum (or each of the spectra which are accumulated) read from the spectral camera is displayed in a graph viewer labeled *Hardware Spectrum*. This viewer opens automatically when the measurement is started.

- **Show**
  If *Yes* is selected, an additional graph viewer is opened. This graph viewer displays the captured graph data object which is the current accumulation of the single spectra (if more then one accumulation is selected).

Time Series (Fast)

This fast time series sequencer records series of spectra (see Section 3.5.13). The parameters listed below are used to capture, store, and display a these series.

- **Capture**
  If *Yes* is selected, a one dimensional multi-graph data object is created and listed in the project manager. All spectra read from the spectral camera are displayed in a graph viewer labeled *Hardware Spectrum*. This viewer opens automatically when the measurement is started.

- **Show**
  If *Yes* is selected, an additional graph viewer is opened. This graph viewer displays the captured multi-graph data object.

- **Create Filt.Man.**
  If a multi-graph data object is created, the filter manager can be used to calculate specific spectral features by using predefined filters and summarize these features in an graph data object. A filter manager can be created automatically and displayed. If this parameter is set to *Yes*, the filter manager is created for all data measured during time series.

Auto Focus

The parameters required to allow the usage of the spectral channel for the auto focusing procedure using the single data function as shown in Section 3.4.12, are described below.

- **Capture**
  If *Yes* is selected, the single data created by this channel is used for the auto focusing function. Only one channel at a time may be set to *Yes*, otherwise the auto focus routine will not start.

▶ **Show**
If *Yes* is selected, the data collected in each cycle of the auto focusing procedure is displayed in a graph window.

3.6.4 Controller

This category of data sources contains the internal outputs of the controller. The channels within this category are for internal use only and should not be modified by any user.

3.7 Auto Save

The auto save parameter group allows the definition for automatic saving of the data acquired. It can either be triggered through the Store Project trigger button or through the corresponding command in the process script sequencer.

If directories defined for the auto saving procedure do not exist, they will be created by the software upon saving.

The parameters available for the auto save function are described below:

Store Project
This trigger button stores the project using the current settings.

Start Directory
In this field the starting directory can be defined. The full path where the file will be stored will be explained below.

Extra Directory
An additional directory for saving the project can be defined using this field. The full path where the file will be stored will be explained below.

File Name
The first part of the file name can be defined using this field. The composition of the full file name is described in the next point.

File Number
Here a number for the file saved can be assigned. This will automatically be incremented with each saving cycle and the number is automatically expanded to four digits. If for example the number entered is *2* the number used will be *0002*.

The total file name will then be:

[File Name]_[File Number].WIP

Next File

This field is for information purposes only and displays the path and filename of the next file that will be saved.

Directory Mode

Various modes can be selected here. Below the resulting file path for all methods will be shown.

- **No Extra Directory**
  [Start Directory]\
- **Extra Directory**
  *[Start Directory]**[Extra Directory]*\
- **Date**
  [Start Directory]\YYYYMMDD\
  Here YYYY identifies the year, MM the month and DD the day.
- **Extra Directory + Date**
  *[Start Directory]**[Extra Directory]*\YYYYMMDD\
- **Date + Extra Directory**
  [Start Directory]\YYYYMMDD*[Extra Directory]*\

Store Mode

Store and *Store and Clear* can be selected for this parameter. The difference is that *Store and Clear* will clear the project after saving it.

Overwrite Mode

This parameter will only be of importance if the file which is about to be saved exists already. If *Overwrite* is chosen, the existing file will be overwritten. If *Add Extra Suffix* is selected the file name shown above will be changed to:

*[File Name]*_*[File Number]*_YYYYMMDD_HHMMSSmmm.WIP

Here YYYY denotes the year, MM the month, DD the day, HH the hour, MM the minute, SS the second and mmm the milliseconds of the moment when the file is saved.

Chapter 4

Video Control Window

The video control window displays the image captured by one of the video cameras of the alpha300 / alpha500 / alpha700 system. It allows access to all functions required for video image display, view calibration, laser position marking, scan range display and image data storage. The video control window can be opened from the menu bar via the hardware control menu (see Section 2.1.1).
The three major functional components of the video control window, which is shown in Fig. 4.1, are discussed below.

Toolbar

The toolbar allows quick access to the functions of the video control window and it contains the following speed buttons:

- **Cursor**
  With this button a spatial cursor is activated. Its standard unit is μm. More information about the role of spatial cursors can be found in the WITec Project manual.

- **Set Tip Position**
  This button allows the user to position a permanent marker in the video image. This is particularly useful for marking the laser or tip position within the video image.

- **Set Reference Point**
  This button allows a spatial synchronization of the video image with a bitmap or an image data object using distinctive features displayed in the respective windows. This feature is especially helpful if the laser is not visible in the video image or the exact tip position is hidden by the cantilever. In this case an image can be scanned and displayed in an image viewer. After activating the set reference point function, the synchronization between the image window and the video control window is achieved by clicking on a specific sample feature in the image viewer followed by a click on the same feature in the video control window.

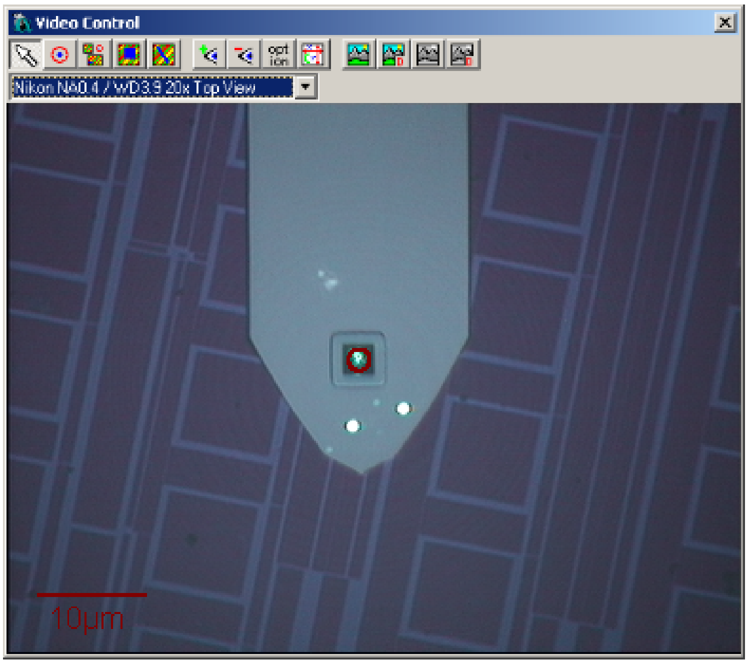


Fig. 4.1: Video Control window.

- **Image Marker**
  With this button a scan area can be defined within the video image. This can be achieved by clicking onto one corner of the desired scan area and while holding the left mouse button, dragging the square into the desired shape.

HINT The area marked will only have an effect on the scan area if the "listen" option in *Image Scan ⇒ Geometry* is set (see Section 3.5.2).
If the selected scan area lies outside the maximum scan range, the geometry parameters will be displayed in red indicating this error.

- **Line Marker**
  Similar to the image marker, the line marker can be used to define the geometry of a future scan. In this case a line is defined by clicking on the start point of the line and while holding the left mouse button, dragging the mouse to the desired end point. If the "listen" option in *Line Scan* (see Section 3.5.3) is set, this line will be used for the next line scan.

- **Calibrate Video**
  This button allows the spatial calibration of the video image. Upon pressing this button, the scan table moves a defined, magnification-dependent distance. Based on the movement of specific features within the video image, the video image display is calibrated. A confirmation window similar to Fig. 4.2 opens upon completion of the calibration. After the parameters

in this window are approved by the user, a calibrated scale bar will be displayed in the video image.

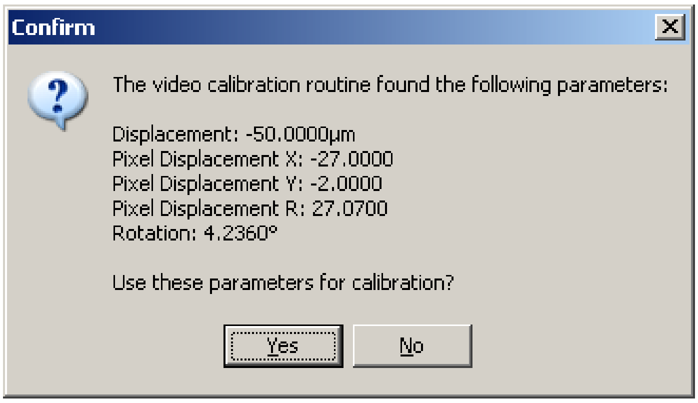


Fig. 4.2: Confirmation of video calibration window.

For successful calibration of the video image display, the video camera must be properly oriented, the objective properly focused on a sample with an irregular but distinctive pattern and all laser sources should be switched off. To check the calibration, several distinctive features can be moved into the center of the video image using the *Scan Table* ⇒ *Listen Position* option (see Section 3.4.3). If the calibration was successful clicking onto a feature should cause this feature to move into the marked laser or tip position.

HINT Failure of the calibration can occur if the entered magnification of the objective is deviating from the actual magnification by more than approximately 20%. Additionally, the calibration may fail if the sample does not show enough distinctive features.
If the laser source is on, a cantilever is mounted or the field stop diaphragm is visible within the video image, the calibration will also fail since these are distinct features which will not move as the scan table does.

▶ **Add View Port**

This button opens the video channel options window as shown in Fig. 4.3. It allows access to all parameters required for the setup of a new view port. These parameters are described under "Options" below. Title, magnification and video input channel will be used to identify the view as an additional entry in the view port drop down menu (see below).

HINT After adding a new view port, the video image display should be calibrated. The calibration will be saved with the respective view.

▶ **Remove View Port**

The view port selected in the drop down window (see below) is removed by clicking this button.

▶ **Options**
This button opens the video channel options window (Fig. 4.3) in which the following parameters can be adjusted for the individual views.

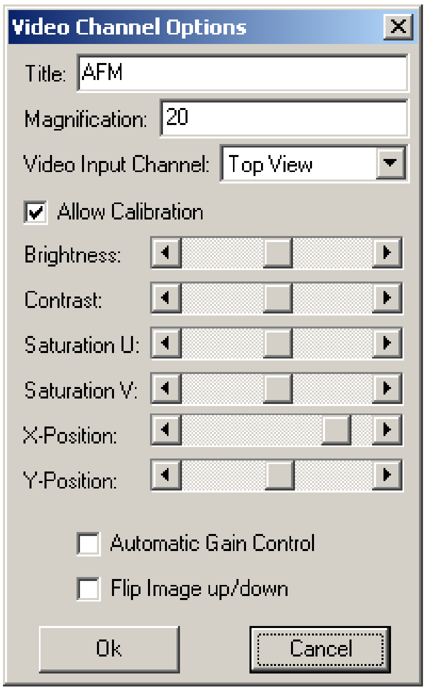


Fig. 4.3: Video Channel Options window.

Title The title is used for the identification of the view in the view port drop down menu (see below).

Magnification The magnification is also used for identification purposes but is also needed for the calibration of the view. Variation of more than approximately 20% from the actual magnification of the objective may lead to problems during the calibration.

Video Input Channel Different cameras can be selected using the video input channel. These are connected to the frame grabber card of the PC with “Top View” being the BNC connector closest to the mother board, then “Bottom View”, “Rear View” and “Aux View”. All alpha300 / alpha500 / alpha700 systems are equipped with a top view camera. The bottom view is used for all systems using an inverted microscope such as the alpha300 S and the rear view is used if the system is equipped with the SNOM reflection mode extension. The auxiliary view allows the attachment of an additional camera if necessary. The information entered here is again used for the identification of the view.

Allow Calibration If this tick box is unchecked, no calibration can be performed. This may be desirable for view ports using the back view since this view cannot be calibrated.

Brightness, Contrast and Saturation These sliders allow the user to change the appearance of the video signal within the control window.

X- and Y-Position Using these sliders, the position of the video image within the video control window can be changed.

Flip Image up/down The image can be flipped if desired using this option.

► **Image**
This speed button copies the image to the graphic export window, whose functions are described in the WITec Project manual.

► **Add Video Image to Project**
Using this speed button, the video image can be added as a color bitmap to the project.

► **Gray-scale Image**
This speed button copies the image as a gray-scale image to the graphic export window, whose functions are described in the WITec Project manual.

► **Add gray-scale Image to project**
Using this speed button, the video image can be added as a gray-scale bitmap to the project.

Drop down window

The drop down window lists the available video ports. By choosing one of the listed views, the calibration for this particular view is loaded and the video image originating from the respective camera is displayed.

Video Image Display

In the lower left hand corner of the video display area, the scale bar for the selected view port is shown. The red circle shows the position of the reference point (in most cases the laser or cantilever position). The red frame around the spot indicates the full scan area of the scanner. For high magnifications, this frame might not be visible if it lies outside the viewing area.
The context menu of the video image display can be accessed using the right mouse button. This context menu allows access to the functions of the above discussed speed buttons.

Chapter 5

Status Window

The status window consists of a 2 column chart which lists the actual value of measured output channels. The left column contains the name of the output channel including its physical unit in square brackets. The right column displays the actual numerical value of the output channel in its physical unit.

Many of the system parameters (output channels) of the alpha300 / alpha500 / alpha700 system can be listed in the status window as described in Section 3.6. However, the display of too many parameters would lead to a complex list of parameters and their respective numerical values. It is therefore recommended to reduce the parameters listed in the status window to a minimum for the selected data acquisition mode as is done for the predefined basic configurations mentioned in Chapter 11. Detailed descriptions of the configurations matched to the individual hardware purchased can be found in separate documents.

Chapter 6

Message Window

The message window is a message interface between the controller hardware and the user as shown in Fig. 6.1. The upper part of the window is a chronological classification of past operations. The lower part of the window displays the current operation followed by the display of the remaining time required for the operation.

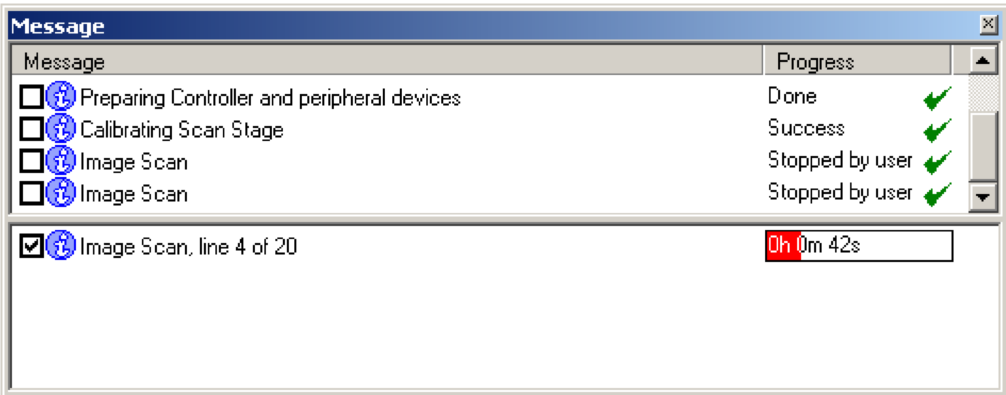


Fig. 6.1: Message window

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The nature of the message can be identified by the symbol displayed in front of the message. The following types of messages are displayed:

Information

This class of messages contains only information about ongoing processes performed by the controller. The message description next to this symbol, informs the user about the actual process.

Warnings

If a controller process fails, a warning message is displayed.

User input for an operation 

Some routines of the controller are automated. Nevertheless they can not be completed without user inputs. Messages which contain the user input symbol describe the action which should be accomplished by the user.

Hazard 

Hazard messages indicate severe problems of the hardware. They contain information about communication errors between computer and controller or failures of the power supply.

Chapter 7

Quadrant Window

The quadrant window shown in Fig. 7.1 is a graphical representation of the four quadrant beam deflection detector. It is useful for the alignment of the beam deflection system used during AFM and SNOM measurements. In addition it provides visual information about the status of the four quadrant detector while acquiring data in the AFM or SNOM operation mode.

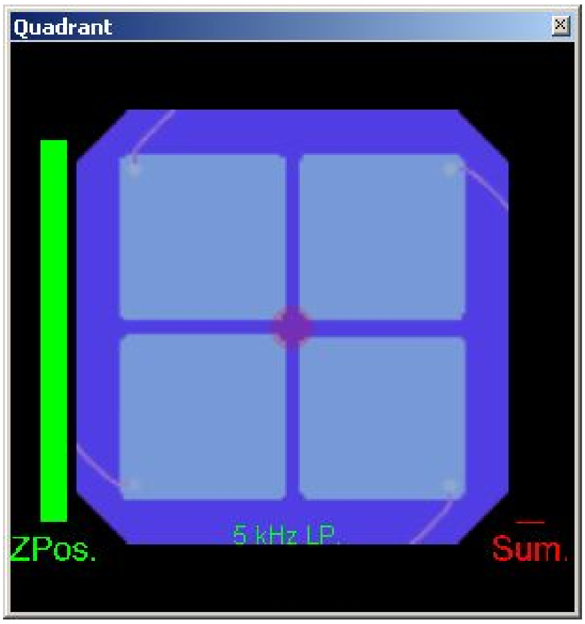

Fig. 7.1: Quadrant Window

The window consists of three parts:

Z-Position Indicator

The column on the left hand side of the window displays the position of the scanner (ZPos.). During the approach of the cantilever towards the sample, the scanner is fully extended, which is indicated with the full size of the column. Upon contact between the cantilever and the sample, the scanner will start to retract, which is indicated through a decrease in the hight of this column. The cantilever reaches its final position when the scanner is retracted to the middle position of the scanner and the column is at half height. If the basic configuration for AFM or SNOM is selected, the numerical value of the position of the scan table is listed in the status window (Chapter 5).

Sum Signal Indicator

The column on the right side of the window (Sum) is proportional in length to the total reflected laser light from the cantilever captured by the four quadrant detector.

The Four Quadrant Diode

The central area displays the four quadrants of the beam deflection detector. Depending on operation mode, this display changes.

- **Contact Mode:** If the system is operated in contact mode, a red marker (dot) appears in this four quadrant display. This marker indicates the position of the laser spot reflected from the cantilever onto the four quadrant diode. The active low pass filter is displayed at the bottom of the four quadrant display.
- **AC Mode:** If the system is operated in AC mode, the red marker is replaced by an arrow in the center of the four quadrants. The length of this arrow is proportional to the oscillation amplitude of the cantilever. The rotation of the arrow indicates the phase offset between modulation and cantilever oscillation. At the bottom of the four quadrant display, the note ”AC coupling” appears, indicating that all DC-voltage offsets are neglected in this representation.
- **PFM Mode:** When operated in pulsed force mode, the red marker is replaced by a red line which only moves in the vertical direction indicating the Top-Bottom signal. No horizontal movement is implemented since the Left-Right signal is not evaluated in PFM. The active low pass filter is displayed at the bottom of the four quadrant display.

Chapter 8

Graphic Control Window

The alpha300 / alpha500 / alpha700 system consists of several devices which may have to be aligned, focused, and/or synchronized. Some of these devices are controllable through extended visual interfaces which are displayed within the graphic control window. Each interface can be selected through the tab sheets visible within the graphic control window.
Generally, these tab sheets consist of a graphic representation of the selected device. The directions of movement available for the specific devices are indicated by red arrows. Clicking with the left mouse button on one of these arrows will move the device in the selected direction using the speed indicated by the numerical value within the window. This speed can be adjusted through the graphical representation of the potentiometer within the window, the potentiometer on the remote control (if available) or the parameter setting of the corresponding device within the control window (see Chapter 3).

The following extended visual interfaces are available within the graphic control window.

Cantilever Positioning

The extended visual interface for the cantilever positioning displays the six possible movements of the cantilever as shown in Fig. 8.1(a). This extended visual interface is used for the alignment of the AFM/SNOM cantilever.

Inverted Microscope

The movement of the inverted microscope of the alpha300 system can be controlled using the extended visual interface of the inverted microscope (Fig. 8.1(b)). The six directions of movement are indicated by the red arrows on this tab sheet.

Microscope Z Movement

The graphic control for the microscope z movement is displayed in Fig. 8.1(c). It displays the upper part of the microscope. The red arrows indicate the two possible directions of movement for this microscope.

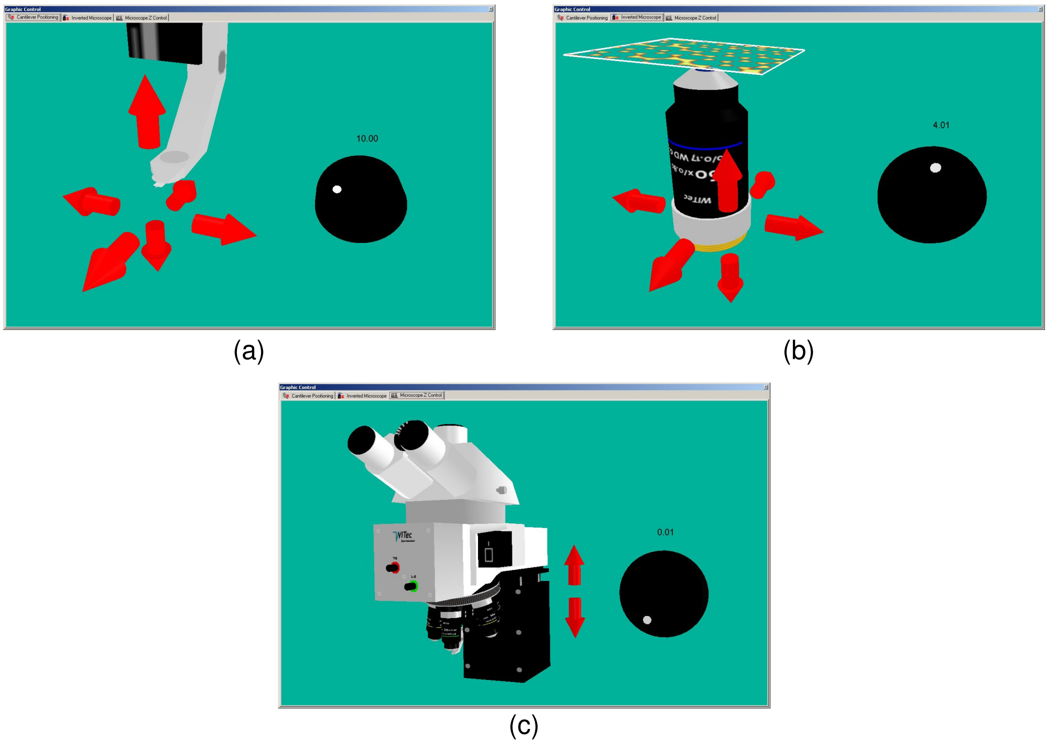

Fig. 8.1: Graphic Control: (a) cantilever positioning; (b) inverted microscope; (c) Z microscope

Chapter 9

Point Viewer

The Point Viewer (see Fig. 9.1) is used to define the points for the use with the sample raster as described in Section 3.5.4. At the points defined in the point list, the process script sequencer (see Section 3.5.15) can be executed before the system automatically moves the sample to the next point in the list. The points can be edited manually or imported from .CSV files or SP1 KLARF 1.2 files. Please contact WITec should you require import functions for different file formats.

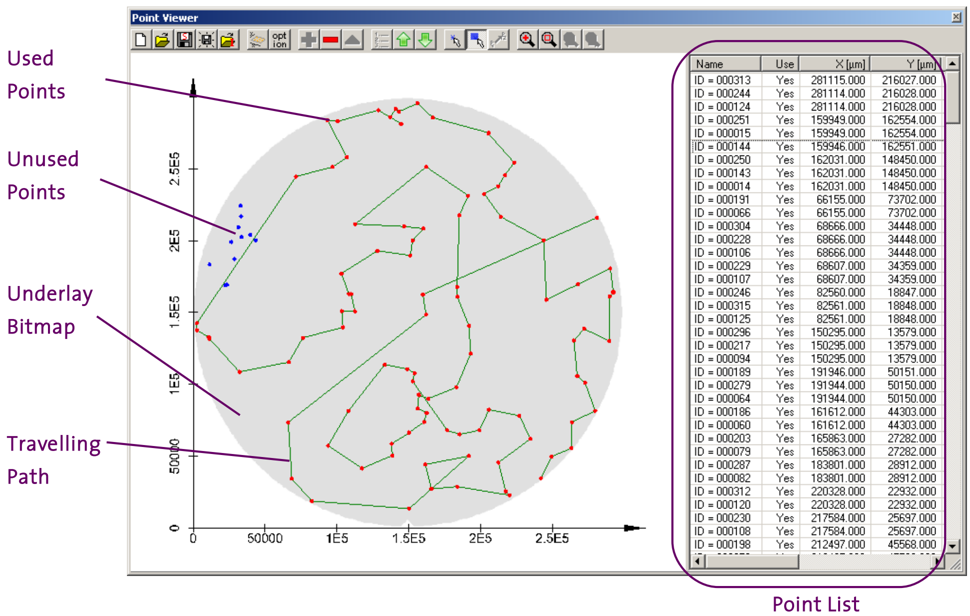

Fig. 9.1: The Point Viewer window showing the menu bar, the sample area and the point list. Some functions of the window are labeled.

In the following, the menu bar and the functions of the speed buttons will be described before the sample area is outlined. The point list and the context menu will then be described.

9.1 Speed Buttons

The following speed buttons are available in the menu bar of the Point Viewer window:

New point list

By pressing this speed button a new point list is created.
The existing point list will be deleted.

Open Point List

This function starts the Windows® standard open-dialog for WITec Point List files (*.wpt). Using this dialog, a saved point list can be opened. The saved point list file also contains the bitmap underlay and the sample and bitmap coordinates. Previously opened point lists will be closed.

Save Point List

This menu function allows a Point List to be saved. If it is a new list, the save file as-dialog will be opened.

Save Point List As

This function is similar to the save point list function, while offering the possibility to change the filename. The Windows® standard save-dialog for WITec Point List files is activated.

Import SP1 KLARF 1.2 File

This function allows the import of data saved in the SP1 KLARF 1.2 file format using the Windows® standard open-dialog. Previously opened point lists will be closed. The bitmap underlay as well as the sample and bitmap size are defined internally and set automatically for the import filter.

Define Sample Size and Underlay Bitmap

This speed button opens the sample size and bitmap underlay dialogs as shown in Fig. 9.2.

This dialog can be used to load a bitmap (in .BMP format) which is used as a background in the sample area of the Point Viewer window. The dialog allows the definition of the sample area and the size and position of the bitmap therein. In Fig. 9.2, a sample area of 200×200μm was defined and the bitmap was defined in the upper left-hand corner of the sample area as can be seen in

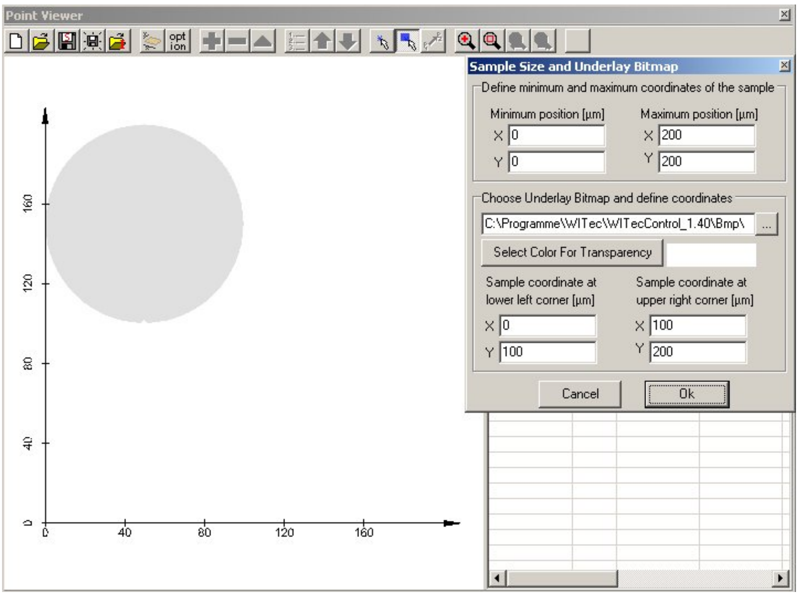

Fig. 9.2: The Sample Size and Bitmap Underlay dialog window with the Point Viewer in the background.

the point viewer in the background of Fig. 9.2. The bitmaps should, if possible, be located in the directory
`C:\Program Files\WITec\WITecControl_X.XX\BMP`
because this is the standard directory where the bitmaps are searched for.

The following entries can be modified in this window:

▶ **Minimum Position [μm] X/Y**
The minimum position of the sample within the coordinate system should be entered here. Following a change to the values entered here, the corresponding fields for the bitmap coordinates in the lower left hand corner are changed to the same value.

▶ **Maximum Position [μm] X/Y**
The maximum position of the sample within the coordinate system should be entered here. Following a change to the values entered here, the corresponding fields for the bitmap coordinates in the upper right hand corner are changed to the same value.

▶ **Underlay Bitmap**
The file containing the underlying bitmap should be entered here. The ... button opens the Windows® standard open-dialog for bitmap files (*.bmp).

▶ **Select Color for Transparency**
This trigger button opens the color selection dialog from which the transparency color for the bitmap can be selected. This color will not be displayed in the sample area. The currently selected color is shown to the right of the trigger button.

- **Sample coordinate at lower left corner [μm] X/Y**
  These fields are automatically filled in following a change to the minimum sample position field, but can also be changed manually. The coordinates of the bitmap at the lower left corner can be entered here. See Fig. 9.2 for an illustration of the effects of the coordinates entered. Here the underlying bitmap is shown at the coordinates as entered in the Define Sample Size and Underlay Bitmap dialog shown.

- **Sample coordinate at upper right corner [μm] X/Y**
  These fields are automatically filled in following a change to the maximum sample position field, but can also be changed manually. The coordinates of the bitmap at the upper right corner can be entered here. See Fig. 9.2 for an illustration of the effects of the coordinates entered. Here the underlying bitmap is shown at the coordinates as entered in the Define Sample Size and Underlay Bitmap dialog shown.

Options

In the options dialog, which is shown in Fig. 9.3, the export parameters for the export and graphic representation of the point list, as well as for the ASCII export of the list itself, are given.

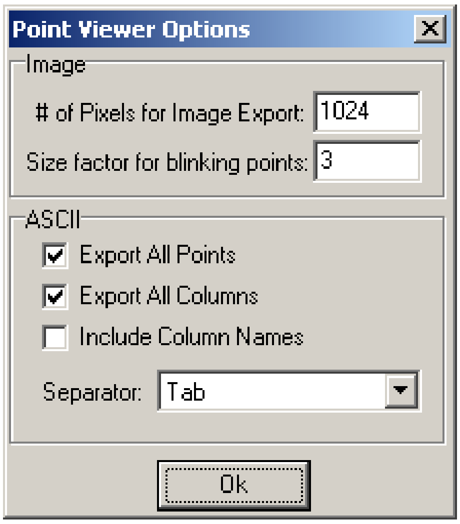

Fig. 9.3: The options dialog for the point viewer.

For the export of an image representing the points as shown in the sample area, the number of pixels in the larger dimension of the bitmap can be entered. The dimension of the smaller side of the exported image will be determined by the aspect ratio of the current view.

HINT	The actual number of pixels may vary due to an automatic crop function, which cuts off excess white borders.

The *Size factor for blinking points* is the factor by which the points are enlarged and then reduced again when blinking. The blinking in the sample area indicates that the points are selected.

For the export of the point list in ASCII format, the following options are available:

- **Export All Points**
  If this check box is selected, all points will be exported regardless of their *Usage* status (see Section 9.4). If it is unchecked, only points with the usage set to *Yes* or *Used* will be exported.

- **Export All Colmns**
  If this checkbox is selected all columns will be exported. Otherwise only those selected through the context menu (see Section 9.4) are included in the export.

- **Include Column Names**
  This selection allows the column names to be included with the exported ASCII file.

- **Separator**
  The following separators for the ASCII export are selectable:

  Space
  The columns are separated by one space.

  Tab
  The columns are separated by a tab.

  Semicolon
  The columns are separated by a semicolon.

Add Point

This speed button is only active if the point list is not imported from a KLARF file but is defined manually as a four column table. If active, it opens the edit point dialog as shown in Fig. 9.4.

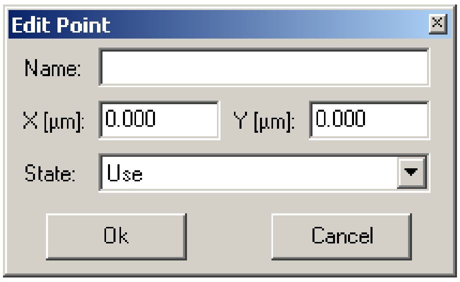

Fig. 9.4: The edit point dialog.

The name for the point, the X and Y coordinates in μm and the state can be selected here. The states are explained in Section 9.4.

Delete Point [Keyboard shortcut: DEL]

This button is only active if points are selected (highlighted in the point list). Pressing this speed button deletes the selected points.

Edit Point

This button is only active if a single point, which has been defined manually, is selected. Upon activating this speed button, the system opens the edit point dialog as shown in Fig. 9.4 and described with the *Add Point* speed button above.

Sort by order

This button sorts the points in the order that they to be are executed. The display order may be changed by, for example, displaying them sorted by their name, usage or coordinates.

HINT Upon defining the points, or upon opening or importing a point list, the order of the points is defined. Re-sorting the points by their name, coordinates or usage will only change the appearance of the points and NOT the order in which they are executed. This speed button displays the points again in the order of execution.

Move Selection Up [Keyboard shortcut: CTRL+ U]

This button causes the selected points to be moved up in the list. It is only active if the list is displayed in the way it is processed.

HINT This changes the order of execution.

Move Selection Down [Keyboard shortcut: CTRL+ D]

This button causes the selected points to be moved down in the list. It is only active if the list is displayed in the way it is processed.

HINT This changes the order of execution.

Select Single Point

If this button is activated, single points from the point list can be selected by clicking on them in the sample area. The selected point will blink in the sample area and will be highlighted in the point list. Pressing the CTRL key while selecting the points allows the selection of multiple points. Pressing the SHIFT key when clicking on a selected point causes this point to be deselected. This function will remain active until de-activated (though clicking onto the button again) or until a different mouse function (, or) is activated.

Select Multiple Points

If this button is selected, multiple points from the point list can be selected by drawing a rectangle around them in the sample area. The selected points will blink in the sample area and be highlighted in the point list. Pressing the CTRL key while selecting the points allows the selection of multiple regions. Pressing the SHIFT key when selecting an area causes the points within this area to be de-selected. This function will remain active until de-activated (by clicking onto the button again) or until a different mouse function (, or) is activated.

Immediately move to selected Point

This button allows the immediate movement of the sample to the selected point. This point will only be active if the sample positioning system is present. Once activated, the system will move the sample to the point selected by the mouse. The point can either be selected by clicking onto the graphic representation in the sample area or by selecting it from the point list. The speed set in Section 3.4.14 is used for this movement. Clicking onto a void area within the sample area has no effect. This function will remain active until de-activated (by clicking onto the button again) or until a different mouse function (, or) is activated.

Zoom in

If this button is selected an area for zooming-in can be selected from the sample area. This function will remain active until de-activated (by clicking onto the button again) or until a different mouse function (, or) is activated.

Zoom to fit all

Pressing this button causes the entire sample area to be displayed. This is the standard view when defining the underlay bitmap and the sample size as well as after loading new point lists.

Zoom to previous 

This button returns to the last zoomed view.

Zoom to next 

This button moves one step forward (if available) in the list of zoomed views.

9.2 Sample Area

The sample area can be seen at the left in Fig. 9.1. Here the bitmap underlay is shown as well as the points. Additionally, the traveling path of the microscope can be displayed through the context menu (see Section 9.4).

The visible parts in the sample area are:

Coordinate System

The coordinate system is scaled according to the sample size as defined by the *Define Sample Size and Underlay Bitmap* dialog (see Fig. 9.2).

Underlay Bitmap

The bitmap chosen through the *Define Sample Size and Underlay Bitmap* dialog (see Fig. 9.2) is displayed at the corresponding coordinates.

Points

The points displayed are either red if set to *Yes* or *Used* or blue if set to *No*. Selected points blink in the sample area.
Points defined outside the sample area are not displayed.

Traveling Path

The traveling path of the instrument is shown in green, connecting the points in the order they will be processed in. Only points set to *Yes* are connected.

HINT The traveling path can be optimized through the context menu (see Section 9.4).

Current Position

The current position of the instrument is indicated by green crosshairs.

9.3 Point List

The point list set up is similar to a spreadsheet, with each row representing a point. The number of columns may vary depending on the import filter used. However, manually defined point lists as well as point lists imported from .CSV files have only four columns:

Name | Use | X [μm] | Y [μm]

These columns are also the first four in other imported point lists. The columns displayed can be selected through the context menu (see Section 9.4). By clicking on the column headers, the list is sorted by these columns (i.e. by name or usage).

HINT This will not change the order in which the points are handled, but only their representation in the list. Use the *Move Selection Up* ( ) or *Move Selection Down* ( ) speed buttons to change the order in which the points are processed.

If points are selected, they will be marked along the entire row.

9.4 The Context Menu

The context menu, which can be seen in Fig. 9.5, can be opened by a right click within the point viewer window.

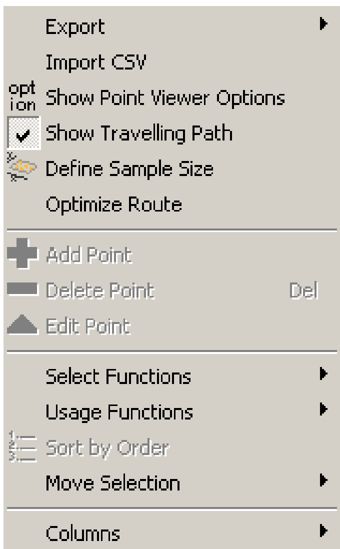

Fig. 9.5: The Point Viewer context menu.

The commands available through the context menu are:

Export

The export menu point allows the export of the sample area as a bitmap as well as the ASCII export of the point list. The exported bitmap will be copied to the Graphic Export window which is described in the WITec Project manual. The exported ASCII data will be copied to the clipboard, from which it can then be pasted into the desired document. The export functions use the settings set in the options dialog described in Section 9.1 on page 92.

Import CSV

Using this menu, comma separated value data (.CSV) can be imported. The data must be a three column CSV file with the first column containing the name of the point, the second the X coordinate in μm and the third the Y coordinate in μm. The format of the name has to be alphanumerical without spaces and special characters. The X and Y coordinates may have a + or - as a leading sign, a dot as the decimal separator and an optional 'e' or 'E' indicating an exponent followed by a signed integer. The strings may not have a thousands separator.

The usage state for all points imported is initially set to *Yes*.

Show point viewer options

This menu point opens the same dialog as the options speed button (

). The dialog is described in Section 9.1 on page 92.

Show Traveling Path

Using this menu entry, the display of the traveling path can be turned on and off.

Define Sample Size

This menu entry opens the *Define Sample Size and Underlay Bitmap* dialog described in Section 9.1 on page 90.

Optimize Route

This menu entry automatically optimizes the traveling route in order to minimize the travel length and thus the traveling time. A window will inform the user about the change in traveling distance due to the re-ordering of the points.

This procedure is not recommended while performing a measurement because it can require substantial processing power. If the point list contains more than 2000 points the software prompts the user for a confirmation of the task due to the considerable amount of time it might take.

Add Point

This menu point has the same functionality as the Add Point speed button (

) which is described in Section 9.1 on page 93.

Delete Point

This menu point has the same functionality as the Delete Point speed button ( ) which is described in Section 9.1 on page 94.

Edit Point

This menu point has the same functionality as the Edit Point speed button ( ) which is described in Section 9.1 on page 94.

Select Functions

This menu point allows the selection of all points as well as the inversion of the current selection.

Usage Function

The usage of the currently selected points can be edited here. The possible choices are:

- **Use**
  At this point the process script sequencer (see Section 3.5.15) is executed once the point list is carried out.
- **Do not use**
  The system will, upon execution of the raster, ignore this point and the system will not drive to it.
- **Used**
  The system automatically sets points with the label *Yes* to *Used* once the process script has been executed at this position.
- **Used -> Use**
  This function changes all points marked *Used* in the current selection to *Yes*. Points marked *No* in the current selection are not changed.

Sort by Order

This menu point has the same functionality as the Sort by Order speed button ( ) which is described in Section 9.1 on page 94.

Move Selection

This menu entry contains the two entries Move Selection Up and Move Selection Down, which are identical to the corresponding speed buttons (,) described in Section 9.1 on page94.

Columns

This menu entry contains all columns of the point list. Activating them in this menu entry will show them in the point list editor.

Chapter 10

Other Windows

All other windows visible, such as the Project Manager, Graph Tools, Image Tools, Cursor Manager and the Drop Action Window, are described in the WITec Project manual.

Chapter 11

Configurations

The WITec Control software is designed to control WITecs alpha300 / alpha500 / alpha700 microscopes. The capabilities of these microscopes include confocal microscopy, confocal Raman microscopy, AFM and SNOM techniques and any combination thereof. By loading a configuration, the alpha300 / alpha500 / alpha700 system is set up for a specific measuring mode (e.g. confocal microscope or AFM contact mode).

When loading a configuration, the following operations are performed:

- the parameters described in Chapter 3 are loaded from hard disk and/or set to predefined values.
- the layout of the parameters in the control window as well as the speed buttons are adjusted.
- the size, position, and whether a window is displayed or not are established.

Configurations can be selected from the main menu of the WITec Control software (Section 2.1.2). The name of the selected configuration is displayed in the status bar of the main menu (Section 2.3). Switching from e.g. high resolution AFM measurements to confocal Raman imaging requires only the selection of the proper configuration.

When switching from one configuration to another, the system should first be set to a safe state, where e.g. the AFM tip is not in contact with the sample anymore.

alpha300 / alpha500 / alpha700 systems are delivered with standard configurations. These configurations can be changed and saved. However, new names should be given to modified configurations. If a new configuration is required, it can be created in collaboration with the WITec support team. The standard configurations which apply to a specific alpha300 / alpha500 / alpha700 system are described in separate documents.

Bibliography

[1] U. Tietze und Ch. Schenk. Halbleiter-Schaltungstechnik. 11. Auflage. Springer Verlag, 1999.