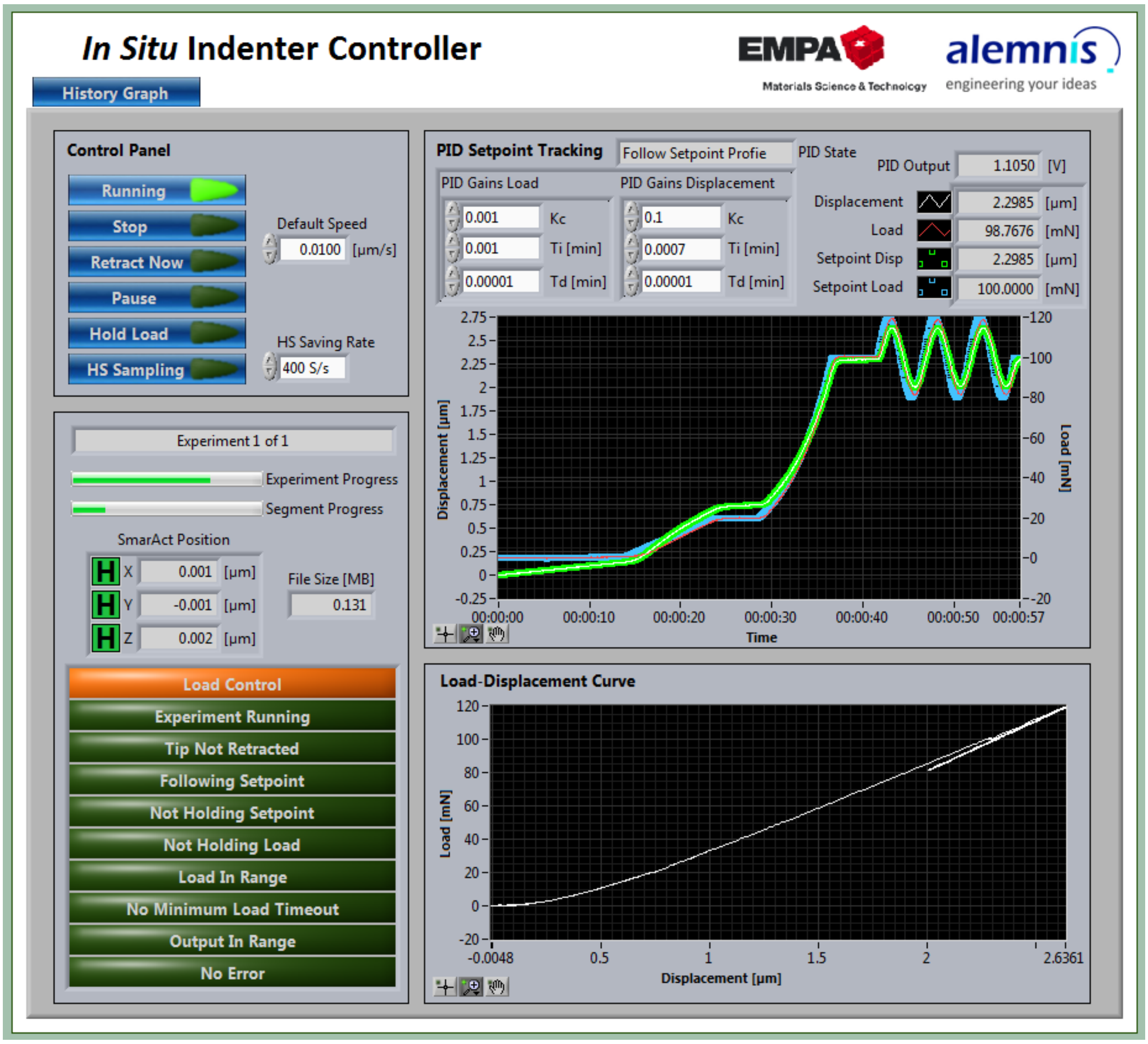
AMICS Manual

For questions please contact damian.frey@empa.ch or damian.frey@bluewin.ch directly



Index

1. Software installation and Hardware configuration 5
I. SmarAct actuators 5
II. Input channels 5
III. Output channels 5
IV. *Noliac* piezo driver 5
2. Computer system requirements 6
3. Configuration file (*.ini) 7
I. System Settings 7
a) Compliance 7
b) Debug 7
c) Default Data Path 7
II. Channel Settings 7
a) Sampling Frequency 7
b) PID Frequency 7
c) Output Frequency 7
d) Overload 7
e) Load and Displacement Drift Limit 8
f) Allowed Displacement Offset 8
g) Load and Displacement Channel 8
h) Aux ai2 and Aux ai3 Channel 8
i) Output Channel 8
III. PID Settings 8
a) Displacement and Load Kc 8
b) Displacement and Load Ti 8
c) Displacement and Load Td 9
IV. SmarAct Settings 9
a) X, Y & Z Axis Index 9
b) Hold Time 9
c) Hold After Stop 9
d) Z Axis? 9
4. Alemnis Micro Indenter Control Software (AMICS) Overview 10
I. Starting *AMICS* 10
II. System settings page 10

III. Setup page ... 11
IV. Setup experiments ... 11
V. Setup batch experiment ... 12
VI. Run experiments page ... 12
VII. History graph ... 13
5. System settings ... 14
I. Allowed displacement offset ... 14
II. Output channel ... 14
III. Input channels ... 14
IV. Drift limits ... 14
V. System compliance ... 14
VI. Connect to *SmarAct* controller ... 14
VII. History graph setup ... 14
6. Setup ... 15
I. Sensor status ... 15
e) Drift ... 15
f) Noise ... 15
g) Current values ... 15
h) Filter rank ... 15
i) Graph with displacement and load values ... 15
II. Tare sensors ... 15
III. Manual tip control ... 16
IV. Current experiment ... 16
V. Batch pattern preview ... 16
VI. Positioning control ... 16
VII. Log file settings ... 17
7. Setup experiments ... 18
I. Control types ... 18
II. Open loop oscillation ... 18
III. Load Control Parameter: ... 18
IV. Segment parameter ... 18
V. Scratch parameter ... 19
VI. Experiment preview ... 19
8. Setup batch experiment ... 20
9. Running experiments ... 21

I. Control panel ... 21

II. Experiment status ... 21

III. PID setpoint tracking ... 21

IV. Load displacement graph ... 22

10. History graph ... 23

11. Remarks ... 24

I. Thermal drift ... 24

II. Noise level ... 24

12. Credits ... 25

1. Software installation and Hardware configuration

Install the *SmarAct* drivers from the CD. Connect the *SmarAct* controller to your computer to finish the installation of the drivers before starting the *Alemnis Micro Indenter Control Software (AMICS)*. It is suggested to use the stage sensors in power-save mode to avoid thermal drift. For more Information about the *SmarAct* actuators please refer to the manual or the website http://www.smaract.de/

Install the *National Instruments Measurement & Automation Explorer (MAX)* and the National Instruments hardware drivers NI DAQmx from the CD/DVD before starting AMICS installation. Plug the DAQ hardware to your computer. For more information about MAX and wiring of the *National Instruments* data acquisition hardware please refer to the *MAX* manual or the website http://www.ni.com/

Install AMICS and restart the computer. After restart check if MAX has assigned the virtual channels to the correct device, module and physical channel. If not, change the assigned physical channels.

I. SmarAct actuators

AMICS allows controlling the *SmarAct* actuators with the *SmarAct* hardware controller or with *AMICS*. However, when controlling with *AMICS*, the actuators might move slower than expected when using the hardware controller (Solution: set the speed in *AMICS* to a higher value).

II. Input channels

Use *MAX* to create virtual channels (Bridge mV/V Input). Create one channel for each sensor (i. e. if multiple load cells are available) and link a scaling (based on the calibration of the sensor) to it. Assign the scaled units to the scale (these units will be used by *AMICS*).

Note: All channels on one module which are used simultaneously must have the same excitation voltage (typically 5 V for good signal to noise ratio and low thermal drift).

III. Output channels

Use *MAX* to create virtual channels. Create one channel for each actuator (i. e. if multiple piezos are available) and link a scaling if the channel is used as open loop displacement channel. Assign the scaled units to the scale (these units will be used by *AMICS*). If no scale is assigned to the output channel *AMICS* uses Volt [V].

IV. *Noliac* piezo driver

Connect the *Noliac* piezo driver to the piezo actuator according to the manual (make sure you have only one ground loop). Choose output piezo driver range with the jumpers according to your piezo actuator.

2. Computer system requirements

These requirements were not tested. It is also depending on what other applications are running on the same computer at the same time. The software needs to run stable so that the PID loop (200 Hz) is performing well (you might have to change the PID loop frequency in the configuration file).

Architecture	Windows XP or later
Processing Power	1.5 GHz Dual-core CPU
Memory	2 GB RAM
Secondary storage	1 GB free disk space (only if National Instruments software is not present)
Screen resolution	1280 x 1024

3. Configuration file (*.ini)

The default configuration file is located in the same folder as the *AMICS* exe file. If you use several configurations (i. e. to use several load cells) you should save them to the configured default path.

I. System Settings

a) Compliance

Unit is displacement per load (i. e. [µm/mN], depending on scaled units of used channels).

This value has to be measured by applying a rigid connection of the load cell and the piezo actuator. Move back and forth with the piezo actuator and fit a slope to the measured displacement-load curve. The compliance is used for compliance corrected displacement logging as well as for Compliance Corrected Displacement control.

Valid values: >0

b) Debug

This can be set to true to see some debug values while running *AMICS*. Normally not used.

Valid values: True, False

c) Default Data Path

Default Data Path is used to save the log files as well as settings files (unless you change to another location).

Valid values: all valid paths, folders separated by backslash "\" (please note that folders which need administrator rights might cause errors)

II. Channel Settings

a) Sampling Frequency

This is the frequency which is used to acquire data from the input channels. Best is to set it to the maximum allowed frequency of your input device (lower noise values).

Valid values: 50000, 40000, 25000, 20000, 10000, 5000, 4000, 2500, 2000, 1000, 500, 400, 250, 200, 100, 50, 40, 25, 20, 10

b) PID Frequency

This is the frequency with which the PID loop is running (you might have to use slower PID loop when running *AMICS* on weak computers).

Valid values: common dividers of Sampling Frequency (200, 100, 50, 40, 25, 20, 10, 5, 4, 2, 1)

c) Output Frequency

This is the output frequency which is used in the Open Loop Displacement mode only (in closed loop modes Output Frequency is equal to PID Frequency).

Valid values: all common dividers of Sampling Frequency

d) Overload

Unit is load unit (i. e. [mN], depending on scaled units of used load channel).

This value has to be set to a value which is around the maximum load of the load cell (it will protect the load cell since *AMICS* will retract to zero displacement when this value is exceeded).

Valid values: >0

e) Load and Displacement Drift Limit

Units are load and displacement units (i. e. [mN] and [µm], depending on scaled units of used load channel).

Set a Load Drift Limit and a Displacement Drift Limit. These values have no effect except coloring the indicator background on the setup page when the drift is out of limits.
Valid values: >0

f) Allowed Displacement Offset

Unit is displacement unit (i. e. [µm], depending on scaled units of used displacement channel).

Set the allowed displacement offset. To start an experiment, the absolute displacement must be lower than this value (tare the displacement before starting the experiment).
Valid values: >0

g) Load and Displacement Channel

These are the names of the virtual Load Channel and the virtual Displacement Channel configured in *MAX*.

Valid values: Strings with names of configured channels in *MAX*

h) Aux ai2 and Aux ai3 Channel

These are the names of the virtual Aux ai2 and the Aux ai3 Channel configured in *MAX*.

Valid values: Strings with names of configured channels in *MAX*

i) Output Channel

This is the name of the virtual Output Channel configured in *MAX*.

Valid values: String with name of configured channel in *MAX*

III. PID Settings

a) Displacement and Load Kc

These are the PID proportional gains to use. See general PID algorithm descriptions for more information.

Valid values: ≥0

b) Displacement and Load Ti

These are the PID integral times in minutes to use. See general PID algorithm descriptions for more information.

Valid values: ≥0

c) Displacement and Load Td

These are the PID derivative times in minutes to use. See general PID algorithm descriptions for more information.

Valid values: ≥0

IV. SmarAct Settings

a) X, Y & Z Axis Index

Axes Indexes like configured on the SmarAct controller.

Valid values: Integers (typically 0, 1, 2)

b) Hold Time

Hold Time after closed loop move. 60000 refers to infinite

Valid values: Integers 0..60000

c) Hold After Stop

If True: axis move 1 nm and hold the position after stopping movement in *AMICS*.

Valid values: True, False

d) Z Axis?

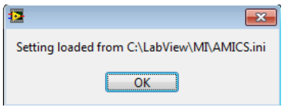
Some Indenters do not have SmarAct Z axis. Set it to True if yours has.

Valid values: True, False

4. Alemnis Micro Indenter Control Software (AMICS) Overview

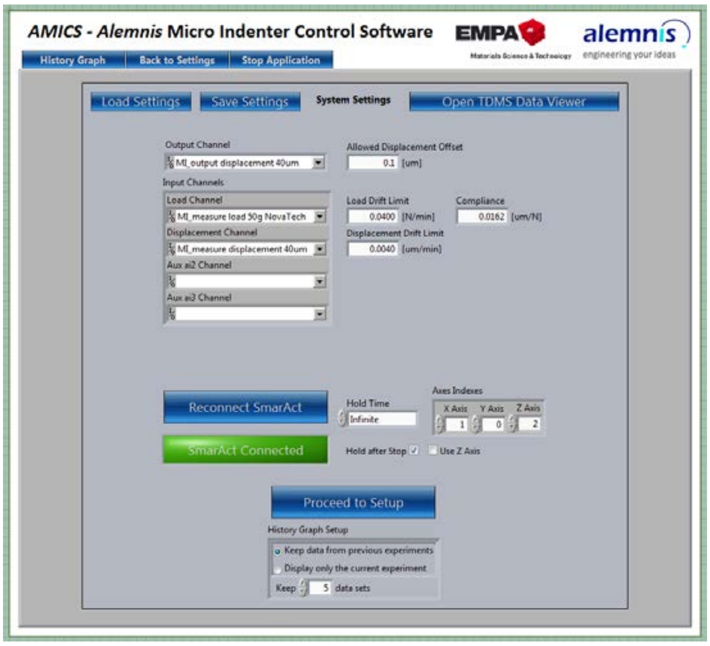
I. Starting *AMICS*

First a popup message with the path of the loaded settings file appears.



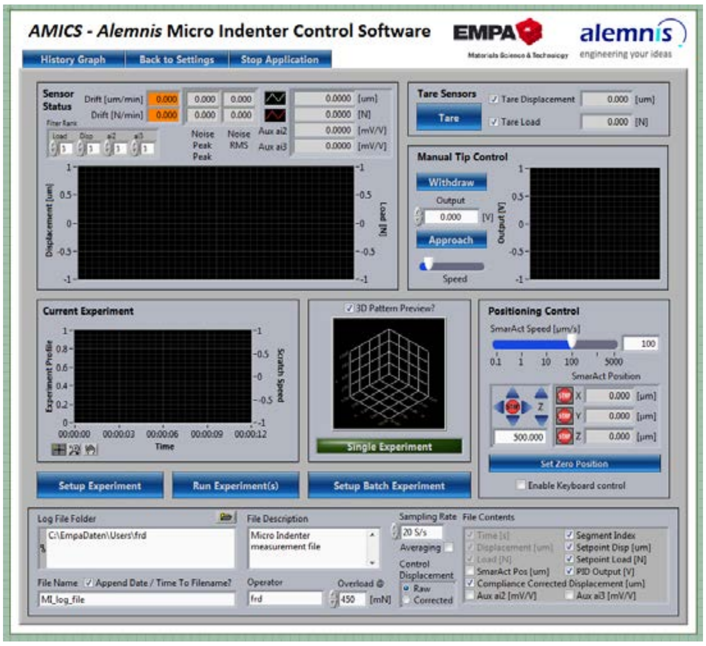
II. System settings page

- Choose the input and output channels
- Set drift limits and system compliance
- Connect *SmarAct* controller and set hold time (refer to *SmarAct* manual)
- Set history graph length
- Open TDMS Data Viewer
- Save and load settings (might be used for different PID settings for load control for hard and soft materials or different load cells / piezo actuators)



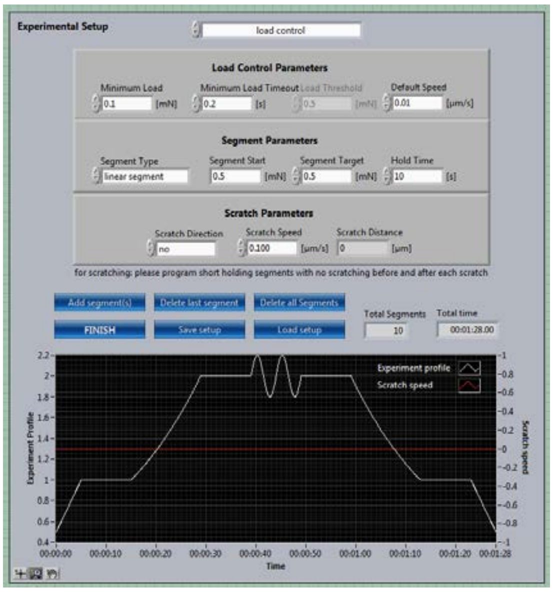
III. Setup page

- Sensor status, set filter ranks
- Tare sensors
- Manual tip control (move piezo actuator)
- Setup experiment(s)
- Control *SmarAct* stage
- Log file settings



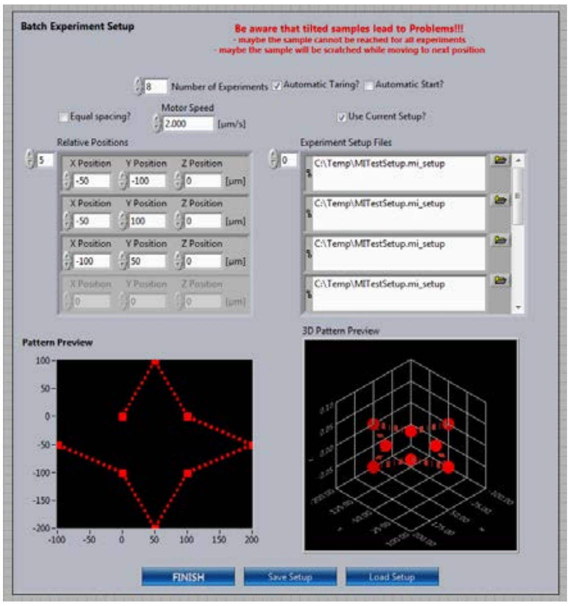
IV. Setup experiments

- Choose control type
- Set load control parameter
- Add segments (linear, proportional, sinus and repeat segments, scratch)
- Save and load setup
- Experiment preview



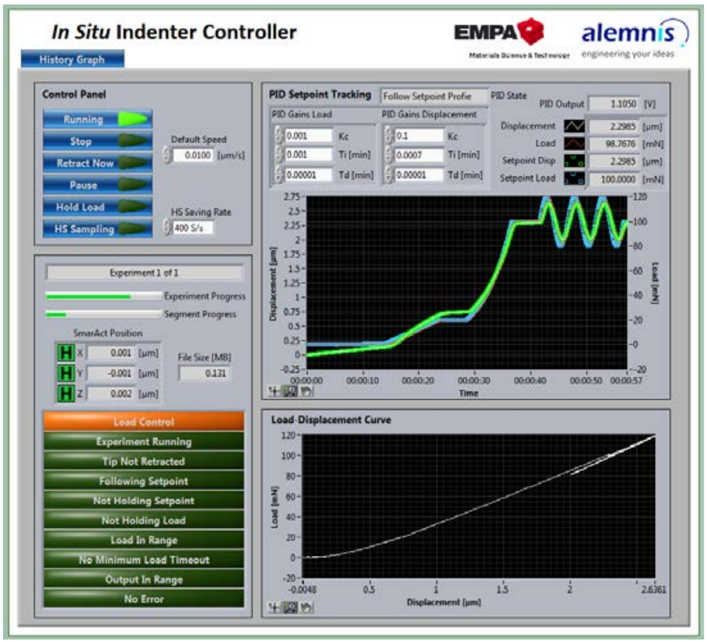
V. Setup batch experiment

- Choose positions with relative coordinates
- Set motor speed
- Choose experiment setup files (different experiments for each position possible)
- Enable / disable automatic taring / automatic start
- Preview
- Save / load batch experiment



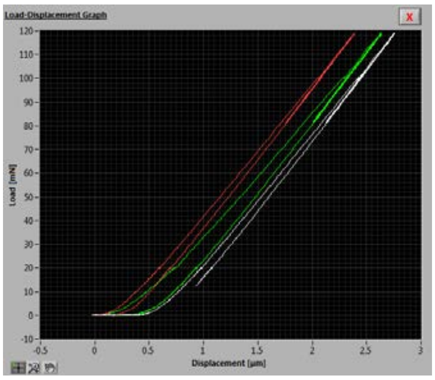
VI. Run experiments page

- Start / stop experiment
- Enable / disable high speed sampling
- Experiments status
- Graphs 20 samples per second update
- PID tuning



VII. History graph

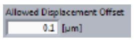
- Load - displacement graph from the current and the latest experiments
- A few samples per second update



5. System settings

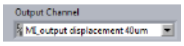
I. Allowed displacement offset

Set the allowed displacement offset. To start an experiment, the absolute displacement must be lower than this value (tare the displacement before starting the experiment).



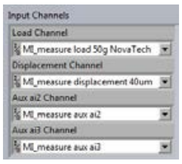
II. Output channel

Choose the virtual channel which is configured by *MAX* and wired to the *Noliac* piezo driver.



III. Input channels

Choose the Input channels which are configured by *MAX* and wired to your sensors. In addition to the load and displacement channels two auxiliary channels are available for two additional bridge sensors.

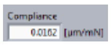


IV. Drift limits

Set a load drift limit and a displacement drift limit. These values have no effect except coloring the indicator background on the setup page when the drift is out of limits.

V. System compliance

Set system compliance. This has to be measured by applying a rigid connection of the load cell and the piezo actuator. Move back and forth with the piezo actuator and fit a slope to the measured displacement-load curve. The compliance is used for compliance corrected displacement logging as well as for compliance corrected displacement control.

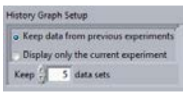


VI. Connect to *SmarAct* controller

Connect / reconnect *AMICS* to the *SmarAct* controller. Enable / disable using Z axis. Set the hold time (refer to manual for more information). Enable / disable hold after stop option (normally when stopping the actuators the position is not hold. With this option enabled *AMICS* moves all axes by 1 nm so that the controller holds the position). Set Axes Indexes.

VII. History graph setup

Set the number of experiments which should be shown in the history graph (current experiment plus previous ones). The history graph has an update rate of five samples per second.



6. Setup

I. Sensor status

e) Drift

Displacement and load drift indicator shows the slope of a linear fit to the measured displayed in the graph. If it is out of limits the indicator has an orange colored background.

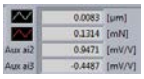
→ displacement drift OK, load drift out of limits

f) Noise

Noise indicator shows the peak to peak noise as well as the RMS noise of the displacement and the load channel.

g) Current values

This indicator shows the current values of the displacement (white plot), the load (red plot) and the two auxiliary input channels (no plot).

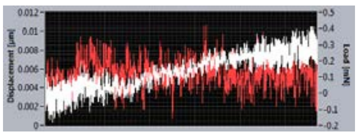


h) Filter rank

Set the median filter rank for each channel. Default is rank 3. This filter is applied to the shown as well as to the saved data.

i) Graph with displacement and load values

This graph indicator shows the values of the displacement (white plot, left Y scale) and the load (red plot, right Y scale). Use this graph to approach the tip to the sample and detect contact. It can also provide visual information about noise and drift levels.

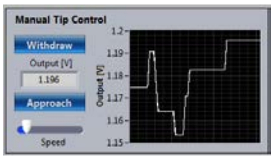


II. Tare sensors

Set the current displacement and / or load value to zero (enable / disable displacement and load taring individually, auxiliary channels are always tared). Indicator shows current taring values. For batch experiments with automatic start only the checked channels will be tared automatically.

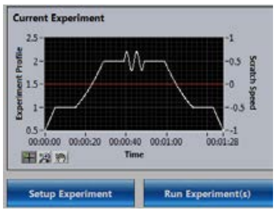
III. Manual tip control

Move the tip back and forth with withdraw and approach buttons or change the output directly. Set the speed to move the tip. Graph and numerical indicator show the current output value on the output channel.



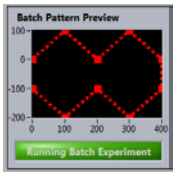
IV. Current experiment

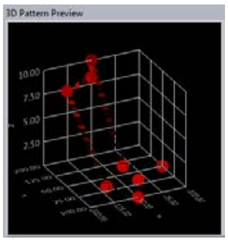
Graph indicator shows the preview of the current experiment profile. Change experiment profile by pressing the setup experiment button. Run experiment(s) by pressing the run experiment(s) button.



V. Batch pattern preview

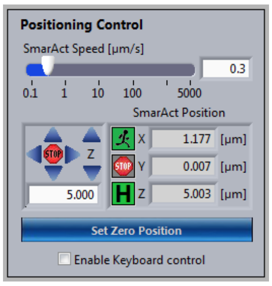
Graph indicator shows a preview of the locations of a batch experiment. Setup a batch experiment by pressing the setup batch experiment button. LED indicator shows whether a batch or single experiment will be run. The second graph shows the 3D preview of the batch experiment.





VI. Positioning control

Use the positioning control to move the *SmarAct* stages in steps or stop all stages. Set the speed and the step size to move the stages. Set the current position to zero. Numerical and graphical indicators show position and state of each axis. Enable keyboard control (LEFT & RIGHT = X axis; UP & DOWN = Y axis; NUMPAD_8 & NUMPAD_2 = Z axis).

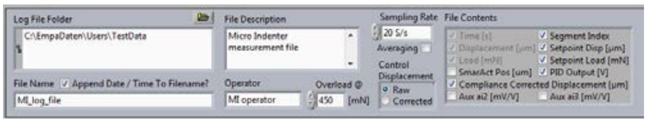


SmarAct states:

- stopped
- moving
- H holding position
- C calibrating

VII. Log file settings

AMICS uses TDMS log files. To open TDMS files directly in Microsoft Excel install the TDMS Excel plugin from http://ftp.ni.com/pub/devzone/epd/tdm_excel_add-in_2012.exe (already installed with the *AMICS* Installer). Select the log file folder (all log files will be saved there, default is default Windows data folder if left empty in config file). Set log file name (file will not be overwritten if this file already exists). Describe the experiment in the file description. Set an operator name (default is windows user name). Set the overload protection threshold (tip will retract when load exceeds this value). Choose the sampling rate (averaging disabled: i. e. 20 S/s: i. e. with PID frequency 200 Hz, one value is saved out of ten. Averaging enabled: i. e. 20 S/s: i. e. with PID frequency 200 Hz, 10 values are averaged and the average value is saved). Choose either to control the raw displacement or the compliance corrected displacement. Choose the file contents (which values will be logged). Choose time to be saved in excel format or elapsed time.

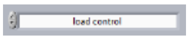


7. Setup experiments

- Add segments
- Delete last segment
- Delete all segments
- Save setup
- Load setup (from setup file or log file)
- Finish (close this window and continue with the current setup)

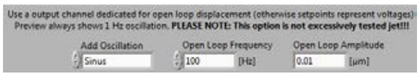
I. Control types

- Open loop displacement (not excessively tested jet, use with care)
- Displacement control
- Load control
- Displacement rate control with targets (targets can be displacement or load)
- Load rate control with targets (targets can be displacement or load)



II. Open loop oscillation

A Sinus can be applied to linear and proportional segments. The amplitude might not be the same for different frequencies, depending on the piezo amplifier and the capacitance of the piezo.



III. Load Control Parameter:

Minimum load → the tip will be retracted when the PID controller is in load control and the load drops below this value longer than minimum load timeout

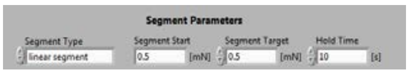
Minimum load timeout → only after this time with load below minimum load the tip will retract

Load threshold → threshold to switch from displacement to load control and back (this value can only be changed when no segments are added)

Default speed → speed used to approach until load threshold is reached and to retract

IV. Segment parameter

- Linear segment (move linearly back and forth or hold value)
- Proportional segment (proportional increase of the setpoint, delta setpoint is calculated by the formula: delta setpoint = last setpoint * proportional constant * dt)
- Sinus (amplitude is ½ peak to peak value, period time is 1 / frequency)
- Repeat segments (set first and last segment to repeat and the number of iterations to be added. See total segments indicator to find the index of the current last segment)



V. Scratch parameter

- Scratch directions (no scratching, right, left, up, down)
- Scratch speed
- Scratch distance indicator shows you how long the scratch will be

If you want to change up, down, left right you can change the axis indexes and the direction of each axis on the SmarAct controller.

VI. Experiment preview

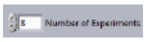
Preview is replaced by a table when setting up rate controlled experiments

Rate-Controlled Experiment Profile

segment index	target	rate	rate type	target type
0	100.000	0.100	linear	load
1	1.000	0.100	linear	displacement
2	50.000	0.100	linear	load

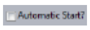
8. Setup batch experiment

Select the number of experiments which will be run in a batch experiment.



Enable automatic taring → the input channels are tared before the start of each experiment
Disable automatic taring → the input channels are not tared before each experiment

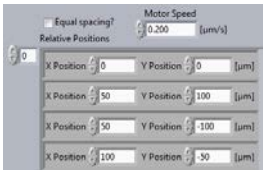
Enable automatic start → the user does not have to press start before every experiment
Disable automatic start → the user has to start each experiment within the batch manually



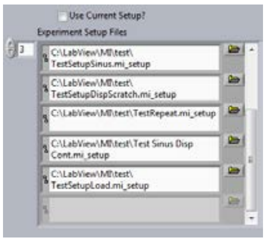
Enable equal spacing → First element in relative positions is the relative position for the first experiment. Second element is the distance to move after each experiment

Disable equal spacing → First element in relative positions is the relative position for the first experiment. Second element is the distance from the first to second experiment. Third is the distance from second to third…

Set the motor speed to move to next position.

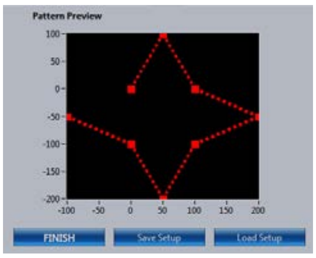


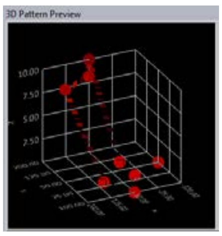
Enable use current setup → use the current setup (from experiment setup) for each experiment
Disable use current setup → select specific experiment setup files for each experiment



Graph indicator shows a preview of the positions for the batch experiment. Second graph shows 3D preview.

Save and load batch experiment setup.





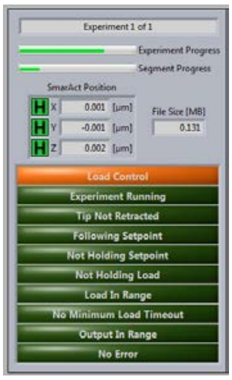
9. Running experiments

I. Control panel

- Start experiment
- Stop experiment
- Finish (goes back to settings page and stops logging)
- Retract to zero displacement (speed is adjustable)
- Pause (holds current displacement or load)
- Hold load (holds the current load)
- High speed sampling (saving rate is adjustable)
- When the experiment has completed or has been stopped by the user you can manually change the displacement setpoint

II. Experiment status

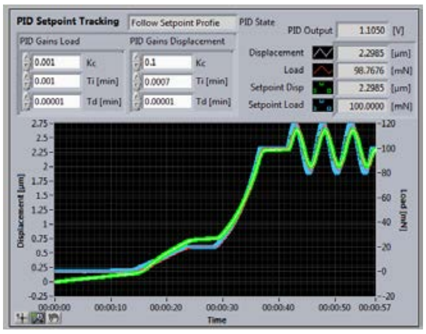
Shows the experiment progress, file size, *SmarAct* stage positions and errors



III. PID setpoint tracking

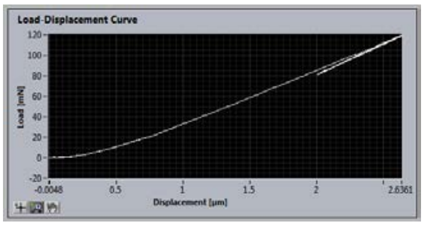
Shows the measured values in a graph as well as numerical indicators

You can tune the PID settings (WARNING: be careful with this, the controller might go crazy and damage tip, sample or even the load cell). PID settings might have to be adapted to material / tip combination for load control experiments or when using another load cell / piezo.



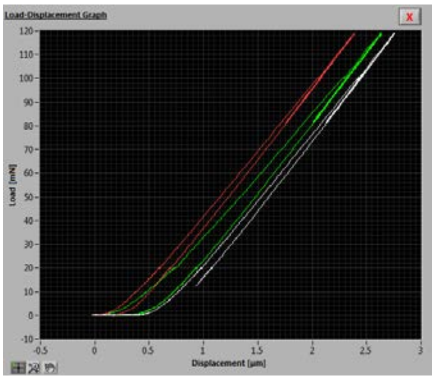
IV. Load displacement graph

This graph shows the load displacement curve of the current experiment (always only the last few values). To see the whole load displacement curve open the history graph.



10. History graph

Shows load displacement graph of several experiments. Unlike the load displacement graph in the run window this graph shows complete experiments. Update rate is lower than in the embedded load displacement graph.



11. Remarks

I. Thermal drift

To avoid a large thermal drift, the excitation voltage for the strain gauges should be adapted to the resistances of the bridges. The thermal drift of the strain gauges and the electronics should be low enough after 15 minutes of measuring (measurement needs to be active, which means the software should be showing measured values → setup page). It is still possible that the drift is higher than expected after these 15 minutes. Then you should think about the thermal stability of the environment.

II. Noise level

The noise level on the input channels is depending on several factors:

- Output of the sensor (slope of the calibration), because the electrical noise level is the same → a higher calibration slope amplifies the noise more than a lower slope
- Excitation voltage, because the electrical noise is the same → a higher excitation voltage amplifies the signal but not the electrical noise
- Filtering: *AMICS* always measures with the sampling frequency configured in settings file and averages each these values to get the PID frequency signal used by the PID controller. Therefore the noise level is much lower than in the original signal measured with sampling frequency. Moreover you can apply the median filter as well as the averaging described earlier in this manual

12. Credits

Alemnis GmbH wants to thank *EMPA (Swiss Federal Laboratories for Materials Science and Technology) - Laboratory for Mechanics of Materials and Nanostructures*. Special thanks go out to the developer of *AMICS* Mr. Damian Frey.