

# **PRECISION TOOL COMMANDER**

## **USER MANUAL**



[www.smaract.com](http://www.smaract.com)





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*Document Version 18-02-12/4530 Software Version 2.1.13*

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# 1 GETTING STARTED

## 1.1 Introduction

*Precision Tool Commander (PTC)* is a graphical user interface (GUI) that supports you in controlling SmarAct MCS and SmarPod positioning systems.

### Intuitive Control

With *PTC* you can immediately start using SmarAct systems without the need for developing your own control software. Positioners can be moved with the PC mouse or by entering exact positions with the keyboard. See chapter 3 – "Using and Configuring the GUI".

### Automated Functions

*PTC* can record a sensor signal while moving positioners over a configurable area (see chapter 4 – "The Scan Function"). The recorded sensor data is plotted as a 2D or 3D diagram and can be exported to CSV and image files.

The *Auto Alignment* tool can be used for the automatic alignment of objects. Finding an optimal configuration for multiple variables can be difficult and time consuming. *Auto Alignment* can optimize of up to six variables which can be selected by the user (chapter 5 – "Automatic Alignment").

### Hardware Compatibility

Measuring hardware can be integrated by software plugins. See section 2.4 – "Plugin Devices" for more information. Plugins for new hardware can be developed on request<sup>1</sup>.

### Additional Information

Information about changes in new software releases can be found in the *PTC Software Changes.rtf* file, which is installed in the *PTC* documentation folder.

## 1.2 Software Installation

To install *PTC* start the installer program *PTC\_Installer\_<version>.exe*. The installer will ask for the SmarAct folder (default: C:\SmarAct\). The *PTC* software and documentation will be installed in the *PTC* folder in the SmarAct folder.

Measuring devices which are integrated via a *PTC* plugin may need additional software. For every plugin a *README...* text file with additional information can be found in the folder

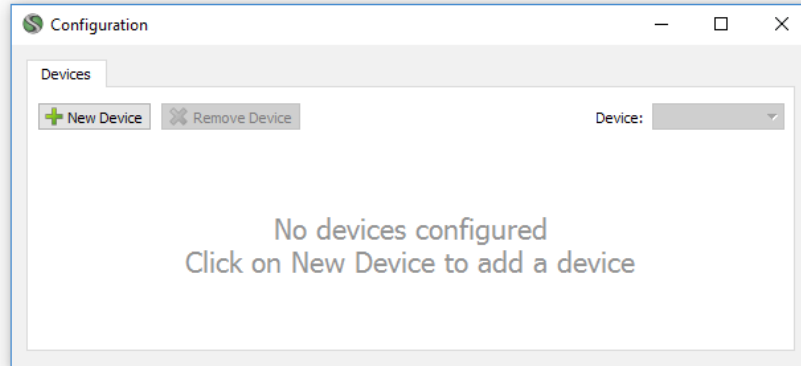
<SmarActFolder>\PTC\Programs\plugins\devices

To uninstall *PTC* run the program in *PTC\Uninstall*.

<sup>1</sup> Please contact *SmarAct* for more information.

## 2 ADDING AND CONFIGURING DEVICES

A *device* in the *PTC* is a representation of a measurement or control hardware. Every physical device that you want to control with *PTC* must be added in the *Configuration* window. To edit the *PTC* configuration, open the configuration window with the button *Configuration* in the main window toolbar. Here you can add, remove and configure devices:



The button *New Device* opens a menu with the device types supported by *PTC*. The device types that can be selected are

- devices directly supported by *PTC*, like MCS and SmarPods, and
- devices for which a plugin is installed in the *PTC* program installation folder.

Selecting a type in the menu adds a new device to the current configuration. Devices are removed with the *Remove Device* button.

The configuration editor for a device can be selected from the *Device* menu.

The devices and their settings can be saved under a configuration name. When multiple configurations have been saved, they can be reloaded with a mouse click, see 3.1.4 – "Saving and Loading Configurations". A configuration also contains the appearance and content of GUI control elements and the settings of the *Auto Alignment* and *Scan* window. When reloading a configuration, these are restored as well.

### 2.1 Device Locators

A *device locator* is an unambiguous address of a SmarAct device, which *PTC* uses to connect to the hardware. (This is not true for plugin devices, which use their own, plugin-specific addressing mechanisms). When configuring an MCS or a SmarPod, the device locator of the MCS controller must be selected from a list or entered manually.

For devices connected over USB the locator can be selected from a list which contains the device locators for all connected and active MCS controllers. USB device locators have the format:

*usb:<mcs-serialnumber>*

where *mcs-serialnumber* is the first part of the serial number which is printed on the housing of MCS devices with a USB interface.

For devices with an ethernet interface the network IP address and port can be entered manually in the locator field. The format for network device locators is

*network:<ip-address>:<port>*

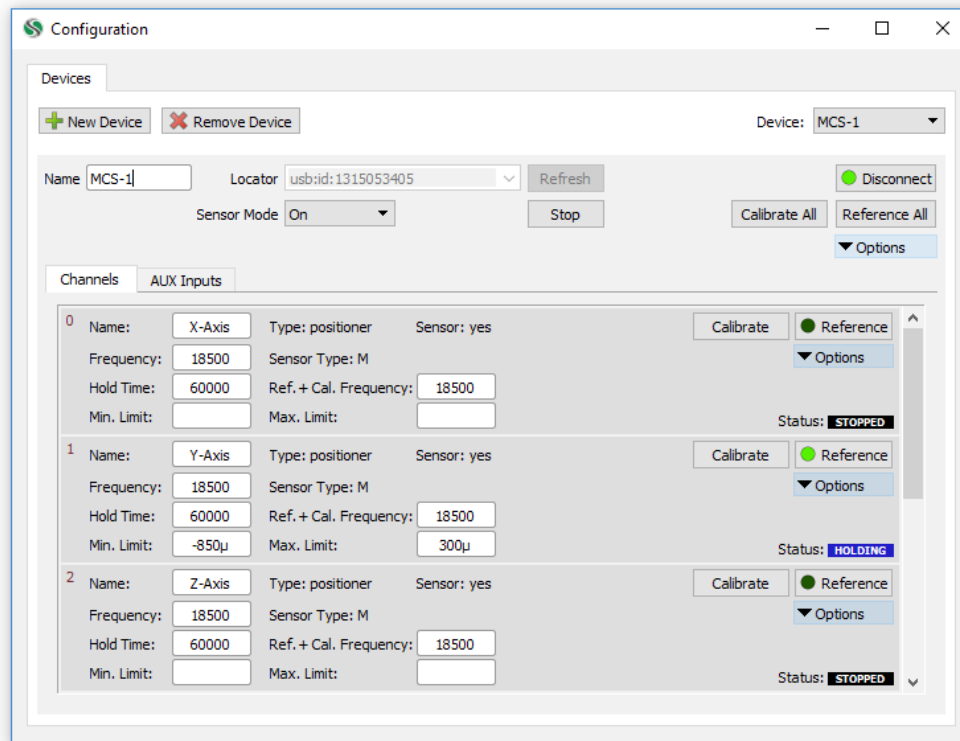
For example, *network:192.168.1.200:5000* is a valid network device locator where *192.168.1.200* is the IP address and *5000* is the port number of the device. Both must match the settings of the device hardware.

Some newer SmarAct controllers support automatic device discovery over the network. If such a device is present in your local network its device locator will appear in the list of locators and can be selected. For these devices it is possible to write the network device locator with the device serial number instead of the IP address, like this:

*network:sn:MCS2-00000123*

## 2.2 MCS Devices

An MCS (*Modular Control System*) controller has a number of *channels* depending on the MCS model. A channel can control one positioner. With MCS device editor global device parameters and individual parameters for every channel can be set:



Depending on the type of the channel and its configuration, the channel editors may show different options. To reference or calibrate a channel it must have a sensor and the *Sensor Mode* must be set to *On* or *Power-Save*.

If the channel is an end effector channel, only the name can be changed. End effectors cannot be used with the current version of PTC.

Some channel configuration parameters cannot be changed with *PTC* (e.g. the *Sensor Type*). To change these parameters other software must be used.

### MCS Device Parameters and Functions

<i>Name</i>	A user-definable device name.
<i>Locator</i>	The device locator of the MCS. The <i>Refresh</i> button updates the list of MCS devices in the <i>Locator</i> menu. Only MCS with a USB interface can be selected in the <i>Locator</i> menu. The locators for controllers with an ethernet interface must be entered manually. See section 2.1 "Device Locators" for information about device locators.
<i>Connect / Disconnect</i>	Connects (if disconnected) or disconnects (if connected) the device. The LED on the button indicates the connection status: <i>off</i> : the device is not connected, <i>green</i> : the device is connected, <i>red</i> : the device connection was interrupted.

<i>Sensor Mode</i>	The power mode for the position sensors: <i>On</i> : the sensors are continuously supplied with power. <i>Power-Save</i> : the sensors are powered for a short time every few hundred milliseconds. <i>Off</i> : the power supply for the sensors is disabled. To move a positioner closed-loop, the sensor must be either <i>On</i> or <i>Power-Save</i> .
<i>Stop</i>	Stops all positioners of this MCS.
<i>Calibrate All</i>	Calibrates all positioners with a sensor. ( <i>Sensor Mode</i> must not be <i>Off</i> )
<i>Reference All</i>	References all positioners with a sensor. ( <i>Sensor Mode</i> must not be <i>Off</i> )
<i>Options</i>	Opens a menu with options for referencing all positioners with the <i>Reference All</i> button in the device editor or with the <i>Reference</i> button in the main window: <i>Reference Channels Together</i> : all positioners are referenced simultaneously. <i>Reference Channels One-by-One</i> : the positioners are referenced one at a time.

### MCS Channel Parameters and Functions

<i>Name</i>	The name of the channel.
<i>Frequency</i>	The frequency of the channel used when moving closed-loop.
<i>Ref. and Cal. Frequency</i>	This frequency is used when referencing or calibrating the channel. Referencing and calibrating move the positioner with a fixed frequency. The MCS controller does not adjust the frequency to compensate slow movement. It may be necessary to find a good Ref. and Cal. frequency experimentally for the channel if referencing with the default value fails.
<i>Hold Time</i>	The time (in milliseconds) the channel will hold the target position after a closed-loop move has finished. If set to 60000, the channel will hold the position indefinitely.
<i>Status</i>	Shows the current MCS channel activity.
<i>Calibrate</i>	Calibrates the channel. A channel should be calibrated when a positioner with a sensor is connected for the first time to that channel. <i>Calibrate</i> is only selectable if the positioner has a sensor.
<i>Reference</i>	References the channel. When referencing has finished successfully, the controller knows the absolute physical position of the actuator. The LED on the button lights up if the channel is referenced. Like <i>Calibrate</i> , this button is only selectable if the positioner has a sensor.
<i>Options</i>	Options for channel referencing. The options available depend on the channel sensor type.
<i>Min.Limit/Max.Limit</i>	Minimum and maximum range limits of the channel. If the fields are empty, no range limits are active and the positioners can move until they are blocked by their physical end-stops. The values can be entered directly or by using the <i>Set Range Minimum</i> and <i>Set Range Maximum</i> functions from the MCS panel channels controls (see 3.3.2). To remove a range minimum or maximum, just clear the field.

#### 2.2.1 Copying Parameters to Other Channels

If a parameter should be set to the same value for all MCS channels, click on the background of a channel editor and select *Copy all settings to other channels* or on a parameter field to open a context menu and select *Copy to other channels* to copy only the selected parameter.



## 2.2.2 MCS AUX Inputs

AUX inputs are analog-to-digital converters (ADC) in SmarAct sensor modules. They can be used like any other data input, for example in the *Scan* or *Auto Alignment* functions.

To use AUX inputs, the MCS must have a recent firmware installed and the sensor modules must have connectors for the analog inputs. Please contact SmarAct for more information about sensor modules with additional analog inputs. AUX inputs may be shown in the MCS device setup even if no sensor modules with additional connectors are used. In this case, the AUX inputs cannot be used and should be ignored. For the specification of the analog inputs like the voltage range and the resolution of the ADC please refer to the documentation of your sensor modules.

Each AUX input can be configured under the *AUX Inputs* tab.

	Name	Scale Factor	Offset	Unit
0	Voltage	3.3	0	V
1	Force	-2100	200	N
2	Aux2	1	0	
3	Aux3	1	0	
4	Aux4	1	0	
5	Aux5	1	0	
6	Aux6	1	0	
7	Aux7	1	0	
8	Aux8	1	0	

### MCS AUX Input Parameters

<i>Name</i>	The name of the AUX input.
<i>Scale Factor</i>	A number which is multiplied with the raw AUX input value. The factor may be negative. Default scale factor is 1.
<i>Offset</i>	The offset value is added to the scaled input value. This parameter may also be negative. Default offset is 0.
<i>Unit</i>	A user-definable unit symbol. Unit symbols are displayed where the AUX inputs are selected, like the <i>Scan</i> or <i>Auto Alignment</i> window.

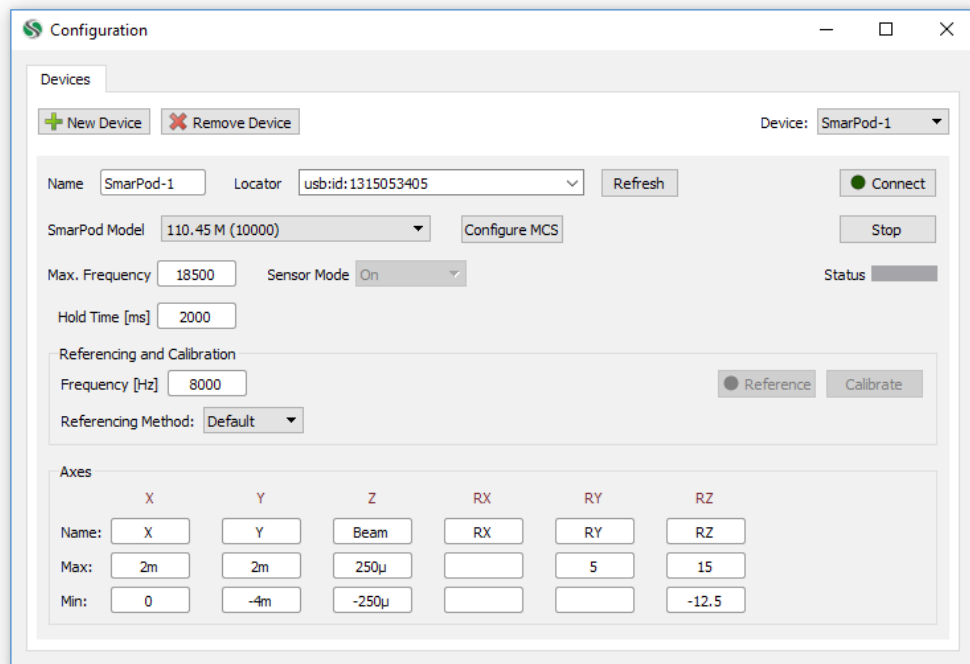
The raw input signals are scaled and shifted with the scale factor and offset. The input value is calculated as follows:

$$value = value_{RAW} * scalefactor + offset$$

where  $value_{RAW}$  is a number between 0 and 1.

## 2.3 SmarPod Devices

A *SmarPod* is a positioning system with six degrees of freedom. It can move in three directions and rotate around three axes. The center of rotations, the *pivot point*, can be set by the user.



It is important to select the correct SmarPod model. If you select a model different to your SmarPod, the SmarPod can behave unexpectedly. If you connect the SmarPod and the error message "wrong system configuration" is displayed, the selected model does not match the settings of the MCS controller. Read section 2.3.1 for more info.

### SmarPod Device Parameters and Functions

<i>Name</i>	A user-definable device name.
<i>Locator</i>	The system locator of the MCS. The <i>Refresh</i> button updates the list of MCS devices in the <i>Locator</i> menu. Only MCS with a USB interface can be selected in the <i>Locator</i> menu. The locator for MCS with an ethernet interface must be entered manually. See section 2.1 "Device Locators" for more information about device locators.
<i>Configure MCS</i>	See below.
<i>Connect / Disconnect</i>	Connects (if disconnected) or disconnects (if connected) the device. The LED on the button indicates the connection status: off: the device is not connected, green: the device is connected, red: the device connection was interrupted.
<i>Max. Frequency</i>	This parameter limits the frequency of the piezo actuators of the SmarPod (50 to 18500Hz). Set a lower value here if not all positioners move well at this frequency.
<i>Hold Time [ms]</i>	The time (in milliseconds) the SmarPod will hold the target position after a move has finished. If set to 60000, the position will be hold indefinitely.

<i>Status</i>	This field show the current SmarPod move status which can be <i>STOPPED</i> , <i>HOLDING</i> , <i>MOVING</i> , <i>CALIBRATING</i> and <i>REFERENCING</i> .	
<i>Sensor Mode</i>	<p>The power mode for the position sensors:</p> <p><i>On</i>: the sensors are continuously supplied with power.</p> <p><i>Power-Save</i>: the sensors are powered only for a short time every few hundred milliseconds. In this mode the sensors generate less heat, which can be important in vacuum environments.</p> <p><i>Off</i>: the power supply for the sensors is disabled.</p> <p>To move the SmarPod, the sensor must be set to <i>On</i> or <i>Power-Save</i>.</p>	
<i>Stop</i>	Stops the SmarPod.	
<b>Axes</b>		
<i>Name</i>	The axis name.	
<i>Min. and Max.</i>	<p>Minimum and maximum range limits of the axis. If the fields are empty, no range limits are active and the axis can move until it reaches the SmarPod physical range limit. The values can be entered directly or by using the <i>Set Range Minimum</i> and <i>Set Range Maximum</i> functions from the SmarPod panel axis controls (see 3.3.3).</p> <p>To remove a range minimum or maximum, just clear the field.</p>	
<b>Referencing and Calibration</b>		
<i>Frequency [Hz]</i>	<p>The frequency used when referencing or calibrating the SmarPod. When referencing, the SmarPod does not move speed-controlled but with a fixed frequency, which can be set here. If the SmarPod moves slowly or not at all during referencing, try it with a different frequency parameter.</p>	
<i>Reference</i>	<p>The button starts the SmarPod referencing (<i>Sensor Mode</i> must be <i>On</i> or <i>Power Save</i>). When a SmarPod has been referenced, the LED on the button lights up.</p>	
<i>Calibrate</i>	<p>The button starts a calibration of the SmarPod positioner sensors (<i>Sensor Mode</i> must be <i>On</i> or <i>Power Save</i>). See below.</p>	
<b>Referencing Method</b>		
<i>Default</i>	<p>The software selects the referencing method that is usually the best for the SmarPod model.</p>	
<i>Sequential</i>	<p>References all positioners one after the other. Available only for rotation-symmetric SmarPods.</p>	
<i>Z-Safe</i>	<p>Optimizes movements to prevent collisions in the Z direction and moves more than one positioner simultaneously. Available for some rotation-symmetric SmarPod models.</p>	
	<i>Z Direction</i>	<p>Specifies the direction in which the SmarPod searches for the positioners reference marks. If the direction is set to <i>Z-</i> the SmarPod stage moves down (<i>Z+</i>: up) until it either finds the reference marks or the positioners reach the physical end of their range. In the latter case the direction reverses and the positioner moves back until the reference marks are found.</p>

<i>XY-Safe</i>	Specifies a safe direction for X and Y. This method is only available for parallel SmarPods. <i>Parallel SmarPods without distance coded sensors:</i> If <i>X Direction</i> is set to X+, the SmarPod first moves in the positive X direction until the positioners have all reached the end of their movement ranges. Then it moves back to the reference marks. Likewise for <i>Y Direction</i> . <i>Parallel SmarPods with distance coded sensors:</i> The positioners move in the specified direction until two reference marks have been found. If a positioner starts between the last reference mark and an end-stop, it reverses the direction and move a short distance in the opposite direction.	
	<i>X Direction</i>	The safe X direction.
	<i>Y Direction</i>	The safe Y direction.

For all SmarPods with distance-coded sensors additional safe direction options "...and Reverse" are available. If selected, a positioner reverses the movement direction when the first of the two reference marks is found to search for the second mark in the opposite direction.

### 2.3.1 Configuring the MCS Controller of a SmarPod

It is usually not necessary to calibrate the positioners or to configure the MCS for the SmarPod model. This should only be done if

- a SmarPod is connected to a MCS for the first time
- the SmarPod or the MCS have been replaced or repaired
- a new firmware has been installed on the MCS controller.

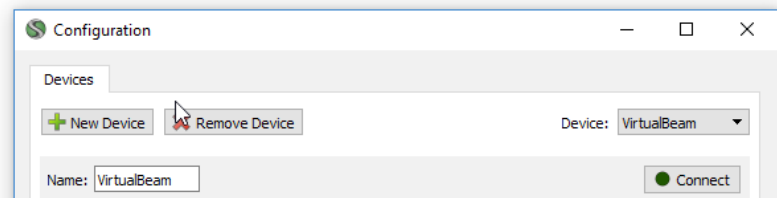
If the error message "wrong system configuration" is shown, the internal settings of the MCS do not match the selected SmarPod model. This may simply mean, that the wrong model has been selected or that the wrong MCS controller has been selected in the *Locator* field (check this first). If these settings are correct but you still get the above error, you can re-configure the MCS by clicking on *Configure MCS*. When the configuration has finished, the SmarPod should be calibrated.

## 2.4 Plugin Devices

PTCs hardware compatibility can be expanded by plugins. A *PTC* plugin typically supports one class of measurement hardware and enables *PTC* to read and process the measured data.

A plugin device can be added by selecting the device type from the *New Device* menu. If a plugin device type is not listed in the menu, even though the plugin is installed, it is not loadable. A plugin may require additional software (drivers) before it can be used. For each plugin a "README" document can be found in the plugin folder (<SmarActFolder>\PTC\Programs\plugins\devices).

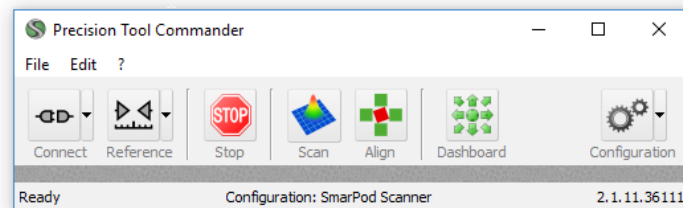
The configuration editor for a plugin device has a *Connect* button and a device name which can be edited when the device is disconnected:



The *README* files contain a description of additional parameters, which are different for every plugin and are not described here.

## 3 USING AND CONFIGURING THE GUI




### 3.1 The Main Window



The main window has a toolbar with buttons for important program functions which are described in this section. The status bar at the window bottom shows the current program status, the selected configuration and the program version. When resizing the window to make it larger, a *dashboard* sidebar is shown in the dark grey area. *Panels* can be added to the area. See 3.3 – "Setting Up Dashboards" for information about working with dashboards and panels.

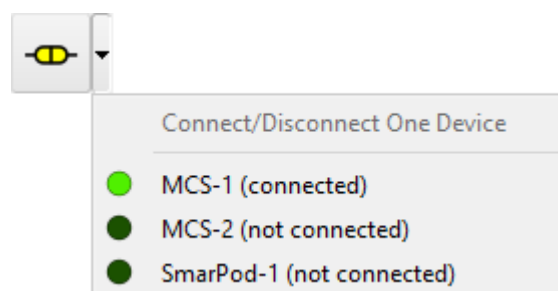
#### 3.1.1 Connecting and Disconnecting Devices

With the *Connect* button, devices can be connected and disconnected. The symbol on the button and its color indicate different connection states:

gray:		no device is connected
yellow:		some devices are connected, some are disconnected
green:		all devices are connected.

When clicking on the button with a gray or yellow symbol, all devices will be connected. If a device cannot be connected, an error message is displayed. When clicking on the button when it shows a green symbol, all devices are disconnected.




If more than one device is configured, the connect button has a side-button with a small arrow which opens a menu with all devices and their individual connection states:



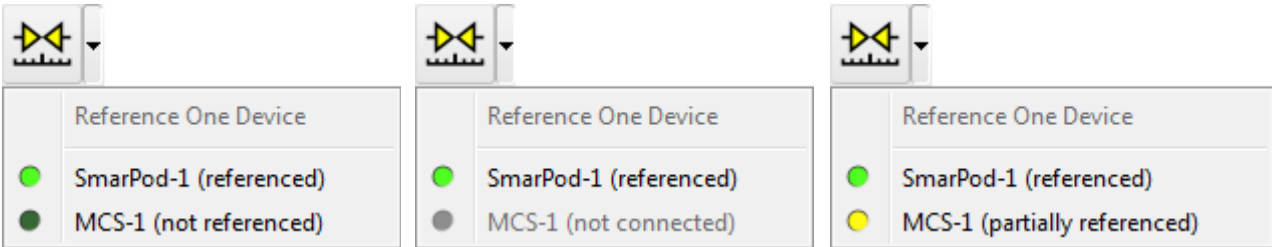
You can connect or disconnect a single device by selecting it from the menu.

### 3.1.2 Referencing Devices

Positioning systems with sensor-equipped positioners must be referenced. Without referencing, the controller cannot know the absolute physical position of an actor. Devices that support referencing can be referenced by clicking on the *Reference* button in the main menu toolbar. Like the *Connect* button, the *Reference* button can have different symbols and colors:

gray:		no referencable device is referenced.
yellow:		some devices are not referenced or only partially referenced. For example, if an MCS has more than one channel with a sensor and not all of them are referenced, the MCS is partially referenced.
green:		all referencable devices are referenced.

If more than one device supports referencing, the *Reference* button has a side-button which opens a list of all referencable devices:



A single device can be referenced by selecting it from the menu.

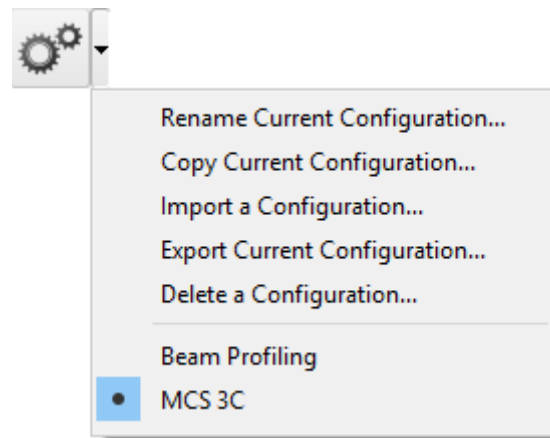
### 3.1.3 Stopping Activities

The *Stop* button in the main window toolbar stops all positioners and running functions, like scans or alignments:



### 3.1.4 Saving and Loading Configurations

The *Configuration* button opens the configuration window. See section 2 "Adding and Configuring Devices" for information about editing a configuration. Next to the *Configuration* button is a side-button that opens a menu with a list of configurations and functions to rename, save, import and delete configurations.



The name of the active configuration has mark. When another configuration is selected, the current configuration is saved and the selected configuration is loaded.

The active configuration can be renamed with *Rename Current Configuration....*

To copy the current configuration under a new name click on *Copy Current Configuration....*

*Import a Configuration...* opens a file dialog to select a configuration file for importing into PTC.

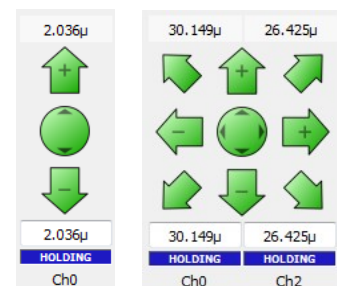
*Export Current Configuration...* opens a file dialog to a destination folder where the current configuration will be saved as a file.

*Delete Configuration...* opens a list of all configuration from which one can be selected for deletion. It is not possible to delete the active configuration.

## 3.2 GUI Control Elements

GUI control elements are available in different panel types, e.g. in MCS panels and SmarPod panels. A control element controls one or more actuators.

A vertical control element (left image) has an up button, a down button and a center button. Depending on the panel type and panel configuration, the control element can have a sensor data field at the top, a numerical entry field and a status field.



### Moving

To move the actuator that is assigned to the control element in forward direction, push the up button. With the center button you can move the actuator with changing speed and direction. Click and hold the mouse button and move the mouse to change the actuator speed between zero and the speed level set in the panel. When moving the mouse in the direction of the down button, the actuator will move backward.

When clicking only shortly on one of the arrow buttons, the actuator will move a defined step forward or backward. Setting the size of the step is panel type dependent. See the description of the panel types below.

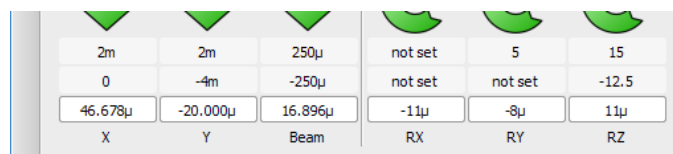


With the center button of a double control element (right image) both actuators can be moved simultaneously and their move speed and direction can be controlled by moving the mouse.

Actuator positions can be entered numerically in the fields below the control elements. See 3.4 – "Entering and Displaying Numbers" for information about how numbers can be entered in *PTC*. The format that is used to display numbers can be changed for each number field by clicking on the field with the right mouse button and selecting a format.

### Range Limits

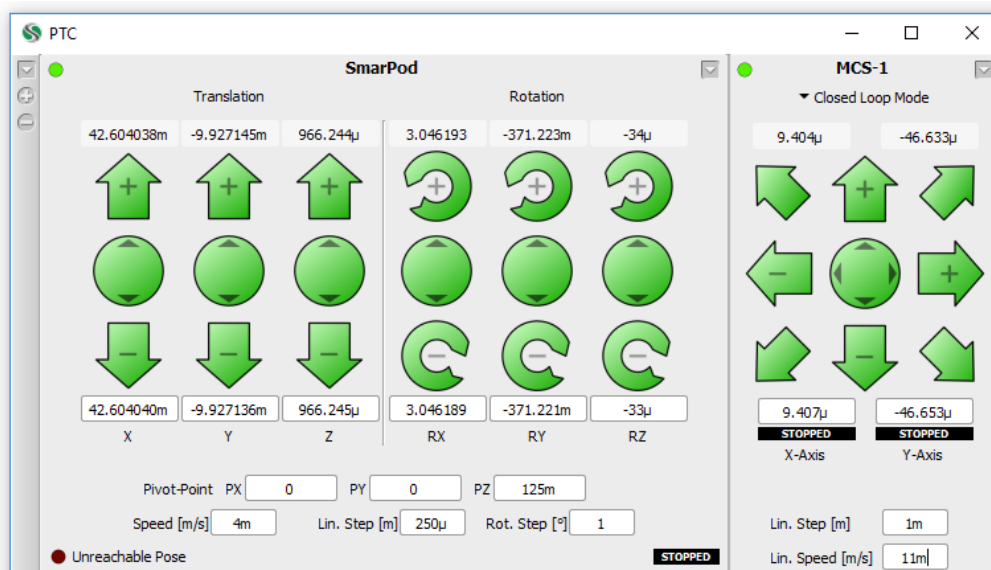
The range limits of the controlled actuator can be shown for each control element. This is enabled in the respective panel menu with the *Show Range Limits* function. If the display of range limits is enabled, the limit fields are shown above the numeric input fields:




The lower field shows the range minimum, the upper one the range maximum. If a range limit is not set, this is indicated by the text "not set" in the respective field.

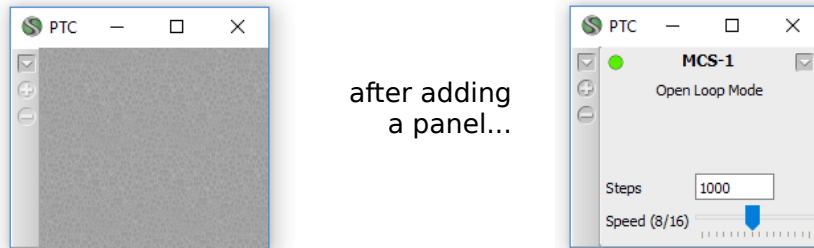
## 3.3 Setting Up Dashboards

A *dashboard* is a user-configurable window for manual device control. *Panels* can be added to a dashboard which provide certain functions depending on their type. The content, size and position of all dashboards are saved and reloaded with the configuration.



The dashboard in the above image has two *panels*, one for device "SmarPod" and one for device "MCS-1". The MCS panel controls the MCS channels "X-Axis" and "Y-Axis" in *closed-loop* mode.

A new dashboard is created with the *Dashboard* button in the main window. The size of the GUI elements in the dashboard can be changed with the plus and minus buttons in the sidebar. To add a new panel, click on the menu button at the top of the dashboard sidebar: .

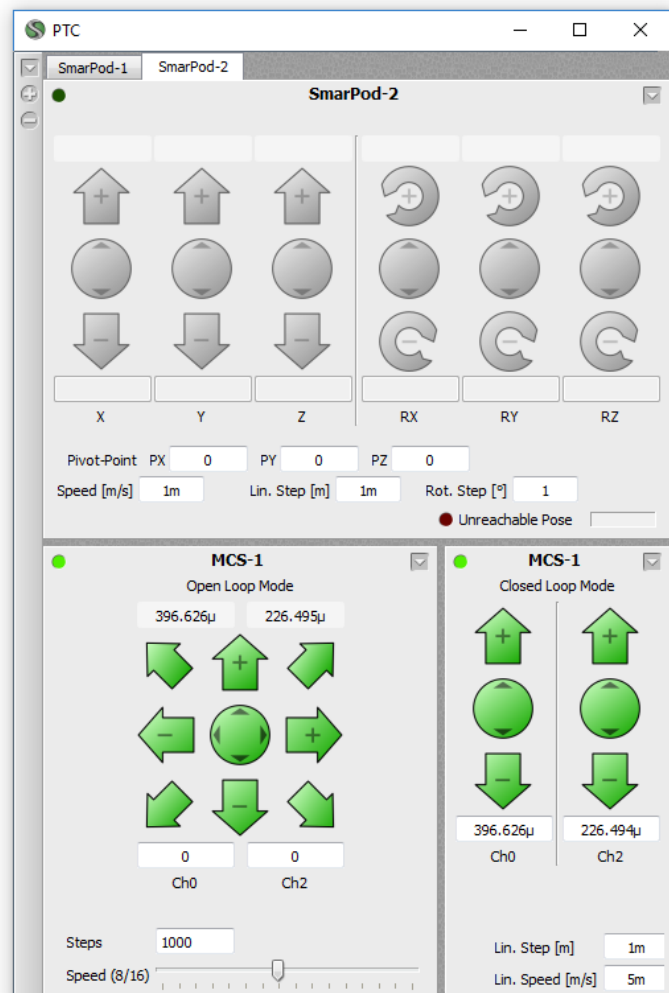


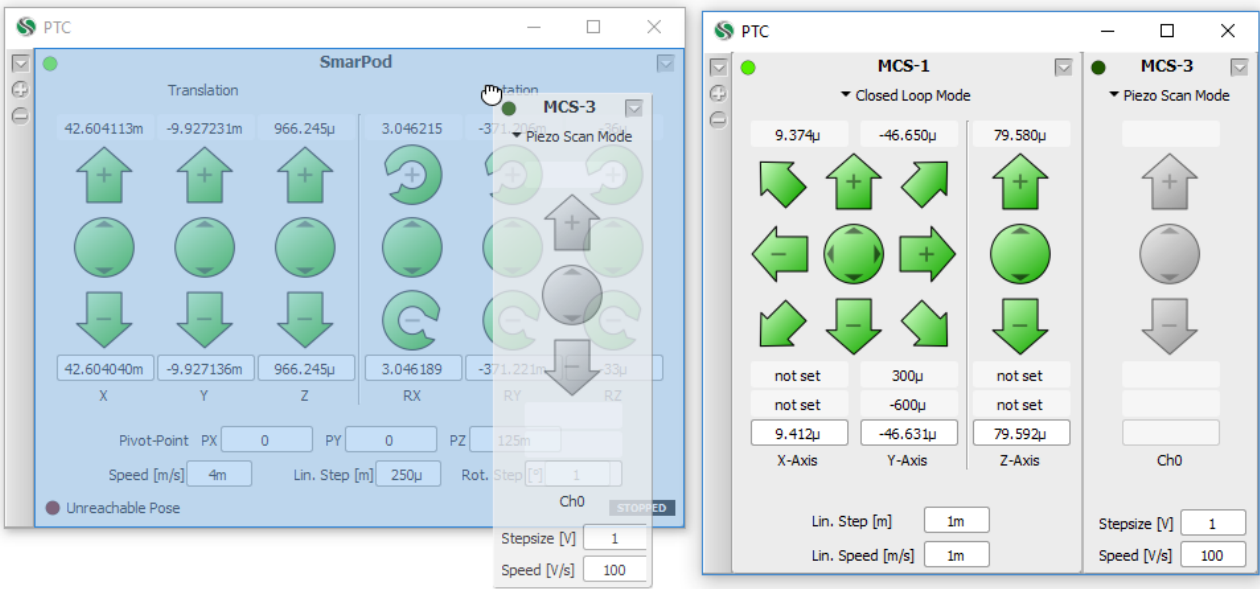
The appearance of a panel depends on the device type. Panel specific options can be changed in the *panel menu* in the upper right corner of the panel. The LED in the upper left corner of the panel shows the connection status of the device. Between the menu button and the connection status LED the device name is displayed.

### 3.3.1 Arranging Panels

Panels can be moved within a dashboard or between dashboards (including the main window) by clicking on the panel name and dragging it to a new location. Within a dashboard, panels can be arranged horizontally or vertically. When a panel is moved to a new place in a dashboard, a blue insertion mark is displayed where the panel would be inserted if the mouse button is released. In some cases different panel placements are possible at the same location. When the panel is hold for some seconds at a certain position, the insertion mark changes its size, which indicates different dashboard layouts.

In addition to side by side placement, panels can be stacked so that only one of the stacked panels is visible. The names of the stacked panels are shown in tabs above the panel stack. To make a stack of two panels, drag one panel above the other which will be highlighted. When mouse button is released the dragged panel will hide the other panel. To drag a panel out of the stack, click on its tab and move it. To move the whole stack of panels click on the name of the visible panel and drag it to a different place.





### 3.3.2 MCS Panels

An MCS panel has control elements for the channels of one MCS. A newly added MCS panel contains no control elements. For each channel of the MCS a control element can be added from the *Add Control* sub-menu the panel menu. If a channel is configured for a rotary positioner, the control element for that channel has rotating arrows. Controls for linear positioners have straight arrows.

You can select a control element with vertical or horizontal orientation or a 9-button control element that controls two MCS channels.

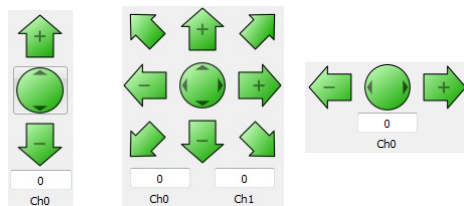
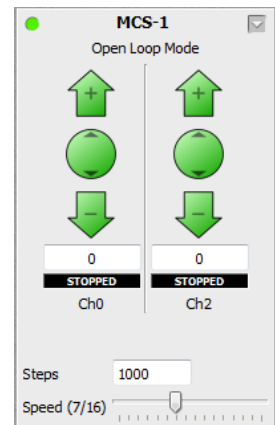
#### MCS Panel Control Mode

MCS panels can operate in different control modes:

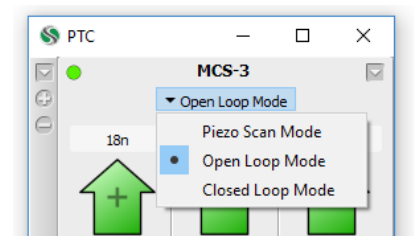
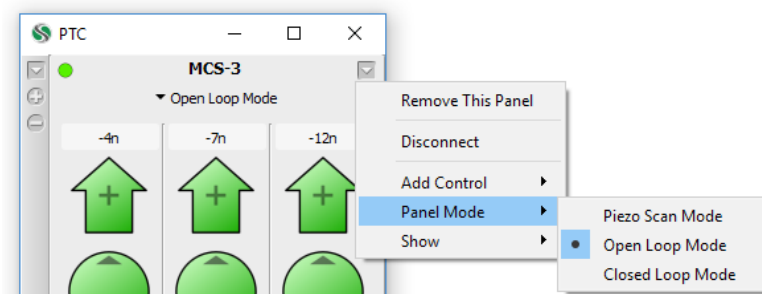
*Open Loop Mode:* In this mode, the positioners are moved open loop. They do not need to be equipped with a position sensor to be movable in this mode. The stepsize used when clicking on an arrow can be set in the *Steps* field.

*Closed Loop Mode:* Positioners are moved closed loop. Control elements for channels without sensors are disabled. The stepsize can be set for linear and rotary actuators separately in the *Lin. Step* and *Rot. Step* fields.

*Piezo Scan Mode:* This mode allows to set the voltage level of the positioners piezo actuator. The voltage changes the deflection of the piezo actuator which moves the positioner very smoothly. The stepsize can be set in the *Stepsize* field.

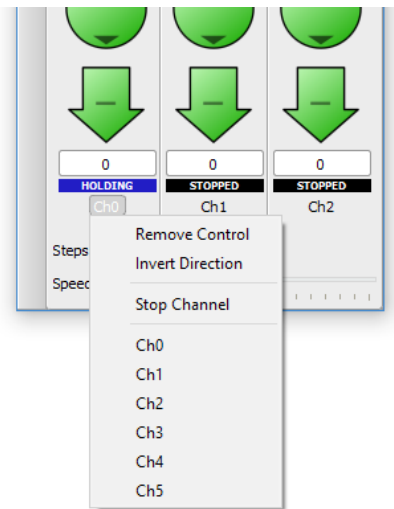


The mode can be changed in the panel menu under *Panel Mode* or in the menu below the panel name:



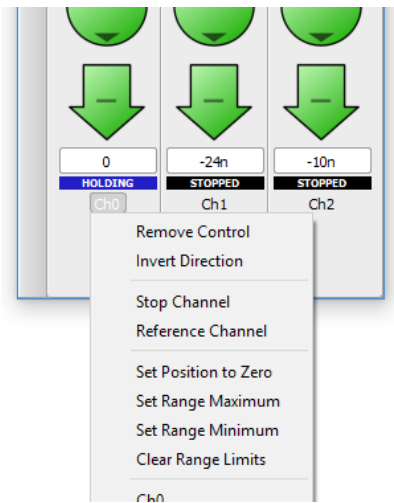
#### Functions For One Channel

The added control element is assigned to a currently unused channel. To assign it to a different channel, click on its name and select a channel from the *Channel Menu*:



- To remove a control element from the panel select *Remove Control* from the channel menu.
- The moving direction for each channel can be changed by selecting *Invert Direction* from the same menu. If the direction is inverted the + and – symbols in the arrows are switched.
- The positioner can be stopped with the *Stop Channel* function.

If the panel control mode is *Closed Loop* (see below) and the channel is equipped with a position sensor, additional functions can be selected from the channel menu:



- The channel can be referenced with *Reference Channel*.
- With *Set Position to Zero* the current position is set to zero.
- *Set Range Maximum* and *Set Range Minimum* change the range maximum and minimum limit to the current position of the channel.
- *Clear Range Limits* removes the range minimum and maximum limits.

### Functions For All Channels in the Panel

In the *Show* sub-menu of the panel menu additional channel information can be shown or hidden:

*Sensor Data*: If selected, sensor data is displayed for channels with a position sensor.

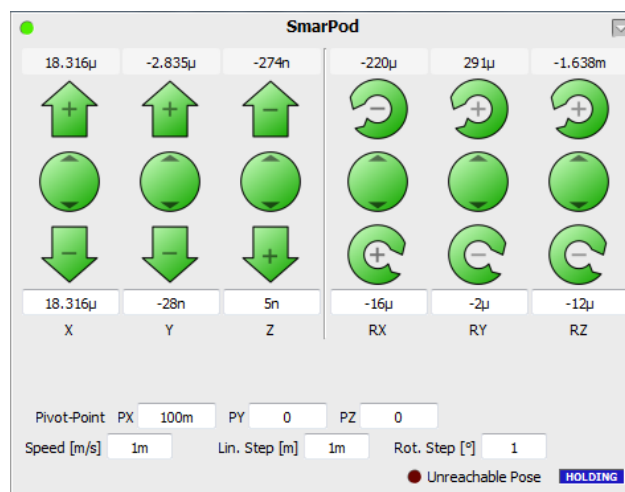
*Channel Status*: The current status of a channel is displayed below the control.

*Range Limits*: The range limits are shown above the numeric input field.

The positioner speed can be set in the panel configuration area below the controls. If *Closed Loop Mode* is selected, speed values in m/s or °/s can be entered. In *Open Loop Mode*, a speed level between 1 to 16 can be set. In *Piezo Scan Mode*, the speed is in V/s.

### 3.3.3 SmarPod Panels

A SmarPod panel has one control element for every SmarPod axis.



The stepsize used when clicking once on an arrow button can be set in the field *Lin. Step* for axes X, Y and Z and *Rot. Step* for RX, RY and RZ.

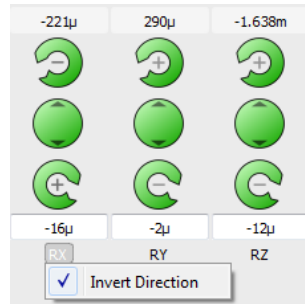
The pivot point coordinates can be entered in the fields *PX* to *PZ*. The speed of the SmarPod is set in m/s.

The status field in the lower right corner of the panel shows the current move status of the SmarPod: *STOPPED*, *MOVING*, *HOLDING*, *REFERENCING* or *CALIBRATING*.

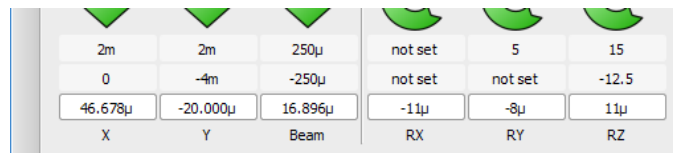
When a pose is entered, that is not reachable for the SmarPod, the red LED *Unreachable Pose* lights up.

In the *Show* sub-menu of the panel menu, sensor data fields can be enabled or disabled.

The direction of a control element can be inverted by selecting *Invert Direction* from the control menu that opens when clicking on the name:



The range limits (see 3.5) for each axis can be shown above the numeric input field by enabling them in the panel menu: *Show > Range Limits*:



### 3.4 Entering and Displaying Numbers

To simplify entering very large or very small numbers, most numeric input fields accept numbers written in different formats. Values can be entered

- in *decimal notation*: 0.0000012
- in *scientific notation*: 1.2e-6
- in *SI-prefix notation*: 1.2u

All of the numbers represent the same value. The following symbols can be entered as SI-prefixes:

*T* (tera...), *G* (giga...), *M* (mega...), *k* (kilo...), *m* (milli...), *u* (mikro...), *n* (nano), *p* (pico...).

The symbol for *micro...* can be entered as the letter *u* which is automatically changed to the greek  $\mu$ .

Once a number is entered and the keyboard focus is moved to another field, for example by hitting the tabulator key, the value is automatically re-formatted with the number format that has been selected for the number field. Most number fields in *PTC* can be configured to show a certain format. Click with the right mouse button on the field and select a format.

Please remember, that numbers in SI notation do not contain the unit, only the SI prefix! For example, the field value "2m" does not denote *two meters*, but *two milli...*, i.e. 0.002.

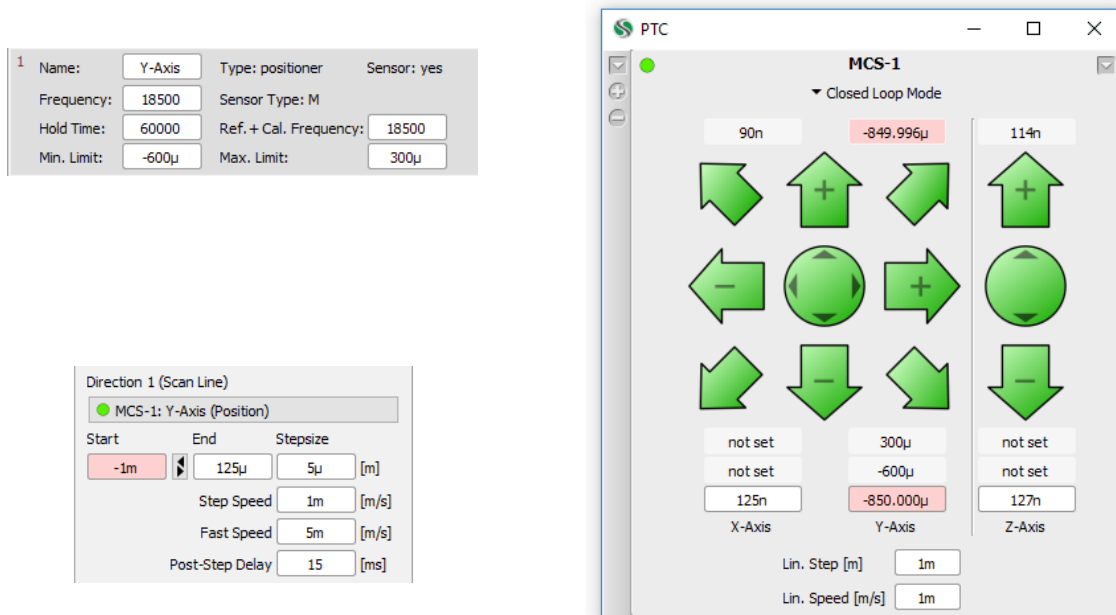
### 3.5 Limiting Movement Ranges

MCS and SmarPod devices allow to set limits for the movement range of each positioner or axis. The range limits can be set in the device configuration or with the controls in different panels, see 3.2.

If an MCS positioner or a SmarPod axis has a limited range, it is not possible to move the positioner/axis beyond the limits. When moving a positioner with a control, the movement will stop at

the range limit.

It is possible that the position is outside the specified range when the range parameters are changed. In this case, number fields in the GUI that contain out-of-range values will indicate this with a red background:



In the image above, the range limits of the MCS-1 device channel "Y-Axis" were set to -600μm and 300μm while the positioner was at -850μm. The sensor input field and the numeric input field of the channel control element as well as the *Start* field in the scan window show a red background, because they are not within range.

Range limits have no effect when referencing or calibrating a positioning device.

If positioners are not holding their positions actively, they can drift over the range limits.

For MCS devices, range limits are effective only for positioners with sensors and in closed-loop mode. This means that if a range limit is set for a channel, one can move the positioners out of range in open-loop or piezo-scan mode.

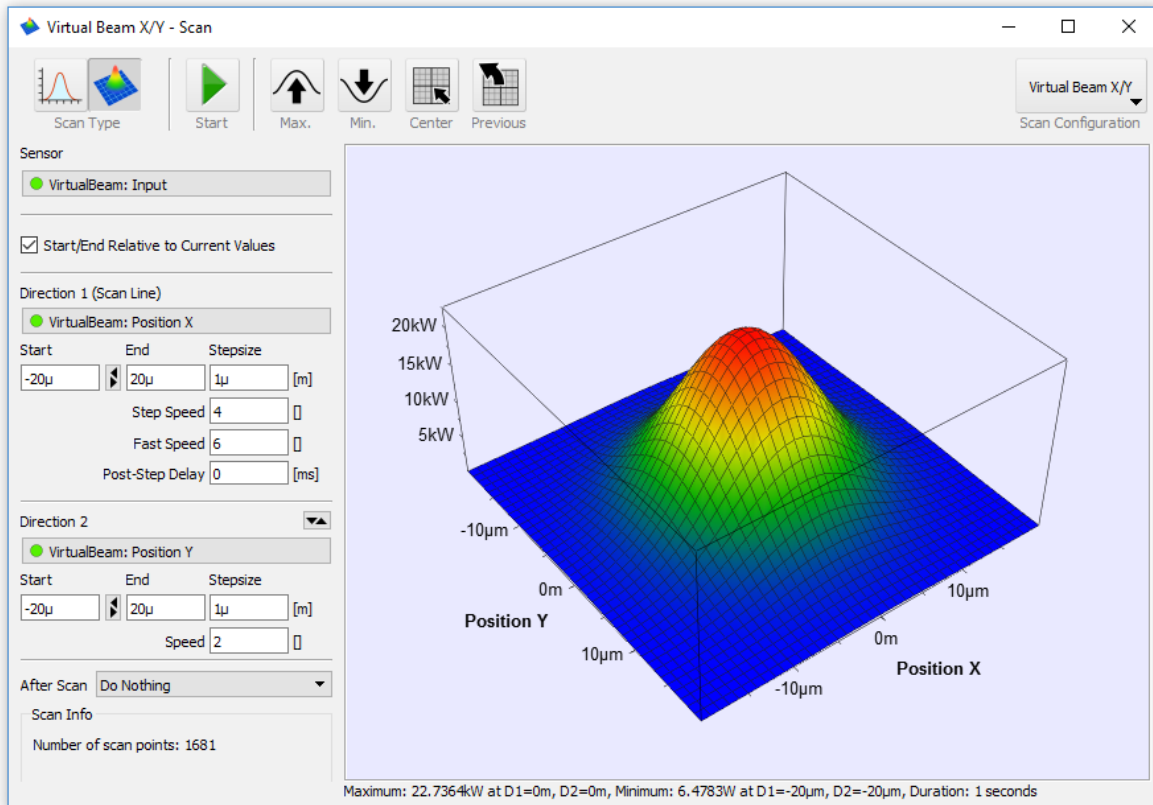


## 3.6 Global Program Settings

In the *Settings* menu the option *Auto Raise Windows* can be checked or unchecked. Check this to move all *PTC* windows to the front when you click on any window. If it is not checked, only the window that was clicked on will be brought to the front.

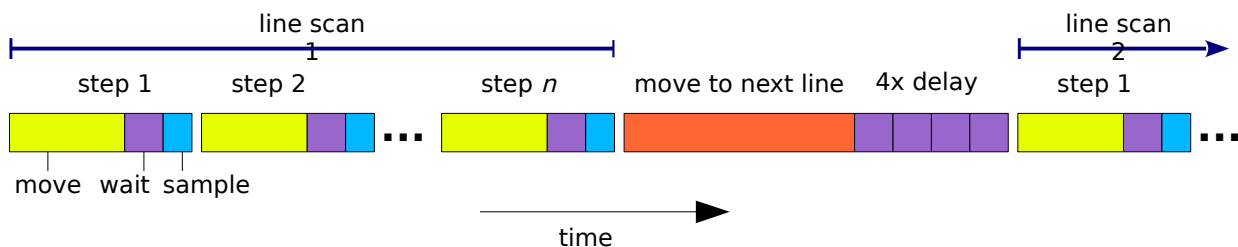
## 4 THE SCAN FUNCTION

With the *Scan* function a sensor signal can be recorded while moving one or two positioners over a defined range.



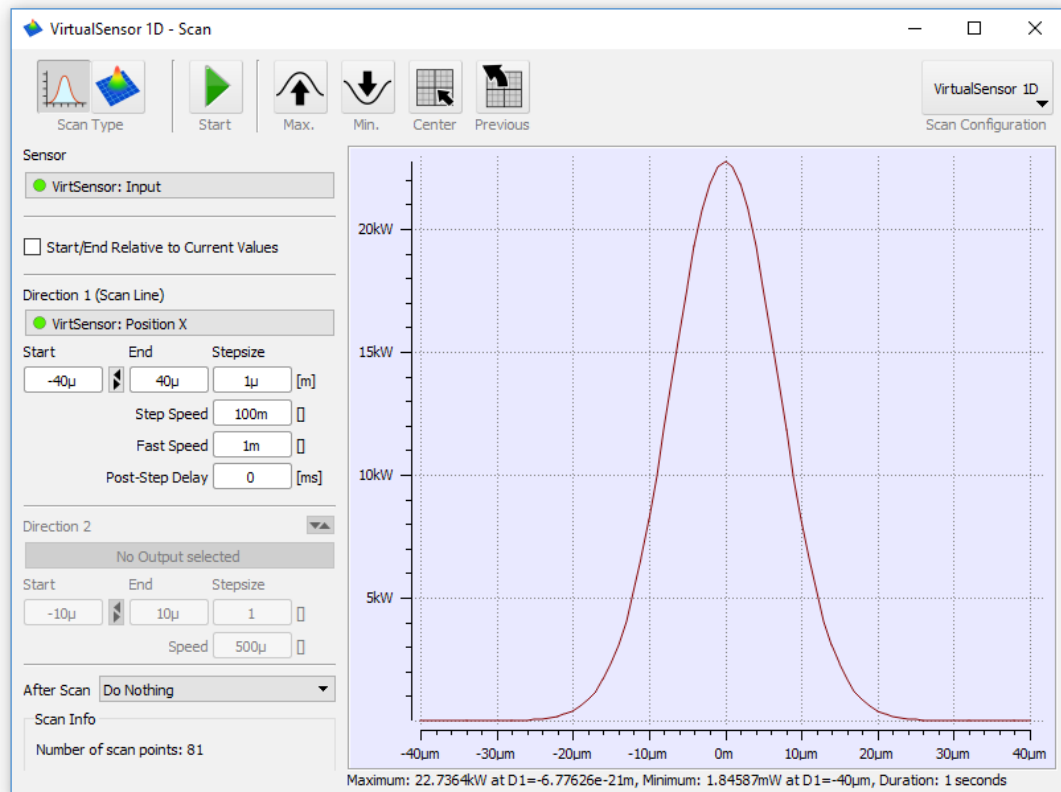
One or two positioners can be selected for scanning a line or an area. *Direction 1* specifies the scan line, the optional *Direction 2* the scan row. For both directions start and end position and the step size can be set. During the scan the sensor input is recorded and plotted in the scan window.

The following figure illustrates the scan algorithm:



A line scan is sub-divided into  $n$  steps of size *Stepsize*. Each step has three phases: move, wait and sample. In the move phase, the direction 1 positioner is moved with *Step Speed* one step forward. When the target position is reached, the algorithm waits *Post-Step Delay* milliseconds before reading the sensor input. If the scan type is 2D the direction 1 positioner is moved with *Fast Speed* back to the line start position while the direction 2 positioner is moved with *Speed* one step further. The scan algorithm waits 4x the *Post-Step Delay* time before starting the next line scan.

1D scans are displayed as a X/Y plot and can be zoomed and moved with the mouse:



- To move the plot click anywhere in the plot and move the mouse.
- To zoom to an area click on the plot while holding the control key and move the mouse to define the area.
- Zoom by using the mouse wheel.  
Hold the shift key to zoom vertically and the control key to zoom horizontally only.
- Use the "Reset zoom" function in the context menu of the 1D plot show the whole plot data.

2D scans are displayed as a three-dimensional plot that can be rotated and zoomed with the mouse:

- To rotate the plot click on it with the left mouse button and move the mouse.
- To zoom in and out move the mouse-wheel when the mouse is over the plot.
- To move the plot hold the control key and the left mouse button and move the mouse.
- Disable or enable the mesh in the context menu.

Scanning an area can help finding a good starting point for a following alignment.

## 4.1 Configuring a Scan

A scan is configured with the fields on the left side of the scan window:

Scan Parameters	
<i>Scan Type</i>	Selects the 1D or a 2D scan mode.
<i>Sensor</i>	The selected sensor.
<i>Start/End Relative to Current Values</i>	If this checkbox is set, the <i>Start</i> and <i>End</i> values are added to the current values of the selected directions. If it is not set, <i>Start</i> and <i>End</i> are absolute values.
<i>Direction 1</i>	The selected output for scanning a line.
<i>Start, End</i>	The start and end positions of the scan range for direction 1.
<i>Stepsize</i>	Position increment for one step.
<i>Step Speed</i>	The speed used when moving a step.
<i>Fast Speed</i>	The speed used when moving to the start position of a scan line (also used when returning to the start of the next scan line in 2D scan mode).
<i>Post-Step Delay</i>	Time (in milliseconds) to wait between a step and reading the sensor value. If a step causes vibrations, the delay can be increased to let the vibration fade out before reading the sensor value.
<i>Direction 2</i>	The output for changing the scan row.
<i>Start, End</i>	The start and end positions for direction 2.
<i>Speed</i>	The speed used when moving the output selected under <i>Direction 2</i> .
<i>After Scan</i>	Select action that is executed after the scan has successfully completed: <i>Do Nothing</i> : the outputs stop at the last scan position. <i>Go to Scan Maximum</i> : set outputs to the position where the signal maximum was found. <i>Go to Scan Minimum</i> : set outputs to the position where the signal minimum was found. <i>Go to Scan Center</i> : set outputs to the scan center. <i>Go to Original Pose</i> : set outputs to the values before the scan.

The "End" position may be smaller than "Start" to scan in negative direction. "Stepsize" must always be positive.

The box "Scan Info" displays the number of scan positions and the expected overall scan time. When a scan parameter is changed "Scan Info" is updated. If you set scan parameters that are invalid, for example a step size that is greater than the distance from start to end, "Scan Info" shows an error.

### 4.1.1 Saving and Restoring Scan Configurations

Scan configurations can be selected, copied, deleted and renamed by clicking on the *Scan Configuration* menu button.

## 4.2 Starting the Scan

To start the scan push the *Start* button in the toolbar of the scan



window:

A scan can be interrupted at any time by pushing the button again or the "Stop" button in the main window. When the scan has finished, the results are shown under the plot area. Immediately after the scan has successfully completed, the action selected in "After Scan" is executed.

### 4.3 Moving to Positions

After a scan the outputs are both at their *End* positions. With the move buttons in the toolbar, you can move set the outputs to different positions:



- *Max.* move to the position of the scanned signal maximum
- *Min.* move to the position of the scanned signal minimum
- *Center* move to the center of the scan area
- *Previous* move to the position before the scan was started.

### 4.4 Exporting Scan Data

Scan data can be exported as image files or data files in CSV (*comma-separated values*) format.

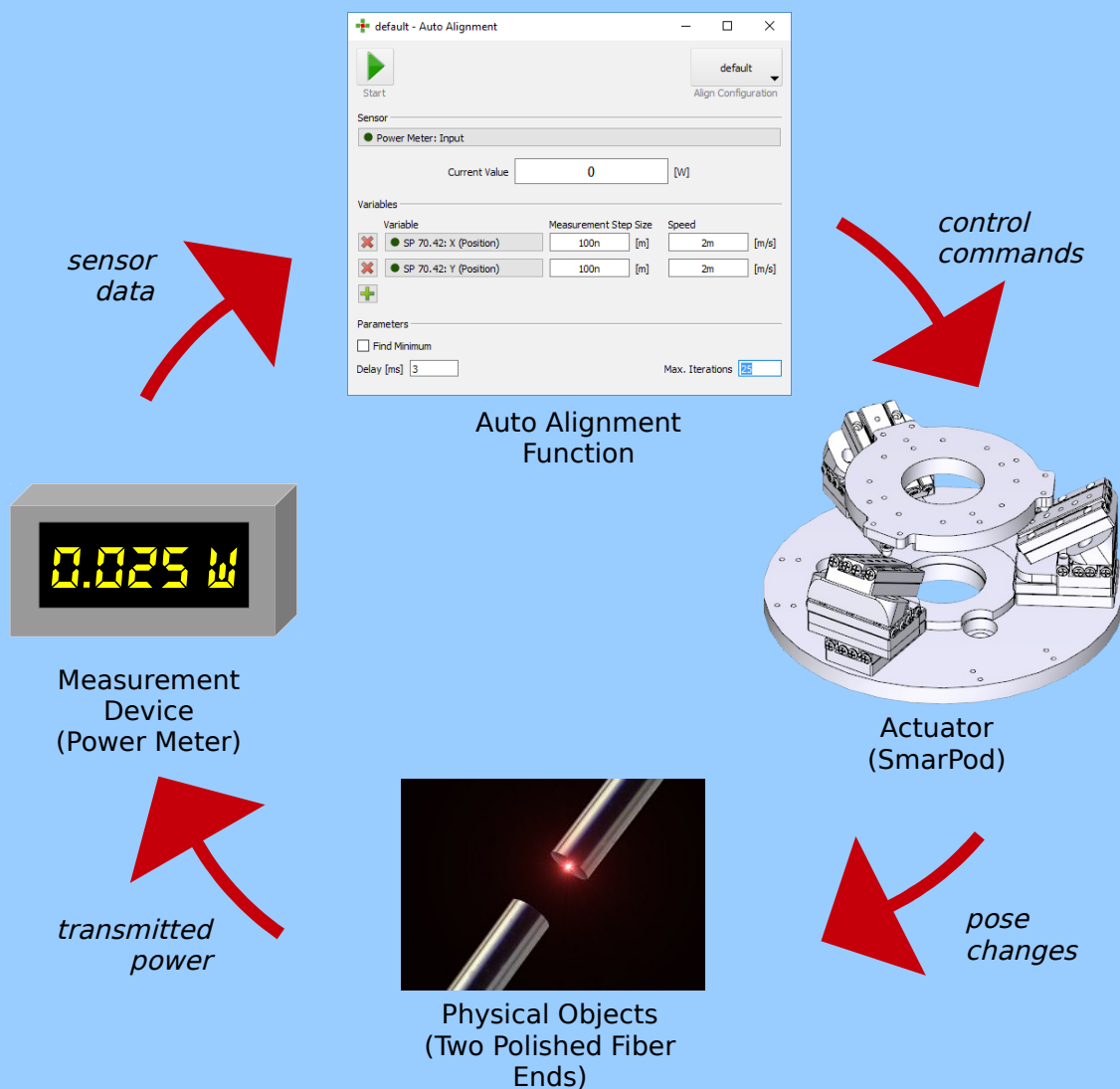
To export the data click with the right mouse button on the plot area and select the function "Export as Data-File..." from the menu. Select the destination folder and a file name in the following window. See chapter 7 "Data File Format" for the CSV file format.

To export the data plot as an image file, select the function "Export as Graphics File..." from the menu. In the following file selection window select the destination folder, file name and the file format.

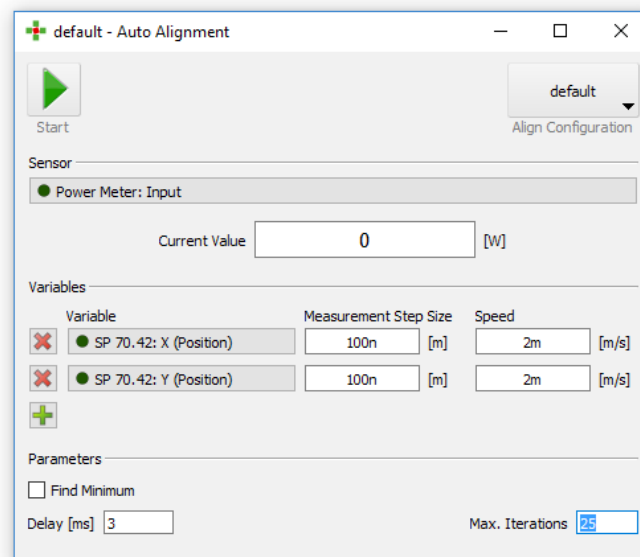
## 5 AUTOMATIC ALIGNMENT

*Auto Alignment* is a powerful tool for aligning objects automatically. *PTC* can optimize up to six variables (positions, angles, voltages) simultaneously. The alignment optimizer uses an iterative gradient-based method ("hill climbing") to search for an optimal configuration of the selected variables. A sensor measures the quality of the alignment. The variables are updated incrementally so that in every step the sensor signal increases until the maximum is reached.

**Example:** Two optical fibers must be aligned to maximize the transmission of light. One fiber end emits light and is attached to a SmarPod, which can change the fibers position and orientation. The other fiber end is fixed and connected to a power meter. *Auto Alignment* uses the power signal for calculating an update for the optimization variables, i.e. the translation and rotation of the SmarPod. By repeating this, the fiber alignment improves incrementally until the coupling efficiency is optimal.



## 5.1 Configuring Auto Alignment



The button *Sensor* opens a menu with sensor inputs. Select the sensor that measures the alignment quality. The value of the sensor is displayed in *Current Value*.

Under *Optimization Variables* select device outputs to be used as variables for optimizing. With the green *plus* button a new variable can be added. The red *X* buttons remove a variable. In the column *Variable* a menu can be opened to select a device output.

*Measurement Step Size*: the size of the step that the *Auto Alignment* function will add to the current value of the variable to measure the gradient of the sensor signal, see 5.2.

*Speed*: the speed that is used when moving the positioner.

If *Find Minimum* is checked, the optimizer searches for the signal minimum instead of the maximum.

The *Delay* value is the time (in milliseconds) the optimizer waits before reading the sensor signal after it has changed the value of a variable. It can be necessary to increase the delay if sensor signal takes time to stabilize after a variable change. For example, a moving positioner can generate vibrations. To avoid that the vibrations are measured and confuse the optimizer, the delay should be set to that the vibrations have time to die out.

In field *Max. Iterations* the maximum number of iterations of the optimization can be set.

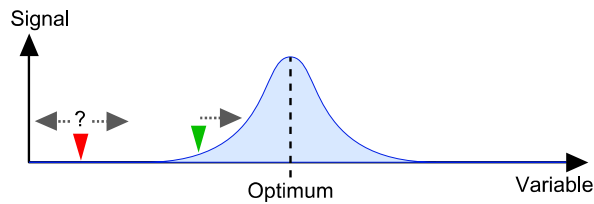
### 5.1.1 Saving and Restoring Auto Alignment Configurations

Alignment configurations can be selected, copied, deleted and renamed by clicking on the *Align Configuration* menu button. Any number of configurations can be saved.

## 5.2 Starting the Alignment

Finding a good starting point for the alignment process is important. The optimization can only succeed, if the variables are sufficiently close to an optimum. If the sensor does not detect a signal (or

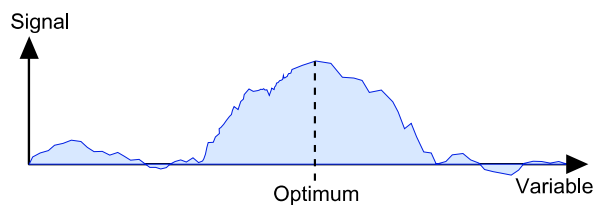
only noise), the optimizer cannot calculate variable increments and the alignment will not improve:



The image shows the signal distribution over a variable. Starting at the left (red) triangle gives the optimizer not enough information to calculate an update for the variable. If the optimization begins at the right (green) triangle, the optimizer can use the signal gradient to update the variable toward the signal maximum.

You can use the Scan function of *PTC* to visualize the sensor signal (see 4 – "The Scan Function"). The Scan function can be used to detect the sensor signal and to set a reasonable starting point. *Auto Alignment* can then be used to fine-tune the variables.

Sensor signals are never as perfect as in the diagram above. In reality, a signal may have local minimums and maximums, which the optimizer must ignore to find the actual optimum, and it may be noisy:

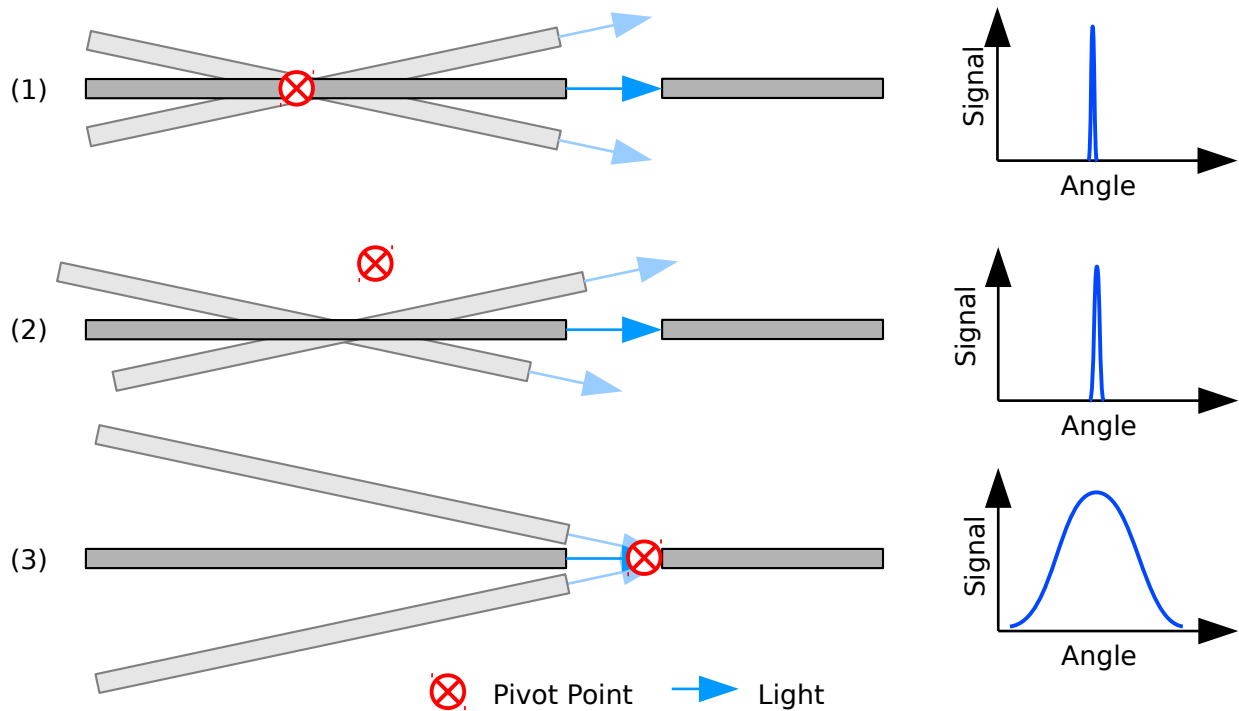


Noise should be reduced if possible. Also, the *Measurement Step Size* should be sufficiently large, so that the noise level is small compared to the signal gradient.

### 5.3 Influence of Pivot Points

For alignments that include optimizing the rotation of a SmarPod, setting the SmarPod pivot point right can be important. The following picture illustrates how a poorly set pivot point can influence alignments. Here, the gray rectangles are glass fibers and the blue line is a beam of light that must be transmitted from the left into the right fiber.





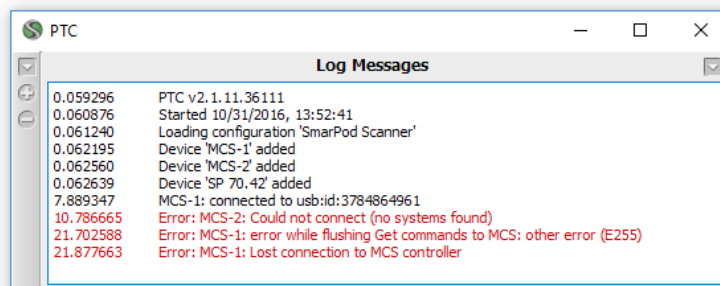
If the pivot point is not placed near the end of the right fiber (cases (1) and (2)), even small rotation angles of the left fiber misalign the beam and the coupling efficiency decreases rapidly. To keep the light focused on the right fiber end, the fiber would have to be translated vertically to compensate for the misalignment. This is a greater challenge for the alignment optimizer and can produce non-optimal results or need much longer.

## 6 THE LOG MESSAGES PANEL

When using *PTC* the program or hardware devices may behave unexpected. The *Log Messages* panel can help you solving problems. It can be opened from the ? menu in the main window or from any dashboard menu. The log messages can be dragged to any dashboard like other panels, see 3.3.1 – "Arranging Panels" for details.

The message panel collects events that are logged when working with *PTC*. Every event is displayed in one or more lines of text and has a time-stamp that shows the time of its occurrence. Normal (non-error) events are black. Errors are printed in red.

The content of the log window can be cleared, selected and copied to the clipboard.



## 7 DATA FILE FORMAT

In this chapter the format of exported data files is explained. A data file for which the export of data info and coordinates have been enabled looks like this:

```
Title,Scan of X and Z
Time,2013.03.22,10:34:30
Direction1,SmarPod:X,0.001065,0.001070,1e-006
Direction2,SmarPod:Z,-1.0,1.0,0.5
Actuator,SmarPod:X,1.61130382185052e-009
Actuator,SmarPod:Y,-0.00268288221408172
Actuator,SmarPod:Z,5.65979152253026e-010
Actuator,SmarPod:RX,-0.0807449645409213
Actuator,SmarPod:RY,-1.15104816580124
Actuator,SmarPod:RZ,-1.73095687872549
Actuator,SmarPod:Pivot X,0
Actuator,SmarPod:Pivot Y,0
Actuator,SmarPod:Pivot Z,0
Option,Coordinates,1
DataBegin
,-1.0,-0.5,0.0,0.5,1.0
0.001065,5.37e-011,6.52e-011,6.14e-011,6.52e-011,5.75e-011
0.001066,5.37e-011,5.37e-011,5.75e-011,6.14e-011,6.14e-011
0.001067,5.75e-011,5.75e-011,4.99e-011,4.99e-011,5.75e-011
0.001068,5.37e-011,5.75e-011,5.75e-011,5.37e-011,5.75e-011
0.001069,4.60e-011,5.37e-011,6.90e-011,5.75e-011,5.75e-011
0.001070,6.52e-011,5.75e-011,6.13e-011,6.13e-011,5.75e-011
DataEnd
```

When opened in a spreadsheet program, the file would look like this:

Title	Scan of X and Z				
Time	03/22/13	10:34:30 AM			
Direction:1	SmarPod:X	0.001065	0.00107	1.00E-006	
Direction:2	SmarPod:Z	-1.0	1.0	0.5	
Actuator	SmarPod:X	0.0010703293			
Actuator	SmarPod:Y	-0.0026828699			
Actuator	SmarPod:Z	-0.0005083403			
Actuator	SmarPod:RX	-0.0807448526			
Actuator	SmarPod:RY	-1.1510190936			
Actuator	SmarPod:RZ	-1.7308416195			
Actuator	SmarPod:Pivot X	0			
Actuator	SmarPod:Pivot Y	0			
Actuator	SmarPod:Pivot Z	0			
Option	Coordinates	1			
DataBegin					
	-1.0	-0.5	0.0	0.5	1.0
0.001065	5.37E-011	6.52E-011	6.14E-011	6.52E-011	5.75E-011
0.001066	5.37E-011	5.37E-011	5.75E-011	6.14E-011	6.14E-011
0.001067	5.75E-011	5.75E-011	4.99E-011	4.99E-011	5.75E-011
0.001068	5.37E-011	5.75E-011	5.75E-011	5.37E-011	5.75E-011
0.001069	4.60E-011	5.37E-011	6.90E-011	5.75E-011	5.75E-011
0.001070	6.52E-011	5.75E-011	6.14E-011	6.14E-011	5.75E-011
DataEnd					

Info-Section: TagsInfo-Section: ValuesCoordinatesData

The red and orange sections contain information about the data. Each information line contains a tag (red) followed by zero or more values (orange). The blue area contains data and coordinates.

This file format can be easily handled by spreadsheet software or specialized programs.

### Tags and Their Meaning

<i>Title</i>	The title of the data.
<i>Time</i>	The first value is the date, the second value the time of starting the data recording.
<i>Direction 1 and Direction 2</i>	The first value is the name of the actuator. The following values are scan start, end and step size.
<i>Actuator</i>	These lines contain the last actuator positions before the start of data sampling. The first value is the actuator name, the second one the actuator position.
<i>Option, Coordinates</i>	If the value is 1 the coordinates have been exported.
<i>DataBegin and DataEnd</i>	Markers that enclose the data section.