VTEM MotionApp #33 Positioning

Commissioning & Troubleshooting Guide

Introduction

Current scope of MA33

- Positioning of pneumatic drives
  - 30 … 500 mm length (technical data guaranteed)
    - parameterization from 20 to 1000 mm
  - diameter 32, 40 and 50 mm
    (20 and 25 not officially supported)
  - mounted horizontally or vertically (technical data guaranteed)
    - parameterization of intermediate orientation
- Tubes: 8 mm PUN/PAN, 1 … 3 m length
- SDAP Sensors and user-defined sensors
  - whole drive stroke (+overlaps) must be covered
    (no sensor-free zone allowed)
  - piston rod must be mounted non-twistable
    to guarantee repeatability

Future releases of MA33

- other drives (length, diameter)
- continuous setpoints for position (interpolated mode)
- handling of noisy setpoints

MA32 Motion Profile and Force will be dropped with the next release
MA32 will not be supported anymore, please update your applications to MA33. Force control can be implemented with MA03 or MA08

this guide requires VTEM firmware version 4.20.0
or newer – older firmware versions are not supported

MA33 Commissioning & Troubleshooting Guide

Part 1: Commissioning

1. Sensor mounting & parameterization
2. Drive parameterization
3. Teach-In
4. Tuning

Part 2: Advanced Commissioning

1. Extended drive list
2. Online valve calibration during teach-in run

Appendix

1. Common mistakes
2. Helpful resources


Part 1: Commissioning
VTEM MotionApp #33 Positioning
Commissioning & Troubleshooting Guide

Commissioning: Overview

Check list

- ☐ Sensor mounted
- ☐ Sensor parameterized on AI module
- ☐ System parameters (drive & sensor) applied
- ☐ Application parameters applied
- ☐ Plausibility checked
- ☐ Automated teach-in run passed
- ☐ Fine tuning with internal signal generator & trace tool
- ☐ PLC application implemented & tested (functional part)
- ☐ PLC diagnostics & error handling implemented & tested

Please proceed step by step and double check that each task is completed before continuing.

Important Notes

Warnings

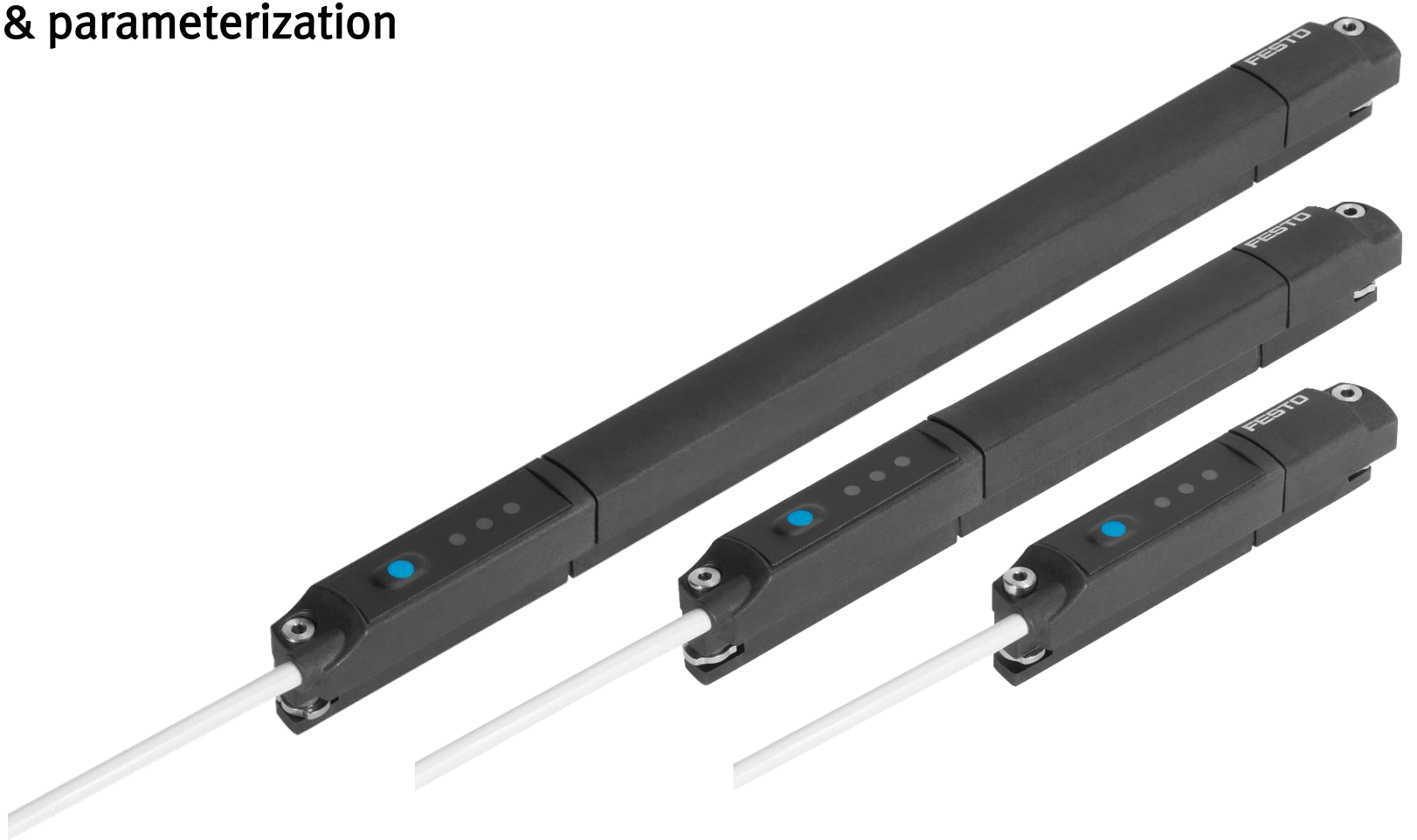
⚠ **Unexpected movement possible** (especially during teach-in)

⚠ **Poor performance possible** due to incorrect parameterization (which might occasionally lead to dangerous movements)

Commissioning: Sensor mounting & parameterization

Supported sensors

- SDAP-MHS-M160[1]
- SDAP-MHS-M100[1]
- SDAP-MHS-M50[1]
- User-defined sensors

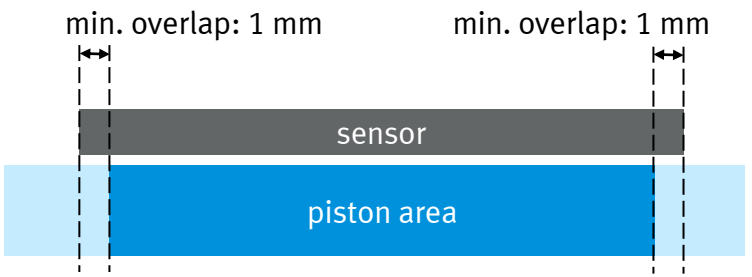


[1] minimal revision of R04

Commissioning: Sensor mounting & parameterization

Sensor mounting (full stroke measurement)

- one single sensor,
  covering the stroke (within mechanical stops)
- positions that cannot be reached mechanically,
  don’t need to be covered by the sensor
- overlaps required



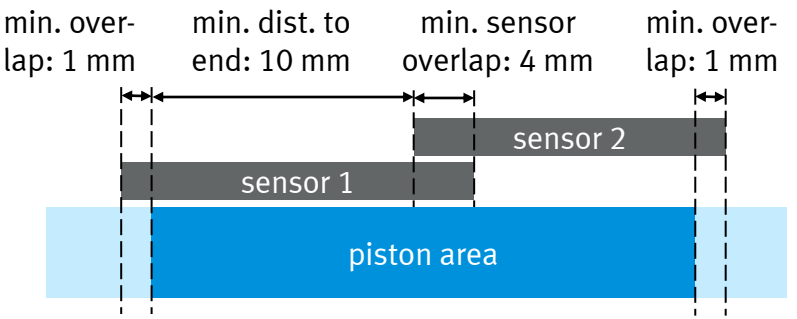
- supported stroke lengths for single sensors

SDAP sensor type	50	100	160
max. stroke (theoretical)	48	98	158
max. stroke (recommended)	40	90	150

recommendations smaller due to effortful sensor mounting process

Sensor mounting (partial stroke measurement)

- two sensors (of same or different length),
  covering the whole stroke (within mechanical stops)
- positions that cannot be reached mechanically,
  don’t need to be covered by the sensor
- overlaps required



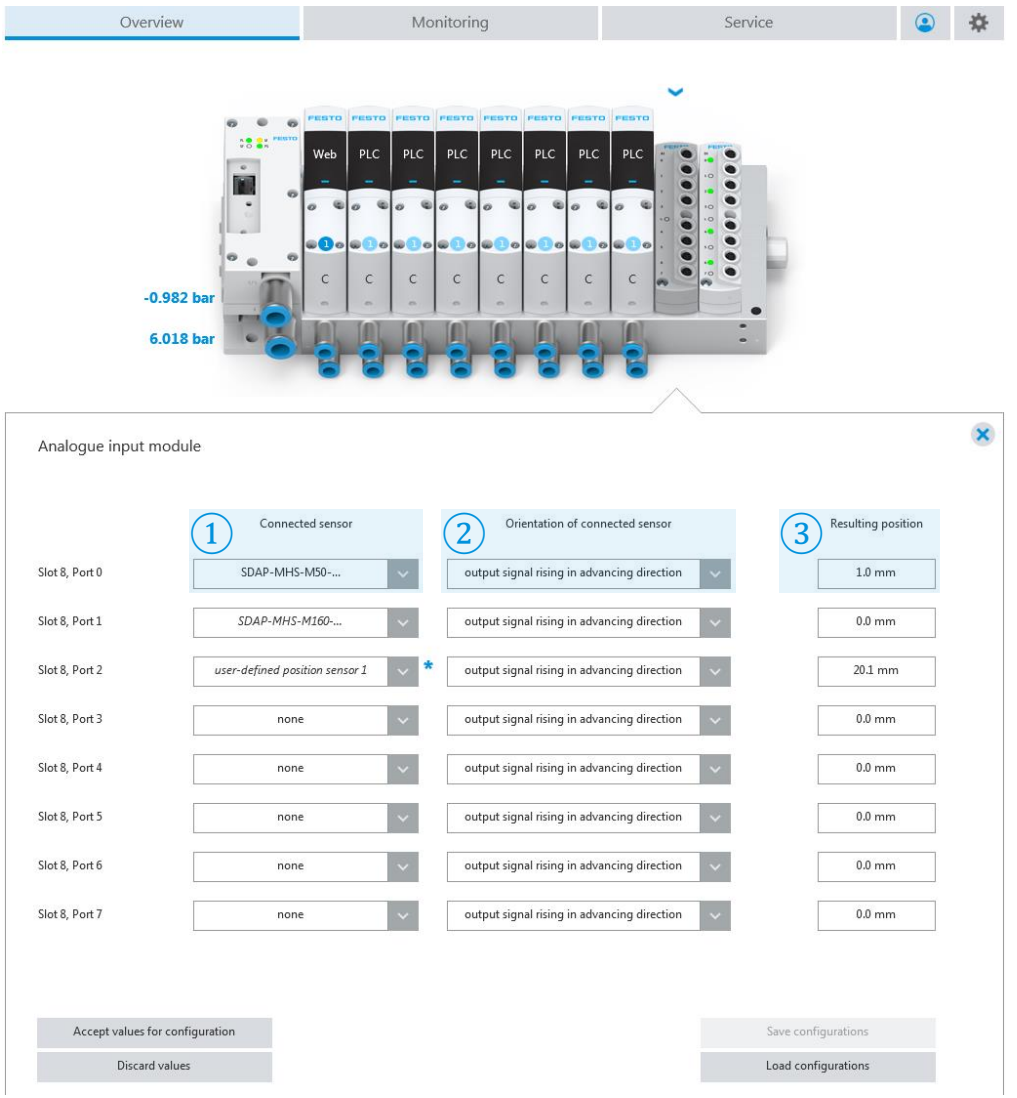
- supported stroke lengths for two sensors

SDAP sensor combination	50+50	50+100	100+100	50+160	100+160	160+160
max. stroke (theoretical)	94	144	194	204	254	314
max. stroke (recommended)	80	130	180	190	240	300

Commissioning: Sensor mounting & parameterization

Sensor parameterization:

- Select corresponding analogue input module on VTEM WebConfig
- For each port that has a sensor attached:
    1. Select the connected sensor type in the dropdown menu
    2. Specify the orientation
       (signal rising/falling in advancing direction)
    3. Check the resulting position signal for plausibility
       (The value shows the relative sensor length)
- Accept values for configuration (and optionally save configurations)



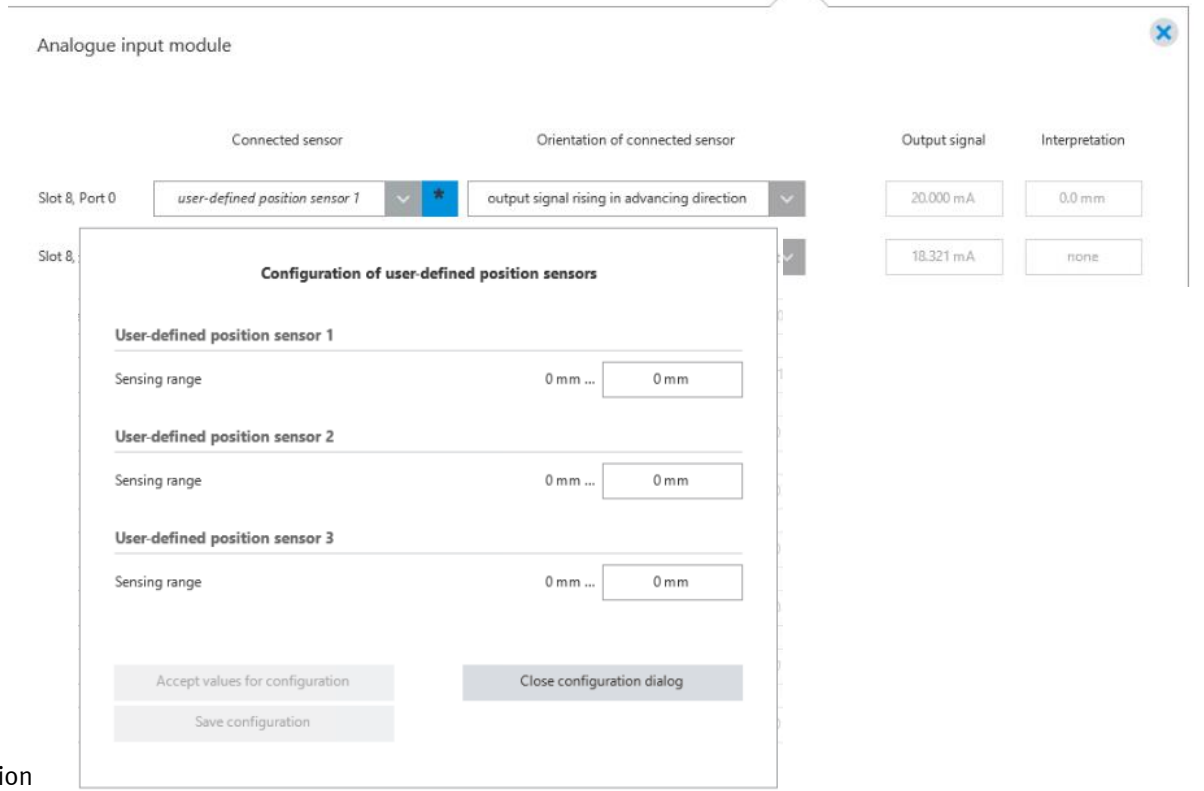
Note: the assignment of sensor to valves/drives is made in the drive configuration

Commissioning: Sensor mounting & parameterization

Sensor parameterization: User-defined sensors

- User-defined position sensors can be defined and selected via the analogue input module configuration page.
- Select a user-defined position sensor (1, 2 or 3). Afterwards, a blue star appears. By clicking on that star, a new configuration page popup appears.
- In that popup, the ranges for up to three user defined position sensor types can be defined. Please accept values for configuration and – optionally – save this configuration.

- Important: Make sure to meet the required specification for the measured position signal which are listed in the official documentation “GAMM-A33 description” [1]

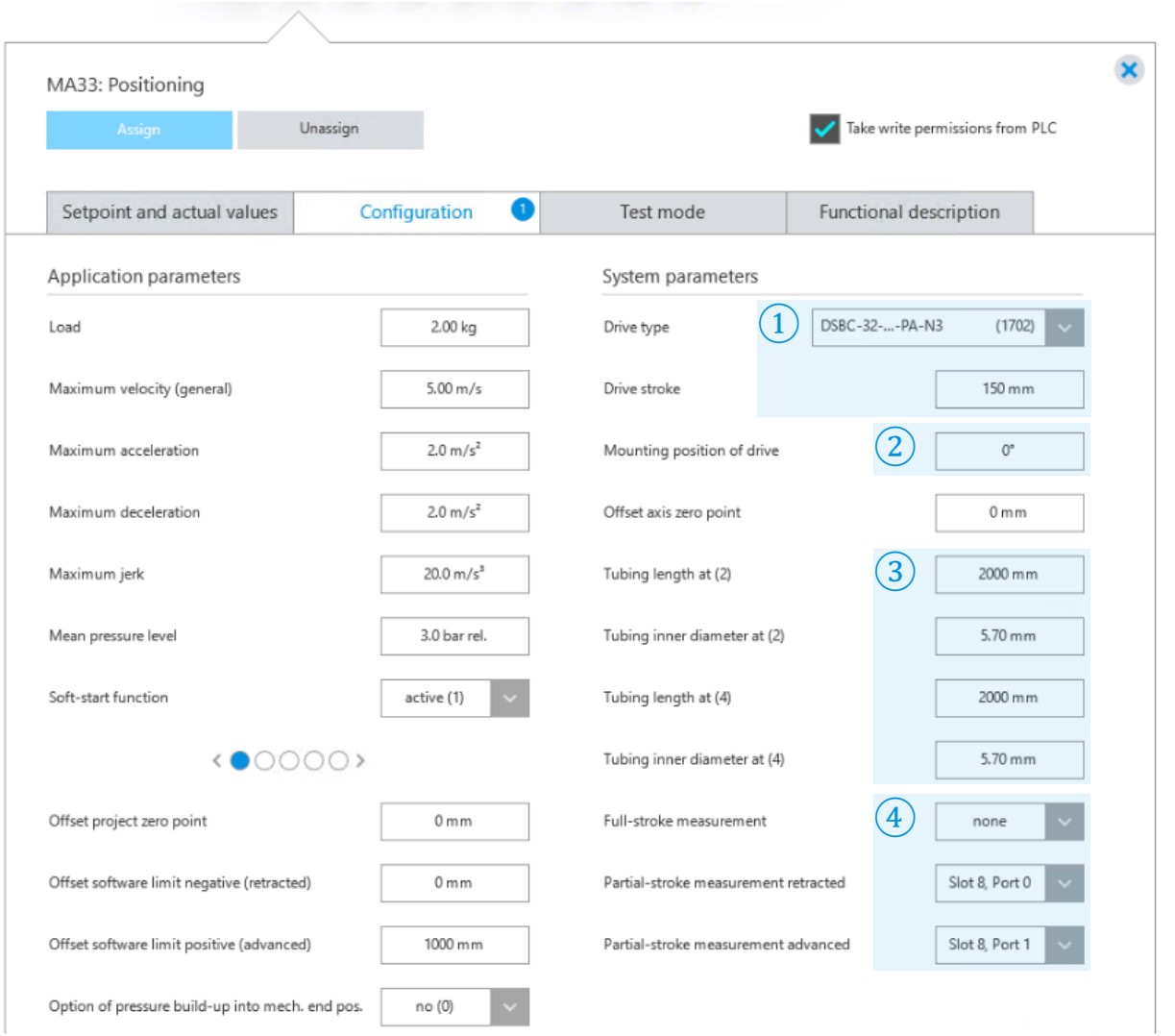


Support Portal: https://www.festo.com/us/en/a/8047502/ ⇢ Support/Downloads: [1]Technical documentation

Commissioning: Drive parameterization

System parameters & sensor selection

- Select the desired valve and assign the positioning app after taking write permissions from PLC
- Select configuration tab
- Parameterize
    1. drive type & drive stroke
       P: recommended, PPV: ok if PPV is fully open,
       PPS: positioning only outside PPS area
    2. mounting position (orientation)
    3. tubing
    4. sensor assignment
        - full stroke measurement
        - partial stroke measurement



Note on tubing:
- Port 4 pressurized ⇒ measured position increases (piston rod cylinder: piston advances)
- Port 2 pressurized ⇒ measured position decreases (piston rod cylinder: piston retracts)

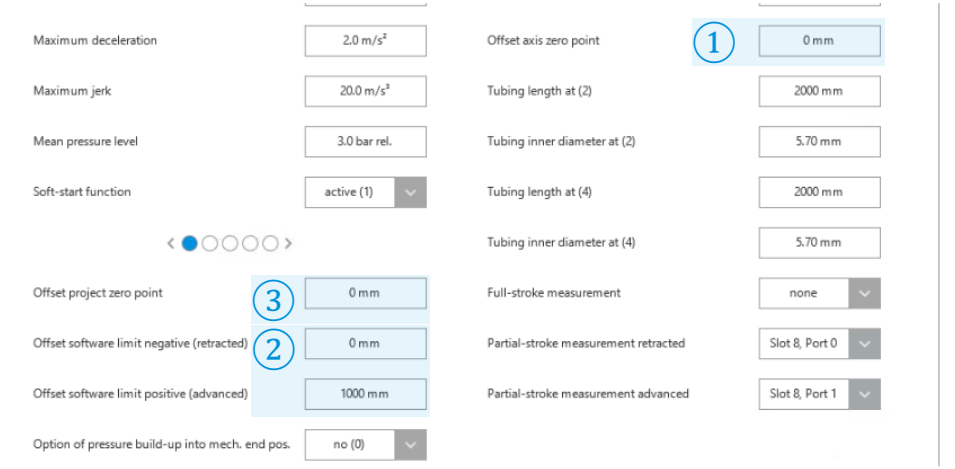
Commissioning: Drive parameterization

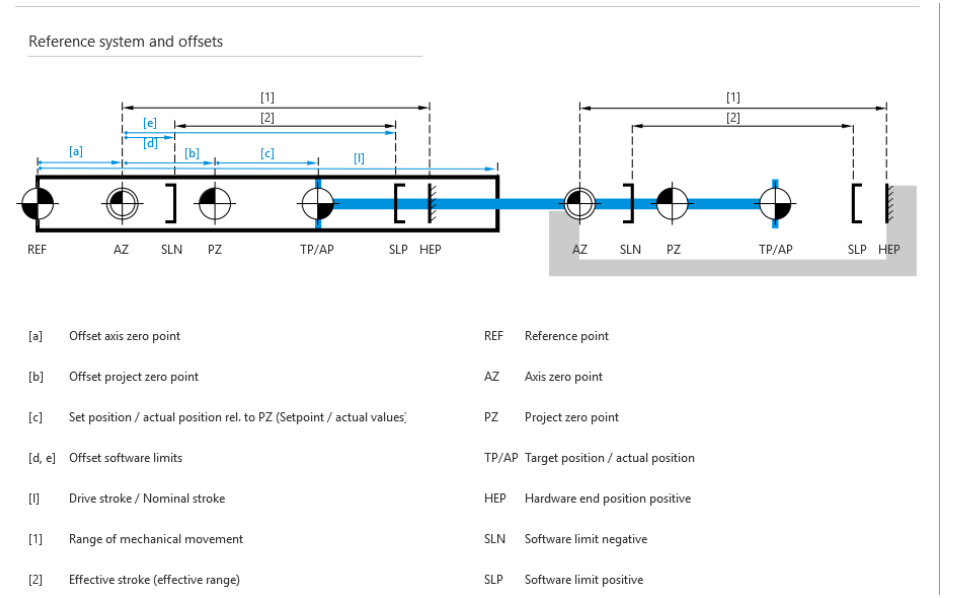
Reference system and offsets

- Scroll down in WebConfig to see a drawing with annotations
- Adjust hardware end position if drive cannot fully retract
    1. offset axis zero point (a)
- Adjust software end positions (optional)
    2. offset software limit negative (d) / positive (e)
- Adjust position offset for setpoint/actual position (optional)
    3. offset project zero point (b)

Note on setpoints and limits:
- Software limits are an additional constraint to the valid setpoint range
- If software limits are defined accordingly, setpoints can be up to 50 mm outside of the mechanical range (1)

As a consequence:
- Effective parameter range of software limits are tested at app start
    - Offset software limit negative (d) must pass condition (a)+(d) in [-50mm,(l)]
    - Offset software limit positive (e) must be greater than (d)
- Setpoints (c) must be within the range [(d)-(b) , min((e)-(b), (l)-(b)-(a)+50mm)], otherwise an error is thrown
- Internally an additional saturation of setpoints takes place (without throwing an error), if the identified hardware end position positive (1)+(a) is smaller than (l). Hence the upper saturation of setpoints is min((e)-(b), (1)-(b)+50mm)

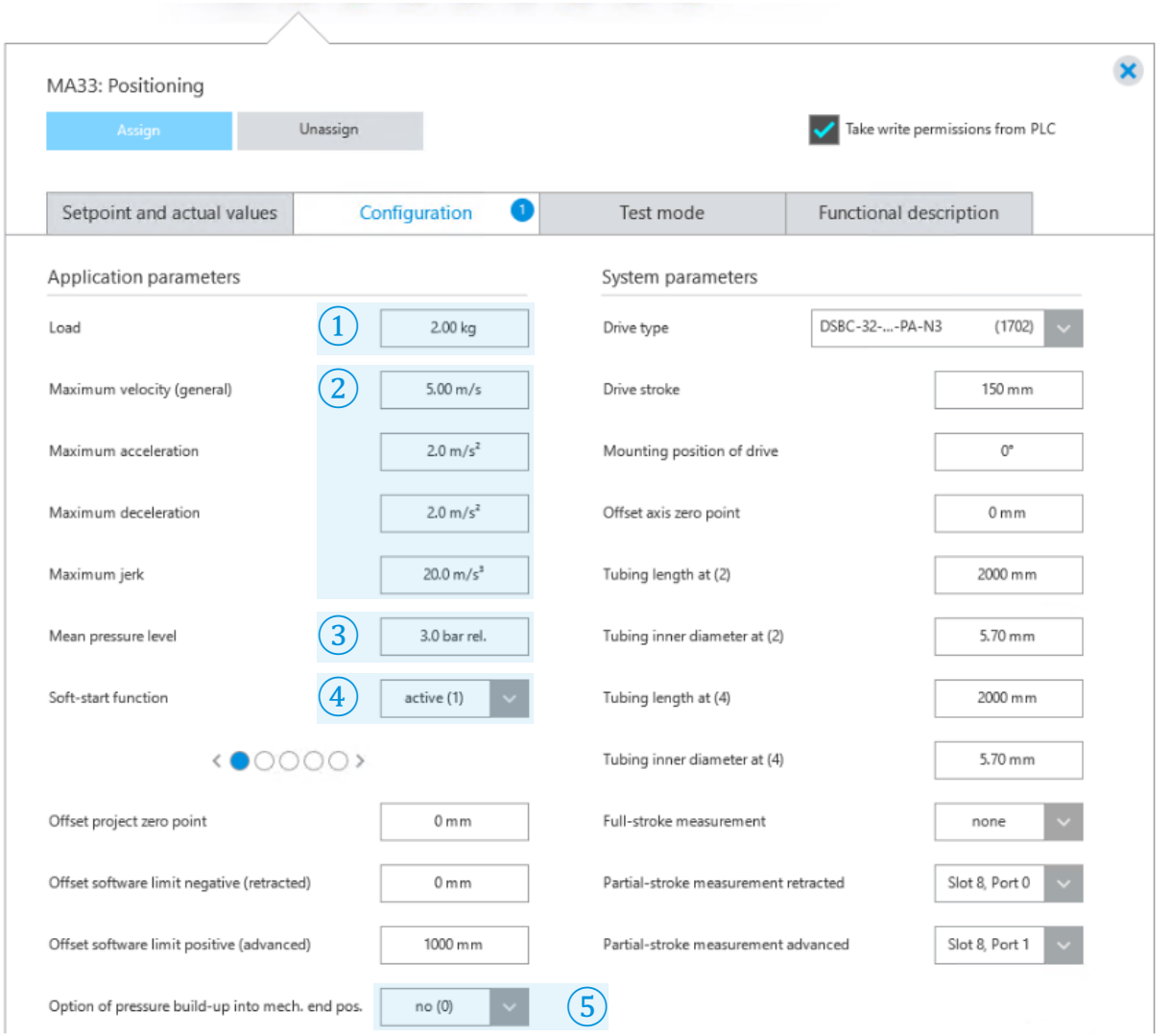




Commissioning: Drive parameterization

Application parameters

1. load for advancing & retracting
2. dynamic parameters
   (use the plausibilization tool, see subsequent slides)
   - maximum velocity (general)
     for plausibilization & limits max. velocity setpoint
   - maximum acceleration, deceleration
   - maximum jerk
3. mean pressure level (optional)
   (should be approx. in the middle between supply pressure and exhaust pressure level, see plausibilization tool)
4. soft-start function (optional)
5. pressure build-up into mech. end pos. function[1] (optional)



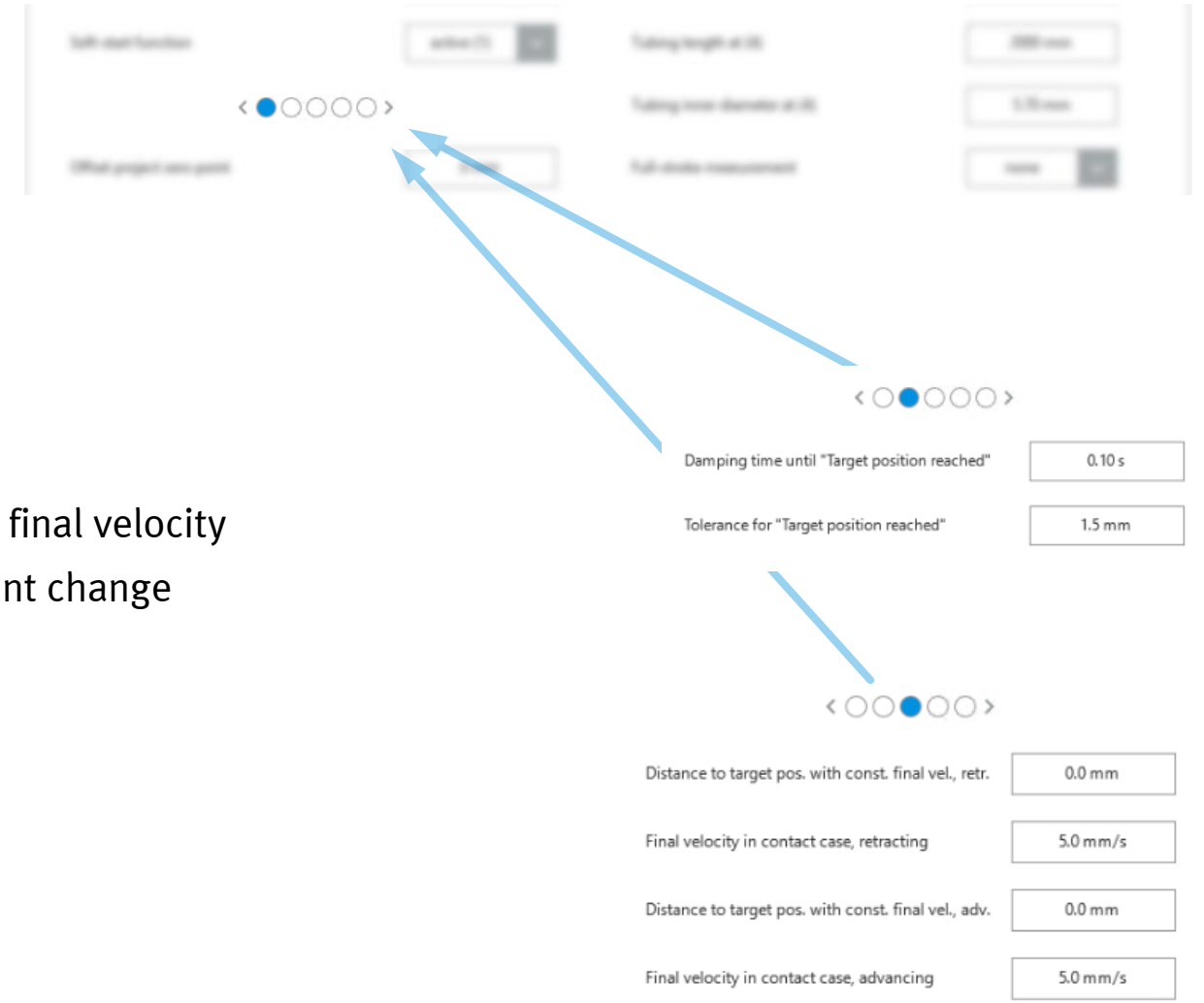
[1] the offset software limits must be configured to allow setpoints outside mechanical end pos.

Commissioning: Drive parameterization

Advanced application parameters & tuning parameters (I)

advanced parameters (optional):

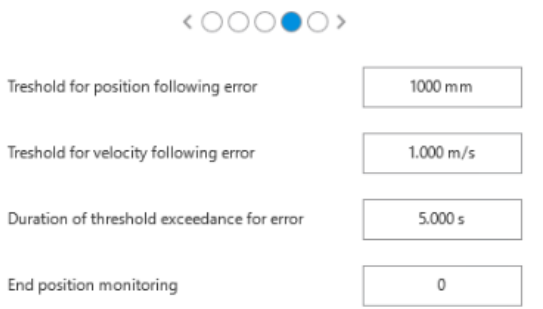
2. target position reached (setpoint)
    - damping time & tolerance
3. approaching velocity for contact case[1] (optional)
    - final velocity & distance to target position with const. final velocity
    - functionallity is activated by the app-option on setpoint change



[1] For an error-free use the target position must be at a mechanical stop.
The final velocity is internally limited by max. general velocity and setpoint 2 max. velocity.
Is the distance to target position too short to reach the final velocity, the final velocity is still targeted.
The distance to target position always refers to the target position (even if the target pos. lies behind the mech. end pos.)

Commissioning: Drive parameterization

Advanced application parameters & tuning parameters (II)



advanced parameters (optional):

4. continuous tracking error handling
    - threshold for position error to trigger an error 153.1 (warning at 50% of that value)
    - threshold for velocity error to trigger an error 153.2 (warning at 30% of that value)
    - duration for position error to trigger warning/error 153.1
      (10% of that value to trigger velocity warning/error 153.2)
    - end position monitoring mode (applicable for software/hardware[1] positions):
      if velocity becomes too high and stopping controlled would hit end position[2],
      the motion apps stops controlled[3] (warning 143.2) and throws error 143.1 afterwards[3]

end position monitoring	retracted: on	off
extended: on	0	2
extended: off	1	3

[1] setpoint outside hardware end position still possible
[2] plus some additional mm
[3] if not disabled by this parameter

Commissioning: Drive parameterization

Advanced application parameters & tuning parameters (III)

advanced parameters (optional):

5. tuning parameters
    - controller gain
    - damping
    - pliability
    - reduction of pilot control
    - coulomb friction

Note: for detailed effects on performance see slides 21-22

conservative plausibilization. the motion app will run regardless of plausibilization results;
however, implausible parameters might lead to bad performance – hence for conservative applications it is advised to find plausible parameters

Commissioning: Plausibilization of parameters (I)

Optional, but recommended. Plausibility check (1) activated ⇢ extra content below & coloured values become visible

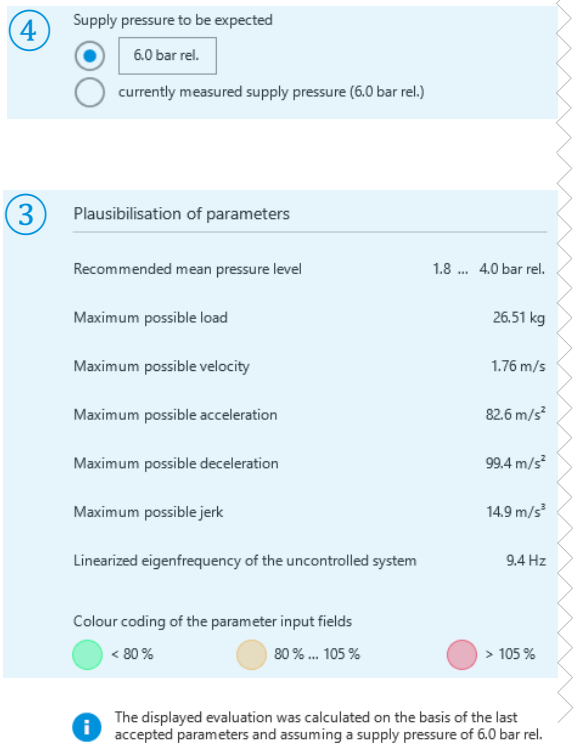
Plausibilization of parameters depending on pneumatic constraints[1]

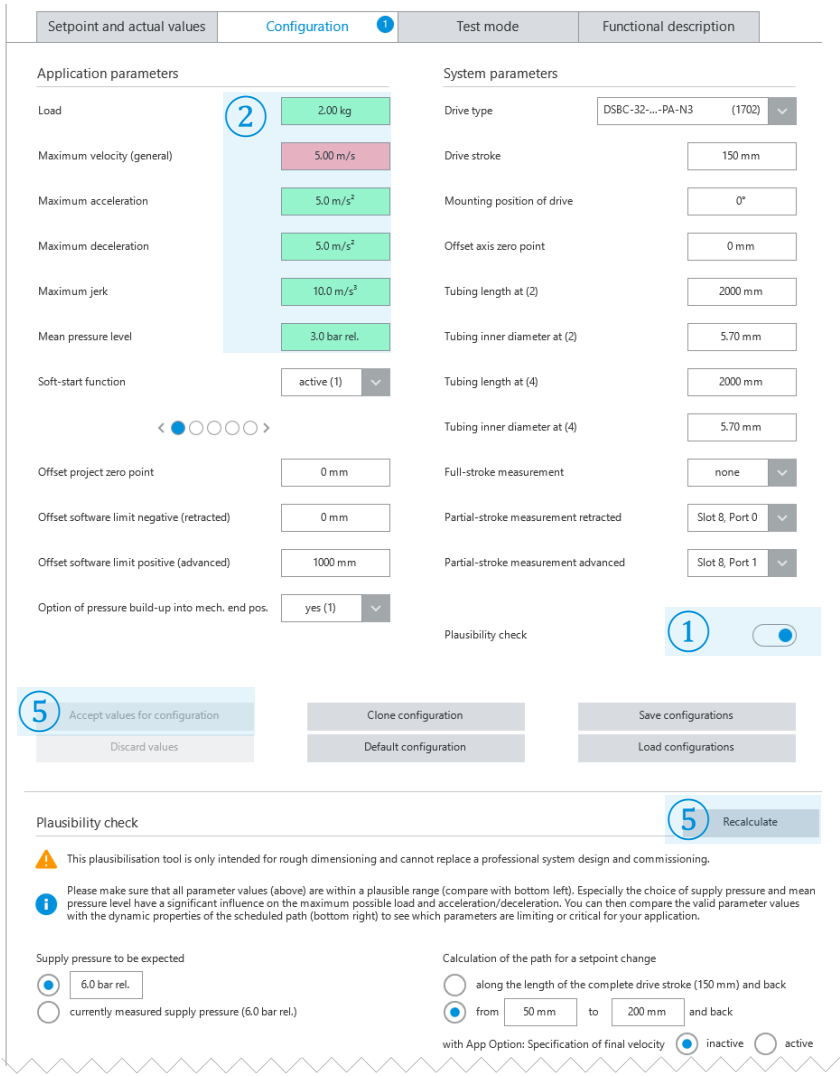
2. Colour-coded parameters
3. Valid parameter range (relevant for colouring)
4. Specification of supply pressure (assumption)
5. Trigger re-evaluation after parameter change

Order of parameter checking

- first check supply pressure and mean pressure[2] for a desired max. load
- then check other application parameters (load and dynamic parameters)

bottom left:





[1] valve, tube, drive type, supply pressure (and mean pressure)
[2] best results if mean pressure is set in the middle of recommended range

conservative plausibilization. the motion app will run regardless of plausibilization results;
however, implausible parameters might lead to bad performance – hence for conservative applications it is advised to find plausible parameters

Commissioning: Plausibilization of parameters (II)

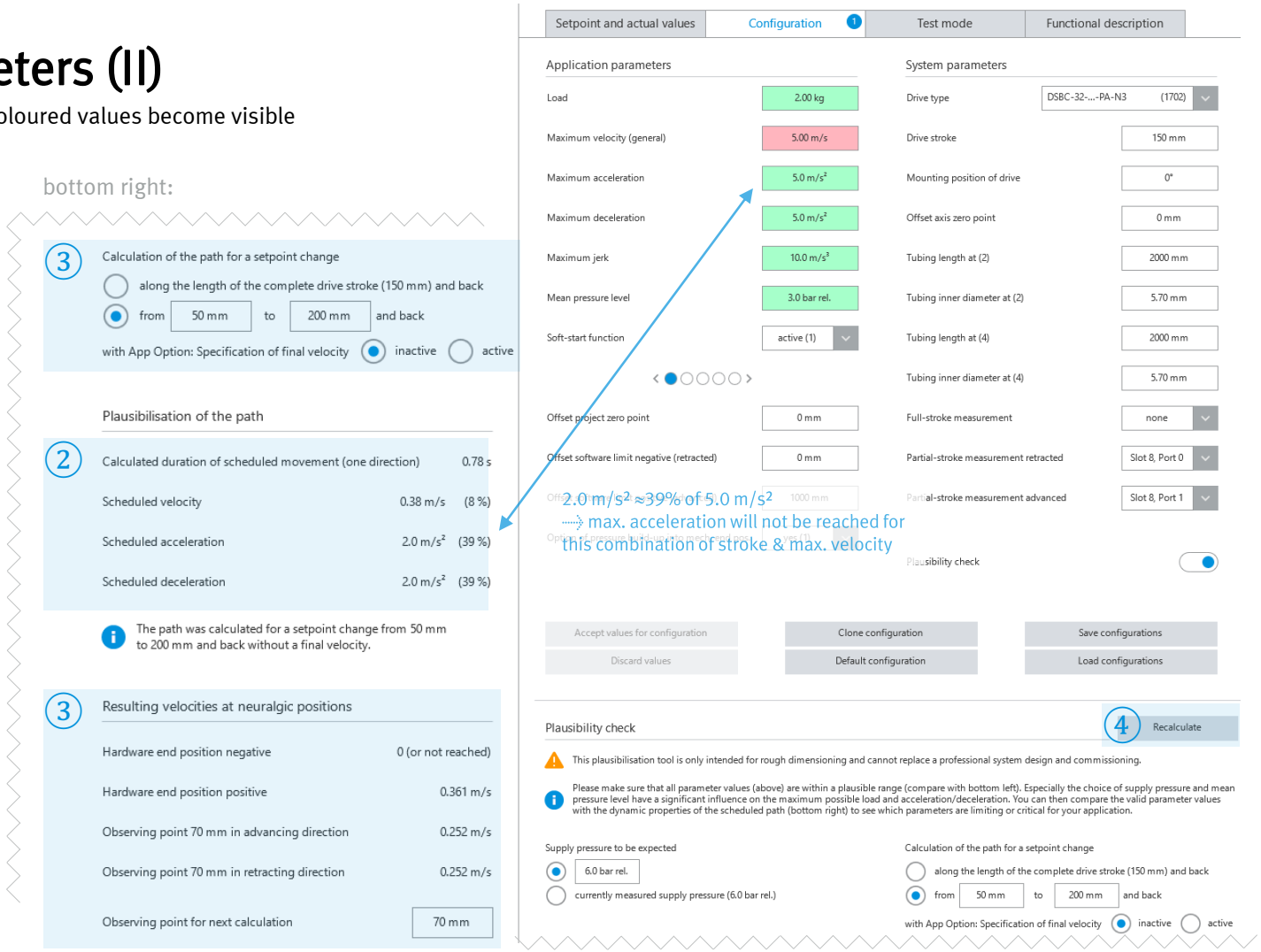
Optional, but recommended. Plausibility check (1) activated ⇢ extra content below & coloured values become visible

Plausibilization of dynamic parameters and resulting scheduled motions

2. transition time, scheduled max. values along the setpoint change[1] and percentage (usage) of specified parameter values
   - 100%: this constraint is active, hence a reduction or raise of this parameter will effect speed and transition time
   - ‹100%: this parameter does not limit speed or time (it can stay like this or it can be reduced)
3. Optional: check scheduled velocity at hardware end positions[2] and at definable observing point

[1] Initially along the full stroke. Select second option to specify start and end point (PZ, limited by software limits, slide 10). After changing conditions of plausibilization, click “Recalculate” (4).

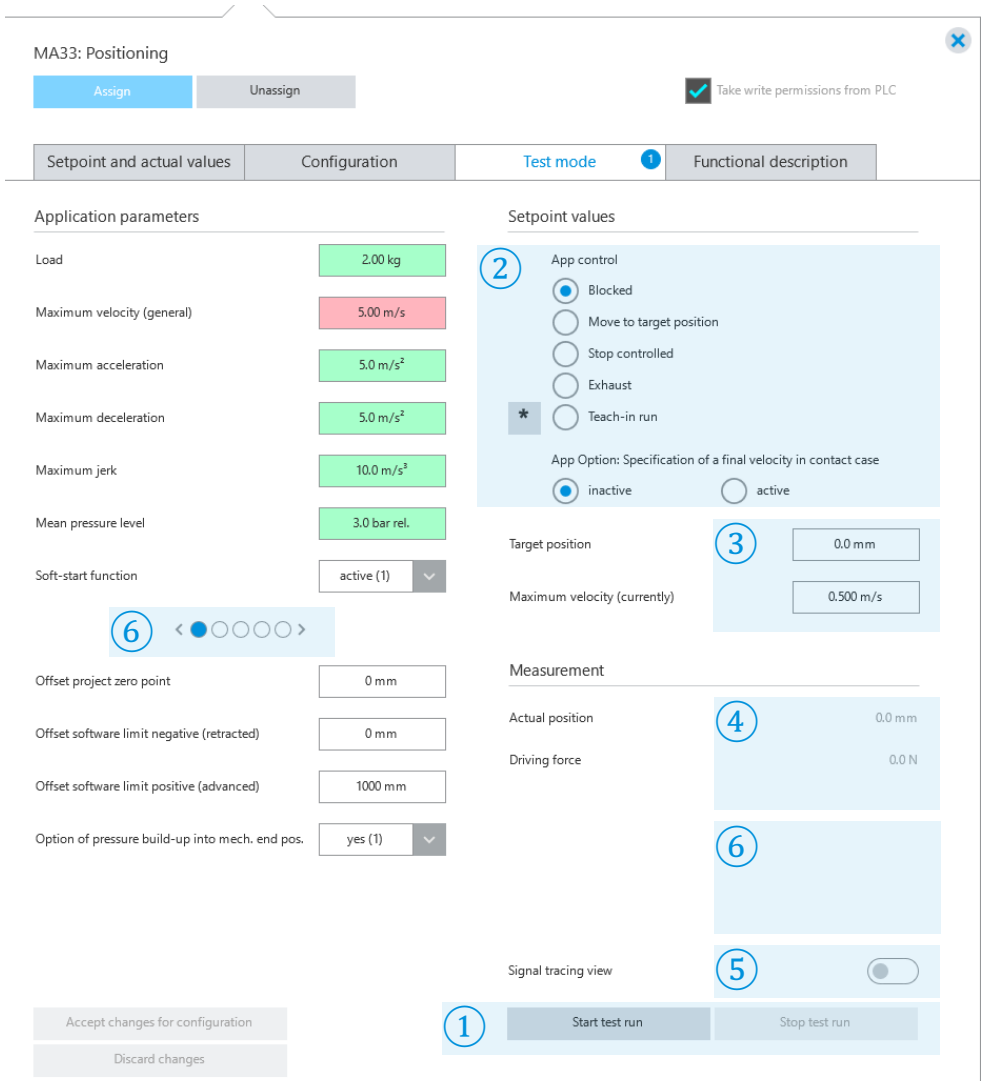
[2] Second option (3) has to be selected. If software limits and setpoints are outside hardware end positions, the impact velocity is computed.



Commissioning: Test mode

Overview

1. Start test run (to leave the test mode tab, stop test run first)
2. Select app control
   - initial “Teach-in run” necessary (see next slide)
   - “Move to target position” to enable positioning (w/ or w/o approaching vel. in contact case)
3. Choose target position & max. velocity
   - Applies only if “Move to target position” is activated
   - Setpoint change is only possible if “Maximum velocity” › 0
   - “Target position” box becomes blue if “Target position reached”
4. Read current measurements (incl. Teach-in status)
5. Activate signal tracing view
6. Switch to tuning parameter ‹○○○○●› to fine tune the application (& to enable detailed view of system properties – expert license only)



Commissioning: Automated commissioning (“Teach-in run”)

Phase 1: sensor placement → Phase 2: dynamic sensor properties → Phase 3: friction identification

Target: Identify sensor offsets

- Mandatory in order to operate positioning app
- Multiple, slow motion in each end position
- After passing phase 1, phase 2 is started automatically

Target: Identify dynamic sensor properties

- Automatically executed after phase 1
- Faster motions from end to end, reducing velocity before the mechanical end positions detected in phase 1
- After passing phase 2, phase 3 is started automatically
- This MotionApp can be operated even if phase 2 is aborted or fails[1]

Target: Identify friction of application (incl. external guide)

- Automatically executed after phase 2
- Fast motions from ~10% to ~90% of the identified drive stroke
- No external disturbances allowed (e.g. spring or second actuator attached to piston)
- After passing phase 3, the commissioning was successful
- This MotionApp can be operated even if phase 3 is aborted or fails[1]
  (e.g. error 142.5 or 143.1)

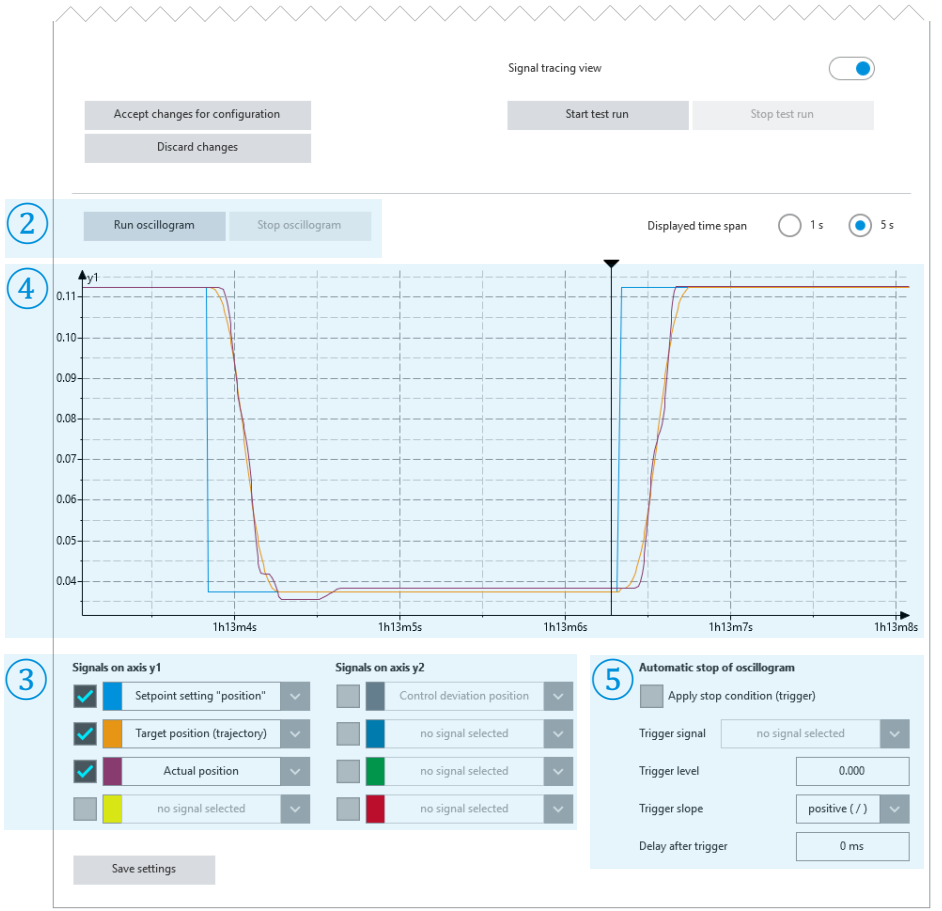
A re-run is necessary after changing the sensor-drive configuration (also mechanically)
The teach-in run can be started via CPX/FB using valve mode 60

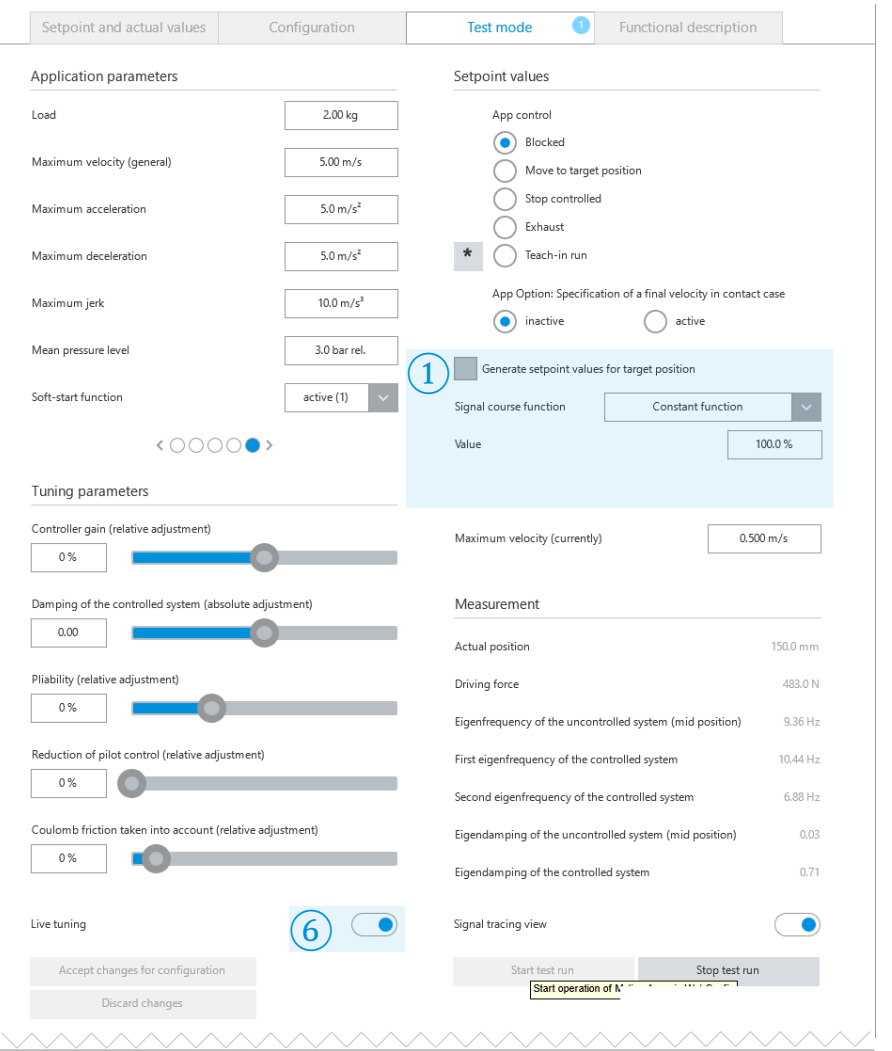
[1] This part of the teach-in run can be deactivated manually (WebConfig * ○ Teach-in run and CBUS).

Commissioning: Signal tracing & live tuning

Test run started & signal tracing view activated ⇢ extra content below becomes visible

1. Periodic setpoint generator
2. Oscillogram activator
3. Signal selector
4. Oscillogram
5. Stop trigger (optional)
6. Enable live tuning switch: selected application and tuning parameters can be edited live while running the application to see immediate effect





Don't forget to apply accept changes and save changes. Signal tracing for PLC setpoints on "setpoint and actual values" tab (live tuning not available yet)

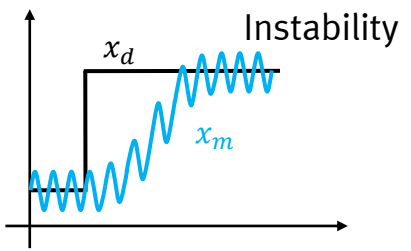
Commissioning: Fine tuning (I)

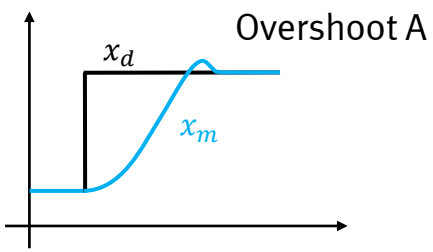
Recipe for fine tuning:

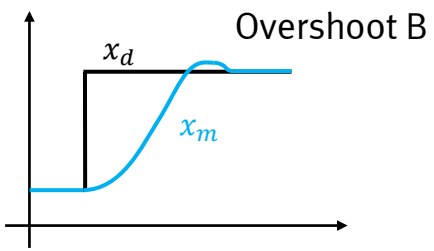
1. Only in case of severe oscillation/instability
   - ➢ Execute “Online valve calibration” (see slide 23, expert license necessary)
2. Tune K1 (e.g. in case of insufficient stationary accuracy)
   - ➢ Increase K1 up to stability limit (steps of ~5%)
   - ➢ Decrease K1 by 5 … 10% points
3. In case of overshoot B/undershoot (due to wrong friction parameters)
   - ➢ Decrease K5 by -10 … -50% points (no influence on stability, steps of ~10%)
4. In case of overshoot A or undershoot (due to lack of damping, steps of ~0.05)
   - ➢ Overshoot A: Increase K2 (decreasing K1 might be necessary)
   - ➢ Undershoot: Decrease K2 (increasing K1 might be necessary)

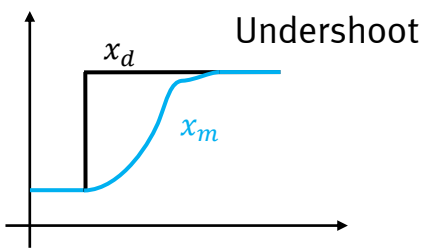
Official tuning parameters as described in MA33 manual 2.7

ID	Name	Digit range (default)
T: 230	K1: controller gain (relative): weak … precise	-50 … 50 (0) × 1%
T: 231	K2: damping (rel): undamped … strongly damped	-99 … 99 (0) × 0.01
T: 232	K3: pliability: stationary precise … compliant/soft	-30 … 70 (0) × 1%
T: 233	K4: reduction of pilot control (relative)	0 … 100 (0) × 1%
T: 234	K5: coulomb friction (relative)	-100 … 1000 (0) × 1%





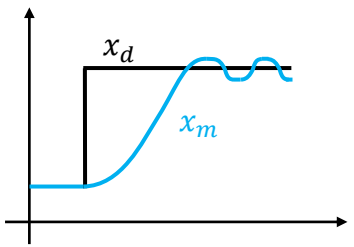




Commissioning: Fine tuning (II)

Recipe for fine tuning:

5. Stick slip movement at stationary setpoint
   - ➢ Increase K3



6. Pliability vs. disturbance stiffness
   - ➢ Decreasing pliability K3 will lead to higher disturbance stiffness and hence to less pliability
   - ➢ Increasing pliability K3 will lead to higher pliability and hence to less disturbance stiffness

Official tuning parameters as described in MA33 manual 2.7

ID	Name	Digit range (default)
T: 230	K1: controller gain (relative): weak ... precise	-50 ... 50 (0) × 1%
T: 231	K2: damping (rel): undamped ... strongly damped	-99 ... 99 (0) × 0.01
T: 232	K3: pliability: stationary precise ... compliant/soft	-30 ... 70 (0) × 1%
T: 233	K4: reduction of pilot control (relative)	0 ... 100 (0) × 1%
T: 234	K5: coulomb friction (relative)	-100 ... 1000 (0) × 1%

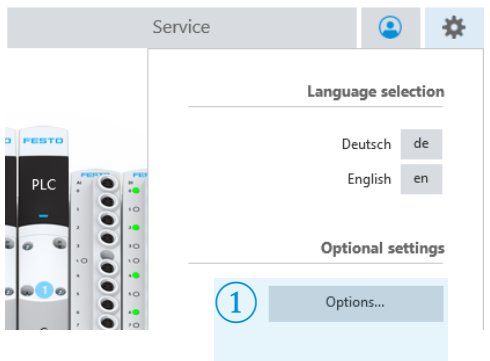
7. Reduction of pilot (feedforward) control
   - ➢ Increasing K4 will lead to less feedforward control. It might be useful in case of overshoots that cannot be reduced by the previous mentioned actions.

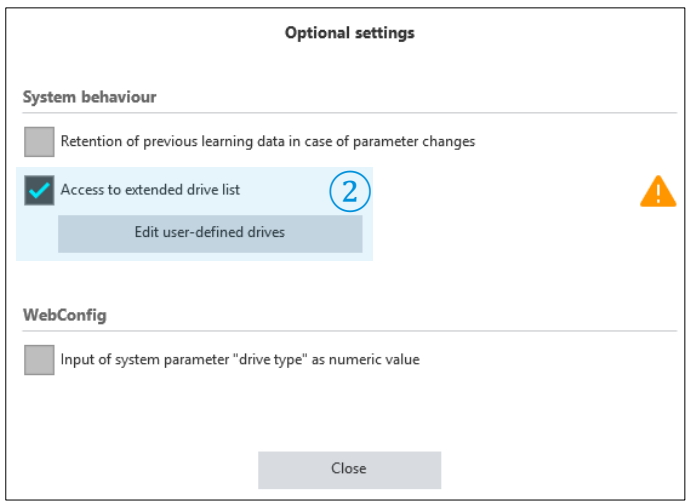

Part 2: Advanced Commissioning
VTEM MotionApp #33 Positioning
Commissioning & Troubleshooting Guide

Advanced Commissioning: Access more drive types

Extended drive list

More drive types can be unlocked under **options** via **access to extended drive list**. This will enable all internal drives to all MotionApps.





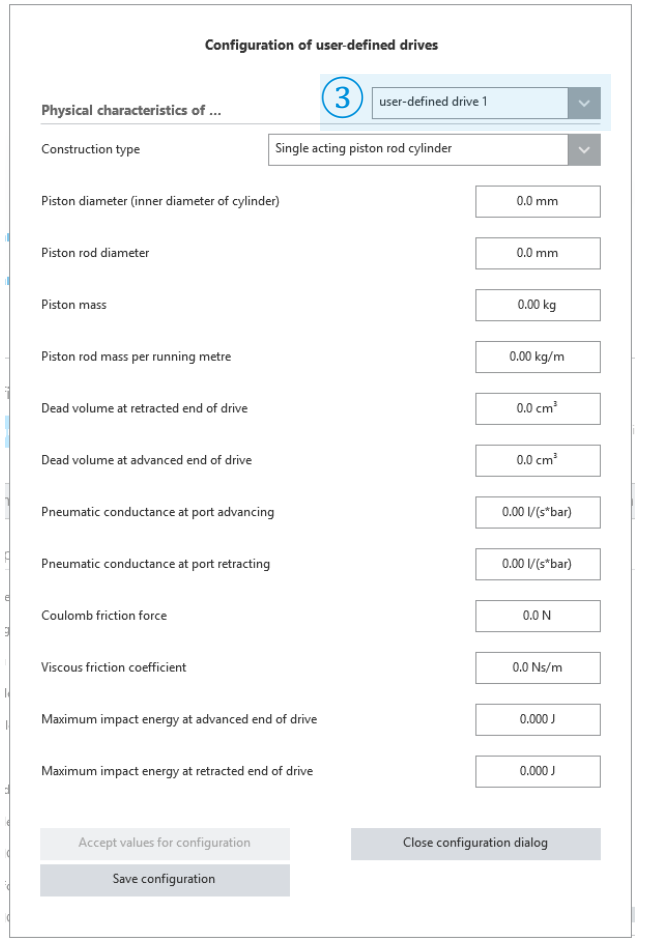
Adding user-defined drives

Up to 8 user-defined drives can be defined via the **edit user-defined drives** dialog.

Please use the tooltips to check the allowed parameter range.

Values with a minimum value > 0 are required.

Don't forget to accept the values and safe your configuration.



when using drives outside the specified scope, a manual tuning of control parameters is necessary

Advanced Commissioning: Access more drive types

MotionApp specific relevance of custom drive parameters & initial guesses

Drive parameters are obtained from drive data sheets. If certain values are unknown, some parameters can be left blank (enter random values) or entered with good guesses.

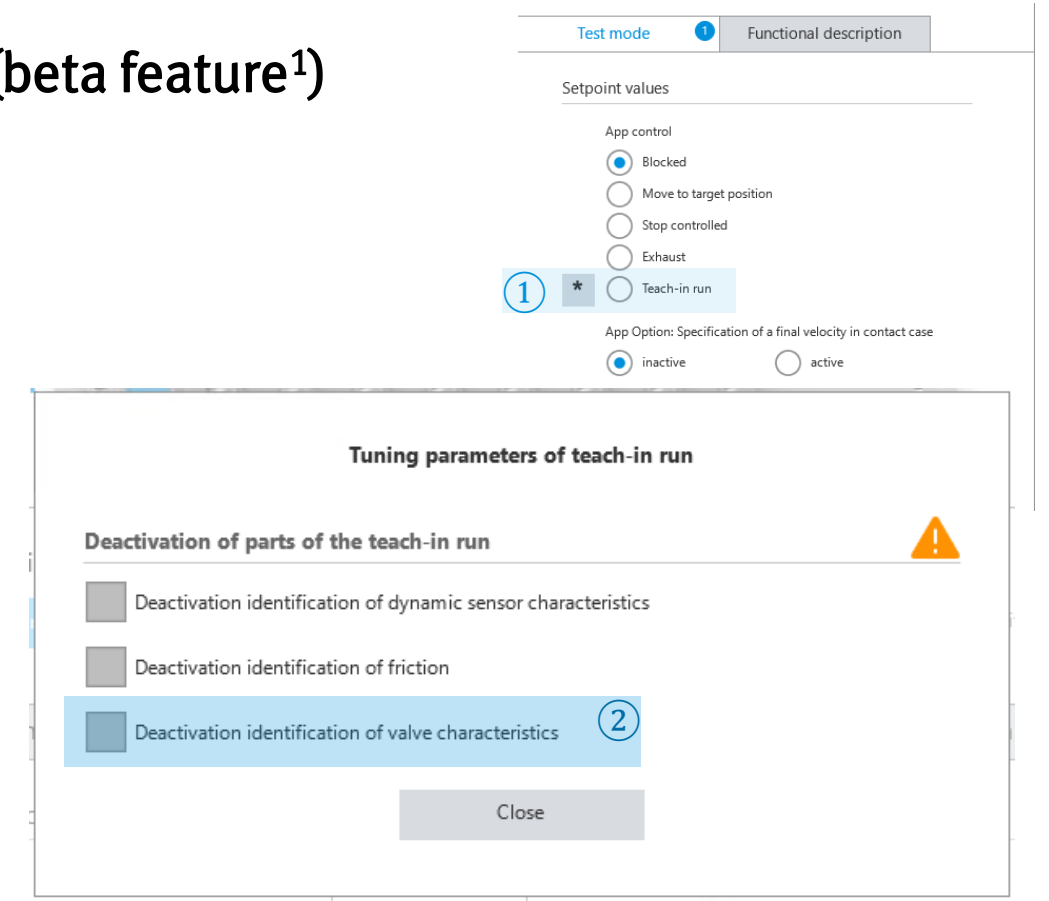
parameter name	MA7	MA8	MA11	MA12	MA33	relevance & initial guesses
piston diameter	x	x	x	x	x	relevant
piston rod diameter	x	x	x	x	x	relevant, 0.0 for rodless drives
piston mass	x		x	x	x	only relevant if application mass small or 0 kg, otherwise a value of 0 kg is ok
piston rod mass	x		x	x	x	only relevant if application mass small or 0 kg
dead volume					x	wrong values (too small or too big) reduce performance when positioning close to end positions of drive
pneumatic conductance						currently not relevant for any official motion app but might be used in upcoming releases of any motion app. initial guess 10.00 l/(s*bar)
coulomb friction force					x	MA33: value is used as initial value for friction identification during teach-in and as fallback value in case the friction identification fails or is manually aborted; value for teach-in run can be approx. ±50% wrong; initial guess i.g. 20-30 N
viscous friction coefficient					x	(see coulomb friction force), initial guess i.g. 20-50 N/(m/s)
max. impact energy					x	MA33: teach-in only (computing max. velocity during teach-in). Higher max. velocity results in better friction identification and better sensor identification but might result in higher impact velocities at hardware stops.

Advanced Commissioning: Extended teach-in run (beta feature[1])

Online valve calibration during teach-in run

Online valve calibration during teach-in run can further improve the performance of the positioning task[1].

- Activation via
  ① Test mode ⇢ * next to Teach-in run
  ② Tick off “Deactivation identification of valve char.”
- The teach-in run has to be re-executed in order carry out the valve calibration.
- The teach-in run takes about 30 to 90s longer



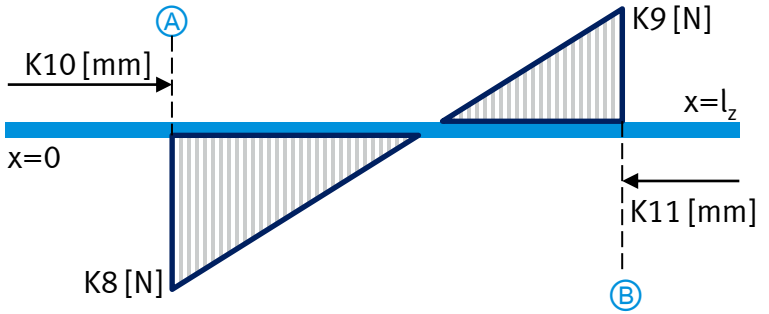
[1] this feature is currently not enabled by default and has to be activated manually once per valve (expert license necessary), default activation during teach-in is planned for future releases, the current implementation of the calibration routine is still in beta

Advanced Commissioning: Fine tuning of the controller (unofficial feature[1])

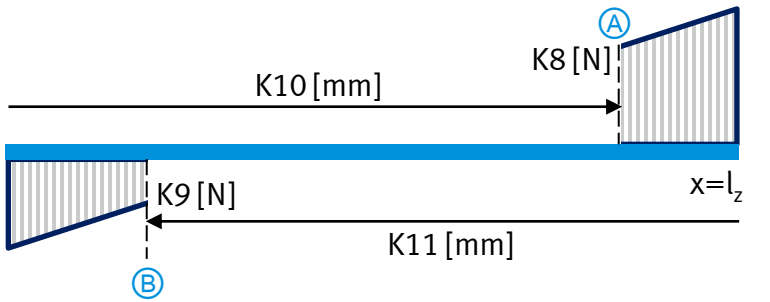
Stroke-dependent force compensation

- Compensation of a linear spring force along the drive
- Definition of forces via tuning parameters K8 and K9
- Definition of support points via parameter K10 and K11
  - Support points A and B for interpolation as offsets from x=0 / x=l_z
  - Default case (K10=0, K11=0): compensation along the full drive stroke
  - Support points can be outside the drive stroke if negative values are entered
- Different window options depending on the relative position of points A and B
  - Point A ‹ Point B: spring force active between both points
  - Point A › Point B: spring force active outside both points
  - Minimum distance between A and B: 10 mm (otherwise force is set to 0)
- Recommended identification of spring forces e.g. via MA03 or MA08

A ‹ B:
between points



A › B:
outside points



ID	Name	Digit range (default)
T: 237	K8: Spring force compensation at x=0+K10	-9000 ... 9000 (0) × 1 N
T: 238	K9: Spring force compensation at x=l_z-K11	-9000 ... 9000 (0) × 1 N
T: 239	K10: Offset from x=0 of point A (definition of force K8)[2]	0 ... 30000 (0) × 1 mm
T: 240	K11: Neg. offset from x=l_z of point B (def. of force K9)[2]	0 ... 30000 (0) × 1 mm

[1] expert license necessary to modify unofficial tuning parameters via expert page or transfer channel

[2] Minimal distance between points A and B: 10 mm, otherwise force is set to 0


Appendix
VTEM MotionApp #33 Positioning
Commissioning & Troubleshooting Guide

Appendix: Common mistakes

Hardware mounting

- Valve port 2 and 4 are connected to the wrong cylinder ports
- Length of mounted sensors does not correspond to configuration
- Incorrect mapping of sensors
- No repeated execution of the teach-in run even after small modifications of the sensor mounting

Teach-in run

- Disturbance force during teach-in run (esp. during friction identification)

Apply setpoints

- Max. velocity (setpoint 2) is 0, no motion possible
- Setpoints noisy or continuously changing

Appendix: Helpful resources

- Official documentation “System – Function – Parameterisation”[1]
- Official documentation “GAMM-A33 description”[1]
- Motion Terminal Quick Reference PLC programming[2]
- Malfunction codes VTEM[2]
- Supported drives VTEM[2]
- Function blocks Codesys[3]
- Function blocks Rockwell[3]
- Function blocks Siemens[3]

Support Portal: https://www.festo.com/us/en/a/8047502/ ⇢ Support/Downloads: [1]Technical documentation / [2]Expert knowledge / [3]Software