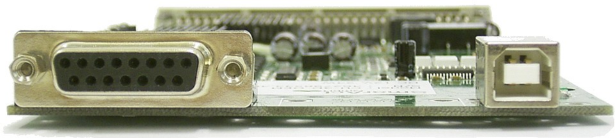
SmarAct GmbH



Control Unit

CU-3DM (USB)

User Manual

version 4.0

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1 Manufacturer Declarations

1.1 Warnings and Safety Instructions

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

1.1.1 Danger - Hazardous Voltage

The CU-3D controller is delivered without a housing so that the system integrator is free to choose the type of housing fitting to his/her application. The integration of the CU-3D may only be done by adequately trained personnel.

The CU-3D controller is capable of generating high output currents at high voltages. They may cause serious or even lethal injury if used improperly. Therefore, strictly observe the following:

- Never touch any part that might be connected to an output with a high voltage.
- Never touch any part on the PCB while the system is connected to a power supply. Note that some parts may be charged shortly after disconnecting the power supply.
- Some parts of the CU-3D may become hot during operation.
- Do not connect products from other manufacturers to the output connectors.

1.1.2 Caution - Installation Instructions

The CU-3D controller must be supplied with proper air circulation. Insufficient air flow can cause overheating, which can result in a limited functionality of the controller.

1.1.3 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 immediately stopped as a safety precaution.

2 Introduction

This document is a user manual for the SmarAct CU-3DM. The CU-3DM is designed to drive piezo based stepping actuators from SmarAct GmbH.

The CU-3DM controller provides the following features:

- **Driver:** With the CU-3DM 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.
- **USB Interface:** The CU-3DM may be controlled by software running on a PC. Please refer to the *USB 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.

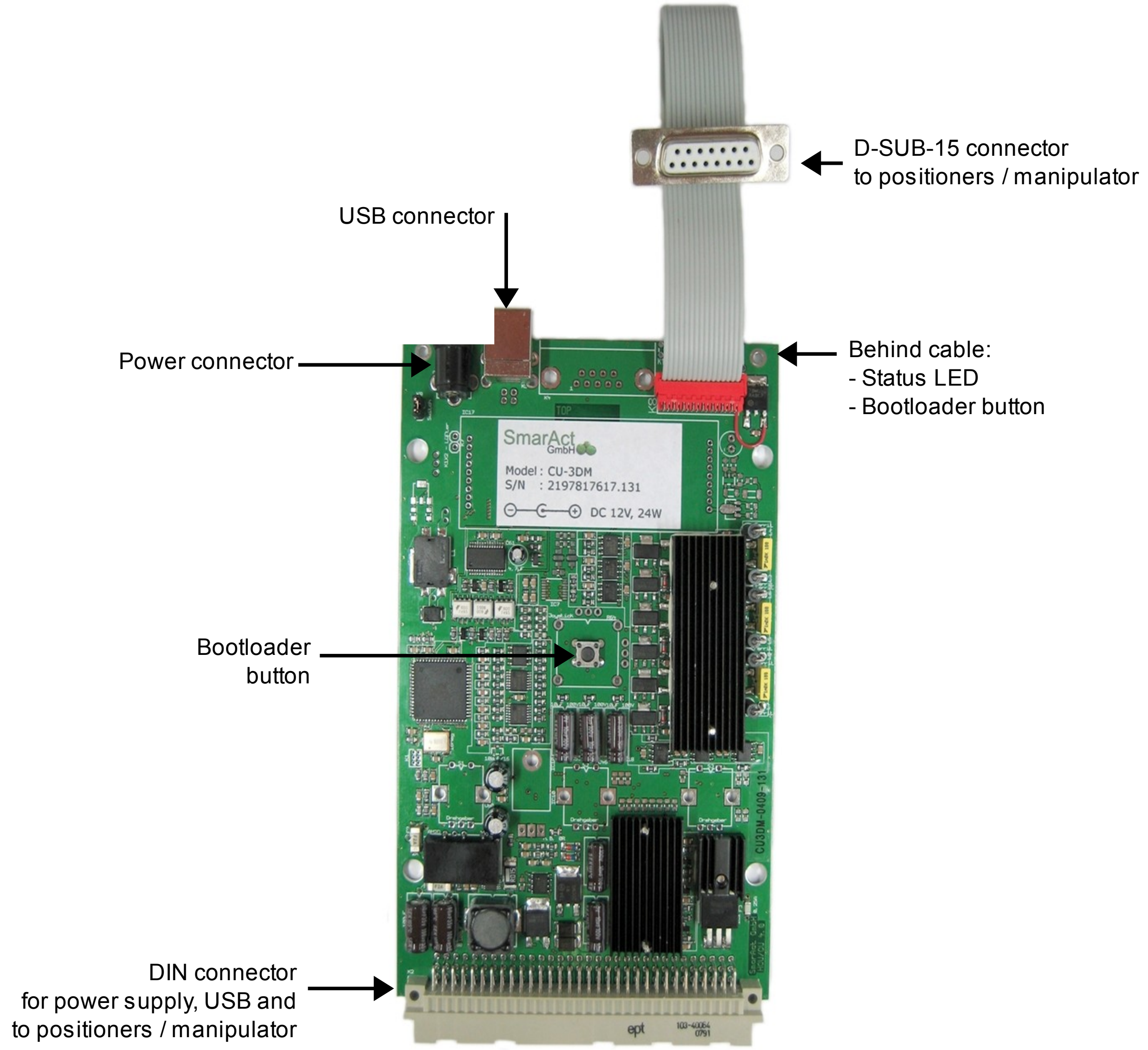
3 System Setup

3.1 Overview

The CU-3DM 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 a PC (proprietary software).

The figure below shows the main components of the CU-3DM. Depending on the desired configuration, the D-SUB-15 connector or the DIN connector may not be assembled.

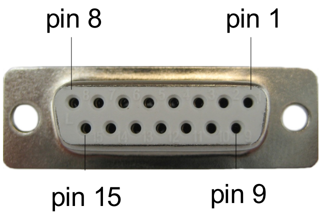


CU-3D Controller (top view)

3.2 *Connectors*

3.2.1 D-SUB-15 Connector to Positioners (optional)

If assembled, the female SUB-D-15 plug (not high density) provides a standard interface at the front side for the signals that drive the positioners.



Connector to Positioners

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, < 10µs, max. speed	20	A
Signal	sawtooth	

3.2.2 DIN Connector for Power Supply and to Positioners (optional)

If assembled, the male DIN41612 plug type C provides a standard interface at the back side for the power supply, the USB connection and the signals that drive the positioners.

Connector to Positioners

The pin assignment is as follows:

Pins	Signal	Function
A29, A30, C29, C30, A6	C-12V	Power supply for CU-3D controller, 12V DC
A31, B31, C31, A32, B32, C32	C-GND	Ground for CU-3D controller
C1	HV-OUT-1	Positioner driving signal, channel 1
C2	HV-OUT-2	Positioner driving signal, channel 2
C3	HV-OUT-3	Positioner driving signal, channel 3
B1	HV-GND-1	Ground for positioner driving signal, channel 1
B2	HV-GND-2	Ground for positioner driving signal, channel 2
B3	HV-GND-3	Ground for positioner driving signal, channel 3
B1, B2, B3, B4	S-GND	Ground for sensor
B15	S-COS2	Cosinus signal from sensor at channel 2
B16	S-SIN3	Sinus signal from sensor at channel 3
B17	S-SIN2	Sinus signal from sensor at channel 2
B18	S-COS3	Cosinus signal from sensor at channel 3
B19	S-COS1	Cosinus signal from sensor at channel 1
B20	S-SIN1	Sinus signal from sensor at channel 1
B21, B22	S-5V	Power supply for sensor, 5V DC
all other	n. c.	DO NOT CONNECT

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 µs, max. speed	20	A
Signal	sawtooth	

3.3 *Power Supply*

For operation the CU-3D must be connected to a fitting power supply:

- Voltage: 12V DC
  The power supply must be voltage regulated.
- Current: min. 2A
  For safety reasons a limitation of the current to not more than 3A is necessary.

3.4 Status LED

The CU-3D controller has an LED on board:

- When the CU-3D board is supplied with power the status LED is on.
- The status LED shows the status of the USB communication:

LED	Status
Red, constant	USB not connected
Green, constant	USB connected, ready for commands
Green, flicker	USB connected, command received

3.5 Bootloader Buttons

The bootloader buttons are only used to perform firmware updates. To upload new firmware:

- Power down the device.
- Connect it to the PC via a USB cable.
- Press and hold one of the two bootloader buttons and power up the device.
- The status LED will blink with 1 Hz when the device is ready for uploading new firmware. You may then release the button.
- Use the update tool provided by SmarAct to upload new firmware.

3.6 Housing

The CU-3D must not be used without a suitable housing. The housing must ensure:

- a protection of the user against the used voltages
- sufficient electromagnetic shielding
- free air convection

3.7 Operating Conditions

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

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

4 Installing the Software

The CU-3D is designed to control your positioners by software only. For this, a simple graphical control program is provided. Alternatively, you may use the DLL or the LabVIEW driver to integrate the CU-3D into proprietary software.

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

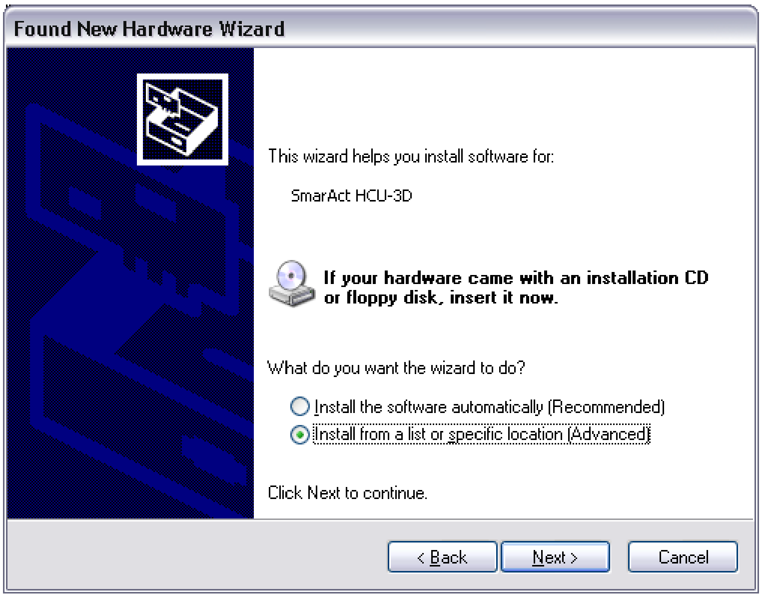
- install the drivers
- optionally install the graphical control program.

4.1 Installing the Drivers

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

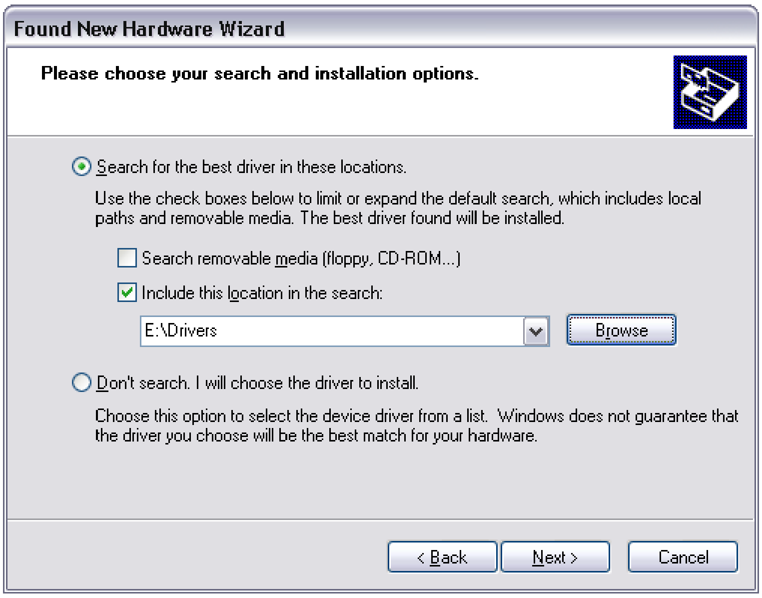
After a short while a dialog will appear that will guide you through the installation.

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.

4.2 Installing the Graphical User Interface

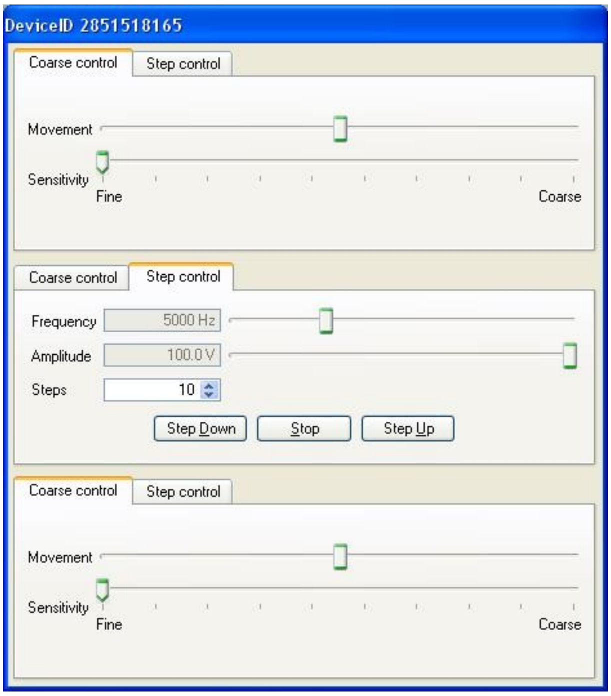
To install the graphical control program start the “setup.exe“ on the software CD. This will start an installation wizard that will guide you through the installation. Follow the instructions on the screen to complete the installation.

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

5 Graphical Control Program

The graphical control program provides an example for a software controlled system via the DLL. Power up your CU-3D and connect it to the PC via the USB cable. 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 two tabs which lets you select between two control modes.

- 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.
- 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.

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.

6 LabVIEW® Support

6.1 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.

6.2 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*.

6.3 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.

6.3.1 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.

6.3.2 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`.

6.3.3 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.

6.3.4 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`)

6.3.5 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`.

6.3.6 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.

6.3.7 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”.

7 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.

7.1 Handling

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

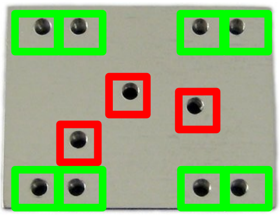
- Generally, caution should be used **to not apply high torques or forces to the slides** with respect to the guides. Therefore, a manipulation system should be held at the base plate when transporting it.
- **Neither the sensor head nor the scale should be touched** since this could affect its operation 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.

7.2 Mounting

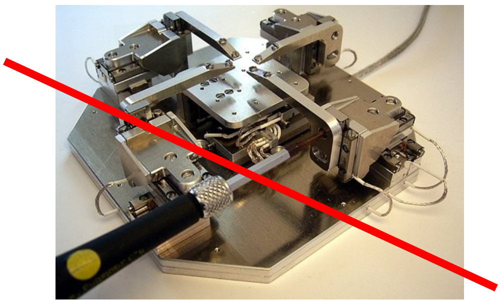
For mounting a device to a manipulation system it is necessary to use screws. There are two common sources of damaging a positioner: Using too long screws and applying too much force and torque to the manipulation system.

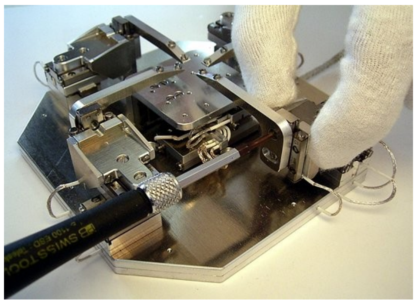
- For some positioners, the **allowable screwing depths** are quite small. By using too long screws, you may hit the internal components and damage the positioner. Therefore, measure the screw length beforehand and shorten the screws, if necessary. The following max. screw-in depths should be respected:

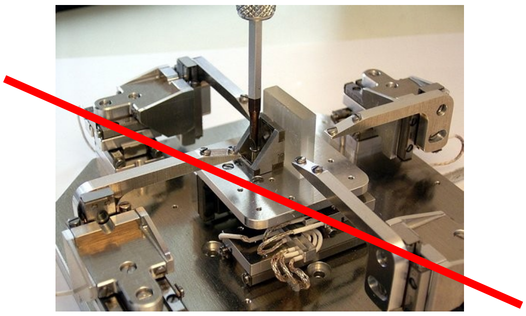
Positioner Series	Max. Screw-in Depth
SL-15xx	Top side and bottom side: 1.0mm
SL-20xx	Top side and bottom side: 1.2mm
SLC-xxxx	Top side: 3.5mm Bottom side: At the sides (green): 2.0mm In-between (red): These holes must not be used!
SR-36xx	Top side: 2.2mm
SR-21xx	Top side: 1.5mm

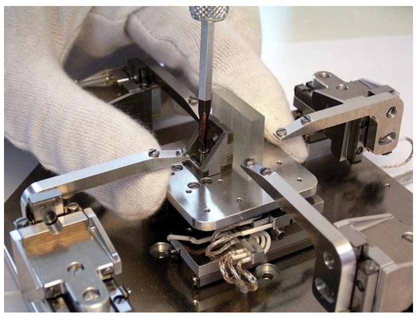


- The most common source for too high torques is the force of a screwdriver when mounting a device to a positioner or when assembling or disassembling a manipulation system. Therefore, a **manipulation system** should generally **not be disassembled**. If a device shall be mounted to a positioner, please **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 positioners.

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.

7.3 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 an 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.

7.4 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.

7.5 Maintenance

SmarAct positioners have a **standard lifetime of 5000m** 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).

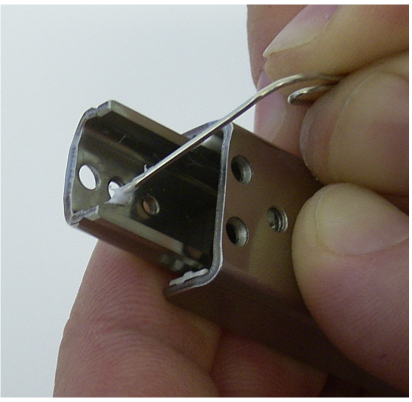
7.5.1 Cleaning

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.

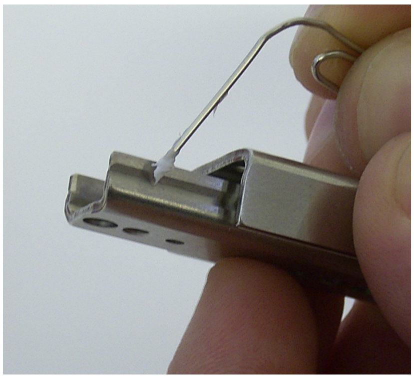
7.5.2 Greasing

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:

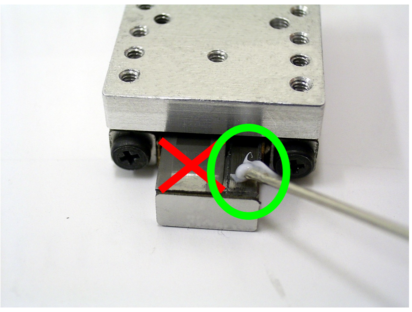
- **Linear positioners** can be greased by applying Fomblin VAC3 UHV grease to the friction surfaces, as shown in the figures below. Please note that neither the sensor head nor the sensor scale must be contaminated with grease.
- **Rotary positioners** cannot be greased because their friction surface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

7.6 Troubleshooting

7.6.1 Blockage

If a positioner is blocked, i.e. it is not moving when commands are given, 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.
- **Change the driving frequency**. Although SmarAct controllers can output signals with up to 18.5 kHz, there are positioners (with double actuator) which cannot be operated in the full frequency range.

7.6.2 Interference

- If you note a micro vibration of the actuator, 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.