



HAYES
CONTROL SYSTEMS

Beckhoff TwinCAT

Basic Configuration of a TwinCAT NC Axis

User Level: Intermediate

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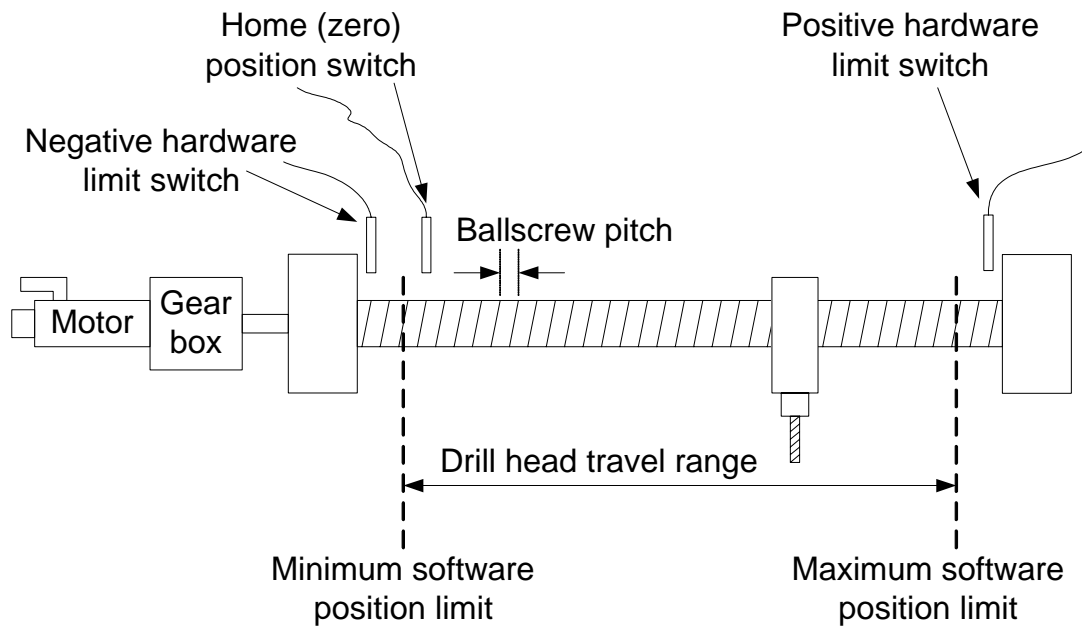
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Version	Updated	Changes
V1.0	28/04/2005	Original document

1. Introduction

1.1. Limited Travel Linear Axis

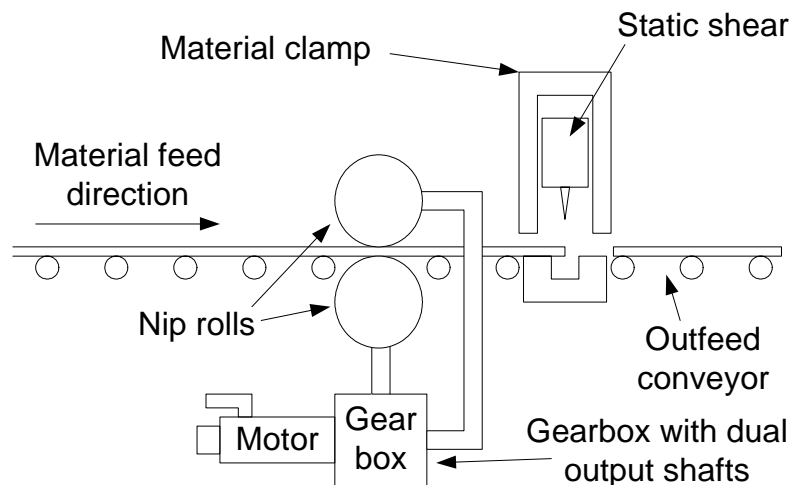
The diagram below shows an example of a linear axis using a motor and ballscrew to move a drill head to the required absolute position. The “zero” or “home” position is determined using the Home Position Switch, and the drill head can be moved to any absolute position along the ballscrew from the home position. The range of travel for the drill head is specified by the software position limits, with backup hardware limit switches connected directly to the drive.



Refer to “PTP Absolute Position Control” and “PTP Axis Homing Control” for details on implementing absolute position control and axis homing control in TwinCAT PLC.

1.2. Continuous Linear Axis

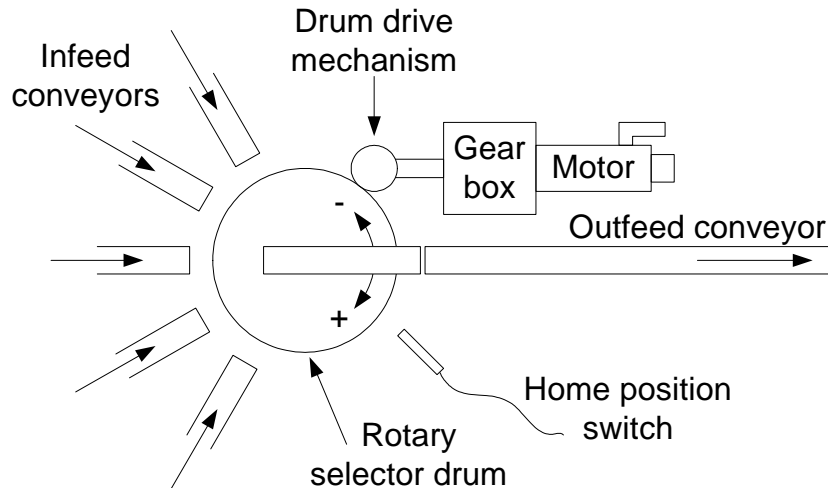
The diagram below shows an example of a continuous “cut-to-length” axis using nip rolls to control the amount of material fed to the static shear. “Relative” positioning is used, as the material fed forwards a specified distance, relative to the previous stop position. Homing and position limits are also not required.



Refer to “PTP Relative Position Control” for full details on relative and continuous position control in TwinCAT PLC.

1.3. Modulo Rotary Axis

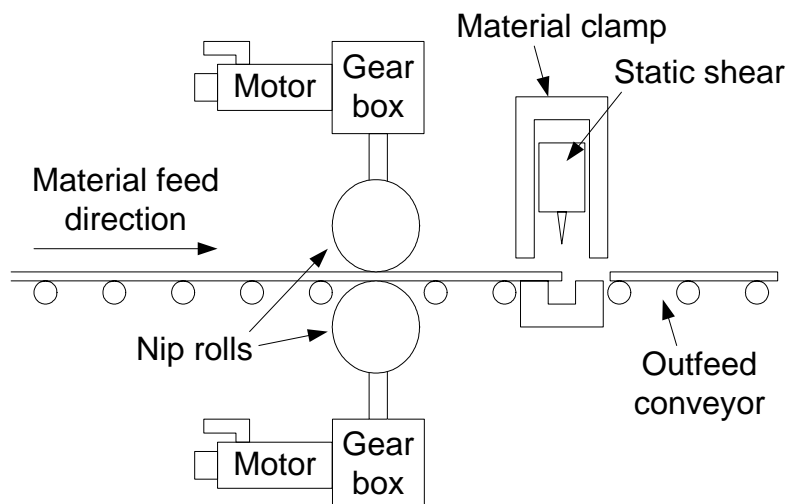
The diagram below shows an example of a rotary drum axis for selecting products (such as coloured bars of soap) from 5 feeder conveyors, and passing them onto next part of the process. "Modulo" positioning is used to move the selector drum to the correct angular position for the next product, with the drum moving through the shortest path to get to the correct angular position. The Home Position Switch is used to determine the angular position of the selector drum at system start-up.



Refer to "PTP Modulo Position Control" for full details on modulo position control in TwinCAT PLC.

1.4. Digital Lock Axis Control

The diagram below shows an alternative mechanical arrangement for the nip roll "cut-to-length" line, with 2 motors independently driving the 2 nip rolls. When the 1st motor moves to feed the material to the static shear, "Digital lock" or "Gearing" control ensures that the 2nd motor automatically follows the exact movements of the 1st motor. The gear ratio between the motors can also be adjusted to compensate for differences in nip roll diameter to prevent any scuffing of the material.



Refer to "PTP Gearing and Digital Lock Control" for full details on relative and continuous position control in TwinCAT PLC.

1.5. Example System

This application note explains the basic implementation and configuration of a TwinCAT NC axis. The actual numerical values shown on the screen captures in this document are for a limited travel linear axis with the following mechanical specifications:

- Motor speed range = 0 to 3000rpm, controlled by an AX2000
- Ball screw pitch = 6mm
- Ball screw length = 1200mm
- Required drill head positioning range = 1000mm
- Gearbox ratio is 3:1 reduction from the motor shaft to the ballscrew

1.6. Additional Information

The user should also be familiar with the document(s) listed below, which are available on request from Hayes Control Systems Ltd at supportgroup@hayescontrols.co.uk:

- Configure the TwinCAT IO System
- Mapping TwinCAT PLC Variables to IO
- Basic Configuration of AX2000 Drives

2. Hardware Configuration

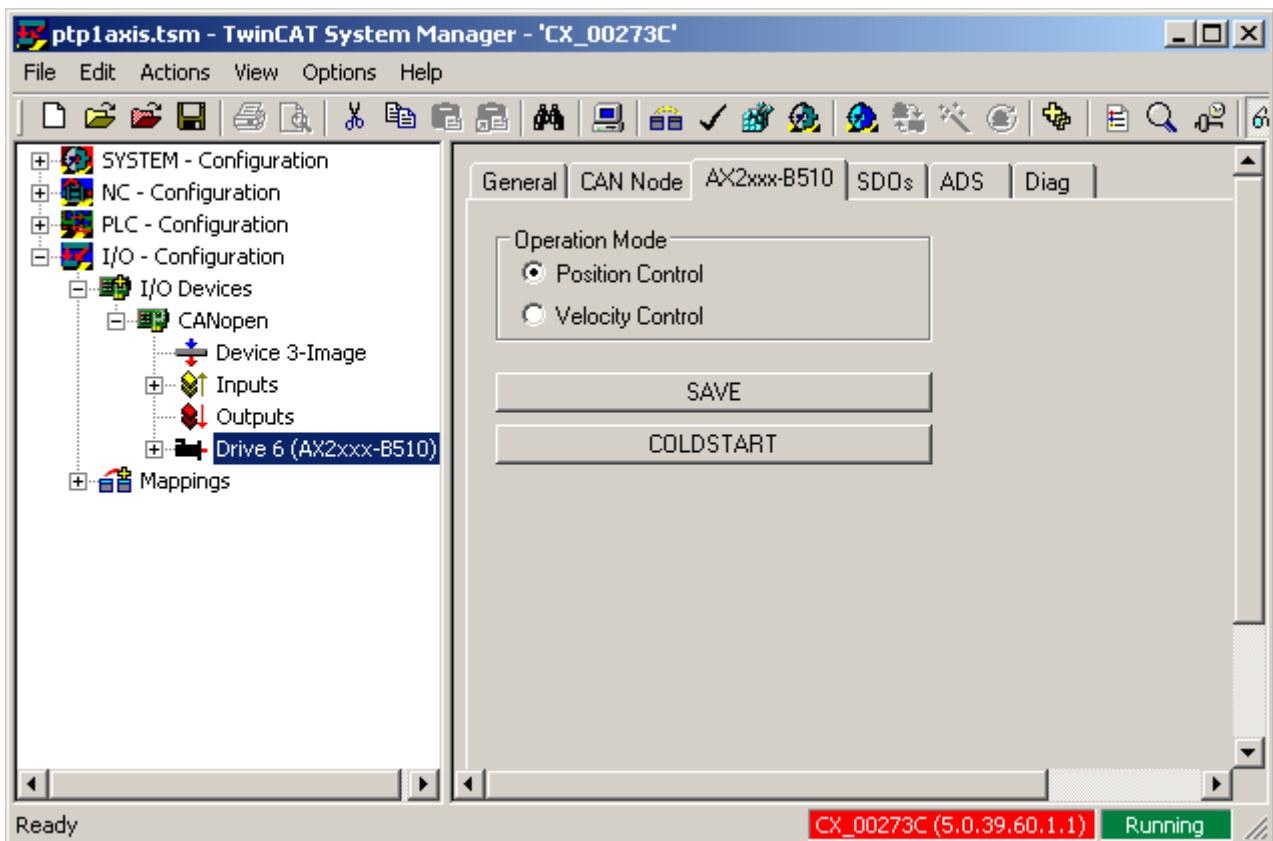
The AX2000 must be pre-configured and tuned for the mechanical load. Full details for configuring and tuning the AX2000 are available in “Basic Configuration of the AX2000”.

2.1. Position Control

In Position Control mode, TwinCAT NC generates a new position reference for the AX2000 on each cycle, and transmits it to the AX2000 via the fieldbus system. The position loop is closed locally in the AX2000, and the current motor position is sent back to TwinCAT NC via the fieldbus for display purposes only. This produces the best dynamic performance as the position loop is not affected by the update rate of the fieldbus system. SERCOS and CANopen both support position control mode.

To select Position Control mode for the AX2000:

1. Select the AX2000 on the fieldbus network
2. Select the AX2xxx-B510 tab
3. Select “Position Control



2.2. Velocity Control

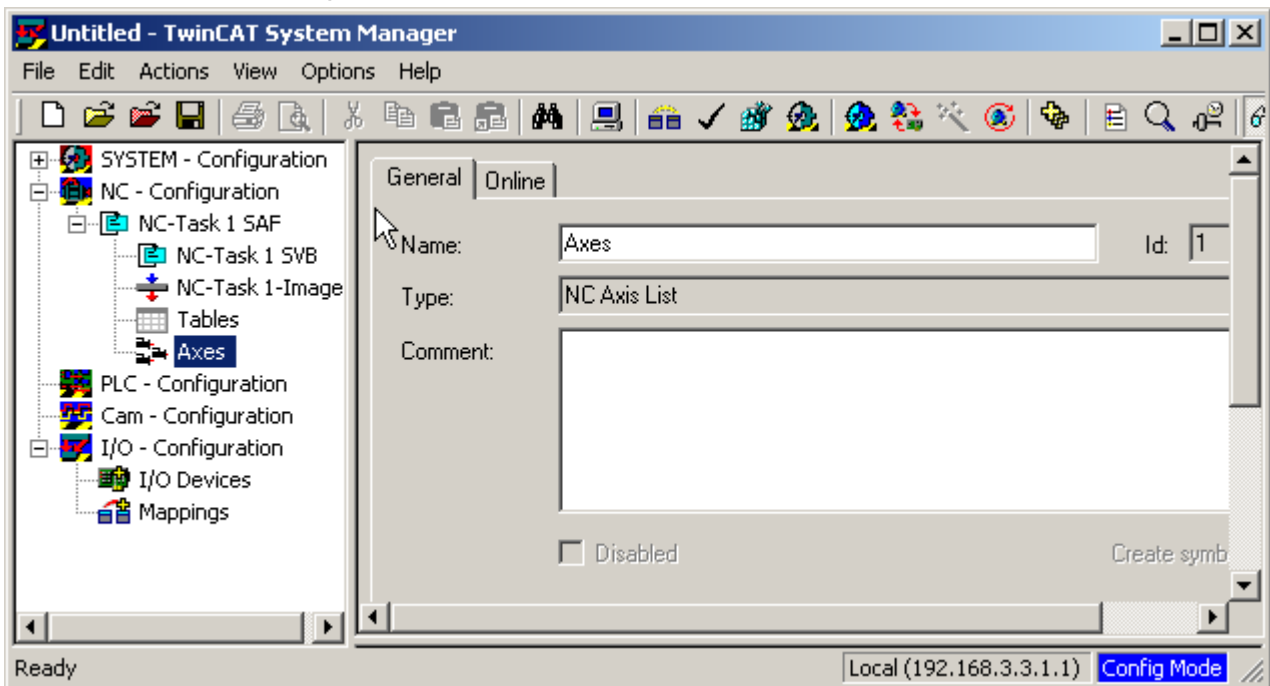
In Velocity Control mode, TwinCAT NC generates both position and velocity references on each cycle, and transmits the velocity reference to the AX2000 via the fieldbus system. The current motor position is sent back to TwinCAT NC via the fieldbus, and this value is used to close the position loop within in TwinCAT NC. SERCOS, CANopen, Lightbus and Real-Time Ethernet all support velocity control mode.

3. TwinCAT NC

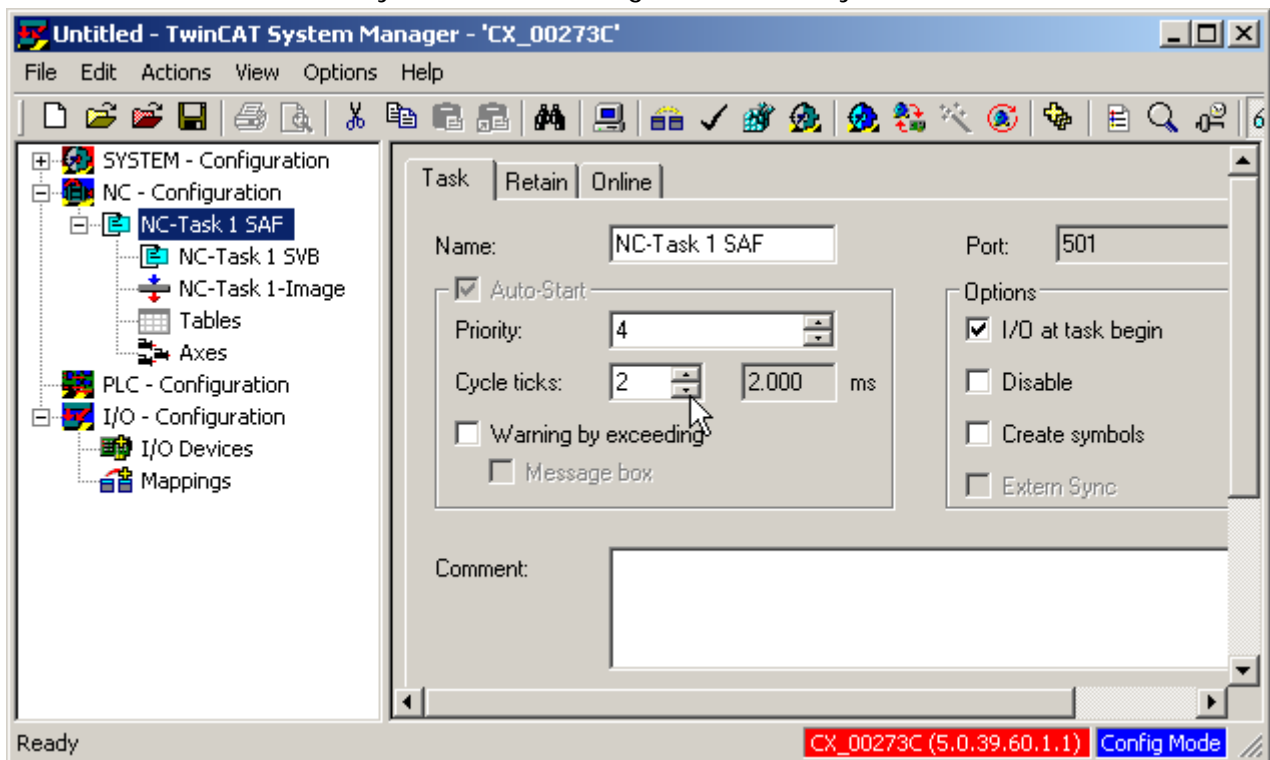
3.1. Add NC Task

To add a TwinCAT NC task to the system configuration:

1. Right click on "NC-Configuration"
2. Select "Append Task..."
3. Click OK to accept the default task name



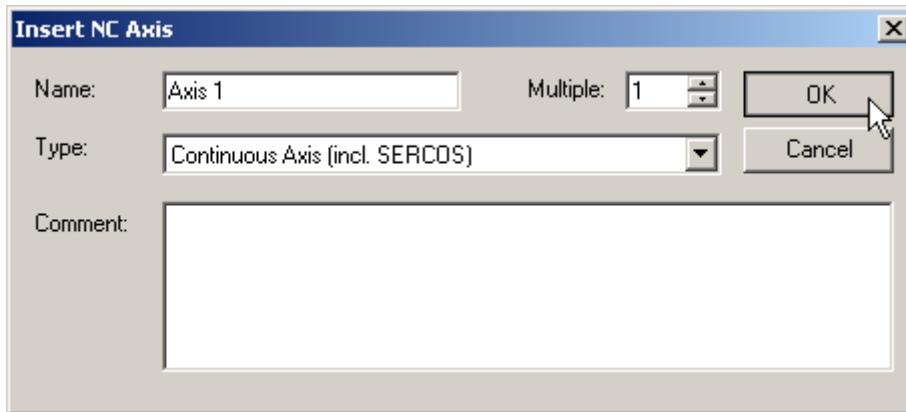
4. Select the NC task ("NC-Task 1 SAF")
5. Select the Task tab
6. Set the number of cycle ticks to 2 to give 2.000ms cycle time



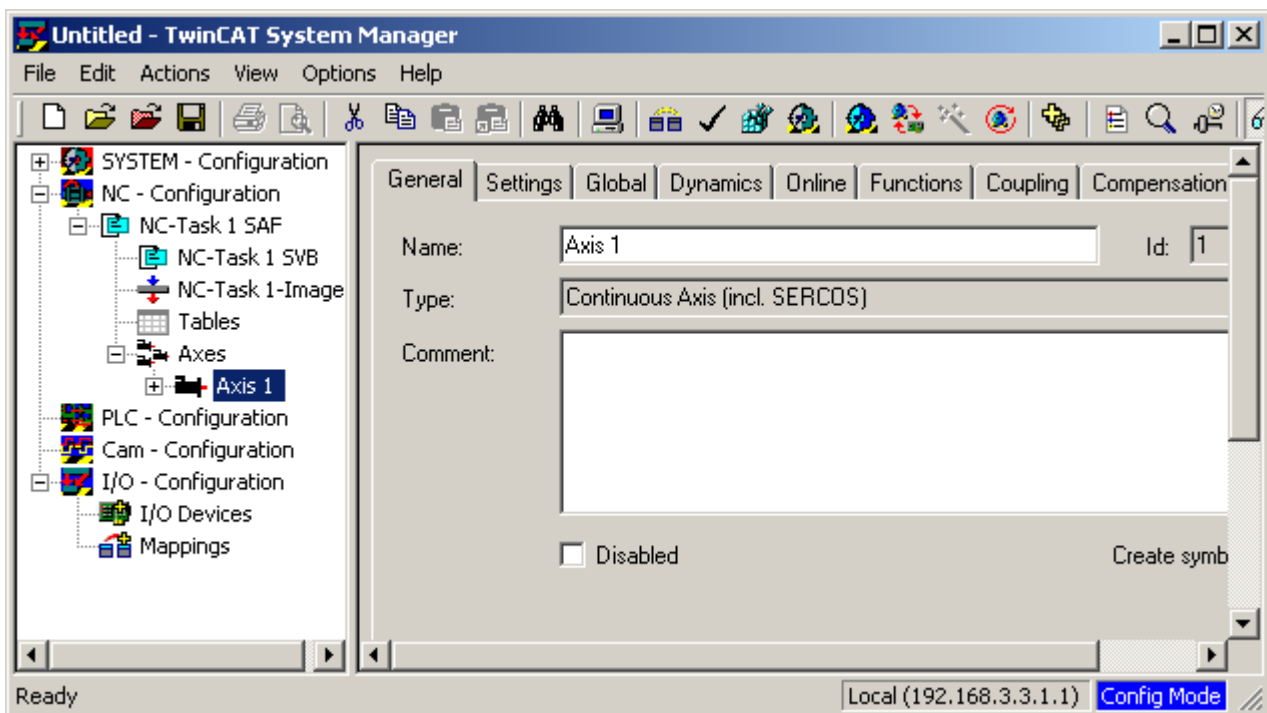
3.2. Add NC Axis

To add an axis to TwinCAT NC:

1. Right click on "Axes"
2. Select "Append Axis..."
3. Select "Continuous Axis (incl. SERCOS)"
4. Set axis name to "Axis 1"
5. Click OK



"Axis 1" will be added to the list of axes available in TwinCAT NC.



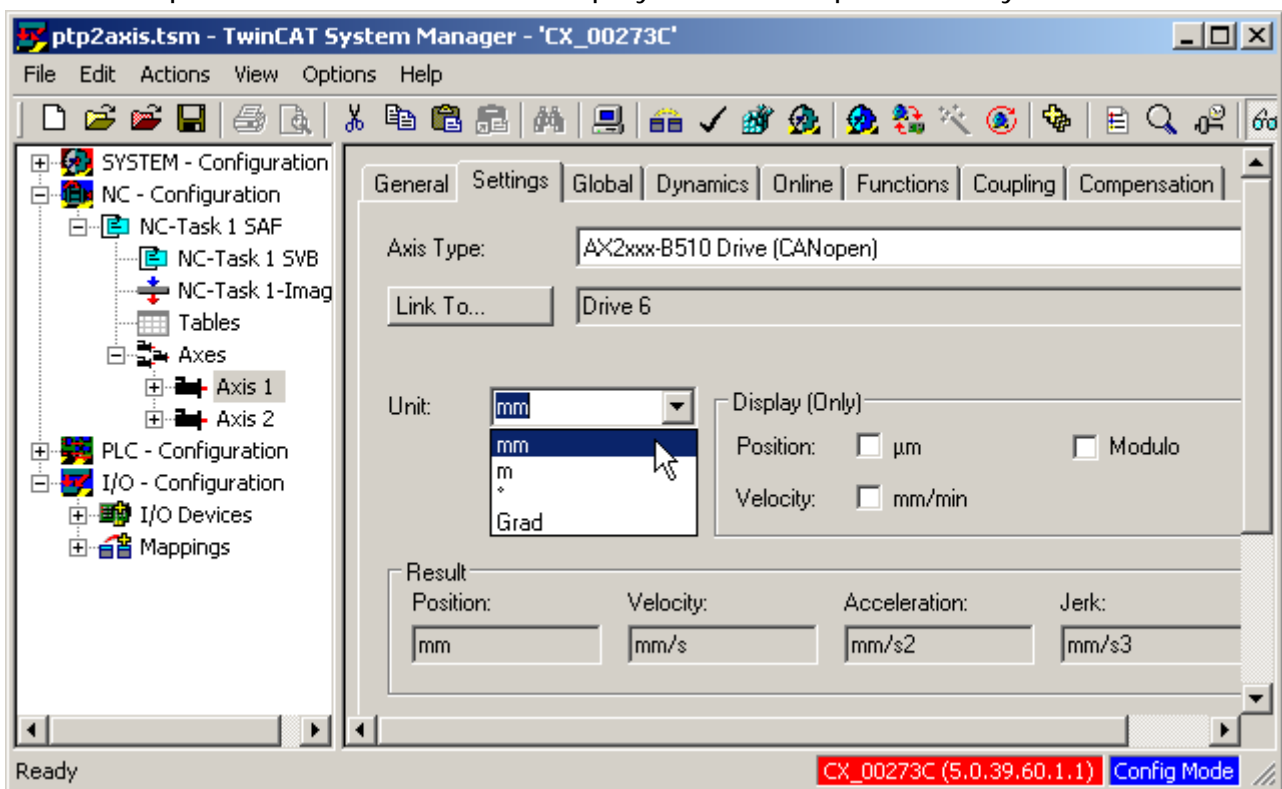
3.3. Axis Units

The unit of measurement for the axis will depend on the type of axis being controlled. A linear axis will generally use mm or m, while a rotary axis will use °.

The position and velocity will usually be displayed in mm and mm/s respectively for a linear axis, but these can be changed to μm and/or mm/min. For a rotary axis, position and velocity are displayed in ° and °/sec, but these can be changed to $\text{m}^\circ/\text{sec}$ and °/min. Select "Modulo" to display the modulo position of the axis.

To select the units for the axis:

1. Select the "Settings" tab
2. Select the required unit in the "Unit:" drop-down list box
3. If required, select the alternative display units for Position and Velocity
4. If required, select "Modulo" to display the modulo position only



3.4. Axis Scaling Factor

The Scaling Factor specifies the distance the axis load will move for 1 increment change of the motor shaft position. This takes into account factors such as gearing, ball-screw pitch or drive roll diameter/circumference, etc, and allows TwinCAT to display the axis position in real units, e.g. mm or °. The number of increments per motor shaft revolution depends on the fieldbus system being used with the AX2000.

Fieldbus	Increments per motor shaft rev
SERCOS	100,000
CANopen	1048576 (2 ²⁰)
Lightbus	65536 (2 ¹⁶)
Real-Time Ethernet	65536 (2 ¹⁶)

$$\text{Scaling Factor} = \frac{\text{Distance}}{\text{Increments} * \text{GearRatio}}$$

where:

Distance travel of the load (mm or °) for 1 turn of the final drive mechanism

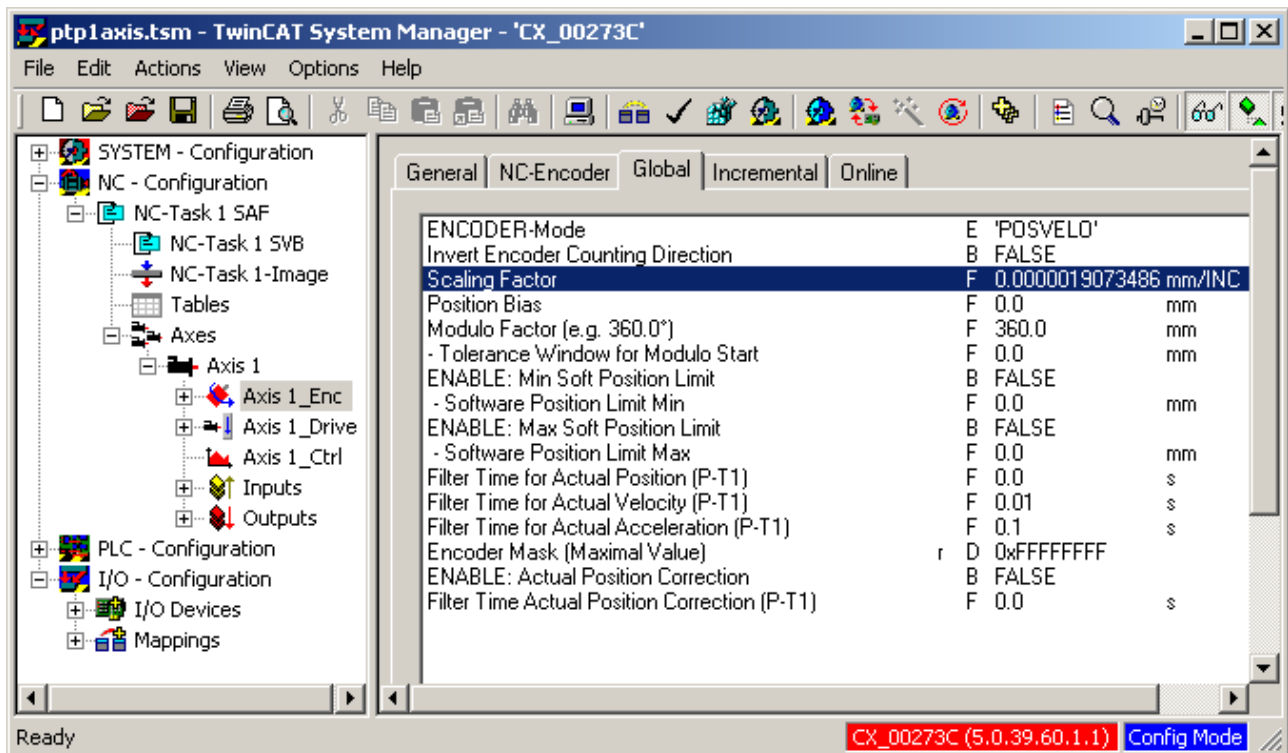
Increments number increments for 1 revolution of the motor shaft

GearRatio total reduction gearing between the motor and final drive mechanism

NOTE: to ensure maximum accuracy, Windows Calculator can be used to do the calculation, and the result cut and paste into Scaling Factor.

To set the Axis Scaling Factor:

1. Expand "Axis 1"
2. Select "Axis 1_Enc"
3. Select the "Global" tab
4. Enter the value required on "Scaling Factor"
5. Press ENTER



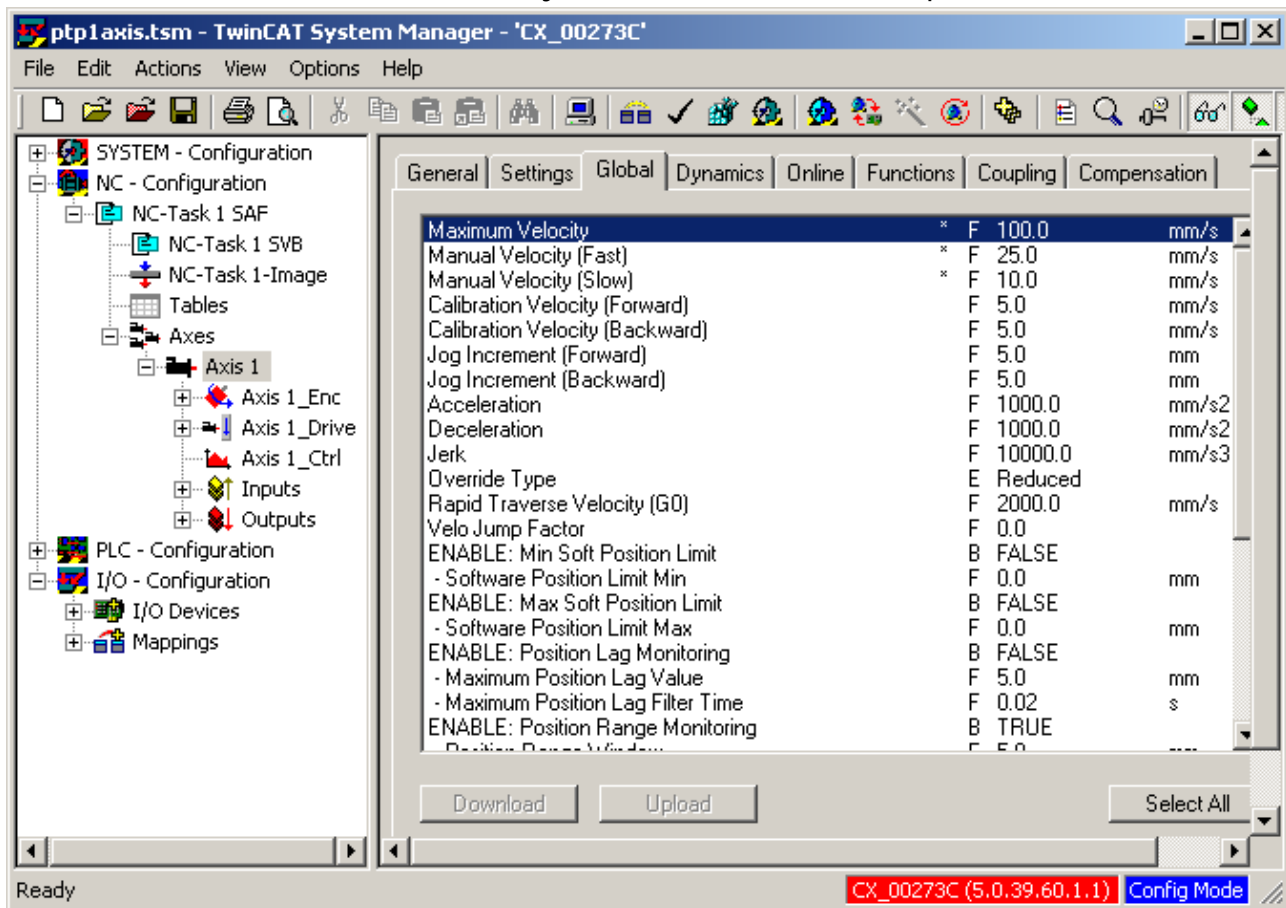
3.5. Axis Velocity Parameters

The maximum velocity must be specified for the axis in the relevant units. (mm or °)
 This is determined by the mechanical limitations of the axis or the actual maximum speed of the motor, whichever gives the lower axis speed.

Parameter	Description
Maximum Velocity	Maximum velocity allowed for a move on the axis
Manual Velocity (Fast)	Specify the fast and slow speeds for the axis under manual control. Manual mode allows axis operation to be checked BEFORE the PLC program is used to control the axis
Manual Velocity (Slow)	

To change the velocity settings for the axis:

1. Select "Axis 1"
2. Select the "Global" tab
3. Set "Maximum Velocity", "Manual Velocity (Fast)" and "Manual Velocity (Slow)" to the required values
4. Press ENTER to ensure each any modified values are accepted

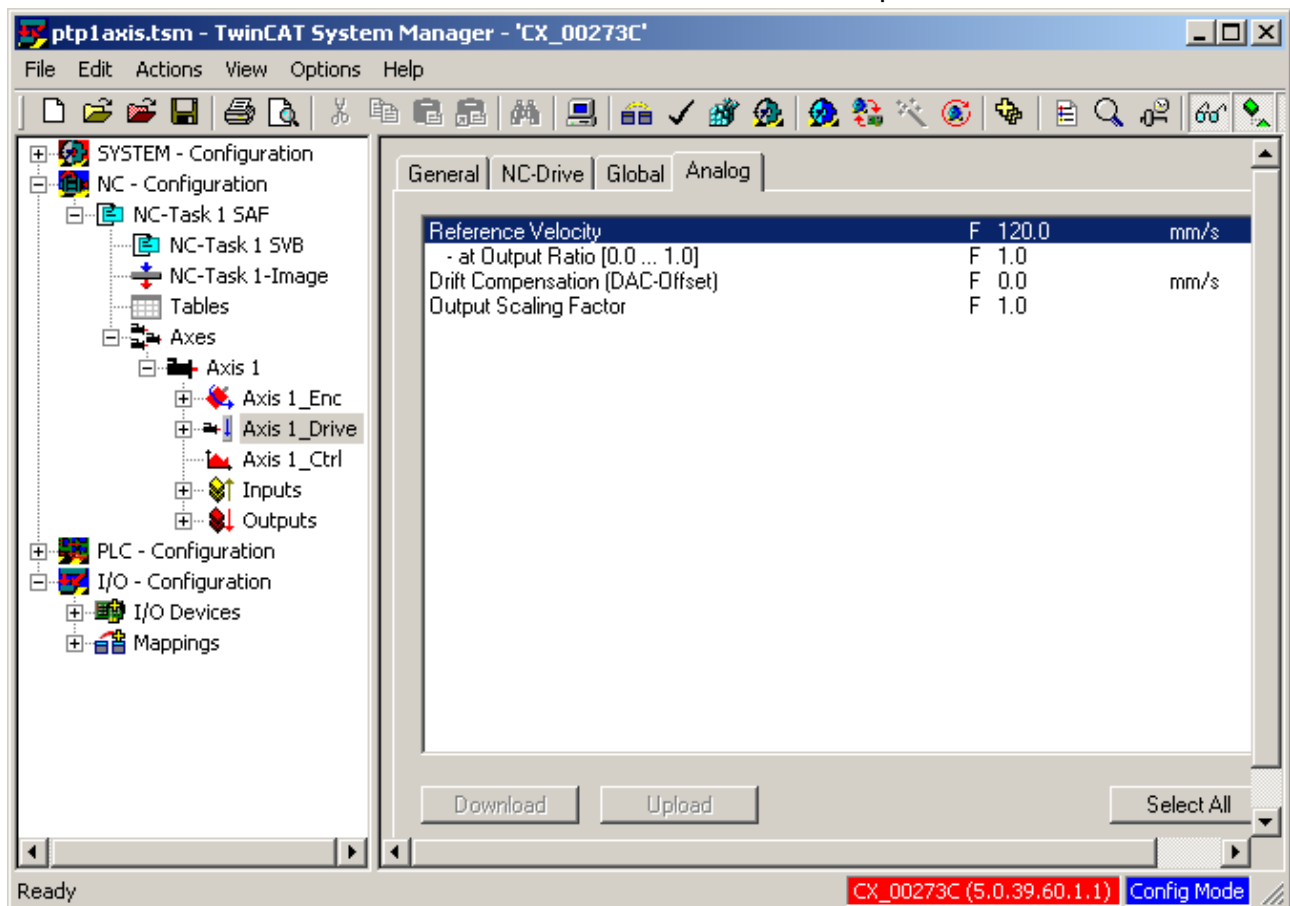


Basic Configuration of a TwinCAT NC Axis

The Reference Velocity is the full scale speed for the axis, and is used in systems where the drive is controlled using a -10V to +10V analogue speed reference. When a fieldbus system is used, Reference Velocity must simply be set to a value greater than Maximum Velocity.

To set the Reference Velocity:

5. Select "Axis 1_Drive"
6. Select the "Analog" tab
7. Set "Reference Velocity" to a value greater than "Maximum Velocity"
8. Press ENTER to ensure that the modified value is accepted



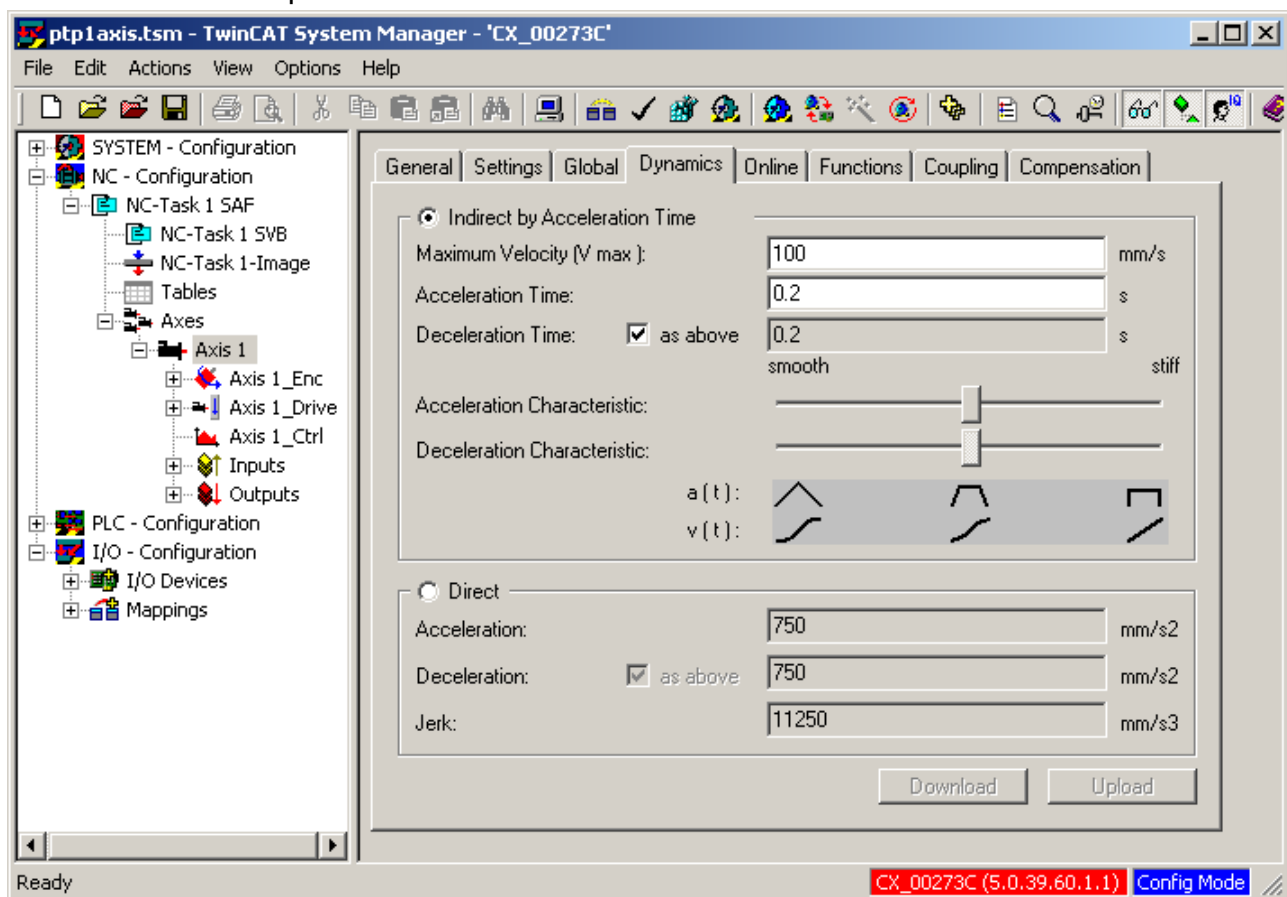
3.6. Acceleration, Deceleration and Jerk

Acceleration, deceleration and jerk can be specified for the axis directly (if the values in mm/s^2) are known, or TwinCAT NC can calculate the acceleration settings based on specified profile timings.

If "Indirect by Acceleration Time" is selected, the acceleration rate is specified as the time taken (Acceleration Time) to go from 0 to Maximum Velocity. Jerk is controlled by the slider bar, with a smoother response giving a lower jerk value, but with a higher peak rate of acceleration. Alternatively, if the acceleration, deceleration and jerk values for the axis are known, they can be entered directly.

To set the acceleration and deceleration settings for the axis:

1. Select "Axis 1"
2. Select the "Dynamics" tab
3. Select "Indirect by Acceleration Time" or "Direct"
4. Enter the required values



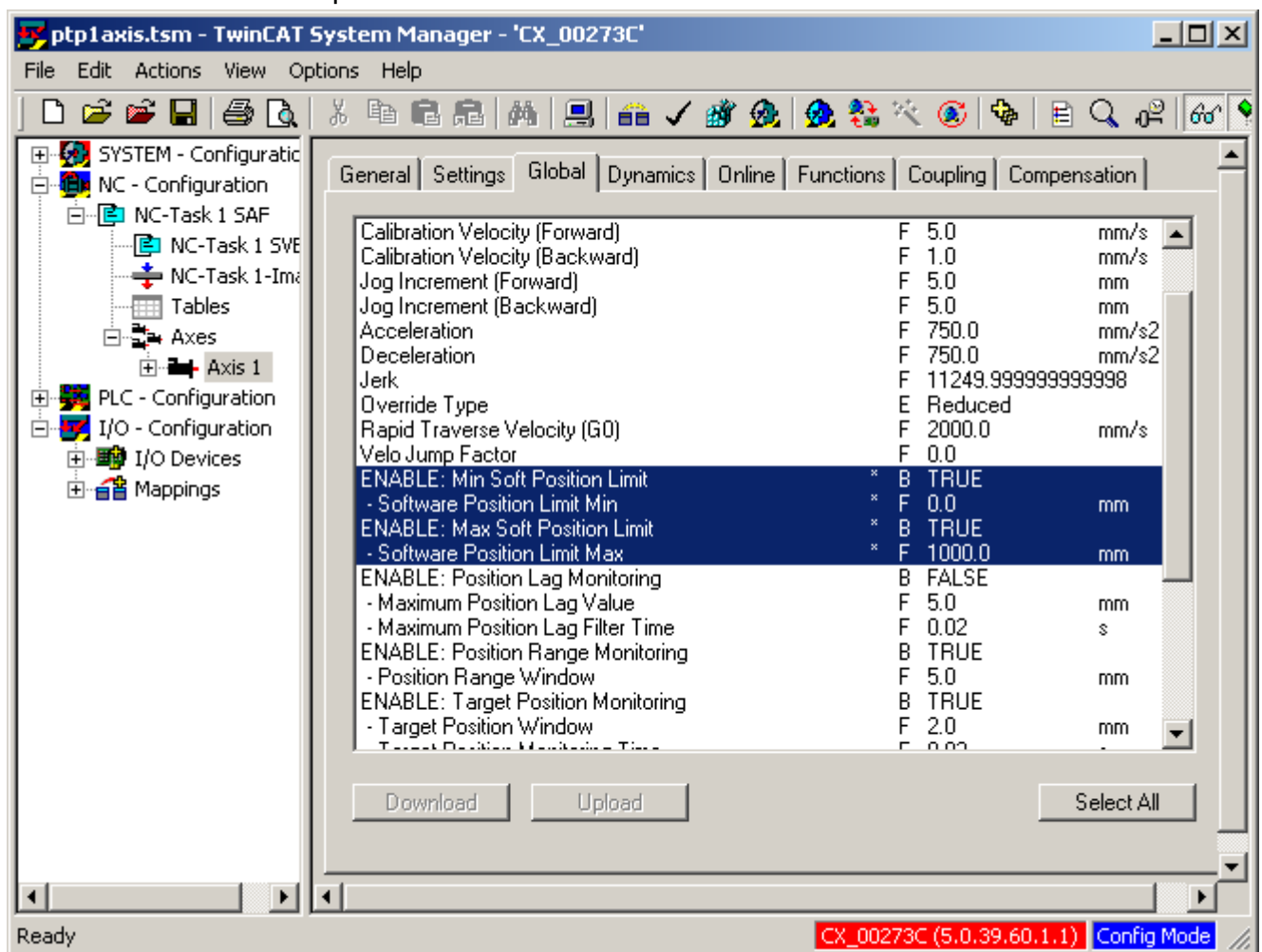
3.7. Axis Position Limits (Optional)

As a linear axis will typically have a limited range of travel, the TwinCAT NC axis can be given software position limits to prevent any move that may cause mechanical damage to the system. If a move is requested that will take the axis outside of these position limits, it will be rejected.

NOTE: *hardware limit switches should also be fitted to the axis drive to inhibit further motion in the current direction when the limit switch is hit. This provides an external hardware backup to prevent axis over-travel in case the TwinCAT NC axis position over-written with an incorrect value, or lost for some other reason.*

To set the position limits for a TwinCAT NC axis:

1. Select "Axis 1"
2. Select the "Global" tab
3. To set a minimum position limit, set "ENABLE: Min Soft Position Limit" to TRUE and enter the required value in "- Software Position Limit Min"
4. To set a maximum position limit, set "ENABLE: Max Soft Position Limit" to TRUE and enter the required value in "- Software Position Limit Max"



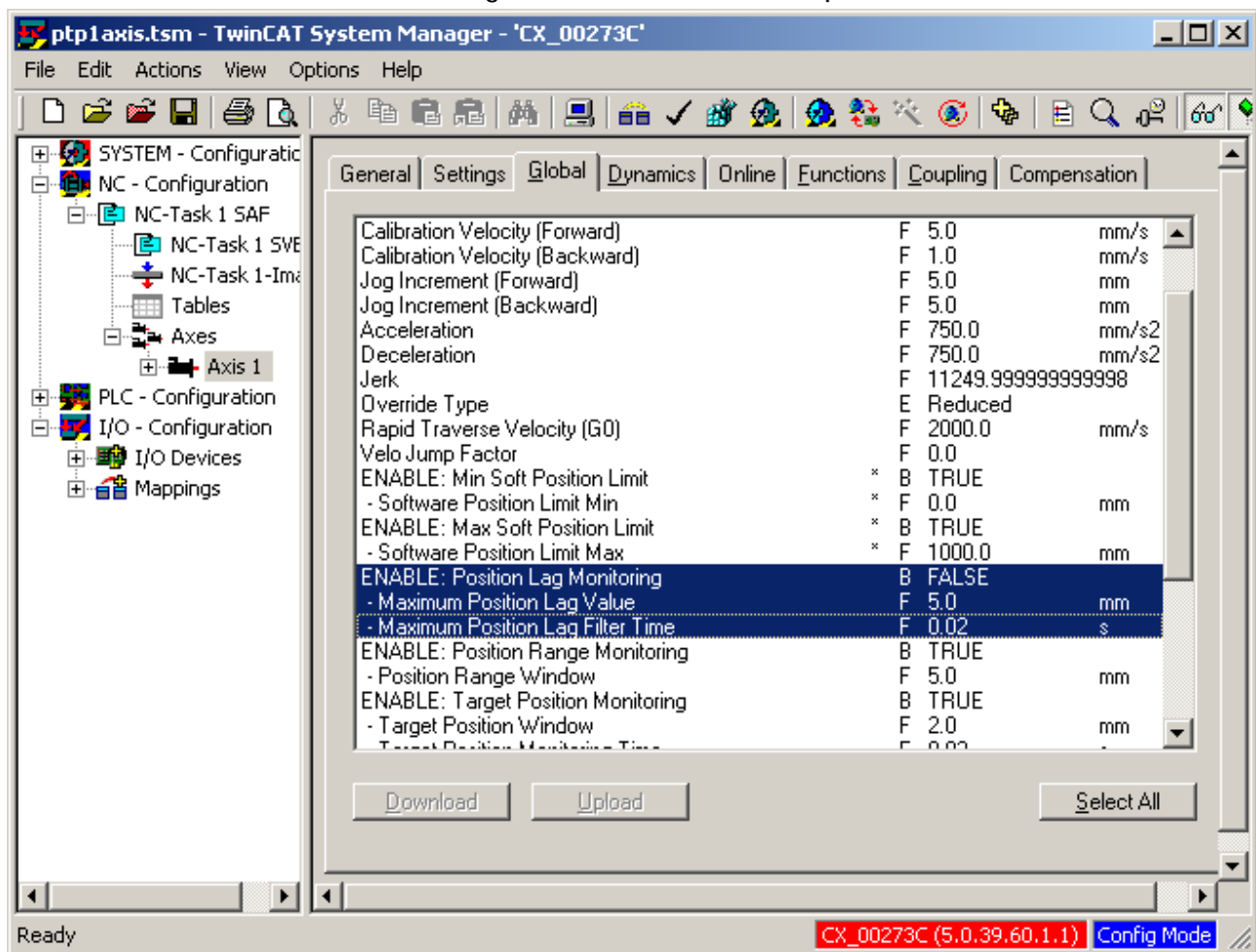
3.8. Position Lag Monitoring (Following Error)

The "Position Lag" or "Following Error" of an axis is the difference between the position reference and the actual axis position at any given moment. A small position error will be seen while an axis is at a constant speed, and it will increase during periods of acceleration and deceleration. A large following error usually indicates that there is problem on the axis.

If Position Lag Monitoring is enabled, TwinCAT NC will trip the axis when the Position Lag exceeds a specified value. A filter is also applied to the Position Lag to prevent spurious trips if the Position Lag Value is exceeded momentarily during period of high acceleration and deceleration.

To enable the Position Lag Monitoring:

1. Select "Axis 1"
2. Select the "Global" tab
3. Set "ENABLE: Position Lag Monitoring" to TRUE
4. Set "- Maximum Position Lag Value" to the required value
5. Set "- Maximum Position Lag Filter Time" to the required value



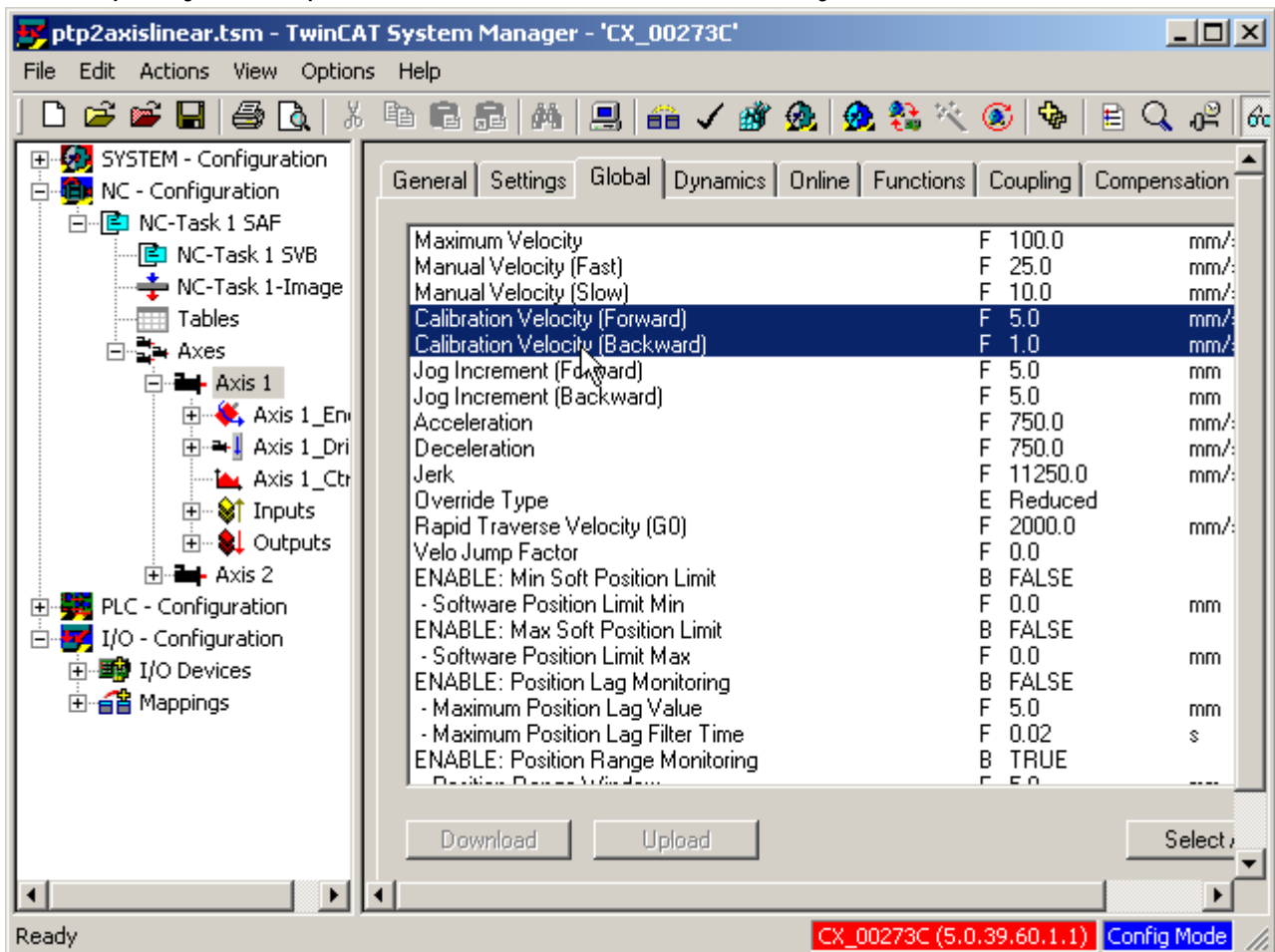
3.9. Axis Homing Parameters

There are 3 phases to homing a TwinCAT NC axis:

- The axis moves towards the home switch at the velocity specified in “Calibration Velocity (Forward)” until the home switch goes to TRUE. The direction of motion is specified by “Invert Direction for Calibration CAM Search”
- The axis decelerates to a slower velocity specified in “Calibration Velocity (Backwards)” and continues moving until the home switch goes FALSE. The direction of motion is specified by “Invert Direction for Sync Impuls Search”
- The axis is stopped and the axis current position is set to the axis home position specified in “Calibration Value”.

To specify the axis homing velocities:

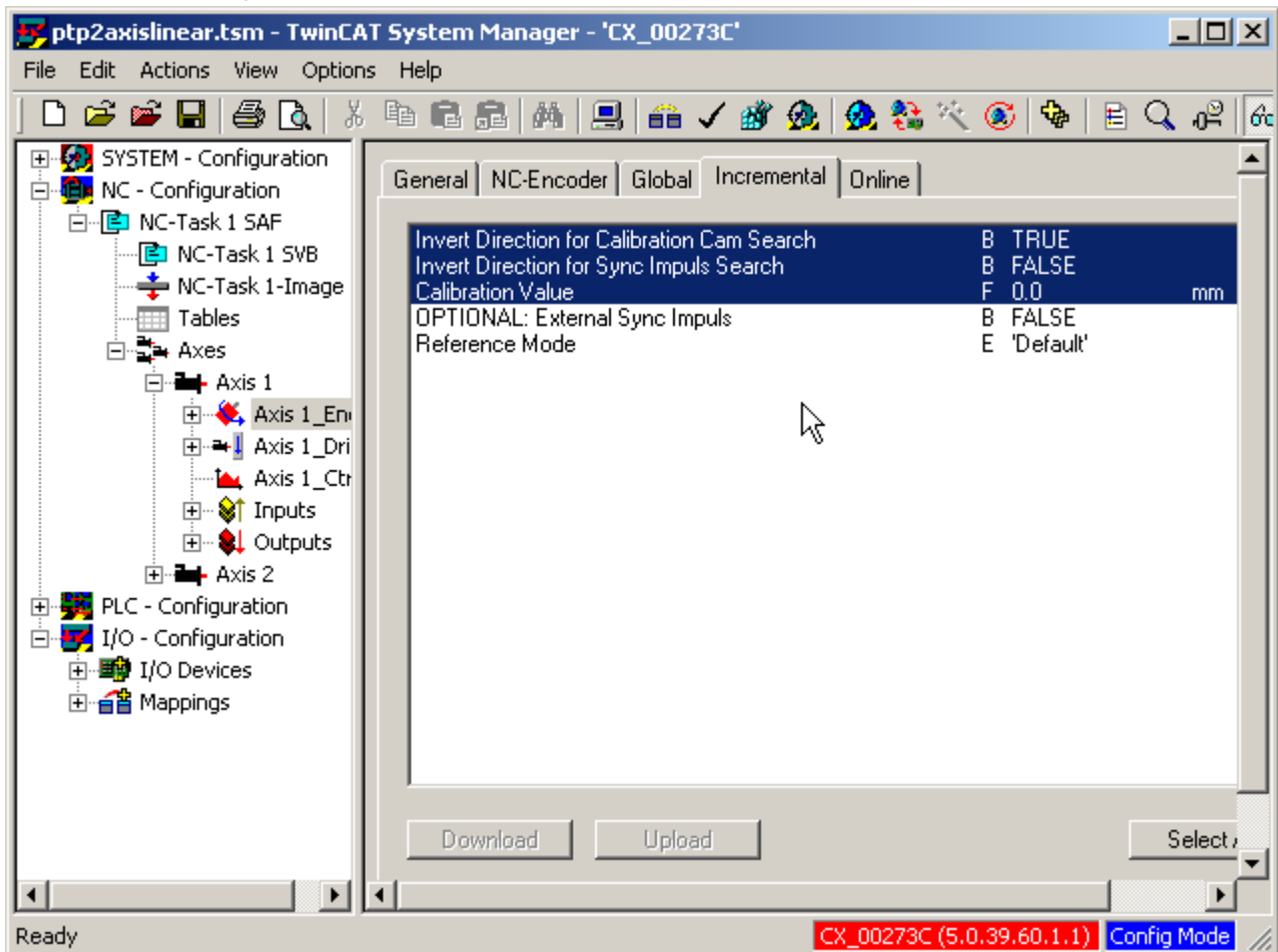
1. Select “Axis 1”
2. Select the “Global” tab
3. Specify the required value for “Calibration Velocity (Forwards)”
4. Specify the required value for “Calibration Velocity (Backwards)”



Basic Configuration of a TwinCAT NC Axis

To specify the direction of motion during each homing phase, and the home position:

5. Select "Axis 1_Enc"
6. Select the "Incremental" tab
7. Set "Invert Direction for Calibration CAM Search" to FALSE for forwards motion, or TRUE for reverse motion
8. Set "Invert Direction for Sync Impuls Search" to FALSE for forwards motion, or TRUE for reverse motion
9. In "Calibration Value", set the position that should be assigned to the axis when the home position has been found.

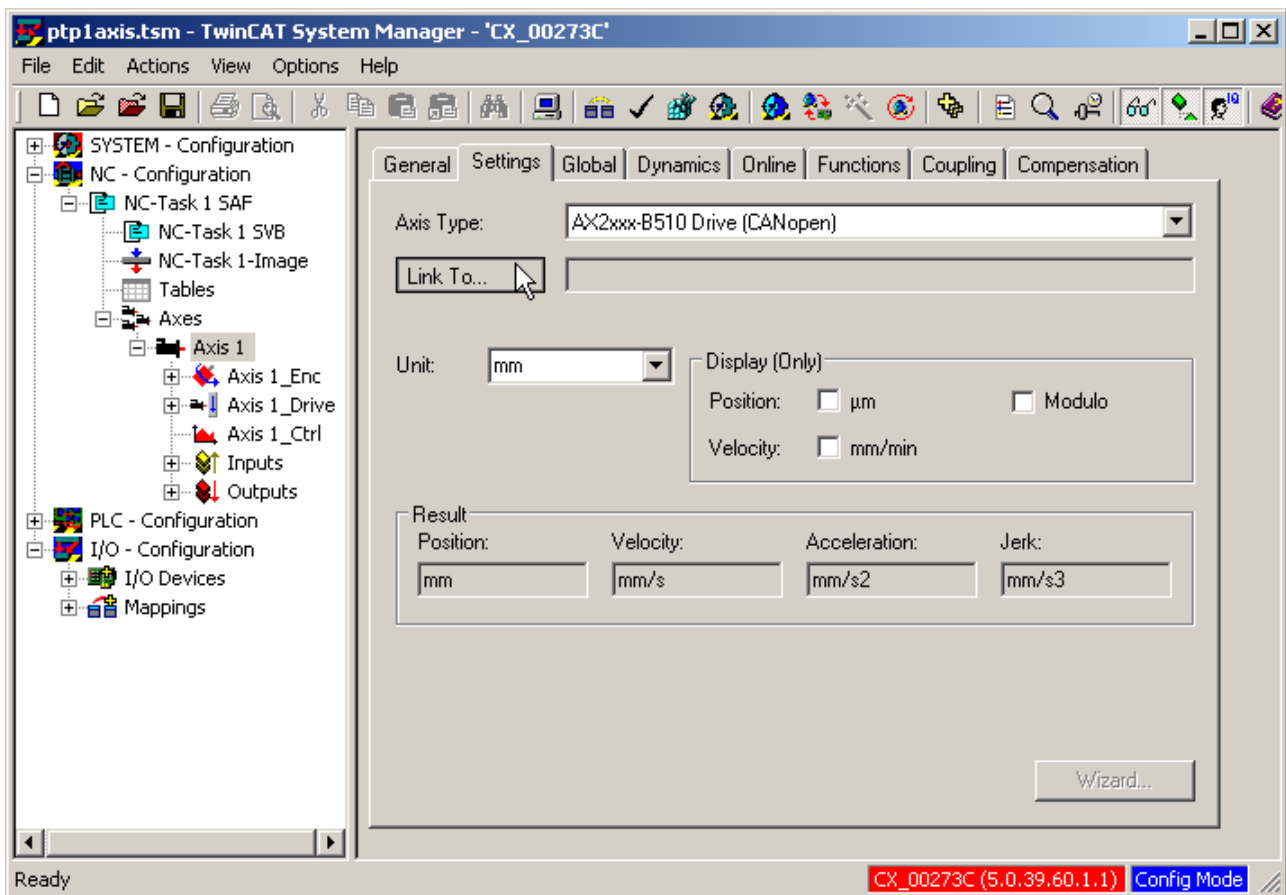


3.10. Link TwinCAT NC Axis to Drive Axis

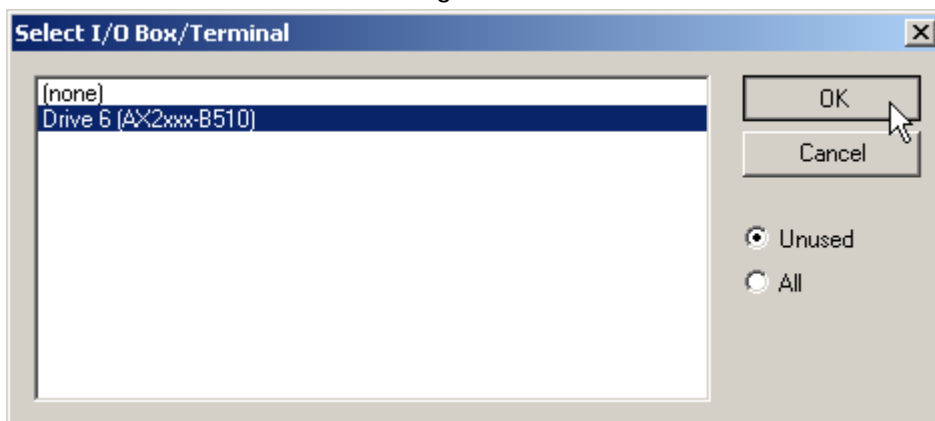
A fieldbus network with an AX2000 must be configured in TwinCAT System Manager. Refer to Chapter 2, "Hardware Configuration" on page 6. This example uses an AX2000-B510 on a CANopen network.

To link the TwinCAT NC axis to a drive axis:

1. Select "Axis 1"
2. Select "Settings"
3. Set "Axis Type" to "AX2xxx-B510 (CANopen)"
4. Click "Link To..."



5. Select the AX2000 that is to be assigned to the TwinCAT NC axis



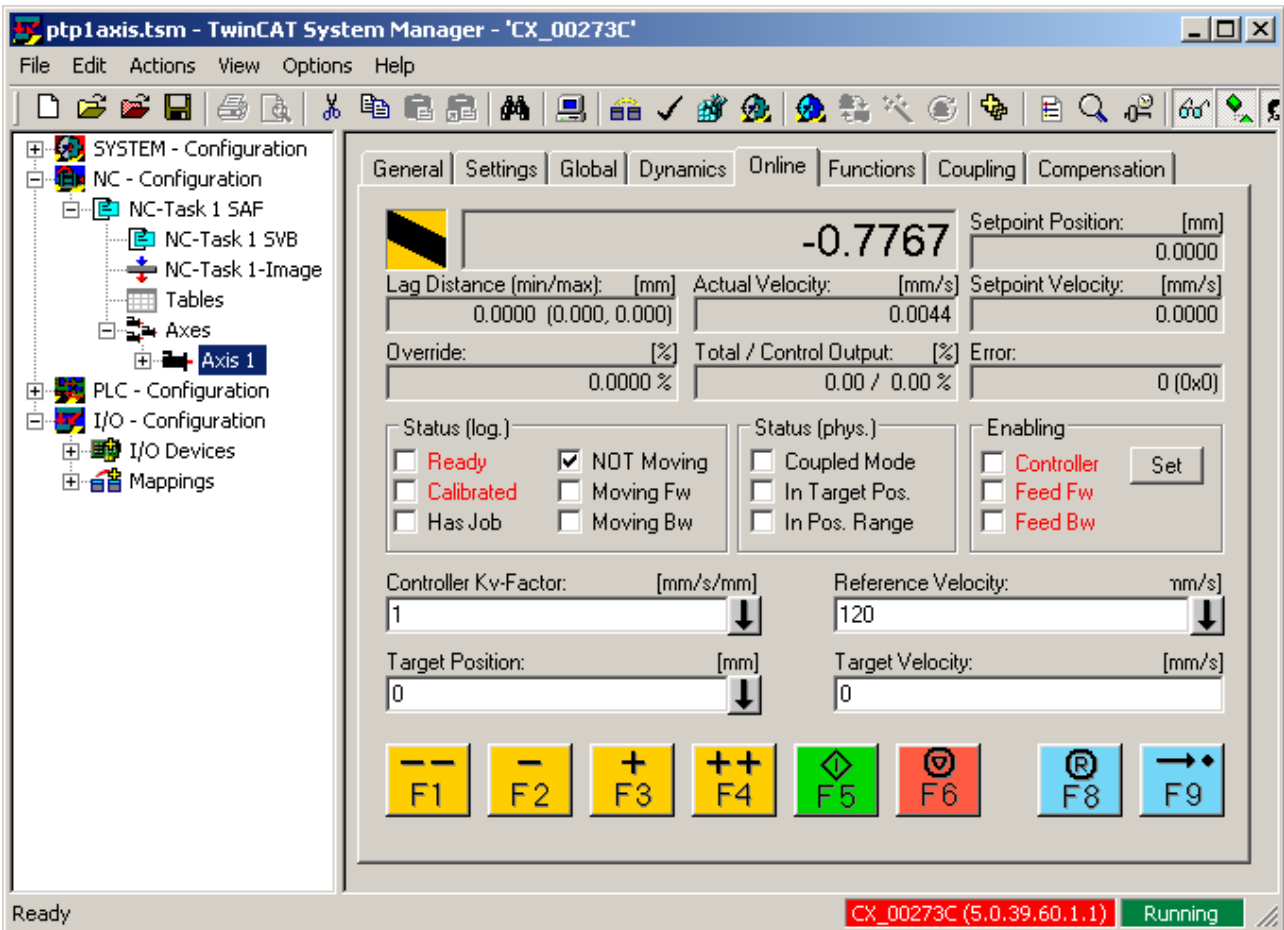
Save, download and activate the TwinCAT system configuration.

4. Manual Control of the TwinCAT NC Axis

When the system configuration has been activated, the position of the axis can be controlled manually from TwinCAT NC in TwinCAT System Manager. This allows the axis to be commissioned and checked before axis control from the TwinCAT PLC program is implemented.

To get to the manual axis control screen:

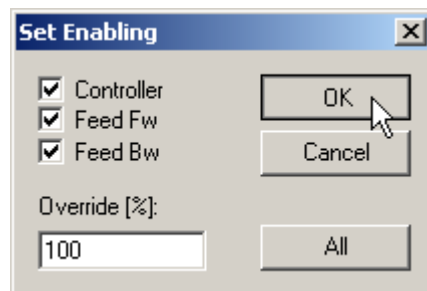
1. Select "Axis 1"
2. Select the "Online" tab



4.1. Enable Axis





To enable the axis:

1. Click "Set"
2. Select "Controller", "Feed Fw" and "Feed Bw"
3. Set "Override (%)" to 100%
4. Click OK. The AX2000 should now enable and hold the motor in position



4.2. Manual Axis Control

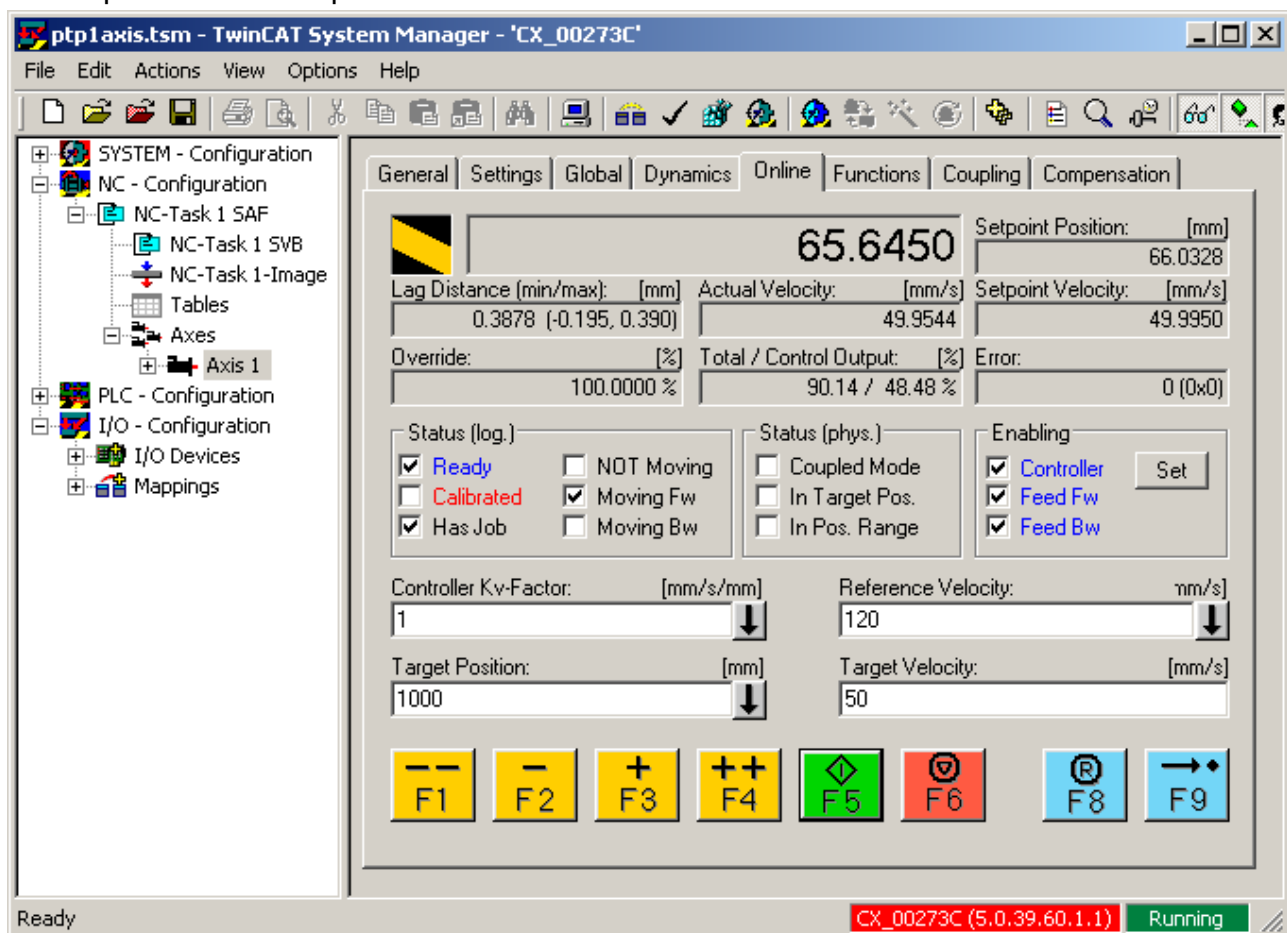
Basic axis movement can be tested using the F1 to F4 buttons. While pressed, these buttons will move the axis at the velocity specified in “Manual Velocity (Fast)” or “Manual Velocity (Slow)”.

Button	Function
	Move backwards at velocity specified in Manual Velocity (Fast)
	Move backwards at velocity specified in Manual Velocity (Slow)
	Move forwards at velocity specified in Manual Velocity (Slow)
	Move forwards at velocity specified in Manual Velocity (Fast)

4.3. Move Axis to Absolute Position

To move the axis to a specified position:

1. Set target position. If max and/or min position limit(s) are enabled, the target position must be within the permitted position range
2. Set target velocity
3. Click the green button or press “F5”. The axis will move to the specified target position and stop



The screenshot shows the TwinCAT System Manager interface for 'ptp1 axis.tsm - TwinCAT System Manager - 'CX_00273C''. The left sidebar shows a tree view with 'Axis 1' selected under 'Axes'. The main window displays the 'General' tab for Axis 1, showing the current position as 65.6450 mm. Below this, there are fields for Lag Distance, Actual Velocity, Setpoint Position, Setpoint Velocity, Override, Total / Control Output, and Error. The 'Status (log.)' section includes checkboxes for Ready, Calibrated, Has Job, NOT Moving, Moving Fw, and Moving Bw. The 'Status (phys.)' section includes checkboxes for Coupled Mode, In Target Pos., and In Pos. Range. The 'Enabling' section has checkboxes for Controller, Feed Fw, and Feed Bw. At the bottom, there are input fields for Controller Kv-Factor (1), Reference Velocity (120), Target Position (1000), and Target Velocity (50). A row of function buttons (F1-F9) is visible, with F5 highlighted in green. The bottom status bar shows 'Ready' and 'Running'.

4.4. Stop Axis

To stop the movement of the axis at any time:

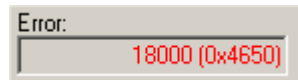
1. Click the red button or press F6



The axis will come to a controlled stop immediately, and the move to the specified target position will be abandoned.

4.5. Reset Axis

If an axis error occurs, the error code will be shown in red in the "Error:" window.



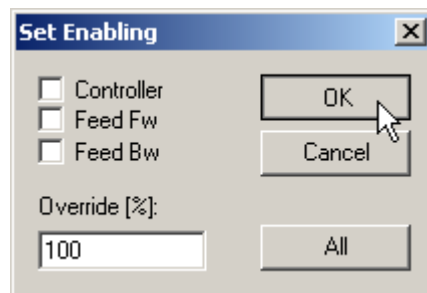
Click the blue button or press F8 or reset the axis.



4.6. Disable Axis

To disable the axis and AX2000:

1. Click "Set"
2. De-select "Controller", "Feed Fw" and "Feed Bw"
3. Click OK



The AX2000 should now disable, and the motor shaft can be turned by hand.