MCS2 - PicoScale as a Sensor Module

Abstract
The **MCS**2 supports the SmarAct **PICO**SCALE laser interferometer as a high precision sensor module. For this, the **PICO**SCALE replaces the usually required **MCS**2 sensor module. This document guides through the setup of using the **PICO**SCALE as sensor module for the **MCS**2.

INTRODUCTION

If a **PICO**SCALE laser interferometer is used as sensor module for the **MCS**2 the position measurement capability of the **PICO**SCALE can provide the feedback signal for the **MCS**2 to perform closed-loop movements. The benefit of this setup is the higher resolution of the **PICO**SCALE as well as the possibility to use any reflective surface as reference for the position measurement. This way the measurement point can be set exactly to the point of interest without any additional mechanical parts in the measurement chain, which could influence the precision.
Note that the setup of the **PICO**SCALE requires an adjustment of the sensor heads which is not described in this user guide. For a detailed description please refer to the *PicoScale Quick Installation Guide* and *PicoScale User Manual*.

HARDWARE SETUP

The **MCS**2 requires one sensor module per three channels. A **PICO**SCALE has three measurement channels and therefore can replace one **MCS**2 sensor module. For devices with more than three channels, additional sensor modules or **PICO**SCALE interferometers are required. Combining **MCS**2 sensor modules and **PICO**SCALE sensors is possible but only in groups of three channels. E.g., for a six channel **MCS**2 a **PICO**SCALE laser interferometer may be used for channel 1 to 3 and an **MCS**2 sensor module for channel 4 to 6.
For the setup described in this user guide a three channel **MCS**2 and a two channel linear positioning stage with integrated **PICO**SCALE sensor heads is assumed. The following hardware is required:

- An **MCS**2 controller including a matching power supply.
- A **PICO**SCALE laser interferometer.
- An adapter-cable (MCS2-A-PS-CABLE-1.5M-1.5M) to connect the **PICO**SCALE to the **MCS**2. This cable acts as a bridge between **MCS**2 and **PICO**SCALE. It connects the digital sensor data from the **PICO**SCALE to the **MCS**2 and provides three D-SUB-15 connectors for the actuator driving signals from the **MCS**2 to the positioning stage.

- A positioning stage of up to three channels per **PICO**SCALE or sensor module. Internal position sensors are not required (if there are any, they are not used by the **MCS**2). Note that positioners with integrated **PICO**SCALE sensor head are available. These positioners feature an already aligned build-in mirror. If these are not used, a reflecting mirror for the interferometer measurement must be mounted to the slides of the positioners.
- To perform the software configuration of the **MCS**2 and to execute the sensor head adjustment of the **PICO**SCALE either an **MCS**2 hand control module (which may be integrated into the main controller or placed inside a separate housing) or a service PC to run the configuration software is required.

Figure 1 shows how the components must be connected. To prepare the setup make the following connections:

- Connect the male D-SUB connector of the MCS2-A-PS-CABLE-1.5M-1.5M adapter to the **MCS**2 D-SUB sensor module connector and the female connector of the adapter to the "SmarAct sensor interface" labeled D-SUB connector of the **PICO**SCALE.
- Connect the positioning stage to the devices. For this, two connections are required:
    1. The actuators which are driven by the **MCS**2 must be connected to the D-SUB connectors of the adapter cable.
    2. The glass fibers of the sensor heads for the position measurement must be connected to the optical sockets of the **PICO**SCALE.

  Note that the channel order must be equal for the **MCS**2 and the **PICO**SCALE for proper operation.
- Connect power cord and power supply to the devices.
- If an **MCS**2 hand control module is available, it may be used for the configuration, otherwise a service PC is required. The PC may be connected via USB or ethernet to the **MCS**2 depending on
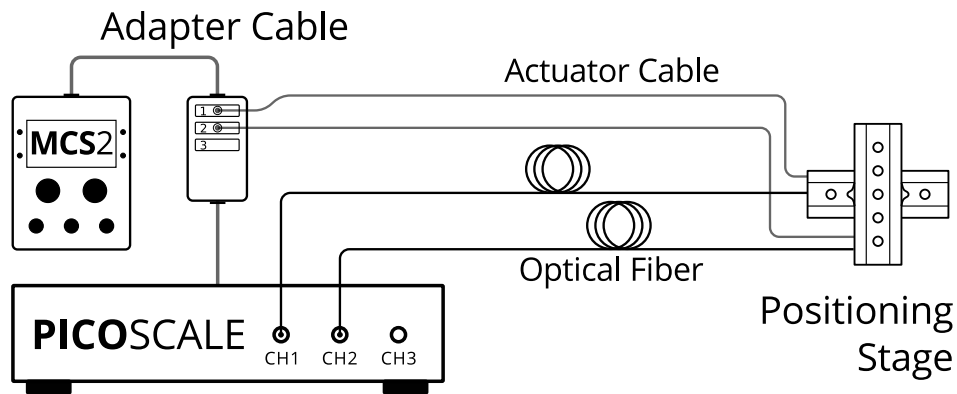
Figure 1. *Hardware Setup of* **MCS**2*,* **PICO**SCALE *and Positioning Stage*

the type of build-in interface. The **PICO**SCALE features both interfaces, USB and ethernet, for the connection to a PC. Note that the PC connection to the **PICO**SCALE is only required for the initial configuration but not for the later positioning operations with the **MCS**2. For more specific connecting information please refer to the user manuals of the devices.

After all electrical and optical connections have been made, power up the devices and proceed with the software setup.

SOFTWARE SETUP

The firmware of the **MCS**2 and the **PICO**SCALE supports the connection of the devices as a base feature. No special firmware or feature upgrades are required. When connecting the **PICO**SCALE to the **MCS**2 the type of sensor module is detected automatically, the data stream is configured and the appropriate filter and stream rates are set. Nonetheless, some additional software configuration is required to route the **PICO**SCALE position signal to the sensor feedback input of the **MCS**2 and to setup the closed-loop operation. For this, please follow the instructions in the given order.

MCS2 Configuration

All configuration steps may be executed with the *MCS2 Service Tool* or with the *MCS2 hand control module*. On the hand control module the settings are available in the channel configuration menu. Note that all described settings must be configured for all active channels.

- First, the positioner type must be configured to
  - **CT044/AT001 (360)** or
  - **CT044/AT002 (361)**

  depending on the type of actuator. The control-loop parameters of these types are tested for positioners with integrated sensor heads. If these are not used, an additional custom tuning may be needed later depending on the mechanical

setup and load to adjust the control-loop for stable closed-loop operation.

- The *control loop input* property must be set to "sensor" for all active channels. For all channels which are not used (no sensor head is connected) the *control loop input* property should be set to "disabled". This way the unused measurement channels are disabled on the **PICO**SCALE. This excludes them from the adjustment which may increase the signal quality. Note that the update of this setting is only executed while connecting the **PICO**SCALE. Therefore a power cycle of the **MCS**2 may be needed to apply the changes.
- By default the **MCS**2 will use the **PICO**SCALE position data source as input for the control-loop. For this the *sensor input select* property must be set to "position". Alternatively, the calculation system can be selected as input by setting the property to "calc-sys". The calculation system of the **PICO**SCALE allows more advanced setups, e.g. angular measurements, but requires additional configuration on the **PICO**SCALE.

Note that these properties are stored to non-volatile memory and need not be configured on every power-up.

PicoScale Adjustment

As a precondition for the position measurement with the **PICO**SCALE, an adjustment process must be executed to align the sensor heads in front of the target mirrors and to optimize the signal quality. The adjustment consists of a manual and an automatic procedure. Also the required *working range* must be specified in the course of the adjustment process. If positioners with integrated sensor heads are used, no physical alignment of the head and mirror is required, since the components are already properly aligned while manufacturing. For the adjustment the *PicoScale Control GUI* may be used. Please refer to the *PicoScale User Guide* for detailed information on the adjustment process.
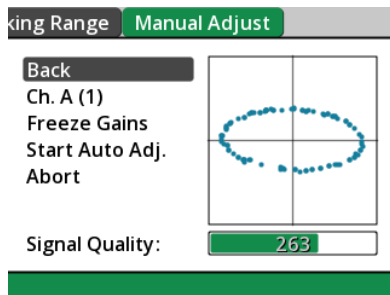
Figure 2. PICOSCALE *Mirror Adjustment on the* MCS2 *Hand Control Module*

If an **MCS**2 hand control module is available, the adjustment sequence may also be started from the menu of the hand control module. Figure 2 shows the corresponding menu.

Once the adjustment has finished, the **PICO**SCALE outputs position data for all active channels which is available as *current position* in the **MCS**2. Different system conditions of the **PICO**SCALE are merged to the "sensor present" *channel state* flag of the **MCS**2 which then indicates the stable position measurement. Note that the "sensor present" flag is a precondition for the **MCS**2 to command closed-loop movement. A "no sensor present" error will be generated when starting a movement if the flag is not set. Check the position measurement resp. repeat the adjustment of the **PICO**SCALE in that case.

MCS2 Calibration and Movement

After the **MCS**2 has been configured and the **PICO**SCALE has been adjusted, each channel of the **MCS**2 must be **calibrated**. The calibration sequence automatically determines (and adjusts) the direction sense between sensor and actuator. The calibration may be started with the *MCS2 Service Tool* or with the *MCS2 hand control module*.

After that, a closed-loop movement may be started to test the setup. For this, specify the *move velocity* and *move acceleration* and start a relative closed-loop movement. If everything is setup correctly, the movement will be executed without any errors.

Note that a custom tuning of the control-loop may be needed for stable closed-loop operation. If an oscillation of the stage or unstable position is observed while moving or actively holding the position the PID gains have to be adjusted. Refer to the *MCS2 Programmers Guide* and *MCS2 Service Tool Manual* for more information on the custom tuning.

MCS2 Referencing

Starting the **referencing** on the **MCS**2 will move the positioner towards one end of the travel range until a mechanical endstop is detected. Here the position is set to zero. Before starting the referencing, the *move velocity* and *move acceleration* as well as the *safe direction* properties should be configured to define the

move parameters and search direction.

Furthermore, make sure that the end position is covered by the configured *working range* of the **PICO**SCALE to guarantee stable position measurement over the entire travel range of the positioner.

Note that the precision of the reference detection is limited due to the fact that only the mechanical endstop can be used as reference and no additional absolute sensor feedback is available to refine the reference search. Instead of using the referencing sequence, the position may be set to any arbitrary value with the *position* property at a known (externally determined) physical position to establish a reference position. If desired, the position scale may be inverted with the *logical scale inversion* property.

Differences to MCS2 Sensor Module Operation

When a **PICO**SCALE is used as a sensor module, some functions and properties are not available or behave differently. Differences are listed in the following:

- The *sensor power mode* property has no effect since no position sensors are connected directly to the **MCS**2.
- The *signal correction options* property has no effect on the sensor signal.
- The *logical scale inversion* inverts the current position *including* the logical scale offset while with the **MCS**2 sensor module the offset is added *after* the inversion of the position.
- Setting the *position* property updates the position of the **MCS**2 and the **PICO**SCALE simultaneously.
- The *sensor input select* property must be used to configure which data sources of the **PICO**SCALE are used for the closed-loop feedback (position or calc-sys).
- The *positioner sensor head type* property may be used to configure the head type which is set to the **PICO**SCALE when an adjustment sequence with the hand control module is started.

CONCLUSION

The setup and configuration of a linear positioning stage with **PICO**SCALE sensor feedback has been described in this user guide. For this setup the position data source of the **PICO**SCALE has been used directly as feedback signal for the control-loop of the **MCS**2.

The **PICO**SCALE offers sophisticated calculation options when using the calculation system. This allows e.g. to perform angular measurements. The calculation system is then used to calculate the tilt angle from the measured distances of two sensor channels. The resulting "calc-sys" datasource may be configured as feedback signal for the **MCS**2 instead of the position datasource. Refer to the **PICO**SCALE user guide *PS-UG00009_AngularMeasurements* which gives an example for the usage of the calculations system.

Sales partner / Contacts

Germany

SmarAct GmbH

Schuette-Lanz-Strasse 9
26135 Oldenburg
Germany

T: +49 441 - 800 879 0
Email: info-de@smaract.com
www.smaract.com

France

SmarAct GmbH

Schuette-Lanz-Strasse 9
26135 Oldenburg
Germany

T: +49 441 - 800 879 956
Email: info-fr@smaract.com
www.smaract.com

USA

SmarAct Inc.

2140 Shattuck Ave. Suite 302
Berkeley, CA 94704
United States of America

T: +1 415 - 766 9006
Email: info-us@smaract.com
www.smaract.com

China

Dynasense Photonics

6 Taiping Street
Xi Cheng District,
Beijing, China

T: +86 10 - 835 038 53
Email: info@dyna-sense.com
www.dyna-sense.com

Natsu Precision Tech

Room 515, Floor 5, Building 7,
No.18 East Qinghe Anning
Zhuang Road,
Haidian District
Beijing, China

T: +86 18 - 616 715 058
Email: chenye@nano-stage.com
www.nano-stage.com

Shanghai Kingway Optech Co.Ltd

Room 1212, T1 Building
Zhonggeng Global Creative Center
Lane 166, Yuhong Road
Minhang District
Shanghai, China

Tel: +86 21 - 548 469 66
Email: sales@kingway-optech.com
www.kingway-optech.com

Japan

Physix Technology Inc.

Ichikawa-Business-Plaza
4-2-5 Minami-yawata,
Ichikawa-shi
272-0023 Chiba
Japan

T/F: +81 47 - 370 86 00
Email: info-jp@smaract.com
www.physix-tech.com

South Korea

SEUM Tronics

1109, 1, Gasan digital 1-ro
Geumcheon-gu
Seoul, 08594,
Korea

T: +82 2 - 868 10 02
Email: info-kr@smaract.com
www.seumtronics.com

Israel

Trico Israel Ltd.

P.O.Box 6172
46150 Herzeliya
Israel

T: +972 9 - 950 60 74
Email: info-il@smaract.com
www.trico.co.il