**BECKHOFF** New Automation Technology

Function description | EN

AX8000

Multi-axis servosystem



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# 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<sup>®</sup>, TwinCAT<sup>®</sup>, TwinCAT/BSD<sup>®</sup>, TC/BSD<sup>®</sup>, EtherCAT<sup>®</sup>, Ether-CAT G<sup>®</sup>, EtherCAT G10<sup>®</sup>, EtherCAT P<sup>®</sup>, Safety over EtherCAT<sup>®</sup>, TwinSAFE<sup>®</sup>, XFC<sup>®</sup>, XTS<sup>®</sup> and XPlanar<sup>®</sup> 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<sup>®</sup> 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

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The copying, distribution and utilization of this document as well as the communication of its contents to others without express authorization is prohibited. Offenders will be held liable for the payment of damages.

We reserve all rights in the event of registration of patents, utility models and designs.

#### 1.1.5 Third-party brands

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

# **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 instruc- tions	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 mes- sages of the AX8000 multi-axis servo system with attribute ta- bles, 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 <u>https://www.beckhoff.com/secguide</u>.

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 <u>https://www.beckhoff.com/secinfo</u>.

### **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:

### **A** DANGER

Failure to comply will result in serious or fatal injuries.

### **WARNING**

Failure to comply may result in serious or fatal injuries.

# **A** 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.

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1.7	Beckhoff Services		
		Beck sive	hoff and its international partner companies offer comprehen- support and service.
		€	www.beckhoff.com/en-en/support/global-availability/
1.7.1	Support services		
		The ual E offer well a	Beckhoff Support offers technical advice on the use of individ- Beckhoff products and system planning. The support engineers you competent assistance, for comprehension questions as as for commissioning.
		۲	+49 5246 963-157
		$\square$	support@beckhoff.com
		⊕	www.beckhoff.com/en-en/support/our-support-services/
1.7.2	Training offerings		
		Train	ing in Germany takes place at the Beckhoff branches or, after

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
- M 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.



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# 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	<b>Firmware</b>	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\Twin-CAT\Functions\TE5950-Drive-Manager-2\Firmware\AX8000 AMP8000
- **Bootloader versions:** C:\Program Files (x86)\Beckhoff\Twin-CAT\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

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



You do not need to enter a password.

ľ

# Firmware update

TcXaeShell	×
Drive 3 (AX8206-0210-0104) requires power cycle.	
ОК	

► Perform a **Power cycle** 

Bootloader update completed. Ready for firmware download.

### AX8000 firmware update/ downgrade within firmware V1.03-V1.06



#### Firmware update completed

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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



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





#### 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

Solution         • • • • • • • • • • • • • • • • • • •	Request device EtherCAT state [bootstrap]
CONTRACTOR DE LA CONTRA	Download the required firmware version via (FoE) download
Edit FoE Name         X           String:         AX89xexxxex_w_v01.06_b0003_0106         OK           Hex:         41 58 38 79 78 78 2D 78 78 78 78 75 75 75         Cancel           Length:         31           Password (hex):         00000000	
TcXaeShell × Drive 3 (AX8206-0210-0104) requires power cycle. OK	▶ 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)



#### 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	
Image: TwinCAT Project1 - TcXaeShell         File       Edit       View       Project       Debug       TwinCAT         Image: Color of the state of	<ul> <li>Right-click: "Solution TwinCAT Project 1"</li> <li>A new selection area opens.</li> </ul>
Solution Explorer       ▼         Image: Solution Explorer (Ctrl+ü)         Search Solution Explorer (Ctrl+ü)         Image: Solution TwinCAT Project1* (1 project)         Image: Solution TwinCAT Project1         Image: Solution TwinCAT Project1 <t< td=""><td></td></t<>	
Build Solution       Ctrl+Shift+B         Rebuild Solution       Batch Build         Configuration Manager       Manage NuGet Packages for Solution         Manage NuGet Packages for Solution       Restore NuGet Packages         New Solution Explorer View       Add         Ond       Commit         Save TwinCAT Project1 as Archive       Ctrl+Shift+B	<ul> <li>Select Add</li> <li>A new selection area opens.</li> </ul>
New Project Existing Project	<ul> <li>Left-click: "New Project"</li> <li>A new "Add new Project" dialog box opens.</li> </ul>
New Item     Ins       Existing Item     Shift+Alt+A       New Solution Folder	Add New Project     ?       > Recent     Sort by: Default       Installed     Image: Control of the system of

Not finding what you are looking for? Open Visual Studio Installer

► Confirm with OK

TwinCAT Drive Manager 2 Project3

TwinCAT Drive Manager 2 is preselected.

Assign project name and storage location

► Left-click: "TwinCAT Drive... TwinCAT Drive Manager 2"

C:\Users\PierreP\source\repos\TwinCAT Project1

Name:

Location:

• <u>B</u>rowse..

× ? - م

OK Cancel

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# 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.

🦉 Search drives	_		×
Set the basic settings for the detected drives Options			
? Term 1 (AX8620-0000-0102) 1 Phase AC 💙 230 💙 V			
? Drive 2 (AX8206-0200-0103).Channel A 🔵 Unknown configuration. 🥑 Scan motor in PreOp 🛛 Config NC: Movement Linear 🔽 NC feed constant 🙆	mm / m	notor rota	tion
? Drive 2 (AX8206-0200-0103).Channel B 🔵 Unknown configuration. 🥑 Scan motor in PreOp 🛛 Config NC: Movement Linear 🔍 NC feed constant 60	mm / m	notor rota	tion
	Continue	Car	cel

# 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.

Search anves
Set the basic settings for the detected drives
? Term 1 (AX8620-0000-0102) 1 Phase AC 🗸 2
? Drive 2 (AX8206-0200-0103).Channel A 🔵 Unl
? Drive 2 (AX8206-0200-0103).Channel B 🔵 Uni
drives
asic settings for the detected drives Options
asic settings for the detected drives <u>Options</u> AX8620-0000-0102) 1 Phase AC V 230 V
asic settings for the detected drives <u>Options</u> AX8620-0000-0102) 1 Phase AC 230 V 2 (AX8206-0200-0103).Channel A O Unknown config
asic settings for the detected drives <u>Options</u> AX8620-0000-0102) 1 Phase AC 230 V 2 (AX8206-0200-0103).Channel A O Unknown config 2 (AX8206-0200-0103).Channel B O Unknown config
asic settings for the detected drives <u>Options</u> AX8620-0000-0102) 1 Phase AC 230 V 2 (AX8206-0200-0103).Channel A O Unknown config 2 (AX8206-0200-0103).Channel B O Unknown config
asic settings for the detected drives <u>Options</u> AX8620-0000-0102) 1 Phase AC 230 V 2 (AX8206-0200-0103).Channel A Unknown config 2 (AX8206-0200-0103).Channel B Unknown config

#### Select supply network:

- 3 Phase AC
- 1 Phase AC
- DC

#### Select voltage:

3 phase and 1 phase networks $[V_{AC}]$	DC [V <sub>DC</sub> ]
100	24
200	48
230	
400	
480	



#### Extended selection options for DC supply

If you select DC supply, you can choose between 24  $V_{\mbox{\tiny DC}}$  and 48  $V_{\mbox{\tiny DC}}$  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

drives Options	
✓ 230 ✓ V	
O Unknown configuration.	📎 Scan motor in PreOp
O Unknown configuration.	🔇 Scan motor in PreOp

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

# 1

#### 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

	—	
NC feed constant 60		notor rotation
NC feed constant 60	mm 🗸 / m	notor rotation
	Continue	Cancel
	_	
NC feed constant 60	mm 🗸 / m	notor rotation
NC feed constant 60	mm 🗸 / m	notor rotation
	-	
	Continue	Cancel

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	0	
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:

Search drives			×
Set the basic settings for the detected drives Options			
✓ Term 1 (AX8620-0000-0102) 1 Phase AC ✓ 230 ✓ V			
🗸 Drive 2 (AX8206-0200-0103).Channel A 🔿 Unknown configuration. ⊘ Scan motor in PreOp AM8021-0BH0-0000 🛛 Config NC: Movement Linear	✓ NC feed constant <sup>−</sup>	10	mm 🗸
V Drive 2 (AX8206-0200-0103).Channel B 🕜 Unknown configuration. 🔿 Scan motor in PreOp			
			>
	Ok	C	ancel
Completedclick Ok or Cancel to accept or reject the result.			

► Finish configuration with OK

# 4.4 Activate configuration

Solution Explorer 🔹 👎 🗙					
◎ ◎ 🏠 🛱 ▾   ఀ⊚ ▾ 🗗   🌶 💶   →  ▾					
Search Solution Explorer (Ctrl+ü)					
<ul> <li>Solution 'TwinCAT Project1' (2 projects)</li> <li>+ Image: TwinCAT Drive Manager 2 Project3</li> <li>+ Image: Term 1 (AX8620-0000-0102) @Device 5</li> <li>Drive 2 (AX8206-0200-0103)</li> </ul>					
Ch A (AM8021-0BH0-0000)					
- <del>™</del> Ch B ਿੱ					
🔺 📲 TwinCAT Project1					
SYSTEM					
MOTION					
🛄 PLC					
🙆 SAFETY					
₩ C++					
ANALYTICS					
Þ 🔀 I/O					

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

► Left-click: "Activate Configuration" in the Visual Studio ribbon A new "Activate Configuration" dialog box opens.

Activate Configuration					
Project:	TwinCAT Project1				
Target:	CX-402546				
	OK Cancel				

► Confirm with OK

Your configuration is now activated.

A new dialog box "TcXaeShell" opens.

TcXaeShell	×					
<b>Restart TwinCAT System in Run Mode</b>						
OK Abbrechen						

► 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	
$\bigtriangledown$	Stop the NC axis	
R	Reset an error from the Motion NC	

#### 4.5.1.1 Manual Scope View

**BECKHOFF** New Automation Technology

🗱 Basic settings

**- 1** -

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.

Stat Start record	95:000   End: 10:58:29,123:000   Po 10,000:000   14 4 > 14   0,00:00:
12637,5	
· <sub>〒</sub> 12622,5-	

◎ Scaling

# 4.5.2 Reversing mode

Automatic Scope View

∧ NC									
Enable controller Online position: -0.0002									
	Manual Functions Parameters								
	Start mode		Reversing sequence		×				
	Target position 1		-500		mm				
	Target velocity		500		mm/	s			
	Target position 2		500		mm				
	Idle time		0.5		s				

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"

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

Trigger start/stop scope	
	Start Stop
Set actual position	
Absolute V 0	Set

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 be- tween the start position and the target po- sition in reversing mode
Idle time	Waiting time between movements
Trigger start/stop scope	Start/stop automatic Scope View record- ing

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# 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.

BECKHOFF New Autor	nation Technology				Online AxisReady Op 🗾 [🕰 NC: Axis 3 Spindel] [e	en-US]
🗱 Basic settings	Scaling	🛞 Run motor	థ <sup>ిల్ల</sup> Tune drive	🕀 Diagnostics	Advanced	

#### 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	K <sub>v</sub> = gain factor = P-part
"Position controller"	
Velocity controller	K <sub>p</sub> = gain factor = P-part
"Velocity controller"	T <sub>n</sub> = time constant; integral action time = I-part
Current controller	K <sub>p</sub> = gain factor = P-part
"Current controller"	T <sub>n</sub> = 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.



1

#### **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.

BECKHOFF New Automation Technology						Online AxisReady Op 🗾 [ 🗠 NC: Axis 3 Spindel] [en-US]
	🗱 Basic settings	Scaling	Run motor	¢¢ Tune drive		Advanced

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.

BECKHOFF New Autor	mation Technology					Online AxisReady	• 7	[ 🚵 NC: Axis 3 S	Spindel] [en-l
🗱 Basic settings	Scaling	🕲 Run moto	r ¢ <sup>©</sup> Tune o	drive 🤇	Diagnostics	Advanced			
Fror code and messa	ige 🛛 🗙			_					Exp
OSL error log		Desident							
heck software config	guration	Device operating	g time: 280.16h	raings	.nannel power sta	ge time: 1d.00h:18m:24s	hannel erro	r counters (1)	Reset erro
Vatch window		Type	Time	Date	Diagnostic Code	Message			
		- Jps	00.54.05.270	12.06.2020	0.0000	Ch & AviaMaiaClas() Ma Farma			
		Information	07:37:45 792 ms	12.06.2020	00000	Chi A, Axisiviainsiotij: No Error		1-21	
		information	07:37:45 782 ms	12.06.2020	UXFFFD	Debug firmware, replace As si Pastored Errormercages from	porristont me	ie i	
		o mormation	05-49-19 494 m	12.06.2020	0x3386	Sustem restart or punc lost	persisterit rite	anory	
		error error	10-31-24 552 mg	11.06.2020	0x8180	Lost Distributed clocks Sunc			
		error Opror	10:31:24 533 ms	11.06.2020	0x8180	System restart or sync lost			
		error error	07:39:46 778 ms	11.06.2020	0x8180	System restart or sync lost			
		error error	07:34:41 368 ms	11.06.2020	0x8180	System restart or sync lost			
		error error	07:30:03 562 m	11.06.2020	0x8180	System restart or sync lost			
		error.	07:29:00 222 ms	11.06.2020	0x8180	System restart or sync lost			
		error .	07:28:19 245 ms	11.06.2020	0x8180	System restart or sync lost			
		error .	07:27:20 255 ms	11.06.2020	0x8180	System restart or sync lost			
		error	07:23:03 158 m	11.06.2020	0x8180	System restart or sync lost			
		error 8	07:21:47 771 ms	11.06.2020	0x8180	System restart or sync lost			
		error 0	06:26:54 286 ms	11.06.2020	0x8180	System restart or sync lost			
		8 error	06:23:13 404 ms	11.06.2020	0x8180	System restart or sync lost			
		😵 error	03:17:10 31 ms	11.06.2020	0x8180	System restart or sync lost			
		S error	00:19:42 465 ms	11.06.2020	0x8180	System restart or sync lost			
		S error	23:47:54 343 ms	10.06.2020	0x8180	System restart or sync lost			
		😵 error	23:26:51 449 ms	10.06.2020	0x8180	System restart or sync lost			
		Serror	23:16:36 672 ms	10.06.2020	0x8180	System restart or sync lost			
		Serror	23:05:47 127 ms	10.06.2020	0x8180	System restart or sync lost			
		S error	22:58:53 148 ms	10.06.2020	0x8180	System restart or sync lost			

#### The following information is available:

Description	Explanation
Error	Critical error that can lead to the device be- ing switched off. May occur when a config- ured 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

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### 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

Ei Ci Ci

W

Different display options are available under "Diagnostics".

way and marray	$\times$	Information type	Explanation
heck software configuration		Error code and message	Error codes and messages with corresponding plain text error message
ompare xml with online description		Check software configuration	Comparison between valid
/atch window			startup list and current configura- tion
		Compare xml with online descrip- tion	Verification of the XML file
		Watch window	Current values of the selected

### 4.7.3 Selection options for AX8xxx

Different display options are available under "Diagnostics".

Error code and message	)
DSL error log	
Check software configuration	
Watch window	

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 en- coder
Check software configuration	Comparison between valid startup list and current configura-tion
Watch window	Current values of the selected parameters

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.

Startup list 🛛 🗡	Powersupply-Axis connection	n			
Process data	Search parameter: power 🗴 Search option: 🗸 Show complete structure				
Parameter list	Index	Name	Actual value		
	0x6003	PSM Actual process values 3			
	0x6003:00	SubIndex 000			
	0x6003:01	Actual brake resistor continuous power			
	0x6003:02	Actual brake resistor short-time energy			
	- 0x6004	PSM Warning register			

Enter a search term under "Search parameter"

#### Note the available options:

Option	Explanation
Show complete structure	Shows all parameters found in the corre-
	sponding 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.

BECKHOFF New Autom	ation Technology				
🛱 Basic settings	Scaling	Run motor	¢ <sup>Ø</sup> Tune drive	🕀 Diagnostics	Advanced

A new selection area opens.

BECKHOFF New Autor	nation Technology					
🗱 Basic settings	Scaling	Run motor	🕸 Tune drive	<b>Oiagnostics</b>	Advanced	
Drive settings						
Drive rotational positi	on resolution 104	8576 (2 <sup>20</sup> )	Inc / motor rotation			
∨ Drive modulo setti	ings					
✓ Drive position offs	et settings					
NC-Parameter set	NC-Parameter settings					
C Linear movemen	t 🔇 Rotatory m	ovement				
	Load	Ge	ar ratio (load side : n	notor side)		
NC Feed constant =	360	•	1 :	10 ) = <b>36</b> ° /	motor rotation	
Invert NC-Encoder counting direction Invert NC-Drive motor polarity						
Suggested default pa	arameter settings	for the linked NC-	axis 🌔 🗎 Save N	IC parameters		

## 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".

NC-Parameter settings	<ul> <li>Select Rotatory movement</li> </ul>
Linear movement Rotatory movement Load NC Feed constant = 360 ° · · · · · · · · · · · · · · · · · ·	<ul> <li>Enter rotary table from example with 360°</li> </ul>
	► Set gear ratio 1:10
	<ul> <li>Confirm settings with "Save NC parameters"</li> </ul>
Gear ratio (load side : motor side) ( 1 : 10 ) = <b>36 ° / motor rotation</b> nvert NC-Drive motor polarity	You have successfully sized your mechanical system. Your "NC Feed constant" is 36° per motor revolution.
NC-axis 🕕 🖬 Save NC parameters	

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# 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).

BECK	HOFF New Automatio	n Technology			Online	AxisReady Op 📃	🔨 [🚌 NC: Axis 1] - [en-US]
48	asic settings	Scaling	Run motor	$\varphi^{O}_{0}$ Tune drive	🕘 Diagnostics	Advanced	
							Reset all
•	Motor		Beckhoff AM8021	-0DH1-0000: Rotary	synchronous AC mot	or Select	Scan Reset
•	Feedback 1		OCT; Rotary; Mult	i turn RESO: 12 Bit; S	ingle turn RESO: 24 B	Select	Scan Reset
-	Brake 🚺		HoldingBrake: AN	18021-0DH1-0000-br	ake		Select
	Technical Data	Motor	brake force				
	Technical dat	a	D		Symb	ol [Unit]	Value
		BrakeType	645°				HoldingBrake
		UBrakeMin			UBrake	Min [V]	21.6
		UBrakeMax			UBrakel	Max [V]	25.4
		IBrakeMin			IBrakeN	fin [A]	0.199
		MBrake			MBrake	[Nm]	2
		TBrakeOn			TBrake	On [s]	0.025
		TBrakeOff			TBrake	Off [s]	0.008
		TBrakeRed			TBrake	Red [s]	3

# 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.

BECKHOFF New Automa	ition Technology	Online	AxisReady Op 🗾 🛙	NC: Axis 1] [en-US]
🛱 Basic settings	Scaling Run mo	otor 🚓 Tune drive 🕘 Diagnostics 🗢 A	dvanced	
Slots settings	]	Use scaling from description file	WritableAndReadOnly	All 🗸
Startup list	Search parameter: axismai	n 🛛 🗙 Search option: 🗸 Sho	w complete structure	
Process data	Index	Name	Set value	Expand all
Deserve also list	+ 0x1620	Ch A AxisMain Outputs		Collapse all
Parameter list	+ 0x1700	Ch A AxisMain Dynamic Outputs		Download
Device commands	- + 0x1A20	Ch A AxisMain Inputs		Addamaad
	+ 0x1B00	Ch A AxisMain Dynamic Inputs		Add to watch
	0x3000	Ch A AxisMain parameters		Add to startup
	- 0x3000:00	SubIndex 000	9	Export list
	- 0x3000:01	Motor brake type	Currentless_locked_m	
	- 0x3000:02	Motor brake usage	Standard_holding_bra 🗸	
	0x3000:03	Drive on delay time	0.05 s	
	- 0x3000:04	Drive off delay time	0.016 s	
	- 0x3000:05	Motor brake current monitoring level	0.199 A	
	- 0x3000:06	Configured drive type	AX8108-0210-0000	
	0x3000:07	Motor brake force	Release_force (0)	
	0x3000:08	Modulo data storage	Modulo_data_storage	
	0x3000:09	Voltage enabled bit support	feature_disabled (0)	

## 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
<b>Channel A:</b> 0x3000:01	Motor brake type	Activates drive internal automatic brake control.
<b>Channel B:</b> 0x3400:01		
Channel A: 0x3000:02	Motor brake usage	Configures the error reaction behavior of the motor brake.
<b>Channel B:</b> 0x3400:02		
<b>Channel A:</b> 0x3000:03	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 val-
<b>Channel B:</b> 0x3400:03		ues after the "drive on delay time" has elapsed. The motor brake management uses this time to unlock the motor brake before motion is enabled.
<b>Channel A:</b> 0x3000:04	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 initi-
<b>Channel B:</b> 0x3400:04		ated 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.
<b>Channel A:</b> 0x3000:05	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
<b>Channel B:</b> 0x3400:05		if brake control is enabled.
<b>Channel A:</b> 0x3000:07	Motor brake force	Force drive internal brake.
<b>Channel B:</b> 0x3400:07		

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# 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 ap- proach standstill.
2	Activation of the control loop at the AX8000; vtar- get = 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 con- trolled 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 dis- abled.
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.

BEC	KHOFF New Autom	ation Technology				Online AxisRea	dy 📴 🛃	[ 🖾 NC: Achse	3] [en-US]
#	Basic settings	Scaling	Run motor	¢ <sup>©</sup> Tune drive	🔇 Diagnostics 🗖	Advanced			
									Reset all
•	Motor		AM8021-0BH0-000	0: Rotary synchrono	us AC motor		Select	Scan	Reset
•	Feedback 1		OCT; Rotary; Multi	turn RESO: 12 Bit; Sir	ngle turn RESO: 24 Bit		Select	Scan	Reset
•	Brake								Select
×	Load		J: 0 kgcm <sup>2</sup> ; Feed co	nstant: 60 × (1 : 20)	= 3 mm / motor rotation	n			
•	Digital IOs								Reset

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

# Digital inputs

BEO	CKHOFF New Automation Technology			Offline	NotReady No st	ate 才 (🖾 NC: /	wis 1] [en-US]
*	Basic settings Scaling	🕲 Run motor	¢₀ <sup>©</sup> Tune drive		Advanced		
							Reset all
ŀ	Motor				Sel	ect Scan	Reset
Þ	Feedback 1				Sel	ect Scan	Reset
ŀ	Brake						Select
Þ	Load						
*	Digital IOs						Reset
	Digital I/O	Positive limit switch	Negative limit switch	Probe unit 1	Probe unit 2	Hardware enable	
	Digital input 1						
	Digital input 2						
	Digital input 3						
	Digital input 4						

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

BECK	HOFF New Autor	nation Technology			Offline	NotReady No sta	ate 🛃 [🗠 NC: A	xis 2] [en-US]
4	asic settings	Scaling	Run motor	¢ <sup>©</sup> Tune drive	<b>Q</b> Diagnostics	Advanced		
								Reset all
•	Motor					Sel	ect Scan	Reset
•	Feedback 1					Sel	ect Scan	Reset
۱.	Brake							Select
•	Load							
-	Digital IOs							Reset
	Dig	ital I/O	Positive limit switch	Negative limit switch	Probe unit 1	Probe unit 2	Hardware enable	
	Digital in	put 1 *						
	Digital in	put 2 *						
	Digital in	put 3						
	Digital in	put 4						
	* this digital i	nput is reserved	for the safety function	ı.				

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)

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

Digital IOs	II: HE;				
Digital I/O	Positive limit switch	Negative limit switch	Probe unit 1	Probe unit 2	Hardware enable
Digital input 1					Reaction TorqueOff
Digital input 2					TorqueOff ClosedLoopRamp
Digital input 3					
Digital input 4					

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

BECI	(HOFF New Autom	ation Technology				Online AxisRea	dy 📴 🛃 🕼	NC: Achse 3] [en-US]
	Basic settings	Scaling	Run motor	¢₀ <sup>©</sup> Tune drive	Q Diagnostics	Advanced		
								Reset all
•	Motor		AM8021-0BH0-00	00: Rotary synchronou	s AC motor		Select	Scan Reset
•	Feedback 1		OCT; Rotary; Mul	ti turn RESO: 12 Bit; Sin	gle turn RESO: 24 Bit		Select	Scan Reset
)	Brake							Select
×	Load		J: 0 kgcm <sup>2</sup> ; Feed o	constant: 60 × (1 : 20) =	3 mm / motor rotati	on		
-	Digital IOs							Reset
	Digi	tal I/O	Positive limit switch	Negative limit switch	Probe unit 1	Probe unit 2	Hardware enable	
	Digital inp	out 1 *						
	Digital inp	out 2 *						
	Digital inp	out 3						
	🛑 Digital inp	out 4						
	* this digital in	nput is reserved	for the safety function	L				-

# 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/s<sup>2</sup>. 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.

BECKHOFF New Automation Technology					
🗱 Basic settings	🕘 Scaling 🛛 🕅 F	lun motor	💖 Tune drive	<b>Oiagnostics</b>	
Control loops 🗙	✓ Ch B Modes of operat	ion Cyclic_syn	chronous_position_n	node_CSP (8) V	
	Controller overview   Ve	locity controlle	er   Error reaction/d	rive halt	
	Show accel. and jerk	in configured	NC unit.		
	Error reaction	NC_Handling	(-1) ~		
	Error reaction delay time	0		S	
	Error stop deceleration	360000		°/s²	
	Error stop jerk	0		°/s^3	

## 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	Fault reaction option code	This object shall indicate which action is performed when fault is de- tected in the PDS.
Channel B: 0x685E		
<b>Channel A:</b> 0x3004:01	Error reaction delay time	This object shall indicate the delay time if an error reaction is per- formed in the PDS.
<b>Channel B:</b> 0x3404:01		
Channel A: 0x6085	Quick stop deceler- ation	This object shall indicate the configured deceleration used to stop the motor with fault reaction slow down
Channel B: 0x6885		ramp.
<b>Channel A:</b> 0x3142:02	Quick stop jerk	This object shall indicate the configured jerk used to stop the motor with fault reaction slow down ramp. If the
<b>Channel B:</b> 0x3542:02		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.

Drive 9 (AX8206-0(AM	Drive 9 (AX8206-0(AM8111-0F20-0000) 😕 🗙					
BECKHOFF New Automa	tion Technology				Online AxisReady Op 🗾 [🗠 NC:	Axis 3 AX8] [en-US]
🛱 Basic settings	🖳 Scaling 🛛 🛞 Run mot	or 🛷 Tune drive 🕘 Diagnostics	Advanced			
Slots settings					🗸 Use scaling from description file 🛛 WritableAndReadOnly 💙	All 🗸
Startup list	Command parameter					
Process data	Commutation offset					✓ Start
Parameter list	Parameters activated b	y the selected command				
Device commands	Search parameter:	X Search option	n: 🔽 Show complete st	tructure		
	Index	Name		Actual value	Set value	Expand all
	0x32CE	Ch A Commutation offset command parame	ters			Collapse all
	0x32CE:00	SubIndex 000		7	7	Download
	0x32CE:01	Static current vector: Method		Measure_offset_with_fr	Measure_offset_with_free_movement_check_and_feedback_direction_check (0)	Download
	0x32CE:02	Static current vector: Current level		100 %	100 9	6 Add to watch
	- 0x32CE:03	Static current vector: Current slope		10 000 %/s	10 000 %/	s Add to startup
	- 0x32CE:04	Static current vector: Duration		3 s	3	s Export list
	- 0x32CE:05	Static current vector: Initial moving distance	per pole pair	90 *	90	•
	0x32CE:06	Static current vector: Test sequence moving d	listance per pole pair	90 °	90	•
1	0x32CE:07	Static current vector: Velocity per pole pair		30 °/s	30 °/	s
	- 0x32C0:16	Commutation offset source		feedback_module (0)	feedback_module (0)	
1	0x32C1:0B	Actual commutation offset		0 *		•
1	- 0x32C1:0C	Is commutation offset valid		True (1)		
	0x32C0:0E	Commutation offset		0 *	0	•
L						

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.

# Commutation

Drive 9 (AX8206-0(AM80	021-0BH0-0000) ↔ ×				
BECKHOFF New Automatic	ion Technology			Online AxisReady Op 🗾 [🕰 NC: A	xis 3 AX8] [en-US]
C Rasic settings	Scaling @ Run mot	or 🏘 Tune drive 🚱 Diagnostics 🗢 Adva	nced		
We busic sectings	Stanny O Ran more				All
Slots settings	<b>c</b>			Se scaling from description file WhitableAndreadOnly	- All
Startup list	Command parameter				
Process data	Commutation offset				✓ Start
Darameter list	Parameters activated by	y the selected command			
T didificater hist					
Device commands	Search parameter:	X Search option: M Show	w complete structure		
	Index	Name	Actual value	Set value	Expand all
	- 0x32CE	Ch A Commutation offset command parameters			Collapse all
	- 0x32CE:00	SubIndex 000	7	7	Download
	- 0x32CE:01	Static current vector: Method	Measure_offset_with_free_movemer	Measure_offset_with_free_movement_check_and_feedback_direction_check (0)	Add to watch
	- 0x32CE:02	Static current vector: Current level	10.000 %	10.000 %	Add to startup
	- 0x32CE:03	Static current vector: Current slope	10 000 76/5	10 000 %/s	Add to startup
	0x32CE:04	Static current vector, butation	9 °	00 °	Export list
	0x32CE:05	Static current vector: Test sequence moving distance p	90 *	90 °	
	0x32CE:07	Static current vector: Velocity per pole pair	30 °/s	30 °/s	
	0x32C0:16	Commutation offset source	motor_parameter_commutation_off	motor_parameter_commutation_offset (1)	
	- 0x32C1:0B	Actual commutation offset	0 *	•	
	0x32C1:0C	Is commutation offset valid	True (1)		
	0x32C0:0E	Commutation offset	0 °	0 °	
	Result				
	Name	Value Unit			
	Raw data	01 00 00 00 A2 AA 00 00			
	Feedback direction	Ok			
	Free Movement	Ok			
	Absolute commutation of	ffset 239.95 °			
	The command 'Commutat	tion offrat' is successfully executed			
	The measured commutation	on offset can be used to set the value in object '0x32C0:0E:C	Ch A Motor parameters / Commutation c	offset'.	
	The measured commutation	on offset can be used to set the value in object '0x32C0:0E:C	.h A Motor parameters / Commutation c	offset".	

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.

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### 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).

Search p	arameter:	x Search option: 🗹 Sho	w complet	te structure
	Index	Name A		Set value
	<ul> <li>0x32CE Ch A Commutation offset command parameters</li> </ul>			
	0x32CE:00	SubIndex 000	7	7
	0x32CE:01	Static current vector: Method	Meas	Check_feedback_direction_and_relative_offset (1)
	0x32CE:02	Static current vector: Current level	100 %	100 %
	- 0x32CE:03 Static current vector: Current slope		1 %/s	10 000 %/s
	0x32CE:04	Static current vector: Duration	3 s	3 s
	0x32CE:05	Static current vector: Initial moving distance per pole p	90 °	90 °
	0x32CE:06	Static current vector: Test sequence moving distance p	90 °	90 °
	0x32CE:07	Static current vector: Velocity per pole pair	30 °/s	30 °/s
-	- 0x32C0:16 Commutation offset source		moto	motor_parameter_commutation_offset (1)
	Ox32C1:0B Actual commutation offset		0 °	•
-	- 0x32C1:0C Is commutation offset valid		True	
	0x32C0:0E Commutation offset		239. °	239.96 °

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  $360^{\circ}/0^{\circ}$  point, resulting in a good range of  $350^{\circ}-359.9^{\circ}$  and  $0^{\circ}-10^{\circ}$ . In most applications, the relative offset will be considerably less.

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# 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 parame-ters	This object contains parameters for commutation offset command.
0x32CE:01	Static current vec- tor: method	This object configures the static current vector method.
0x32CE:02	Static current vec- tor: Current level	This object configures the static current vector current level in percent based on the motor standstill current (0x6075).
0x32CE:03	Static current vec- tor: 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 cur- rent vector: Duration	This object configures the time the constant current vector is applied before the commutation offset is calculated.
0x32CE:05	Static current vec- tor: 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 vec- tor: 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 vec- tor: 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 ac- tual value".
0x32C1:0B	Actual commutation offset	This object displays the actual motor commutation offset. Beckhoff motors use the default value $(0^{\circ})$
0x32C1:0C	Is commutation off- set valid	This object displays if the actual motor commutation offset is valid.
0x32C1:0E	Commutation offset	This object configures the motor commutation offset. Beckhoff mo- tors 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.

	Ŧ	Load 1: 25	kgcm <sup>2</sup> ; Feed constant: 20 × (1 : 10) = 2 mm / motor rotation
I		General	
I		Settings	
I		Movement	S Linear O Rotatory
I	•	NC Feed constant =	Load Gear ratio (load side : motor side)
I	-		
I	•	Load inertia (reflected on motor side)	25 kgcm <sup>2</sup> 🗸 (b) of Kp (0.001589033) Nm/(rad/s) Tn (0.008 s Recalculate VCtrl Kp and reset Tn
I	8	Mechanical torque limit on motor	0.5 Nm 🔽 🖡
I	9	Mechanical speed limit on motor	4000 rpm 🔽 🌀 🙆 🧃
	-		• •

"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.

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# 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	This object indicates the configured maximum bipolar permissible torque/force in the motor. The value shall			
	Value	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 pro- portional gain	This object contains the proportional gain of the velocity controller.			
0x3140:02	Velocity control in- tegral 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.

BECK	(HOFF New Autom	ation Technology				Online AxisRead	s 💀 🛃	[ <mark>2003</mark> NC: Axi	s 3] [en-US]
#	Basic settings	Scaling	Run motor	¢ <sup>©</sup> Tune drive	Oiagnostics	🕈 Advanced			
									Reset all
۲.	Motor		BECKHOFF AM8	021-0D20-0000: Rota	ry synchronous AC mo	otor	Select	Scan	Reset
•	Feedback 1		OCT; Rotary; Mu	lti turn RESO: 12 Bit;	Single turn RESO: 18 Bi	it 🗌	Select	Scan	Reset
)	Brake								Select
Þ	Feedback 2						Select	Scan	Reset
-	Load		J: 25 kgcm²; Feed	i constant: 360 × (1 :	20) = 18 * / motor rot	ation			
	General								
	Settings								
	Movement		⊖ Linear	Rotatory					
	NC Feed cons	tant =	Load 360	•••	Gear ratio (load side	20 ) = 18	° / motor rot	ation 🗎	0
	Load inertia (r	eflected on moto	r side) 25	kgcm² 🗸 🖉	🗊 🛷 📢 Kp 1.178	135 Nm/(rad/s)	Tn 0.008	s	
	Mechanical to	rque limit on mo	tor 1.2525	Nm Y					
	Mechanical sp	eed limit on mot	or 8550	rpm 🗸					

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#### 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.

BEC	KHOFF here Automation Technology		Online AxisReady Dp 🔀 (🖾 NC: Axis 3) (en-US)
*	Basic settings 🙆 Scaling 🛞 I	lun motor 🛯 🕫 Tune drive 🕘 Diagnostics 🗢 Advanced	
			Reset all
۰.	Motor BEC	XHOFF AM8021-0D20-0000: Rotary synchronous AC motor	Select Scan Reset
•	Feedback 1 OC	E: Rotary; Multi turn RESO: 12 Bit; Single turn RESO: 18 Bit	Select Scan Reset
Þ.	Brake		Select
÷	Feedback 2		Select Scan Reset
*	Load 3: 2	kgcm <sup>2</sup> ; Feed constant: 251.1327412 × (1 : 10) = 25.11327412 mm / motor rotation	
	General		
	Settings		
	Movement	S Linear O Rotatory	
	NC Feed constant =	Load         Gear ratio (load side : motor side)           251.132741         mm         X         (1         :         10         )         = 25.11327412 mm / motor rotation	tion; Max NC jog speed = 200 mm /s
	Load inertia (reflected on motor side)	25 kgcm <sup>2</sup> (3) of Kp 1.178135 Nm/(rad/s) Tn 0.008 s	
	Mechanical torque limit on motor	1.2525 Nm ¥	
	Mechanical speed limit on motor	8550 rpm 🗸	

### 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.

Drive	13 (AX8206-0(A	L8021-0E00-0000)* +	×							-
BEC	KHOFF	ation Technology					Offline NotReady	No state	[LCD_NC: As	is 3] [en-US]
4	Basic settings	Scaling @	Run motor	0° Tune drive		Advanced				
										Reset all
۰.	Motor	В	ECKHOFF AL8021	-0E00-0000: Linear	synchronous AC motor			Select	Scan	Reset
۰.	Feedback 1	6	nDat2.2; Linear; Si	ingle turn RESO: 17	Bit; Digital RESO: 368 n	m/INC; Analog RESO: 2	0000 nm/sig. period	Select	Scan	Reset
×.	Brake									Select
×.	Feedback 2							Select	Scan	Reset
*	Load	M	Æ 25 kg: Unit: mm	1						
	General									
	Settings									
	Movement		🕲 Linear 🤇	Rotatory						
			Load							
	Scaling unit =			mm < ;1	Max NC jog speed = 1	0 mm /s				
	Load mass (re	flected on motor side	0 25	kg 🗸 🕫	4					
	Mechanical fo	rce limit on motor	300	N						
	Mechanical sp	eed limit on motor	11	m/s ¥						

# 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.

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#### 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.

BECKHOFF New Automation Technology									
🛱 Basic settings	Scaling	🕲 Run motor	🎄 Tune drive 🛛 🕀 Diagnosti		Advanced				
A new "Drive Settings" selection area opens.									

BECKHOFF New Automa	tion Technology		Offline NotReady No state 🗾 [🕰 NC: Axis 1] [en-US]							
🗱 Basic settings	Scaling	Run motor	🍪 Tune drive	🕀 Diagnostics	Advanced					
Drive settings										
Drive rotational positio	Drive rotational position resolution 4294967296 (2 <sup>12</sup> ) 💙 Inc / motor rotation									
∧ Drive modulo settir	igs (j)									
Modulo data sto	rage source: Fee	dback1 🗸								
Modulo value:	50	mm => 42949	67296 Inc							
V Drive position offse	t settings (j)									
NC-Parameter setti	ngs									
Linear movement	O Rotatory mo	ovement								
	.oad	G	iear ratio (load side : n	notor side)						
NC Feed constant =	60	mm 🖌 x (	1 :	1 ) = <b>60 m</b>	<b>nm / motor rotation</b> ; Max m	nove distance =	n	nm		

#### Activate function

Drive settings	
Drive rotational position resolution 4294967296 (2 <sup>22</sup> ) V	Inc / motor rotation
∧ Drive modulo settings (j)	
Modulo data storage source: Feedback1 🗸	
Modulo value: 60 mm => 4294	967296 Inc

► Select the "Modulo data storage source"

#### Observe the setting options:

Selection	Setting
Feedback 1	Memory source connected feed- back 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	Position range limit	This object shall indicate the configured maximal and minimal posi-				
0x607B		tion range limits. It shall limit the numerical				
Channel B		range of the input value.				
0x687B						
Channel A	Modulo Data stor-	Store modulo remainder cyclic and powersafe.				
0x3000:08	age					
Channel B						
0x3400:08						
Channel A	Gear ratio	This object shall indicate the configured number of motor shaft revo-				
0x6091		lutions and number of driving shaft revolutions.				
Channel B						
0x6891						

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

Reading out the data sets

#### 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  $[t_{\text{NC}}]$
- Gearing factor [i]
- Modulo Value [Modulo value<sub>load</sub>]. The Modulo Value corresponds to the Feed Constant and can be taken from Drive Manager 2.



## 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 2

Determine axis position

The first switch-off point is at 12.5 motor revolutions or 2 application revolutions +  $180^{\circ}$ . The encoder provides the value correctly after the machine is switched on again.

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.

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.



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## **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 <u>here</u>.

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

Tw	TwinCAT Project Oversampling AX8000 🗧 🗙											
	General EtherCAT DC Proces			Proces	s Dat	a Plc	Slots	Startup	CoE - Online	AoE - Online	Diag History	Online
	Sync M	anager:			P	DO List:						
	SM	Size	Туре	Flags		Index	Size	Name			Flags	SM
	0	512	MbxOut			0x1B03	0.0	Ch A I	nterpolator Dyn	amic Inputs		
	1	512	MbxIn			0x1623	4.0	Ch A I	nterpolator Outp	outs		2
	2	18	Outputs			0x1703	0.0	Ch A I	nterpolator Dyn	amic Outputs		
	3	26	Inputs			0x1A26	4.0	Ch A F	ositionControl I	nputs		3
	4	0	DynO			0x1B06	0.0	Ch A F	ositionControl I	Dynamic Inp		
	5	0	DynIn			0x1626	0.0	Ch A F	ositionControl (	Outputs		
						0x1706	0.0	Ch A F	PositionControl I	Dynamic Ou		
						0x1A2A	0.0	Ch A \	/elocityControl I	nputs		
						0x1B0A	0.0	Ch A \	/elocityControl I	Dynamic Inp		
						0x162A	0.0	Ch A \	/elocityControl (	Outputs		
						0x170A	0.0	Ch A \	/elocitvControl	Dvnamic Ou		
						0x1A32	0.0	Ch A T	ForqueControl Ir	nputs		3
						0x1B12	0.0	Ch A 1	ForqueControl E	ynamic Inp		
						0x1632	0.0	Ch A 1	ForqueControl C	Outputs		

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.

UX IBUA	0.0	Ch A velocityControl Dynamic in	ip
0x162A	0.0	Ch A VelocityControl Outputs	
0x170A	0.0	Ch A VelocityControl Dynamic O	u
0x1A32	0.0	Ch A TorqueControl Inputs	3
0x1B12	0.0	Ch A TorqueControl Dynamic In	D
0x1632	0.0	Ch A TorqueControl Outputs	
0x1712	0.0	Ch A TorqueControl Dynamic Ou	.t
0v1A36	0.0	Ch A Svnc Serva Matar Innuts	
PDO Con	tent (0x1A3	):	
Index	Size	Offs Name	Туре
		0.0	
	0x160A 0x162A 0x170A 0x1A32 0x1812 0x1632 0x1712 0x1436 PDO Con Index	0x160A         0.0           0x162A         0.0           0x170A         0.0           0x132         0.0           0x1812         0.0           0x1632         0.0           0x1712         0.0           0x1336         0.0           0x1436         0.0           0x1438         0.0           0x164         0.0	0x162A       0.0       Ch A VelocityControl Dynamic in         0x162A       0.0       Ch A VelocityControl Outputs         0x170A       0.0       Ch A VelocityControl Dynamic O         0x1A32       0.0       Ch A VelocityControl Dynamic O         0x1B12       0.0       Ch A TorqueControl Dynamic In         0x1632       0.0       Ch A TorqueControl Dynamic In         0x1632       0.0       Ch A TorqueControl Dynamic In         0x1632       0.0       Ch A TorqueControl Dynamic Outputs         0x1712       0.0       Ch A TorqueControl Dynamic Outputs         0x1A36       0.0       Ch A Sync Servo Motor Inputs         PDO Content (0x1A32):       Index       Size       Offs       Name         0.0       0.0       D       D       D       D

Right-click "PDO Content"

A new dialog box opens.

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*1	Add New Item	6	Ctrl+Shift+A
$\sim$	Delete		Del
	Edit		
•	Print		Ctrl+P
	Move Up		
	Move Down		

#### Left-click "Add New Item"

#### A new dialog box "Edit PDO Entry" opens

Edit Pdo Entry			×			
Name:	TorCtrl torque/force actual	value	OK			
Index (hex):	3241 1286	<u> </u>	Cancel			
Sub Index:	9					
Data Type:	REAL	$\sim$				
Bit Lentgh:	32					
Show only o	bjects from related module					
From Dictionary:						
0x3241:01 - VeloCtrl torque/force demand value 0x3241:02 - Feed forward torque/force demand value 0x3241:03 - Limited torque/force demand value 0x3241:04 - Filtered torque/force demand value 0x3241:05 - Reserved 0x3241:06 - Torque ctrl statusword 0x3241:07 - Reserved						
0x3241:08 - Neg torque/force limit effective 1						
Ux3241:0A - Deceleration torque/force limit actual 0x3241:0B - Additional VeloCtrl torque/force demand value 0x3241:0C - Cogging compensation torque demand value 0x3242:01 - Iq TorqueProportional demand						

- 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  $\mu s.$  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<sup>n</sup>

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

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# **11.4 PLC integration**

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

Solution Explorer	Right-click "Task"	
○ ○ 🏠 🗄 -   <sup>*</sup> ⊙ - @   🌶 🗕   →  -	► Left-click "Add New Item"	
Search Solution Explorer (Ctrl+ü)		
Search Solution Explorer (Ctrl+a) Solution TwinCAT Project12 (1 project) Solution TwinCAT Project12 Search Solution TwinCAT Project12 Search Solution TwinCAT Project12 Search Solution TwinCAT Project12 Search Solution TwinCAT Project Search Solution TwinCAT Project Proj	<ul> <li>Left-click "Add New Item"</li> <li>Select "Task with image" [1], give it a "OK" [2]</li> </ul>	name and confirm with
Type TwinCAT Task TwinCAT Task With Image TwinCAT Job Task (Worker Task) TwinCAT Fast Cycle Task TwinCAT Virtual Task Solution Explorer Solution Explorer Sol	<ul> <li>Right-click "Input"</li> <li>Left-click "Add New Item"</li> </ul>	
Search Solution Explorer (Ctrl+ü)		
Solution TwinCAT Project12 (T project)	Insert Variable	
<ul> <li>✓ SYSTEM</li> <li>✓ License</li> <li>✓ Real-Time</li> <li>✓ Tasks</li> <li>✓ Task 3</li> <li>✓ Image</li> </ul>	General Name: Var 1 Multiple Start Address: Byte: 0 🗣 Bit:	Cancel
Add New Item Ins	Data Type	>Size Name Space 🔥
Task Recalc Addresses	OTCID	4
Task 5	PTCGP	4
NQ	PTCID	4
	REAL ST. AVEOOD, P. 0150, FeedBackOntion	4
	ST_AX5000_P_0401	4 A×5000

TcFileFindHandle

TcFileHandle

TCOM\_STATE

TCPIP\_EVENT

ToTropollo

Search Type:

TcSourceInfoType

<del>-</del>67

Create String Type.

4

4

4

4

4

Create Array Type

2

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

Create Array Type	Define "Arr	ray" size [1] and confirm	m with "Oł	<" [2]
Base Type: REAL				
2         0         •          0         •         New OF           3         0         •          0         •         New OF				
New Type: ARRAY [03] OF REAL				
OK				
Insert Variable General Nama: Start Address: Byte: 16  Bit: 0	<ul><li>Select the</li><li>Confirm wi</li></ul>	created "Array Type" a th "OK" [2]	and issue a	a name [1]
Data Type         >Size         Name Space           UNESTRUCT_OVENCOUT         12         TcUne           ST_AX5000_P.0160_Manufacturet.imt95ettings         12         AX5000           ST_AX5000_P.0160_Manufacturet.imt95ettings         12         AX5000           ST_AX5000_P.0261         12         AX5000           ST_AX5000_P.0261         12         AX5000           ST_AX5000_P.0261         12         AX5000           ST_AX5000_P.0272         12         AX5000           ToisnoLevelinfo         12         TComintDataHdr           TCSensitedSourceInfloType         12         Streating(13)           StatikG(13)         14         FSOE_16         Safety           ARRAY[0.5] OF REAL         16         V           Ausen         te         V				
Solution Explorer V V X	► In the Solu	tion Explorer, left-click	"Array" el	ement
Image: Search Solution Explorer (Ctrl+0)	TwinCAT Project12	2 ⇔ X		
Solution 'TwinCAT Project12' (1 project)	Variable Flags	Online		
IwinCAT Project12     SYSTEM	Name:	Torque Array[0]		
License  Real-Time	Type:	REAL ({18071995-0000-0000-0	000-00000000	000D})
Tasks	Group:	Inputs	Size:	4.0
→ lask 3 → lask 3 → lask 3 → lask 3 → lask 3	Address:	0 (0x0)	User ID:	0
Inputs     Torgue Array	Linked to			
Torque Array[0]	Commont	``		
Torque Array[1]	Commenc			
Torque Array[3]				
Task 4				
	ADS Info:	Port: 301, IGrp: 0x3040010, IOff	s: 0x8000000	), Len: 4
	Full Name:	TIRT*Task 3*Inputs*Torque Arra	ay[0]	

► Left-click "Linked to"

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► 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.

BEC	KHOFF New Autom	ation Technology	Onl	ine NotReadyWith	Error Op 才	[ 🖾 No linke	d NC/CNC axis	en-U
*	Basic settings	Scaling	🕸 Tune drive	🕂 Diagnostics	숙 Advance	d		
							Rese	et all
Þ	Motor		AM8021-0BH0-00 motor	000: Rotary synchrono	us AC	select Se	can Re	eset
۲	Feedback 1		OCT; Rotary; Multi RESO: 24 Bit	i turn RESO: 12 Bit; Sir	ngle turn	Select	can Re	eset
Þ	Brake						Se	lect
Þ	Feedback 2				S	Select	can Re	eset
-	Load		J: 0 kgcm <sup>2</sup> ; Feed c	onstant: 10 mm / mot	tor rotation			
	General							
	Settings							
	🕥 Linear mo	vement 🔿 Rota	tory movement					
		Load		Gear ratio (load side	: motor side)			
	Feed constant	= 10	mm 🗸 x	( 1 :	1)=	= 10 mm / moto	or rotation	
			r					

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

# Second feedback

BEC	KHOFF New Autom	ation Technology	Online NotReadyWithError O	p 🛛 (	🖾 No I	inked NC/C	NC axis] [en-U
*	Basic settings	Scaling	🕸 Tune drive 🛛 🕀 Diagnostics 🕈 A	dvanced			
							Reset all
Þ	Motor		AM8021-0BH0-0000: Rotary synchronous AC motor	Sele	ect	Scan	Reset
•	Feedback 1		OCT; Rotary; Multi turn RESO: 12 Bit; Single turn RESO: 24 Bit	Sele	ect	Scan	Reset
Þ	Brake						Select
F	Feedback 2			Sele	ct	Scan	Reset

#### Select the feedback and confirm with OK.

Select a feedback	- 🗆 X
Filter settings	Search feedback:
Vendor	Selection
Function O rotary Iinear	<ul> <li>AMO</li> <li>Heidenhain</li> <li>Heid#EnDat2.2 Heid#AT3017-E2.2 (Single turn RESO: 17 Bit; Digital RESO: 368 nm/INC; Analog RESO: 20000 nm/sig. period)</li> </ul>
Absolute interface	Heid#AT3018-E2.2 (Single turn RESO: 18 Bit; Digital RESO: 368 nm/INC; Analog RESO: 20000 nm/sig. period)
Absolute interface  EnDat2.2  BiSS C unidirectional	Heid#LIC21xx-E2.2-50nm (Single turn RESO: 32 Bit; Digital RESO: 50 nm/INC; Analog RESO: 20000 nm/sig. per Heid#LIC21xx-E2.2-100nm (Single turn RESO: 32 Bit; Digital RESO: 100 nm/INC; Analog RESO: 20000 nm/sig. p Heid#LIC40xx-E2.2-1nm (Single turn RESO: 36 Bit; Digital RESO: 1 nm/INC; Analog RESO: 1000 nm/sig. period) Heid#LIC40xx-E2.2-5nm (Single turn RESO: 36 Bit; Digital RESO: 5 nm/INC; Analog RESO: 1000 nm/sig. period) Heid#LIC40xx-E2.2-10nm (Single turn RESO: 36 Bit; Digital RESO: 1 nm/INC; Analog RESO: 1000 nm/sig. period) Heid#LIC41xx-E2.2-10nm (Single turn RESO: 36 Bit; Digital RESO: 1 nm/INC; Analog RESO: 1000 nm/sig. period) Heid#LIC41xx-E2.2-10nm (Single turn RESO: 36 Bit; Digital RESO: 1 nm/INC; Analog RESO: 1000 nm/sig. period) Heid#LIC41xx-E2.2-5nm (Single turn RESO: 36 Bit; Digital RESO: 5 nm/INC; Analog RESO: 1000 nm/sig. period) Heid#LIC41xx-E2.2-10nm (Single turn RESO: 36 Bit; Digital RESO: 1 nm/INC; Analog RESO: 1000 nm/sig. period) Heid#LIC41xx-E2.2-10nm (Single turn RESO: 36 Bit; Digital RESO: 1 nm/INC; Analog RESO: 1000 nm/sig. period) Heid#LIC41xx-E2.2-10nm (Single turn RESO: 32 Bit; Digital RESO: 1 nm/INC; Analog RESO: 20000 nm/sig. period Heid#LC115-5V-2E2-5u (Single turn RESO: 32 Bit; Digital RESO: 1 nm/INC; Analog RESO: 20000 nm/sig. period Heid#LC415-5V-2E2-5u (Single turn RESO: 32 Bit; Digital RESO: 10 nm/INC; Analog RESO: 20000 nm/sig. perio Heid#LC415-5V-2E2-5u (Single turn RESO: 32 Bit; Digital RESO: 1 nm/INC; Analog RESO: 20000 nm/sig. perio Heid#LC415-5V-2E2-5u (Single turn RESO: 32 Bit; Digital RESO: 1 nm/INC; Analog RESO: 20000 nm/sig. perio
	>
	Ok Cancel

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.

🧧 Axis	main builder	- 0	$\times$							
Click	Click Ok to accept the settings									
	Name	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	1000000	~					
				Ok Can	cel					

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

BECKHOFF New Automation Technology								
🗱 Basic settings	Scaling	Run motor	🕸 Tune drive	👧 Diag	nostics 🛛 숙 A	dvanced		
NC-Parameter settings								
S Linear movement O Rotatory movement								
NC Feed constant =       10       mm       x       (1       :       1       )       = 10 mm / motor rotation ; Max move distance =								
Invert NC-Encoder counting direction Invert NC-Drive motor polarity								
Suggested default pa	rameter settings	for the linked NC-axi	s 🚺 🗎 Save N	IC paramete	ers			
Parameter			Online value	IsSelected	Current value	Current unit	New value	
Scale factor numerat	or			$\checkmark$	10		0.001	
Scale factor denomin		$\checkmark$	1048576		1000			
Encoder mask				$\checkmark$	4294967295		4294967295	
Encoder sub mask				$\checkmark$	1048575		9999999	
Invert encoder count		$\checkmark$	False		False			
Invert motor polarity				$\checkmark$	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*.

BEC	KHOFF New Autom	ation Technology				
*	Basic settings	Scaling	🛞 Run motor	¢ <sup>☆</sup> Tune drive	🕂 Diagnostics	숙 Advanced
•	Motor		AM8021-0BH0-000	0: Rotary synchrono	us AC motor	
•	Feedback 1		OCT; Rotary; Multi ti	urn RESO: 12 Bit; Sir	ngle turn RESO: 24 Bit	
۶.	Brake					
Ŧ	Feedback 2		EnDat2.2; Linear; Sir	ngle turn RESO: 32 E	Bit; Digital RESO: 1 nm/	INC; Analog RESO: 2
	Function	Overview	Technical Data			
	Informatio	n				
	Info		EnDat2.2; Heid#LC415	5-5V-2E2-3u; Linear	; Single turn RESO: 32 E	Bit; Digital RESO: 1 n
	Serial number	r				
	Connector		ConnectorFront_Corre	espondingToDriveC	hannel 🗸	
	Invert fee	dback direction				

#### **A** 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

BECKHOFF New Automation Technology	Online N
🗱 Basic settings 🕘 Scaling 🐵 Run motor 🔅 Tune drive	Oliagnostics
Slots settings	Use scaling from descript
Startup list	osition_mode_secondary_feedback_CSP2 (-1)
Process data PDOs 🕑 🖬 🗸 Flat list Search PDOs:	X
Parameter list V Outputs	
Device commands	
Actual motor brake current (0x3401:01)	→ Position actual value invalid (0x683E:02)
IGBT temperature (0x3401:02)	1st Additional position actual value invalid (0x683E:03)
Missing output cycle counter increments (0x34	01:03) Ch B Statusword (0x6841:00)
Output stage safety state (0x3401:04)	Ch B Position actual value (0x6864:00)
Dyninput cycle counter (0x3401:05)	1st additional position actual value (0x68E4:01)
Missing dynoutput cycle counter increments (0	x3401:06) Ch B Following error actual value (0x68F4:00)

# 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:

BECKHOFF New Aut	tomation Technology						
Basic settings	🖳 Scaling 🛛 🤅	Run motor	🔅 Tune drive	🕀 Diagnostics	Advanced		
Control loops 🗙	✓ Ch B Modes of ope	eration Cyclic_sy	nchronous_position_	mode_CSP (8) 🗸	Info: change the operation mode	e will modify the process data on t	he mode of Flexible 💙 and rel
Auto tuning	Controller overview	Current controlle	er 🕨				
5	X Tff	<u>&gt;</u>		]		Current controller	
4	T set add.			5			
	T set						

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# 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	Modes of operation	This object shall indicate the requested operation mode.			
0x6060					
Channel B					
0x6860					
Channel A	Modes of operation	This object shall provide the actual operation mode.			
0x6061	displayed				
Channel B					
0x6861					
Channel A	VeloCtrl torque/	This object indicates the torque/force controller demand value from			
0x3241:01	force	the velocity controller			
Channel B					
0x3641:01					
Channel A	Target torque/force (T set)	This object shall indicate the configured input value for the torque/			
0x6071:00		force controller. The value shall be given per thousand of motor			
Channel B					
0x6871:00					
Channel A	Torque/force offset	This object shall provide the offset for the torque/force value. The			
0x60B2:00	(T set add.)	offset shall be given in per thousand of motor			
Channel B		standstill torque/force. In cyclic synchronous position mode and cyclic synchronous velocity mode, this object			
0x0002.00		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	Interpolated accel-	This object indicates the torque/force controller demand value from			
0x3061:03	eration demand value (T ff)	the interpolator.			
Channel B					
0x3461:03					
Channel A	Motor standstill	This object indicates the motor standstill torque (M0)/force (Fc).			
0x6076:00	torque	If an electronic datasheet of the motor is available			
Channel B		"Standstill current" (I0) will be multiplied by the torque constant (Kt)/			
0x6876:00		(KI). The value is scaled to minm/min.			

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# **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

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

## 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

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

### **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

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

### 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

BECKHOFF New Aut	omation Technology					Offline NotRea	dy No state	🔽 [🚓 NC: A	xis 3] [en-l	US
Basic settings	Scaling	Run motor	🚓 Tune drive	<b>O</b> Diagnostics	Advanced					
Control loops 🗙	✓ Ch A Modes o	f operation Cyclic_sy	nchronous_position	_mode_CSP (8) 🗸	Info: change the operati	on mode will modify the	process data	on the mode of [	lexible 🗸	an
Auto tuning	Controller overvie	ew     Current controll	er 🕨 <u>Torque comma</u>	nd value filter						

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

Controller overview + Current controller + Torque com					
Filter 0 +			<u> </u>		
Notch			2		~
Frequency	10		Hz	$\sim$	
Bandwidth	10		Hz	$\sim$	
Depth [dB]	20				3
Result parame	ters:				
Filter type		Notch	filter (5)	$\sim$	
Low pass frequ	uency	10		Hz	
Low pass damping		0.5			
High pass frequency		10		Hz	:
High pass damping		0.05			

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.

BECKHOFF New Aut	nation Technology Offline NotReady No state 🗾 [🕰 NC: A	is
Section Sectio	Scaling 🛞 Run motor 🛷 Tune drive 😋 Diagnostics 🗢 Advanced	
Control loops	Ch A Modes of operation Cyclic_synchronous_position_mode_CSP (8)	exi
Auto tuning	Controller overview   Controller   Controlle	
	Current controller	
	Tet Filter Forum Torque force demand value Tact	

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.

BECKHOFF New Automatic	on Technology		
🗱 Basic settings	🕘 Scaling 🛛 🛞 Run moto	or 🕸 Tune drive 🕀 Diagnostics 🗖	Advanced
Slots settings $\times$			Vse scaling fro
Startup list	Search parameter: torque ct	rl 🛛 🗙 Search option: 🗸	Show complete stru
Process data	Index	Name	Actual value
	- 0x3241	Ch A TorqueCtrl actual values	
Parameter list	- 0x3241:00	SubIndex 000	12
Device commands	- 0x3241:01	VeloCtrl torque/force demand value	0 Nm
	- 0x3241:02	Feed forward torque/force demand value	0 Nm
	- 0x3241:03	Limited torque/force demand value	0 Nm
	- 0x3241:04	Filtered torque/force demand value	0 Nm
	0x3241:05	Reserved	0
	- 0x3241:06	Torque ctrl statusword	0
	- 0x3241:07	Pos torque/force limit effective	1.082958 Nm
	- 0x3241:08	Neg torque/force limit effective	-1.082958 Nm
		TorCtrl torque/force actual value	0.00437825 Nm
	- 0x3241:0A	Deceleration torque/force limit actual	1.565527 Nm
	- 0x3241:0B	Additional VeloCtrl torque/force demand value	0 Nm
	0x3241:0C	Cogging compensation torque demand value	-0.0043782 Nm

#### 13.7.1 Object description

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

# 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	luvw 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.

$$\tau = 5s \frac{-1}{Ln\left(1 - \frac{Configured channel thermal rated current (3243:0B)}{channel peak current 0x3243:04}\right)}$$
$$t_DemandCurrent = \Im * Ln\left(1 - \frac{Configured channel thermal rated current (3243:0B)}{Demand Current}\right) * -1$$



Calculation example 1 AX8118 and a supplied current of 22 A

$$T_{\rm L} = 5s \frac{-1}{\ln\left(1 - \frac{\rm Configured channel thermal rated current (3243.0B)}{\rm channel peak current 0x3243:04}\right)} = 5s \frac{-1}{\ln\left(1 - \frac{128A}{40A}\right)} = 8,363s$$

$$t_{\rm Demand Current} = T_{\rm e} + \ln\left(1 - \frac{\rm Configured channel thermal rated current (3243.0B)}{\rm Demand Current}\right) * -1 = 8,363s * Ln\left(1 - \frac{18A}{22A}\right) * -1 = 14,26s$$



#### **Calculation example 2**

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

$$T_{\rm b} = 5s \frac{-1}{\ln\left(1 - \frac{Configured channel thermal rated current (324308)}{Channel peak current 0x3243:04}\right)} = 5s \frac{-1}{\ln\left(1 - \frac{8A}{20A}\right)} = 9,788s$$

$$t_{\rm b} = 9,788s + \ln\left(1 - \frac{Configured channel thermalested current (324308)}{Demand Current}\right) * -1 = 9,788s * \ln\left(1 - \frac{8A}{13A}\right) * -1 = 9,35s$$

#### 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.

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# 14.4 Object description

CoE object	Designation	Description
0x3242:0B	Irms actual	Internal current value
0x3243:0B	Configured channel thermal rated cur- rent	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 cur- rent	This read only object indicates the maximal channel rated current. This value dependents on the mains voltage and the PWM fre- quency.
0x3243:04	Channel Peak Cur- rent	This read only object indicates the maximal channel peak current. This value dependents on the mains voltage and the PWM fre- quency.

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