BECKHOFF New Automation Technology

Function description | EN

AX8000

Multi-axis servosystem

2025-04-02 | Version 2.0.0

Table of contents

1 Documentation notes

1.1 Disclaimer

Beckhoff products are subject to continuous further development. We reserve the right to revise the documentation at any time and without notice. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams, and descriptions in this documentation.

1.1.1 Trademarks

Beckhoff®, TwinCAT®, TwinCAT/BSD®, TC/BSD®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC®, XTS® and XPlanar® are registered and licensed trademarks of Beckhoff Automation GmbH.

The use by third parties of other brand names or trademarks contained in this documentation may lead to an infringement of the rights of the respective trademark owner.

1.1.2 Patents

The EtherCAT technology is protected by patent rights through the following registrations and patents with the relevant applications and registrations in various other countries:

- EP1590927
- EP1789857
- EP1456722
- EP2137893
- DE102015105702

EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH.

1.1.3 Limitation of liability

All components of this product described in the original operating instructions are delivered in a hardware and software configuration, depending on the application requirements. Modifications and changes to the hardware or software configuration that go beyond the documented options are prohibited and nullify the liability of Beckhoff Automation GmbH & Co. KG.

The following is excluded from the liability:

- Failure to comply with this documentation
- Improper use
- Use of untrained personnel
- Use of unauthorized spare parts

1.1.4 Copyright

1.1.5 Third-party brands

Third-party trademarks and wordmarks are used in this documentation. The trademark endorsements can be found at: https://www.beckhoff.com/trademarks

1.2 Version numbers

On request we can send you a list of revision levels for changes to the documentation. Please send your request to:

motion-documentation@beckhoff.com

Origin of the document
This documentation was originally written in German. All other languages are derived from the German original.

Product features
The valid product features are always those specified in the current documentation. Further information given on the product pages of the Beckhoff homepage, in emails or in other publications is not authoritative.

1.3 Scope of the documentation

In addition to this documentation, the following documents are part of the complete documentation:

AX8000	Definition
Translation of the original instructions	Information on the electrical and mechanical characteristics of the AX8000 multi-axis servo system, including instructions for handling the product
CoE object description	Documentation of the CAN over EtherCAT objects with attribute tables
Diagnostic messages	Documentation of the error messages of the AX8000 multi-axis servo system with attribute tables, problem descriptions and possible solutions

1.4 Staff qualification

This documentation is aimed at trained specialists working in control technology and automation who have knowledge of the applicable and required standards and directives.

Specialists must have knowledge of drive technology and electrical equipment as well as knowledge of safe working on electrical systems and machines. This includes knowledge of proper setup and preparation of the workplace as well as securing the working environment for other persons.

The documentation published at the time must be used for each installation and commissioning. The products must be used in compliance with all safety requirements, including all applicable laws, regulations, provisions and standards.

Instructed person

Instructed persons have a clearly defined task area and have been informed about the work to be carried out. Instructed persons are familiar with:

- the necessary protective measures and protective devices
- the intended use and risks that can arise from use other than for the intended purpose

Trained person

Trained persons meet the requirements for instructed persons. Trained persons have additionally received training from the machine builder or vendor:

- machine-specific or
- plant-specific

Trained specialists

Trained specialists have received specific technical training and have specific technical knowledge and experience. Trained specialists can:

- apply relevant standards and directives
- assess tasks that they have been assigned
- recognize possible hazards
- prepare and set up workplaces

Qualified electricians

Qualified electricians have comprehensive technical knowledge gained from a course of study, an apprenticeship or technical training. They have an understanding of control technology and automation. They are familiar with relevant standards and directives. Qualified electricians can:

- independently recognize, avoid and eliminate sources of danger
- implement specifications from the accident prevention regulations
- assess the work environment
- independently optimize and carry out their work

1.5 Safety and instruction

Read the contents that are related to the activities you will perform with the product. Always read the For your safety chapter in the documentation. Observe the warning notes in the chapters so that you can handle the product and work with it properly and safely.

1.5.1 Notes on information security

The products of Beckhoff Automation GmbH & Co. KG (Beckhoff), insofar as they can be accessed online, are equipped with security functions that support the secure operation of plants, systems, machines and networks. Despite the security functions, the creation, implementation and constant updating of a holistic security concept for the operation are necessary to protect the respective plant, system, machine and networks against cyber threats. The products sold by Beckhoff are only part of the overall security concept. The customer is responsible for preventing unauthorized access by third parties to its equipment, systems, machines and networks. The latter should be connected to the corporate network or the Internet only if appropriate protective measures have been set up.

In addition, the recommendations from Beckhoff regarding appropriate protective measures should be observed. Further information regarding information security and industrial security can be found in our https://www.beckhoff.com/secguide.

Beckhoff products and solutions undergo continuous further development. This also applies to security functions. In light of this continuous further development, Beckhoff expressly recommends that the products are kept up to date at all times and that updates are installed for the products once they have been made available. Using outdated or unsupported product versions can increase the risk of cyber threats.

To stay informed about information security for Beckhoff products, subscribe to the RSS feed at https://www.beckhoff.com/secinfo.

1.6 Explanation of symbols

Various symbols are used for a clear arrangement:

- ► The triangle indicates instructions that you should execute.
- • The bullet point indicates an enumeration.
- […] The square brackets indicate cross-references to other text passages in the document.
- [1] The number in the square brackets refers to the position in the adjacent figure.
- [+] The plus sign in square brackets indicates ordering options and accessories.

In order to make it easier for you to find text passages, pictograms and signal words are used in warning notices:

⚠ DANGER

Failure to comply will result in serious or fatal injuries.

⚠ WARNING

Failure to comply may result in serious or fatal injuries.

⚠ CAUTION

Failure to comply may result in minor or moderate injuries.

NOTICE

Notes are used for important information on the product. The possible consequences of failure to observe these include:

- product malfunctions
- damage to the product
- damage to the environment

Information
This symbol indicates information, tips, and notes for handling the product or the software.

Examples
This symbol shows examples of how to use the product or software.

Required tool
This symbol indicates a tool that is required for the following steps.

Required accessories [+]
This symbol shows the accessories required for the following steps. The accessories are not included in the scope of delivery and can be ordered from Beckhoff.

Assembly material required
This symbol shows the assembly material required for the following steps. The assembly material is not included in the scope of delivery and must be purchased separately.

Permitted cleaning agents
This symbol indicates the permitted cleaning agents that the components may be cleaned with. The permitted cleaning agents are not included in the scope of delivery and must be purchased separately.

QR codes
This symbol shows a QR code that you can scan to watch videos or animations. Internet access is required in order to use it.

1.7 Beckhoff Services

Beckhoff and its international partner companies offer comprehensive support and service.

www.beckhoff.com/en-en/support/global-availability/

1.7.1 Support services

The Beckhoff Support offers technical advice on the use of individual Beckhoff products and system planning. The support engineers offer you competent assistance, for comprehension questions as well as for commissioning.

+49 5246 963-157
support@beckhoff.com
www.beckhoff.com/en-en/support/our-support-services/

1.7.2 Training offerings

Training in Germany takes place at the Beckhoff branches or, after consultation, at the customer's premises. Beckhoff offers both face-to-face and online training courses.

+49 5246 963-5000
training@beckhoff.com
www.beckhoff.com/en-en/support/training-offerings/

1.7.3 Service offerings

The Beckhoff service experts support you worldwide in all areas of after-sales service.

+49 5246 963-460
service@beckhoff.com
www.beckhoff.com/en-en/support/our-service-offerings/

1.7.4 Headquarters Germany

Beckhoff Automation GmbH & Co. KG
Hülshorstweg 20
33415 Verl, Germany

+49 5246 963-0
info@beckhoff.com
www.beckhoff.com/en-en/

A detailed overview of the Beckhoff locations worldwide can be found at:

www.beckhoff.com/en-en/company/global-presence/

1.7.5 Downloadfinder

In the Download finder you will find configuration files, technical documentation and application reports to download.

www.beckhoff.com/documentations

2 For your safety

Read this chapter containing general safety information. Furthermore, the chapters in this documentation contain warning notices. Always observe the safety instructions for your own safety, the safety of other persons and the safety of the product.

When working with control and automation products, many dangers can result from careless or incorrect use. Work particularly thoroughly, not under time pressure and responsibly towards other people.

2.1 General safety instructions

This chapter contains information on safety relating to the software and the associated products. These products do not run independently and are therefore categorized as incomplete machines. The products must be installed by the machine manufacturer in a machine or system. Read the documentation prepared by the machine manufacturer.

Protective equipment

Do not remove or bypass any protective devices. Check all protective devices before operation. Make sure that all emergency switches are present at all times and can be reached by you and other people. People could be seriously or fatally injured by unprotected machine parts.

Careful handling of the software

Only make adjustments within the possible and technical load limits of the components. Careless adjustments of parameters or other settings can lead to serious injuries and damage to the system due to unpredictable movements of the components.

Protection against manipulation and account rights

Be sure to secure your monitor workstation from unauthorized personnel. As a user or administrator, you have access to various settings within the system. Secure your access against unauthorized access and changes. For example, use strong passwords and lock your access when you leave the workplace. Also, comply with the terms of the applicable IT policies.

Security Guide

Further information on how to protect Beckhoff products against various hazards within the scope of risk management can be found in the Security Guide:

- Document: IPC Security Guideline

3 Firmware update

Firmware is software embedded in the servo drive that controls basic functions of the device hardware. Following the principle of continuous software development, the firmware is continuously improved and extended, so that there are different versions with different functionalities.

3.1 Firmware versions

There is an appropriate bootloader to load the firmware versions correctly. The firmware versions and bootloader versions can be found in the following directory after the TwinCAT 3 Drive Manager 2 installation:

Installation on TwinCAT 4024

- **Firmware versions:** C:\TwinCAT\Functions\TE5950-Drive-Manager-2\Firmware\AX8000 AMP8000
- **Bootloader versions:** C:\TwinCAT\Functions\TE5950-Drive-Manager-2\Firmware\AX8000 AMP8000\Bootloader

Installation on TwinCAT 4026

- **Firmware versions:** C:\Program Files (x86)\Beckhoff\TwinCAT\Functions\TE5950-Drive-Manager-2\Firmware\AX8000 AMP8000
- **Bootloader versions:** C:\Program Files (x86)\Beckhoff\TwinCAT\Functions\TE5950-Drive-Manager-2\Firmware\AX8000 AMP8000\Bootloader

The following table shows the available firmware versions:

EtherCAT revision	Firmware (latest build)	Bootloader
AX8yxx-xxxx-0103	V1.03 b0006	≥ V1.21 (latest version: V1.35)
AX8yxx-xxxx-0104	V1.04 b0010	≥ V1.21 (latest version: V1.35)
AX8yxx-xxxx-0105	V1.05 b0012	≥ V1.21 (latest version: V1.35)
AX8yxx-xxxx-0106	V1.06 b0003	≥ V1.21 (latest version: V1.35)
AX8yxx-xxxx-0107	V1.07 b0001	≥ V2.0.0

Table: EtherCAT revisions and associated firmware versions

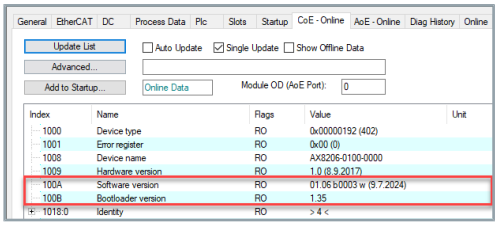


Illustration: Figure: CoE directory

The current firmware and bootloader versions can be found in the following CoE objects:

- 100A: software version
- 100B: bootloader version

3.2 Firmware update / downgrade within firmware version V1.03–V1.06

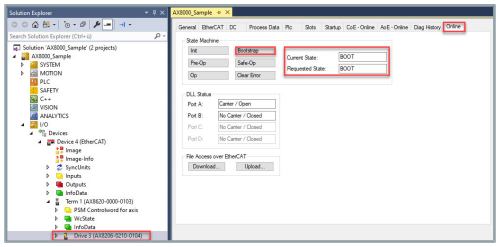
Do not perform firmware updates during operation
Firmware updates must not be performed while a machine is in operation. The update can be performed in configuration mode or in TwinCAT Run Mode. If the machine is in Run Mode, make sure that the axis on which the firmware update is being performed is disabled.

Firmware update from version V1.01 / V1.02 to higher versions
If you want to update from firmware version V1.01 or V1.02 to a higher version, please contact our technical support first.

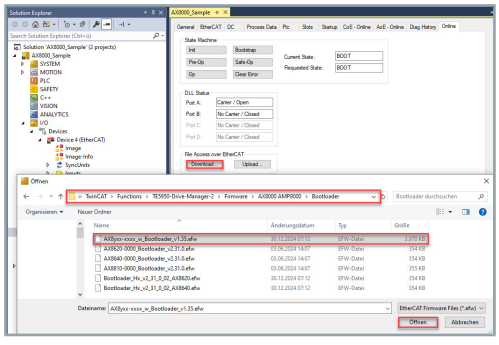
Bootloader update

Checking the bootloader version
You should always update to the latest available bootloader version.

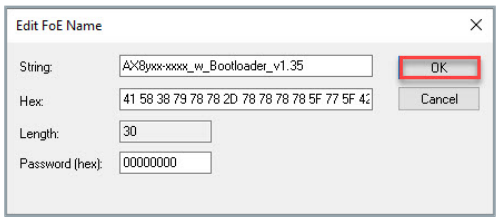
Prerequisite:
Current bootloader version (object: 0x100B) < latest bootloader version



► Request device's EtherCAT state [**bootstrap**]

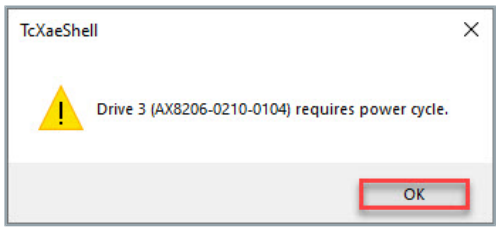


► Download (FoE) the required bootloader version



► Confirm with **OK**

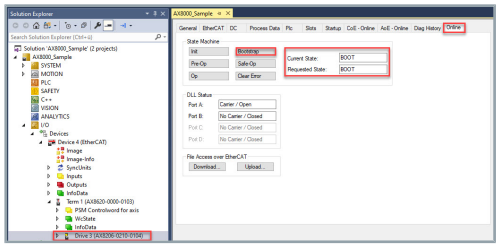
You do not need to enter a password.



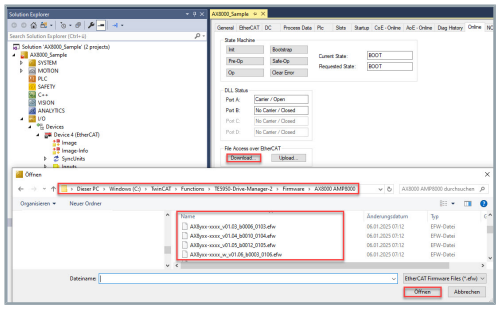
► Perform a **Power cycle**

Bootloader update completed.
Ready for firmware download.

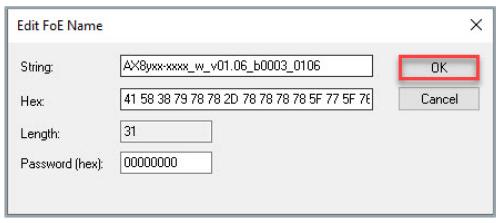
AX8000 firmware update/ downgrade within firmware V1.03–V1.06



► Request device's EtherCAT state [**bootstrap**]



► Download the required firmware version via (FoE) download



► Confirm with **OK**

You do not need to enter a password.

► Perform a **Power cycle**

Firmware update completed

The EtherCAT revision states the minimum firmware version required for the current configuration. If the firmware is lower than the firmware associated with the EtherCAT revision, the device cannot be operated.

Conditions for operation

Firmware version ≥ EtherCAT revision

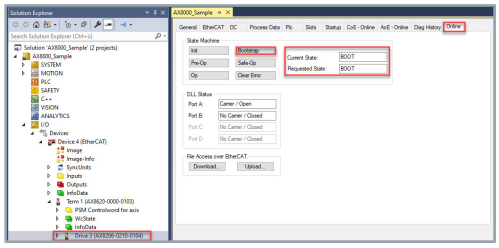
The relationship between EtherCAT revision and firmware version is explained in the "Firmware versions", [Page 16] chapter.

3.3 Firmware update | Firmware version (V1.03–V1.06) to V1.07 or higher

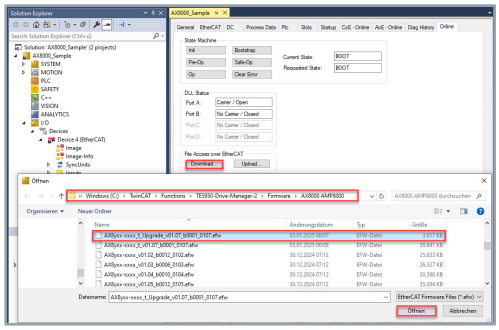
Do not perform firmware updates during operation
Firmware updates must not be performed while a machine is in operation. The update can be performed in configuration mode or in TwinCAT Run Mode. If the machine is in Run Mode, make sure that the axis on which the firmware update is being performed is disabled.

Firmware update to version 1.07
No separate bootloader update process is required for the update to firmware version V1.07, as this is included in the overall firmware update process.

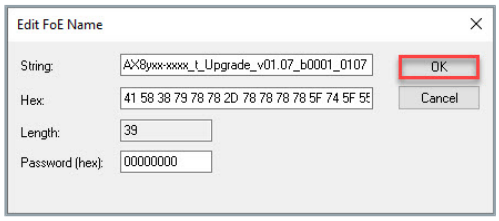
AX8000 firmware update from (V1.03–V1.06) to V1.07 or higher



► Request device's EtherCAT state [**bootstrap**]



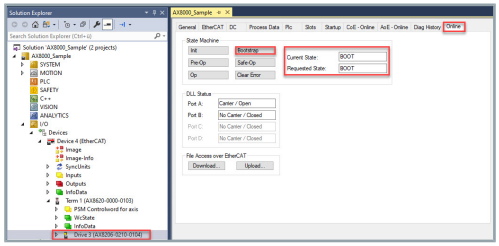
► Download (FoE) the V1.07 upgrade file: AX8yxx-xxxx_t_Upgrade_v01.07_b0001_0107



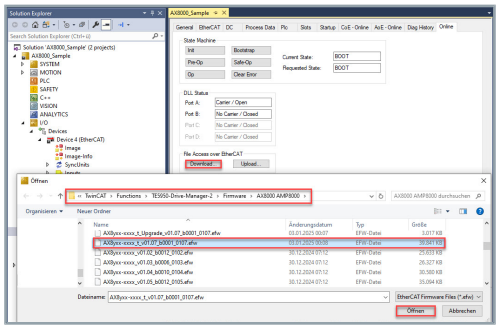
► Confirm with **OK**

You do not need to enter a password.

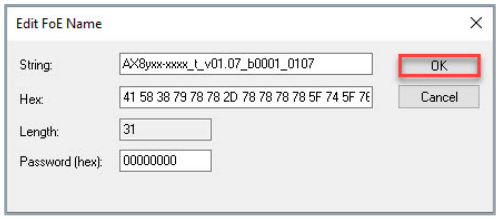
► Perform a **Power cycle**



► Request device's EtherCAT state [**bootstrap**]

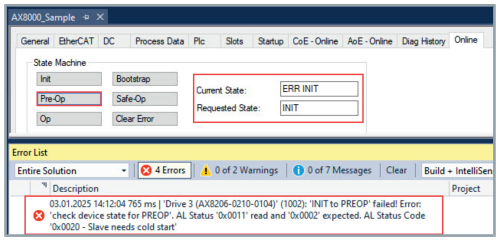


► Download (FoE) the V1.07 firmware file:
AX8yxx-xxxx_t_v01.07_b0001_0107



► Confirm with **OK**

You do not need to enter a password.



► Request EtherCAT state [PreOp] of the device:
Wait for the error message:
“0x0020 – Slave needs cold start”

► Perform a **Power cycle**

The firmware update is complete.

The EtherCAT revision states the minimum firmware version required for the current configuration. If the firmware is lower than the firmware associated with the EtherCAT revision, the device cannot be operated.

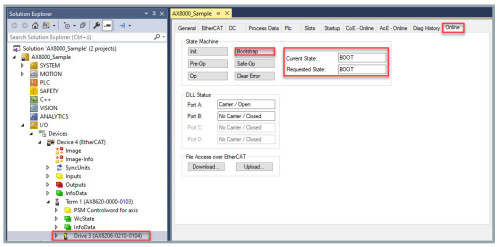
Conditions for operation

Firmware version ≥ EtherCAT revision

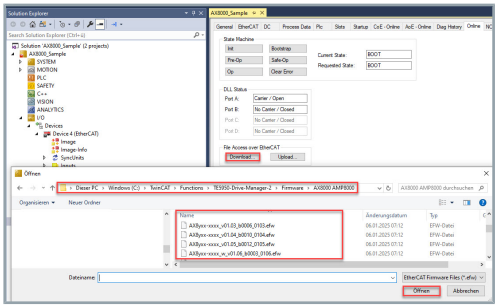
The relationship between EtherCAT revision and firmware version is explained in the "Firmware versions", [Page 16] chapter.

3.4 Firmware update | Firmware version V1.07 to V1.07 or higher

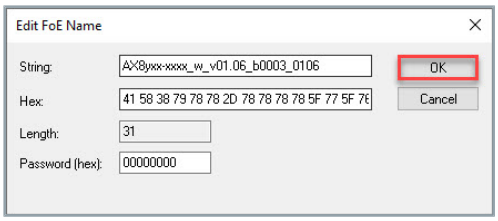
Firmware update/downgrade
AX8000 within V1.07 or higher



► Request device EtherCAT state [**bootstrap**]



► Download the required firmware version via (FoE) download



► Perform a “**Power cycle**”

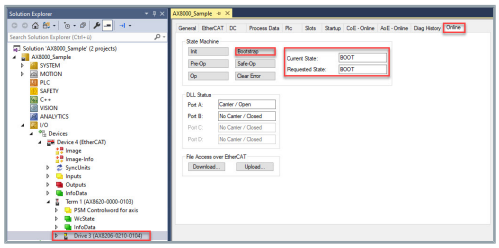
The firmware update/downgrade is complete.

3.5 Firmware downgrade | Firmware version V1.07 or higher to (V1.03–V1.06)

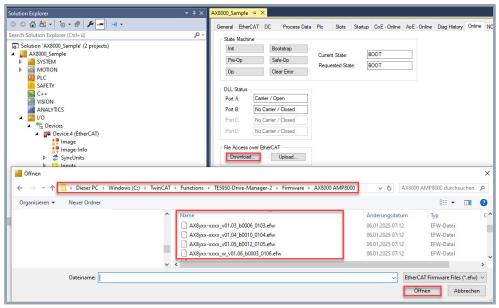
Do not perform firmware updates during operation
Firmware updates must not be performed while a machine is in operation. The update can be performed in configuration mode or in TwinCAT Run Mode. If the machine is in Run Mode, make sure that the axis on which the firmware update is being performed is disabled.

Downgrade process
A separate bootloader downgrade process is not necessary for the firmware downgrade procedure from V1.07 or higher to (V1.06–V1.03).

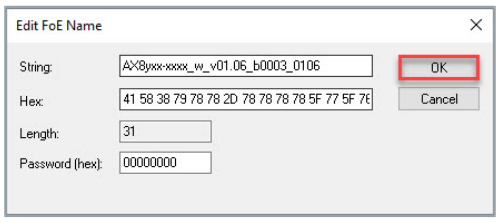
AX8000 firmware downgrade from V1.07 or higher to (V1.06–V1.03)



► Request device's EtherCAT state [**bootstrap**]

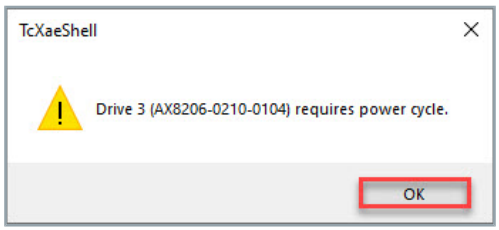


► Download the required firmware version via (FoE) download



► Confirm with **OK**

You do not need to enter a password.



► Perform a **Power cycle**

Completed firmware downgrade

The EtherCAT revision states the minimum firmware version required for the current configuration. If the firmware is lower than the firmware associated with the EtherCAT revision, the device cannot be operated.

Conditions for operation

Firmware version ≥ reference firmware version for the EtherCAT revision

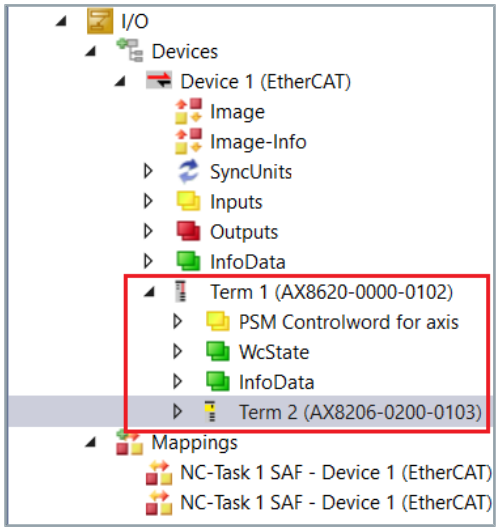
4 TC3 Drive Manager 2

TC3 Drive Manager 2 is a commissioning software for Beckhoff drive solutions. It is integrated as an independent project in a Visual Studio environment.

The following products are supported:

- Power supply modules of the AX86x0 series
- Axis modules of the AX8xxx series
- Combined AX85xx power supply modules and axis modules
- Capacitor modules of the AX8810 series
- Servo terminals of the EL72xx, EP72xx, EJ72xx and ELM72xx series
- Integrated AMI81xx servo drive
- AMP8000 Distributed servo drive system
- Servo drives from the AX5000 series

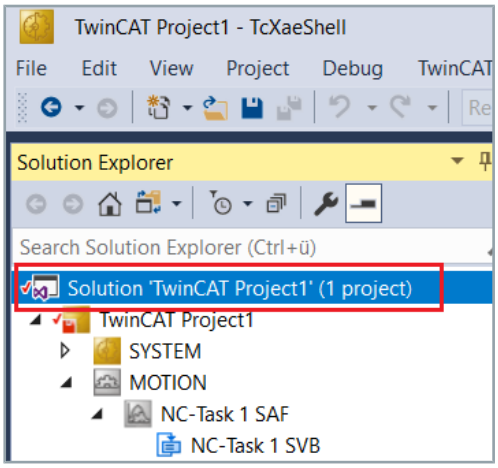
4.1 Requirement



To use the TC3 Drive Manager 2, create your axes in the Solution Explorer.

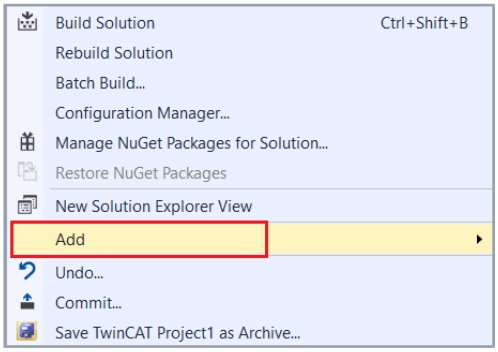
Read the TC3 User Interface manual
For safe control of the basic functions and to make adjustments to your project environment in TwinCAT 3, please read the following documentation:
TC3 | User Interface

4.2 Inserting a project



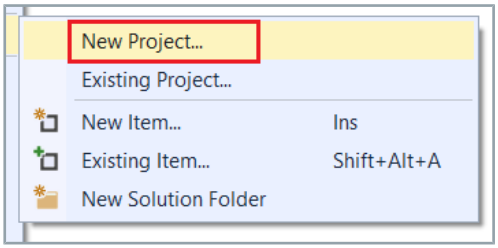
► Right-click: “Solution TwinCAT Project 1”

A new selection area opens.



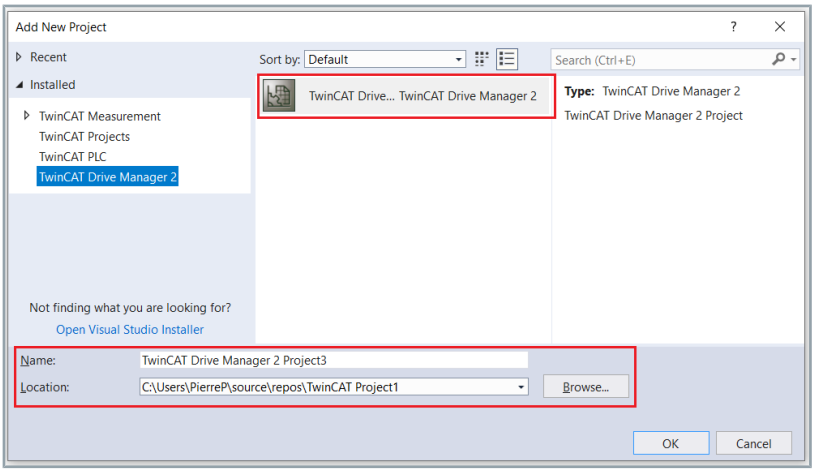
► Select Add

A new selection area opens.



► Left-click: "New Project"

A new "Add new Project" dialog box opens.



TwinCAT Drive Manager 2 is preselected.

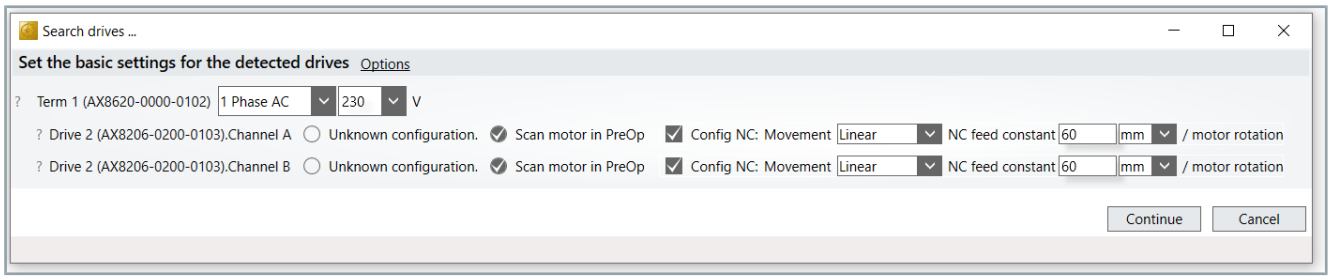
► Left-click: “TwinCAT Drive... TwinCAT Drive Manager 2”

► Assign project name and storage location

► Confirm with OK

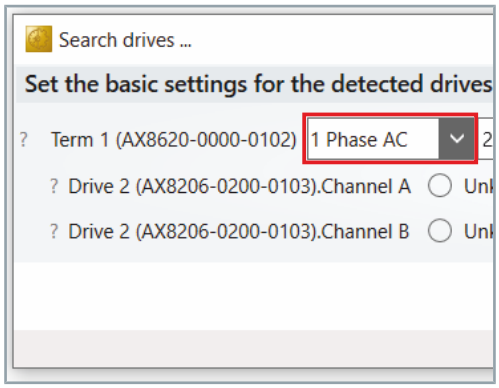
4.3 Basic settings

In the "Search drives..." dialog box you can configure the connected components of the AX8000 multi-axis servo system and make basic settings.



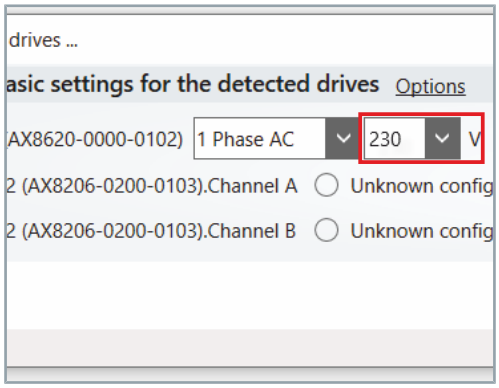
4.3.1 Power supply

Select the power supply for your power supply module. If there is no supply voltage, the default settings are used.



Select supply network:

- 3 Phase AC
- 1 Phase AC
- DC

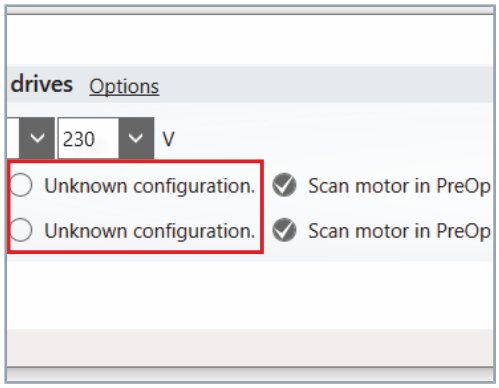


Select voltage:

3 phase and 1 phase networks [V_{AC}]	DC [V_{DC}]
100	24
200	48
230	---
400	---
480	---

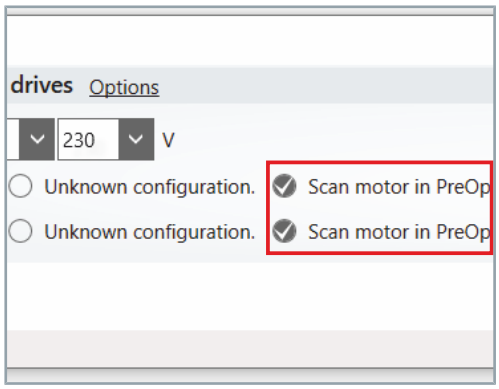
Extended selection options for DC supply
If you select DC supply, you can choose between 24 V_{DC} and 48 V_{DC} in the voltage selection.

4.3.2 Unknown configuration



If you select this option, your axis module is transferred into the configuration with its default values. You can change the basic settings later in the project.

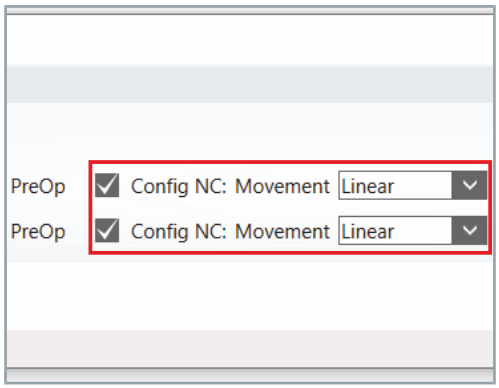
4.3.3 Scan motor in PreOp



Motors of the AM8000 and AM8500 series with electronic type plate are automatically scanned and transferred to the configuration.

Establish “PreOp” operating state and connect motor
The “Scan motor in PreOp” function is only available if a motor is connected and the axis module is in the “PreOp” operating state.
You can also establish the “PreOp” operating state when no motor is connected. In this case, no motor data are displayed and no default settings are loaded.

4.3.4 Config NC: Movement



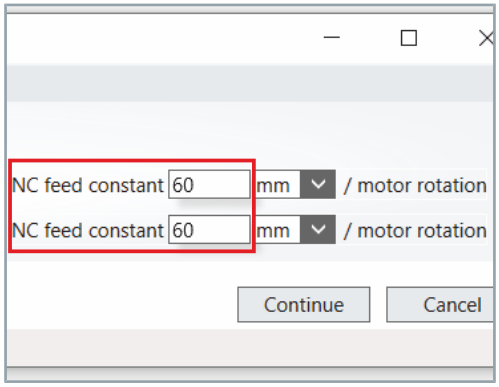
This function allows you to make basic scaling settings on the NC axis.

Selection options:

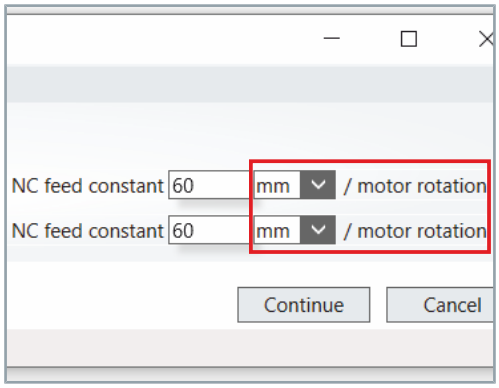
Selection	Configuration
Linear	The NC axis is configured as a linear axis
Rotary	The NC axis is configured as a rotary axis

Linking the NC axis to the axis module
The function "Config NC: Movement" requires an active connection between the NC axis and the axis module. Make sure the NC axis is linked to the axis module.

4.3.5 NC feed constant



This function defines the distance travelled per motor revolution. Adjust the mechanics via the "Scaling" menu.



Selection options:

Linear NC axis	Rotary NC axis
mm	°
m	degrees
---	s

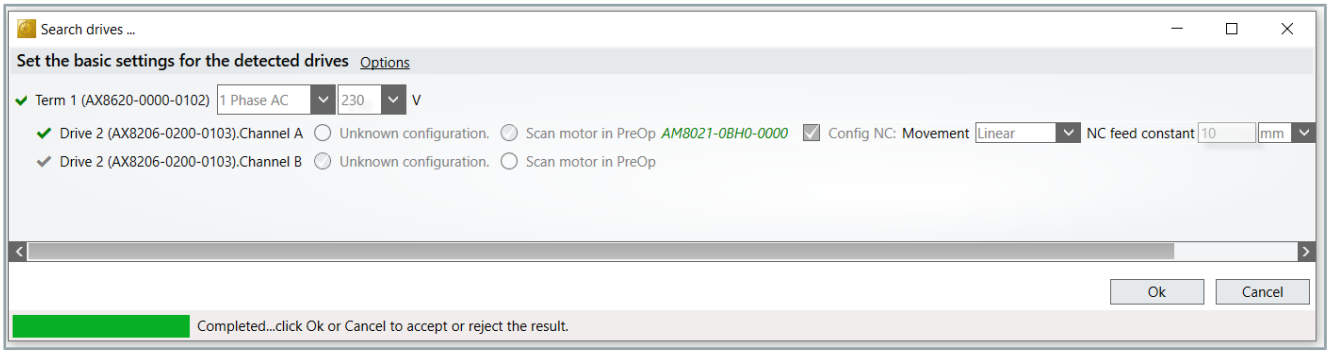
Read Excursus: "Scaling"
For further information on determining the "NC Feed constant", please refer to the "Excursus: Scaling", [Page 39].

4.3.6 Scanning motors

► Confirm settings with OK

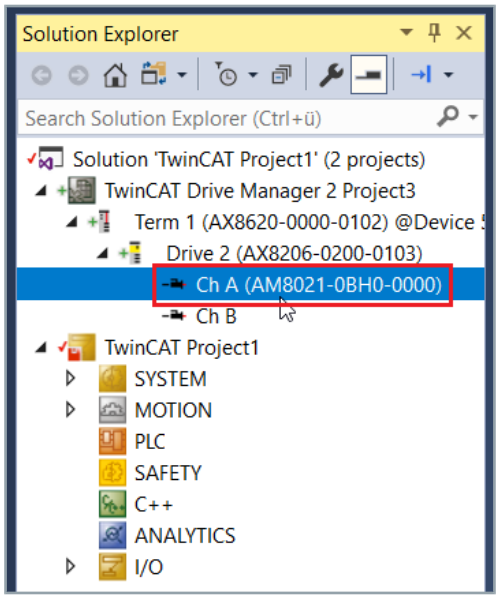
The motors are now scanned and transferred to your configuration.

The scanned motors are displayed in green:



► Finish configuration with OK

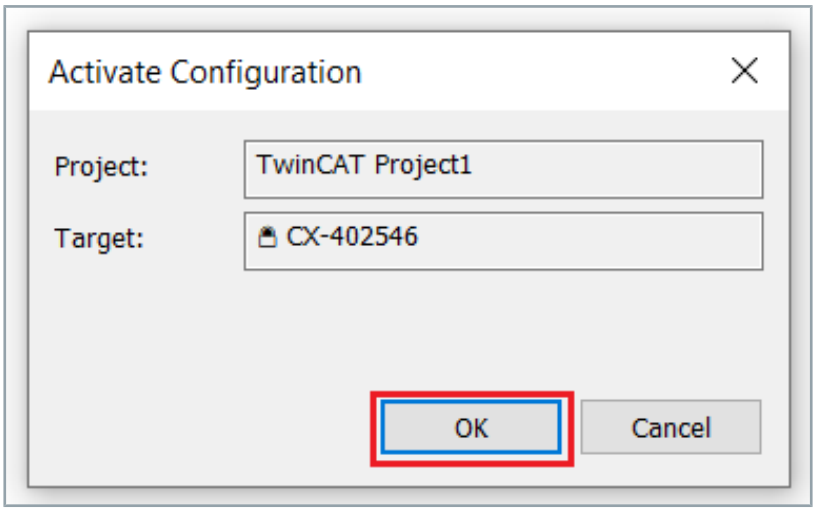
4.4 Activate configuration



► Select drive [Ch A (AM8021-0BH0-0000)]

► Left-click: "Activate Configuration" in the Visual Studio ribbon

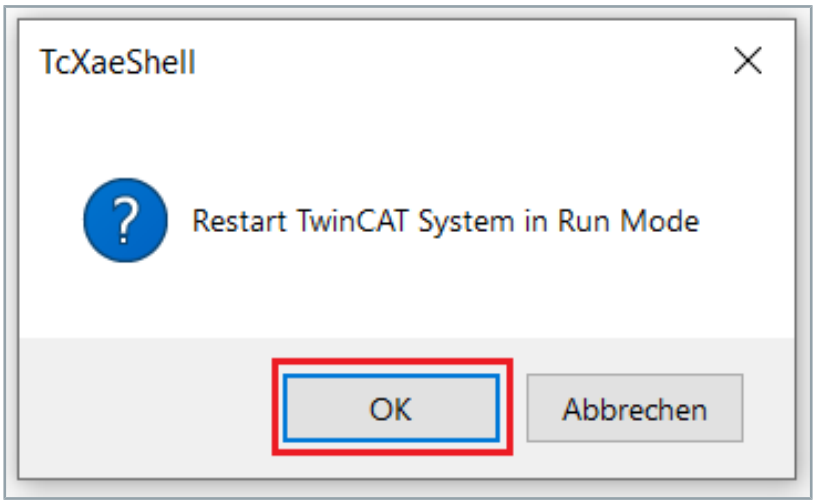
A new "Activate Configuration" dialog box opens.



► Confirm with OK

Your configuration is now activated.

A new dialog box "TcXaeShell" opens.



► Confirm with OK

TwinCAT is now in "Run mode".

4.5 Run Motor

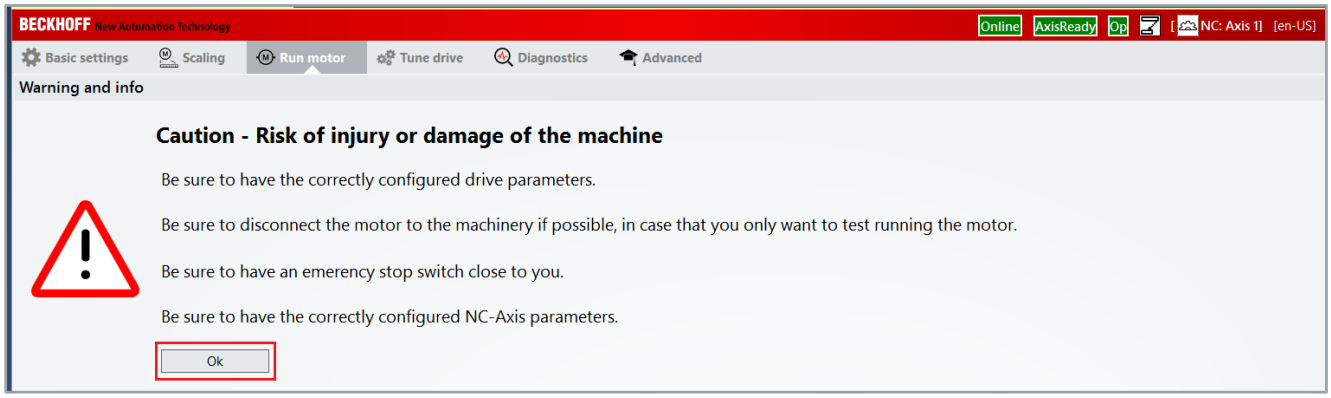
⚠ WARNING

Checking parameters and settings
Before you put your test setup or motor into operation, make sure that:

- The drive parameters are configured correctly
- The motor is separated from the machine or system in manual mode
- Emergency stop switches are within easy reach
- The NC axis parameters are configured correctly

Non-observance can lead to serious or even fatal injuries during operation.

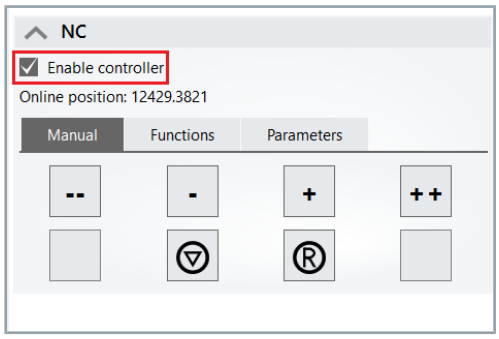
This function allows you to move the motor in manual mode.



► Enable function with OK

A new "NC" dialog box opens.

4.5.1 Manual operation



► Activate "Enable controller"

You can now move the motor in manual mode.

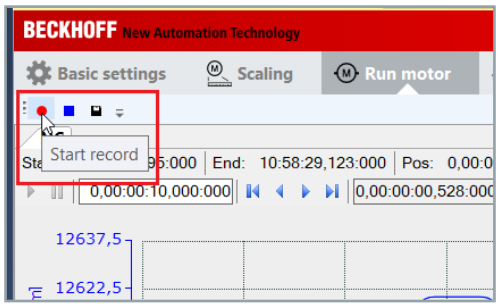
The following functions are provided:

Coding	Explanation
-	Move the motor in negative direction
--	Rapidly move the motor in negative direction
+	Move the motor in positive direction
++	Rapidly move the motor in positive direction
▽	Stop the NC axis
R	Reset an error from the Motion NC

4.5.1.1 Manual Scope View

In manual mode you have the option of starting a manual Scope View recording.

This allows you to record the velocity, position and following error. Scope View is an integrated feature of TC3 Drive Manager 2.

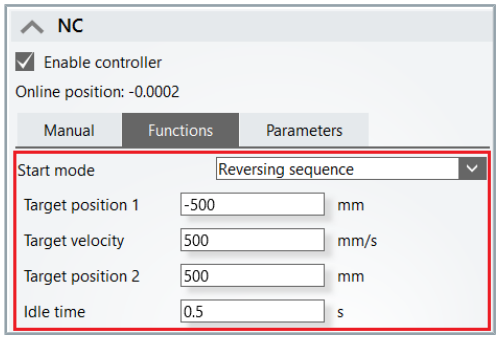


► Left-click: "Start record"

You have successfully enabled your Scope View.

4.5.2 Reversing mode

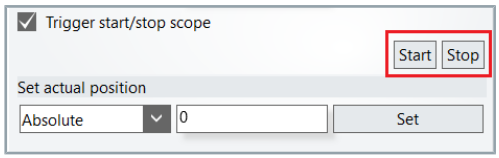
With the “Reversing sequence” function, you can move your axes between a defined start position and the end position.



- ► Activate “Enable controller”
- ► Enter start position “Target position 1” and target position “Target position 2”
- ► Enter the “Target velocity” and the “Idle time”

Automatic Scope View

You can start reversing mode with an automatic Scope View recording at the same time.



- ► Activate “Trigger start/stop scope”
- ► Activate/deactivate reversing mode with Start/Stop

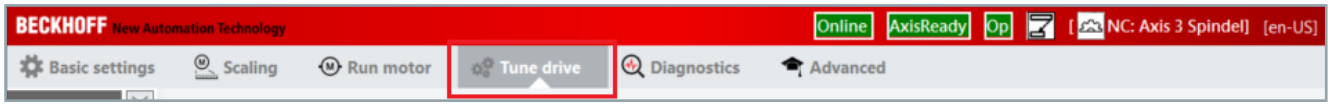
The following setting options are available:

Term	Explanation
Target position 1	Start position of the axis to be moved
Target position 2	Target position of the axis to be moved
Target velocity	Velocity at which your axis moves between the start position and the target position in reversing mode
Idle time	Waiting time between movements
Trigger start/stop scope	Start/stop automatic Scope View recording

4.6 Tune drive

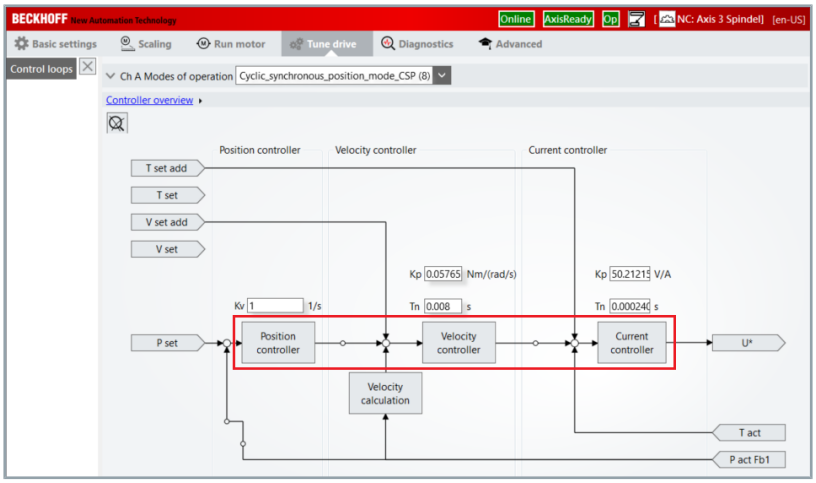
This function allows you to make settings on the position controller, velocity controller and current controller. It provides access to the control parameters that can be set with the TC3 Drive Manager 2.

Select the "Tune Drive" menu in the selection area of the TC3 Drive Manager 2.



A new selection area opens.

Further selection areas are available by left-clicking on the different controllers. In the following table the setting options are assigned to the controllers.



The following setting options are available:

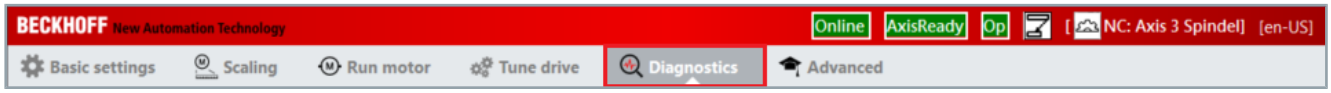
Controller structure	Explanation
Position controller "Position controller"	K_v = gain factor = P-part
Velocity controller "Velocity controller"	K_p = gain factor = P-part T_n = time constant; integral action time = I-part
Current controller "Current controller"	K_p = gain factor = P-part T_n = time constant; integral action time = I-part

4.7 Diagnostics

This function can be used to read out error codes and error messages to verify whether the drive is operating without errors or whether errors and warnings are present.

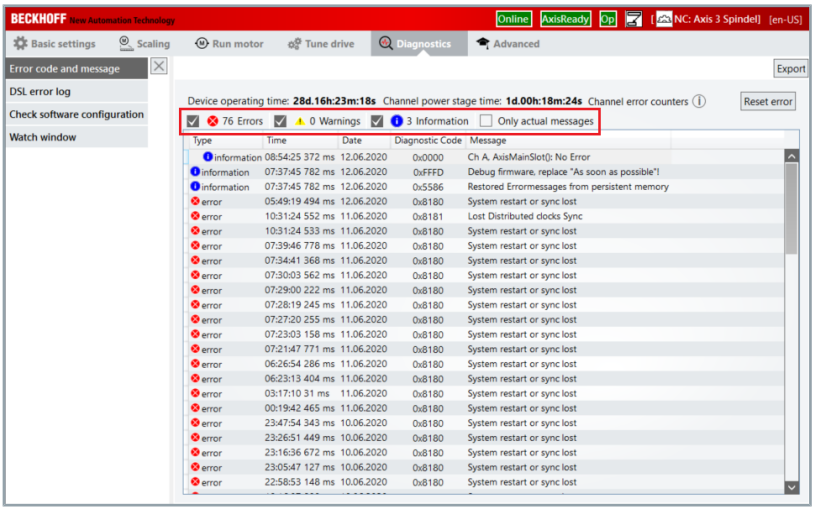
Different selection options
Note that different choices appear in the “Diagnostics” menu, depending on the component that is connected and configured.
Below you will find information on the selection options for power supply modules of the AX86xx series and axis modules of the AX8xxx series.

Select the “Diagnostics” menu in the selection area of the TC3 Drive Manager 2.



A new selection area opens.

Various error and information types are available for interpretation and analysis. This allows conclusions to be drawn about possible faults in the drivetrain or in your components.

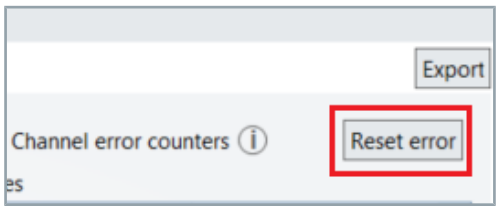


The following information is available:

Description	Explanation
Error	Critical error that can lead to the device being switched off. May occur when a configured limit value is exceeded, for example.
Warning	Precursor of a device shutdown. Indicates that limit values may be exceeded.
Information	General information that has no effect on the components or the configuration of the drivetrain
Only actual messages	This button limits the display to current messages

4.7.1 Deleting messages

You can acknowledge errors in the servo drive once the error has been resolved. Corresponding information and messages are then deleted from the error list.

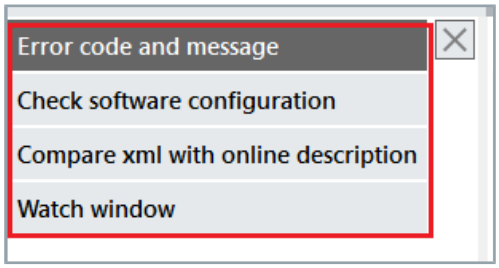


► Click the "Reset error" button

You have successfully reset the errors in the servo drive.

4.7.2 Selection options for AX86xx

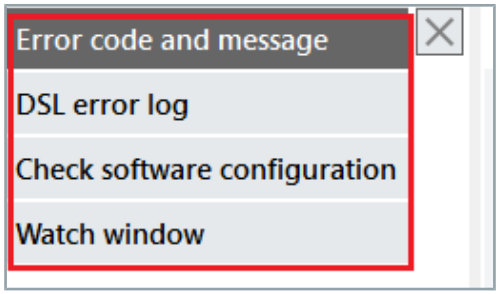
Different display options are available under "Diagnostics".



Information type	Explanation
Error code and message	Error codes and messages with corresponding plain text error message
Check software configuration	Comparison between valid startup list and current configuration
Compare xml with online description	Verification of the XML file
Watch window	Current values of the selected parameters

4.7.3 Selection options for AX8xxx

Different display options are available under "Diagnostics".

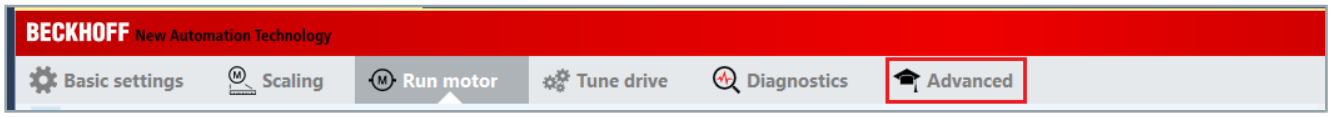


Information type	Explanation
Error code and message	Error codes and messages with corresponding plain text error message
DSL error log	Current error history of the encoder
Check software configuration	Comparison between valid startup list and current configuration
Watch window	Current values of the selected parameters

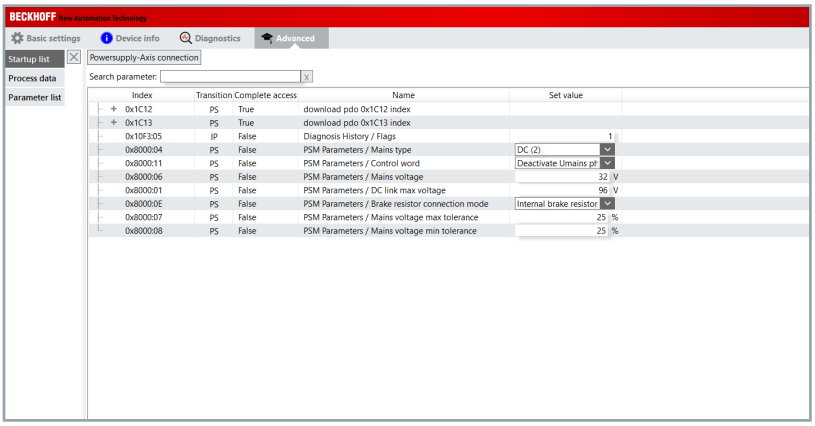
4.8 Advanced

This function provides further settings for your configuration.

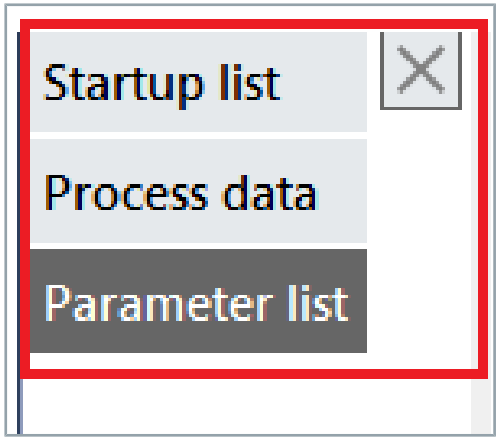
Select the "Advanced" menu in the selection area of the TC3 Drive Manager 2.



A new selection area opens.



4.8.1 Selection options

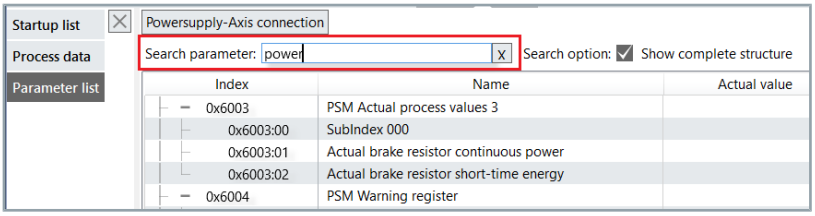


Different list display options are available under "Advanced".

Start search function:

► Left-click: "Startup list", "Process data" or "Parameter list"

A new selection area opens.



► Enter a search term under "Search parameter"

Note the available options:

Option	Explanation
Show complete structure	Shows all parameters found in the corresponding parameter group

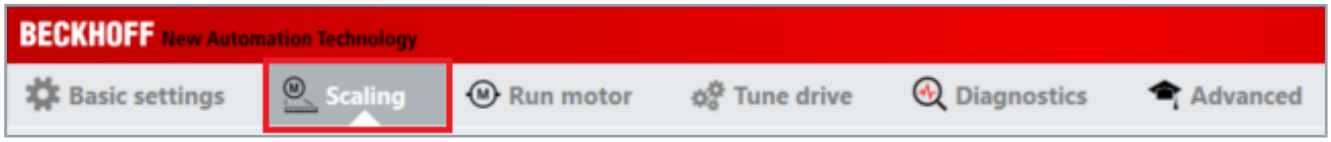
You have successfully performed the search function.

4.9 Excursus: Scaling

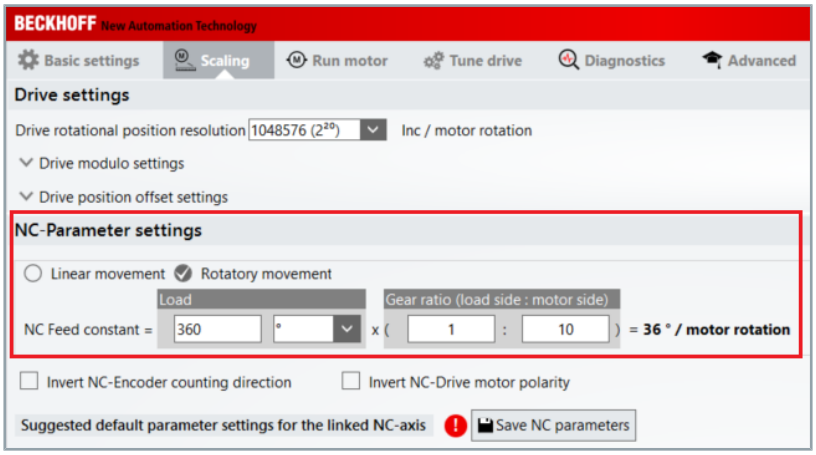
The following settings are provided as examples. They can vary depending on the application, machine or system.

Settings for a rotary NC axis as an example
Requirement:
A rotary table with 360°
A gear unit with a transmission ratio of i = 10
Result:
NC feed constant = 36° per motor revolution

In the menu “NC feed constant”, you have the option to enter the data of your mechanism. To do this, select the “Scaling” menu in the selection area of the TC3 Drive Manager 2.

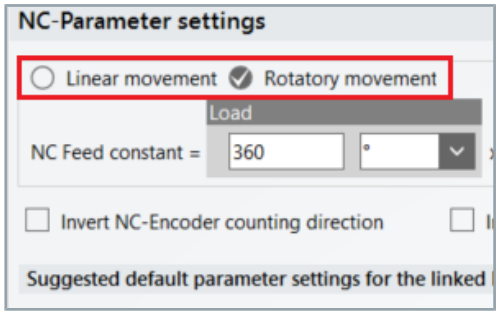


A new selection area opens.

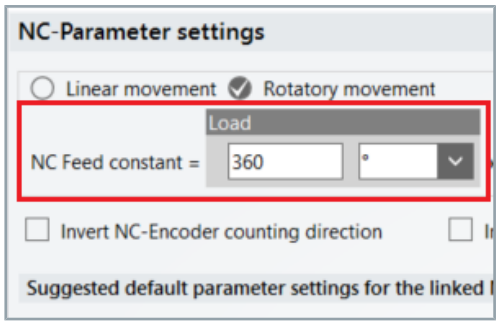


4.9.1 Settings

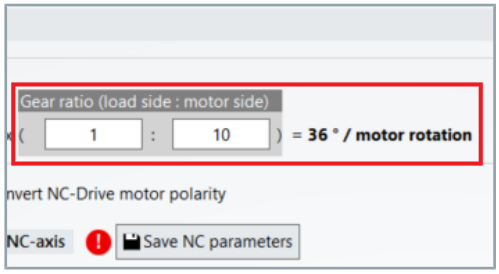
In the selection area for "NC parameter settings" you can size your mechanical system and thus determine the "NC Feed constant".



► Select Rotatory movement



► Enter rotary table from example with 360°



► Set gear ratio 1:10

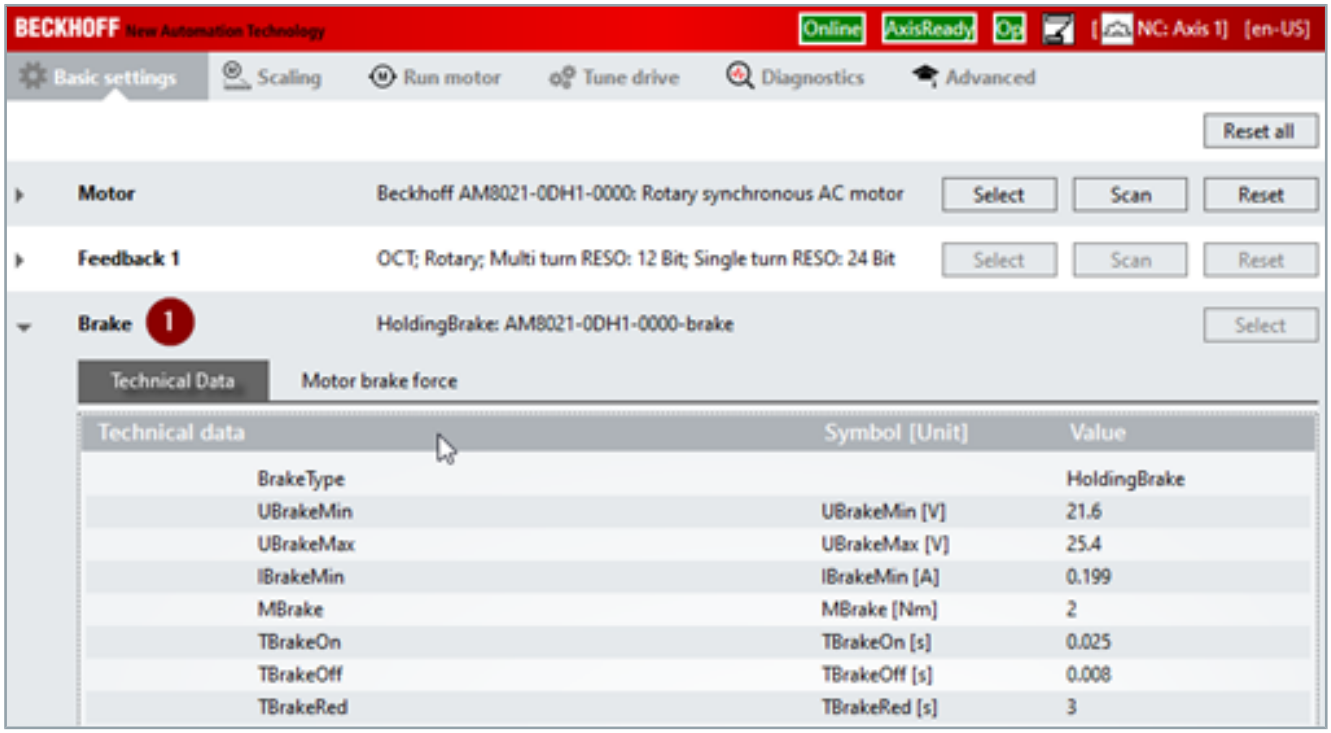
► Confirm settings with "Save NC parameters"

You have successfully sized your mechanical system. Your "NC Feed constant" is 36° per motor revolution.

5 Brake control

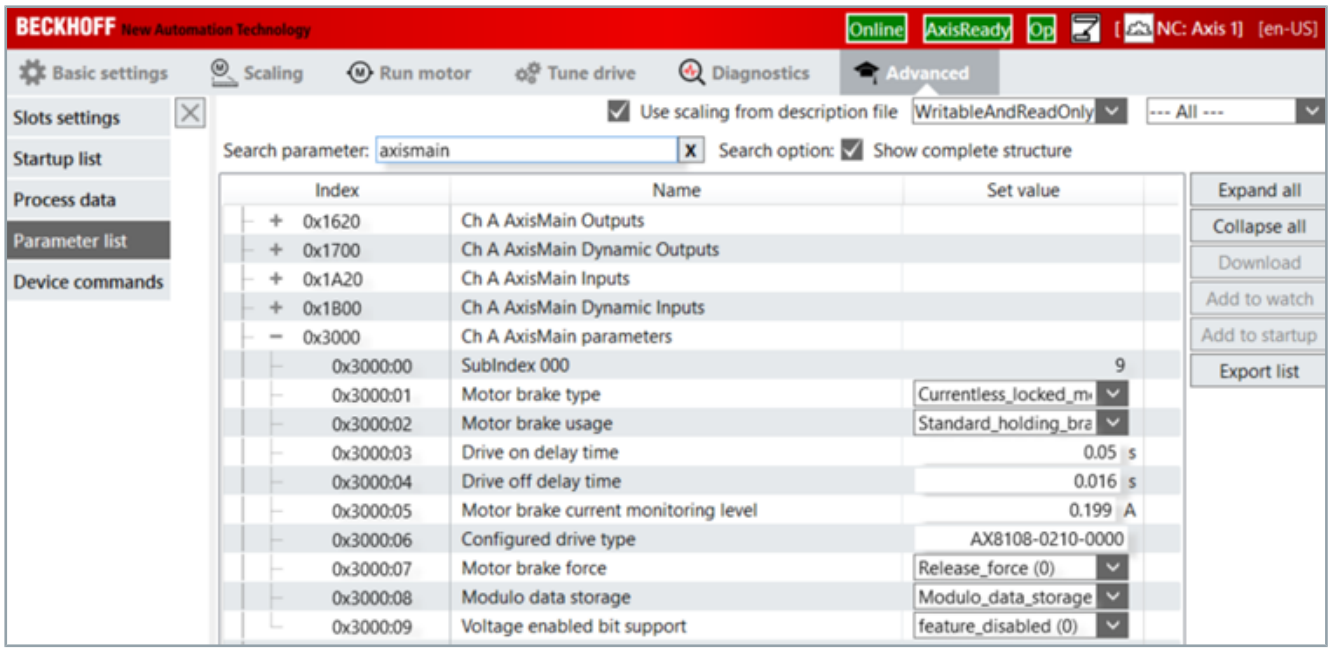
5.1 Function

If your servomotor is equipped with a motor brake, it is controlled via the AX8000 servo drive. The motor brake data for Beckhoff servomotors from the AM8000 series originate from the electronic identification plate. The technical data of the configured motor brake can be viewed in DriveManager 2 via the Brake item (1).



5.2 Configuration

Configuration of the motor brake in the Drive Manager 2 takes place via parameter "AxisMain parameters". The setting options of this parameter are described below.



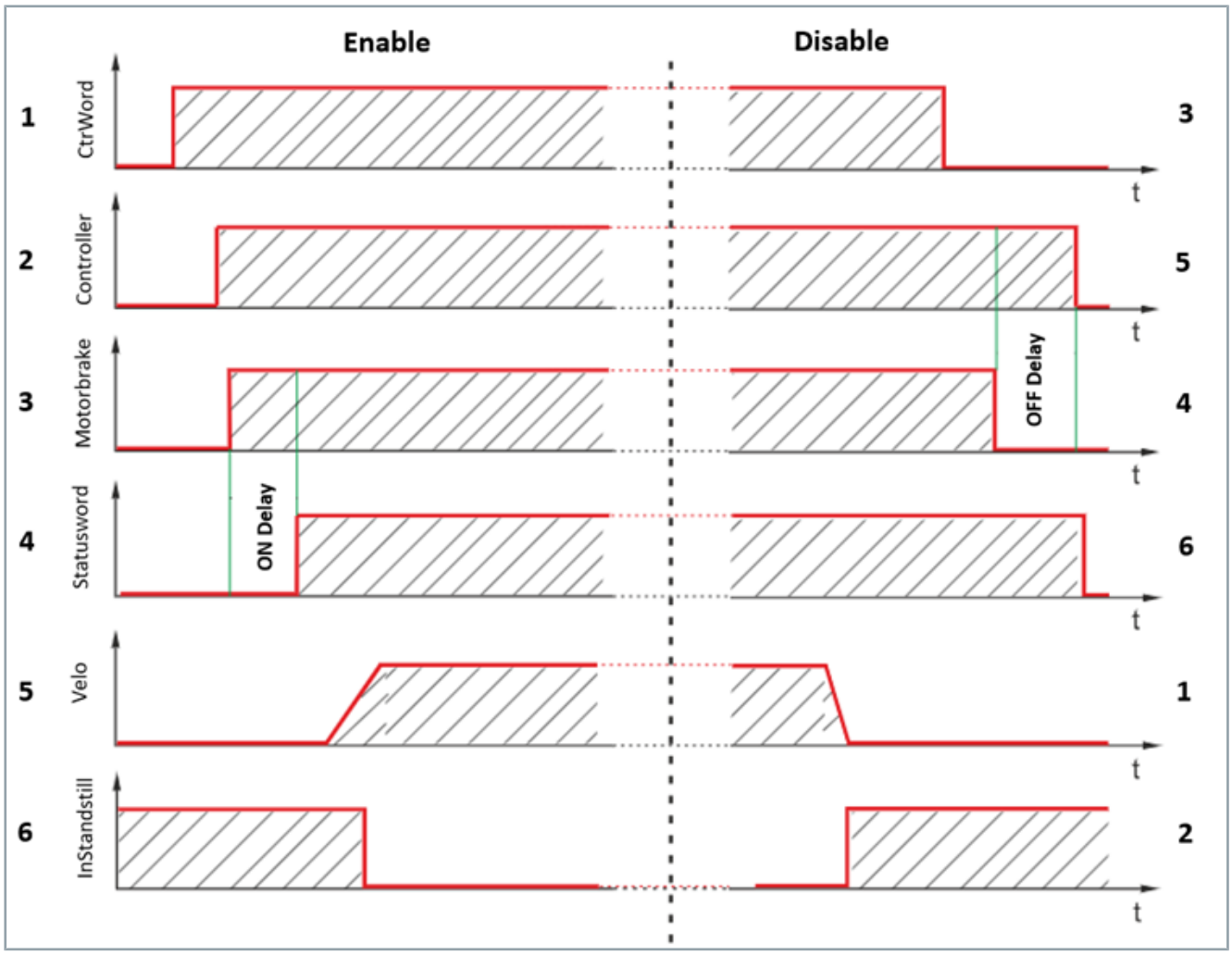
5.3 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

CoE object	Designation	Description
Channel A: 0x3000:01 **Channel B:** 0x3400:01	Motor brake type	Activates drive internal automatic brake control.
Channel A: 0x3000:02 **Channel B:** 0x3400:02	Motor brake usage	Configures the error reaction behavior of the motor brake.
Channel A: 0x3000:03 **Channel B:** 0x3400:03	Drive on delay time	With the transition of the PDS state machine to "operation enabled" "drive on delay time" is started. The drive follows the command values after the "drive on delay time" has elapsed. The motor brake management uses this time to unlock the motor brake before motion is enabled.
Channel A: 0x3000:04 **Channel B:** 0x3400:04	Drive off delay time	After "operation enabled" of the PDS state machine is removed and the axis is in the standstill window, the locking of the brake is initiated and the drive off delay time is started. The torque/force remains activated in the drive until the configured drive off delay time is elapsed. The motor brake management uses this time to lock the motor brake before the torque/force is switched off.
Channel A: 0x3000:05 **Channel B:** 0x3400:05	Motor brake current monitoring level	If the motor brake current remains below the specified threshold, an error is reported. Motor brake current monitoring level is only active if brake control is enabled.
Channel A: 0x3000:07 **Channel B:** 0x3400:07	Motor brake force	Force drive internal brake.

5.4 Flow diagram

The following diagram shows the temporal and functional relationship between the enable signal and opening or disable signal and closing of the motor brake.



5.4.1 Control

In the following, you will find information about the "Enable" and "Disable" processes of the motor brake.

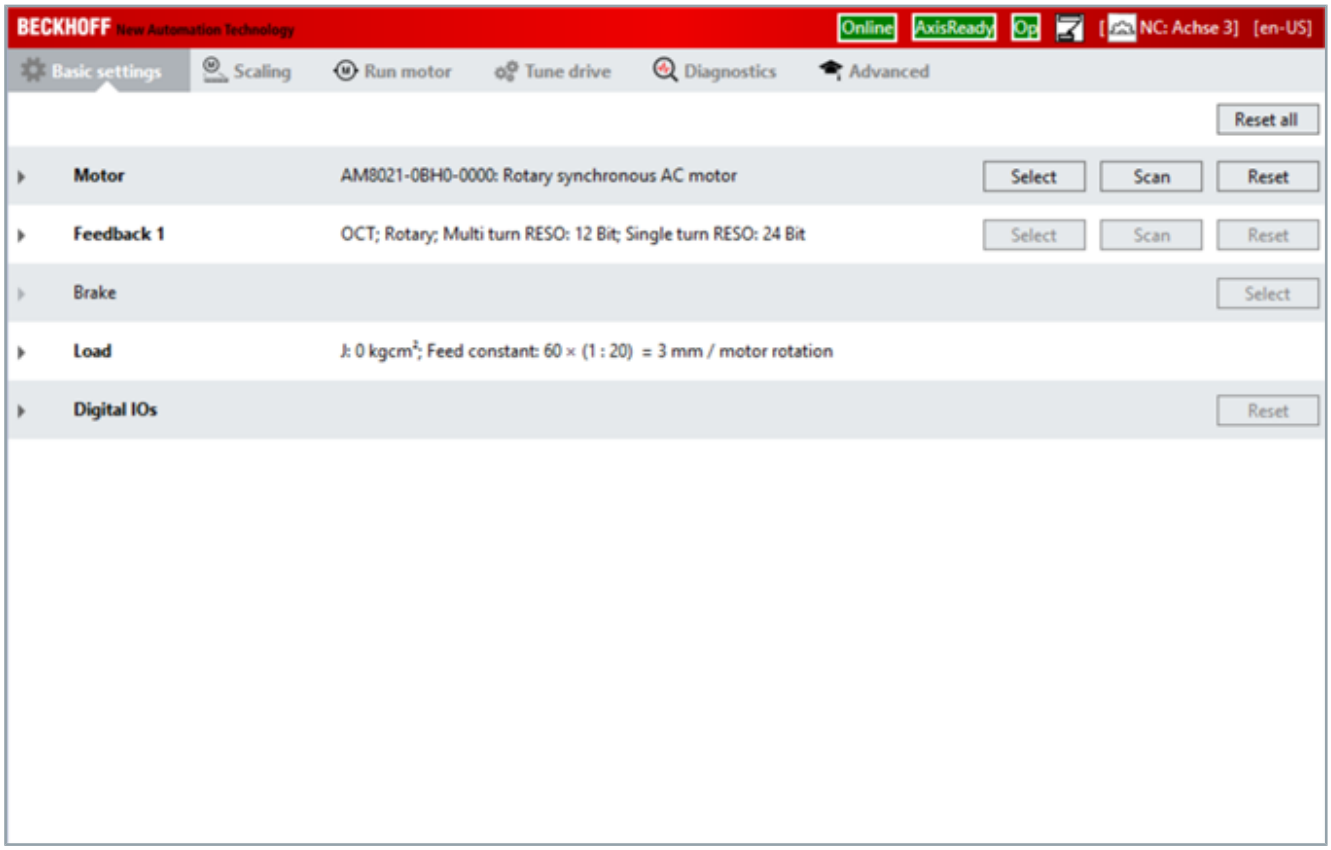
5.4.1.1 Enable / Disable

Position	Enable process	Disable process
1	Triggering of an enable request for the holding brake from the controller NC to the AX8000	The target speed and the actual velocity approach standstill.
2	Activation of the control loop at the AX8000; vtarget = 0	The servo drive detects the standstill of the axis with the aid of the standstill window.
3	Control of the brake output on the AX8000	The controller NC disables the axis. It is controlled with it v_{target} = 0. The axis no longer follows the setpoints of the NC
4	After the "Drive on delay time" has elapsed, the AX8000 follows the setpoints of the NC	The brake output for the motor brake is now disabled.
5	The NC specifies a travel profile to the AX8000	When the "Drive off delay time" has elapsed, the controller in the AX8000 is disabled.
6	The standstill flag changes its status from 1 to 0, since the axis is now in motion	The drive control is now fully disabled.

6 Digital inputs

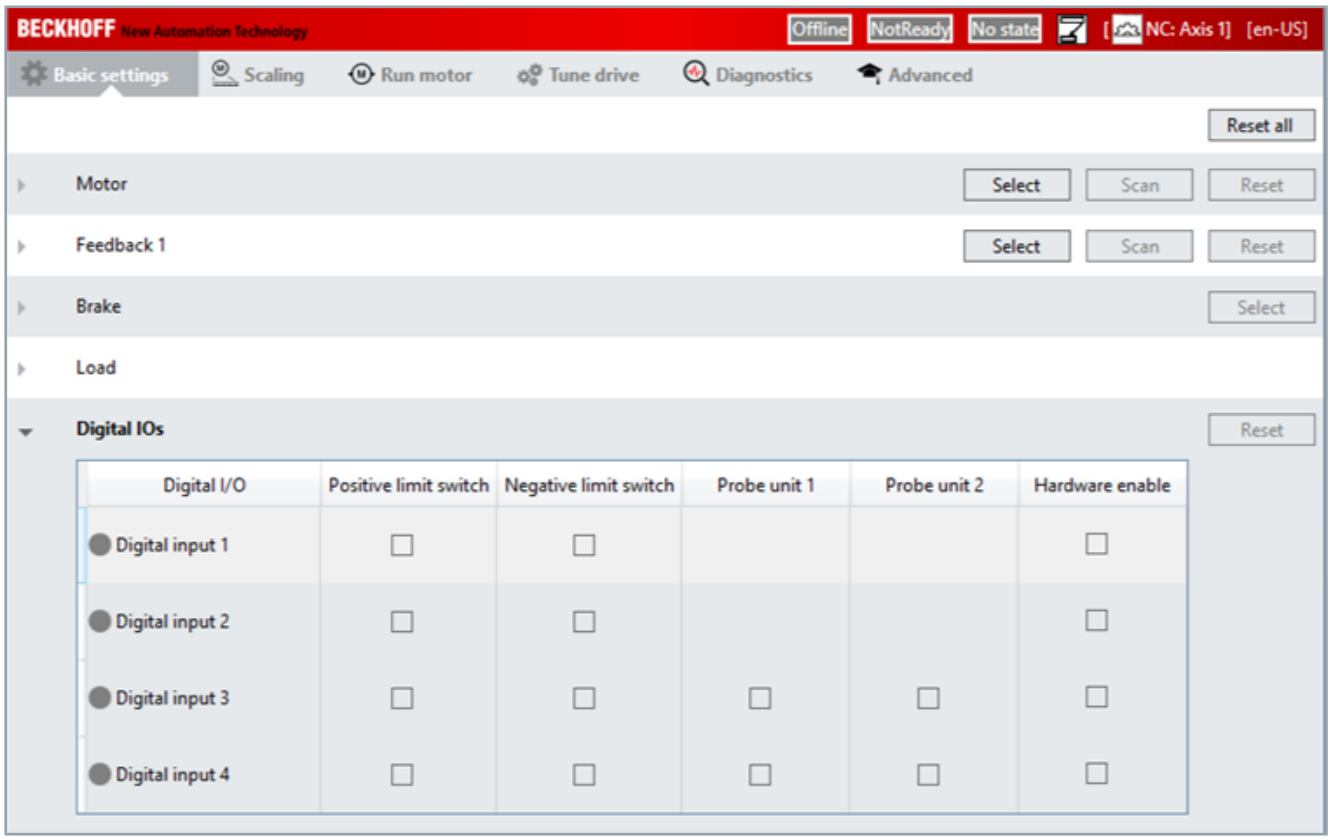
6.1 Configuration

The digital inputs can be configured differently via the TC3 Drive Manager 2. The lower part of the "Basic settings" tab contains the selection menu for the digital inputs.

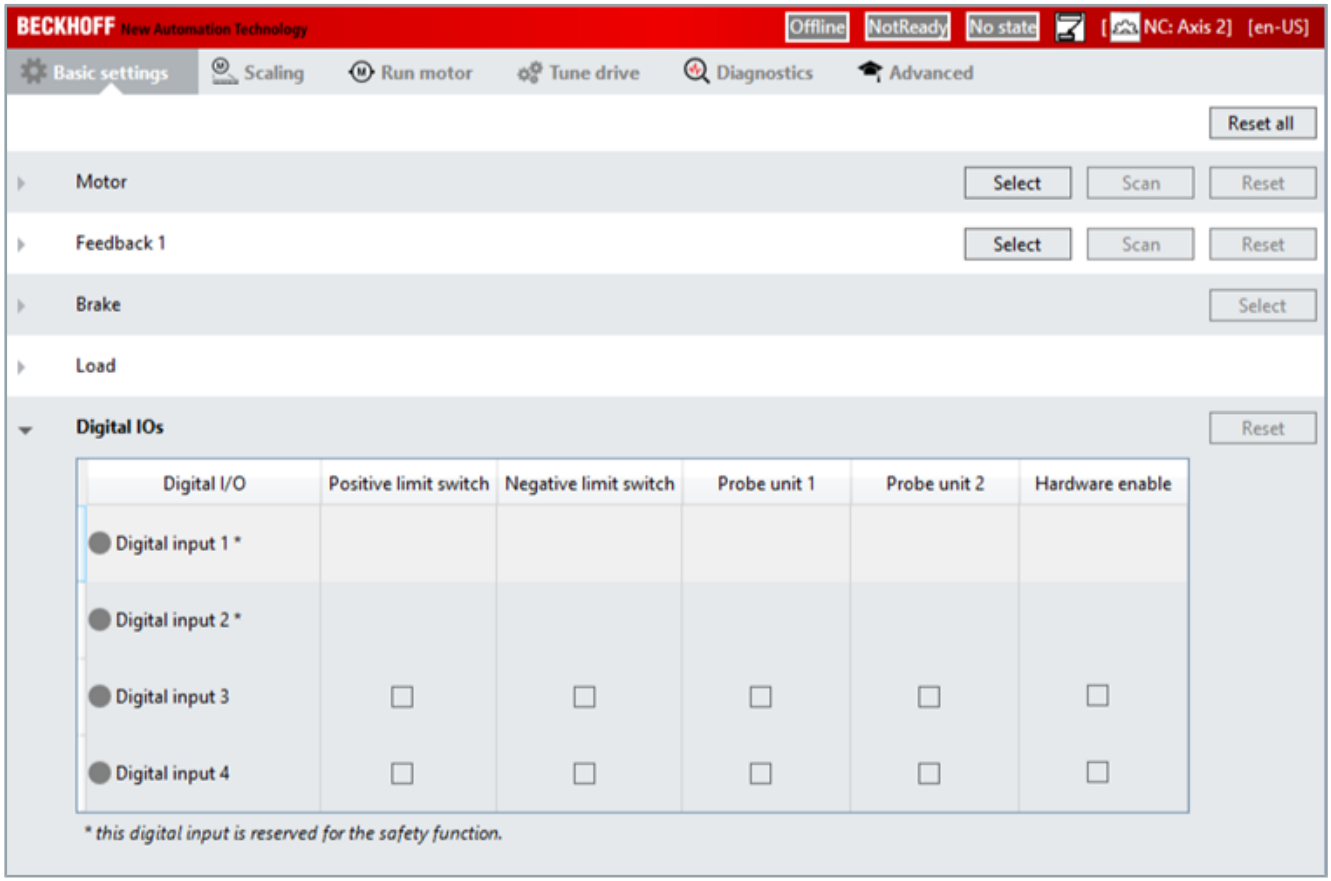


The selection menu may differ depending on the AX8000 device (AX8xxx-x0xx, AX8xxx-x1xx, AX8xxx-x2xx). For devices with safety functionality, the top two inputs are preset as safe inputs and cannot be used for other functions (limit switch, touch probe, hardware enable).

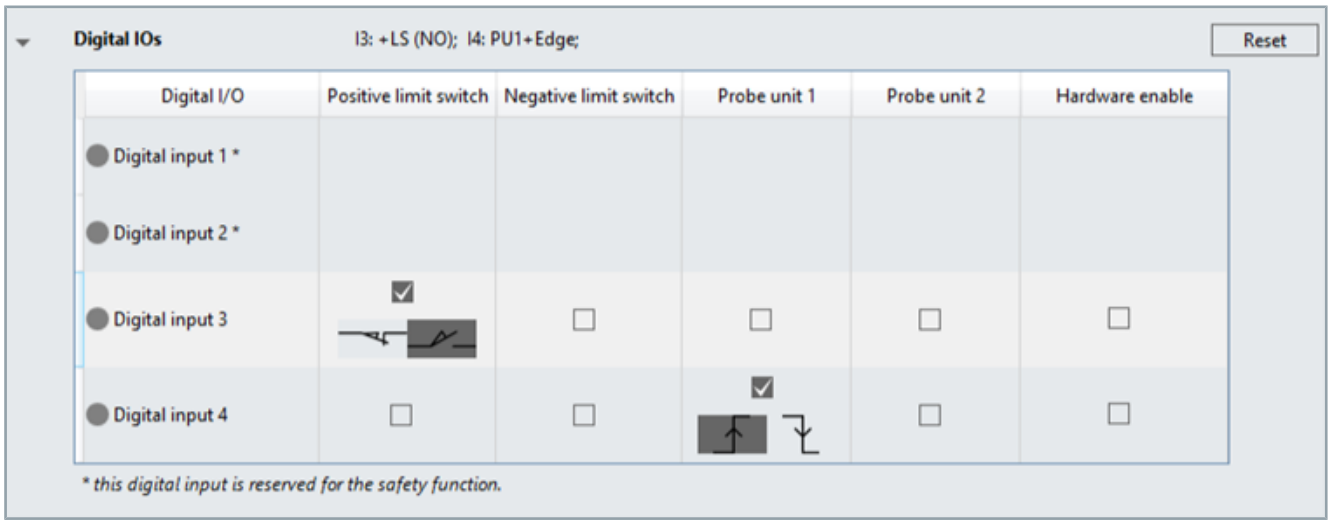
AX8xxx-x0xx Device without Safety / Digital input 1 and 2 can be used additionally



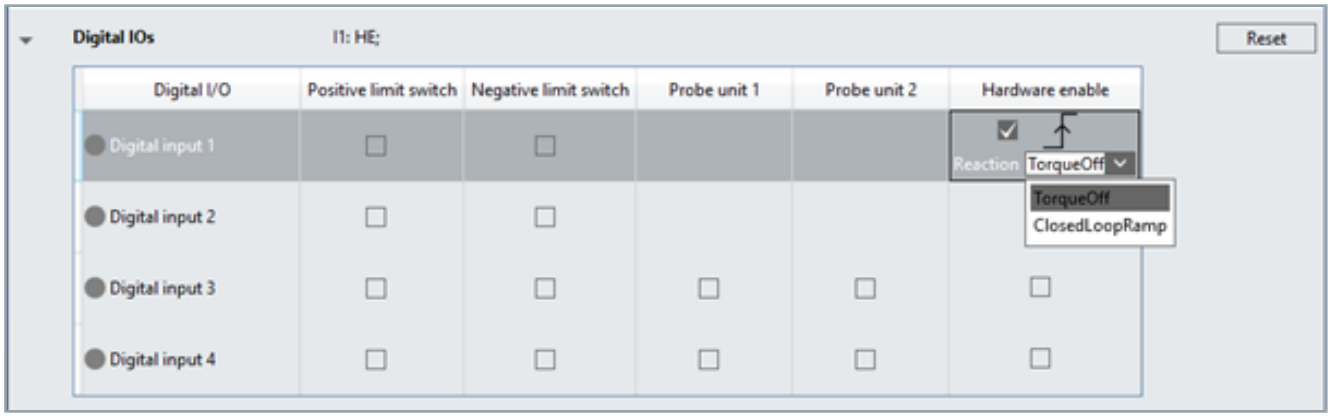
AX8xxx-x2xx device with Safety / Digital input 1 and 2 are preassigned Safety inputs



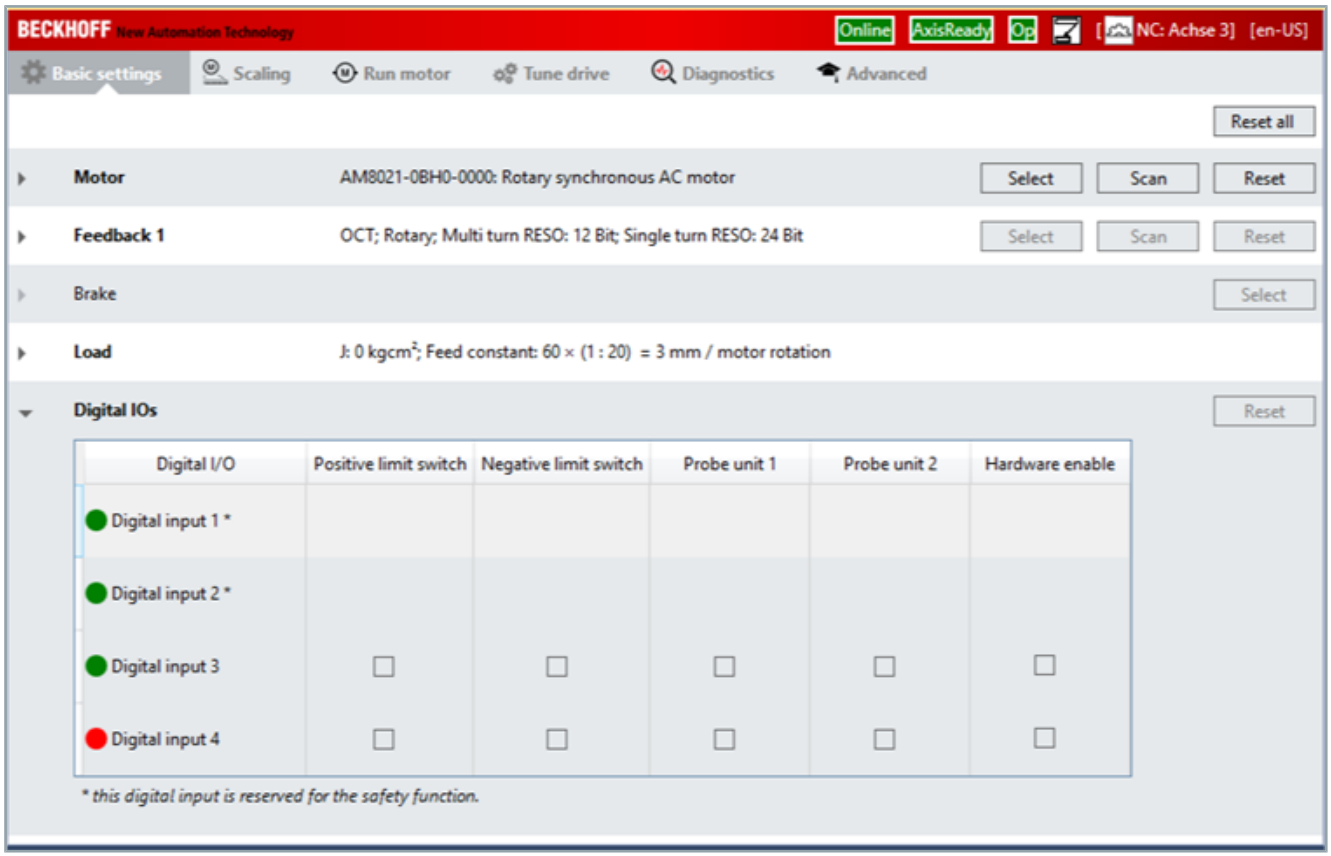
The activation of the functions is done by checking the appropriate box. In the following picture, for example, a positive limit switch and a touch probe. The logic of the switch can be changed by selecting the buttons below the tick. (normally closed contact / normally open contact)



If you use an input as hardware enable you have the choice between the reaction "Torque off" or "Closed Loop Ramp".



The state of the inputs is indicated online by the red (level low) or green (level high) button.

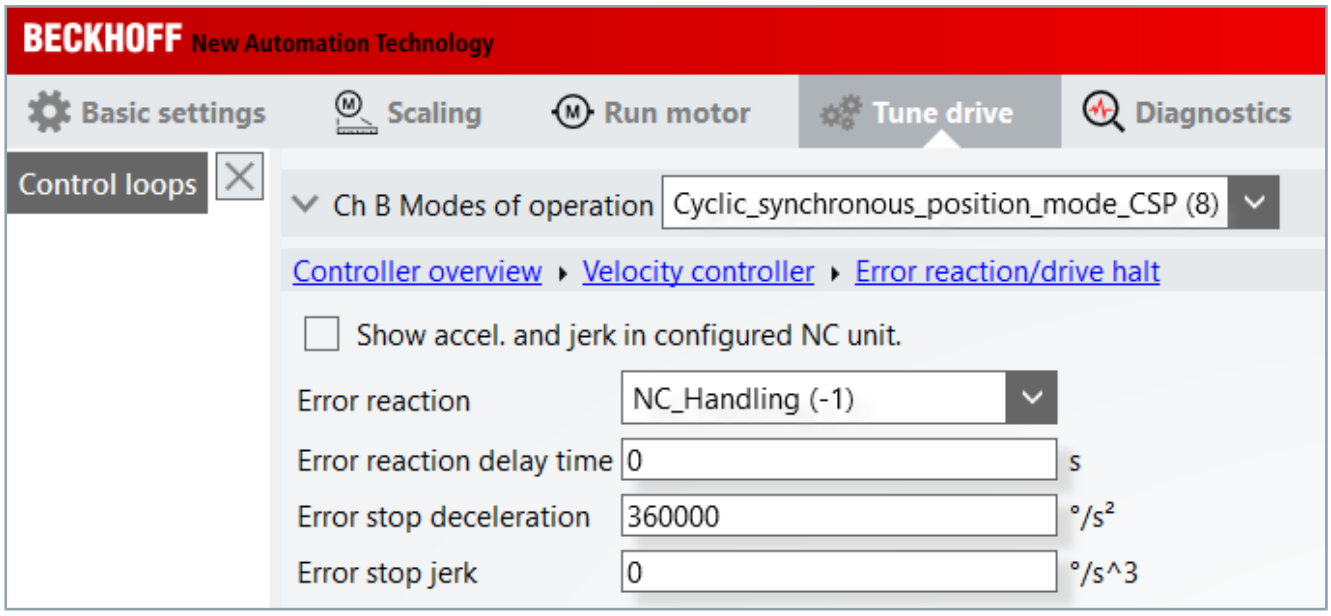


7 Error reaction

7.1 Function

The configuration "Error reaction / drive halt" can be set in Drive Manager 2 in the velocity controller. The default value is a controlled stop ramp with a delay of 1000 revolutions/s². This value is related to the motor shaft.

If the checkbox “Show accel. and jerk in configured NC unit” is activated, the deceleration is displayed in the NC unit.



7.2 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

CoE object	Designation	Description
Channel A: 0x605E **Channel B:** 0x685E	Fault reaction option code	This object shall indicate which action is performed when fault is detected in the PDS.
Channel A: 0x3004:01 **Channel B:** 0x3404:01	Error reaction delay time	This object shall indicate the delay time if an error reaction is performed in the PDS.
Channel A: 0x6085 **Channel B:** 0x6885	Quick stop deceleration	This object shall indicate the configured deceleration used to stop the motor with fault reaction slow down ramp.
Channel A: 0x3142:02 **Channel B:** 0x3542:02	Quick stop jerk	This object shall indicate the configured jerk used to stop the motor with fault reaction slow down ramp. If the value is zero, the jerk is infinite.

8 Commutation

8.1 Function

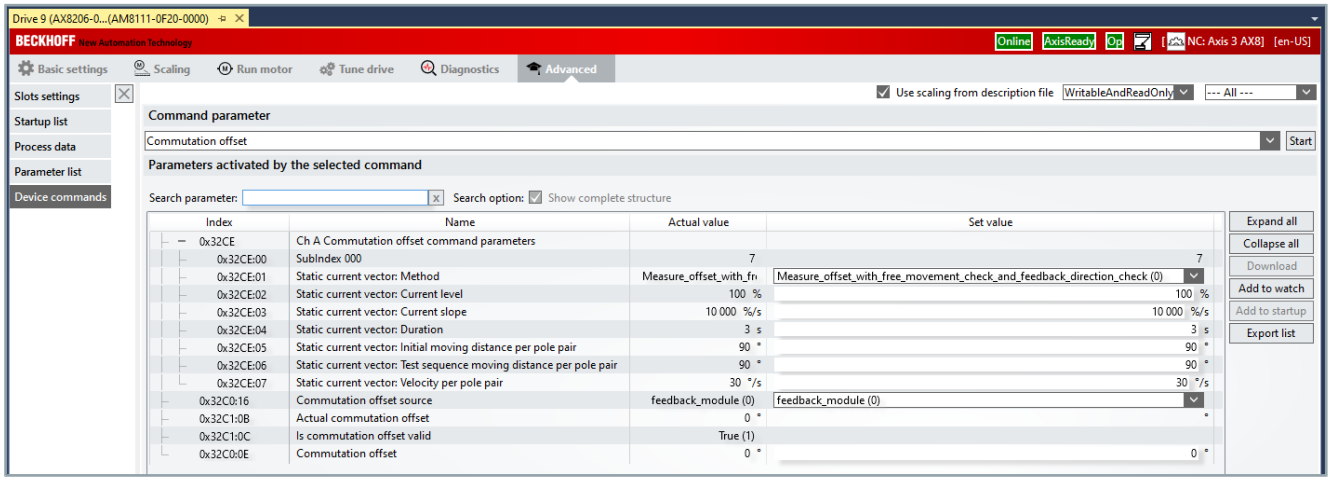
The drive function "Commutation Offset" can determine the commutation offset between encoder and rotor, which can then be used to energize a motor. Most control methods for PM-SM with encoder require the use of a correct commutation offset.

System prerequisites for the function
You have the option to use the "Commutation Offset" in the current implementation starting with firmware v1.03 b0001.

8.2 Configuration

⚠ WARNING

Checking parameters and settings
Make sure that the motor can move freely and that there are no people near the axis. The motor performs a movement when the command is executed. If the axis is loaded and its freedom of movement is restricted, this can have a negative effect on the result.
Non-observance can lead to serious or even fatal injuries during operation.



► Double-click on the channel of an AX8000 for which the commutation angle is to be determined.

The DM2 opens.

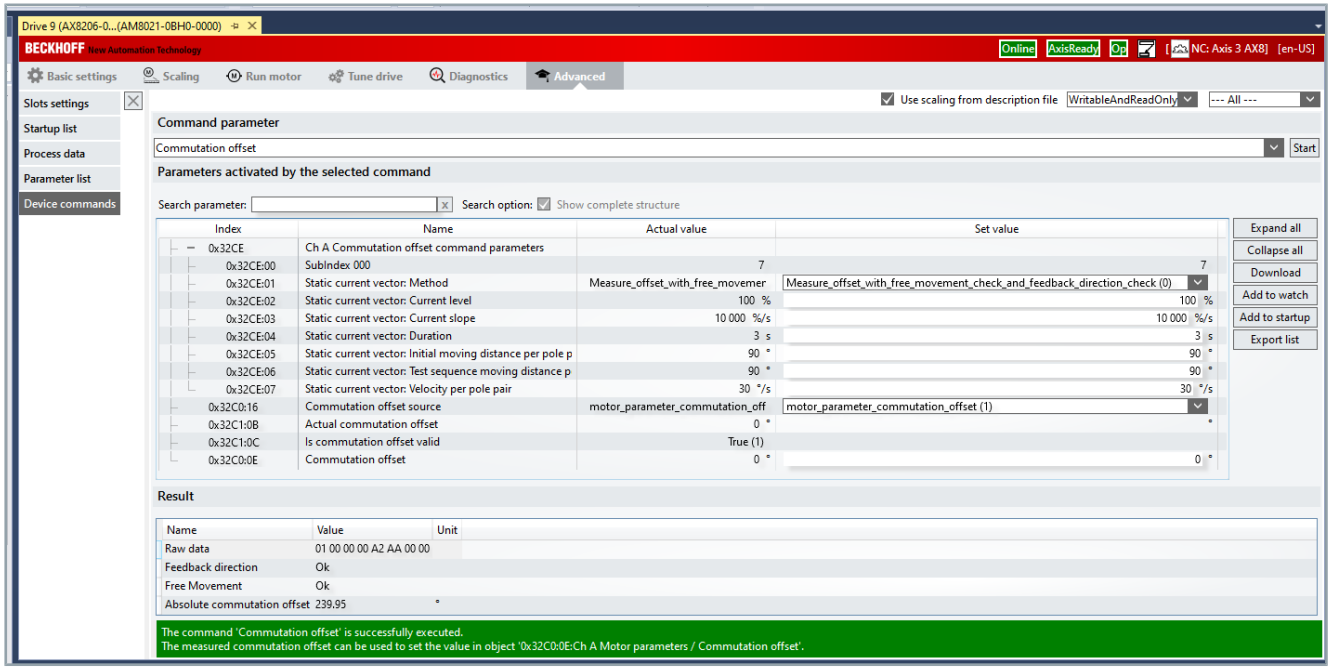
► Switch to the "Advanced" tab and click on "Device commands" on the left.

► Select the command "Commutation Offset".

As a rule, the standard settings can be used.

► Now click on "Start" to start the commutation determination.

► Confirm the warning accordingly. The command is executed and the motor moves.



As soon as the command is terminated, the results are displayed at the bottom of the DM2. In the above case, the motor could move freely (mandatory for the command), the sense of rotation of the encoder matches the sense of rotation of the rotary field in the stator and an absolute offset of 239.95° was determined.

This offset was determined independently of the currently parameterized offset and can therefore be adopted directly under 0x32C0:0E.

► Set 0x32C0:16 Commutation Offset source to “motor_Parameter_Commutation_offset (1)” so that the entered offset is used.

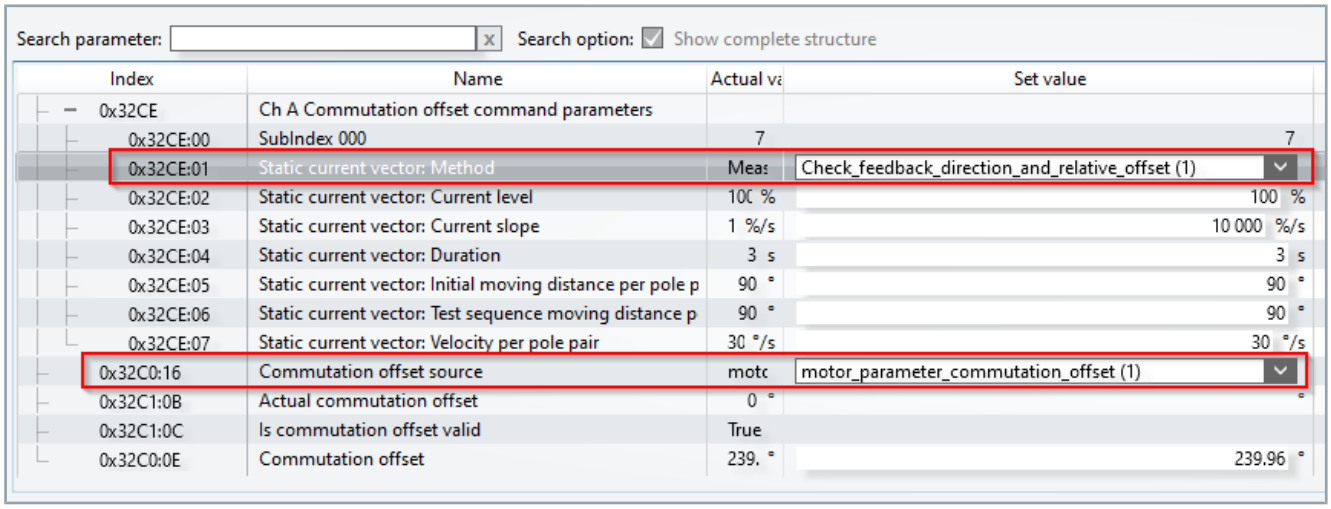
If the Solution is now activated, the changes are permanently adopted and the motor can be operated.

8.2.1 Final control

After activating the configuration we advise a final check of the commutation offset.

To do this, go to the "Commutation Offset" command as described above.

► Select the parameters as shown below (for 0X32C0:0E use the value you have determined before).



The setting "Check_Feedback_direction_and_realative_offset (1)" determines the commutation offset relative to the currently parameterized offset.

The result thus indicates how large the deviation is after all settings. Since the measurement can have different tolerances depending on the system and a small misalignment can be tolerated, a deviation of +-10° is considered acceptable. This range spans around the 360°/0° point, resulting in a good range of 350°-359.9° and 0°-10°. In most applications, the relative offset will be considerably less.

8.3 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

CoE object	Designation	Description
0x32CE	Commutation offset command parameters	This object contains parameters for commutation offset command.
0x32CE:01	Static current vector: method	This object configures the static current vector method.
0x32CE:02	Static current vector: Current level	This object configures the static current vector current level in percent based on the motor standstill current (0x6075).
0x32CE:03	Static current vector: Current slope	This object configures the static current vector current slope in percent per ms based on the motor standstill current (0x6075).
0x32CE:04	32CE:04 Static current vector: Duration	This object configures the time the constant current vector is applied before the commutation offset is calculated.
0x32CE:05	Static current vector: Initial moving distance per pole pair	This object configures the static current vector moving distance per pole pair before commutation offset calibration.
0x32CE:06	Static current vector: Test sequence moving distance per pole pair	This object configures the static current vector moving distance per pole pair for the test movement.
0x32CE:07	Static current vector: Velocity per pole pair	This object configures the static current vector velocity per pole pair for the test movement.
0x32C00:16	Commutation offset source	This object configures the memory source of the "Offset position actual value".
0x32C1:0B	Actual commutation offset	This object displays the actual motor commutation offset. Beckhoff motors use the default value (0°).
0x32C1:0C	Is commutation offset valid	This object displays if the actual motor commutation offset is valid.
0x32C1:0E	Commutation offset	This object configures the motor commutation offset. Beckhoff motors use the default value (0°).

9 Load

9.1 Function

The "Load" function is used in this area to configure the load, i.e. everything that is connected to the motor shaft.

A distinction is made between:

- "Linear" applications and
- "Rotary" applications.

Linear applications are for example: belt, spindle, pinion/rack and linear motor.

Rotary applications are for example: rotary table, swivel arm and fan.

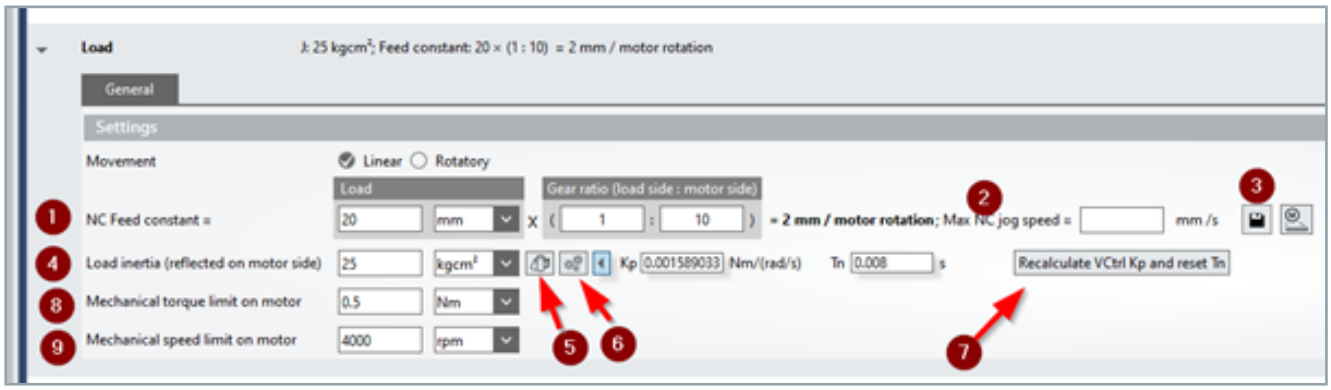
9.2 Configuration

The "NC Feed constant" [1] is required to define the scaling between drive and logical axis NC-/NC-I. It indicates how much stroke is generated by one motor revolution and is therefore dependent on the mechanics which are attached to the motor or gear shaft.

In the following screenshot a spindle with 20 mm pitch and a gear with a speed increasing ratio of 10 is configured. The "NC Feed constant" therefore amounts to 2mm/motor rotation.

In addition, the "Max NC jog speed" [2] of the NC can be limited for a linear application.

If you click on the floppy disk symbol [3], the "NC Feed constant" [1], the "Drive rotational position resolution" and the "Max NC jog speed" are transferred to the NC. The scaling is now complete.



"Load Inertia (reflected on motor side)" [4], represents the mass inertia acting on the motor shaft. The value is included in the control and improves the axis behavior. "Calculate Load Inertia Manually" [5] supports you in calculating the effective mass inertia. Via the button "Identify load inertia automatically. Go to „tune drive – Advanced Tuning" for details." [6] will take you to the Advanced Tuning function.

If the value at [4] has been changed, the button "Recalculate VCtrl Kp and reset Tn" [7] appears. If this is clicked, Kp and Tn are calculated including the new value.

To protect connected gear units or mechanics from overload, the following two values can be limited:

- "Mechanical torque limit on motor" [8] = max. torque on the motor shaft.
- "Mechanical speed on motor" [9] = max. speed at the motor shaft.

9.3 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

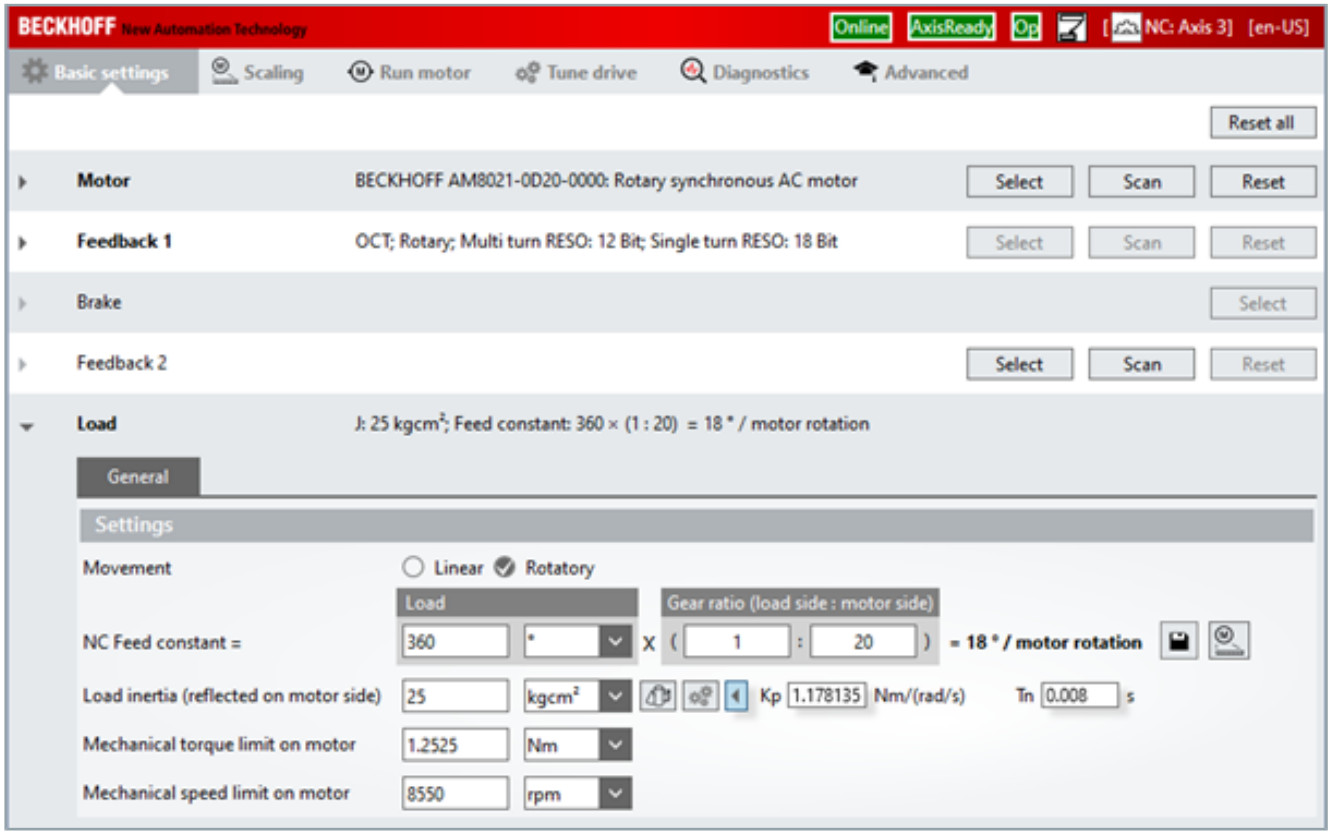
CoE object	Designation	Description
0x3140:07	Load inertia/mass	This object is to configure the inertia of the application or load.
0x6072	Ch A Bipolar Torque/Force Limit Value	This object indicates the configured maximum bipolar permissible torque/force in the motor. The value shall be given per thousand of standstill motor torque/force (0x6076).
0x3140:03	Bipolar velocity Limit Value	In this object you can configure the maximum velocity of this axis.
0x3140:01	Velocity control proportional gain	This object contains the proportional gain of the velocity controller.
0x3140:02	Velocity control integral action time	This object contains the integral action time of the velocity controller.

9.4 Examples

In the following you will get different examples for the configuration of the load.

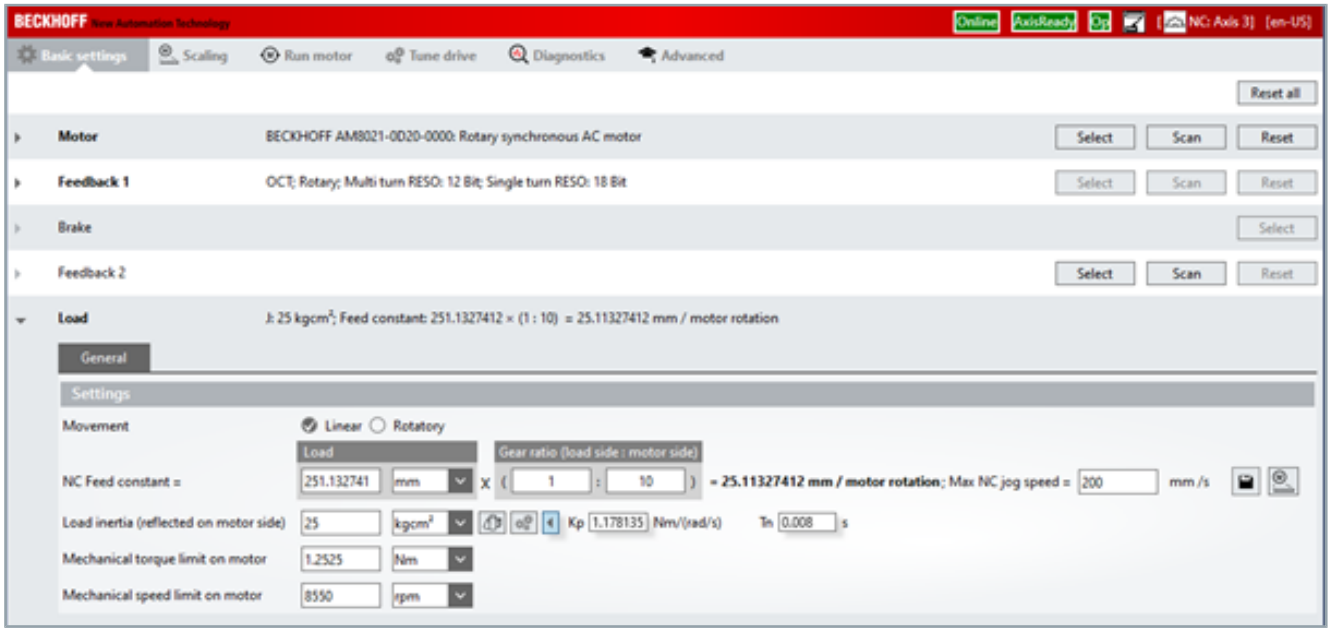
9.4.1 Rotary table

Here, a rotary table and a gear unit with a ratio of i = 20 have been configured.



9.4.2 Belt drive

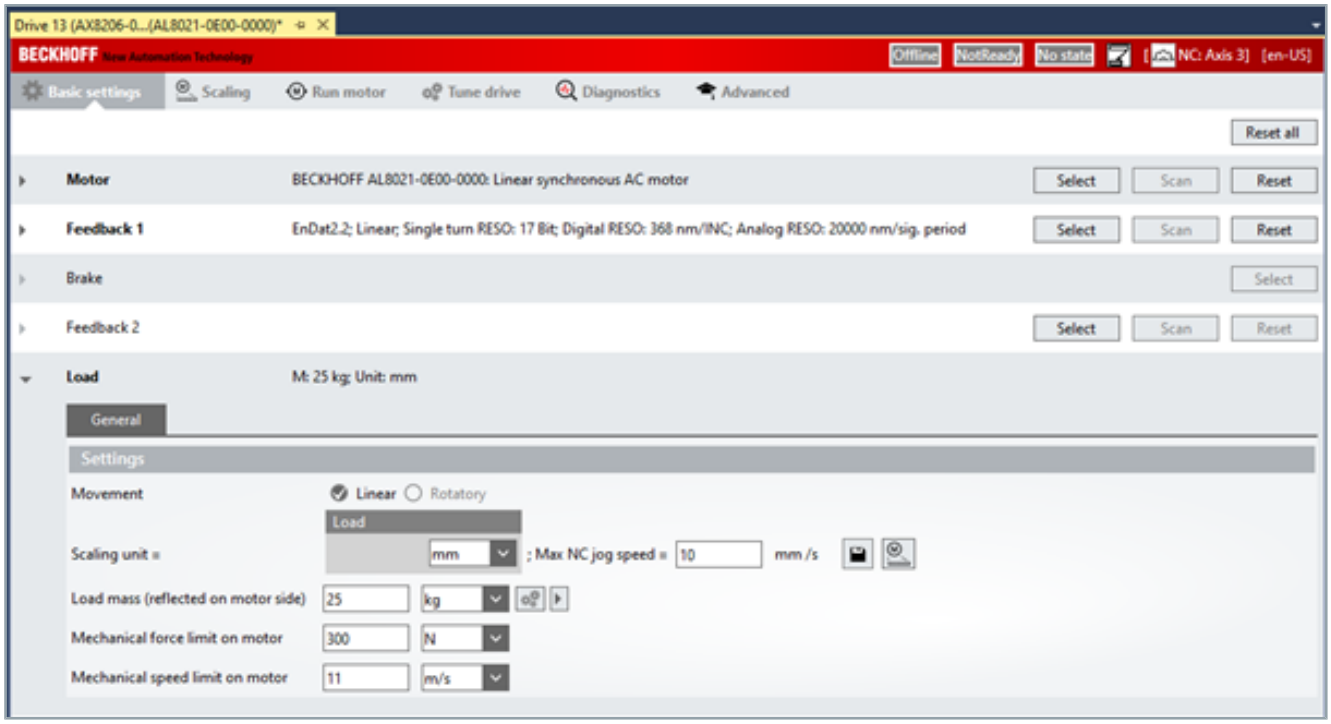
Here, a belt drive and a gear unit with a speed reducing ratio of i = 10 have been configured. The drive pinion has a diameter of 80 mm. The NC feed constant results as follows: 80 mm * Pi / 10 = 25.132 mm.



9.4.3 Linear motor

A linear motor is a direct drive. So there is no additional transformation by mechanics. Therefore the DM2 takes the pole pitch of the motor from the motor data set as "NC Feed constant".

Note that the units for a linear motor are changed to kg, N and m/s accordingly.



10 Modulo

10.1 Function

After start-up, the AX8000 axis module reports the current position to the higher-level controller. An encoder overflow which occures while using the axis, can be handled by the NC. If the system is restarted, however, an unintentional position jump can then occur, since the position is reconstructed from the encoder position.

The modulo function handles this by cyclically storing values in the servo drive. This enables the drive to restore the axis position including the overflow of the encoder. The function can also be applied to prime ratios.

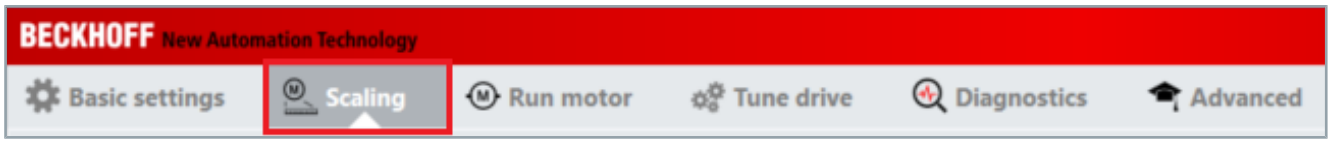
Information on the Modulo function
If the ratio corresponds to a value of 2^n, the Modulo function is not required. In this case the maximum encoder value is an integer multiple of the maximum application value. This means that no position offset occurs during startup.

10.2 Requirements

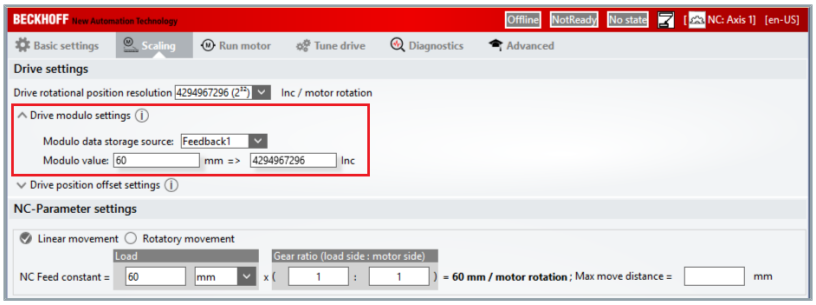
Availability and feedback
The Modulo function is available as of axis module firmware v1.02 b0005.
A servomotor with multi-turn encoder is required.

10.3 Configuration

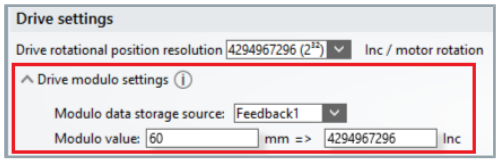
To do this, select the "Scaling" menu in the selection area of the TC3 Drive Manager 2.



A new "Drive Settings" selection area opens.



Activate function



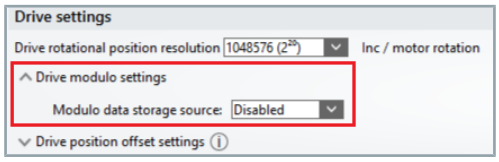
► Select the "Modulo data storage source"

Observe the setting options:

Selection	Setting
Feedback 1	Memory source connected feedback 1
Disabled	Disable function

► Set modulo range "Modulo value

Disable function



► Set "Modulo data storage source" to "Disabled"

10.4 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

With two-channel devices, the Modulo function can be used independently on both channels. The objects of channel B are provided with an offset.

CoE object	Name	Description
Channel A 0x607B **Channel B** 0x687B	Position range limit	This object shall indicate the configured maximal and minimal position range limits. It shall limit the numerical range of the input value.
Channel A 0x3000:08 **Channel B** 0x3400:08	Modulo Data storage	Store modulo remainder cyclic and powersafe.
Channel A 0x6091 **Channel B** 0x6891	Gear ratio	This object shall indicate the configured number of motor shaft revolutions and number of driving shaft revolutions.

10.5 Operation modes

10.5.1 Operation with modulo

When the Modulo function is active, data sets are stored and read out. This allows the modulo position to be reconstructed. The range of the encoder is subdivided into four equal ranges. A quarter range comprises 1024 revolutions.

Saving the data sets

Data for the reconstruction of the modulo position is stored:

- At each change from one 1024 revolution to the next 1024 revolution
- With each change of the EtherCAT state from SaveOP to PreOp

Reading out the data sets

If the EtherCAT state changes from Boot to Init, the data is read out.

10.5.1.1 Maximum velocity

You can calculate the maximum speed at which the modulo values are still stored using the following parameters and formula:

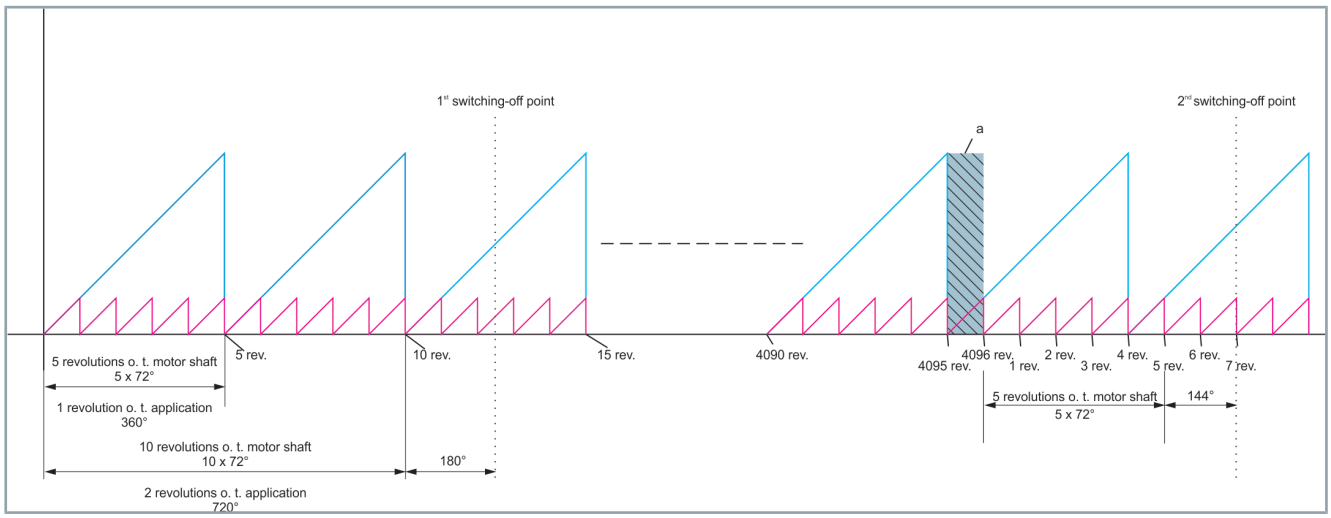
- Cycle time of the NC [t_{NC}]
- Gearing factor [i]
- Modulo Value [Modulo $value_{load}$]. The Modulo Value corresponds to the Feed Constant and can be taken from Drive Manager 2.

$$v_{max,motor} = \frac{1}{4} \cdot \frac{Modulo\ value_{load}}{t_{NC}} \cdot i$$

10.5.2 Operation without modulo

Application with gear unit and encoder
In the following an encoder with 4096 revolutions and a gear unit with a ratio of 1:5 is shown.

If the maximum encoder position at 4096 revolutions is exceeded, the encoder begins to count from zero again. The encoder position can no longer be used to detect that 4096 revolutions have already been made.



Switch-off point 1

The first switch-off point is at 12.5 motor revolutions or 2 application revolutions + 180°. The encoder provides the value correctly after the machine is switched on again.

Switch-off point 2

The second switch-off point is at 4103 motor revolutions or 820 application revolutions + 216°. Due to the overflow, the encoder has not taken the revolution in range [a] into account. It shows seven motor revolutions, but only one application revolution + 144°. One motor revolution is missing, which corresponds to 72° of the application.

Determine axis position

To determine the correct axis position, the overflows or the resulting position offset must be stored.

11 Oversampling

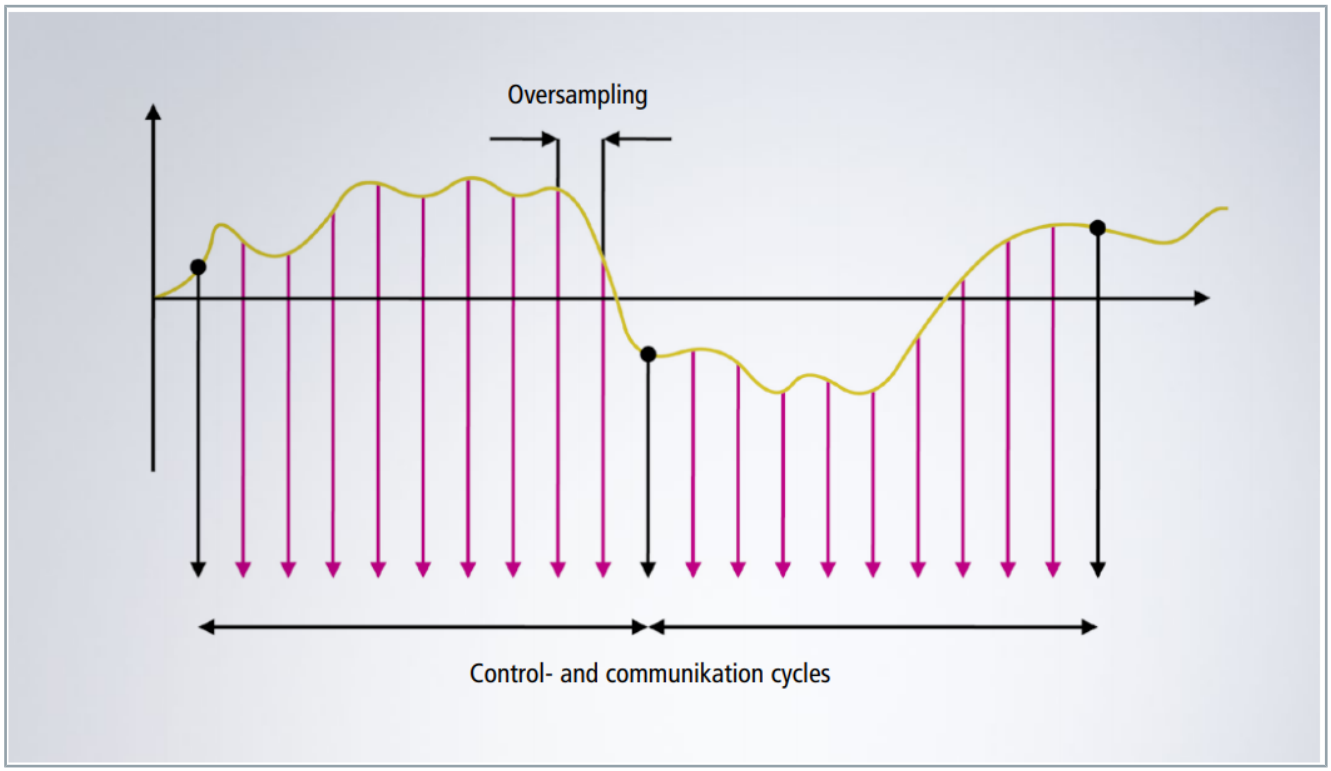
11.1 Function

Process data are usually transferred exactly once per communication cycle. Conversely, the temporal resolution of a process data directly depends on the communication cycle time. Higher temporal resolution is only possible through a reduction in cycle time - with associated practical limits.

Oversampling enables the multiple sampling of a process data within a communication cycle and the subsequent (inputs) or previous (outputs) transfer of all data in an array. The oversampling factor describes the number of samples within a communication cycle and is therefore a multiple of one.

Triggering of the sampling within the I/O components is controlled by the local clock (or the global system time), which enables associated temporal relationships between distributed signals across the whole network.

System requirements for the function
You have the possibility to use the oversampling on axis modules from the AX8xxx series with firmware version 1.03 or newer. The function can be used on the device and on the channel.



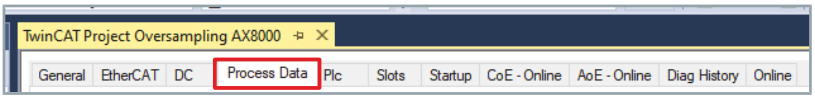
11.2 Configuration

You have the possibility to configure variables several times in one PDO in order to use the oversampling.

A general explanation of PDOs and the ProcessData tab can be found here.

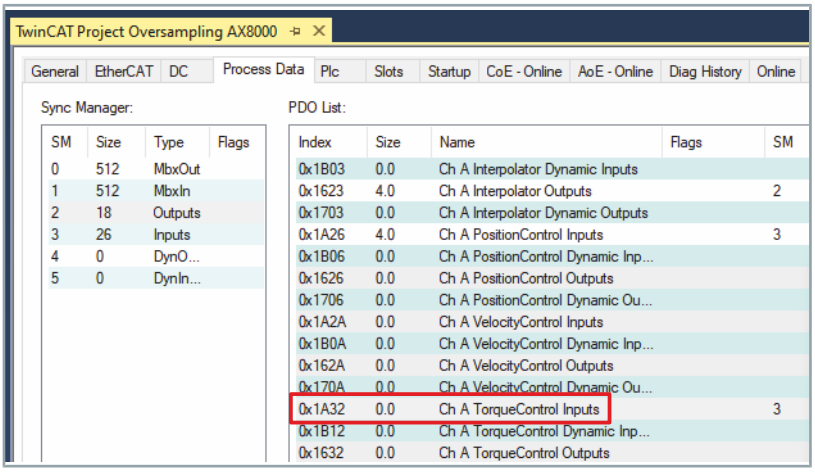
Proceed as follows to use the oversampling:

► Selecting the required axis module in the I/O tree



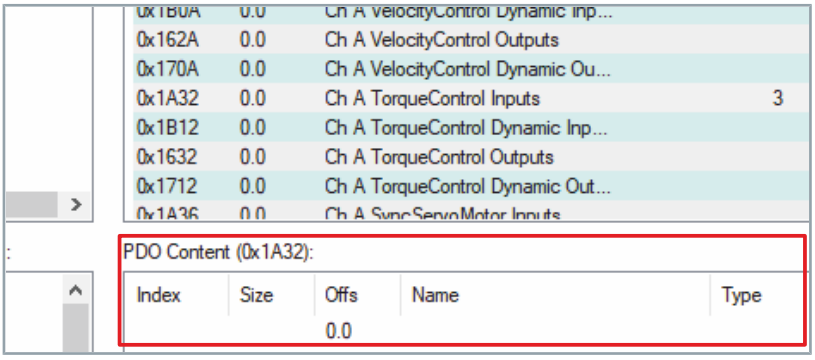
► Left-click "Process Data"

The dialog box "Process Data" opens



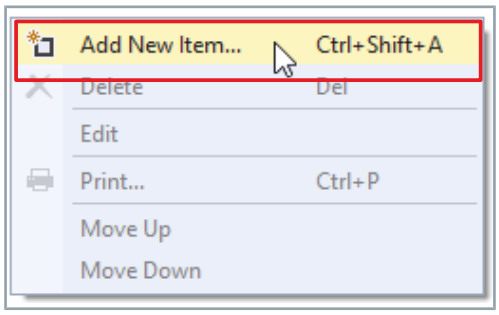
► Select "0x1A32 ChA Torque Control Inputs"

The currently configured PDOs can be found in the dialog box "PDO Content" below the "PDO List". These are part of the previously selected PDO.



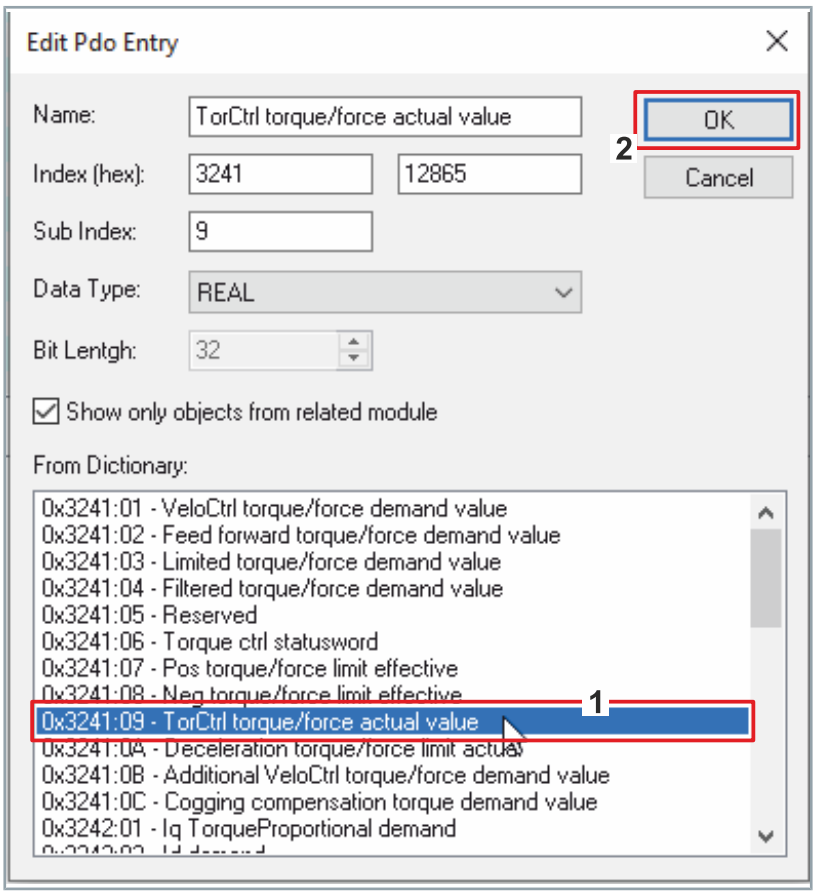
► Right-click "PDO Content"

A new dialog box opens.



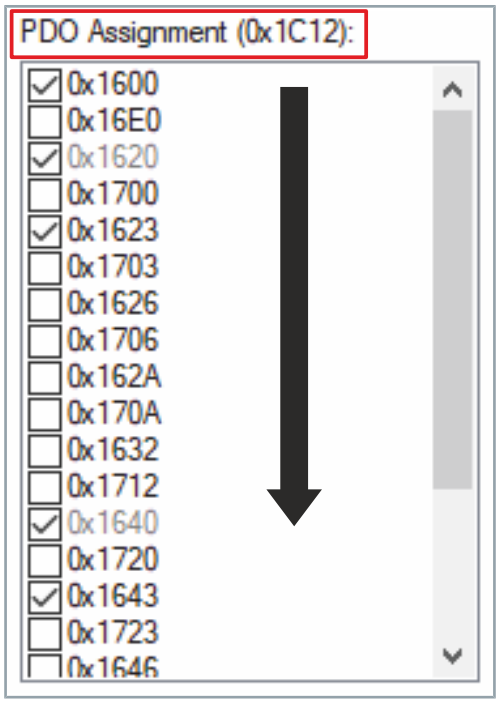
► Left-click "Add New Item"

A new dialog box "Edit PDO Entry" opens



► Select "0x3241:09 TorCtrl Torque/Force actual value" [1]

► Confirm with "OK" [2]



► In the "PDO Assignment", check whether the checkbox for the PDO "0x1A32" is active

If the checkbox is not active, the PDOs in the process image are not ready:

► Activate the TwinCAT configuration in order to accept changes

Repeat the above actions in order to add further PDOs to the process image. The oversampling is now active for all PDOs that exist multiple times in the process image.

The oversampled variables must directly follow each other in the configuration. No other variable may be inserted.

11.3 Oversampling factor

Oversampling enables the multiple sampling of a process data within a communication cycle. The oversampling factor describes the number of samples within a communication cycle and is therefore a multiple of one.

The AX8000 has an internal cycle time of 62.5 µs. A process data can´t be updated faster than that.

11.3.1 Maximum oversampling

The highest oversampling factor results from:

- Cycle time of the AX8000
- Cycle time of the task to be synchronized; e.g. the NC task SAF

Calculation
max_over_factor = cycle time of sync task / cycle time AX8000
= cycle time of sync task / 62.5 µs

11.3.2 Possible values of the oversampling factor

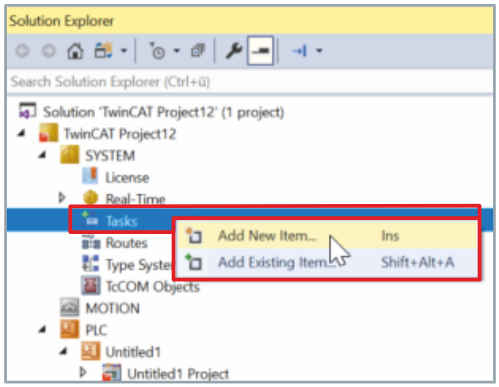
If the oversampling is to be implemented with less than the maximum oversampling factor, the number of samples cannot be selected arbitrarily. Otherwise, the values would not match the timing of the controller cycle time.

Calculation
possible_over_factor = max_over_factor / 2^n

Note that the oversampling function does not work if a PDO is only transferred once per cycle. Select an appropriate value for "n".

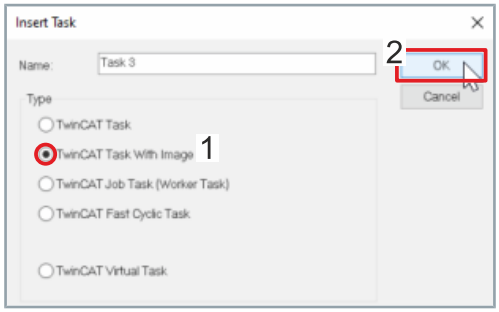
11.4 PLC integration

The values transferred by oversampling can be used in the higher-level controller or generated there. An array can be used to group several process data together for this.

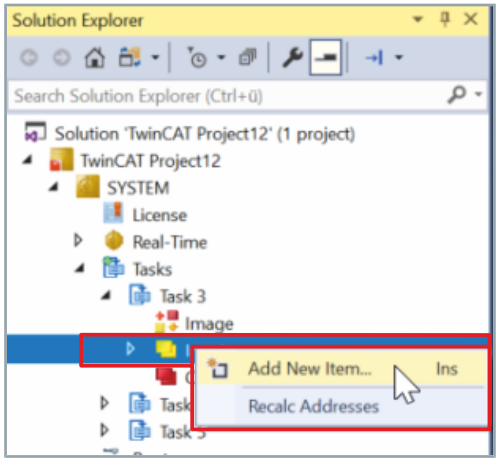


► Right-click "Task"

► Left-click "Add New Item"

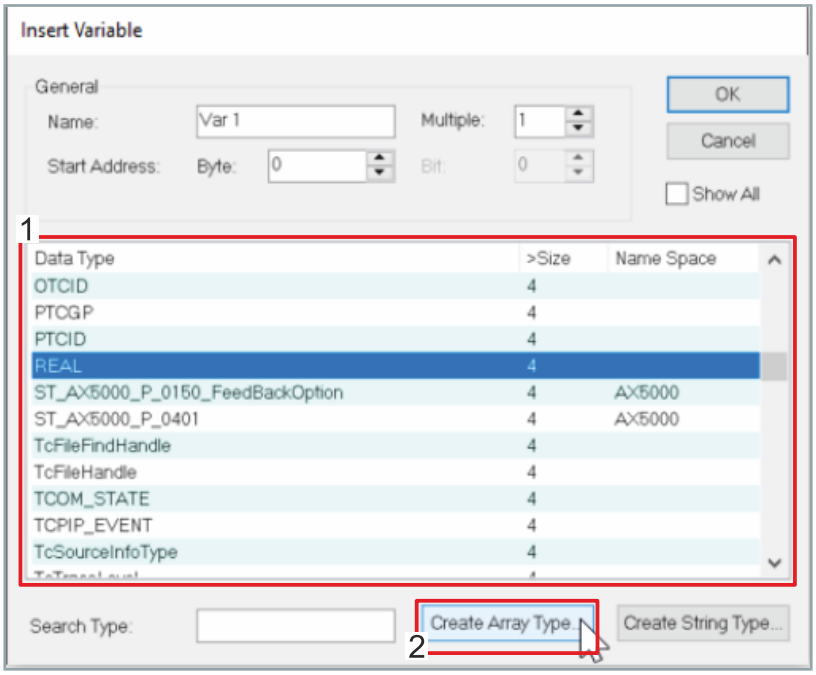


► Select "Task with image" [1], give it a name and confirm with "OK" [2]

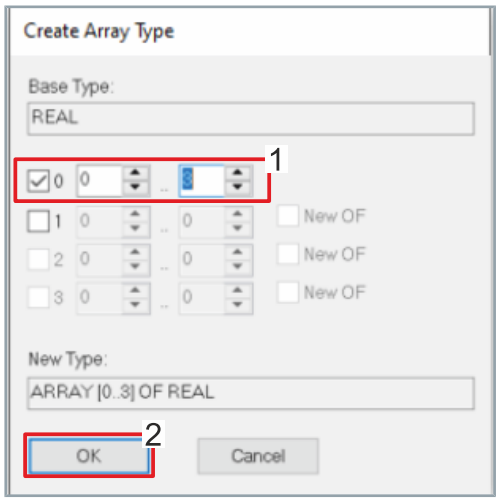


► Right-click "Input"

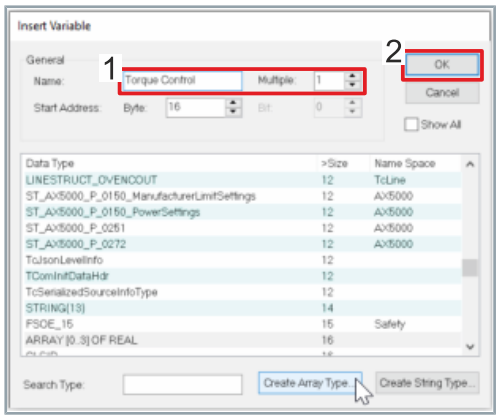
► Left-click "Add New Item"



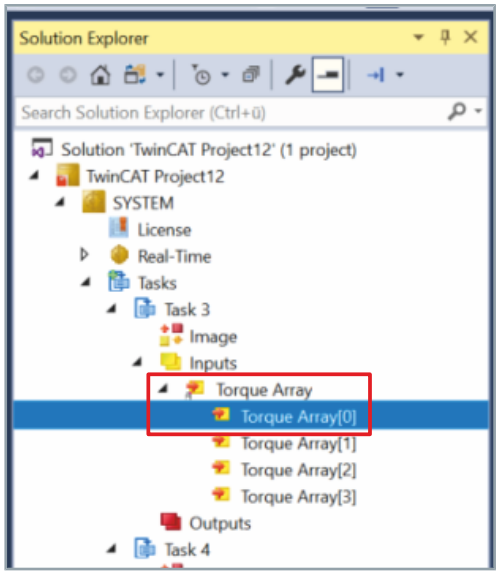
► Select a variable type from the list and click "Create Array Type"



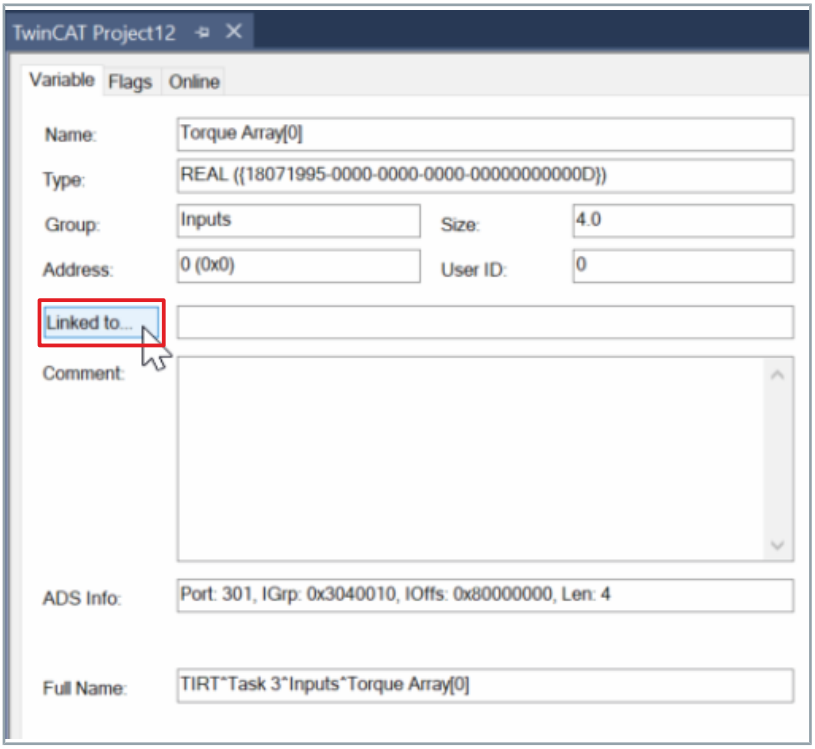
► Define "Array" size [1] and confirm with "OK" [2]



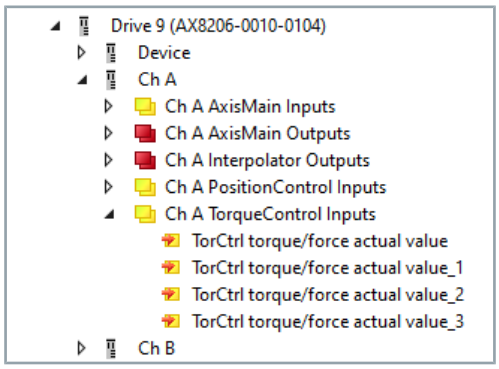
► Select the created "Array Type" and issue a name [1]
► Confirm with "OK" [2]



► In the Solution Explorer, left-click "Array" element



► Left-click "Linked to"



► Select "Sample" and confirm with "OK"

Repeat this step for all "Array" elements.

You can now use the "Array" in a "Scope", for example.

12 Second feedback

12.1 Function

With the multi-feedback interface it is possible to operate a second feedback system on the AX8xxx-xx10. In addition to the Hiperface DSL, feedback systems with Endat 2.2 or BiSS-C can be used.

The second feedback is typically used to achieve a higher resolution or to compensate for mechanical backlash. Please proceed as follows to use a second feedback system:

System prerequisites for the function
The position control function is available as of firmware v1.03 b0001.

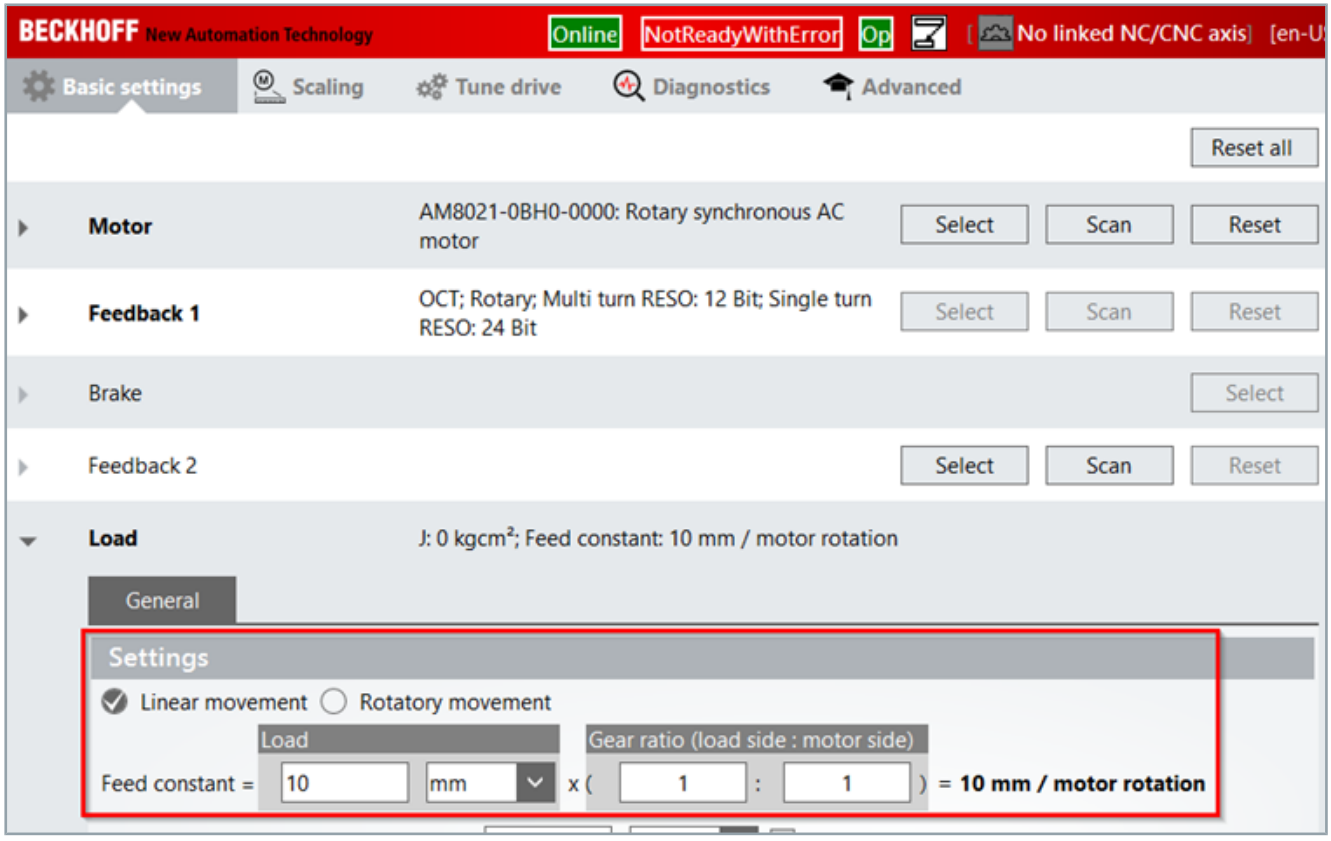
12.2 Hardware

System requirements for the operation of a second feedback system with Endat 2.2 or BiSS-C is the following hardware identifier "AX8xxx-xx10".

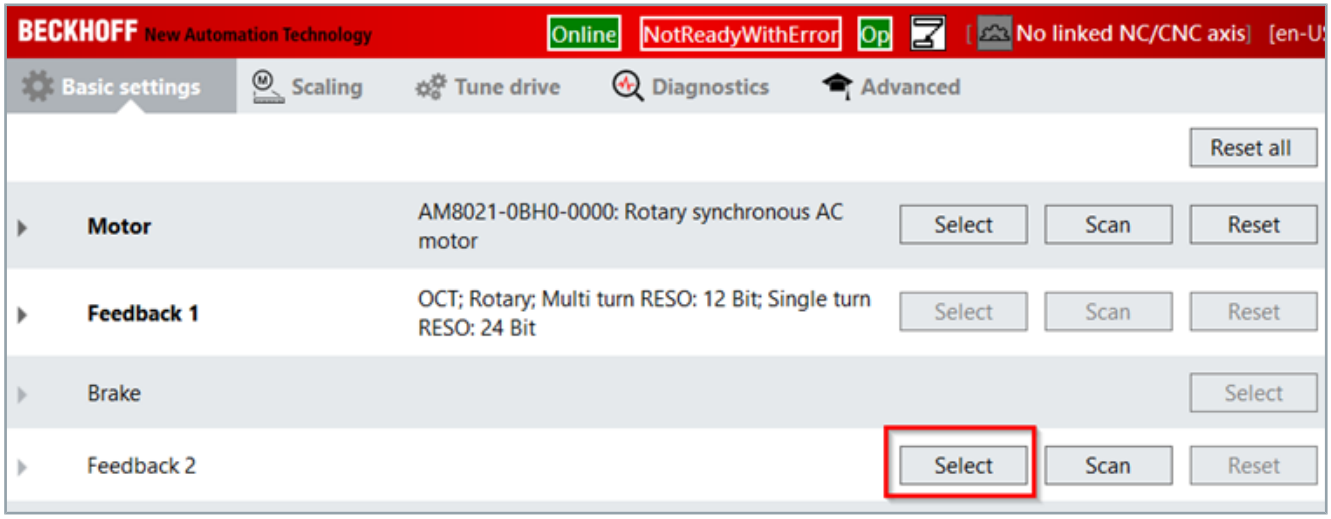
The simultaneous use of BiSS-C and Endat 2.2 on one module is not possible.

12.3 Configuration

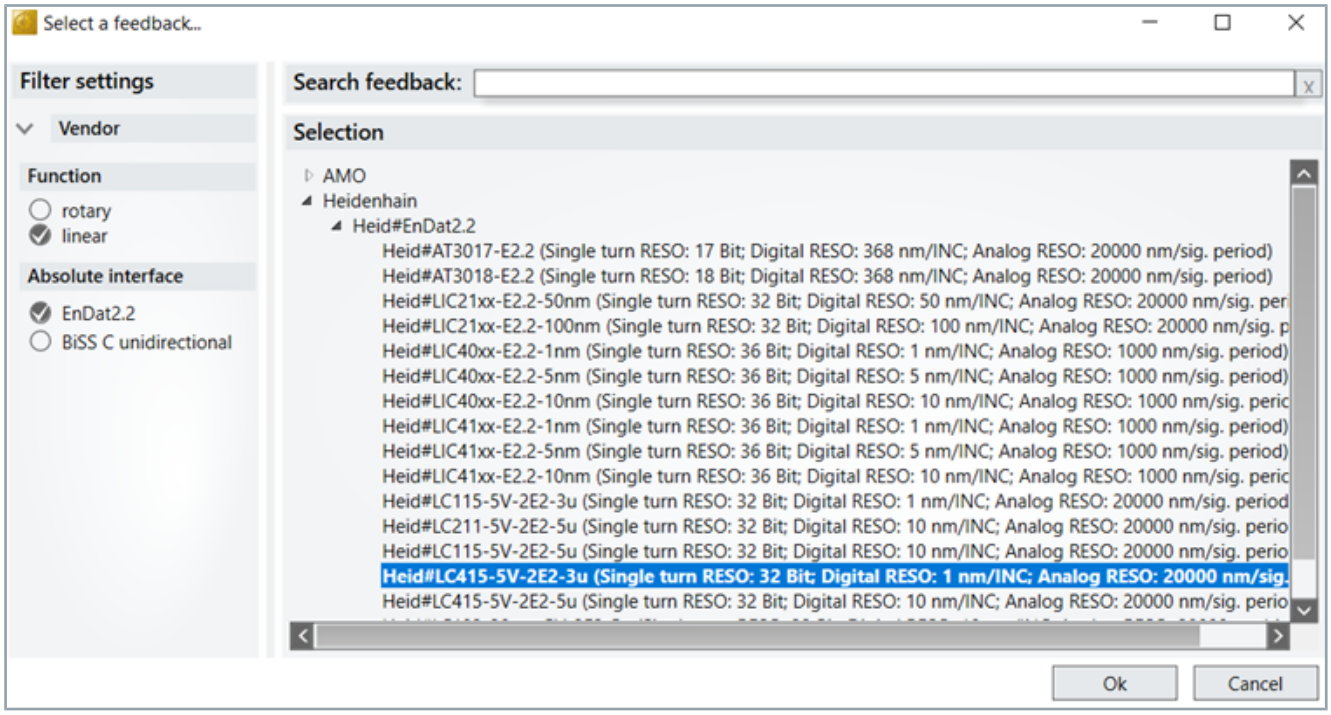
Make sure that the scaling is set correctly by the application in relation to the first feedback system. Consider their mechanics and any speed increasing and reducing ratios that may be present.



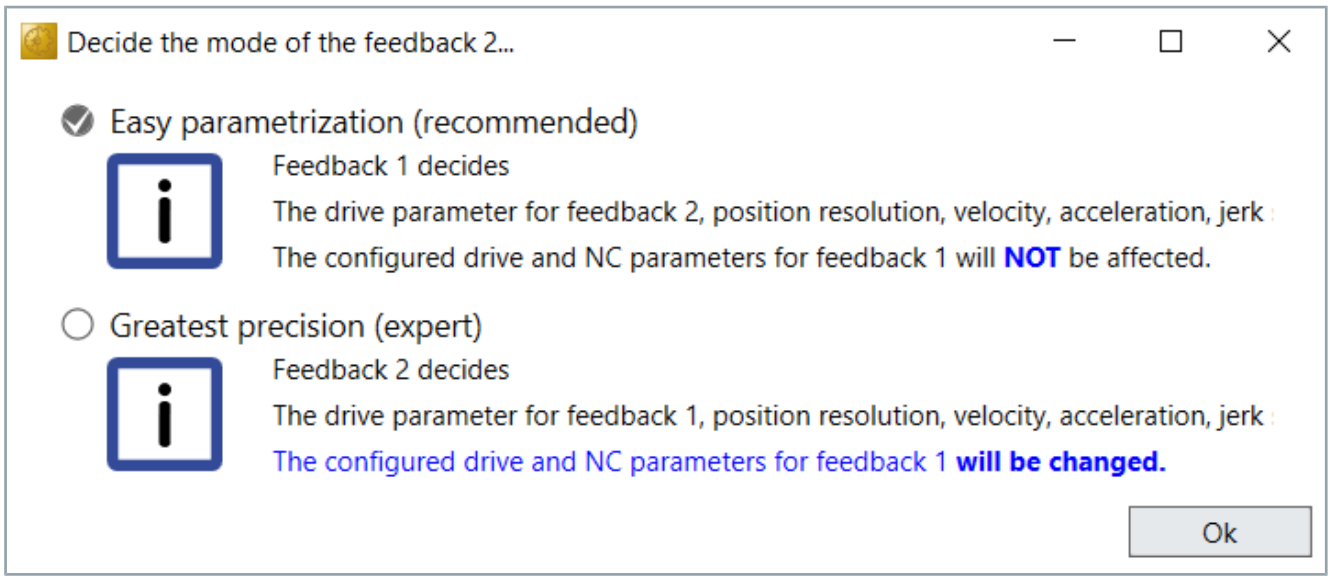
Clicking the Select button opens the window for selecting a second feedback.



Select the feedback and confirm with OK.



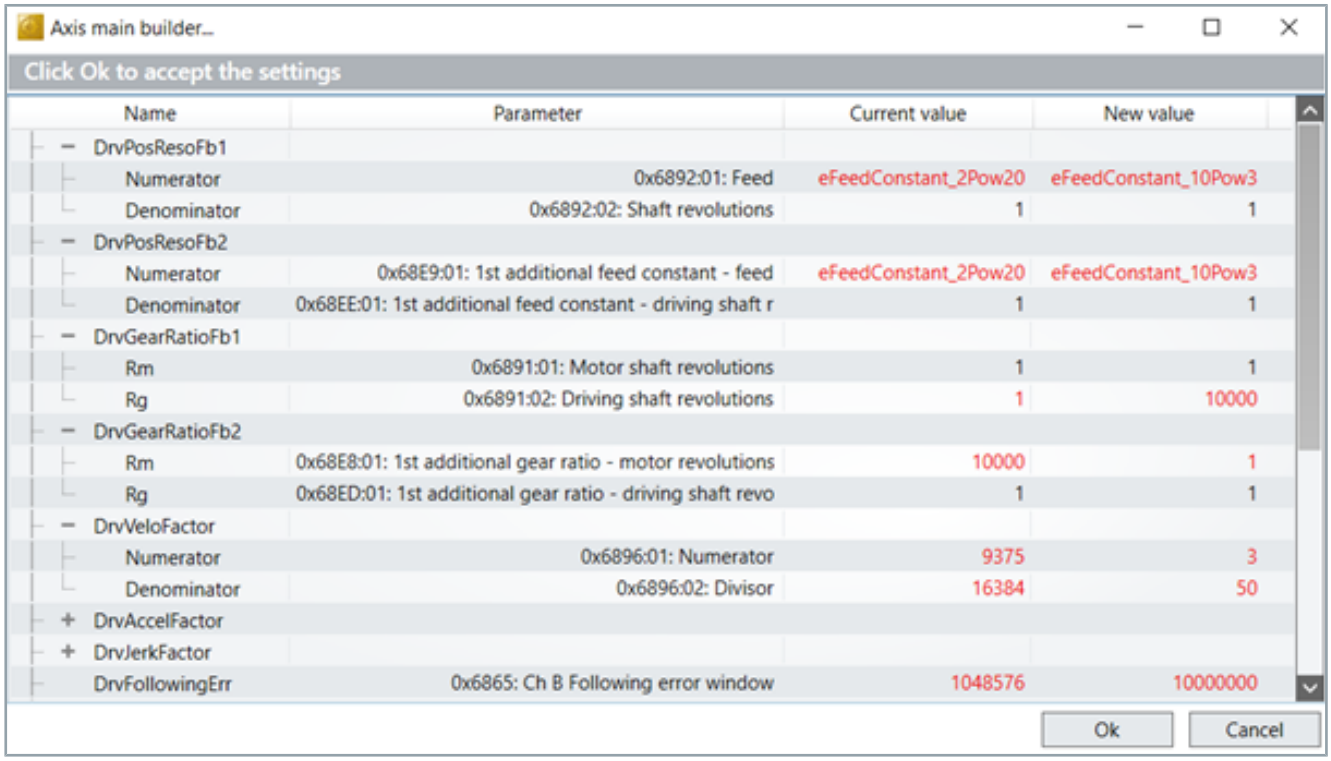
In the next step, a dialog box opens to specify the scaling of the second feedback system.



Easy parametization (recommended): the scaling of the second feedback is referred to the first feedback. Settings from the NC are not changed.

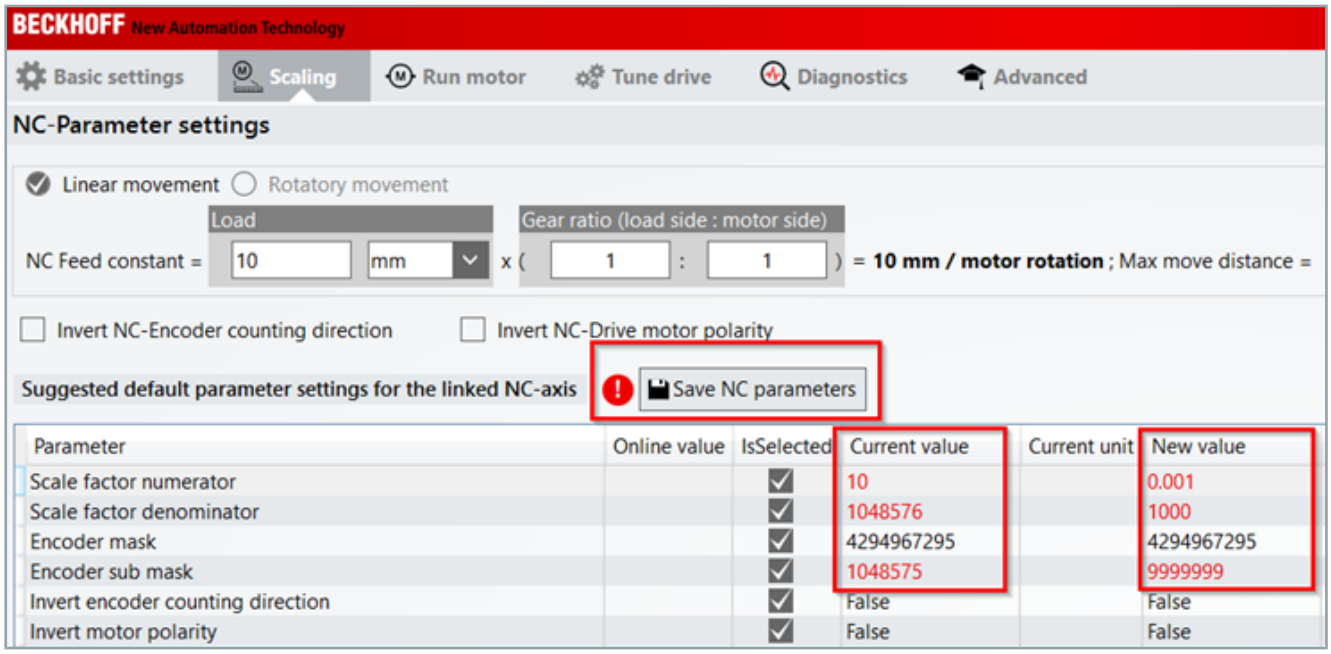
Greatest precision (expert): the scaling of the first feedback is referred to the second feedback. With this setting, the scaling in the NC axis must be adjusted. The necessary changes are made by DriveManager 2.

A summary of the changes in the AX8000 Startup list is displayed in the last dialog box.



Name	Parameter	Current value	New value
DrvPosResoFb1			
Numerator	0x6892:01: Feed	eFeedConstant_2Pow20	eFeedConstant_10Pow3
Denominator	0x6892:02: Shaft revolutions	1	1
DrvPosResoFb2			
Numerator	0x68E9:01: 1st additional feed constant - feed	eFeedConstant_2Pow20	eFeedConstant_10Pow3
Denominator	0x68EE:01: 1st additional feed constant - driving shaft r	1	1
DrvGearRatioFb1			
Rm	0x6891:01: Motor shaft revolutions	1	1
Rg	0x6891:02: Driving shaft revolutions	1	10000
DrvGearRatioFb2			
Rm	0x68E8:01: 1st additional gear ratio - motor revolutions	10000	1
Rg	0x68ED:01: 1st additional gear ratio - driving shaft revo	1	1
DrvVeloFactor			
Numerator	0x6896:01: Numerator	9375	3
Denominator	0x6896:02: Divisor	16384	50
DrvAccelFactor			
DrvJerkFactor			
DrvFollowingErr	0x6865: Ch B Following error window	1048576	10000000

If the Greatest precision mode was selected during commissioning, the necessary changes in the NC must be applied by clicking on *Save NC parameters*.



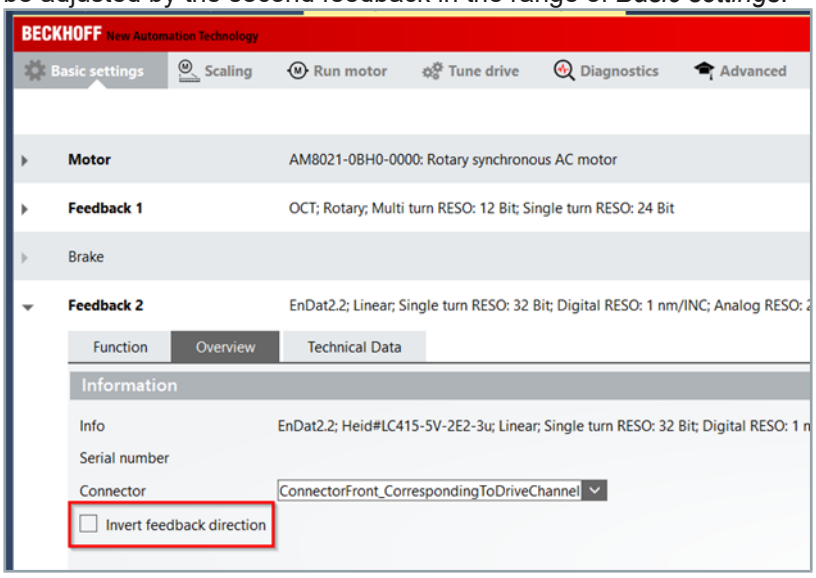
Parameter	Online value	IsSelected	Current value	Current unit	New value
Scale factor numerator		☑	10		0.001
Scale factor denominator		☑	1048576		1000
Encoder mask		☑	4294967295		4294967295
Encoder sub mask		☑	1048575		9999999
Invert encoder counting direction		☑	False		False
Invert motor polarity		☑	False		False

Activate the configuration and check whether the two feedback systems have the same counting direction.

- Make a note of the values.

- Ch A Position Actual Value(0x6064).
- 1st additional position actual value(0x60E4:01).
- Move the axis a little bit.
- Check the two values again and match the counting direction.

If the counting direction is opposite, then the counting direction can be adjusted by the second feedback in the range of *Basic settings*.



⚠ WARNING

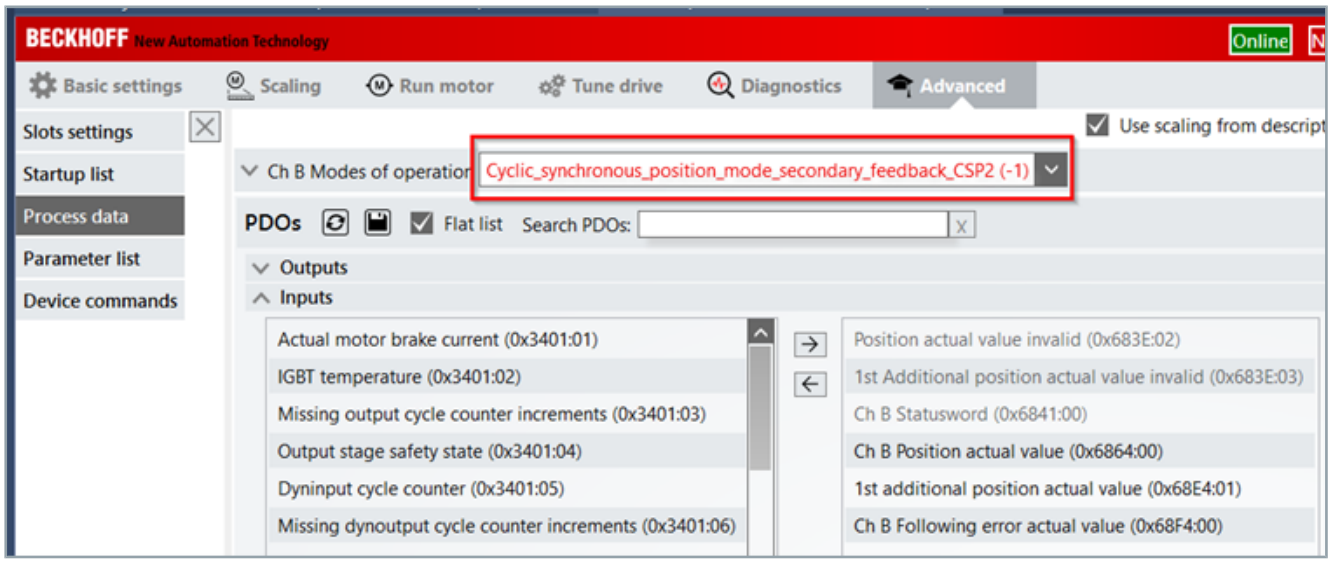
Attention
After the first activation of the configuration with a BiSS-C or Endat 2.2 feedback, the AX8000 requires a 24 V DC Power Cycle. The message Need cold start (0x5193) draws attention to this.

The operation mode CSP (Cyclic synchronous position mode) can be switched to CSP2 (Cyclic synchronous position mode secondary feedback) if the counting direction of the feedback systems is identical.

With this change the DriveManager2 will insert the position value from the second feedback into the process image and link it to the NC.

After activating the configuration, the position is controlled to the second feedback.

Second feedback



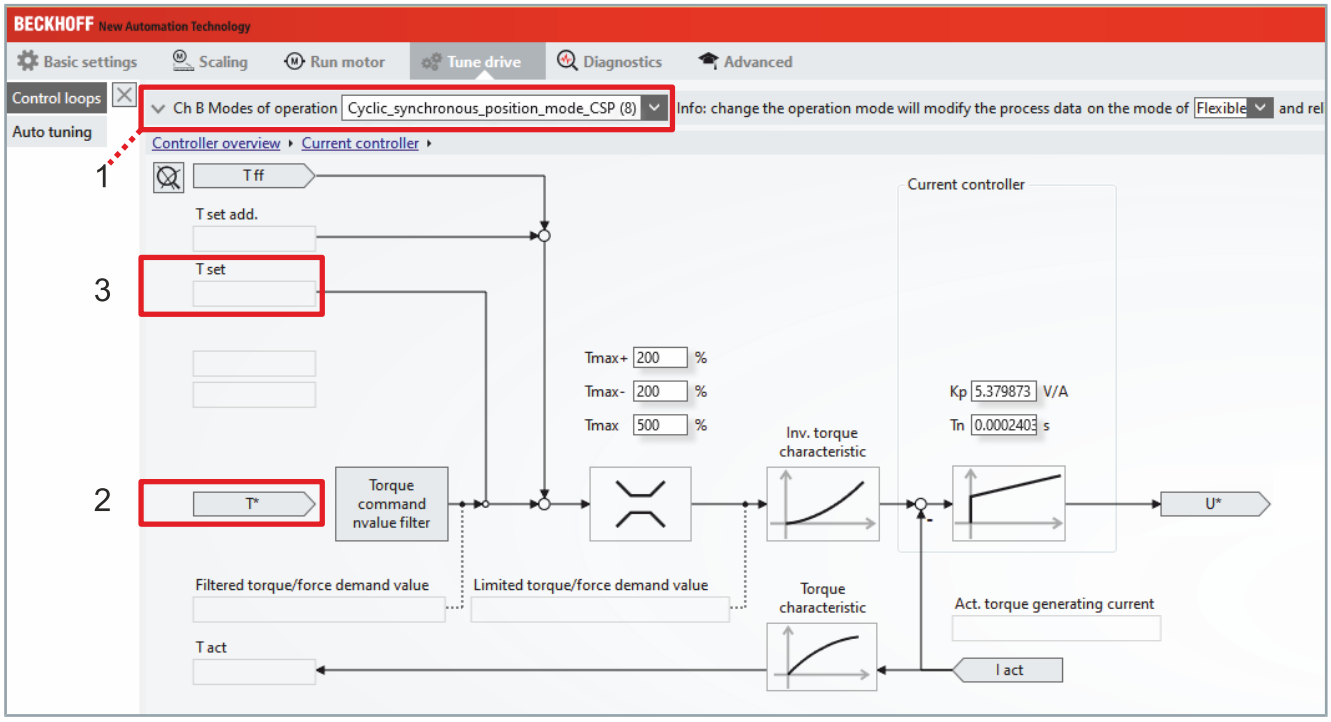
13 Current controller

The current controller represents the inner controller of the cascading control loop structure. Based on field-oriented control, a PI controller provides the required current components. The q-current is proportional to the torque (for linear motors it is proportional to the force). The settings for the current controller parameters K_p and T_N are based on the motor winding data and the optimum bandwidth (compromise between dynamics and noise generation).

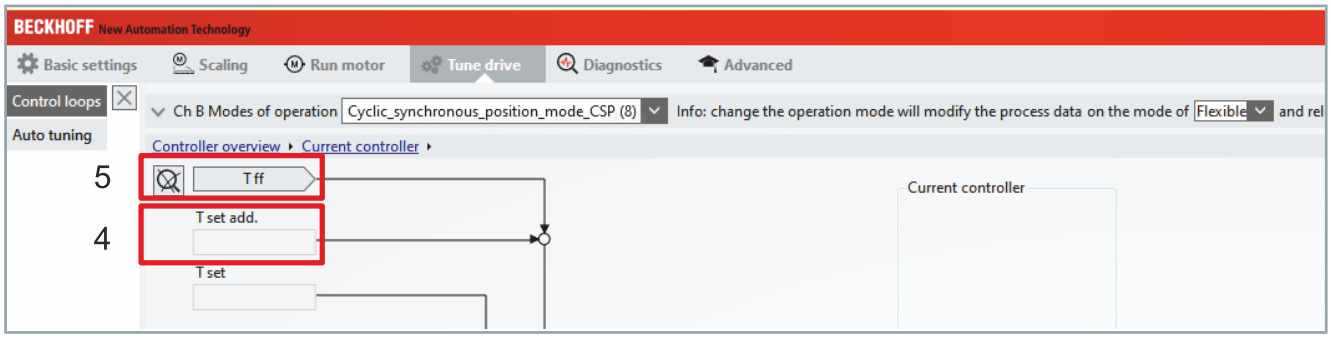
For Beckhoff motors the settings for the optimum bandwidth are taken from the electronic nameplate. For the most applications these settings can be left unchanged.

13.1 Setpoint value calculation

Depending on the set "Mode of Operation" [1], the setpoint is either generated in the speed controller [2] or supplied directly via the torque interface [3]:



Then, the addition of the pre-control variables [4] and [5] is performed:



13.1.1 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

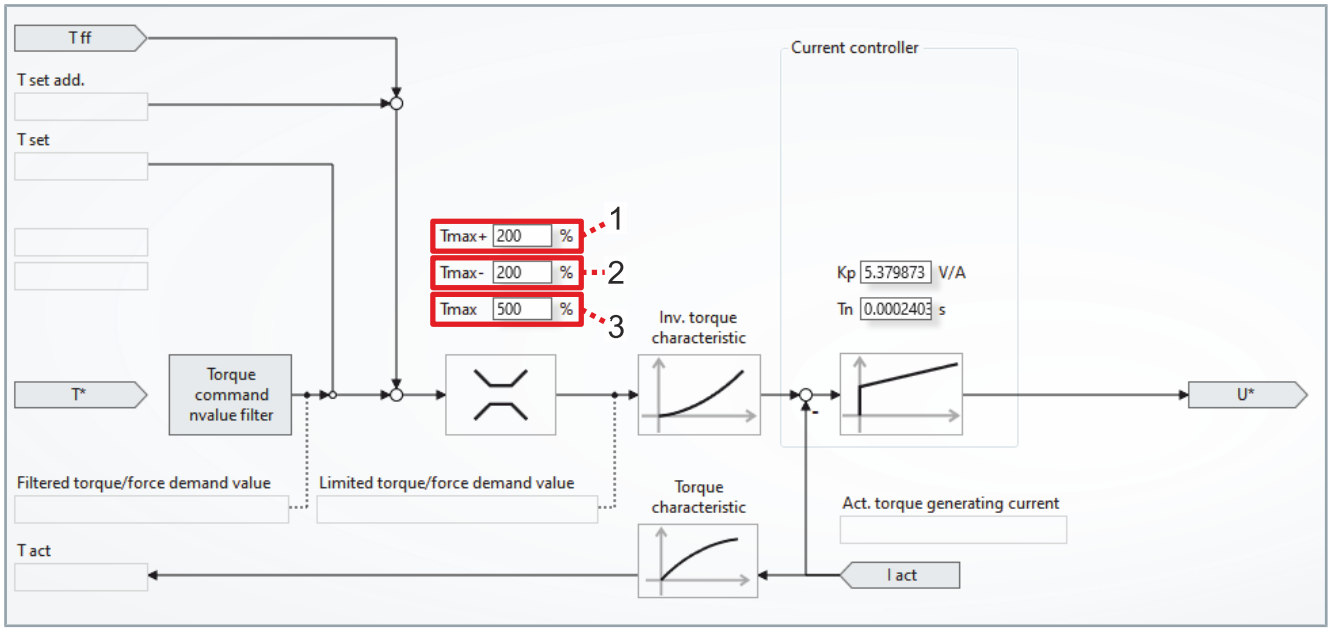
CoE object	Designation	Description
Channel A 0x6060 **Channel B** 0x6860	Modes of operation	This object shall indicate the requested operation mode.
Channel A 0x6061 **Channel B** 0x6861	Modes of operation displayed	This object shall provide the actual operation mode.
Channel A 0x3241:01 **Channel B** 0x3641:01	VeloCtrl torque/ force demand value (T*)	This object indicates the torque/force controller demand value from the velocity controller
Channel A 0x6071:00 **Channel B** 0x6871:00	Target torque/force (T set)	This object shall indicate the configured input value for the torque/ force controller. The value shall be given per thousand of motor standstill torque/force (0x6076).
Channel A 0x60B2:00 **Channel B** 0x68B2:00	Torque/force offset (T set add.)	This object shall provide the offset for the torque/force value. The offset shall be given in per thousand of motor standstill torque/force. In cyclic synchronous position mode and cyclic synchronous velocity mode, this object contains the input value for an external calculated torque/force feed forward. In cyclic synchronous torque mode it contains the commanded additive torque/force of the drive, which is added to the target torque/force value.
Channel A 0x3061:03 **Channel B** 0x3461:03	Interpolated accel- eration demand value (T ff)	This object indicates the torque/force controller demand value from the interpolator.
Channel A 0x6076:00 **Channel B** 0x6876:00	Motor standstill torque	This object indicates the motor standstill torque (M0)/force (Fc). If an electronic datasheet of the motor is available "Standstill current" (I0) will be multiplied by the torque constant (Kt)/ (Kf). The value is scaled to mNm/mN.

13.2 Torque limiting

The torque setpoint is limited:

- unipolar positive [1],
- unipolar negative [2] and
- bipolar [3].

In addition, the thermal model of the AX8000 or the motor can act as a limitation. In addition to static limiting, these parameters can be inserted into the process image in order to implement a cyclic change from the PLC.



13.2.1 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

CoE object	Designation	Description
Channel A 0x60E0 **Channel B** 0x68E0	Positive torque/ force limit value	This object indicates the configured maximum positive torque/force in the motor. The value shall be given per thousand of standstill torque/force (0x6076). Positive torque/force takes effect in the case of motive operation is positive velocity or regenerative operation is negative velocity.
Channel A 0x60E1 **Channel B** 0x68E1	Negative torque/ force limit value	This object indicates the configured maximum negative torque/force in the motor. The value shall be given per thousand of standstill torque/force (0x6076). Negative torque/force takes effect in the case of motive operation is negative velocity or regenerative operation is positive velocity.
Channel A 0x6072 **Channel B** 0x6872	Bipolar torque/force limit value	This object indicates the con_gured maximum bipolar permissible torque/force in the motor. The value shall be given per thousand of standstill motor torque/force (0x6076).

13.3 Design channel current

The "Channel rated current" and "Channel peak current" show the rated current and the peak current of the respective channel of the AX8000 axis module. The torque of the motor is largely proportional to the current. For this reason, the two parameters are decisive in order to be able to achieve the rated torque or peak torque of the configured motor. When selecting the motor, make sure that the two currents match the requirements of the application.

13.3.1 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

CoE object	Designation	Description
Channel A 0x3243:03 **Channel B** 0x3643:03	Channel rated current	This read only object indicates the maximal channel rated current. This value dependents on the mains voltage and the PWM frequency.
Channel A 0x3243:04 **Channel B** 0x3643:04	Channel peak current	This read only object indicates the maximal channel peak current. This value dependents on the mains voltage and the PWM frequency.

13.4 Configuration channel current

The "Configured channel rated current" or " Configured channel peak current" define the rated current and the peak current, respectively, with which the motor is operated at the axis module.

The "Configured channel rated current" is set by "Default" to the standstill current of the configured motor. If the standstill current of the motor exceeds the rated current of the channel, then the channel rated current is entered in the object: Object 0x3243:03.

The "Configured channel peak current" is set by "Default" to twice the standstill current of the configured motor. If the double standstill current of the motor exceeds the rated current of the channel, then the channel peak current is entered in the object: Object 0x3243:04. To achieve the maximum torque from the combination of channel peak current and motor, either the "Channel peak current", object 0x3243:03, or the motor peak current, 0x32C0:03, can be entered in this object. Please note that the smaller of the two values must be selected.

13.4.1 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

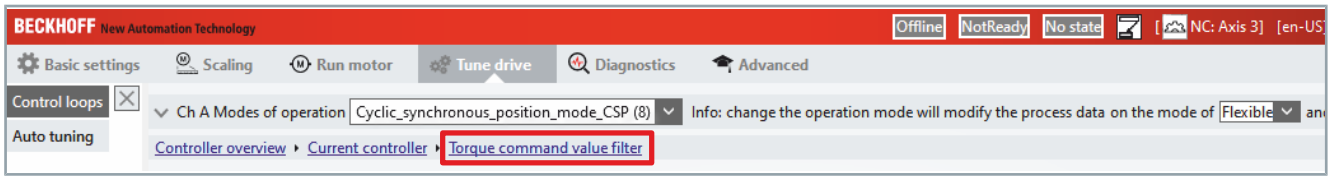
CoE object	Designation	Description
Channel A 0x3243:01 **Channel B** 0x3643:01	Configured channel rated current	This object configures the channel rated current. The range of this object depends on 'Channel rated current' (0x3243:03) and on the other optional channel. The summation is limited.
Channel A 0x3243:02 **Channel B** 0x3643:02	Configured channel peak current	This object configures the channel peak current. The range of this object depends on 'Channel peak current' (0x3243:04) and on the other optional channel. The summation is limited.
Channel A 0x32C00:03 **Channel B** 0x36C00:03	Motor peak current	This object configures the motor peak current. If the electronic datasheet of the motor is available take "Peak current"

13.4.2 Maximum asymmetry

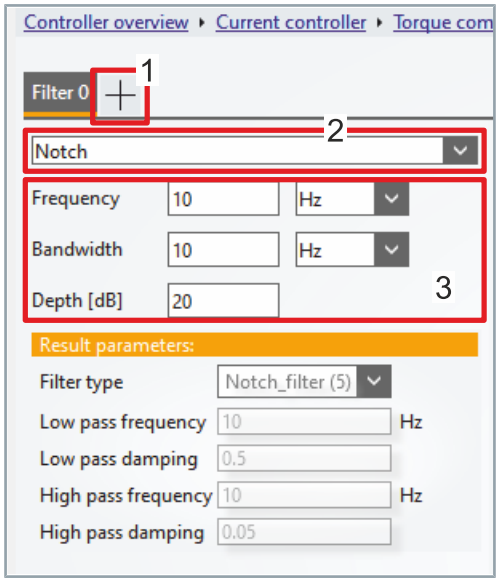
The AX8206 two-channel axis module offers the option of distributing the channel rated current or the channel peak current asymmetrically to channel A and channel B.

Information on device-specific asymmetry
The device-specific asymmetry can be found in the following document:
AX8000 | Multi-axis servo system – Original operating instructions

13.5 Torque setpoint filter



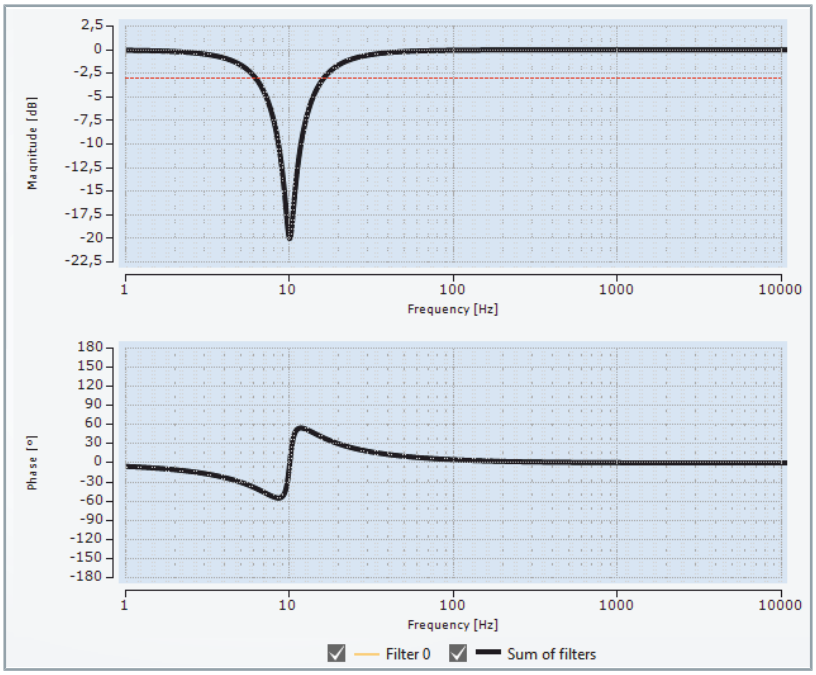
The filtering of the torque setpoints is done via the "Torque command value filter" button.



A new filter is inserted by left-clicking on the plus symbol [1]. The available options [2] are:

- Lowpass 1st order
- Lowpass 2nd order
- Phase correction 1st order
- Phase correction 2nd order
- Notch

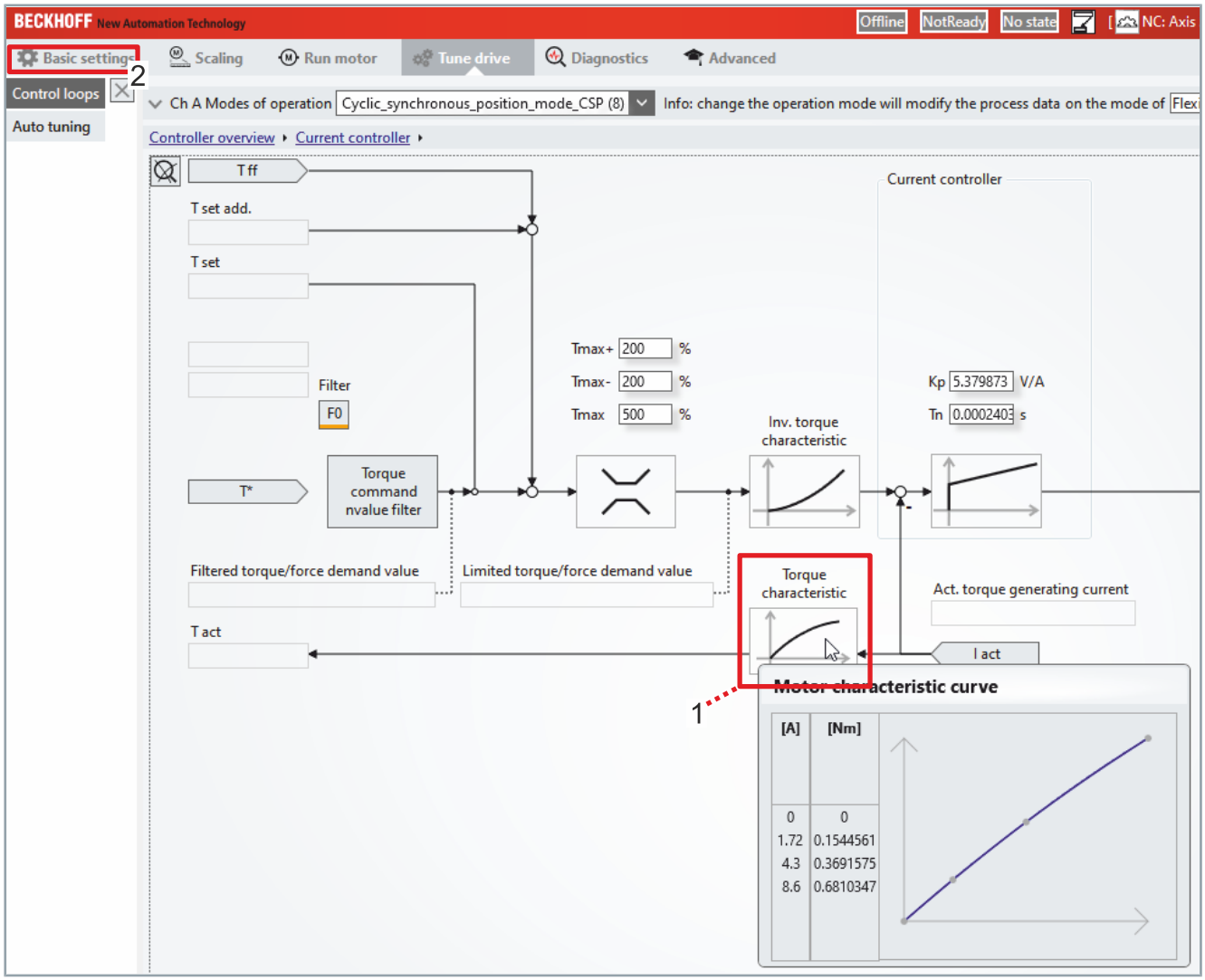
The corresponding parameters for the filters are to be entered below the selection [3].



The amplitude and phase curves can be seen in the area on the right (4). A newly inserted filter requires the activation of the configuration.

13.6 Motor torque characteristic

The torque constant kt [Nm/A] describes the linear relationship between the torque/force forming current Iq and the torque or force. On closer examination, the torque characteristic flattens due to saturation effects. The current controller of the AX8000 takes this nonlinearity for Beckhoff motors of the AM8000/AL8000 series into account via the "Torque characteristic" [1]. This data is contained in the electronic identification plate or the motor data file (.xeds). The read-back or setting of the torque is therefore also possible with high currents.

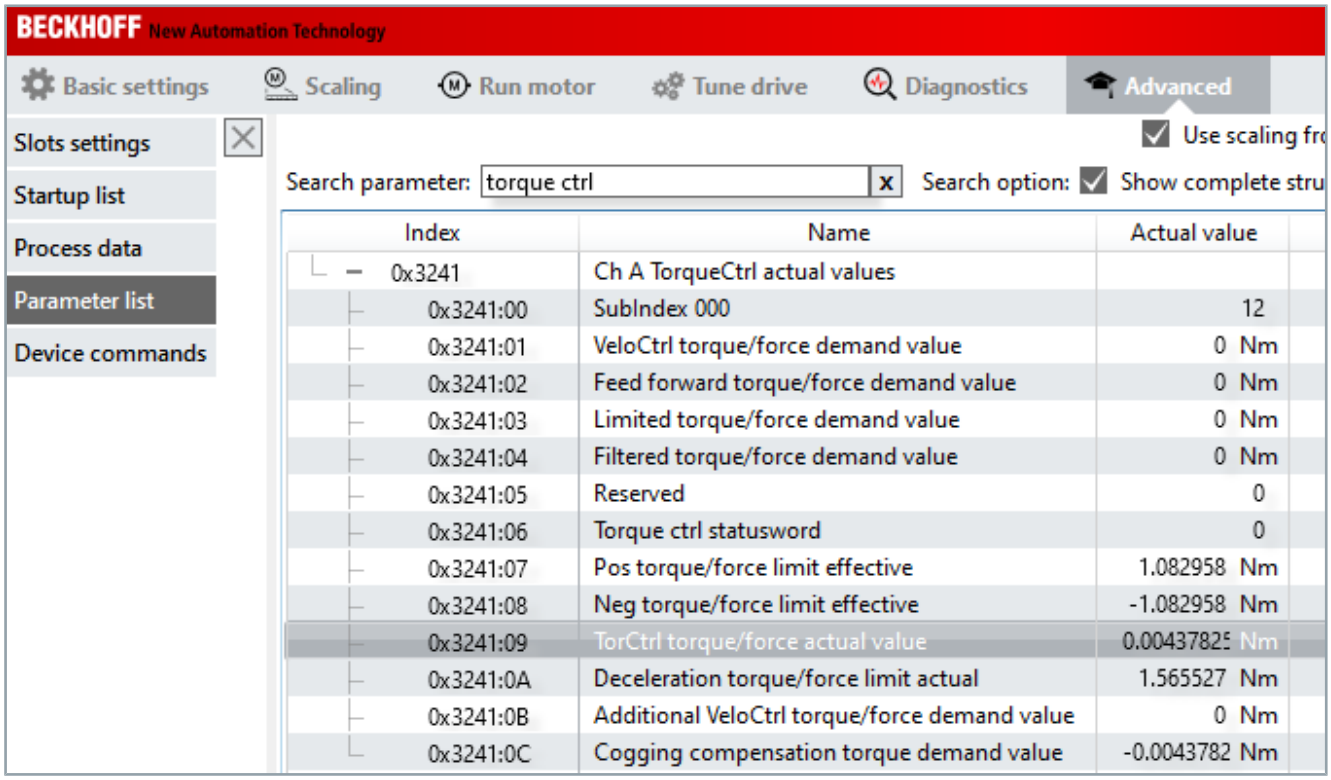


The curve for third-party motors is parameterized on the "Basic settings" tab [3] when the external motor is created.

13.7 Actual Torque

The current torque [M] or force [F] can be read out via the "Torque/force actual value" parameter. This variable can be included in the process image and is thus available for diagnostics in the TwinCAT Measurement project or for processing in the PLC.

In addition to the percentage display, the current torque can be read out via the variable "TorCtrl torque/force actual value" in newton meters or Newton.



13.7.1 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

CoE object	Name	Description
Channel A 0x3241:09 **Channel B** 0x3641:09	TorCtrl torque/force actual value	This object indicates the actual value of torque/force.
Channel A 0x6077 **Channel B** 0x6877	Torque/force actual value	This object shall indicate the configured input value for the torque/force controller. The value shall be given per thousandth of the motor standstill torque/force (0x6076) M0.

13.8 PWM clock frequency

Generation of the output voltage for the AX8000 servo drive is based on a PWM clock frequency of 8 kHz. In order to reach an acceptable compromise between power loss and requirements for the insulation system of the motor, the AX8000 operates with a maximum rate of voltage rise (d_u / d_t) of 5 kV per µs.

Stages and show applications often require almost silent operation of the servo drive and motor. For lower noise emission, the PWM clock frequency can be increased from 8 kHz to 16 kHz. The increased frequency can only be perceived with difficulty by the human ear. The output power of the output stage must be reduced by a factor of 2 at an increased clock frequency.

0x3243	Ch A TorqueCtrl parameters		
0x3243:00	SubIndex 000	11	11
0x3243:01	Configured channel rated current	1.6 A	1.6 A
0x3243:02	Configured channel peak current	4.8 A	4.8 A
0x3243:03	Channel rated current	8 A	A
0x3243:04	Channel peak current	20 A	A
0x3243:05	Configured channel peak torque/force	1.565527 Nm	Nm
0x3243:06	Max channel accepted velocity	41090 rpm	rpm
0x3243:07	Iuvw max sum	2.5 A	2.5 A
0x3243:08	Amplifier output voltage slope	5E+09 V/s	V/s
0x3243:09	Cycle Time	6.25E-05 s	6.25E-05 s
0x3243:0A	PWM mode	PWM_8kHz_re	PWM_8kHz_regular (0)

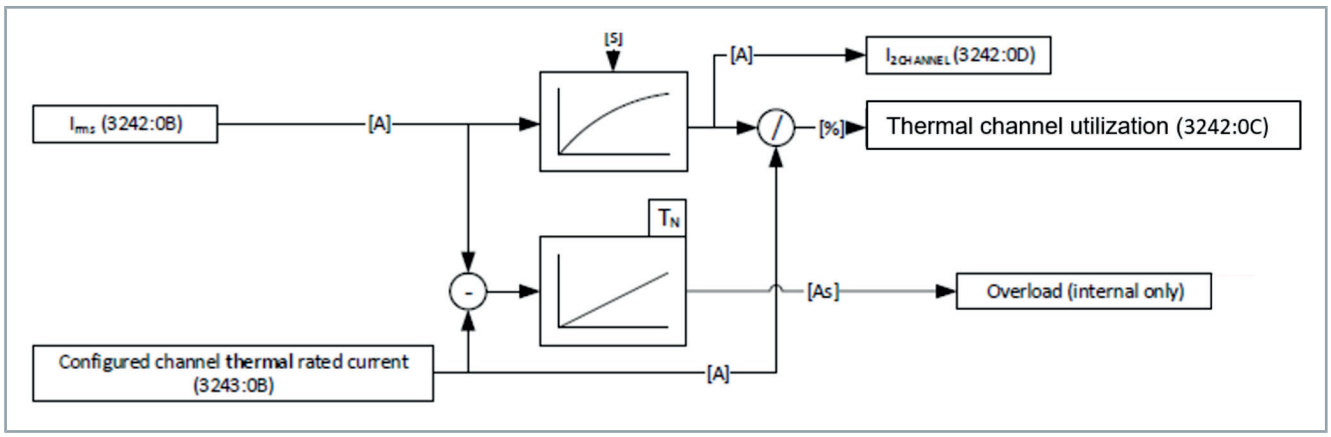
You can set the following values:

Value	Description
0: PWM 8 kHz; default value	PWM clock frequency = 8 kHz
1: PWM 16 kHz	PWM clock frequency = 16 kHz

14 Thermal model

14.1 Function

The thermal model of the servo drive monitors the current flow and calculates the power conversion in the output stage. If necessary, the currents are limited to ensure the protection of the device. In addition, there is the thermal motor model, which ensures the protection of the motor.



Initially, the AX8000 monitors and limits the actual current to the "configured channel peak current". If the "Thermal Channel Utilization" increases to a value of >100%, the limitation is reduced to the "configured channel rated current". If the Thermal Channel Utilization drops below 100%, the limit is raised again to the "configured channel peak current".

14.1.1 Two-channel devices

For two-channel devices, the system checks whether the configuration is valid. Here, the "configured channel Rated current" of one channel may be increased if the current of the other channel is decreased accordingly. The AX8206 is designed as a two-channel 6 A device. However, 8 A can be used permanently on one channel and 4 A on the second channel. The maximum total device current of 12 A is thus reached but not exceeded. This means that motors with different current intensities can be combined. The device specifications must be observed.

14.1.2 Calculation

The following two formulas can be used to calculate how long a required current can be provided before the limitation for controller protection intervenes.

$$\tau = 5s \frac{-1}{\mathrm{Ln}\left(1 - \frac{\text{Configured channel } \textbf{thermal} \text{ rated current (3243:0B)}}{\textit{channel peak current } 0x3243:04}\right)}$$

$$t\_DemandCurrent = \tau * \mathrm{Ln}\left(1 - \frac{\text{Configured channel } \textbf{thermal}\text{ratedcurrent (3243:0B)}}{\text{Demand Current}}\right) * -1$$

Calculation example 1
AX8118 and a supplied current of 22 A

$$\tau = 5s \frac{-1}{\mathrm{Ln}\left(1 - \frac{\text{Configured channel } \textbf{thermal} \text{ rated current (3243:0B)}}{\textit{channel peak current } 0x3243:04}\right)} = 5s \frac{-1}{\mathrm{Ln}\left(1 - \frac{18A}{40A}\right)} = 8{,}363s$$

$$t\_DemandCurrent = \tau * \mathrm{Ln}\left(1 - \frac{\text{Configured channel } \textbf{thermal}\text{ratedcurrent (3243:0B}}{\text{Demand Current}}\right) * -1 = 8{,}363s * Ln\left(1 - \frac{18A}{22A}\right) * -1 = 14{,}26s$$

Calculation example 2
AX8206 and a provided current of 13 A and a configured channel rated current of 8 A.

$$\tau = 5s \frac{-1}{\mathrm{Ln}\left(1 - \frac{\text{Configured channel } \textbf{thermal} \text{ rated current (3243:0B)}}{\textit{channel peak current } 0x3243:04}\right)} = 5s \frac{-1}{\mathrm{Ln}\left(1 - \frac{8A}{20A}\right)} = 9{,}788s$$

$$t\_DemandCurrent = \tau * \mathrm{Ln}\left(1 - \frac{\text{Configured channel } \textbf{thermal}\text{ratedcurrent (3243:0B}}{\text{Demand Current}}\right) * -1 = 9{,}788s * Ln\left(1 - \frac{8A}{13A}\right) * -1 = 9{,}35s$$

14.2 System requirements

The "Thermal model of the servo drive" is used for all channels of all axis modules and is included in all firmware versions.

14.3 Configuration

The configuration is done automatically when the motors are selected. If required, the parameters involved can be edited. This can occur, for example, if higher peak currents are required or if unequal current distribution is to be used with 2-channel devices.

14.4 Object description

In the following you will find information about which CoE objects are involved in the function. The configuration is always dependent on the application and environmental and operational conditions.

CoE object	Designation	Description
0x3242:0B	Irms actual	Internal current value
0x3243:0B	Configured channel thermal rated current	This object configures the channel thermal rated current. The value of this object depends on the 'Configured channel rated current' (0x3243:01) and on the configuration of the optional other channel.
0x3242:0D	I2 Channel	Internal current value
0x3242:0C	Thermal channel utilization	This object contains the actual thermal IGBT utilization.
0x3243:01	configured channel rated current	This object configures the channel rated current. The range of this object depends on 'Channel rated current' (0x3243:03) and the on the configuration of the optional other channel. The summation is limited.
0x3243:03	Channel rated current	This read only object indicates the maximal channel rated current. This value dependents on the mains voltage and the PWM frequency.
0x3243:04	Channel Peak Current	This read only object indicates the maximal channel peak current. This value dependents on the mains voltage and the PWM frequency.

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