



Hand Control Unit

HCU-3DM, USB

User Manual

version 4.0

Table of Contents

1	Manufacturer Declarations.....	3
1.1	Declaration of Conformity.....	3
1.2	Warnings and Safety Instructions.....	4
2	Introduction.....	5
3	System Setup.....	6
3.1	Connectors.....	6
3.2	Connecting Cables.....	6
4	Operation Controls.....	8
4.1	Movement Control Mode.....	8
4.2	Menu Mode.....	11
5	Installing the Software.....	17
5.1	Installing the Drivers.....	17
5.2	Installing the Graphical User Interface.....	19
6	Graphical Control Program.....	20
6.1	Coarse Control.....	20
6.2	Step Control.....	21
6.3	Closed Loop.....	21
7	LabVIEW® Support.....	22
7.1	LabVIEW® Driver.....	22
7.2	System Requirements.....	22
7.3	LabVIEW® Examples.....	22
8	Technical Data.....	25
8.1	Power Supply.....	25
8.2	Connectors at the HCU-3D Controller.....	25
8.3	Operating Conditions.....	26
9	Positioner - Handling Instructions.....	27
9.1	Handling.....	27
9.2	Mounting.....	27
9.3	Environment.....	29
9.4	Electrical Connection.....	29
9.5	Maintenance.....	30
9.6	Frequently asked Questions.....	31

1 Manufacturer Declarations

1.1 Declaration of Conformity

Declaration of Conformity

according to ISO/ IEC Guide 22 and EN 45014

Manufacturer: SmarAct GmbH
Manufacturer's Address: Flötenstraße 70
26125 Oldenburg, Germany



The manufacturer hereby declares that the product

Product name: HCU-3D
Model Numbers: HCU-3D, HCU-3DM
Product Options: all

complies – if installed in a compatible chassis from SmarAct – with the following European directives:

73/23/EEC Low-voltage Directive
89/336/EEC EMC Directive

The applied standards certifying the conformity are listed below:

Electromagnetic Emission: EN61000-6-3, EN55011
Electromagnetic Immunity: EN61000-6-1
Safety (Low Voltage Directive): EN61010-1

June 30, 2009
Oldenburg, Germany

A handwritten signature in black ink, appearing to read 'Axel Kortschack', written over a horizontal line.

Axel Kortschack
Managing Director

1.2 Warnings and Safety Instructions

Please note the following warnings and safety instructions carefully when using the product.

1.2.1 Danger - Hazardous Voltage

The HCU-3D controller described in this manual is capable of generating high output currents at high voltages. They may cause serious or even lethal injury if used improperly.

- Never touch any part that might be connected to an output with a high voltage.
- Do not connect products from other manufacturers to the output connectors.

Output connectors with dangerous signals are labelled with the following symbol:



1.2.2 Caution - Installation Instructions

The HCU-3D controller must be installed horizontally with 3cm air circulation area behind it. Insufficient air flow can cause overheating, which can result in a limited functionality of the controller.

1.2.3 Caution - Connecting Instructions

The system is NOT hot-pluggable. Always make sure to power down the device before connecting or disconnecting any plugs! The only exception to this is the USB cable. It may be safely removed or attached during operation. Note though that when removing the USB cable, all positioners will be stopped immediately as a safety precaution.

2 Introduction

This document is a user manual for the SmarAct HCU-3D (Hand Control Unit). The HCU-3D is designed to drive piezo based stepping actuators from SmarAct GmbH.

The HCU-3D controller provides the following features:

- **Driver:** With the HCU-3D described in this manual you can control up to three positioners.
- **Sensor Feedback:** The positioners may be equipped with integrated sensors to perform closed-loop positioning control.
- **Operation Controls:** The HCU-3D offers easy and ready-to-go control by the joystick and control knobs - without the need of complex installation procedures.
- **USB Interface:** The HCU-3D may also be controlled by software running on a PC. Please refer to the *USB Software Interface Documentation* for more information on the provided command set.

Please note that this manual has been provided for information only and that the products described are subject to change without notice.

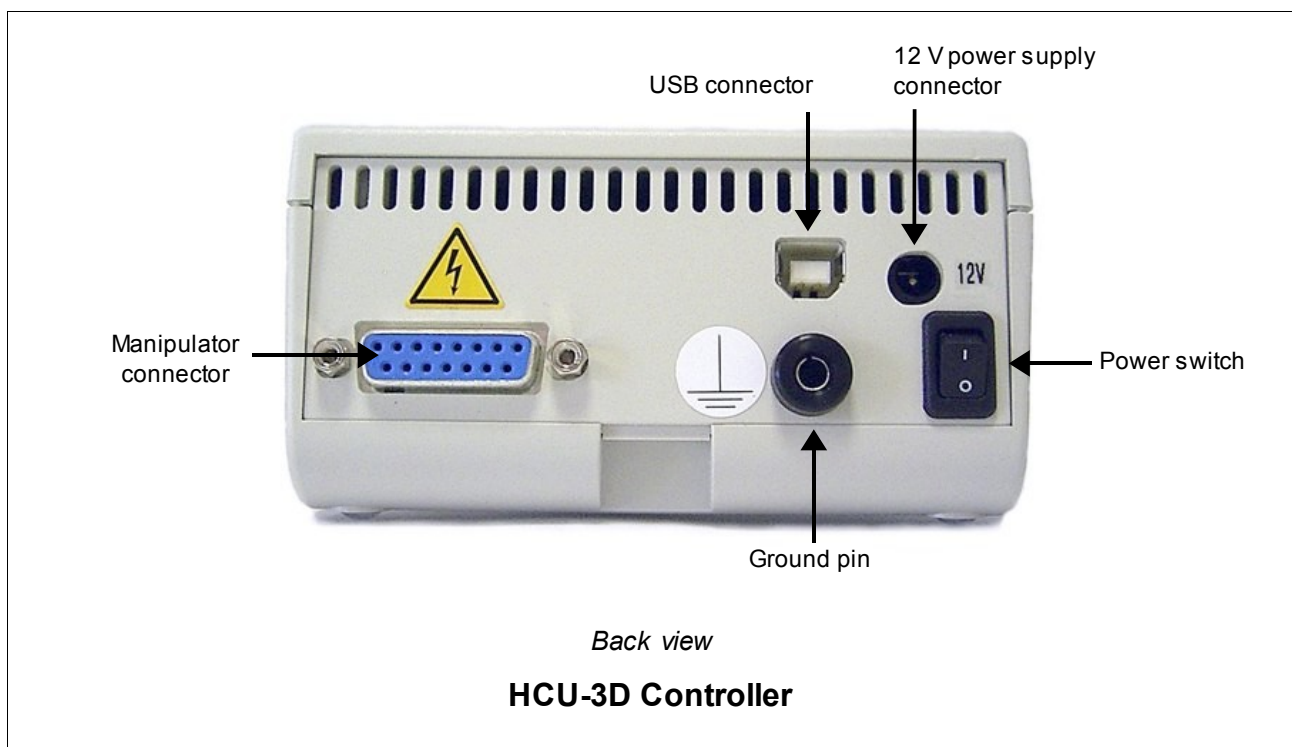
3 System Setup

3.1 Connectors

The HCU-3D is a table-top control device

- that drives the positioners
- that processes the sensor data from the integrated position sensors
- that performs closed-loop position control
- that processes commands from the operation controls
- that processes commands from a PC (proprietary software).

The figure below shows the connectors of the HCU-3D.



3.2 Connecting Cables

Please follow the following instructions for connecting all cables to the HCU-3D controller:

1. Make sure that the **power switch** is in the “**off**” position (0).
2. Connect the **manipulator** to the D-SUB 15 pin female connector of the **HCU-3D controller**.
3. If the cable from the manipulator is delivered with a vacuum feedthrough, **install the feedthrough** at a flange of the vacuum chamber and connect the matching connectors to both sides of the feedthrough.
4. Connect the **power supply**, which is delivered with the controller, to the power supply connector of the **HCU-3D controller**.

5. Connect the **PC**, on which the software will be installed, USB connector of the **HCU-3D controller**. Please use the enclosed USB cable.
6. If desired, connect the **ground potential of the mechanical system setup** to the ground pin of the **MCS controller**. This is highly recommended for applications in scanning electron microscopes where the ground potential of the system setup should be equivalent to the ground potential of the controllers.
7. Power up the controller by switching the **power switch** to the "**on**" position (1).

4 Operation Controls

This section describes how to use the HCU-3D to drive to the positioners and to configure the device.



There are three main modes of operation.

- The *Movement Control Mode* is the default and is active after power-up. It controls the movement of the positioners.
- In *Parameter Control Mode* the movement parameters for each channel may be adjusted.
- The *Menu Mode* is used to configure the device.

The modes are described in more detail below.

4.1 Movement Control Mode

In normal operation the joystick and the knobs are used to control positioners. Each knob is used to control one positioner. The joystick and the control knobs may be freely mapped to certain positioners in the *Menu Mode* (see below). Turning a knob or moving a joystick will perform a movement. The type of the movement depends on the control mode that is currently configured for the channel. Each channel may be configured with its own control mode independently (see *Menu Mode* below). The direction of the movement depends on the direction you turned the knob or moved the joystick and also on the invert configuration of the joystick or channel (see *Menu Mode* below).

There are three different movement control modes: a simple control mode, an advanced control mode and a closed-loop (CL) control mode. Which one is active may be selected in the *Menu Mode* (see below).

Each control mode has its own parameters. Generally, the parameters of a control mode for a channel may be changed by pressing the corresponding knob. This brings up an arrow indicating the parameter change state. See the following sections for a detailed description of the control modes and their parameter settings.

4.1.1 Simple Control Mode

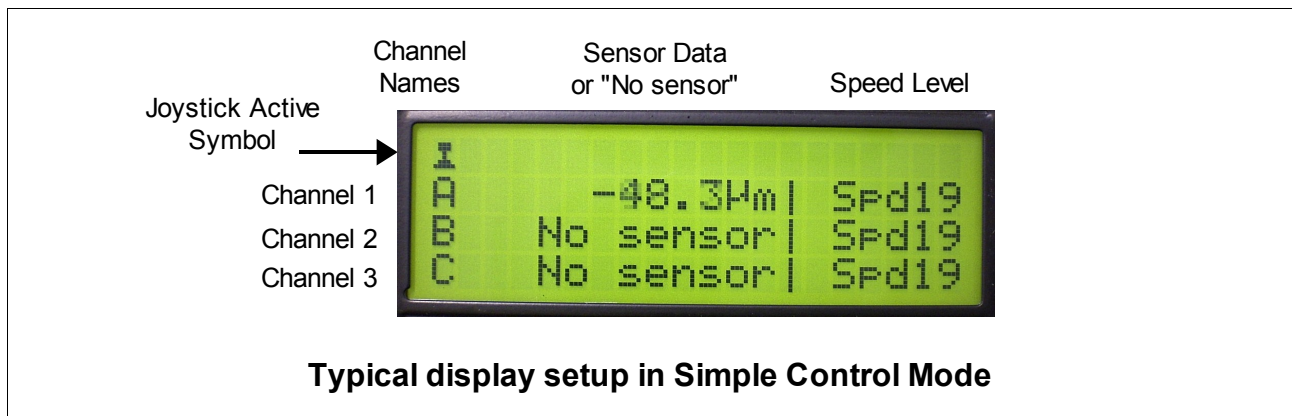
In this mode a positioner is moved according to its current *Speed Level*. The speed level is a generic number ranging from 1 (slowest) to 19 (fastest) and the positioner will perform stepping movements.

When turning a knob the positioner will perform bursts of steps.

Moving the joystick will lead to a continuous movement until released. A higher deflection will perform a movement with a higher speed. The speed range is adjusted with the speed level parameter.

Display

The Figure below shows a typical display setup of the Simple Control Mode. The first line indicates the activity state of the joystick. When a joystick symbol is displayed, the joystick is active, otherwise it is inactive. The remaining three lines are assigned to the three channels. On the left side of each channel line the name of the channel is shown (may be changed in the *Menu Mode*). If sensor data is available it will be displayed in the middle of the channel line, otherwise "No Sensor" will be displayed. On the right side of each channel line the speed level is shown.



Changing the Speed Level

To change the speed level press the knob corresponding to the channel. An arrow will appear next to the speed level display indicating the Parameter Control Mode. In this state the knob is used to adjust the speed level. Turning the knob right will increase the speed level, turning it left will decrease it. Pressing the knob will hide the arrow and exit the Parameter Control Mode.

4.1.2 Advanced Control Mode

The Advanced Control Mode is also used for stepping movements. However, in this mode you have more control over the parameters that the steps are performed with. You may adjust amplitude and frequency separately as well as the number of steps that are performed per burst.

Turning a knob will perform a burst of steps with the given parameters.

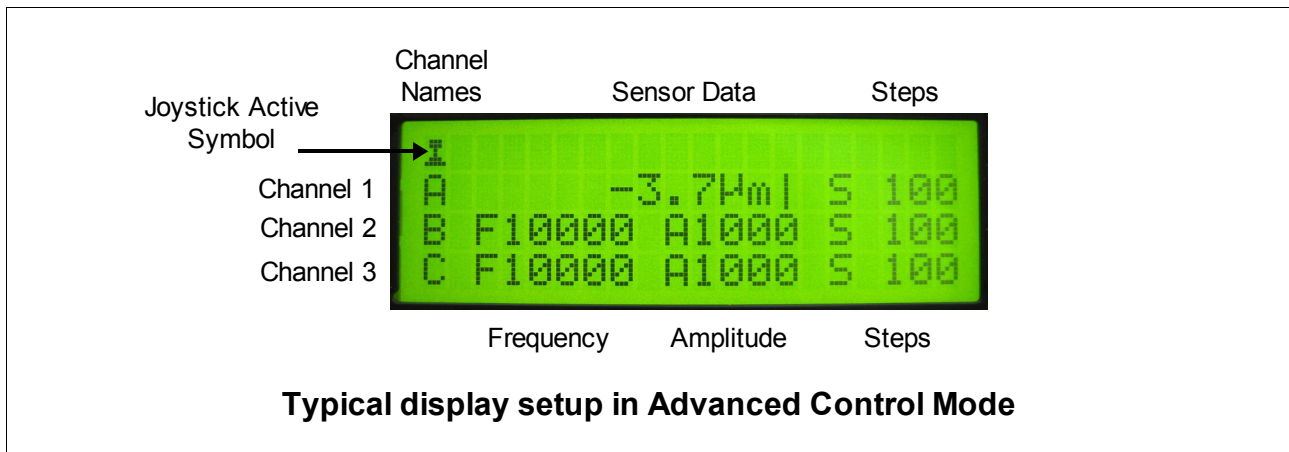
Moving the joystick will lead to a continuous movement until released. A higher deflection will perform a movement with a higher frequency. The range of frequencies (and therefore the sensitivity of the joystick) is controlled by the *Steps* parameter. A higher value will result in a coarser movement. The step width remains related to the *Amplitude* parameter. Note that the *Frequency* parameter has no influence when you control the positioner with the joystick.

Display

The Figure below shows a typical display setup of the Advanced Control Mode. Again, the first line indicates the activity state of the joystick. When a joystick symbol is displayed, the joystick is active, otherwise it is inactive. The remaining three lines are assigned to the three channels. On the left side of each channel line the name of the channel is shown (may be changed in the *Menu Mode*). The following columns display available sensor data and the movement parameters for the positioners.

If there is sensor data available it will be displayed in the middle of the channel line and the *Steps* parameter on the right side (indicated by an "S"). In this case the *Frequency* ("F") and *Amplitude* ("A") parameters are hidden. If there is no sensor data available all three parameters will be displayed in the channel line.

- "F" refers to the frequency (in Hz) that the steps are generated with.
- "A" refers to the amplitude (in 0.1 Volts) that the steps are performed with. The outcome of a high amplitude is a large step width.
- "S" refers to the number of steps that are performed per burst.



Changing Parameters

To change the parameters press the knob corresponding to the channel. Sensor data (if available) is hidden and all parameters are displayed along with an arrow symbol indicating the parameter currently being edited. Turning the knob will increase respectively decrease the current parameter. The parameters can be adjusted within the following ranges:

- Frequency: 53 values from 5Hz to 18,500Hz.
- Amplitude: 49 values from 150 (15V) to 1,000 (100V).
- Steps: 55 values from 1 to 10,000.

To change the current parameter press and hold the knob. The arrow will change to a left/right arrow symbol. Turning the knob in this state (while pressed) will change the current parameter.

Pressing and releasing the knob without having changed the current parameter will exit the parameter change state.

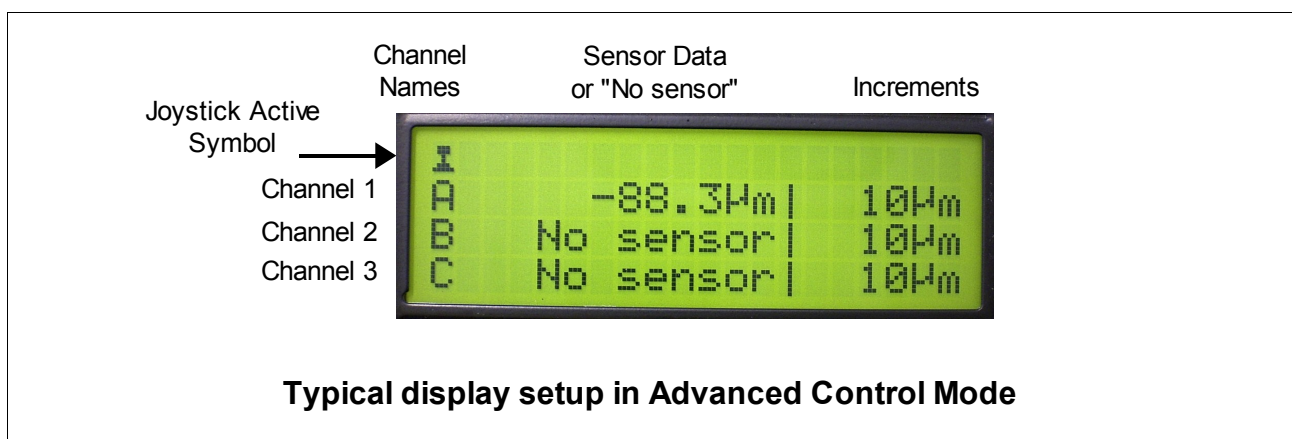
4.1.3 Closed-Loop Control Mode

The Closed-Loop Control Mode is only available to positioners that are equipped with an integrated sensor. If so you may instruct the positioner to travel a certain (relative) distance. The joysticks can not be used to control positioners in this mode. Turning a knob will move the positioner by the

configured increment. For this, the HCU-3D controller periodically processes sensor data and moves the positioner accordingly (closed-loop control). The desired position is held after having reached it by a period of time that is configurable via the *Menu Mode* (Hold Time). The holding process is stopped when the hold time elapses, a new movement command is issued or when changing to the Parameter Control Mode or the Menu Mode.

Display

The Figure below shows a typical display setup of the Closed-Loop Control Mode. Again, the first line indicates the activity state of the joystick. When a joystick symbol is displayed, the joystick is active, otherwise it is inactive. The remaining three lines are assigned to the three channels. On the left side of each channel line the name of the channel is shown (may be changed in the *Menu Mode*). If sensor data is available it will be displayed in the middle of the channel line, otherwise "No Sensor" will be displayed. On the right side of each channel line the current increment is shown.



Changing the Increment Parameter

To change the increment parameter press the knob corresponding to the channel. An arrow will appear next to the increment display indicating the parameter change state. In this state the knob is used to adjust the increment. Turning the knob right will increase the increment, turning it left will decrease it. Pressing the knob will hide the arrow and exit the parameter change state.

4.2 Menu Mode

To enter the menu mode press any two knobs simultaneously. The Figure below shows an example display setup. The navigation through the menu and sub menus follows a simple scheme. The first line of the display shows the name of the current menu. The rest of the lines display the menu entries. Turning any knob will cycle through the entries in a scrolling manner. The arrow indicates the current menu entry (always the middle line). Pressing any knob will select the current menu entry.



4.2.1 Main Menu

The main menu has the following entries:

0. Exit - Returns to the movement control mode.
1. Sensor Options - Enters a sub menu with sensor-related options.
2. Joystick Config - Enters a sub menu for configuring the joystick.
3. Knob Config - Enters a sub menu for configuring the three control knobs.
4. Channel Config - Enters a sub menu for configuring the three channels.
5. Control Modes - Enters a sub menu for toggling between the control modes.
6. Save Config - Writes the current device configuration to the internal EEPROM. It will be loaded as default configuration on any future power ups.
7. Restore Config - Reads the device configuration from the internal EEPROM. This can also be achieved by resetting the device.
8. Firmware - Enters a sub menu for firmware updates.

4.2.2 Sensor Options Menu

The Sensor Options menu has the following entries:

0. Exit - Returns to the main menu.
1. Zero All - The current position of all positioners is set to zero.
2. Zero "A" - The current position of the positioner at channel 1 is set to zero.
3. Zero "B" - The current position of the positioner at channel 2 is set to zero.
4. Zero "C" - The current position of the positioner at channel 3 is set to zero.
5. Calibrate - Enters a sub menu for calibrating the sensors.
6. Set Types - Enters a sub menu for setting the sensor types.
7. Set Safe Directions – Enter a sub menu for setting the safe directions.
8. Hold Time - Configures the hold time for closed-loop commands (in seconds). Select the menu entry repeatedly to cycle through the available values. Select “inf” for infinite hold time.

Calibration Menu

The Calibration menu has the following entries:

0. Exit - Returns to the Sensor Options menu.
1. Reference "A" - The positioner 1 will go to the reference point
2. Reference "B" - The positioner 2 will go to the reference point
3. Reference "C" - The positioner 3 will go to the reference point
4. Calibrate "A" - The positioner 1 will calibrate its sensor.
5. Calibrate "B" - The positioner 2 will calibrate its sensor.
6. Calibrate "C" - The positioner 3 will calibrate its sensor.

For positioners with integrated sensors the calibration may be used to increase the accuracy of the position calculation and to calibrate the signals at the end-stop for the reference point. The calibration should be done once for each channel if the positioner is connected to a new channel, a new controller and after the safe-direction was changed. The calibration data is automatically saved to non-volatile memory. Therefore, if the electrical setup is unchanged it is not necessary to issue the calibration routine on each power up. Note though that newly connected positioners have to be calibrated in order to ensure proper operation.

Important: The calibration routine takes a few seconds to complete and the positioner will perform a movement in the range of up to several mm and then travelling to the mechanical end-stop depending on the used sensor type. It must be ensured, that the calibration routine is not issued while the positioner is near a mechanical end stop. Otherwise the calibration might fail and lead to unexpected behavior when using the closed-loop control mode. As a safety precaution, also make sure that the positioner has enough freedom to move without damaging other equipment.

Set Types Menu

The Set Types menu has the following entries:

0. Exit - Returns to the Sensor Options menu.
1. Type "A" - Selecting this entry toggles between the different sensor types for the positioner at channel 1.
2. Type "B" - Selecting this entry toggles between the different sensor types for the positioner at channel 2.
3. Type "C" - Selecting this entry toggles between the different sensor types for the positioner at channel 3.

The following sensor types are used by the given positioner types:

Sensor Type	Positioner Series	Positioner Type
M	SL-xxxx-M, SLC-xxxx-M	Linear positioner
GA	SGO-45-M	Goniometer with 45mm radius
GB	SGO-50-M	Goniometer with 50mm radius
GC	SR-2110-M	Rotary positioner with end-stops
GD	SGO-60.5-M	Goniometer with 60.5mm radius
GE	SGO-77.5-M	Goniometer with 77.5mm radius
RA	SFW-M	Filter wheel with absolute position sensor
GF	SR1209-M	Rotatory positioner
RB	SR1910-M	Rotatory positioner

Set Safe Directions

The Set Safe Directions menu has the following entries:

0. Exit - Returns to the Sensor Options menu.
1. Dir. "A" - Selecting "forward" or "backward" toggles between the two directions for travelling to the reference point for channel 1.
2. Type "B" - Selecting "forward" or "backward" toggles between the two directions for travelling to the reference point for channel 2.
3. Type "C" - Selecting "forward" or "backward" toggles between the two directions for travelling to the reference point for channel 3.

4.2.3 Joystick Config Menu

The Joystick Config menu has the following entries:

0. Exit - Returns to the main menu.
1. X mapping - Specifies which channel should be controlled by the x-axis of the joystick. Selecting this menu entry will cycle through the channels. A value of "none" deactivates the x-axis of the joystick. A channel already selected for the y-axis of the joystick won't be selectable until you deselect this channel within *Y mapping*.
2. Y mapping - Specifies which channel should be controlled by the y-axis of the joystick. Selecting this menu entry will cycle through the channels. A value of "none" deactivates the y-axis of the joystick. A channel already selected for the x-axis of the joystick won't be selectable until you deselect this channel within *X mapping*.
3. Invert X - Selects whether the x-axis of the joystick should be inverted or not.
4. Invert Y - Selects whether the y-axis of the joystick should be inverted or not.
5. Stick active - This option can be used to globally activate or deactivate the joystick.

By default, the x-axis of the joystick is mapped to channel 1 and the y-axis is mapped to channel 2. Mapping both joystick axes to the same channel is not possible.

The joystick is active by default which is indicated by a small symbol in the top left corner of the display. It may be deactivated to avoid accidental movement of the positioners.

4.2.4 Knob Config Menu

The Knob Config menu has the following entries:

0. Exit - returns to the main menu.
1. Invert "A" - If set to "yes", turning the left knob will generate an inverted movement for the positioner at channel 1.
2. Invert "B" - If set to "yes", turning the middle knob will generate an inverted movement for the positioner at channel 2.
3. Invert "C" - If set to "yes", turning the right knob will generate an inverted movement for the positioner at channel 3.

4.2.5 Channel Config Menu

The Rename Channel menu has the following entries:

0. Exit – Returns to the main menu.
1. Mapping - Selecting this entry toggles between the different combinations of mapping the three channels to the three physical ports (see below).
2. Rename "A" - Selecting this entry will let you change the name of channel 1.
3. Rename "B" - Selecting this entry will let you change the name of channel 2.
4. Rename "C" - Selecting this entry will let you change the name of channel 3.

A port represents a physical signal output pin of the controller. Each positioner is connected to a port of the control electronics. A channel is a logical representation of a positioner. Each channel has a name and is mapped to a port and thus to a positioner.

There are six possible mapping combinations: "1, 2, 3", "1, 3, 2", "2, 1, 3", "2, 3, 1", "3, 1, 2" and "3, 2, 1". E.g. the mapping "2, 1, 3" means that channel 1 is mapped to the physical port 2, channel 2 is mapped to the physical port 1 and channel 3 is mapped to the physical port 3.

The names of the channels will be displayed in the movement control mode and parameter control mode. Each channel can be given a name of one character. Selecting one of the entries will bring up a blinking cursor. In this state the character may be changed by turning any knob. To exit the name edit mode, press and release a knob.

4.2.6 Control Modes Menu

The Control Modes Menu has the following entries:

4. Exit – Returns to the main menu.
1. Mode "A" - Selecting this entry toggles between the simple, the advanced and the closed-loop (CL) control mode for the positioner at channel 1.
2. Mode "B" - Selecting this entry toggles between the simple, the advanced and the closed-loop (CL) control mode for the positioner at channel 2.
3. Mode "C" - Selecting this entry toggles between the simple, the advanced and the closed-loop (CL) control mode for the positioner at channel 3.

4.2.7 Firmware Menu

The Firmware menu has the following entries:

0. Exit – Returns to the main menu.

1. Current version – Displays the current version of the firmware on your HCU-3D.
2. Update firmware – Switches to the firmware update mode.

5 Installing the Software

For more precise control and automation, the HCU-3D can be connected to a PC via a USB cable, which makes it possible to control the positioners by software. For this, a simple graphical control program is provided. Alternatively, you may use the DLL or the LabVIEW driver to integrate the HCU-3D into proprietary software.

In order to control your positioners by software you need to:

- install the drivers
- optionally install the graphical control program.

5.1 Installing the Drivers

Power up the HCU-3D and connect the device to the computer via the USB cable. A popup window will indicate that new hardware has been found.

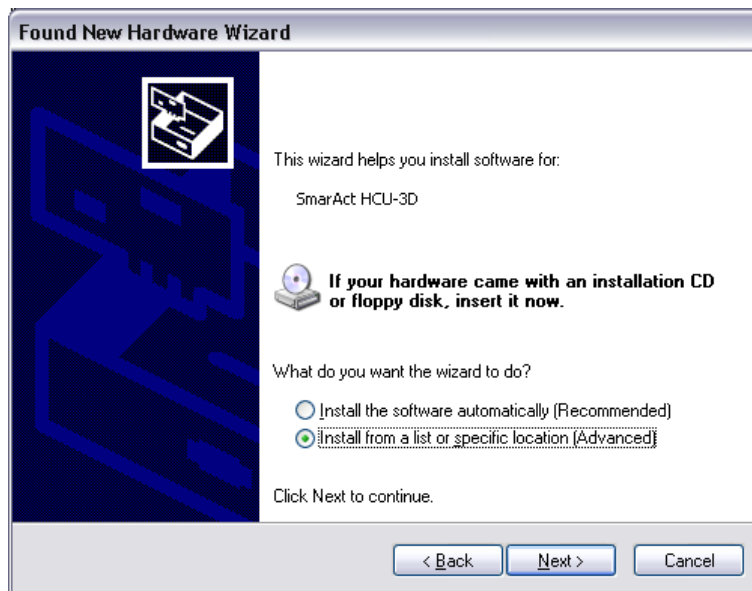
Note: For USB connection the SCU uses a FTDI chip. If you have already other systems with FTDI installed, we recommend to install the delivered driver to ensure the proper functionality.



After a short while a dialog will appear that will guide you through the installation.



Since the drivers are located on the software CD, select “No, not this time” and press “Next”.



Select the second radio button (“Install from a list or specific location”) and click “Next”. The next window will let you select the source of the driver files.



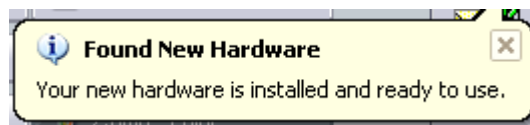
The driver files are located in the “Drivers” folder on the software CD. Either select “Search removable media” or enter the complete path under “Include this location in the search”. Press “Next”.

When the drivers have been installed...



... press “Finish” to complete the installation.

A popup window will inform you that the hardware is ready to use.



5.2 Installing the Graphical User Interface

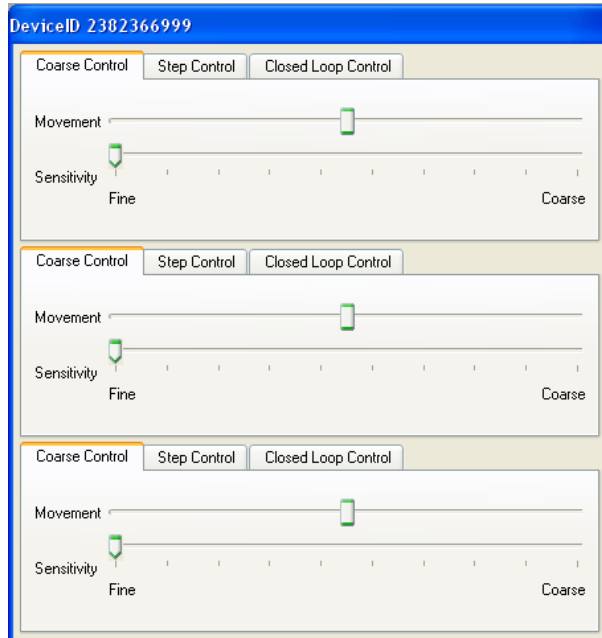
To install the graphical control program start the “setup.exe” on the software CD. This will start an installation wizard that will guide you through the installation. Follow the instructions on the screen to complete the installation.

Note: It is recommended to uninstall older versions of the graphical control program before installing a new one.

6 Graphical Control Program

The graphical control program provides an example for a software controlled system via the DLL. Power up your HCU-3D and connect it to the PC via the USB cable (The control program is not compatible with the RS-232 interface). Start the application (SCU3DDemoGUI) and select "Connect" from the connection menu.

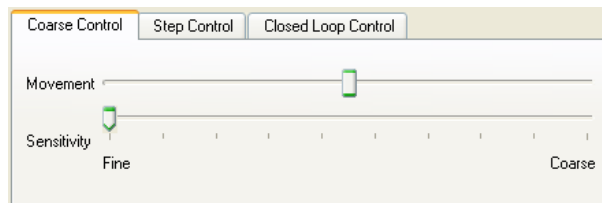
A control window will appear which lets you control your positioners.



In case you connect more than one device to the PC there will be multiple control windows. The Device ID in the title bar of each window corresponds to the number printed on the CU-3D. This lets you identify which control window belongs to which device.

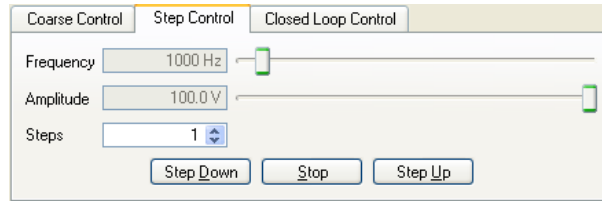
The control window is divided into three panels, one for each positioner. Each panel has three tabs which lets you select between three control modes.

6.1 Coarse Control



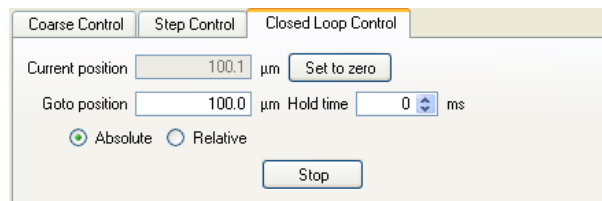
The **coarse control** mode is similar to a joystick. The movement slider is in a middle position by default. Moving the slider with the mouse cursor will drive the positioner in the according direction. A higher deflection will result in a higher frequency that the positioner is driven with. Releasing the slider will return it to its middle position and stop the positioner. The sensitivity slider lets you adjust the frequency range of the movement. Note that in this mode the positioners will be driven with the full step width of 100 Volts.

6.2 Step Control



The **step control mode** lets you adjust the various movement parameters. Set them as desired and press “Step Up” or “Step Down” to drive the positioner with the given parameters. Press “Stop” to abort an ongoing movement. The typical lowest voltage for standard positioners is in the range of 30-50 V. If you perform steps with a lower voltage you will still hear the sound of the frequency, but the positioner won't move.

6.3 Closed Loop



With the **closed loop control** you can perform closed-loop operations, if the positioner has an integrated micro position sensor. To set a position to the zero position press the “Set to zero” button. Now you can perform absolute and relative closed-loop operations. Select if you want to perform an absolute or relative closed-loop operation and insert the value in microns into the “Goto position” field then press the enter key and the positioner will move to the desired position.

You can adjust the hold time. Just enter a value between 0 and 60,000 ms. 0ms means no hold time, 60,000ms means an infinity hold time. Any value between defines a holding time for this certain value.

Disclaimer Note: The demonstration software described in this user manual is distributed “as is”. There is no guarantee that it is free of errors. SmarAct GmbH is not responsible for any direct or indirect damage that may be caused by the usage of this software.

By using this software you agree to use it on your own responsibility.

7 LabVIEW® Support

7.1 LabVIEW® Driver

For those who want to control SmarAct's positioners via LabVIEW®, several VIs can be found on the software CD. All VIs encapsulate the “SCU3DControl.dll” and its functionality. Each VI is named as the corresponding DLL-function and has the same parameter names, types and ranges. The VIs “CommandTesterSync” and “CommandTesterAsync” allow to test each command separately in synchronous and asynchronous communication mode, respectively. Please refer to the *USB Interface Documentation* for a detailed description of each function.

7.2 System Requirements

LabVIEW version 8.2 or higher is required to use the LabVIEW® driver. If the asynchronous mode shall be used, *LabVIEW® Full*, *LabVIEW® Professional* or *LabVIEW® Developer Suite* is required. If the synchronous mode shall be used, *LabVIEW® Base* works as well.

Each LabVIEW® VI that is provided encapsulates a function of the SCU3DControl.dll. The DLL and therefore the LabVIEW® driver uses mechanisms of the Microsoft Windows® operating system and requires either *Windows® NT, 2000, XP or Vista*.

7.3 LabVIEW® Examples

On the CD you can find examples, which show how to use the above mentioned VIs.

Before starting the VIs make sure that you copy the “LabVIEW” folder and the “DLL” folder into one folder on the PC which is connected to the SCU controller.

The examples provide a start for the integration of the driver VIs into your own application.

- **Example 0**
Initialisation of one of several devices.
- **Example 1**
Simple example with system initialisation, step movement and system release.
- **Example 2**
Stop functionality is added.
- **Example 3**
Status request is added.
- **Example 4**
Motion status is displayed by an LED.
- **Example 5**
Sequence of command and break
- **Command Tester**
All commands can be triggered and tested.

License Note: The different examples are using synchronous or asynchronous communication between SCU controller and application. All asynchronous examples with the suffix “_Async” use events for the handling of button presses and SCU returns and therefore require *LabVIEW® Full*, *LabVIEW® Professional* or *LabVIEW® Developer Suite*. All synchronous examples with the suffix “_Sync” use a polling mechanism instead and are therefore running with *LabVIEW® Base* as well.

7.3.1 Example 0

"Sample0_InitSystems" shows a small sequence that shows the application of all functions that are related to device initialisation. First, the list of available devices is retrieved with `SA_GetAvailableDevices`. The list of devices that shall be initialised is cleared and one of the found device IDs is added to the list. The succeeding call of `SA_InitDevices` only initialises the given device. Finally, the number of initialised devices (`SA_GetNumDevices`) and the device ID of the first device (`SA_GetDeviceID`) is retrieved.

7.3.2 Example 1

"Sample1_Sync" and "Sample1_Async" provide a simple example for system initialisation, step movement and system release.

In both examples the connection to the SCU controller is initialised with `SA_InitDevices` before the application starts reacting on user input. In "Sample1_Sync" the statuses of the buttons are polled and corresponding SCU commands are invoked at each polling cycle while in "Sample1_Async" SCU commands are invoked by LabVIEW® "Mouse Down" events from the buttons. The "Up" and "Down" buttons invoke step movements (`SA_StepMove_S/A`) with constant parameters (number of steps, amplitude and step frequency) at the currently selected channel. The "Exit" button stops the LabVIEW® event handling loop or polling loop and releases the connection to the SCU controller with `SA_ReleaseDevices`.

7.3.3 Example 2

In "Sample2_Sync" / "Sample2_Async" a "Stop" button that invokes the corresponding SCU command `SA_Stop_S/A` is added to "Sample1_Sync" and "Sample1_Async", respectively.

7.3.4 Example 3

In "Sample3_Sync" and "Sample3_Async" a status request button and a status display is added to "Sample2_Sync" and "Sample2_Async".

In "Sample3_Sync" pressing the "get Status" button invokes `SA_GetStatus_S`, which immediately returns the current movement status of the positioner.

In "Sample3_Async" pressing the "get Status" button invokes `SA_GetStatus_A`, which requests the status. It is then displayed after the asynchronous reception of a status packet. The packet reception mechanism is initialised by creating a Windows event with the Windows function `CreateEvent` and by passing the Windows event handle to the DLL with `SA_SetReceiveNotification_A`. Each time a packet has arrived in the USB-buffer, the Windows event becomes signaled and the `WaitForSingleObject` function is released. Subsequently `SA_ReceiveNextPacket_A` reads the packet and, if it is of type `SA_STATUS_PACKET_TYPE`, it is displayed. The `WaitForSingleObject` function must be released before terminating the application by setting the Windows event to signaled (`SetEvent`).

7.3.5 Example 4

In "Sample4_Sync", "Sample4a_Async" and "Sample4b_Async" a "working ..." LED replaces the textual status display of "Sample3_Sync" and "Sample3_Async".

In "Sample4_Sync" the status is continuously requested in a second loop with `SA_GetStatus_S`. The "working ..." LED is then turned on if the status is of type `SA_STEPPING_STATUS`, `SA_SCANNING_STATUS`, `SA_TARGET_STATUS`, `SA_CALIBRATING_STATUS`, or `SA_FINDING_REF_STATUS`. The LED is turned off otherwise.

In "Sample4a_Async" the "working ..." LED is turned on each time a stepping motion is started and turned off when a packet of type `SA_COMPLETED_PACKET_TYPE` has been received. The packet reception mechanism is identical to "Sample3_Async", but the SCU transmission of completed packets is deactivated by default and must be activated initially for all channels with `SetAllReportOnComplete` (using `SA_SetReportOnComplete_A`).

In "Sample4b_Async" all events, i.e. buttons press events and SCU packet reception events, are handled by the LabVIEW® event handling loop. For this, LabVIEW® user events are registered for all SCU packets with `RegisterForSCU3DEvents` and passed to `SCU3DEventDispatcher`. The dispatcher contains a Windows event handling loop, which, upon reception of a packet, generates a corresponding LabVIEW® event with the packet data. The LabVIEW® event handling loop contains an event case "SCU3DCompleted", which turns on the "working ..." LED. At program termination The LabVIEW® user events are unregistered with `Unregister for Events`.

7.3.6 Example 5

"Sample5_Seq_Sync" gives an example of a small sequence. In this case a burst of steps is alternated with a waiting time. The sequence is simply programmed with a LabVIEW® sequence, which can be placed inside a loop to repeat the sequence.

7.3.7 CommandTester_Sync / CommandTester_Async

In "CommandTester_Sync" and "CommandTester_Async" all commands that are available in the DLL can be triggered and tested individually. "CommandTester_Sync" is an extension of "Sample4_Sync" and "CommandTester_Async" is an extension of "Sample4b_Async".

Disclaimer Note: The LabVIEW® driver and the examples described in this user manual are distributed "as is". There is no guarantee that they are free of errors. SmarAct GmbH is not responsible for any direct or indirect damage that may be caused by the usage of this software.

By using this software you agree to use it on your own responsibility.

8 Technical Data

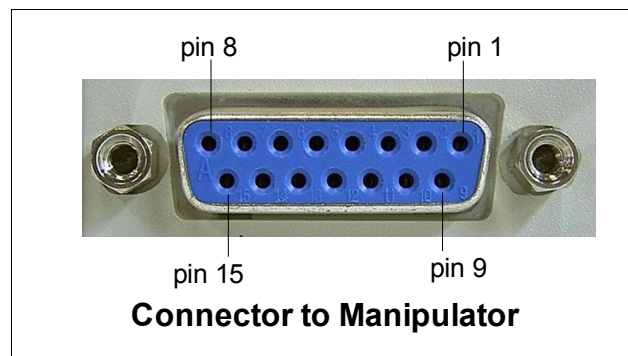
8.1 Power Supply

The HCU-3D controller is supplied by a 12V DC/ 24W power supply. Please use the power supply that is shipped with the HCU-3D controller.

8.2 Connectors at the HCU-3D Controller

8.2.1 Connector to Manipulator

The manipulator must be connected to the D-SUB 15 pin female connector at the HCU-3D controller.



The pin assignment is as follows:

Pin	Signal	Function
1	HV-OUT-1	Positioner driving signal, channel 1
2	HV-OUT-2	Positioner driving signal, channel 2
3	HV-OUT-3	Positioner driving signal, channel 3
4	S-GND	Ground for sensor
5	S-SIN1	Sinus signal from sensor at channel 1
6	S-SIN2	Sinus signal from sensor at channel 2
7	S-SIN3	Sinus signal from sensor at channel 3
8	S-5V	Power supply for sensor, 5V DC
9	HV-GND-1	Ground for positioner driving signal, channel 1
10	HV-GND-2	Ground for positioner driving signal, channel 2
11	HV-GND-3	Ground for positioner driving signal, channel 3
12	S-COS1	Cosinus signal from sensor at channel 1
13	S-COS2	Cosinus signal from sensor at channel 2
14	S-COS3	Cosinus signal from sensor at channel 3
15	S-5V	Power supply for sensor, 5V DC
Shielding	S-GND	Ground for sensor

The positioner driving signals are specified as follows:

Driving Signal (HV-OUT-x)	Value	Unit
Output voltage range	0 to 100	V
Average current per channel	200	mA
Peak current per channel, < 10 μ s, max. speed	20	A
Signal	sawtooth	

8.3 Operating Conditions

The HCU-3D controller must be used in normal environmental conditions:

- Indoor usage only.
- Temperature range: 5°C to 40°C.

9 Positioner - Handling Instructions

SmarAct's positioners are high-precision products which have to be handled with care. There are certain conditions which have to be avoided or taken care of. If there should arise any questions on handling the positioners please contact the SmarAct team.

9.1 Handling

SmarAct positioning systems are precision devices and caution should be used when handling a positioner or manipulator.

- Generally, caution should be used **to not apply high torques or forces to the slides** with respect to the guides. Therefore, a manipulation system should be held at the base plate when transporting it.
- **Neither the sensor head nor the scale should be touched** since this could affect its operation or damage it. Fingerprints can be removed by wiping carefully with isopropanol-tinctured cotton buds.
- The positioners consist of steel parts that can rust, if touched with bare hands. Therefore, **gloves** should be worn when handling positioners or manipulators. As an additional protection, outer surfaces can be lubricated with **white oil** if the positioners are not applied in vacuum conditions.
- The cables are attached directly at the positioners and **special care** should be taken **not to damage the cables**. For most of the positioner series repairing a cable is very difficult and expensive.

9.2 Mounting

For mounting a device to a manipulation system it is necessary to use screws. There are two common sources of damaging a positioner: Using too long screws and applying too much force and torque to the manipulation system.

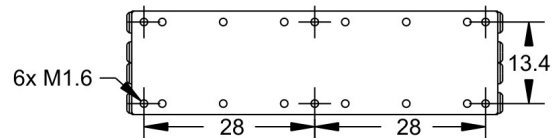
- For some positioners, the **allowable screw-in depths** are quite small. By using too long screws, you may hit internal components and damage the positioner. Therefore, measure the screw length beforehand and shorten the screws, if necessary. The following max. screw-in depths should be respected:

Positioner Series	Maximum Screw-in Depth
-------------------	------------------------

SL-15xx	Top side: 1.0mm Bottom side: 1.0mm
---------	---------------------------------------

SL-20xx	Top side: 1.2mm Bottom side: 1.2mm
---------	---------------------------------------

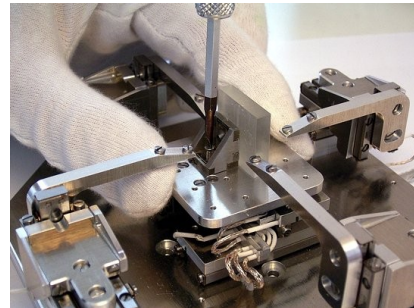
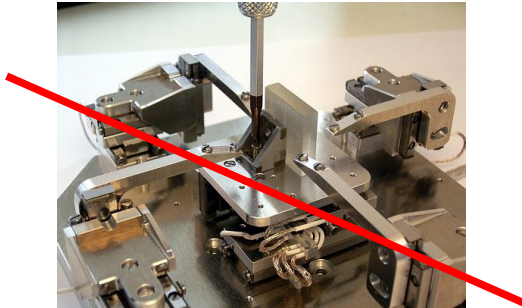
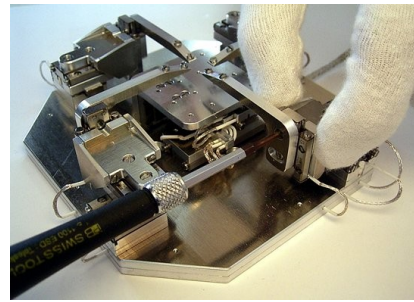
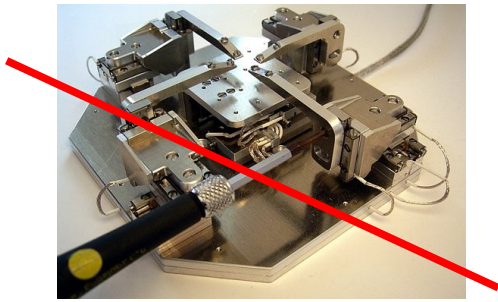
SLC-xxxx	Top side: 3.5mm Bottom side: At the sides, marked with cross: 3.5mm No other holes must be used!
----------	--------------------------------------------------------------------------------------------------------



SR-36xx	Top side: 2.2mm Bottom side: No holes must be used! Mounting with through holes.
---------	----------------------------------------------------------------------------------------

SR-19xx	Top side: 1.5mm Bottom side: No holes must be used! Mounting with through holes.
---------	----------------------------------------------------------------------------------------

- The most common source for too high torques is the force of a screwdriver when mounting a device to a positioner or when assembling or disassembling a manipulation system. Therefore, a **manipulation system** should generally **not be disassembled**. If a device shall be mounted to a positioner, please **hold the positioner directly** and not indirectly via any other part which it is connected to. E.g. when mounting something to the Z positioner of an XYZ manipulator hold the Z positioner directly and not the base plate of the manipulator.



NOT THIS WAY: Don't apply a force or torque to a positioner by holding it indirectly via other mounting devices to it.

THIS WAY: Hold the positioner directly when mounting devices to it. Minimise the applied forces and torques.

- When mounting a device to a manipulation system or when mounting the manipulation system to an experimental setup make sure to **screw the parts tightly together**. Again, please do not apply too high forces and torques to the manipulation system.

9.3 Environment

The positioners should be operated

- at **room temperature** (5°C to +40°C)
- in a **dry atmosphere**
- **without high magnetic fields**.

Dusty environments should be avoided. Dust may settle in-between the raceway, the balls or rollers and the slider, which would have a negative effect on the precision. Also the micro or nano position sensor is sensitive to dust on the scale.

Do not drive the positioners in liquid, especially not in conductible liquid.

Furthermore, humid environment (e.g. in an incubator) may lead to rust, which may be avoided by using a lubrication.

9.4 Electrical Connection

When **connecting** the positioners to the controllers, please make sure that the **controller is switched off**. Especially positioners with integrated sensors are **not hot-pluggable**.

You can supply driving signals in the range from -20V to 120V. Driving the positioners outside this specification will cause damage of the driving piezo ceramic.

9.5 Maintenance

SmarAct positioners have a **standard lifetime of 10,000m** where they don't require any maintenance, except cleaning after having been touched etc. After that lifetime it may be necessary to grease the positioners (see below).

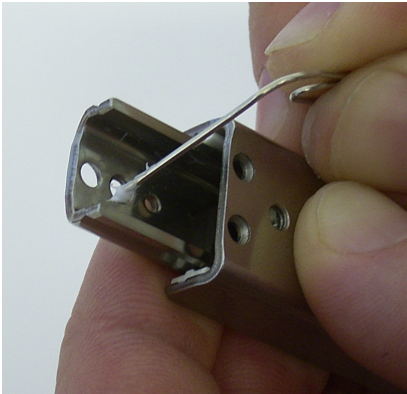
9.5.1 Cleaning

Positioners can be cleaned with **isopropanol-tinctured cotton buds**. Do not use acetone. If any grease has been removed from the friction surface by the cleaning process, it must be replaced.

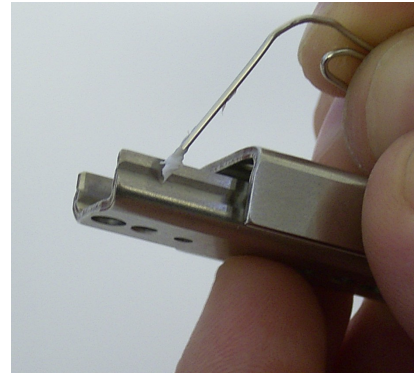
9.5.2 Greasing

After the standard lifetime (see above) the max. velocity and the blocking force of a positioner may degrade. It may be necessary to **grease** the surface where the friction element is in contact with the slide:

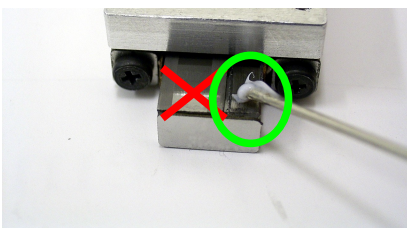
- **Linear positioners** can be greased by applying Fomblin VAC3 UHV grease to the friction surfaces, as shown in the figures below. Please note that neither the sensor head nor the sensor scale must be contaminated with grease.
- **Rotary positioners** cannot be greased because their friction surface is covered.



SL-line: Greasing the friction surface at the inner side of the slide.



SL-line: Greasing the friction surface at the outer side of the slide.



SLC-line: Greasing the friction surface at one side of the slide.

9.6 Frequently asked Questions

The following collection of frequently asked questions (and answers) can provide a first help for the most common questions. If these FAQ cannot solve the problem immediately or in case of any doubt please don't hesitate to contact the SmarAct team.

9.6.1 Positioner Performance

- Q: The **max. velocity** of the positioner drops fast.
A: It may be necessary to grease the positioners. See above: Maintenance - Greasing.
- Q: The positioner seems to **loose steps**.
A: Each step varies a bit from the step before. Since a positioner is making many steps, this error can cumulate to deviations which can clearly be seen. If you want the positioners to move with a high repeatability or high absolute accuracy, you need to use some kind of feedback. Therefore, we offer optical position sensors which can be integrated into the positioners without changing their outer dimensions. In some cases the user has a different kind of feedback, like the image of a microscope, or the intensity of a laser beam etc.
- Q: I can **hear the positioner** doing steps, but apparently it is **not moving**. How can this be?
A1: The positioners must be driven with a certain minimum amplitude in order to function properly. This minimum value may vary from positioner to positioner. Try increasing the amplitude value.
A2: The steps may be smaller than the resolution of the measurement device (microscope etc.). Try increasing the amplitude value.
- Q: The positioner is moving **slower upwards than downwards** when supplied with a **mass**.
A: This is the case even when using the same parameters for the steps: A slip-stick drive is an inertial-friction drive. Its velocity strongly depends on the force it has to apply. It always moves faster in the direction of an external force acting on the positioner. Such an external force is the load which a positioner has to move up and down, for example. To avoid this you might want to use the speed control feature of the MCS controller.
- Q: The positioner has different **blocking forces** at different **frequencies**.
A: This is a normal behaviour of stick-slip-drives.
- Q: Is every **positioner** applicable in **any orientation**?
A: Yes, any positioner can be used horizontally, vertically or at any other angle. Please note that when mounted horizontally the load can be much higher (allowable load) than when mounted non-horizontally (blocking force).

9.6.2 Blockage

- Q: The positioner is **blocked**, i.e. it is **not moving when commands** are given.
A: Please check the following points:
 - If the positioner has reached one of the **mechanical end stops** move it in the **other direction**.
 - Sometimes it helps to **increase the voltage amplitude** in step mode. The amplitude must be higher than a certain threshold, which is normally in the range of up to 50V. This threshold amplitude is different for different positioners.

9.6.3 Sounds

- Q: Why does my **positioner** make some **sound**?
A: This is normal. The sound you hear is the positioner moving with the frequency of the steps.
- Q: Why are the **positioners** making **strange rattling noises** when they are controlled via **joystick**?
A: This is normal. The sound you hear is the update rate of the joystick.
- Q: Why do all **positioners move slightly** when switching the **MCS controller on or off**?
A: The resting potential of the MCS output is 50V. When switching on the MCS controller, the output voltage is increased from 0V to 50V, which causes the deflection. When switching off the MCS controller, the output voltage is decreased from the current value to 0V. In addition, positioners with an integrated nanosensor are performing a scanning movement to detect the mounting direction of the nanosensor.

9.6.4 Sensor

- Q: What happens in **power-save mode**?
A: In power-save mode the nanosensor will be switched off most of the time and switched on every 0.5s to read out the current data. Only when closed-loop movement commands are performed the nanosensor is continuously switched on until the target position is reached.
- Q: The **sensor is not working**.
A: Please check that the sensor mode is set to "enabled" or "power-save mode".

9.6.5 Interference

- Q: When working in an **SEM** I note a **micro vibration** of the actuator.
A: Make sure that you connect the **pin plug of the control unit to the electrical ground of the setup**. When working inside a vacuum chamber of a scanning electron microscope (SEM), it is important that you put the potential of the pin plug to the same potential as the SEM chamber or to a potential that is kept constant.

9.6.6 PC-based Control

- Q: After plugging in the USB cable and **switching on the MCS** I **cannot connect** to it via software.
A: It takes some time (about 3s) before the USB port of the MCS is ready to receive commands.