maxon motor control

**MAXPOS Positioning Controllers** 

**Application Notes** 

**Edition July 2015** 



**Positioning Controllers** 

**Application Notes** 



Document ID: rel3986

### PLEASE READ THIS FIRST

The present document represents a compilation of helpful "Good-to-Knows" that might come in handy in your daily work with MAXPOS Positioning Controllers.

The individual chapters cover particular cases or scenarios and are intended to give you a hand for efficient setup and parameterization of your system.



#### We strongly stress the following facts:

- The present document does not replace any other documentation covering the basic installation and/ or parameterization described therein!
- Also, any aspect in regard to health and safety, as well as to secure and safe operation are not covered in the present document – it is intended and must be understood as complimenting addition to those documents!

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### 1 About this Document

### 1.1 Intended Purpose

The purpose of the present document is to provide you specific information to cover particular cases or scenarios that might come in handy during commissioning of your drive system.

Use for other and/or additional purposes is not permitted. maxon motor, the manufacturer of the equipment described, does not assume any liability for loss or damage that may arise from any other and/or additional use than the intended purpose.

The present document is part of a documentation set. Please find below an overview on the documentation hierarchy and the interrelationship of its individual parts:



Figure 1-1 Documentation Structure

### 1.2 Target Audience

This document is meant for trained and skilled personnel working with the equipment described. It conveys information on how to understand and fulfill the respective work and duties.

This document is a reference book. It does require particular knowledge and expertise specific to the equipment described.

#### 1.3 How to use

Take note of the following notations and codes which will be used throughout the document.

Notation	Explanation
«Abcd»	indicating a title or a name (such as of document, product, mode, etc.)
¤Abcd¤	indicating an action to be performed using a software control element (such as folder, menu, drop-down menu, button, check box, etc.) or a hardware element (such as switch, DIP switch, etc.)
(n)	referring to an item (such as order number, list item, etc.)
<b>→</b>	denotes "see", "see also", "take note of" or "go to"

 Table 1-1
 Notations used in this Document

In the later course of the present document, the following abbreviations and acronyms will be used:

Short	Description		
CiA	CAN in Automation		
CoE	CAN Application Protocol over EtherCAT		
CSP	Cyclic Synchronous Position Mode		
CST	Cyclic Synchronous Torque Mode		
CSV	Cyclic Synchronous Velocity Mode		
ESI	EtherCAT Slave Information (EtherCAT Device Description)		
ESM	EtherCAT State Machine		
ETG	EtherCAT Technology Group		
FoE	File Access over EtherCAT		
MAXPOS	MAXPOS Positioning Controller		
PDO	Process Data Object		
PPM	Profile Position Mode		
PVM	Profile Velocity Mode		
SDO	Service Data Object		
STO	Save Torque Off		
Table 1-2	Abbreviations & Acronyms		

### 1.4 Symbols and Signs

In the course of the present document, the following symbols and sings will be used.

Туре	Symbol	Meaning		
	(typical)	DANGER	Indicates an <b>imminent hazardous situation</b> . If not avoided, it <b>will result in death or serious injury</b> .	
Safety Alert		WARNING	Indicates a <b>potential hazardous situation</b> . If not avoided, it <b>can result in death or serious injury</b> .	
		CAUTION	Indicates a <b>probable hazardous situation</b> or calls the attention to unsafe practices. If not avoided, it <b>may result in injury</b> .	
Prohibited Action	(typical)	Indicates a dangerous action. Hence, <b>you must not</b> !		
Mandatory Action	(typical)	Indicates a mandatory action. Hence, <b>you must</b> !		
	!	Requirement / Note / Remark	Indicates an activity you must perform prior continuing, or gives information on a particular item you need to observe.	
Information		Best Practice	Indicates an advice or recommendation on the easiest and best way to further proceed.	
	**	Material Damage	Indicates information particular to possible damage of the equipment.	

Table 1-3 Symbols & Signs

#### 1.5 Trademarks and Brand Names

For easier legibility, registered brand names are listed below and will not be further tagged with their respective trademark. It must be understood that the brands (the below list is not necessarily concluding) are protected by copyright and/or other intellectual property rights even if their legal trademarks are omitted in the later course of this document.

Brand Name	Trademark Owner		
BiSS	© iC-Haus GmbH, DE-Bodenheim		
EnDat	© DR. JOHANNES HEIDENHAIN GmbH, DE-Traunreut		
EtherCAT®	© EtherCAT Technology Group, DE-Nuremberg, licensed by Beckhoff Automation GmbH, DE-Verl		
Sendix	© Fritz Kübler GmbH, DE-Villingen-Schwenningen		
Sysmac	© OMRON Corporation, JP-Kyoto		
TwinCAT®	© Beckhoff Automation GmbH, DE-Verl		
Windows®	© Microsoft Corporation, USA-Redmond, WA		
Table 1-4 Bran	d Names and Trademark Owners		

maxon motor control MAXPOS Positioning Controllers MAXPOS Application Notes

#### **1.6** Sources for additional Information

Find the latest edition of the present document as well as of additional documentation and software on the Internet: →maxpos.maxonmotor.com

For further details and additional information, please refer to below listed sources:

#	Reference			
[1]	BiSS-C specifications ➔www.ichaus.de			
[2]	ETG.1000: EtherCAT Specification →www.ethercat.org			
[3]	USB Implementers Forum: Universal Serial Bus Revision 2.0 Specification: →www.usb.org/developers/docs/usb20_docs/			
[4]	Manufacturer-specific USB protocol: →www.microchip.com/mcp2210/			
[5]	IEC 61158-x-12: Industrial communication networks – Fieldbus specifications			
[6]	IEC 61800-7: Adjustable speed electrical power drives systems			
[7]	maxon motor: MAXPOS Firmware Specification →maxpos.maxonmotor.com			
[8]	Dr. Urs Kafader: The selection of high-precision microdrives ISBN 978-3-9520143-6-3 ➔academy.maxonmotor.com			
Table 1-5	Sources for additional Information			

#### 1.7 Copyright

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# 2 Communication Guide

### 2.1 In Brief

#### OBJECTIVE

The present application note explains the MAXPOS communication interfaces.

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2.2 Functionality	2-9
2.3 EtherCAT Interface	2-9
2.4 Integration of ESI Files	. 2-12
2.5 USB Interface	. 2-12
2.6 Error Code Definition	. 2-12

### 2.2 Functionality

MAXPOS controllers are commanded by an EtherCAT Master. The USB interface is used for configuration only.

### 2.3 EtherCAT Interface

The MAXPOS Positioning Controllers' implementation of EtherCAT follows the EtherCAT Technology Group (ETG) specifications.



#### Reference

You may access all relevant data and the free-for-download documentation (available in different languages) from the EtherCAT website (→http://ethercat.org/). Navigate to downloads section and search for the document "EtherCAT Technology Introduction".

The document "EtherCAT\_Introduction\_xxxx.pdf" will serve well as an introduction to EtherCAT and does include information on the technology, implementation, and possible applications.

For MAXPOS firmware and hardware, consult maxon motor's comprehensive documentation set available at →http://maxpos.maxonmotor.com. Among others, you will find the following documents:

#### **MAXPOS FIRMWARE SPECIFICATION**

- Operating modes
- Communication and error handling
- Object dictionary
- etc.

#### MAXPOS HARDWARE REFERENCE

- Technical data
- Wiring diagrams and connection overview
- etc.

#### 2.3.1 Communication Specifications

Торіс	Description		
Applicable Communication Standards	IEC 61158 Type 12 EtherCAT Slave CoE (CAN Application Layer over EtherCAT) according to IEC 61800-7 Profile Type 1 (CiA 402) CANopen-Standard Device Profile for Drives and Motion Control		
Physical Layer	IEEE 802.3 100 Base T (100 Mbit/s, Full Duplex)		
Fieldbus Connection	X9 (RJ45): EtherCAT Signal IN X10 (RJ45): EtherCAT Signal OUT		
SyncManager	SM0: Mailbox output SM1: Mailbox input SM2: Process data outputs SM3: Process data inputs		
FMMU	FMMU0: Mapped to process data output (RxPDO) area FMMU1: Mapped to process data input (TxPDO) area FMMU2: Mapped to mailbox status		
Process Data	Variable PDO mapping		
Mailbox (CoE)	SDO Request, SDO Response, SDO information <i>Note:</i> TxPDO/RxPDO and Remote TxPDO/RxPDO are not supported.		
Distributed Clocks	Free-run, DC mode (can be selected) Supported DC cycle: 100 μs minimal (200 μs typical)		
LED Indicator	EtherCAT Status (green LED / red LED) EtherCAT Port Activity/Link Status (green LED)		

Table 2-6 Communication Specifications

#### 2.3.2 EtherCAT State Machine (ESM)

The EtherCAT State Machine coordinates both Master and Slave during startup and operation. Their interaction (Master  $\leftrightarrow$  Slave) results in changes of states being related to writes to the Application Layer Controlword: AL Ctrl (0x0120).

Upon initialization of Data Layer and Application Layer, the ESM enters "Init" state which defines the Application Layer's root of the communication relationship between Master and Slave. In the Application Layer, no direct communication between Master and Slave is possible. The Master uses "Init" state...

- to initialize a configuration register set and
- to configure the Sync Manager.

Operation of the connected MAXPOS (the Slave) requires its prior initialization by the Master via the ESM. Within the ESM, transitions between certain states must follow a given scheme and will be initiated by the Master. The Slave itself must not execute any transition.

For an overview of the EtherCAT State Machine  $\rightarrow$  Figure 2-2, for further descriptions  $\rightarrow$  as from Table 2-7.



Condition	Description			
Power ON	<ul> <li>MAXPOS is ON</li> <li>MAXPOS autonomously initializes and switches to state "Init"</li> </ul>			
Init	<ul> <li>Master will synchronize the EtherCAT field bus</li> <li>Asynchronous communication between Master and Slave (Mailbox) will be established. At this time, no direct communication (Master n Slave) will yet take place.</li> <li>When all devices have been connected to the field bus and have successfully passed configuration, state will be changed to "Pre-Operational"</li> </ul>			
Pre-Operational	<ul> <li>Asynchronous communication between Master and Slave (Mailbox) will be active.</li> <li>Master will setup cyclic communication via PDOs and necessary parameterization via acyclic communication.</li> <li>Upon successful completion, the Master will change to state "Safe-Operational".</li> </ul>			
Safe-Operational	<ul> <li>Used to establish a safe operation condition of all devices connected to the EtherCAT field bus. Thereby, the Slave sends actual values to the Master while ignoring new setpoint values of the Master and using save default values instead.</li> <li>Upon successful completion, the Master will change to state "Operational"</li> </ul>			
Operational	<ul> <li>Acyclic as well as cyclic communication is active</li> <li>Master and Slave exchange setpoint and actual values</li> <li>MAXPOS be enabled and operated via the CoE protocol</li> </ul>			
Bootstrap	<ul><li>Only FoE is possible (Mailbox)</li><li>Firmware download via FoE</li></ul>			

Table 2-7 EtherCAT State Machine – Conditions

Status Transition	Status		
IP	Start of acyclic communication (Mailbox)		
PI	Stop of acyclic communication (Mailbox)		
PS	Start of cyclic communication (Process Data) Slave sends actual values to Master Slave ignores setpoint values by the Master and uses default values		
SP	Stop of cyclic communication (Process Data) Slave ceases to send actual values to the Master		
SO	Slave evaluates actual setpoint values of the Master		
OS	Slave ignores setpoint values from Master and uses internal default values		
OP	Stop of cyclic communication (Process Data) Slave ceases to send actual values to the Master Master ceases to send actual values to the Slave		
SI	Stop of cyclic communication (Process Data) Stop of acyclic communication (Mailbox) Slave ceases to send actual values to the Master Master ceases to send actual values to the Slave		

Communication Guide Integration of ESI Files

Status Transition	Status		
OI	Stop of cyclic communication (Process Data) Stop of acyclic communication (Mailbox) Slave ceases to send actual values to the Master Master ceases to send actual values to the Slave		
IB	Start Bootstrap Mode Firmware download via FoE (Mailbox)		
BI	Reset device after successful firmware download		

Table 2-8 EtherCAT State Machine – Transitions

Parameter	Address	Bit	Description
Control	0x120	30	0x01: Init Request 0x02: Pre-Operational Request 0x03: Bootstrap Mode Request 0x04: Safe-Operational Request 0x08: Operational Request
Error Acknowledge	0x120	4	0x00: No error acknowledgment 0x01: Error acknowledgment at rising edge
Reserved	0x120	75	-
Application-specific	0x120	158	-

Table 2-9 EtherCAT State Machine – Control Register

### 2.4 Integration of ESI Files

SDOs are used to access the object dictionary. The corresponding interface is CoE. The MAXPOS is described with an XML file bearing the so-called ESI (EtherCAT Slave Information).

For in-detail description and examples on integration into the EtherCAT Master Environment → chapter "3 Integration into EtherCAT Master Environment" on page 3-13.

#### 2.5 USB Interface

The USB interface is used for configuration only, MAXPOS controllers are commanded by an EtherCAT master.

maxon MAXPOS drives' USB interface follows the "Universal Serial Bus Revision 2.0 Specification". You may wish to download the file from the Internet (for URL → page 1-8, item [3]; full details are described in chapter "7.3 Physical Layer").

For further information on manufacturer-specific USB protocol →page 1-8, item [4].

#### 2.6 Error Code Definition

For for detailed information on error codes, device-specific errors, and error handling methodology → separate document «MAXPOS Firmware Specification», chapter "Error Handling".

# 3 Integration into EtherCAT Master Environment

### 3.1 In Brief

#### OBJECTIVE

The present application note explains how to integrate the MAXPOS into several EtherCAT Master Environments by using various tools. Additional Master Environments will follow.

#### CONTENTS

3.2 Beckhoff TwinCAT	 
3.3 Omron Sysmac NJ	 

### 3.2 Beckhoff TwinCAT

### INTEGRATING ESI FILES

To integrate a MAXPOS EtherCAT axis into the Beckhoff Master System, copy the ESI (EtherCAT Slave Information) XML file to the following folder. Note that the actual folder designation (\*\*\*) depends on the TwinCAT version you are using:

- For TwinCAT XAE use path "C:\TwinCAT\\*\*\*3.1\Config\lo\EtherCAT\".
- For TwinCAT2 use path "C:\TwinCAT\lo\EtherCAT\".

#### SCANNING THE ETHERCAT SLAVE DEVICE

- 1) Connect the MAXPOS to the EtherCAT Master and turn on power.
- 2) Open the Beckhoff System Manager and create a new project using menu ¤File¤, then ¤New¤.
- 3) Open menu ¤Options¤, then select ¤Show Real Time Ethernet Compatible Devices¤.



Integration into EtherCAT Master Environment Beckhoff TwinCAT

4) If "Installed and ready to use devices" does not list a network card, you will need to install the EtherCAT driver for one of the present network cards.

a) Click one of the listed network cards.

b) Click ¤Install¤.



Figure 3-4 Integration – Beckhoff TwinCAT | Install Ethernet Adapters

5) In the TwinCAT System Manager navigation tree, click right on ¤I/O Devices¤, then select ¤Scan¤.





6) Click ¤OK¤ to confirm.

HINT: Not :	Il types of devices can be found automatically

Figure 3-6 Integration – Beckhoff TwinCAT | Confirmation

Integration into EtherCAT Master Environment Beckhoff TwinCAT

- 7) All detected E/A devices (network cards) will be listed.
  - a) Tick to select the network card to which the EtherCAT devices are connected to and untick all others.
  - b) Click ¤OK¤.

	W	1
Device 2 (EtherCAT)	[Local Area Connection 2 (ASIX AX88178 USB2.0 to Gigq\DE	OK Cancel
		Select Al
		Unselect #

Figure 3-7 Integration – Beckhoff TwinCAT | New I/O Devices found

8) Click ¤YES¤ to confirm.

Scan for boxes	Cp.
Yes	No



 The TwinCAT System Manager now searches for connected devices. If one or more controller were found, the following message will appear. Click ¤Yes¤.

	13	
EtherCAT drive(s	) added. Append linked axis to NC	-Configuration

Figure 3-9 Integration – Beckhoff TwinCAT | Add Drives Message

- 10) Make your selection depending on the intended use:
  - Click ¤Yes¤ if you plan to use the drive as a NC-Configuration
  - Click ¤No¤ if you do not plan to use the drive a NC-Configuration
- 11) Click ¤Yes¤ to confirm.



Figure 3-10 Integration – Beckhoff TwinCAT | Activate Free Run Message

Integration into EtherCAT Master Environment Beckhoff TwinCAT

12) Save the project.

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File Edit View Project Debug TwinCAT PLC	Tools Window Help										
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🕀 🦉 SYSTEM											
MOTION	Ubject Id: Ju	XU3U2	20001								
NC-Task 1 SVB	Type:	1AXPC	DS 50/5								
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	😤 PositionActualValu	e X	0×00000000 (0)	DINT	4.0	60.0	Input	0	nDataIn1 . In . Inp	uts . E	
	🔁 VelocityActualValu	e	0x00000000 (0)	DINT	4.0	64.0	Input	0			
	TorqueActualValu	3	0x0000 (0)	INT	2.0	68.0	Input	0			
	<ul> <li>ModeUrOperatio.</li> <li>DigitalIpout</li> </ul>		0×00 (0)	LIDINT	4.0	70.0	Input	0			
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	🔁 State		0x0008 (8)	UINT	2.0	1548.0	Input	0			
	📌 . AdsAddr		172.18.66.108.3.1:	AMSADDR	8.0	1550.0	Input	0			
	🔁 Chn0		0×00 (0)	USINT	1.0	1558.0	Input	0			
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Figure 3-11 Integration – Beckhoff TwinCAT | Save Project

### CHANGING OPERATING MODES TO CSP

Via the EtherCAT interface, usually the following operating modes will be used:

- Cyclic Synchronous Position (CSP)
- Cyclic Synchronous Velocity (CSV)
- Cyclic Synchronous Torque (CST)

If you intend to operate the MAXPOS in Cycle Synchronous Mode, you will need to configure PDO Mapping accordingly by defining "Slots".

Additionally, the following "regular" MAXPOS operating modes may be used:

- Profile Position Mode (PPM)
- Profile Velocity Mode (PVM)

13) Upon recognition of the involved axes, the structure tree will be displayed as to the following example.



Figure 3-12 Integration – Beckhoff TwinCAT | Structure Tree

- 14) Use the tab ¤Slots¤ to allocate the operating mode to be used:
  - a) Select a ¤Slot¤ from the left pane.
  - b) Select the desired operating mode from the right pane ¤Module¤.

G	eneral EtherCAT DC Process Data Slots	Startup CoE - Online Di	iag History Online	1
	Slot		Module	Description
	Axis 1	-	CSP Mode	Cyclic Synchronous Position Mode; synchronou
	➡ Module 1 (CSP Mode)		CSV Mode	Cyclic Synchronous Velocity Mode; synchronou
			CST Mode	Cyclic Synchronous Torque Mode; synchronou:
			PPM/PVM Mode	Profile Position Mode/Profile Velocity Mode

Figure 3-13 Integration – Beckhoff TwinCAT | Configuration of Slots

Integration into EtherCAT Master Environment Beckhoff TwinCAT

### VERIFY CSP SETTINGS

15) Enable the Distributed Clock from the MAXPOS.



Figure 3-14 Integration – Beckhoff TwinCAT | Distributed Clock

16) In the Solution Explorer, click on tree item ¤NC-Task 1 SAF¤, then tab ¤Task¤. Set cycle time to 2 ms.

File Edit View Project Debug TwinCAT PLC Tools Window Help	
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Solution Explorer       If X         MAXPOS       If and infine         Image: Info       Image: Info         Image: Info       Image: Info	

Figure 3-15 Integration – Beckhoff TwinCAT | Cycle Ticks

#### CONFIGURATION OF THE AXIS

17) In the Settings tab, verify that ¤Link To I/O...¤ is assigned to the MAXPOS axis (naming is by your choice).

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Image: Solution MAXPOS   Solution MAXPOS   Image: Solution MAXPO	File Edit View Project Build Debug TwinCAT PLC	Tools Scope Window	Help			
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Figure 3-16 Integration – Beckhoff TwinCAT | Axis Link

18) In the Parameter tab, adjust the motor speed settings as to the motor's capability and to the supply voltage.

MAXPOS - Microsoft Visual Studio				
e Edit View Project Build Debug TwinCAT PLC	Tools Scope Window Help			
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}				
Solution 'MAXPOS' (1 project)	General Settings Parameter Dynamics Online Func	tions Coupling Compensation		
MAXPOS	Parameter	Offline Value	Online Value	T Unit
SYSTEM	- Velocities:			
MOTION	Reference Velocity	133.0		F mm/s
NC-Task 1 SVB	Maximum Velocity	133.0		F mm/s
📲 Image	Manual Velocity (Fast)	120.0		F mm/s
Tables	Manual Velocity (Slow)	20.0		F mm/s
⊿ ⊒a Axes	Calibration Velocity (towards plc cam)	2.0		F mm/s
Enc	Calibration Velocity (off plc cam)	2.0		F mm/s
⊳ ⊶I Drive	Jog Increment (Forward)	5.0		F mm
ta Ctrl	Jog Increment (Backward)	5.0		F mm
Inputs	+ Dynamics:			
	+ Limit Switches:			
SAFETY	+ Monitoring:			
6 C++	+ Setpoint Generator:			
▲ <mark></mark>	+ NCI Parameter:			
<ul> <li>E Devices</li> <li>E Device 2 (Ether(AT))</li> </ul>	+ Other Settings:			
Image     Image     Image     SyncUnits     Inputs     InfoIts     InfoIts     InfoIts     InfoIts     InfoIts     InfoIts     InfoIts     NC-Task 1 SAF - Device 2 (EtherCAT) 1     NC-Task 1 SAF - Device 2 (EtherCAT) 1				

Figure 3-17 Integration – Beckhoff TwinCAT | Speed Settings

Integration into EtherCAT Master Environment Beckhoff TwinCAT

> Set Dead Time Compensation to approximately three to four times the set NC-Task SAF Cycle ticks (→ "Verify CSP Settings" on page 3-18; step 16)



Figure 3-18 Integration – Beckhoff TwinCAT | Dead Time Compensation

20) Make sure to set the correct encoder resolution.





- 21) Configure the position control loop as follows:
  - Position control: Proportional Factor Kv  $\rightarrow$  "0.0"
  - Feedforward Velocity: Pre-Control Weighting  $[0.0...1.0] \rightarrow$  "1.0"

CO MAXPOS - Microsoft Visual Studio					
File Edit View Project Build Debug TwinCAT I	PLC Tools	Scope Window Help			
- M · M · M 日 日 日 1 · M · M · M · M · M · M · M · M · M ·	- B.   » [	Release - TwinCAT RT (x86) - 🧭		- 🔊 🕾 🕸 🏷 🔊 🗳 🗆	•
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	•				
Solution Explorer + 4 3	MAXPOS	×			
	General	NC-Controller Parameter Online			
Solution 'MAXPOS' (1 project)					
MAXPOS					
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A NC-Task 1 SAF		Position Lag Monitoring	TRUE	·	
NC-Task 1 SVB		Maximum Position Lag Value	5.0		mm
🚔 Image		Maximum Position Lag Filter Time	0.02		s
Tables		Position Control Loop:			
A area Axes		Position control: Proportional Factor Ky	0.0		mm/s/
AXIS I		Feedforward Velocity: Pre-Control Weighting (0.0	1.0		
⇒ I Drive	+	Other Settings:			
ta Ctrl		one seeings		56	
Inputs					
Outputs					
PLC					
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Devices					
a 🗮 Device 2 (EtherCAT)					
🛔 🖉 Image					
Image-Info					
> Z SyncUnits					
N Outputs					
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Drive 1 (MAXPOS)					
<ul> <li>Mappings</li> </ul>		10 M			
NC-Task 1 SAF - Device 2 (EtherCAT) 1	Do	wnload Upload Expand All Colla	ps All Select All		
NC-Task 1 SAF - Device 2 (EtherCAT) In	nfo				

Figure 3-20 Integration – Beckhoff TwinCAT | Position Control Loop Settings

- 22) In the Parameter tab, set the correct "Output Scaling Factor (Velocity)". Scaling may be calculated as follows:
  - Scaling = 7500 / (Encoder impulse number \* 4)
  - e.g. Encoder with 500 impulse per turn: Scaling = 7500 / (500 \* 4) = 3.75

MAXPOS - Microsoft Visual Studio					
File Edit View Project Build Debug TwinCAT Pl	C Tool	ls Scope Window Help			
- 🖓 - 🖻 - 💕 🖌 😺 👗 👘 - 🔍 - 💭 -		Release + TwinCAT RT (x86) +	20	- 🔍 🕾 🖄 🌫 🖬 🛃 🖬 -	-
: 🔝 🛄 🥩 🔨 🎯 😚 🐾 🛛 <local></local>		·[] = ∢ ⊡ •	同時時の一番番目に		
Solution Explorer 🗸 구 🗙	MAXP	OS X			
	THE VI				
Solution 'MAXPOS' (1 project)	Gene	eral NC-Drive Parameter Time Compensation			
MAXPOS		Darameter	Offline Value	Online Value	Unit
SYSTEM		Output Settings:	onine value		
MOTION		Invert Motor Polarity	FALSE V	1	
NC-Task1 SAF		Reference Velocity	133.0	1	mm/s
		at Output Patio [0.0 1.0]	10		iiiiiy s
Tables		Position and Velocity Scaling	1.0		
⊿ <sup>al</sup> aia Axes		Output Scaling Eactor (Pacition)	10		
Axis 1		Output Scaling Factor (Volocity)	2.75		
> 💘 Enc		Output Scaling Pactor (Velocity)	0.0	4	
The Ctrl		Minimum Drive Output Limitation [ 1.0	1.0		5
👂 🛄 Inputs		Minimum Drive Output Limitation [-1.0 1.0]	-1.0		
Dutputs		Maximum Drive Output Limitation [-1.0 1.0]	1.0		
PLC PLC	+	Torque and Acceleration Scaling:			
SAFETY	+	Other Settings:			
Devices					
a 🗮 Device 2 (EtherCAT)					
🛔 🛃 Image					
Image-Info					
> Z SyncUnits					
D Outputs					
InfoData					
Drive1 (MAXPOS)					
Mappings	11 -				
NC-Task 1 SAF - Device 2 (EtherCAT) 1		Download Upload Expand All Co	ollaps All Select All		
NC-Task 1 SAF - Device 2 (EtherCAT) Inf		Active states as an initial state of	90 CM 90		
Figure 3-21 Integration - F	Rock	hoff TwinCAT I Output Se	ttinge		

Figure 3-21 Integration – Beckhoff TwinCAT | Output Settings

Integration into EtherCAT Master Environment Beckhoff TwinCAT

- MAXPOS Microsoft Visual St File Edit View Project Build Debug TwinCAT PLC Tools Scope Windo v Help 🛅 • 🗇 - 😂 😹 🍠 👗 ዄ 🖄 🔊 - (\* - 🚑 - 🖳 ) 🕨 Release - 🖂 🕾 🖄 🎌 🛃 🖬 - 📮 TwinCAT RT (x86) - 12 🔝 🛄 🧔 🌮 🌂 🎯 😚 🐜 🛛 <Local> - e ( %i () Solution Explorer MAXPOS riable Flags Online Solution 'MAXPOS' (1 project) MAXPOS Velocity Name SYSTEM Туре DINT 4 MOTION NC-Task 1 SAF NC-Task 1 SVB Task 1 SVB Tables Tables CSP Outputs 4.0 Size Group 0 81 (0x51) Address User ID: Linked to and Axes Axis 1 Comment 👯 Enc ≇∎ Drive Þ ta Ctrl Inputs PLC SAFETY C++ C++ Port: 11, IGrp: 0x3040010, IOffs: 0x81000051, Len: 4 ADS Info: 4 
   I/O

   Image

   Image
   TIID^Device 2 (EtherCAT)^Drive 1 (MAXPOS)^Module 1 (CSP Mode)^CSP Full Name Outputs
   InfoData
   Drive 1 (MAXPOS) HI Module 1 (CSP Mode) CSP Inputs ControlWord TargetPosition PositionOffset 🔕 0 Errors 🔥 0 Warnings 🕕 0 Messages 🛛 🔿 VelocityOffset TorqueOffset
   ModeOfOperat
   DigitalOutput Description File Line Column Project
- 23) In the Solution Explorer, select ¤CSP Outputs¤ and set the link for the "Velocity Offset" variable.

Figure 3-22 Integration – Beckhoff TwinCAT | Variable Settings

24) In folder ¤Drive¤ \ ¤Out¤, select "nDataOut2" of Axis 1 as link variable.



Figure 3-23 Integration – Beckhoff TwinCAT | Variable Offset

### 3.3 Omron Sysmac NJ

#### **CREATING PROJECT FILE**

1) Create a Project File form the Project Window.

#### ETHERCAT CONFIGURATION

2) In the Multiview Explorer, select ¤Configurations and Setup¤, then ¤EtherCAT¤.



Figure 3-24 Integration – Omron Sysmac NJ | Configuration & Setup

This will open the ¤Edit Pane¤ and will automatically create the master.



Figure 3-25 Integration – Omron Sysmac NJ | Master

Integration into EtherCAT Master Environment Omron Sysmac NJ

### IMPORT ESI LIBRARY

3) In the EtherCAT tab, click right on the master and select ¤Display ESI Library¤.



Figure 3-26 Integration – Omron Sysmac NJ | Import of ESI Library

4) Click ¤this Folder¤ to import the MAXPOS ESI file.



Figure 3-27 Integration – Omron Sysmac NJ | Import of MAXPOS ESI File

5) Store your settings, close and restart the «Sysmac Studio».

Integration into EtherCAT Master Environment Omron Sysmac NJ

6) Select the desired MAXPOS slave(s) from the ¤Toolbox¤ and Drag&Drop it (them) to the ¤Master¤ in the EtherCAT tab.



Figure 3-28 Integration – Omron Sysmac NJ | Slave

#### **MAXPOS PARAMETERS**

7) In the EtherCAT tab, click right on the slave and select ¤Edit Module Configuration¤.



Figure 3-29 Integration – Omron Sysmac NJ | Slave Parameters

Integration into EtherCAT Master Environment Omron Sysmac NJ

This will oper	i a new tab	named	"Node1:	MAXPOS	(XXX)".
----------------	-------------	-------	---------	--------	---------

MAXPOS Project - new_Controller_C	0 - Sysmac Studio		
File Edit View Insert Project	Controller Simulation Tools Help		
X 4 6 6 5 C 6	1 ∄⊀Ж⊑₩₩0 ₹ ▲≫₩₩₽ № № № № № №	° ∐@@ %	
Multiview Explorer 🔹 🎙	御 EtherCAT Nodel: MAXPOS (E001) ×	¥	Toolbox 👻 🖡
new_Controller_0 💌	Positi Slot i Module i O Node1 : MAXPOS (E001)		Group All groups
Configurations and Setup	0 Axis 1	Device name E001	Others
Comparison of the the text of tex		Model MAXPOS Product name MAXPOS 50/5	
► Sì CPU/Expansion Racks		Revision 0x01200000 Number of modules 0	
→ I/O Map ■ II Controller Setup		PDO Map Settings Module config send Do not send 🔻	
► ⊕ Motion Control Setup			
<ul> <li>Event Settings</li> </ul>			Input Keyword
Task Settings     Data Trace Settings			Cyclic Synchronous Position Mode
<ul> <li>Programming</li> </ul>			Cyclic Synchronous Velocity Mode
			Cyclic Synchronous Torque Mode:
			Profile Position Mode/Profile Velo
		Device name	
		Set a name for the slave.	
	Output	- ‡ X	
			Model : CSP Mode
			Vendor : maxon motor a
🗄 filter 🗹	Output 🔨 Build		

Figure 3-30 Integration – Omron Sysmac NJ | New Node

8) Select the desired operation mode from the ¤Toolbox¤ and Drag&Drop it to the respective axis in the EtherCAT tab.



Figure 3-31 Integration – Omron Sysmac NJ | Operation Mode

Integration into EtherCAT Master Environment Omron Sysmac NJ

9) Go Online to set the connection method (→Omron's "Sysmac Studio Operation Manual").



Figure 3-32 Integration – Omron Sysmac NJ | Going Online

10) In the EtherCAT tab, click right on the master and select ¤Write Slave Node Address¤.



Figure 3-33 Integration – Omron Sysmac NJ | Slave Node Address

This will display a dialog box.

Slave Node Address Writing	ŋ
Present valuelSet valuelActual network configuration	41
Master	Ш.
1 1 MAXPOS Rev0x01200000	Ш.
	н.
	н
Node addresses are set for slaves. When any value other than 0 is set to a slave whose node address can be set from bardware the settion has origin. In other cases, the addresses	
set here are applicable.	
Write Cancel	

Figure 3-34 Integration – Omron Sysmac NJ | Slave Node Address Writing

Integration into EtherCAT Master Environment Omron Sysmac NJ

- 11) If the node address is set correct, click ¤Cancel¤. Otherwise edit the node address and click ¤Write¤ and power off/power on the MAXPOS to activate the new node address.
- 12) In the EtherCAT tab, click right on the master and select ¤Compare and Merge with Actual Network Configuration¤.

MAXPOS Project - new_Controller_0	) - Sysmac Studio	
File Edit View Insert Project	Controller Simulation Tools Help	
X 🖲 🖬 🏛 ち ぐ 🛙	中人影相談を図 英 🛛 🛪 🖉 ちゅう 🖬 〇 記込 江のの ジ	
Multiview Explorer  Perg.Controller_0  Configurations and Setup  Controller Setup  Controller Setup  Controller Setup  Controller Setup  Controller Setup  Control S	The Next Configuration       Image: Configuration         Image: Conf	Toolbox     9       All vendors     V       Groups     Store all versions       V     V       V

Figure 3-35 Integration – Omron Sysmac NJ | Network Configuration

13) Both the actual network and Sysmac Studio configuration will be read and compared. Upon completion, the results are displayed.

S Compare and Merge with Actual Network Configuration						
Node Address/Network configuration on Sysmac Studio	Node addresslActua	al network configuration	Netw	omparison resul	t Actua Lo	wer Configuration
Master Master		Master	Mast	Matched	Mast_	
1 E001 MAXPOS Rev:0x0120	1	MAXPOS Rev:0x01200	00 1 : M	Matched		Matched
Apply actual net	work configuration					
Some slaves such as Power Supply Units are not included in t	he actual network cor	nfiguration.				
		Close				

Figure 3-36 Integration – Omron Sysmac NJ | Comparison & Merger

- 14) Click ¤Apply actual network configuration¤, then click ¤Close¤.
- 15) Go Offline.

Integration into EtherCAT Master Environment Omron Sysmac NJ

16) In the Multiview Explorer, click right on ¤Axis Settings¤ and select ¤Add¤, then ¤Axis Settings¤.



Figure 3-37 Integration – Omron Sysmac NJ | Axis Settings

- 17) Rename the axis as desired.
- 18) Go to ¤Axis Basic Settings¤ and set the following parameters:
  - Axis use = Used axis
  - Axis type = Servo axis
  - Output device 1" = Node:1, Slot : 0 CSP Mode(M1)

Expand the Detail Settings pane and set the respective values in the columns ¤Device¤ and ¤Process Data¤.

MAXPOST	MAXPOSI (0) ×					
<b>薇</b>	👯 Axis Basic Settings					
	Axis number 0			A		
14444	Axis use Used axis 🔻					
***	Axis type Servo axis 🔻					
	Feedback control No control loop					
	Input device 1 <not assigned=""></not>	Channe				
	Input device 2 <not assigned=""></not>	Channe	▼			
	Input device 3 <nolassigned> &gt;</nolassigned>	Channe	V			
	Output device 1 Node : 1, Slot : 0 CSP Mod	e(M1)  Channe				
	Output device 2 <not assigned=""></not>	Channe	· · · · · · · · · · · · · · · · · · ·			
	Output device 3 <not assigned=""> +</not>	Channe				
	<ul> <li>Detailed Settings</li> </ul>					
	Reset to Default					
6A	Function Name	Device	Process Data			
$\odot$	Output (Controller to Device)					
	* 1. Controlword	Node : 1, Slot : 0 CSP Mode(M1) +	6040h-00.0(CSP Outpu 🔻			
	* 3. Target position	Node : 1, Slot : 0 CSP Mode(M1)	607Ah-00.0(CSP Outpo			
- <b>H</b> -	5. Target velocity	<not assigned=""></not>	<not assigned=""></not>			
-	7. Target torque	<not assigned=""></not>	<not assigned=""></not>			
	9. Max profile Velocity	<not assigned=""></not>	<not assigned=""></not>			
177	11. Modes of operation	<not assigned=""></not>	<not assigned=""></not>			
123	15. Positive torque limit value	<not a<="" assigned="" td=""><td><not assigned=""></not></td><td></td></not>	<not assigned=""></not>			
	21. Touch as the function	cNet assigned 2	<not assigned=""></not>			
	44. Software Switch of Encoder's Innu	<not assigned=""></not>	<not assigned=""></not>			
ā	Input (Device to Controller)					
	22. Statusword	Node : 1. Slot : 0 CSP Mode(M1) +	6041h-00.0(CSP Inputs +			
	<ul> <li>23. Position actual value</li> </ul>	Node : 1, Slot : 0 CSP Mode(M1) +	6064h-00.0(CSP Inputs V			
	24. Velocity actual value	<not assigned=""></not>	<not assigned=""> 🔍</not>			
	25. Torque actual value	<not assigned=""></not>	<not assigned=""></not>			
	27. Modes of operation display	<not assigned=""></not>	<not assigned=""></not>			
	10 T 1 1 1	a the second sec	1			

Figure 3-38 Integration – Omron Sysmac NJ | Axis Basic Settings

Integration into EtherCAT Master Environment Omron Sysmac NJ

- - pulses per motor rotation
  - travel distance per motor rotation

<pre>{} MAXPOS:</pre>	(0) ×
<b>\$</b>	Unit Conversion Settings
<u>∓</u> +E	Unit of display o pulse mm oum on md degree omch Command pulse count per motor rotation 2000 pulse/rev Work travel distance per motor rotation 2000 pulse/rev Reference: Unit conversion formula Reference: Unit conversion formula
3	Number of pulses (pulse) = Work travel distance per motor rotation (LREAL) * Travel distance [Unit of display]
•	
Ø	
ф	
123	
Ō	

Figure 3-39 Integration – Omron Sysmac NJ | Unit Conversion Settings

- 20) Go to  $\tt m$  Operation Settings  $\tt m$  and set the following parameters:
  - velocity
  - acceleration rate
  - deceleration rate
  - other monitor parameters



Figure 3-40 Integration – Omron Sysmac NJ | Operation Settings

- 21) Go to a Servo Drive Settings and set the following parameters:
  - maximum position setting
  - minimum position setting
  - select ¤Do not detect¤
  - In the Detail Settings pane, select ¤Do not accept¤ main circuit power off¤.

I MAXPOS	1 (0) ×
ţ,	o Servo Drive Settings
	▼ Modulo Position Settings
10000 ++ 1++++	Modulo maximum position setting value 2147483617 pulse Modulo minimum position setting value -2147483648 pulse
-	▼ Detailed Settings
$\odot$	POS state control method Switched in by Servin OFF ▼ Main circuit power supply OFF detection ● Detect  C Do not detect
4	
Ø	
ф	
123	
Ō	

Figure 3-41 Integration – Omron Sysmac NJ | Servo Drive Settings

#### REGISTER ST PROGRAM

22) In the Multiview Explorer, select ¤Programming¤ \ ¤POUs¤, click right on ¤Programs¤ and select ¤Add¤ \ ¤Structured text¤.

"Program0" will now be added to ¤Programs¤.

Select ¤Program0¤, click right on ¤Add¤ \ ¤Section¤ to add a new section.



Figure 3-42 Integration – Omron Sysmac NJ | Register ST Program

Integration into EtherCAT Master Environment Omron Sysmac NJ

- 23) Rename the newly added section to "VelOffsetPart".
- 24) Insert the following structure text and code. Define the variable as "External". Thereby...60 = rescaling turns per second to turns per minute,

2000 = encoder impulse number per turn \* 4 (for example, encoder with 500 impulses per turn: 500 \* 4 = 2000).

Variables		
•	1 Vel_Rpm_MAXPOS1:=LREAL_TO_DINT(MAXPOS1.Cmd.Vel) * 60 / 2000;	
Figure 3-43	Integration – Omron Sysmac NJ   Section0 Variables	

25) Add the variable "Vel\_Rpm\_MAXPOS1" to the "I/O Map".

MAXPOS Project - new_Controller_0	- Sysmac Str	udio	-	-			
File Edit View Insert Project	Controller	Simulation Tools Help					
Х 41 6 首 つ ぐ 12	ð /	、 🏭 🛤 🕮 🗮 🗚			I Q Q N		
Multiview Explorer 🔷 🗸	Section0	- Program0 🚽 I/O Map 🗙				👻 Toolbox	÷ 0
new_Controller_0 ▼ Configurations and Setup > ?? EtherCAT	EtherCA Node1	Port	Description	R/W Data Type	Variable	Variable Comment <search></search>	
CPU/Expansion Racks      L/O Map      Controller Setup      Motion Control Setup		<ul> <li>CSP Note</li> <li>CSP Outputs_ControlWord_6040_0</li> <li>CSP Outputs_TargetPosition_607A,</li> <li>CSP Outputs_PositionOffset_6080_</li> <li>CSP Dutputs_VelocitioOffset_6080_</li> </ul>	v . v	V UINT V DINT V DINT		_	
er' Cam Data Settings ► Event Settings ➡ Task Settings		CSP Outputs_TorqueOffset_6082_0 CSP Outputs_ModeOfOperation_6i CSP Outputs_DigitalOutput_60FF_0 CSP Outputs_TouchProbeFunction		V INT V SINT V UDINT	Vel_Rpm_MAXPOS1		
Vota Trace Settings      Programming      POUs      Of. Programs		CSP Inputs_StatusWord_6041_00 CSP Inputs_PositionActualValue_60 CSP Inputs_VelocityActualValue_60 CSP Inputs_TorqueActualValue_60	R R R R	UINT DINT DINT INT			
		CSP Inputs_ModeOfOperationDisp CSP Inputs_DigitalInput_60FD_00 CSP Inputs_TouchProbeStatus_608 CSP Inputs_TouchProbeDeritem18	R R R	SINT UDINT UINT			
► III Data ► III Tasks	CPU Rac	CSP Inputs_TouchProbePosition1N	R	DINT			

Figure 3-44 Integration – Omron Sysmac NJ | I/O Map

26) Add a new program in folder ¤Programming¤ \ ¤PUOs¤ \ ¤Programs¤.

MAXPOS Project - new_Controller_0 -	- Sysmac Studio	- • • • ····
File Edit View Insert Project (	Controller Simulation Tools Help	
Xeeboce	山へ影気はAB R A A A A A A A A A A A A A A A A A A	
Multiview Explorer 🔹 🌻	Section0 - Program0 ×	- Toolbox - 🖣
	Variables	<search></search>
	Namespace - Using	Analog Conversion
Configurations and Setup	internals Name   Data Type   Constant   Comment	BCD Conversion
CPU/Expansion Racks	Vel Rom MAXPOS1 DINT	Bit String Processing
+* I/O Map ► 2 Controller Setup		Communications
► ⊕ Motion Control Setup	0 1 Vel.Rpm_MAXPOS1:=LREAL_TO_DINT(MAXPOS1.Cmd.Vel) * 60 / 2000:	Comparison
er Cam Data Settings		Conversion
Event Settings Its Task Settings		Counter
🖂 Data Trace Settings		Data Movement
Programming		Data Type Conversion
Programs Add	a.	► rcs
Progra	Ladder - ()	Ladder Tools
L @ Sec.		▶ Math
L 🕸 Function Blocks		Motion Control
► III Data ► III Tasks		▶ Other

Figure 3-45 Integration – Omron Sysmac NJ | Program

27) Write a short program as to the following example:



Figure 3-46 Integration – Omron Sysmac NJ | Example Program

#### TASK SETTINGS

- 28) Go to ¤Task Settings¤ and set the following parameters:
  - Program0 (VelOffsetPart) must executed within the communication task
  - the sample program may be executed in a lower task (set the tasks as below)



Figure 3-47 Integration – Omron Sysmac NJ | Task Settings

Integration into EtherCAT Master Environment Omron Sysmac NJ

29) Go to ¤Program Assignment Settings¤ and assign the scaling program to the "Primary Task" and the application program to the "Periodic Task".

Multiview Explorer 🚽 🖣	No Task Settin	ngs X				-
new_Controller_0  Configurations and Setup		Program A	ssignment Settings			
► III EtherCAT		🔻 🖿 PrimaryTask				
► 51 CPU/Expansion Racks	1	1 00	Program name		Initial status	-
a⁼ I/O Map	C III	1 Programu			KUN	
► I Controller Setup	_					
er' Cam Data Settings	í 📰	▼ 🕅 PeriodicTask0				
Event Settings			Program name		Initial status	
Task Settings		1 Program1		▼	Run	
Data Trace Settings	VAR	+ ~ ~ 💼				
Programming						
	<b>\$</b> 2					
	ez <sub>d</sub>					

Figure 3-48 Integration – Omron Sysmac NJ | Program Assignment Settings

- 30) Go Online and download the program.
- 31) Click ¤Execute¤ to transfer the program to the controller.

Transfer to Controller	6
The following data will be transferred.	٦
- Configurations and Setup EtherCAT, CPU/Expansion Racks, I/O Map, Controller Setup Motion Control Setup, Cam Data Settings, Event Settings Task Settings	
- Programming POUs, Data, Library	
Options	h
Clear the present values of variables with Retain attribute. Do not know for the present values of variables with the present value of the present values of variables with the present value of the present values of variables with the present value of the present values of variables with the present value of values	
Do not transfer the program source. All data will be re-transferred when this option is changed. Do not transfer the following. (All items are not transferred.)	
C-series Special Unit parameters and EtherCAT slave backup parameters.     Slave Terminal Unit operation settings and NX Unit application data.     Do not transfer the EtherNet/IP connection settings (built in port and Unit).	
Execute Clos	í

Figure 3-49 Integration – Omron Sysmac NJ | Transfer to Controller Options

32) Click ¤Yes¤ to confirm.



Figure 3-50 Integration – Omron Sysmac NJ | Controller Reset

# 4 PDO Mapping

### 4.1 In Brief

#### OBJECTIVE

The present application note explains how to change the default PDO mapping settings and how to exclude or customize them using Beckhoff TwinCAT.

### 4.2 Changing PDO Mapping using Beckhoff TwinCAT

1) Select the device using the project tree in "Solution Explorer". Click the PDO you wish to edit.



Figure 4-51 PDO Mapping – Beckhoff TwinCAT | Process Data Display

#### PDO Mapping

Changing PDO Mapping using Beckhoff TwinCAT

2) Click the desired preconfigured PDO mapping from the list. Then click right to open the context menu.

Click either ¤Delete¤ to remove an existing variable or ¤Insert¤ to add < new variable.

ieneral Et	therCAT	DC	Process	Data	Slots	Startup	CoE - Onli	ne Diag H	listory	Online			
Sync Mana	ager:			PDC	) List:								
SM Si	ize	Туре	Flags	Inc	dex	Size	Name			Flags	SM	SU	
0 10	024 1	MbxOut		0x	1A00	27.0	CSP Inpu	ıts			3	0	
1 10	024 1	MbxIn		Ox	1600	23.0	CSP Out	puts			2	0	
2 23	3 (	Outputs					And the second second	5-16-10					
3 27	7 1	Inputs											
<	m	1	•			(0.1400	W-10						
< PDO Assign	m gnment <mark>(</mark> 0 D	1 (x1C12):	•	PDC	) Content dex	(0x1A00 Size	l): Offs	Name			Туре	Defau	it (he
< PDO Assign	nment <mark>(</mark> 0	1 2x1C12):	•	PDC Inc Oxt	) Content dex 606C:00	(0x1A00 Size 4.0	I): Offs 6.0	Name VelocityAc	tualVa	lue	Type DINT	Defau	lt (he
< PDO Assign ♥ 0x1600	pnment (O	7 ]x1C12):	,	PDC Inc Oxt	0 Content dex 606C:00 6077:00	: (0x1A00 Size 4.0 2.0	): Offs 6.0 10.0	Name VelocityAc TorqueAct	tualVa	lue : ue	Type DINT INT	Defau	lt (he
< PDO Assign	ment (0	1 (x1C12):	,	PDC Inc Oxt	0 Content dex 606C:00 6077:00 6061:00	(0x1A00 Size 4.0 2.0 1.0	); Offs 6.0 10.0 12.0	Name VelocityAc TorqueAct ModeOfOp	tualVa tualVal	lue ue 1Display	Type DINT INT SINT	Defau	lt (he
< PDO Assign	m griment (0 D	1 2x1C12):	•	PDC Inc Oxt Oxt	0 Content dex 606C:00 6077:00 6061:00 60FD:00	(0x1A00 Size 4.0 2.0 1.0 4.0	); Offs 6.0 10.0 12.0 13.0	Name VelocityAc TorqueAct ModeOfO; DigitalInpu	tualVa tualVal peration	lue ue iDisplay	Type DINT INT SINT UDINT	Defau	lt (he
< PDO Assign ♥ 0x1600	m gnment (0 D	1 ]x1C12):	•	PDC Inc Oxt Oxt Oxt	0 Content dex 606C:00 6077:00 6061:00 60FD:00 60B9:00	(0x1A00 Size 4.0 2.0 1.0 4.0 2.0	)): Offs 6.0 10.0 12.0 13.0 17.0	Name VelocityAc TorqueAct ModeOfOp DigitalInpu TouchProl	ctualVa tualVal peration it be Stati	lue ue nDisplay us	Type DINT INT SINT UDINT UINT	Defau	t (he
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Figure 4-52 PDO Mapping – Beckhoff TwinCAT | Select PDO from Default List

3) Choose the object you wish to map.

Vame:	Ĩ			OK
ndex (hex):	0	0		Cancel
Sub Index:	0			
) ata Type:	(none)		•	
Bit Lentgh:	1	<u>.</u>		
	SSI Special	Bits mental Encoder 2 In	dex Position	
0x3012:06 - 5 0x3020:04 - 1 0x3080 - Hor 0x3000 - Cur 0x3001 - Cur 0x3005 - Vel 0x3141:01 - 1 0x3150:01 - 1 0x31E4:01 - 1 0x31E4:02 - 1	ne Position rent Deman rent Actual ocity Actual Digital Input Digital Outpu Internal Dat	d Value Value Averaged Value Averaged Properties Logic St ut Properties Logic S a Recorder Controlk a Recorder Statusw	ate State vord ord	

Figure 4-53 PDO Mapping – Beckhoff TwinCAT | Edit PDO Values

PDO Mapping

Changing PDO Mapping using Beckhoff TwinCAT

4) You may map up to ten objects for RxPDO and ten for TxPDO.

Do so by entering the object name and the desired values, then press ¤OK¤. Repeat for other objects, if desired.

For details on the default settings  $\rightarrow$  Table 4-10 and  $\rightarrow$  Table 4-11.

PDO Index	Default Value	Bit Length	Description	Function Group
	0x6040	16	Controlword	
	0x607A	32	Target Position	
	0x60B0	32	Position Offset	
0×1600	0x60B1	32	Velocity Offset	Cyclic Synchronous
0.1000	0x60B2	16	Torque Offset	Position Mode
	0x6060	8	Mode of Operation	
	0x60FE	32	Digital Output	
	0x60B8	16	Touch Probe Function	
	0x6040	16	Controlword	
	0x60FF	32	Target Velocity	
	0x60B1	32	Velocity Offset	
0x1601	0x1601 0x60B2		Torque Offset	Velocity Mode
+	0x6060	8	Mode of Operation	
	0x60FE	32	Digital Output	
	0x60B8		Touch Probe Function	
	0x6040	16	Controlword	
	0x6071	16	Target Torque	
0v1602	0x60B2	16	Torque Offset	Cyclic Synchronous
0x1002	0x6060	8	Mode of Operation	Torque Mode
	0x60FE	32	Digital Output	
	0x60B8	16	Touch Probe Function	
	0x6040	16	Controlword	
	0x607A	32	Target Position	
	0x60FF	32	Target Velocity	
0v1602	0x6083	32	Profile Acceleration	Profile Position Mode
021003	0x6084	32	Profile Deceleration	Profile Velocity Mode
	0x6081	32	Profile Velocity	
	0x6060	8	Mode of Operation	
	0x60FE	32	Digital Output	

Table 4-10 PDO Mapping – Default Values for RxPDO

#### PDO Mapping

Changing PDO Mapping using Beckhoff TwinCAT

PDO	Default	Bit	Description	Size
Index	Value	Length		[Bits]
	0x6041	16	Statusword	_
	0x6064	32	Position Actual Value	_
	0x606C	32	Velocity Actual Value	_
	0x6077	16	Torque Actual Value	Cyclic Synchronous
0x1A00	0x6061	8	Mode of Operation Display	Position Mode
	0x60FD	32	Digital Input	
	0x60B9	16	Touch Probe Status	
	0x60BA	32	Touch Probe Position 1 Positive Value	
	0x60BB	32	Touch Probe Position 1 Negative Value	
	0x6041	16	Statusword	
	0x6064	32	Position Actual Value	
	0x606C	32	Velocity Actual Value	_
	0x6077	16	Torque Actual Value	
0x1A01	0x6061	8	Mode of Operation Display	Cyclic Synchronous
	0x60FD	32	Digital Input	
	0x60B9	16	Touch Probe Status	_
	0x60BA	32	Touch Probe Position 1 Positive Value	_
	0x60BB	32	Touch Probe Position 1 Negative Value	_
	0x6041	16	Statusword	
	0x6064	32	Position Actual Value	_
	0x606C	32	Velocity Actual Value	_
	0x6077	16	Torque Actual Value	
0x1A02	0x6061	8	Mode of Operation Display	Cyclic Synchronous     Torque Mode
	0x60FD	32	Digital Input	
	0x60B9	16	Touch Probe Status	_
	0x60BA	32	Touch Probe Position 1 Positive Value	_
	0x60BB	32	Touch Probe Position 1 Negative Value	_
0x1A03	0x6041	16	Statusword	
	0x6064	32	Position Actual Value	
	0x606C	32	Velocity Actual Value	Profile Position Mode
	0x6078	16	Current Actual Value	
	0x60F4	32	Following Error Actual Value	Profile Velocity Mode
	0x6061	8	Mode of Operation Display	-
	0x60FD	32	Digital Input	

 Table 4-11
 PDO Mapping – Default Values for TxPDO

# 5 Extended Encoders Configuration

#### OBJECTIVE

The present application note explains the configuration of some selected BiSS-C encoder types. Nevertheless, it will not explain BiSS-C fundamentals.

#### SCOPE

Hardware	Order #	Firmware Version	Reference
MAXPOS		0121h	Firmware Specification
MAXPOS 50/5	447293	0121h or higher	Hardware Reference

 Table 5-12
 PDO Mapping – covered Hardware and required Documents

#### TOOLS

	"
Software «MAXPOS	Studio» Version 1.3 or higher

Table 5-13 PDO Mapping – recommended Tools

### 5.1 BiSS C Absolute Serial Encoder

#### 5.1.1 Configuration



### Note

If  $t_{Busy}$  or  $t_{Timeout Time}$  ( $t_{Out}$ ) should not be specified by the manufacturer, start with 40  $\mu$ s and iteratively reduce until a communication error occurs. Data rate, number of data bits, and timeout time will affect the sampling rate. Therefore, keep timeout time and busy time as short as possible.

#### 5.1.1.2 **Data Frame**

#### Data Frame



Figure 5-55 Extended Encoders - BiSS | Data Frame

#### 5.1.1.3 **Difference between Position Bits and Data Bits**

The maximum position size that can be processed by MAXPOS is 32 bits internally. Therefore, the original data size must be manually reduced if necessary. For original multi-turn data sizes smaller 32 bits, no reduction is required. Single-turn encoders are limited by 31 bits.



Figure 5-56 Extended Encoders - BiSS | Position Bits

#### 5.1.1.4 **Supported Data Formats**

Some encoder manufacturers require 12 Bit data patterns (BiSS-C Profile BP1). Therefore, the original data is padded with zeros if its own data format is unequal to n\* 12 bit. Zero padding can be left or right aligned. Data alignment is defined by the object "Data Format 0x3014-0x06".



Format



MI SI		MT	ST	
-------	--	----	----	--

ST Single-turn Zero bits (12 bit padding)

Ζ

MT Multi-turn



#### 5.1.2 Configuration Examples

#### MAXON BISS 12 BIT SINGLE-TURN #488783

Object ID	Object Name	Value	Comment
0x3014-0x03	BiSS Data Rate	3400 kBit/s	Up to 9400 kBit/s possible
0x3014-0x04	BiSS Timeout Time	3 μs	
0x3014-0x05	BiSS Busy Time	1 μs	
0x3014-0x06	BiSS Data Bits		
	Single-turn Bits	12	
	Multi-turn Bits	0	
	Data Format	Single-turn	Without zero bits, right aligned
	F0	none	
	F1	Error	
0x3014-0x07	BiSS Position Bits		
	Single-turn Bits	12	
	Multi-turn Bits	0	
0x3014-0x08	BiSS Encoder Type		
	Direction	CCW	Depending on application
0x3014-0x09	BiSS Encoder Protocol		
	CRC Polarity	CRC inverse	
	CRC Polynomial	0x43	

Table 5-14 Extended Encoders – BiSS | Configuration Example MAXON 12 Bit ST

#### HENGSTLER 19 BIT SINGLE-TURN, AD34/0019AU.ONBVB

Object ID	Object Name	Value	Comment
0x3014-0x03	BiSS Data Rate	3400 kBit/s	Up to 7500 kBit/s possible
0x3014-0x04	BiSS Timeout Time	15 μs	
0x3014-0x05	BiSS Busy Time	4 μs	
0x3014-0x06	BiSS Data Bits		
	Single-turn Bits	19	
	Multi-turn Bits	0	
	Data Format	Single-turn	Without zero bits, right aligned
	F0	none	
	F1	Error	
0x3014-0x07	BiSS Position Bits		
	Single-turn Bits	19	
	Multi-turn Bits	0	
0x3014-0x08	BiSS Encoder Type		
	Direction	CCW	Depending on application
0x3014-0x09	BiSS Encoder Protocol		
	CRC Polarity	CRC inverse	
	CRC Polynomial	0x43	

Table 5-15 Extended Encoders – BiSS | Configuration Example Hengstler 19 Bit ST

HENGSTLER 12 BIT MULTI-TURN,	<b>19 BIT SINGLE-TURN</b>	AD34/1219AU.ONBVB
------------------------------	---------------------------	-------------------

Object ID	Object Name	Value	Comment
0x3014-0x03	BiSS Data Rate	3400 kBit/s	Up to 9400 kBit/s possible
0x3014-0x04	BiSS Timeout Time	12 μs	
0x3014-0x05	BiSS Busy Time	5 μs	
0x3014-0x06	BiSS Data Bits		
	Single-turn Bits	19	
	Multi-turn Bits	12	
	Data Format	Multi-turn Single-turn	Without zero bits, right aligned
	F0	none	
	F1	Error	
0x3014-0x07	BiSS Position Bits	1	
	Single-turn Bits	19	
	Multi-turn Bits	12	
0x3014-0x08	BiSS Encoder Type		
	Direction	CCW	Depending on application
0x3014-0x09	BiSS Encoder Protocol		
	CRC Polarity	CRC inverse	
	CRC Polynomial	0x43	

Table 5-16 Extended Encoders – BiSS | Configuration Example Hengstler 12 Bit MT

#### KÜBLER SENDIX ABSOLUTE TYPE 5873, 17 BIT SINGLE-TURN

Object ID	Object Name	Value	Comment
0x3014-0x03	BiSS Data Rate	3400 kBit/s	Up to 7500 kBit/s possible
0x3014-0x04	BiSS Timeout Time	16 μs	
0x3014-0x05	BiSS Busy Time	4 μs	
0x3014-0x06	BiSS Data Bits		
	Single-turn Bits	17	
	Multi-turn Bits	0	
	Data Format	Single-turn	Without zero bits, right aligned
	F0	none	
	F1	Error	
0x3014-0x07	BiSS Position Bits		
	Single-turn Bits	17	
	Multi-turn Bits	0	
0x3014-0x08	BiSS Encoder Type		
	Direction	CCW	Depending on application
0x3014-0x09	BiSS Encoder Protocol		
	CRC Polarity	CRC inverse	
	CRC Polynomial	0x43	

Table 5-17 Extended Encoders – BiSS | Configuration Example Kübler Sendix 17 Bit ST

Extended Encoders Configuration BiSS C Absolute Serial Encoder

#### KÜBLER SENDIX ABSOLUTE TYPE F3663, 24 BIT MULTI-TURN, 17 BIT SINGLE-TURN

Object ID	Object Name	Value	Comment
0x3014-0x03	BiSS Data Rate	3400 kBit/s	Up to 7500 kBit/s possible
0x3014-0x04	BiSS Timeout Time	16 μs	
0x3014-0x05	BiSS Busy Time	4 μs	
0x3014-0x06	BiSS Data Bits		
	Single-turn Bits	17	
	Multi-turn Bits	24	
	Data Format	Single-turn	Without zero bits, right aligned
	F0	none	
	F1	Error	
0x3014-0x07	BiSS Position Bits		
	Single-turn Bits	17	
	Multi-turn Bits	15	Position bits aligned to 32 bits in a sum (MT/ST)
0x3014-0x08	BiSS Encoder Type		
	Direction	CCW	Depending on application
0x3014-0x09	BiSS Encoder Protocol		
	CRC Polarity	CRC inverse	
	CRC Polynomial	0x43	

Table 5-18 Extended Encoders – BiSS | Configuration Example Kübler Sendix 24 Bit MT/17 Bit ST

Extended Encoders Configuration BiSS C Absolute Serial Encoder

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# 6 Using Safe Torque Off (STO) Functionality

### 6.1 In Brief

#### OBJECTIVE

The MAXPOS offers the STO (Safe Torque Off) safety feature based on IEC61800-5-2.

The present application note explains how to setup and configure the MAXPOS controller for using the STO functionality. Certification of the STO functionality is under process but not yet finalized. Thus, up to now, the STO functionality of the MAXPOS is not certified.

#### 6.2 Functionality



The STO function is the most common and basic drive-integrated safety function. It ensures that no torque-generating energy can continue to act on a motor and prevents unintentional starting.

STO has the immediate effect that the drive can no longer supply any torque-generating energy. STO can be used whenever the drive will be brought to a standstill in a sufficiently short time by load torque or friction, or if coasting down of the drive is not relevant to safety. STO enables safe working when, for example, the protective door is open (restart interlock) and has a wide range of uses in machinery with moving axes (such as handling or conveyor systems).

Mechanical brakes must be used if output shafts of motors or gearboxes are affected by forces that could trigger a movement once the motor has been shut down. Possible applications are vertical axes or motors with high inertia.

### 6.3 STO I/O States

The below table defines the behavior of the STO inputs.

STO-IN1 (DigIN5)	STO-IN2 (DigIN6)	STO-OUT(DigOUT4)	Power Stage
Inactive	Inactive	Inactive	Disabled
Inactive	Active	Inactive	Disabled
Active	Inactive	Inactive	Disabled
Active	Active	Active	Can be enabled

Table 6-19 Safe Torque Off (STO) – States of STO I/Os

# Using Safe Torque Off (STO) Functionality Configuration

### 6.4 Configuration

#### 6.4.1 Hardware Settings

By default, the galvanic isolated digital inputs 5 and 6 are defined as "general purpose inputs" and digital output 4 is defined as "general purpose output". With the following steps they will be set for «Safe Torque OFF».



### STOP!

Make sure to disconnect the MAXPOS controller from any power source.

- 1) Open the housing.
- 2) Find jumper JP3 (→Figure 6-59).



Figure 6-59 Safe Torque Off (STO) | MAXPOS 50/5 – Location JP3

3) Set **both** jumper switches 1 and 2 to "OFF" ( $\rightarrow$  Figure 6-60).



Figure 6-60 Safe Torque Off (STO) | MAXPOS 50/5 – JP3 OFF; STO activated

4) Close the housing.

The MAXPOS controller is now configured for STO functionality:

- DigIN5 (X7 pin 7) and DigIN6 (X7 pin 8) are now set as STO input (STO-IN1 and STO-IN2).
- DigOUT 4 (X8 pin 6) is now set as STO-OUT (Safe Torque OFF output signal).

Using Safe Torque Off (STO) Functionality Configuration

#### 6.4.2 Digital Inputs 5 and 6 PLC Level

DigIN56		
Type of input	Galvanic isolated, single-ended	
Input voltage	+24 VDC	
Max. input voltage	±30 VDC	
Logic 0	U <sub>in</sub> <5 VDC	
Logic 1	U <sub>in</sub> >9 VDC	
Input current at logic 1	>1.5 mA @ 5 VDC >2.0 mA @ 9 VDC typically 2.6 mA @ 24 VDC	
Switching delay	<2 µs @ 24 VDC	





Using Safe Torque Off (STO) Functionality Configuration

#### 6.4.3 Digital Output 4

DigOUT4		
Type of output	Galvanic isolated, open source	
Output voltage	$U_{out} \ge (+V_{DigOUT} - 0.2 V)$	
Max. load current	I <sub>load</sub> ≤500 mA	
Leakage current	I <sub>leak</sub> ≤10 μA	
Switching delay (rising edge)	<50 µs @ 24 VDC; I <sub>load</sub> ≤10 mA	
Switching delay (falling edge)	<200 µs @ 24 VDC; I <sub>load</sub> ≤10 mA	
Max. load inductance	175 mH @ 500 mA	





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