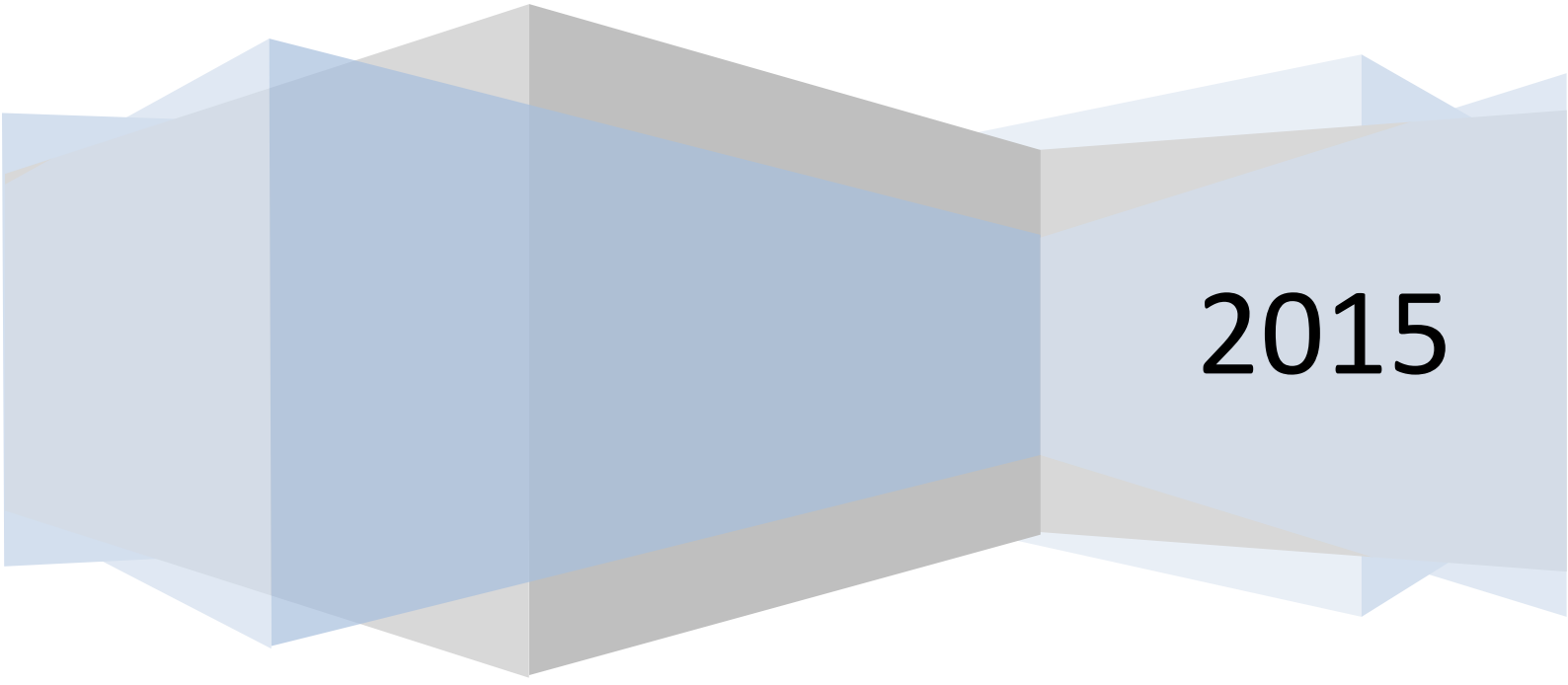
Prevac sp. z o.o.

Multi axis manipulator control software

Version 5.1

www.prevac.eu



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INTRODUCTION

Ladies and gentleman, we are proud to present you the latest version of the software controlling the multi-axis manipulator system released by PREVAC Sp. z o. o. We hope that it will greatly help you in an academic work.

Any comments and observations on the work of the software, please contact: support@prevac.pl

DESCRIPTION OF APPLICATION

The software is designed to operating multi axis manipulator. Software allows user to control each of manipulator axis and move in the following types: absolute, relative and continuous. It gives the ability to configure the manipulator parameters such as current of rest and motion, the elimination of backlash, encoder parameters and depending on axial.

INSTALLING

SOFTWARE INSTALLATION

a) Download from FTP ftp.prevac.eu ManipulatorInstall.exe file.

b) Run the ManipulatorInstall.exe file. Installation wizard will open. Follow the direction in the installation wizard.

MOXA INSTALLATION

a) Run the installation of MOXA communication device. Follow the directions in the installation wizard.
b) Restart your computer after installation is complete.
c) After the computer restarts, you must configure the communication port to the standard used by manipulator software. To do this go to system *Device Manager*, find and expand a *Multiport Serial Cards* tab and then double click on the MOXA (Fig. 1).
d) In the properties window go to MOXA *Port Configuration* tab (Fig. 2). Then from the list of available ports, select the port which it is SMCD10 driver connected to and set the following parameters:
   - UART FIFO – **Enabled**
   - Tx Mode – **Classical**
   - Fast Flush – **Enable**
   - Interface – **RS-485-2W**

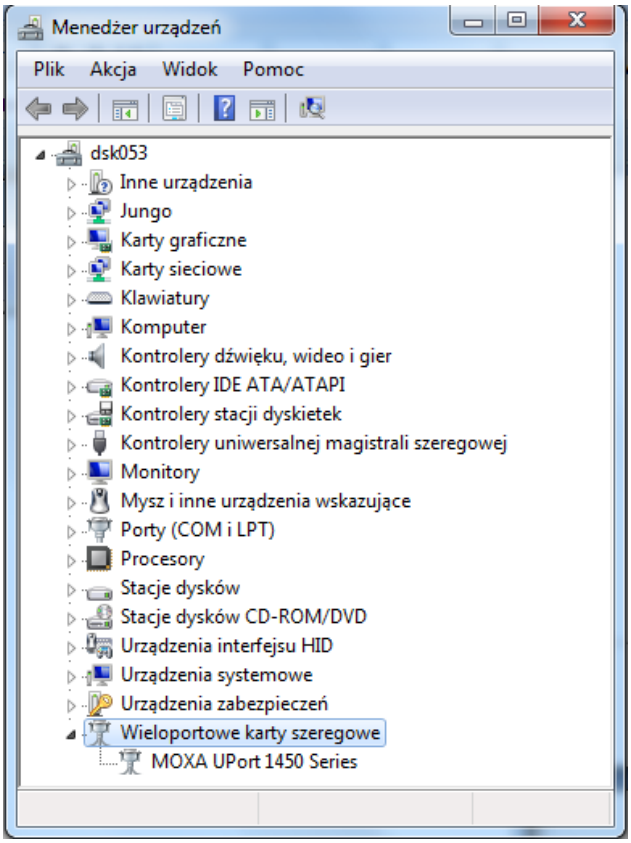


Fig. 2 Device Manager

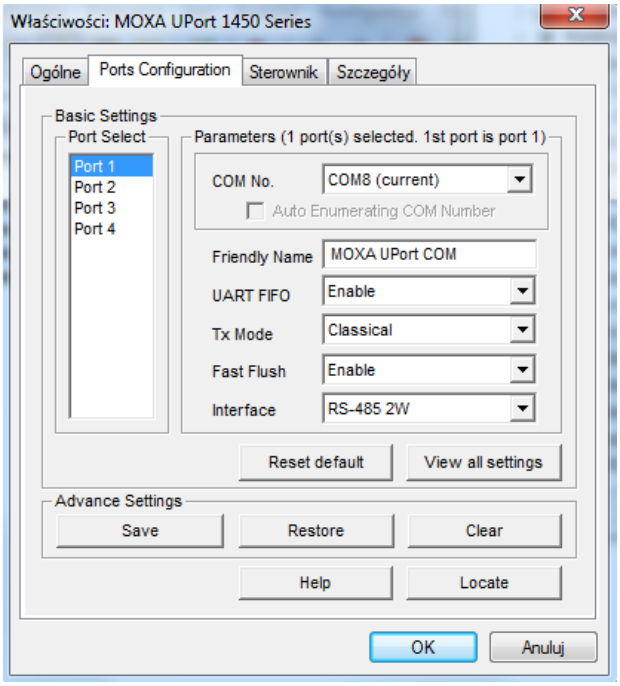


Fig. 1 MOXA card properties

INSTALLATION OF MANIPULATOR MODULE IN THE SES SOFTWARE

1. After starting the SES software you must load the manipulator interface (if not already loaded). To do this go to *Setup->User Interface* (Fig. 3) menu. Window appears as in figure 4. When the user presses the *Add* button, he will be asked to indentify the interface file named Manipulator_k.dll. This file should be located in the dll subdirectory of the main program directory (default c:\SES 1.2.5r2\dll\Manipulator_k.dll). Once loaded, the additional *Manipulator* menu should appear.

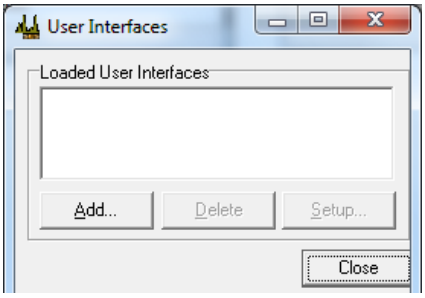


Fig. 4 SES user interface

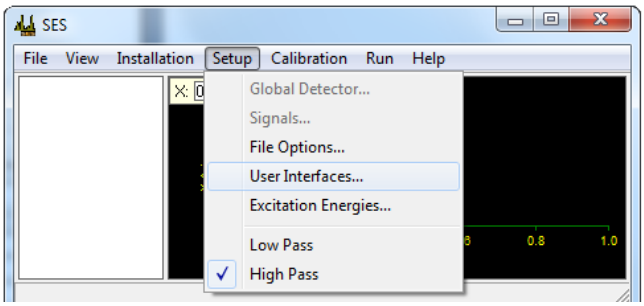


Fig. 3 SES Setup Menu

2. After loading manipulator interface into SES menu, load manipulator functionality (if it wasn't previously changed), which is contained in the file libraries loaded dynamically. To do so user must go to the *Manipulator->Setup* (Fig. 5) menu. Window appears as shown in Figure 6. By clicking the *Browse* button user specify the path to the Manupulator.dll file (this file contains the functionality of the manipulator software). The file is located in the directory where user installed the manipulator software (default c:\ProgramFiles\Prevac\Manipulator\ Manipulator.dll).

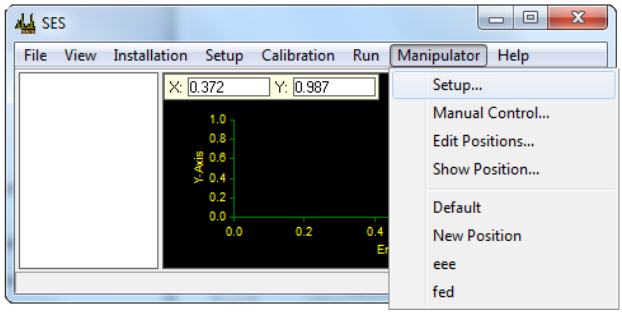


Fig. 5 SES application Manipulator Menu

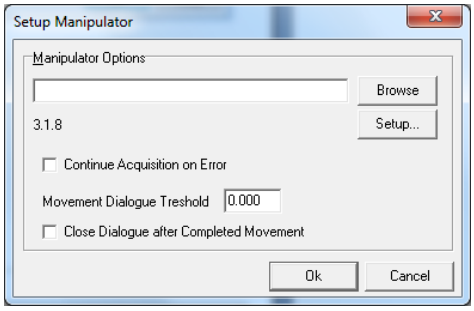


Fig. 6 SES Application Manipulator Setup Window

3. If all the above steps are performed correctly, the system tray (near the clock) icon of Manipulator application should appear.

STARTING

THE CONDITIONS REQUIRED FOR PROPER WORK

- Power on the stepper motor controllers SMCD10
- Properly configured MOXA communication device
- Properly connected communication cables between the SMCD10 controller and the MOXA communications device
- MOXA communication device connected to PC USB port

RUN MANIPULATOR APPLICATION

In order to run the application, follow the steps below

- Go to the *Start* menu, then select *All Programs*
- Find the *Prevac* directory
- Run the *Manipulator* application

When you first run the application, manipulator configuration window pops (Fig. 7). Then you can load the configuration file named default.pcf provided with the installation file, or manually configure the manipulator. If you choose manual configuration of the manipulator, don't forget to save it after you finish. Otherwise the configuration will be lost and the window as shown in Figure 7 will appear again the next time you start the application.

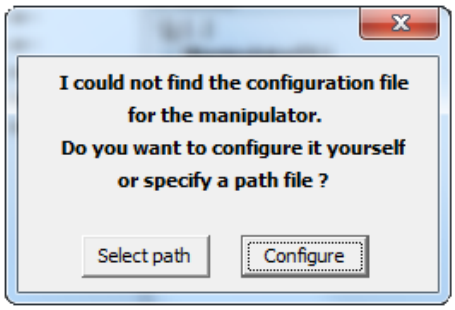


Fig. 7 Manipulator configuration choice window

After selecting the configuration of the manipulator, application will start with specific number of axes (Fig. 8). In the axis status field, is displayed state of the system driver , associated with a given axis. The most common states of the driver are *Motion finished* and *Stopped,* meaning that last movement ended and state which doesn't allow run axis motion called *No Communication*. In the case of *No communication* message, check whether the conditions required for the proper operation of applications (see " The conditions required for proper work "). Other messages are described in the "Status" chapter.

RUN SES APPLICATION

*Manipulato*r application is started automatically with the *SES* program. In order to ensure the correct operation of the SES, prior to its lauch, close all running *Manipulator* applications. Otherwise the SES program won't have communication with a system drivers. After running the *SES*, *Manipulator* application is available in the system tray.

RUN MANIPULATOR MOTION

After a successful application start, window appears as in Fig. 8. In order to start moving manipulator, set the parameters such as target position and speed of driving traffic, and then press the *Start* button for that axis. We can also run the motion of the entire manipulator by pressing the *Start* button after filling manipulator motion parameters for all axes. While setting the motion parameters for a given axis, should be noted that the position of the target motion is not always the position, which is served in a panel of the axis. It is dependent on the motion type selected for the drive axle. Available motion types are: absolute, relative and continuous. In absolute motion, given motion position in panel is a target position. In relative motion, target position is actual position plus the driving distance given in relative motion panel. For the continuous type there is no such thing as a target position. For the continuous motion type concept of target position does not exist. Axis actuated continuously, finalize beyond the time specified by the user, or by pressing the *Stop* button.

The figure below explains the basic elements of the application. Full description of the interface is in the "User Interface" chapter. Description of the movement of panels is in the "Types of movement" section.

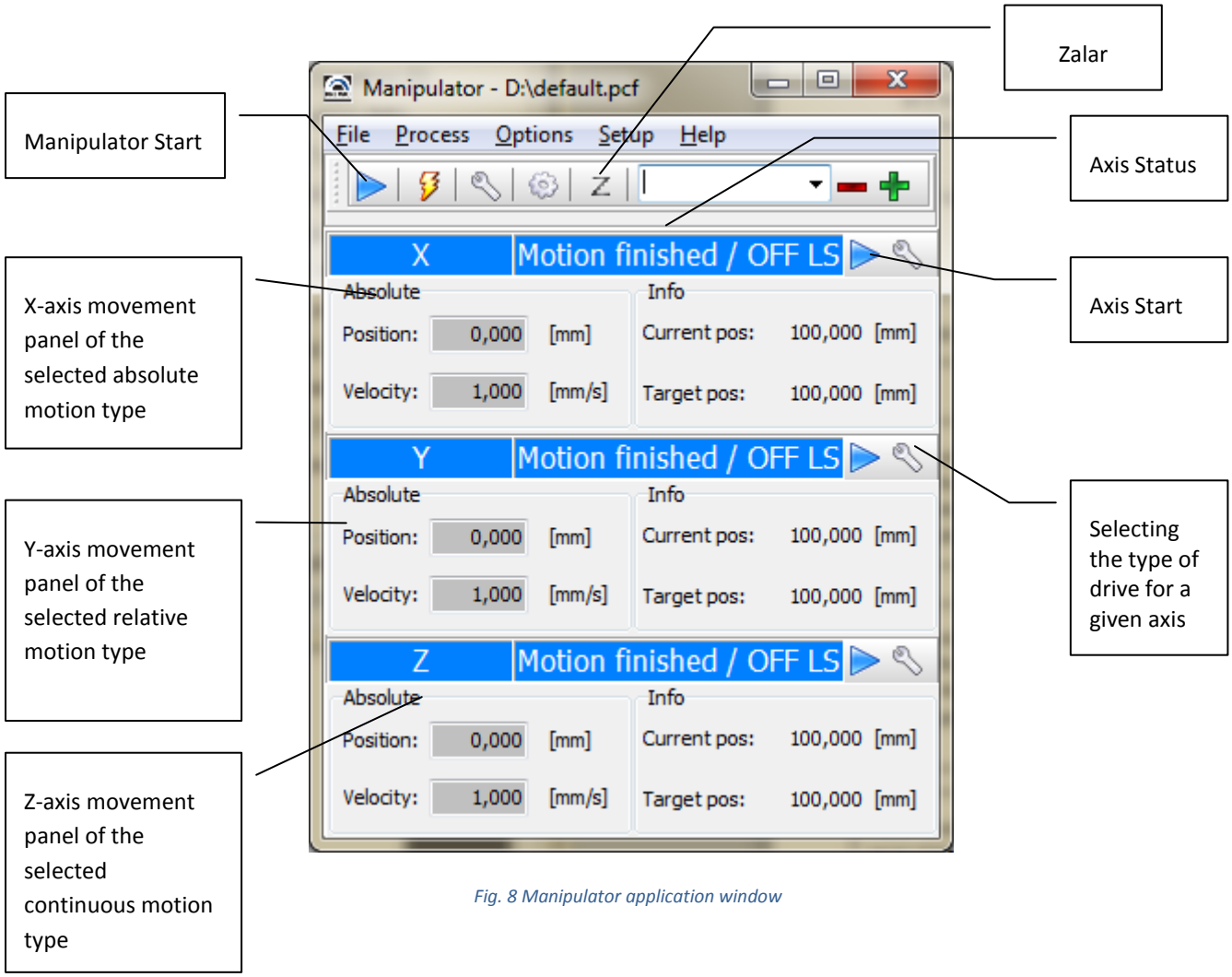


Fig. 8 Manipulator application window

In the case of frequently performed movements such as access to the transfer position, we can save the parameters of the corresponding shift to a file. To do this, for each axis to choose the right type of drive and set the appropriate parameters. Then, in the *Configuration Name* field, write your own file name and press *Add* button. Figure 9 presents a sample set of shifts for the X, Y and Z axis, which is write under the name *Transfer*. In this example, each axis moves to the absolute position of 1 mm at a rate of 1 mm / s.

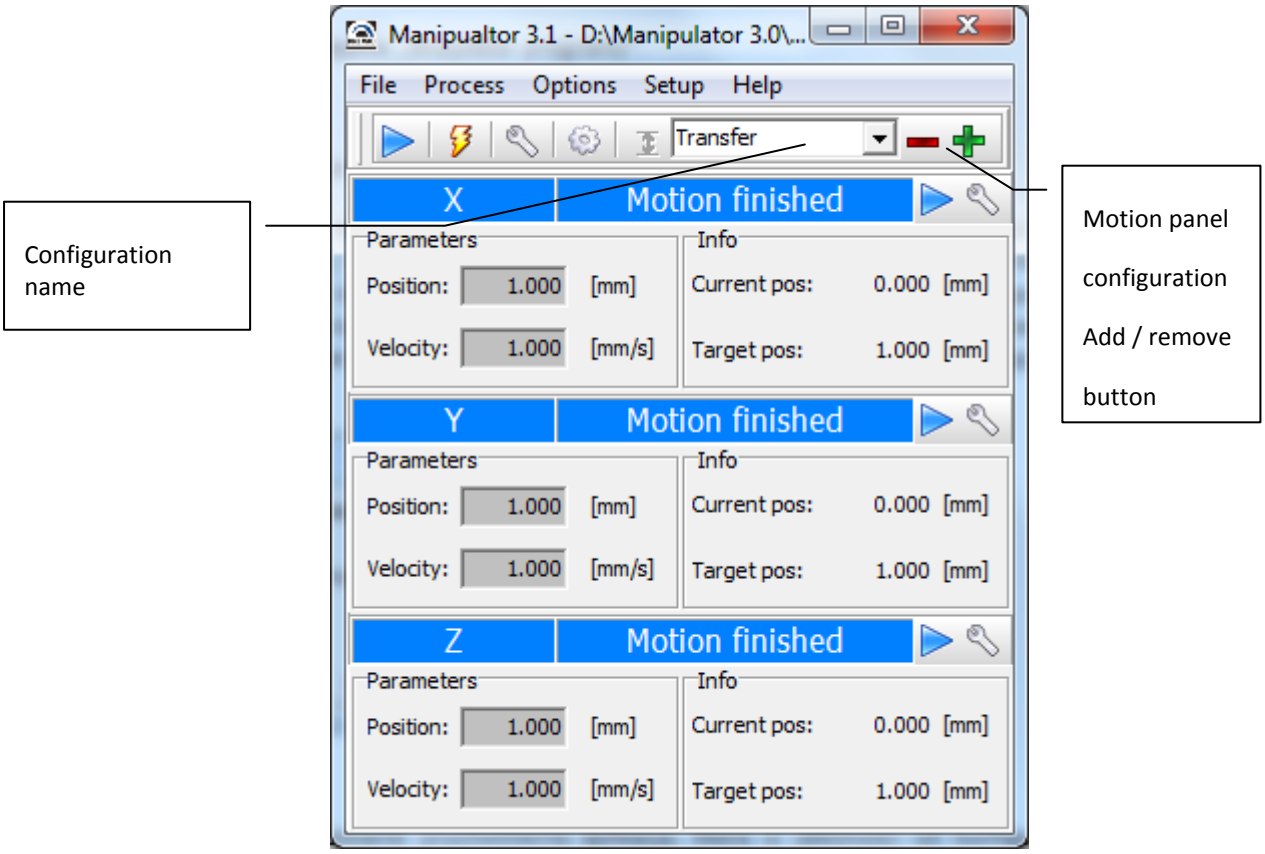


Fig. 9 Motion panel configuration example

USER INTERFACE

MAIN WINDOW OF APPLICATION

Main application window (Fig. 10) is divided into:

- Top bar – contains control icons and setting for all manipulator axis.
- Axis panels – contains forms representing the current type motion assigned to that axis.

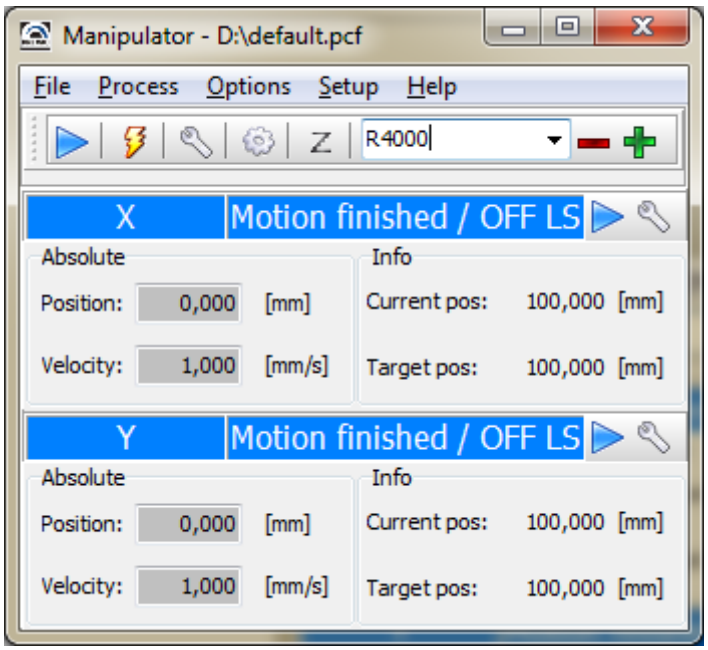


Fig. 10 Application main window

APPLICATION MAIN MENU

Application main menu consists of several tabs:

- File
  - Close application

Fig. 11 Application File Menu

- Process
  - Start, Stop – common start compatible with the type of axis motion, or stop the manipulator

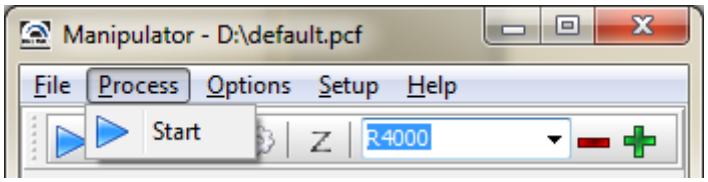


Fig. 12 Application Process Menu

- Options
  - Normal Current – turning off / on the quiescent current for all manipulator axis (magnetic state of silence)

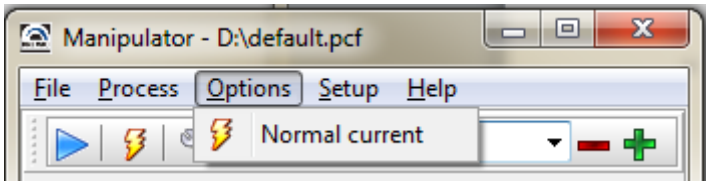


Fig. 13 Application Options Menu

- Setup
  - Calibration – manipulator axis calibration form
  - Setup parameters – manipulator axis parameters form

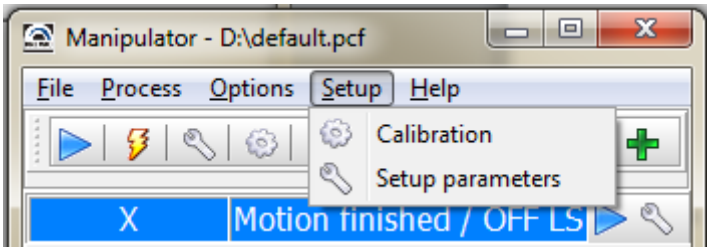
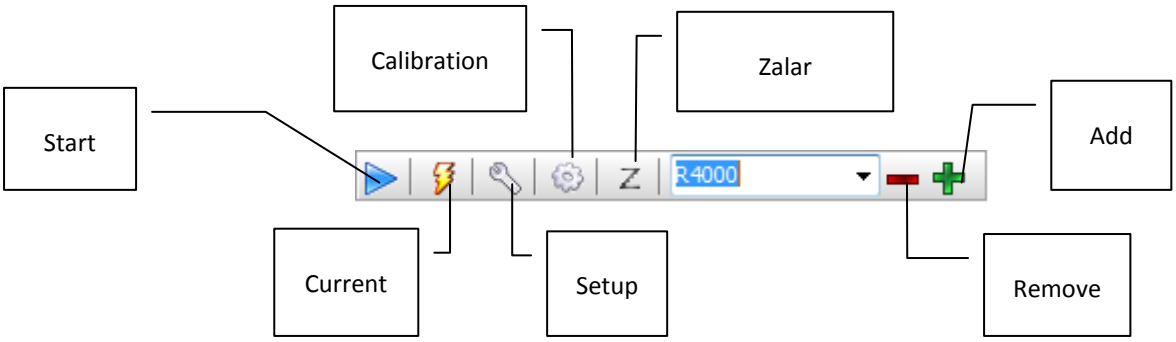


Fig. 14 Application Setup Menu

TOOLBAR



- Start and Stop – start / stop manipulator motion
- Current – turn on / turn off maintaining quiescent current (magnetic state of silence)
- Setup – show manipulator configuration panel
- Calibration – show manipulator calibration panel
- Zalar – turn on / turn off Zalar mode
- Add – save the parameters configuration for all axes under given name
- Remove – removes saved parameters configuration

MANIPULATOR AXIS CONTROL PANEL

Control panel is responsible for visualization and representation the axis of the manipulator and allow you to select the type of motion of the axis. Signalize also that axes are calibrated.

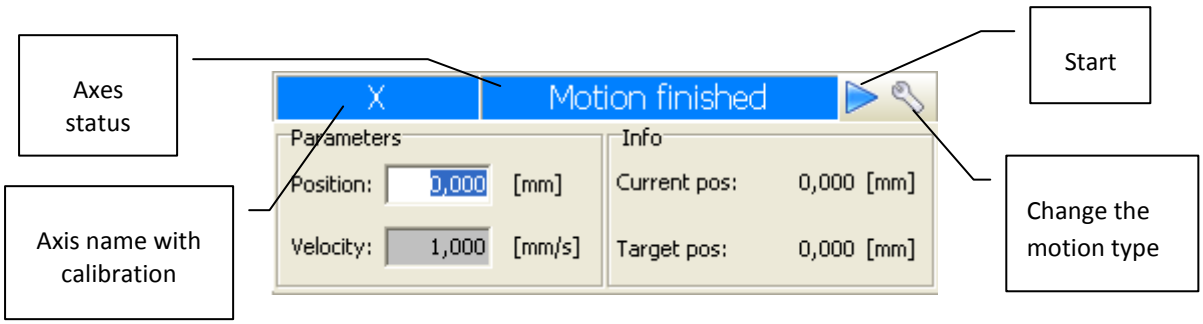


Fig. 15 Manipulator axes panel

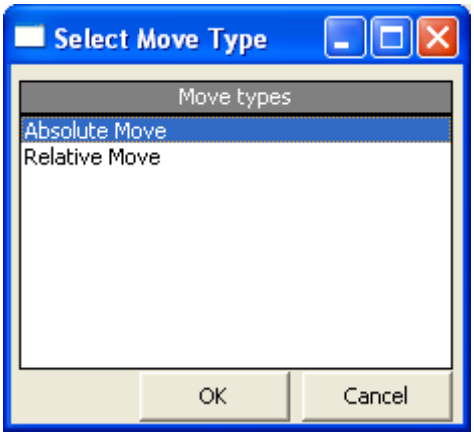


Fig. 16 Manipulator motion types for given axes

Information about the calibration state of the axis is contained in the axes background color name. The red color defines the axis is not calibrated. Blue defines the axis is calibrated.

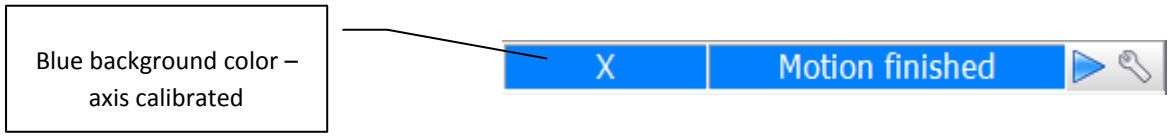


Fig. 17 Calibrated axis motion control panel

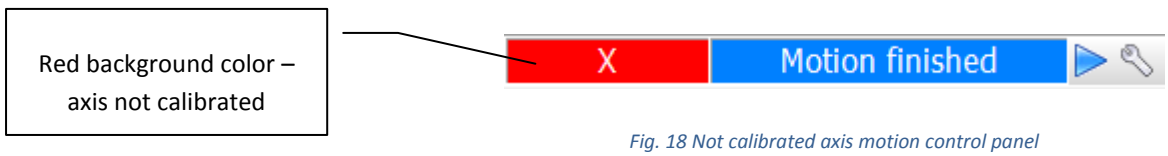


Fig. 18 Not calibrated axis motion control panel

MANIPULATOR AXIS CALIBRATION PANEL

The calibration panel has three buttons used during the calibration process:

- Set – sets the value as the axis position, for example 0
- Auto – starts the auto calibration process (finding the reference position on rear limit switch and shift the axis of a predetermined distance to the reference position – the adoption of this position as 0.
- Clear – button used to remove driver errors such as: hardware driver after reboot, visible two limit switches, etc.
- User configuration – option allow users on change of calibration distance. If option is enabled user may configuration of distance from backwaord limit switch which will be reference point as position 0. If option is disabled calibration will be performed automatically with saved parameters.

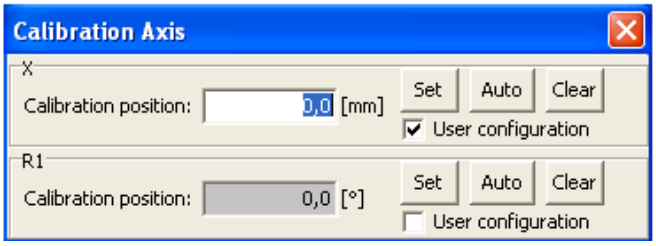


Fig. 19 Manipulator axis calibration panel

SETUP PARAMETERS

MAIN WINDOW

The main windows is divided into three parts:

- Toolbar
- List of axis
- Bookmarks with options for each axis

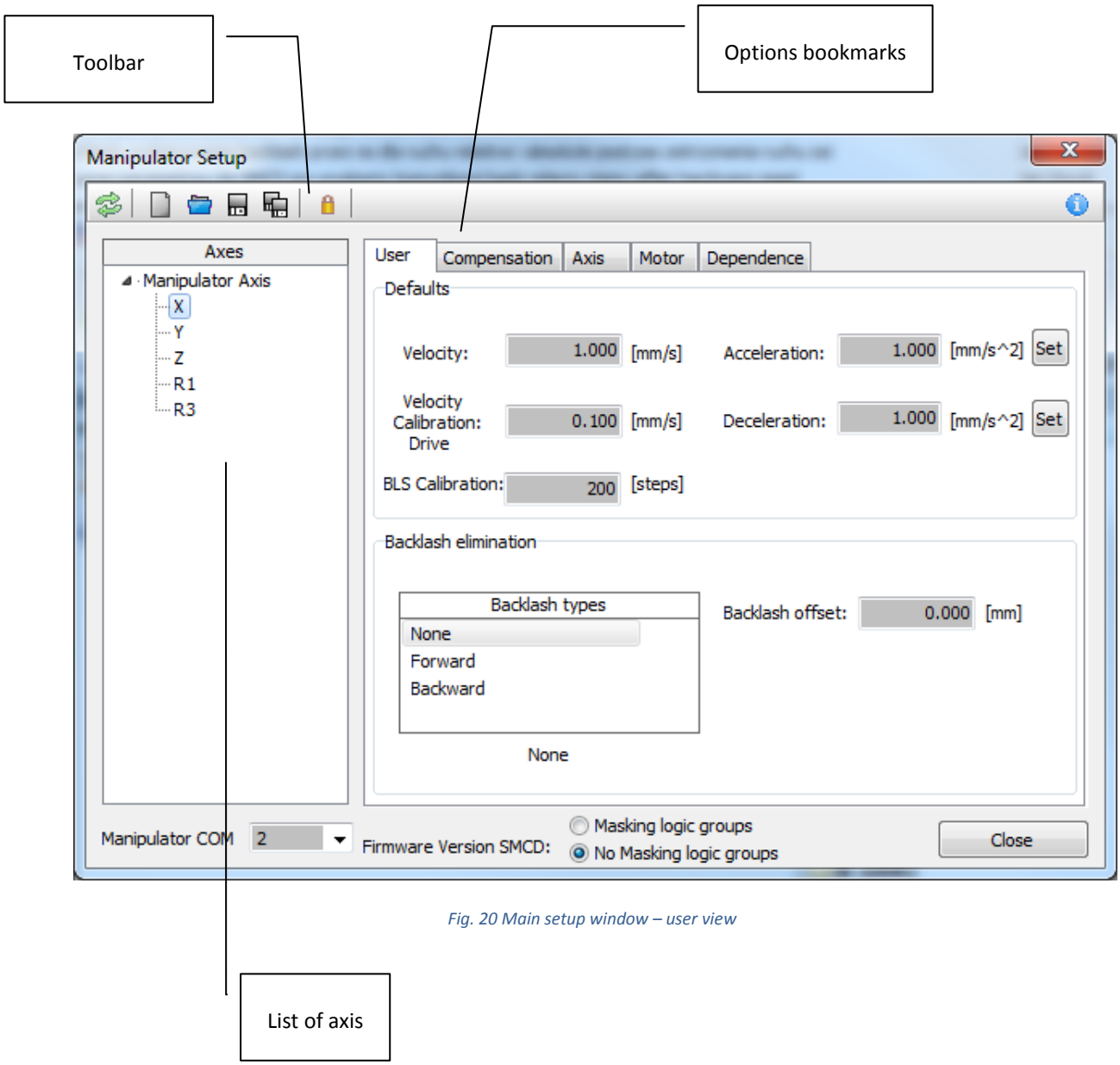
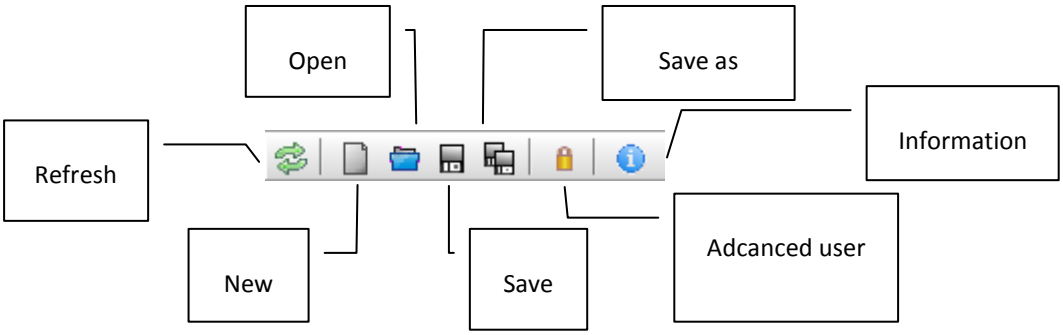


Fig. 20 Main setup window – user view

TOOLBAR



- Refresh – updates the settings and parameters of the axis
- New – creates a new project
- Open – opens a saved project
- Save – saves the current project
- Save as – allows you to save the current project under a new name
- Advanced user –allows you to launch the advanced options of manipulator configuration. We have access to following tabs: *Axis*, *Motor* and *Dependence*. We can configure the available motion types for given manipulator axis and choose proper firmware version.
- Information – gives informations about the Manipulator software

LIST OF AXIS

Panel containg all axes while allowing:

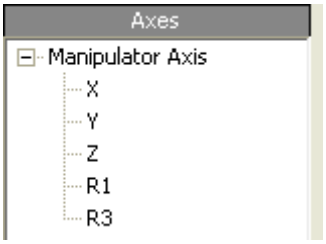


Fig. 21 List of axis view

- Adding a linear or rotary axes
- Removal of the axis
- Renaming axis
- Setting the axial dependence

All of above list of options for the axes are only available for advanced user. Access to them is possible by clicking right mouse button on the desired axis.

There are available following options when you click the right mouse button on the *Manipulator axis* position

- Add New Axis ---->Linear – adds new linear axis
- Add New Axis ---->Rotatory – adds new rotatory axis

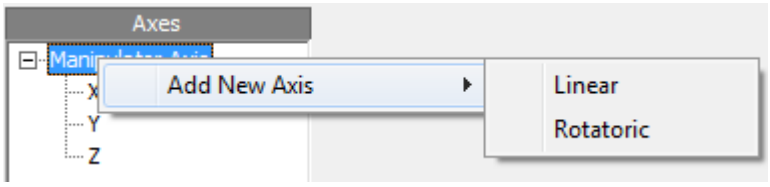


Fig. 22 Add new axis menu

When you click the right mouse button on any axis position, following options are available:

- Add New Axis – add new linear axis and set it as a dependent of the selected axis
- Set Axis Dependence – sets selected axis as a dependence axis
- Remove Axis Dependence – removes axis dependence
- Rename Axis – renames axis (names must be unique)
- Remove Axis – removes axis of manipulator

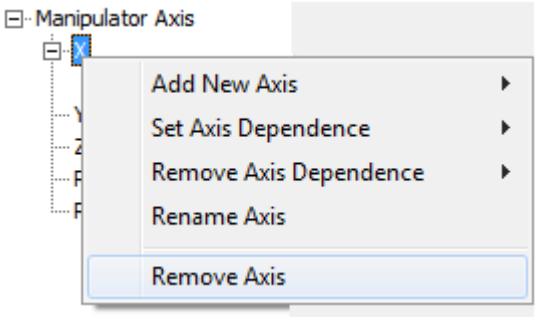


Fig. 23 Manipulator axis management menu

Dependent axis view

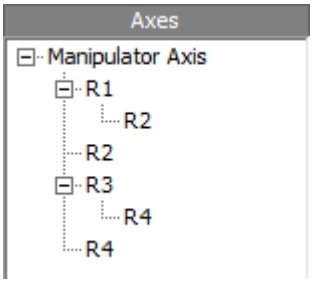


Fig. 24 Axis dependent

Axial dependence is presented as a tree in which successive nodes represent a relationship of dependence. In Figure 24 we see two main axes R1 and R3, which are dependent on one axis, in succession R2 and R4.

COMPENSATION TAB

This panel is responsible for setting the parameters of motion compensation sample size. In the absence of an incorrect configuration compensation move instead of the panel below displays the message "*Move Compensation is not configured*"

Motion compensation is to keep the sample in the axis of symmetry of the manipulator regardless of its thickness. Compensation is performed through an appropriate axes linear motion, depends of the exceeding sample thickness over manipulator symmetry axis.

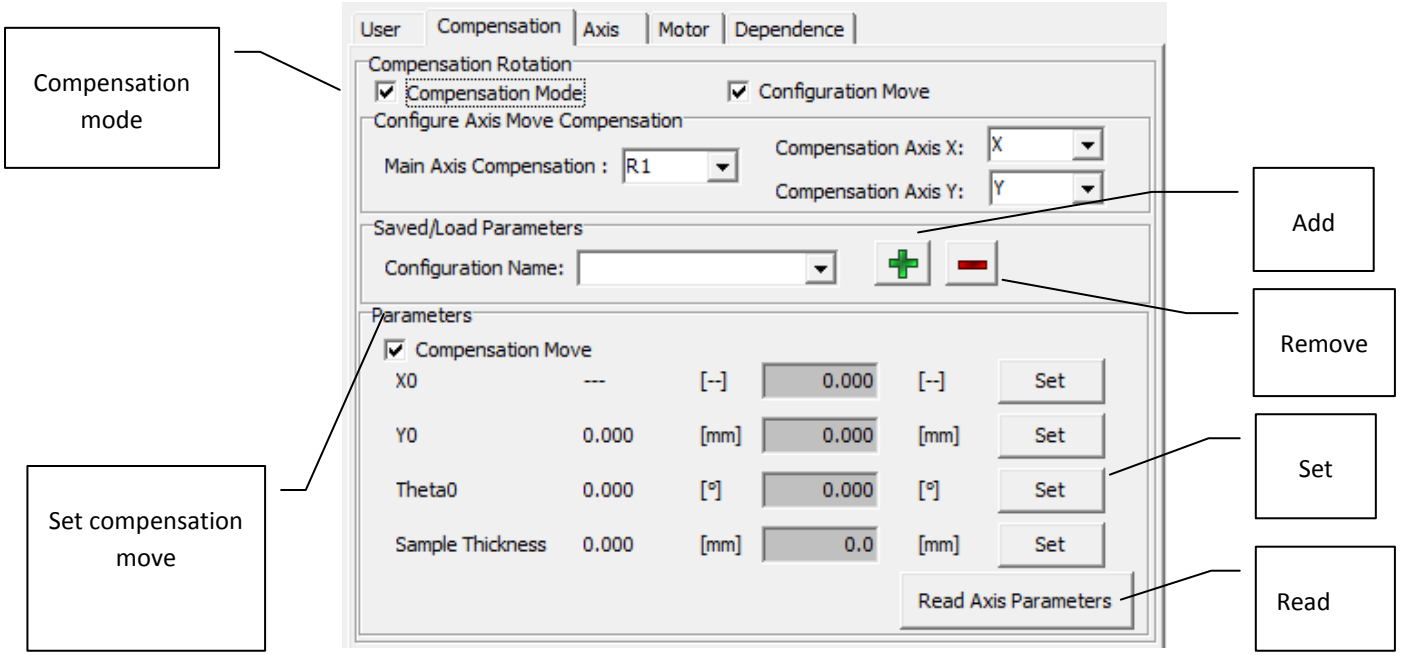


Fig. 25 Thickness compensation tab

- Compensation Mode – selecting this option allows you to configure parameters of compensated motion (available since ver 3.1).
- Configuration Move – allows to configure motion compensation
- Main Axis Compensation – sets main axis of motion compensation
- Compensation Axis X/Y – sets axes to compensate for movement of main axis compensation
- Compensation Move – selecting this option causes run compensated motion of main compensation axis.
- Set – sets device corresponding parameter
- Sample Thickness –thickness of the samples exceeding the manipulator symmetry axis
- X0,Y0, Theta0 – compensated motion parameters (angles of the manipulator compensated axes)
- Add –saves current configuration
- Remove – removes configuration with a given name
- Read – reads current parameters of sample compensation

ZALAR

In this window User can define movement of the manipulator around a point that is part of the sample.

Due to the mechanics of the manipulator sample movement is performed about an axis of rotation. In this window User can also define all parametres regarding compensation of sample thickness during manipulator displacement. Compensation is performed based on simple moves of linear axes. Those linear movements directly depends from the thickness of the sample and they are performed based on symmetry axis of manipulator.

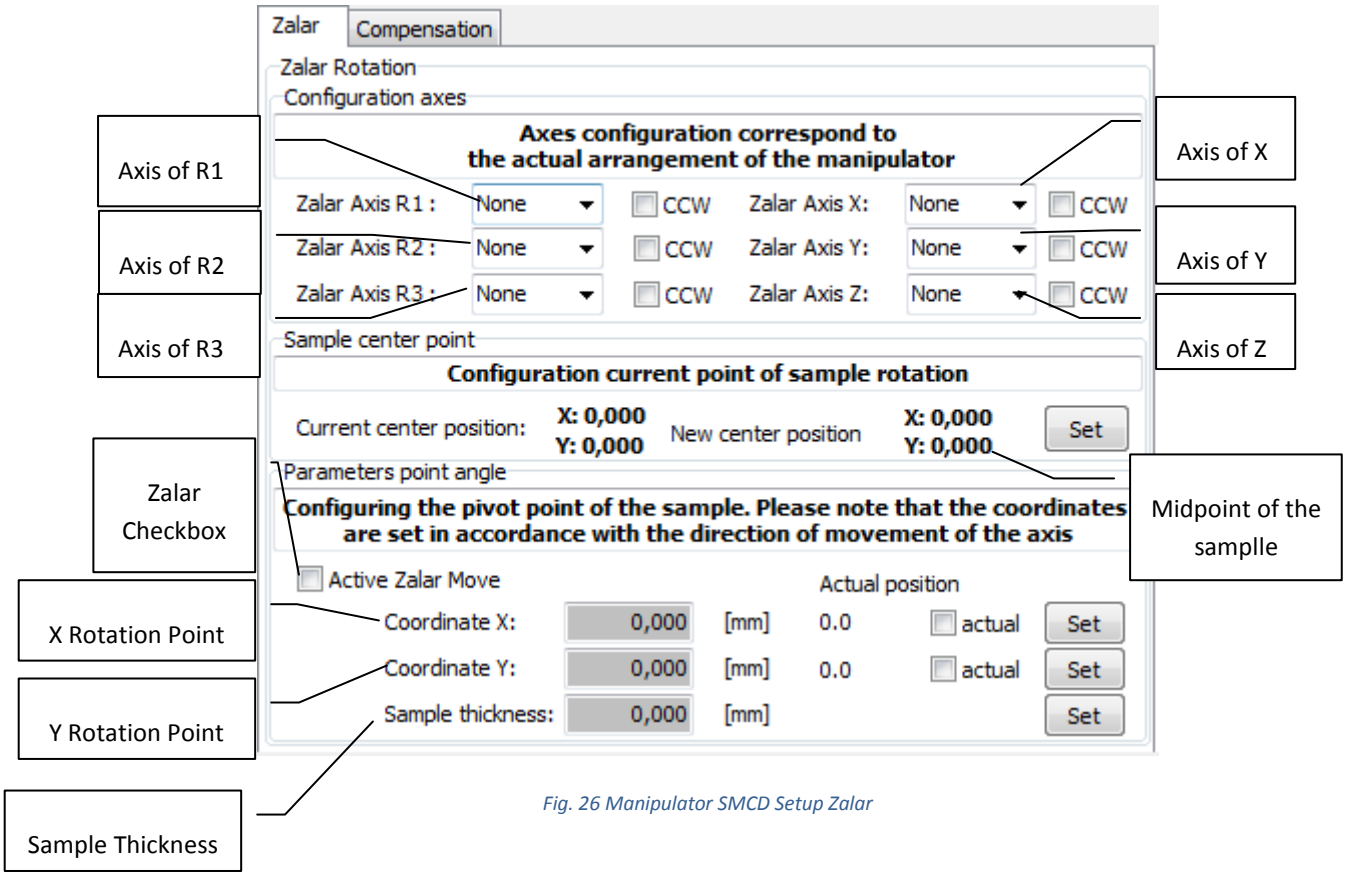


Fig. 26 Manipulator SMCD Setup Zalar

- Axis of R1 movement
  (CCW is an option that when activated adjusts the axis to clockwise coordinate system)
- Axis of R2 movement
  (CCW is an option that when activated adjusts the axis to clockwise coordinate system)
- Axis of R3 movement
  (CCW is an option that when activated adjusts the axis to clockwise coordinate system)
- Axis of the rotation which manipulator performs movement as R1
  (CCW is an option that when activated adjusts the axis to clockwise coordinate system)
- Axis of the rotation which manipulator performs movement as R3
  (CCW is an option that when activated adjusts the axis to clockwise coordinate system)
- Axis of the rotation which manipulator performs movement as R2
  (CCW is an option that when activated adjusts the axis to clockwise coordinate system)
- The midpoint of the sample to which the manipulator will calibrate.

To enable administration of coordinates trading in accordance with actual sample points, set the measure taken in accordance with the rotation axis R2.
This section just set the center of rotation of the sample. That means we give X and Y coordinates which are responsible for the center of rotation of the sample relative to the axis R2. In most cases it will be a point 0.0 which is set after calibration X and Y. It may happen, however, that this point will be shifted because the point (0;0) will be used in transfer.

- Zalar movement is active only when this checkbox is selected.
- X position of the point around which manipulator will take movement (Checkbox Actual sets as point of rotation actual position of X).
- Y position of the point around which manipulator will take movement (Checkbox Actual sets as point of rotation actual position of Y).
- Thickness of the sample on which is zalar used (It is a parameter which is needed to compensate.)

ZALAR – PRINCIPLE OF OPERATION

Zalar movement allows us to turn the sample around the point (X,Y), which is on the surface of the sample and also take into account compensation as well as sample thickness. Due to the mechanics of the manipulator sample movement always runs around the rotation axis. The movement is involved only with one axis.

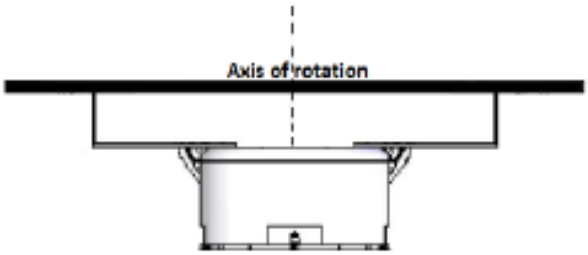


Fig. 27 Manipulator Zalar Axis of rotation

To allow the rotation of the sample around a set point in the movement off-axis rotation are entered linear axes X, Y, whose job is to maintain a ixed pivot point.
After turning around the axis R2 sample point P around the measurements are made will be moved to P'. For measurements were carried out around the same point but at a different angle to be point P' to move into the P-site by the motion compensation, the X and Y distances from ΔX and ΔY

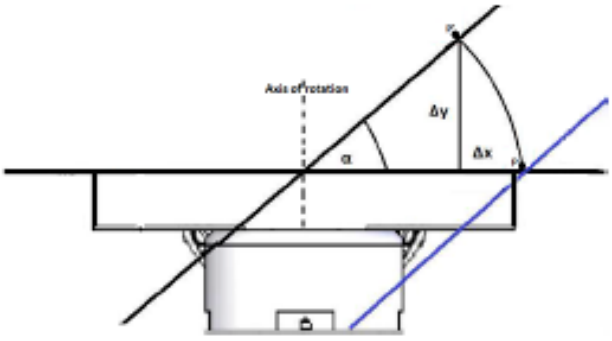


Fig. 28 Manipulator Zalar Point P Rotation

Movement Zalar also allows compensation thickness of the sample. That means we keep a ixed point of rotation regardless of the thickness of the sample. In maintaining a ixed point of rotation involving the Z-axis and the relationship with respect to the axis rotates, the Y-axis during the rotation

about the axis R1 or X-axis during the rotation about the axis R3.

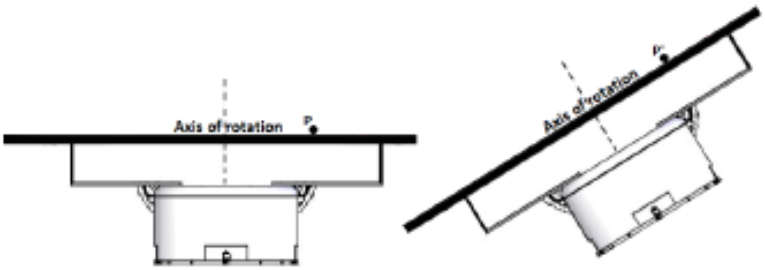


Fig. 29 Manipulator Zalar Point Compensation

After turning around the axis of the R3 sample point P around which measurements are made will be moved to P' . For measurements were carried out around the same point but at a different angle to be point P' to move into the P-site by the motion compensation, the X and Z from the distance ΔX and ΔZ

ZALAR – EXAMPLE OF ZALAR USE

From the user's perspective, the program is suf□icient to give the coordinates of the pivot point and the thickness of the sample, after the administration of these coordinates suf□icient to run Zalar by checking the checkbox labeled Active Zalar move.

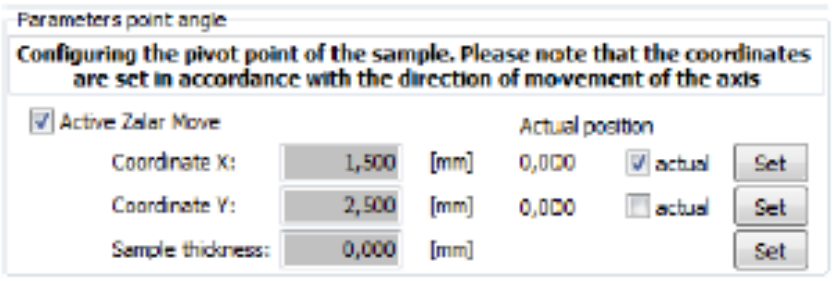


Fig. 30 Manipulator Zalar Point Assignation in Setup

The important thing is that, in order to approve the designated points you need to use the "Set".
It should also be remembered that when activated by the checkbox Zalar in the Setup Zalar will not yet be activated. Activation occurs during the start of the **rotatic** axis movement and it is executed automatically. When moving the axis for eg. X, then Zalar is not active.
In the case of checking the "Actual" checkbox software as a pivot point set the current position of the X or Y axis, depending on the case.

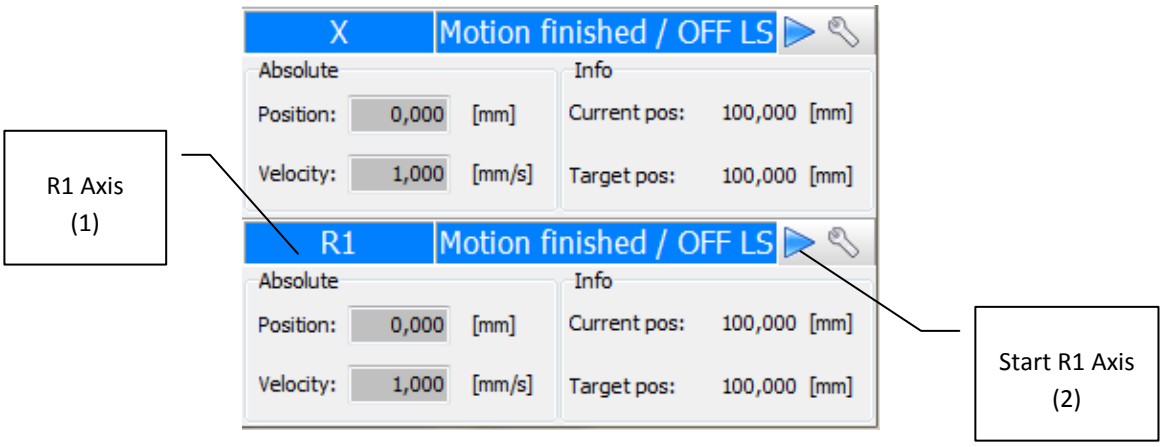
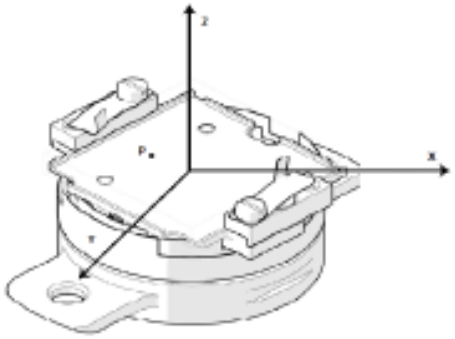


Fig. 31 Manipulator Zalar Movement

In this case Zalar will start only in the case of axis designated with number "1" (R1 axis) on the image using the button designated with number "2". While using X-axis Zalar will be disabled.



Designate a point which is in the area of the sample is dependent on the X-axis and Y-axis, so we have to take into account the position of this point in relation to these axes.

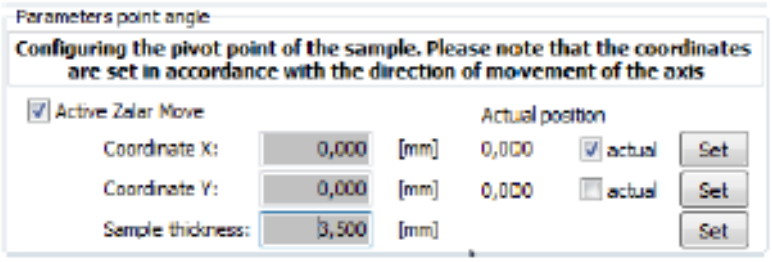


Fig. 32 Manipulator Zalar Point Assignation in Setup

From the point of view of the user should only give a sample thickness above the axis of rotation.
If the point coincident with the axis of rotation R2 are coordinate axes X and Y are as (0, 0). If we want to compensate for the thickness of the sample and perform rotation around any point of the sample is beyond the sample thickness give the pivot point.

USER TAB

Panel available for advanced users.

Panel allows you to enter various parameters of the axis of the manipulator:

- Acceleration –axis acceleration value
- Deceleration – axis deceleration value
- Velocity – default value of axis motion velocity
- Velocity Calibration Drive - velocity of slow move to limit switch while auto calibration
- BLS Calibration - descent value from limit switches while auto calibrating, given In steps
- Backlash types – selection of the type of backlash for the elimination of the selected manipulator axis (recommended – Forward backlash elimination).
- Backlash offset – value of the backlash elimination (backlash elimination mechanism has been described in the chapter "The elimination of backlash ").

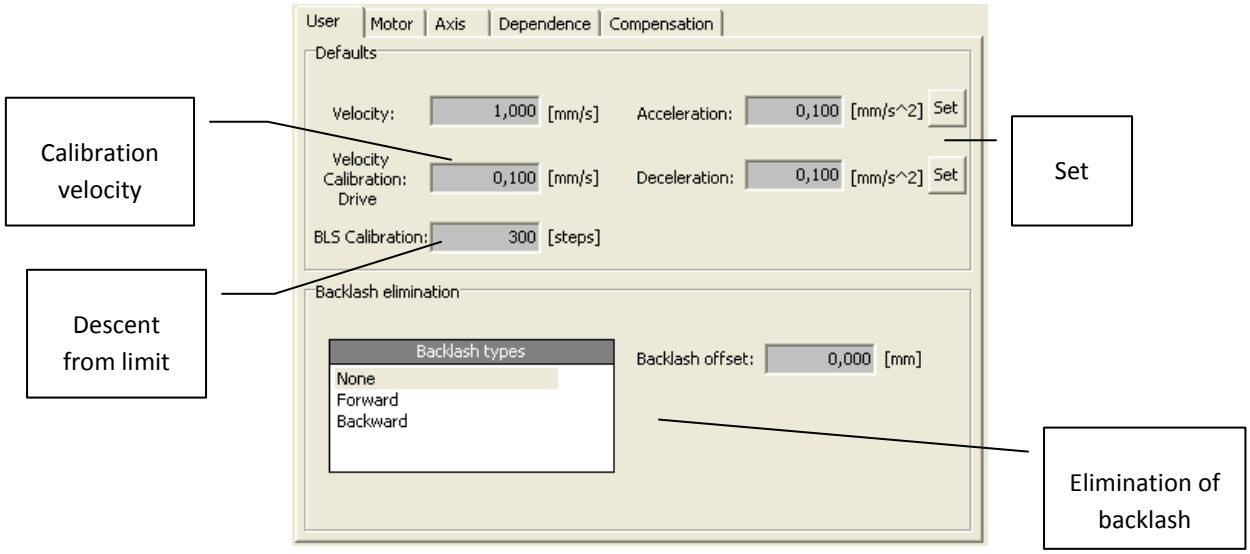


Fig. 33 User settings tab

MOTOR TAB

This panel is available for advance users.

The panel contains information about each device parameters.

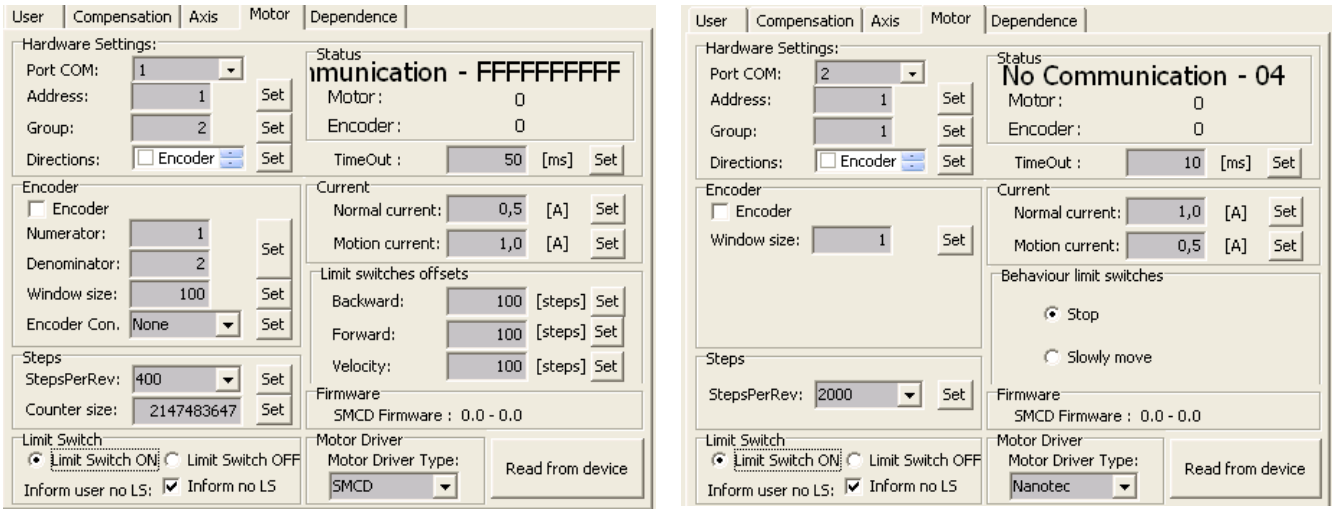


Fig. 34 Motor settings tab

- Port COM – sets the communication port for given axis
- Address – sets the address of the SMCD driver connected to given axis
- Group – sets a logical group of a SMCD driver which is address extension
- Directions – changing the direction of encoder, controller, motor and limit switch.
- Encoder – Turning on / off encoder window control kontroli okna enkodera
- Numerator – encoder parameter
- Denominator – encoder parameter
- Window size – permissible diffrence between the current motor position and the encoder value
- Encoder Con. – sets encoder mode (*None* is recommended)
- Steps – enter the number of motor steps in full rotation
- Counter size – size of the counter of positions (after exceeding it, counter will count from 0)
- Limit Switch ON/OFF – turn on / off limit switches (option available for serviceman protected by password)
- Inform user no LS – inform user about disable control limit switches
- TimeOut – the time for waiting for reply from the SMCD controller
- Normal current – determine the motor idle current
- Motion current – determine the motor motion current
- Read from device – reads SMCD driver parameters
- Limit switches offsets:
  - Backward – determine the descent distance from rear limit switch
  - Forward - determine the descent distance from front limit switch
  - Velocity – descent velocity from specified limit switch
- Behavior limit switches – determine behavior of motor after reach of limit switch
  - Stop – stopped motion after reach of limit switch
  - Move Slowly – after reach of limit switch motor will be moves slowly with limit switch
- Motor Drive Type – determine type of controller:
  - SMCD – type of SMCD controller
  - Nanotec – type of Nanotec controller

AXIS TAB

This panel is available for advance users.

The panel contains all specified axis parameters.

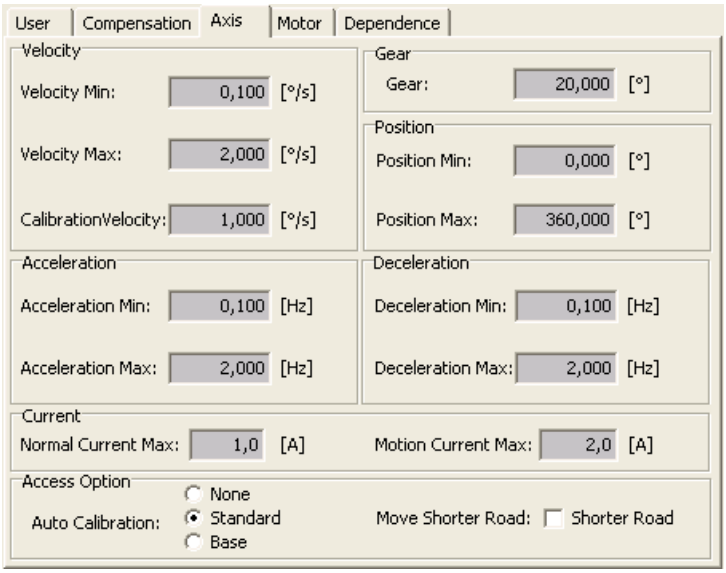


Fig. 35 Axes parameters tab

- Velocity Min – determine the minimum velocity of specified axis
- Velocity Max – determine the maximum velocity of specified axis
- Calibration Velocity – sets velocity while auto calibration
- Acceleration Min – sets the minimum value of axis acceleration
- Acceleration Max – sets the maximum value of axis acceleration
- Deceleration Min – sets the minimum delay for axis motion
- Deceleration Max – sets the maximum dely for axis motion
- Normal Current Max – maximum current motor stop which can be set to controller
- Motion Current Max – maximum current motion motor which can be set to controller
- Auto Calibration – specify the axis auto calibration type as:
    - None – auto calibration for given axis is not possible
    - Standard – standard auto calibration for ordinary limit switches
    - Base – type of auto calibration adapted to Hall sensor
- Move Shorter Road – sets the shorter road for axis motion (fe. from position 5 to position 355 axis will move backwards with this option selected, otherwise axis will move forward). This option is available only for rotation axis.
- Continous Backlash – turning on the mechanism of backlash elimination when stopping continous motion for rotary axis.
- Gear – determine the axis gear ratio
- Position Min/Max – determine the range of values, where the given axis will move

DEPENDENCE TAB

This panel is available only for advance users.

In this panel we can define relationships between the axes. After defining the dependent axes for given axis, user should define dependency ratio.

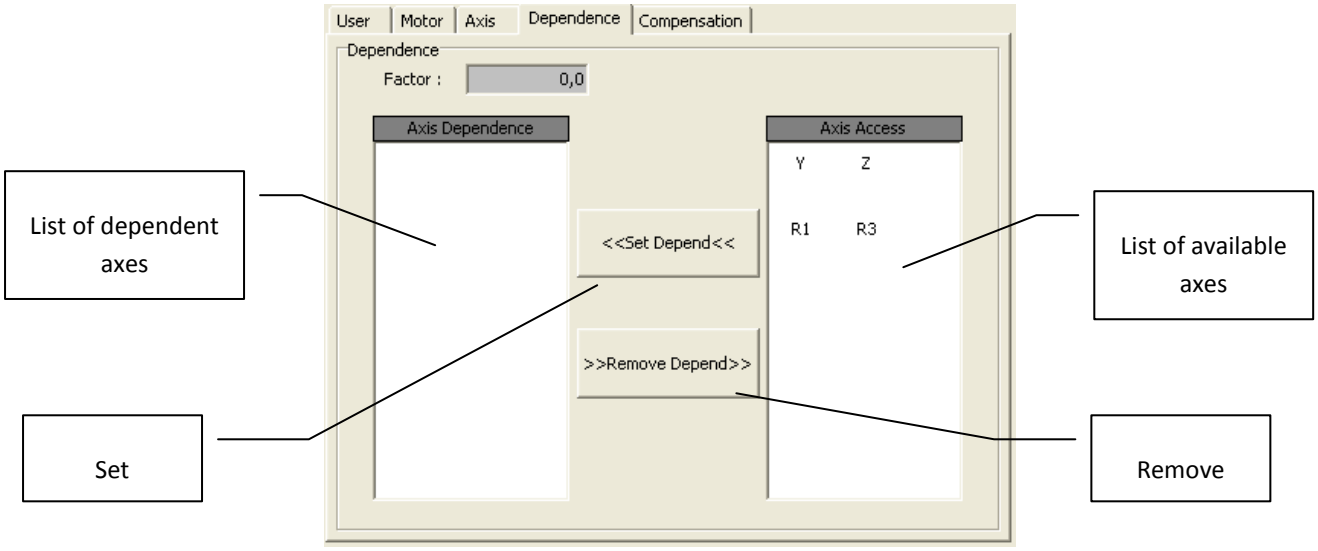


Fig. 36 Definitions tab of dependence axial

- Factor – specify the dependence value of the axis according to the overriding axis
- List of dependent axes – set of axis of dependent directly from the given. User can add and remove choosen axes from the list
- List of available axes – set of all possible axis, from which we can add axis as a relative dependent to given
- Set Depend – sets axis as dependent from given
- Remove Depend – remove axis dependent, between choosen and given axis

CHOOSING THE FIRMWARE VERSION

Firmware version is used while configuring dependent axis. For firmware version older than 3.5, application allows to control only one level of dependency of axes. In versions 3.5 or later, number of levels of axes dependencies can be any number. The difference lies in recognizing logical groups for broadcast commands. In case of version 3.5 or later there is a mechanism for masking logical groups, which allows using broadcast commands. Command is send to driver which are in different logical groups (values of logical groups must be the power of 2).

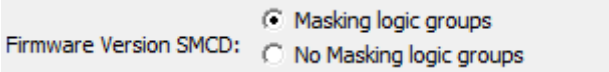


Fig. 26 Selection of firmware version

- Masking logic groups – this options is set for firmware version 3.5 or later. Allows the user to configure any number of levels of axes dependencies
- No Masking logic groups – this option is set for firmware version older than 3.5. Allows the user to configure one level of axes dependency

- Allows to configure one level of axes dependencies

CHOSE PORT COM

Option allows select communication port for a specific family of controllers: SMCD, Nanotec. This allows on perform a global start and stop all axes manipulator. Depending on axis of manipulator may be available options:

- only SMCD - manipulator consists only of the drivers SMCD
- only Nanotec - manipulator consists only of the drivers Nanotec
- SMCD and Nanotec - manipulator consisted both drivers: Nanotec and SMCD (image below)

ADDING NEW AXIS

Adding new axis is possible with enabled advanced users mode (firmware version 3.1 or later).

In case of removing axis from software which is controlling manipulator work, or adding new driver to stepper motor into system, *Manipulator* application can add New axis responsible for controlling certain driver.

To add a new axis, go to the *Setup Parameters* window (check „User interface"). On the left side of window the axis list is presented. To add new axis, go to the *Manipulator Axis* node and expand the menu, accessible from the right mouse button (Fig. 31). Then select corresponding type of axis (linear or rotary). Newly added axis will appear on the list of axes, with a default name indicating the type of axis. In the main window a new panel will appear, corresponding to axis of the newly created axis. The panels may differ depending on the version of software. For version older than 3.1 panel appears as shown in Figure 32, and for version 3.1 of the panel will look like in Fig 33. The difference consists of the available types of motions, visible for versions earlier than 3.1 and not available for version 3.1 or later.

Fig. 27 Add a new axis menu

Fig. 37 Axis panel without determined type of motion

Fig. 38 Axis panel with determined type of motion

In case of the absence of the type of motion on the axis panel, user needs to select it from a motion types list. If the list is empty, Jeżeli lista jest pusta, add the types of motion from the list. List will appear by clicking in the upper left corner of the type of motion window (prominent place shown on fig .34, available only to advanced users).

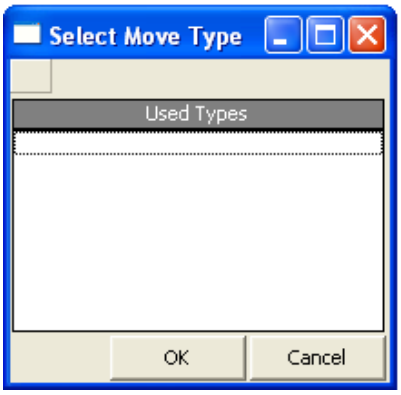


Fig. 39 Window for selecting motion types with hidden types

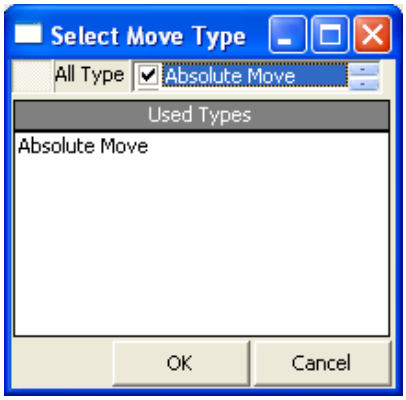


Fig. 40 Window of available motion types

After adding a new axis, and set the appropriate types of motion, you must configure its parameters. The user should also specify the parameters of the stepper motor driver that is associated with a given axis. For proper communication with the driver software is required to set the correct COM port and then the logical address and group. Controller parameters should be assigned by clicking the set button, keeping in mind the earlier turning off of all other drivers. Attemp to set an address or a logical group of driver, if not turning off power supply on the other axes may lead to an incorrect address settings on all drivers and the need to address configuration / logical group on all manipulator axes. If communication is established you must configure the driver parameters available in the *User* and *Motor* tab.

Available features include acceleration, deceleration, reunions with limit switches, current values, the parameters of the encoder and the number of motor steps in full rotation. User shouldn't forget to approve each feature by clicking *Set* button. After setting parameters user should configure parameters of axis like: value of gear, the elimination of backlash (check "Elimination of backlash" chapter), descent from limit switch and free access to limit switch while auto calibrating, type of auto calibration, values range for acceleration, decelaration and speed and range of position limiting movement of the linear axis and correcting for rotary axis (current value is converted into a value between positions). The exact description of the parameters, user can find in sections *"User tab"*, *"Motor tab"* and *"Axis tab"* of the *"Parameters Setup"* chapter.

AUTOCALIBRATION

Auto calibration process is for searching of reference postion on rear limit switch. This involves shifting the postion of axes of a specified distance from the rear limit switch and setting that position as a 0 position. In Manipulator application we can divide two types of auto calibration: *Standard* i *Base.* For the *Base* type doesn't have to be turned on rear limit switch. Proccess will automatically turn on it and turn off after finish. *Base* type is deadicated to the rotational axis using a Hall sensore based limit switch. Appropriate type is selected on the Setup tab of the axis parameters.

Fig. 28 Choice of auto calibration

Auto calibration process can be run by click *Auto* button located In the *Calibration Axis* window. This window can be run from the toolbar or main menu (fig. 38). It should be noted that this process is not always available for a given axis. It is conditioned by the configuration of the manipulator. In the absence of auto-calibration of the axis, the Auto button is not available.

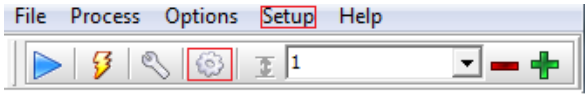


Fig. 41 How to display the auto calibration

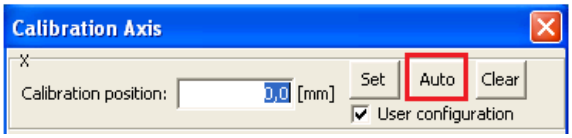


Fig. 42 How to run auto calibration process

Auto calibration proceeds automatically In the following steps:

1. Move towards the rear limit switch
2. Am moving away from limit switch by distance set In *BLS Calibration* parameter (*User tab* of *Parameters Setup* window)
3. After passing the distance of descent of the limit switch, there is slow access to limit switch in order to exact positioning it. Access speed is specified in *Velocity Calibration Drive* parameter- *User* tab, *Parameters Setup* window.
4. After reaching the limit switch there is departure from it by calibration distance the determined in the previous auto calibration process. After the end of movement If is enabled calibration process is ended and go to point 7 otherwise will be performed correction of calibration according with point 5.
5. After the end of movement user is asked if the point where the axis currently is located the is correct (corresponds to its reference point). If so, confirm this fact by click *Yes* button. The process of autocalibration at this point is completed.

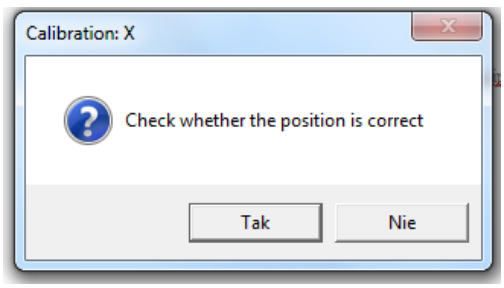


Fig. 43 Question window about the accuracy of calibration

6. If you consider that the refrence point was not achived in this window (Fig. 40), click *NO* button. Then you will be asked to set in manual mode the refrence position, consisting on performing motion on certain axes from the control panel menu of certain axis or manually after turn off current axis. After obtaining the refrence postion, confirm this fact by clicking the *OK* button (fig. 41). If you want to stop the process, click Cancel (fig. 40)

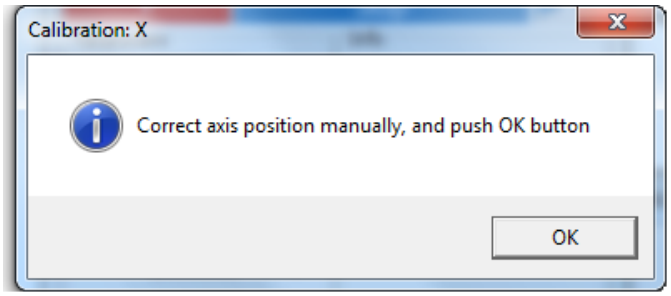
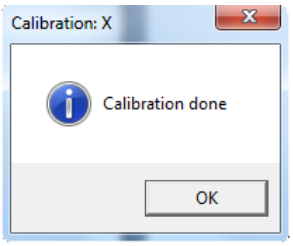


Fig. 44 Confirmation window for manual setting of referential position

7. After successful execution of the process of auto calibration the user is informed of its completion (Fig. 42)



Rys. 45 Auto calibration confirmation window

In case of an error during the process, auto calibration is stopped and a message is displayed as Fig. 43. Events that could lead to such a situation are listed below:

- Stopping the movement of the axis by user
- Axis error (descriptions of the errors can be found in „Axis status" section)
- Timed out waiting for a specific event during the process

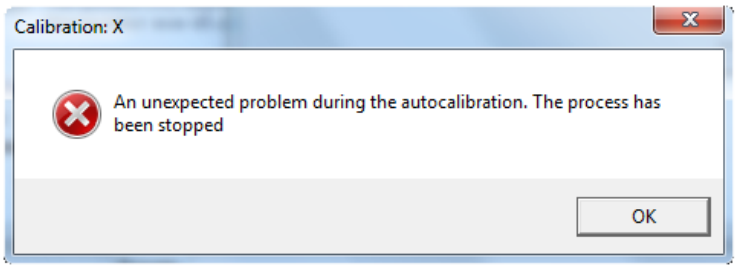


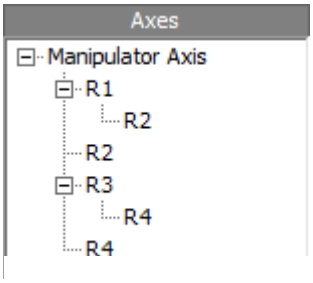
Fig. 46 *Window indicating that interruption error occured while auto calibration process*

Notes:

- Descent from rear limit switch cannot be too short because the process is interrupted after a timeout
- Performing auto calibration for the axis having dependent axes is not possibile. In that case the process of auto calibration should be carried out separately for each axis. While auto calibrating main axis, all of the dependent axes should be removed.

AXIAL DEPENDENCE

The multi-axis manipulators often there is an association the between axes called – axial relationship, relied on direct connection between the main and dependent axis. Setting main axis into motion, dependent axes involuntarily changes its position, despite we didn't drive it into motion. Such movement is undesired and should be corrected. *Manipulator* software from version 3.1, corrects motion for axes strongly dependent, where axis dependence level occurs.



Rys. 47 Axes dependence

Manipulator software from version 3.1 allows the user to configure the dependence axis in two ways (available for advanced users):

- on the dependence axes list (*Setup Parameters* window)
- on the *Dependency* tab in *Setup Parameters* window.

The list of axes, configuration of dependence axis is available on the right mouse button, by selecting the appropriate function and axis. *Set Axis Dependency* function (Fig. 45) sets the dependent axis for choosen main axis, available after expand *Set Axis Dependency* section. Removing axial depnedece can be achived by select *Remove Dependency Axis* option (fig. 46)

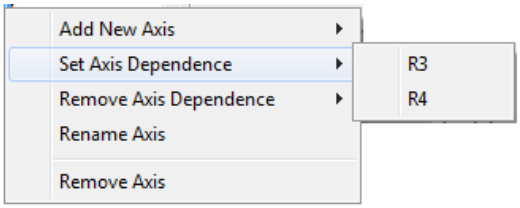
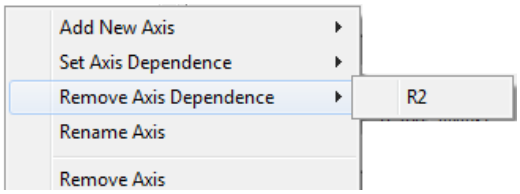


Fig. 48 Adding dependence axis



Rys. 49 Removing the dependence axis

Configuration of *Factor* parameter takes place In the *Dependency* tab (fig. 47) in *Setup Parameters* window. That parameter describes how the main axis motion affect on the dependence axis motion, in other words how far the dependent axis will move while main axis movement, despite we didn't drive it in into motion. This motion will be corrected so that the dependence axis will remain in the same position. In this tab you can also set the relationship between the main axis and the rest of axes. On the *Axis Dependency* list there are dependent axis of the given main axis. On the *Axis Access* list there are axes which can be added as a dependent. Adding or removing axes dependent axes is done by *Set Depend* and *Remove Depend* buttons.

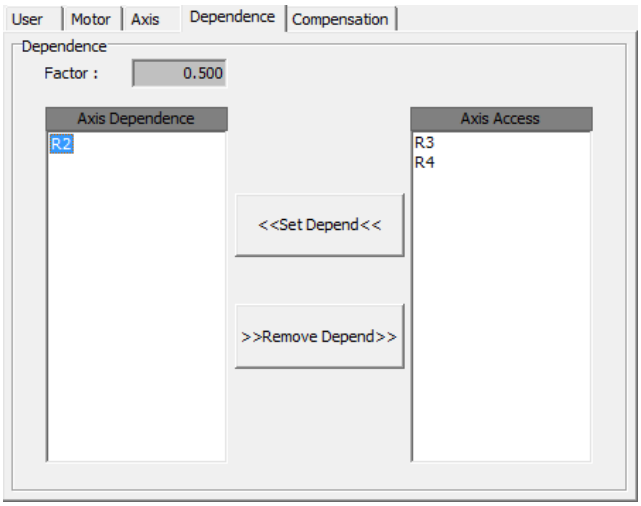


Fig. 50 Dependent axis configuration tab

Limitations :

- axes cannot be dependent on each other
- depending on the branch, specified axis can be found only once

Motion and its consequences:

While driving the dependent axes, stopping the motion of the main or dependent axis, in case of interference of user or move to limit switch, will cause the stop of dependent axes. From the manipulator perspective that kind of situation shouldn't happen, because then dependent axis won't be calibrated anymore. In order to reduce the value of the axis while move to limit switch while its not calibrated, value of the descent of limit switch is automatically set to 0 for all involved dependent axes in motion.

The sequence performing of motion:

1. Motion of the main axis automatically cause motion of dependent axes
2. Making a possible mechanizm for the elimination of backlash by the main axis, cause motion of the dependent axes
3. Making a possible mechanizm for the elimination of backlash by the dependent axes
4. Making a possible own motion by dependent axes

BACKLASH ELIMINATION

In order to maximize the accuracy of the manipulator motion, each of axis has a mechanism to eliminate backlash, whose task is to remove gear backlash and tension in motor mechanics. Due to the hardware architecture of the engine, backlash may be created in the direction of front or rear movement.

Process of elimination of backlash consists on moving an additional distance by the given axis, in direction of axis motion and performing a motion into opposite direction by the distance of backlash elimination.

Setting up the elimination of backlash take place in the *User* tab in *Setup Parameters* window (Fig. 47). We can choose the following options:

- None – no elimination
- Forward – backlash elimination into backward motion
- Backward – backlash eliminacja into forward motion

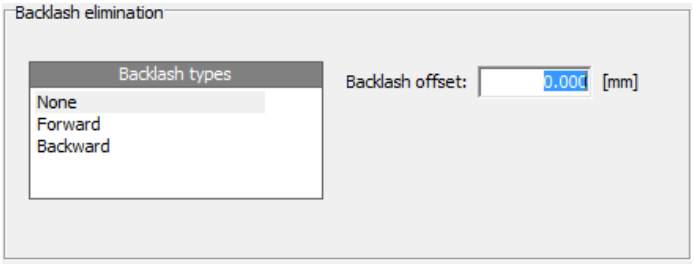


Fig. 51 Backlash configuration

Backlash Offset field is used to set the value of the backlash elimination (typically 1mm).

Forward elimination takes place in the direction of moving „backward „. *Backward* elimination takes place in the direction of moving „forward".

TYPES OF MANIPULATOR

RELATIVE TYPE

Relative type of motion of manipulator consists to move a predetermined distance from current position to the position incresed by given distance.

In order to perform this motion mode in *Manipulator* applications for a specified axis, in the main window find the panel responsible for the motion of a given axis. Then use the drive mode button (Figure 50) to open the window for selecting types of driving.

In shown bellow window (fig. 49) select Relative Move if its available. The choice must be confirmed by clicking *OK* button. After approval your choice, relative motion option will be added into axis panel. Before starting the drive user should set motion parameters, such like: motion distance in *Distance* field and motion velocity in *Velocity* field. After setting those parameters we can start the axis motion by click *Start* button. In addition, the relative motion form has been supplemented with *Clear distance after motion* marker, which resets the distance after the motion is finished if its selected.

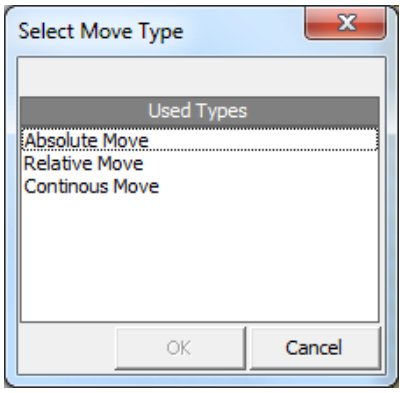


Fig. 52 Selection of motion modes

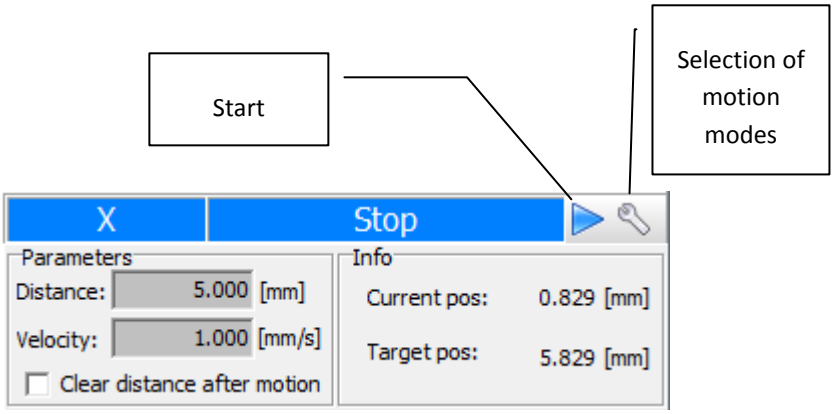


Fig. 53 Relative type of motion panel

- Distance – distance of motion
- Velocity – velocity of motion
- Clear distance after motion – clears the distance after finishing motion

ABSOLUTE TYPE

Absolute type of motion of the manipulator axis consists to motion the axis from current position to given position. In order to perform this motion mode in Manipulator application for specified axis, find in main window panel responsible for motion of a given axis. Then open the motion type window (fig. 51). In resulting window (Fig. 51) select *Absolute Move*, if its available. The choice must be confirmed by clicking OK. After approval your choice, absolute motion form will be added into axis panel. Before starting the motion, user should supplement motion parameters such as: motion position in *Position* field and motion velocity in *Velocity* field. After inserting these parameters, user can start motion with *Start* button.

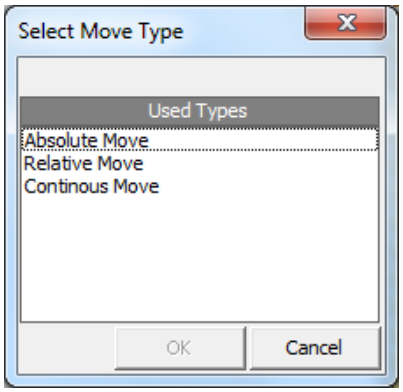


Fig. 54 Selecting the type of motion window

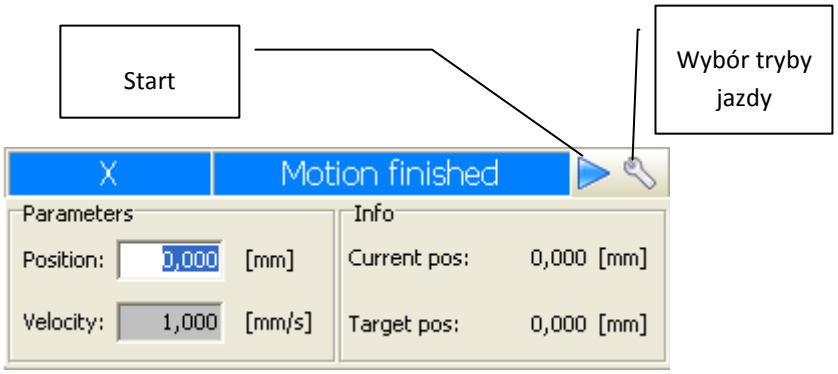


Fig. 55 Absolute motion type panel

- Position – target motion position
- Velocity –motion velocity

CONTINUOUS TYPE

Continuous motion type of manipulator axis rely on continuous motion the axis on the current position in a given direction.

In order to choose this mode in "Manipulator application" for specified axis, user should find the panel in main window, responsible for the motion of a given axis. Then use the motion mode button (fig. 53) to open the window for selecting type of motion. In displayed window (Fig. 52) Continuous Move should be selected, if its available. The choice must be confirmed by clicking OK button. After approval, continuous motion options will be loaded into panel. Before starting the motion, user should supplement motion parameters such as: motion direction in *CW* or *CCW* field and motion velocity in *Velocity* field. After inserting these parameters, user can start motion with *Start* button. In addition, continuous motion option have been completed with a *Continous* marker, which allows you to run a continuous motion for specified time. Time is set in the *Time* field.

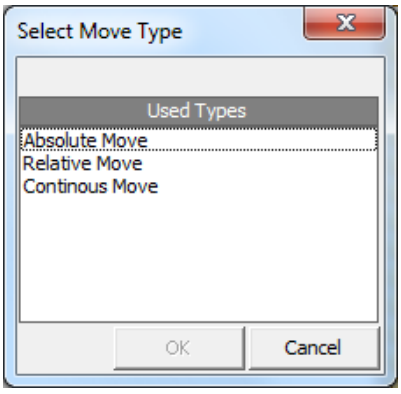


Fig. 56 Selecting the type of motion

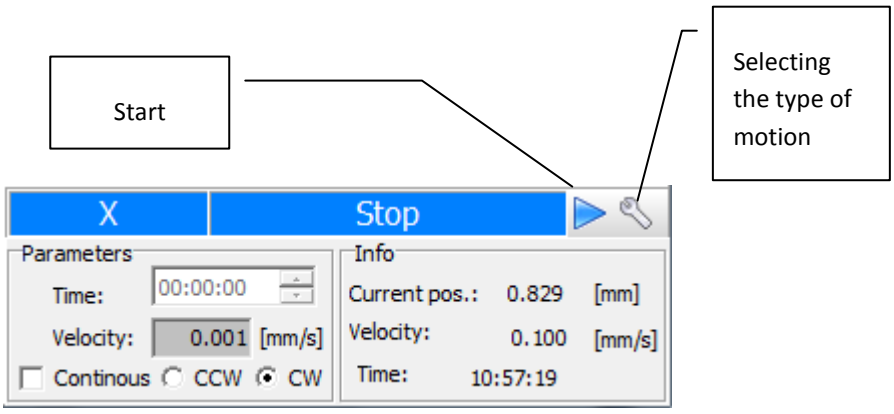


Fig. 57 Panel for continuous type of motion

- Time – motion time (active after selected *Continous* option)
- Velocity – motion velocity
- Continous – option option which activates performing of continuous type of motion on specified time
- CCW – setting the direction of motion to counter-clockwise
- CW – setting the direction of motion to clockwise

DRIVER STATUS

MOTION STATUS

- Moving – state indicates that the axis is in motion

  Moving...
- Moving Backlash – state indicates that the elimination backlash process is performed

  Moving Backlash
- Motion finished – state indicates that movement of axis between limit switches has been completed

  Motion finished
- Stop – axis motion has been stopped by user

  Stop
- Backward limit switch reached – move has been completed by properly descent from the rear limit switch

  Backward limit switch
- Forward limit switch reached – forward limit switch reached – move ended by proper descent from the front limit switch

  Forward limit switch

WARNING STATUS

- After hardware reset – state which indicates that the stepper motor has been rebooted.

  After hardware reset

  Recommended Action: Remove *After hardware reset* state using *Clear* function (*Clear* button in *Calibration Axis* window).

  Note: In this state reading and setting of the driver parameters is not possible. Performing auto calibration is not available in versions older than 3.1.

- On backward limit switch – reaching the rear motion limit switch – descent distance of the limit switch is probably too short

  On backward limit
- On forward limit switch – reaching the front motion limit switch – descent distance of the limit switch is probably too short

  On forward limit switch
- No Comunication – lack of communications between software and steeper motor driver

  No Communication

  Possible reasons for the occurrence of the *No Communication* warning*:*
  - Stepper motor driver is turned off
  - SMCD driver is not properly connected to the RS485 Moxa hub in computer with installed software
  - incorrectly selected communications port in software
  - address and / or logical group of driver is incorrectly set
  - COM port is occupied by another application

- Chip Select (locked) – device locked by an external signal. Unlock the device is possible through the release of an external signal. Then remove the error by use *Clear* function in *Axis Calibration* window.

ERROR STATUS

- Both limit switch visible – both of limit switches are visible.

Possible reasons:

- Short-circuiting the electronic of limit switches
- No connection between limit switch electronic and SMCD10 driver

Recommended Action: Check the cable connection between limit switch electronic, SMCD driver and manipulator.

- BLS wrong limit switch –stopping the movement by limit switch opposite to motion direction. When moving forward rear limit switch has been overrun.

Possible reasons:

- Reverse logic of limit switches in the driver

Solving the problem:

Follow the instructions below:

1. Remove error in the driver trough *Clear* option in Calibration window (after removing the error, in under no circumstances should move axis!)
2. Reverse the logic of the driver by changing the "Limit Switch" flag of "Direction" parameter in the "Motor " tab which is in "Parameters Setup" window.
3. Descent from limit switch

Warning: Dangerous state, any improper steps can lead to damage a limit switches, motor or chamber. After removing error do not move the axis before earlier change of limit switch logic.

Recommended: Contatct with service

- FLS wrong limit switch – stopping the movement by limit switch opposite to motion direction. While moving backward the front limit switch have been run over.

Possible causes:

- Reverse logic of limit switches in the driver

Solving the problem:

Follow the instructions below

1. Remove error in the driver trough *Clear* option in Calibration window (after removing the error, in under no circumstances should move axis!)
2. Reverse the logic of the driver by changing the "Limit Switch" flag of "Direction" parameter in the "Motor " tab which is in "Parameters Setup" window.
3. Descent from limit switch

Warning: Dangerous state, any improper steps can lead to damage a limit switches, motor or chamber. After removing error do not move the axis before earlier change of limit switch logic.

Recommended: Contatct with service

- Mechanical problem – signalization for exceeded acceptable fluctuation of position counter from encoder position (fluctuation value is defined in the *Window Size* of *Encoder* group, in the Motor tab on *Setup Parameters* window).

Possible causes:

- to small junction window
- incorrectly configured encoder parameters
- encounter while motor motion on for strong resistance

Solving the problem:

- setting the larger junction window (recommended 1mm)
- correctly configured the encoder parameters
- remove possible obstacle on the axis movement

- Hardware Error – driver hardware error

Warning: The error may be temporary and you can try to remove it by using the *Clear* option from the *Axis Calibration* window. In case of any problems associated with the removal of this error, please contact the Service Center.

MESSAGES

The application can display the following messages:

INFORMATION MESSAGES

- Configuration panels has been saved on given name – configuration of axis parameters with chosen motion types have been saved on computer hard drive.

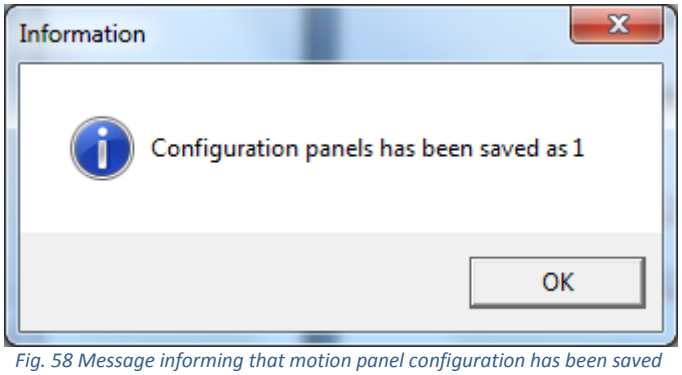


Fig. 58 Message informing that motion panel configuration has been saved

- Configuration panel name has been removed – configuration of axis parameters with choosen motion types have been removed from computer hard drive.

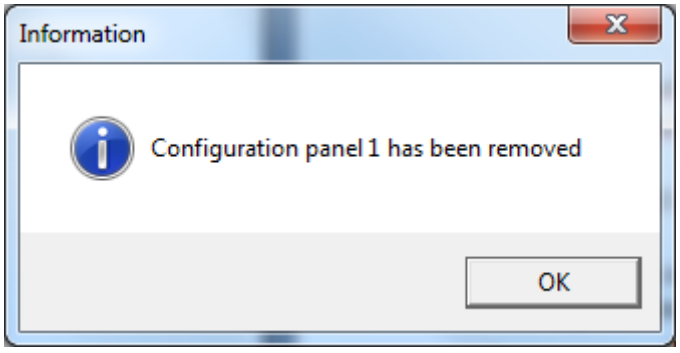


Fig. 59 Message informing that motion panel configuration has been removed

- All parameters have been correctly received – reading parameters from the stepper motor driver has been completed successfully

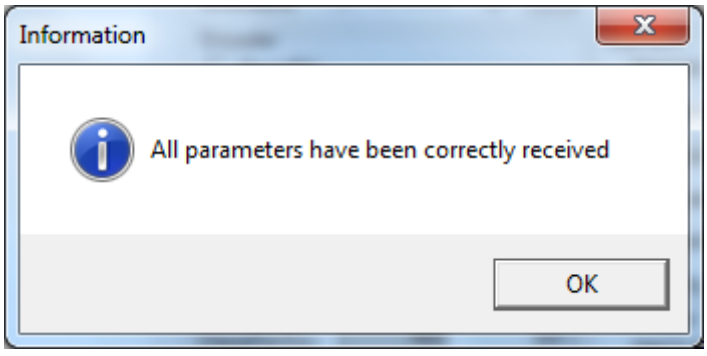


Fig. 60 Message informing that SMCD parameters have been correctly received

- The parameters were set correctly in the driver – value of choosen parameter is correctly set in the stepper motor driver.

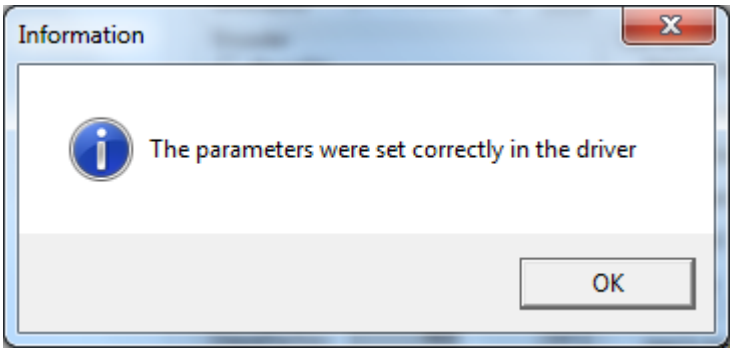


Fig. 61 Message informing that SMCD parameter has been correctly changed

- Configuration with given name was added – parameter configuration of compensation mode has been saved to disk under the given name

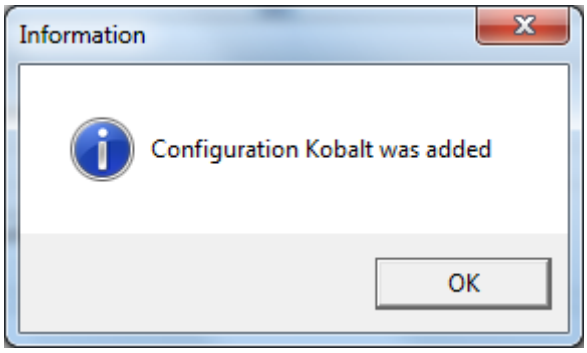


Fig. *62 Message informing that configuration motion compensated has been added*

- Configuration with a given name has been was removed – parameter configuration with a given name has been removed from the disk

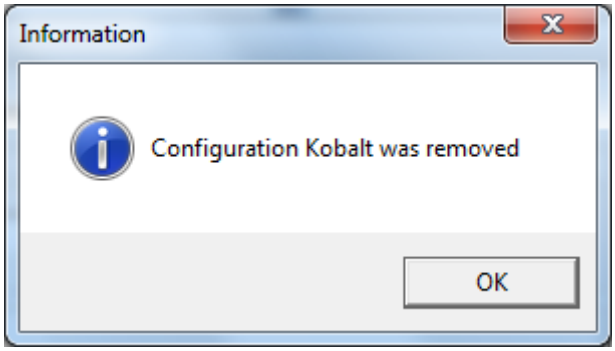


Fig. 63 Message informing that configuration of compensated motion has been removed

- If you want to change Acceleration you must click the set button – message reminding to approve of settings the *Acceleration* parameter in the stepper motor driver, if you don't click *Set parameter* button.

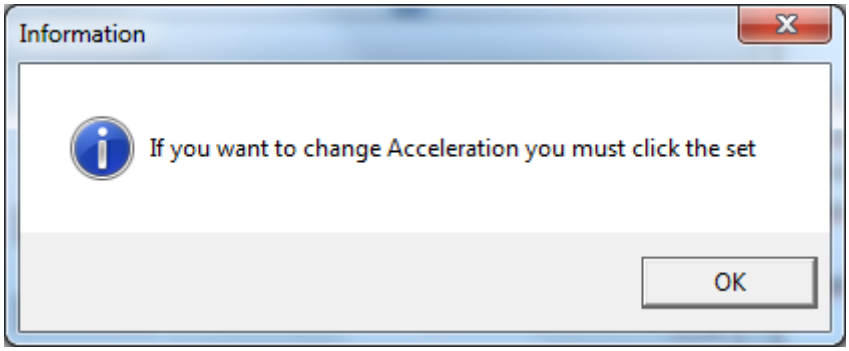
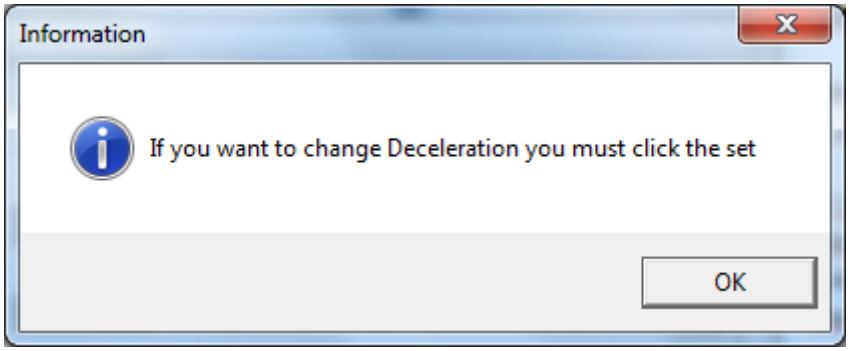


Fig. 64 Message reminding that you must click Set *button after changing acceleration*

- If you want to change Deceleration you must click the set – message reminding to approve of settings the *Decceleration* parameter in the stepper motor driver.



Rys. 65 Message reminding that you must click Set *button after changing deceleration*

- Check whether the position is correct – message appears while auto calibration process. This is a question if automatically set position, based on parameter saved while last process is correct. Clicking YES confirms process, otherwise the searching process for reference point starts.

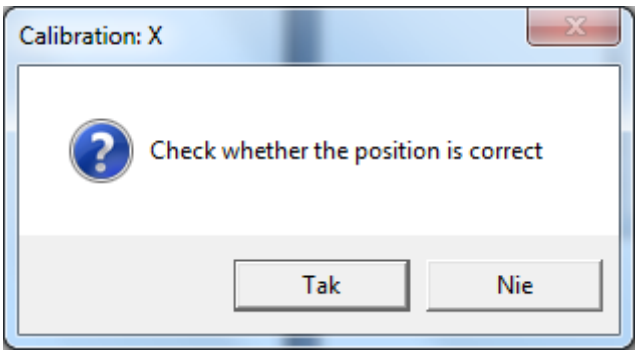


Fig. 66 Verifying correctness of position after auto calibration

- Calibration Done – information about the successful completion of the auto calibration

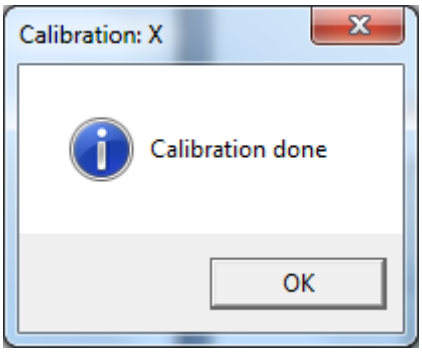


Fig. 67 Message confirming successful completion of auto calibration

- Correct axis position manually, and push OK. button – message informing user to manually set the reference position with in the axis panel and approved the new position by click OK button

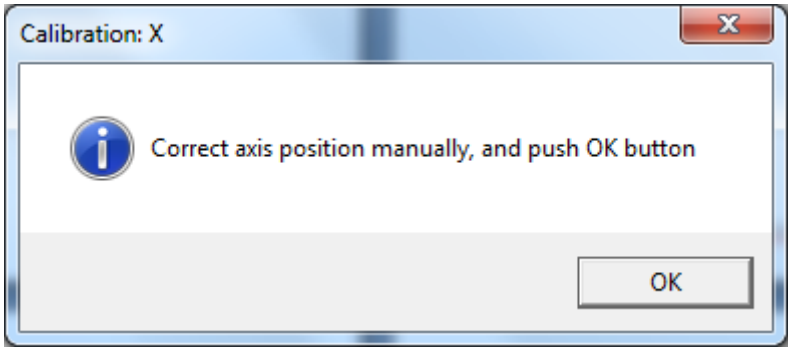


Fig. 68 information about manually searching reference position

- Settings are correctly saved in file: C:default.pcf – save application settings with manipulator parameters to a file

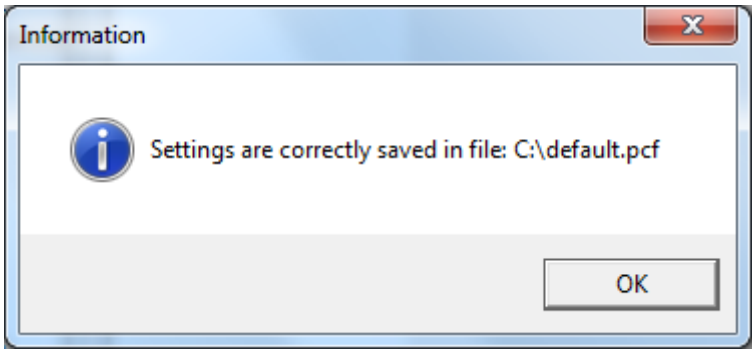


Fig. 69 Message about successful write manipulator parameters to a file

WARNING MESSAGES

- Not all parameters have been correctly received – message warning that not all of parameters are read correctly (maybe even all).

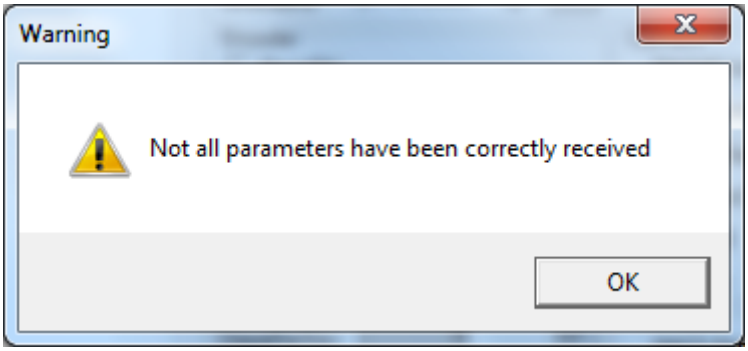


Fig. 70 Message informing that incorrect parameters were received from the SMCD controller

Possible reasons:

- transmission interference

ERROR MESSAGES

- Can't run axis X. Axis is banned movement mode (compensation or dependency) for a continous type – komunikat oznacza, że nie można wykonać ruchu osią ponieważ dla typu ruchu *Continous*, który jest aktualnie wybrany dla osi, niedozwolona jest jazda w trybie kompensacji oraz osiami zależnymi. Message means, that you cannot perform axis motion, because for *Continous* motion, which is currently selected, compensation and dependent axis motion is not allowed. If we want to perform axis motion, change type of motion to *Absolute* or *Relative*.

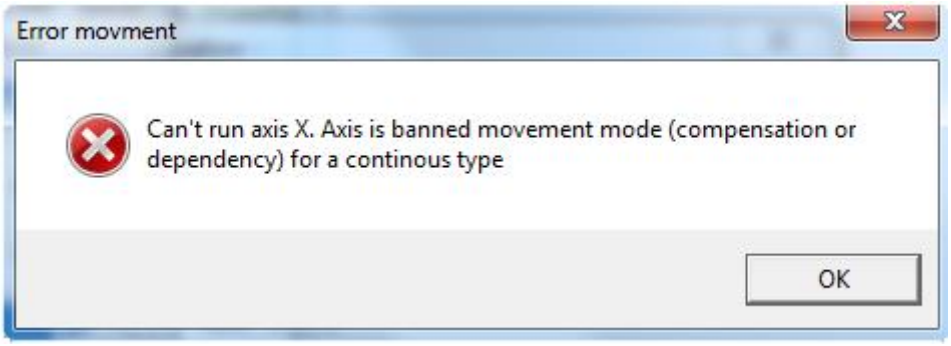


Fig. 71 Communication informing about lock of continuous motion

- In the state Hardware Reset parameters can't read – message means that driver of the axis of stepper motor is capable of *Hardware Reset*, which is not possible to read the parameters of the driver.

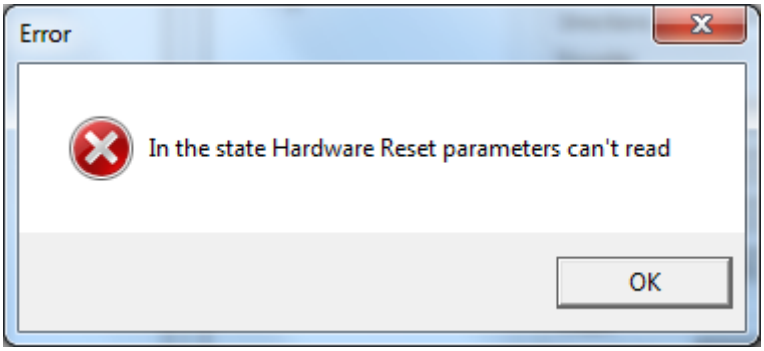


Fig. 72 Communication about the inability to read parameters from the SMCD driver

Recommended action:

- Removal of the *Hardware Reset* state by *Clear* function of *Calibration Axis* window.

- The problem with sending the controller parameters – message indicating that the attempt to set a parameter failed.

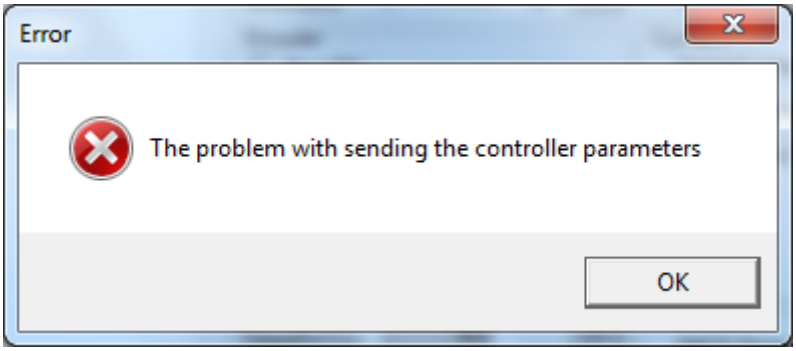


Fig. 73 The error message associated with sending parameters to the SMCD driver

Possible reasons:

- Communication problems
- Incorrect parameter value

- I can't set the correct acceleration in dependnecy move – message indicating, that the main axis cannot set the parameter for acceleration of the dependent axis on main axis value in the dependent motion, because of exceeding *Min* or *Max* value of that parameter.

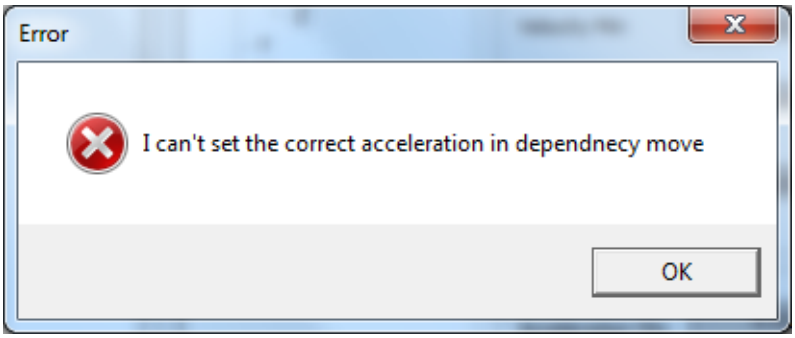


Fig. 74 Message indicating error while setting acceleration for the dependent axis by the main axis

Recommended action:

- Adjust range of acceleration parameter for the dependent axis

- I can't set the correct deceleration in dependnecy move – message indicating, that deceleration parameter cannot be set for the dependent axis by main axis, to the value of main axis for the dependent motion, due to the exceeding *Min* or *Max* value for this parameter.

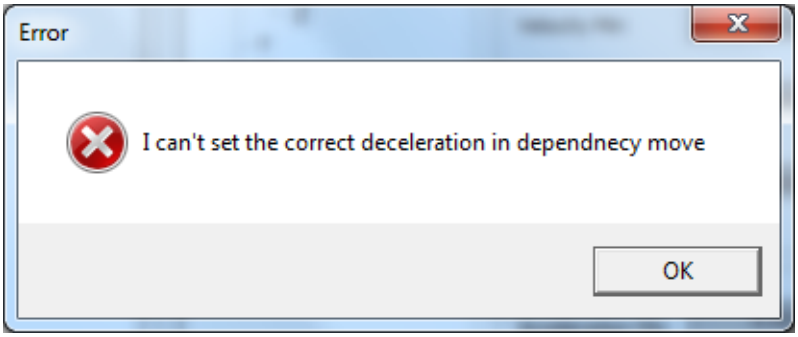


Fig. 75 Message indicating inability to set deceleration for the dependent axis by main axis

Recommended action:

- Properly adjust the range parameter of deceleration, for chosen dependent axis

- I can't set the correct velocity in dependnecy move –message indicating that main axis cannot set velocity parameter for the dependent axis, due to the exceeding the Min or MAX value for this parameter

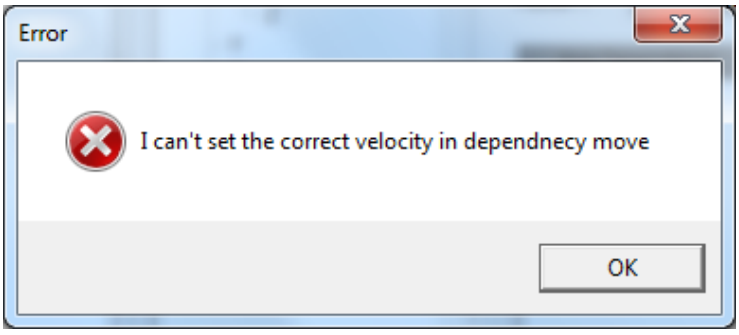


Fig. 76 message about inability to set velocity of the dependent axis by main axis

- Can't run manipulator. Not all parameters are correct – message indicating that the process of initialization of manipulator with motion parameters failed.

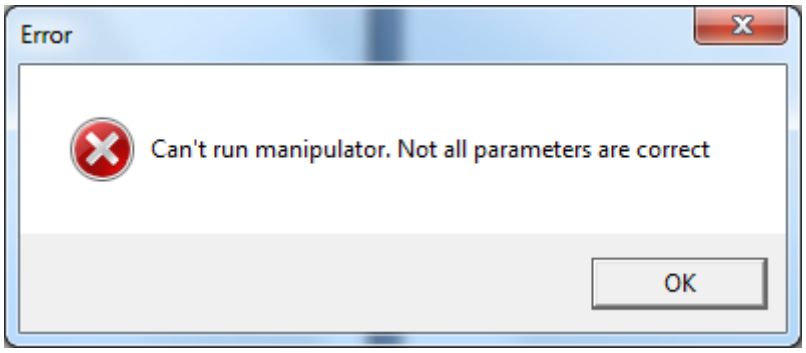


Fig. 77 Message indicating about incorrect driver initialization

Possible reasons:

- one of the stepper motor driver
- communication problems

- An unexpected problem during the autocalibration. The process has been stopped" – a message indicating the occurrence of an inappropriate situation with autocalibration. Such a situation we define: motion interruption by user or driver error.

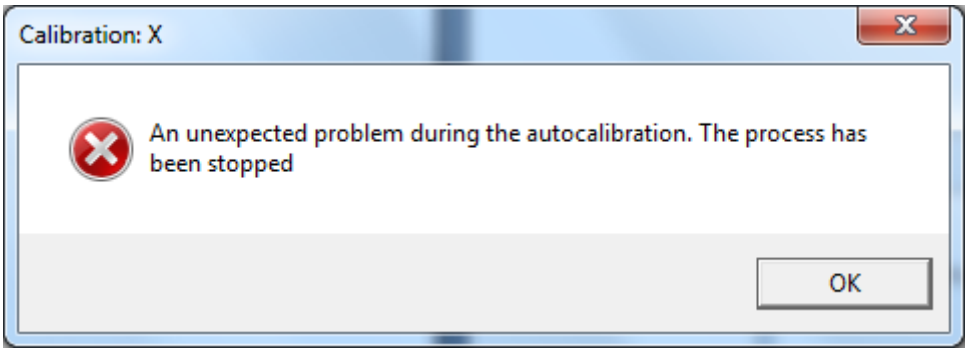


Fig. 78 Message indicating error during auto calibration

- Error has occurred in the manipulator. The movement was stoped – message informing the user of error occurs during the manipulator motion on one axis. The corollary of this is stopping the motion of the manipulator.

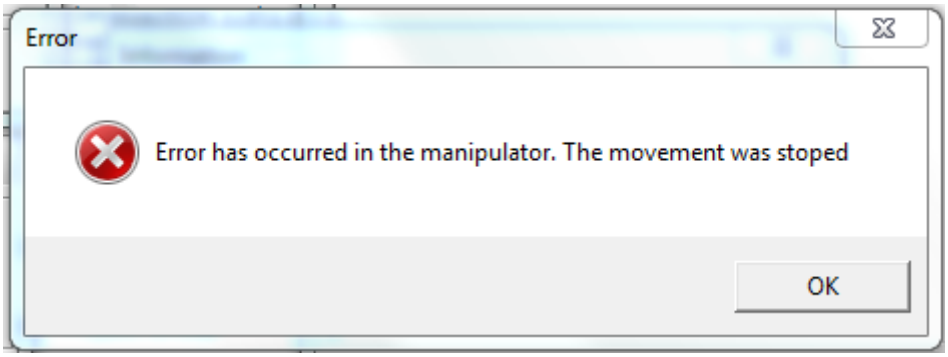


Fig. 79 Message indicating the stop of manipulator motion

- Can’t set a velocity for axis : No Answer – message indicating an incorrect parameter setting for axis velocity, during the process of motion initialization, due to lack of confirmation of the action by the driver.

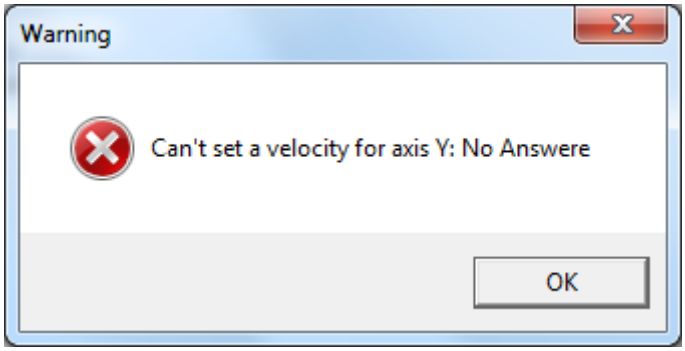


Fig. 80 Message indicating that setting velocity parameter is not possible

- Can’t set a target for axis : Now Answer – message indicating an incorrect parameter setting the target position, for a given motion axis during the initialization, in the absence of action confirmation by the driver.

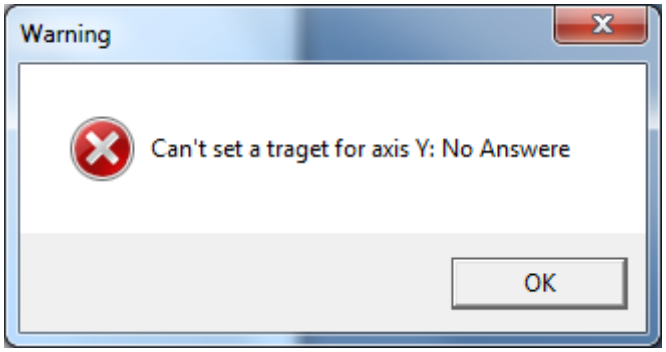


Fig. 81 Message indicating lack of possibility to set the motion position

- I can't start motion of axis until movement in the branch will not be complete – message indicating, that the motion of given axis or dependent axes is not over yet, resulting in inability to perform motion on a given axis. komunikat oznaczający, że ruch danej osi bądź osi zależnych jeszcze się nie zakończył co skutkuje brakiem możliwości wykonania ruchu daną osią.

- Auto-calibration can not be executed for the axle with the axes depend – message indicating inability to perform auto calibration process for axis which having dependent axes.

  Recommended action: before start of the auto calibration process remove the axial dependence.

LIST OF ILLUSTRATIONS