maxon motor control **EPOS3 EtherCAT Positioning Controllers**

Firmware Specification **Edition May 2016**

EPOS3 EtherCAT

Positioning Controllers

Firmware Specification

epos.maxonmotor.com

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PLEASE READ THIS FIRST

These instructions are intended for qualified technical personnel. Prior commencing with any activities …

- *you must carefully read and understand this manual and*
- *you must follow the instructions given therein.*

We have tried to provide you with all information necessary to install and commission the equipment in a **secure**, **safe** and **time-saving** manner. Our main focus is …

- to familiarize you with all relevant technical aspects,
- to let you know the easiest way of doing,
- to alert you of any possibly dangerous situation you might encounter or that you might cause if you do not follow the description,
- to **write as little** and to **say as much** as possible and
- not to bore you with things you already know.

Likewise, we tried to skip repetitive information! Thus, you will find things **mentioned just once**. If, for example, an earlier mentioned action fits other occasions you then will be directed to that text passage with a respective reference.

Follow any stated reference – observe respective information – then go back and continue with the task!

PREREQUISITES FOR PERMISSION TO COMMENCE INSTALLATION

The EPOS3 EtherCAT is considered as partly completed machinery according to EU directive 2006/42/EC, Article 2, Clause (g) and therefore **is intended to be incorporated into or assembled with other machinery or other partly completed machinery or equipment**.

You must not put the device into service, …

- *unless you have made completely sure that the other machinery – the surrounding system the device is intended to be incorporated to – fully complies with the requirements stated in EU directive 2006/42/EC!*
- *unless the surrounding system fulfills all relevant health and safety aspects!*
- *unless all respective interfaces have been established and fulfill the stated requirements!*

TABLE OF CONTENTS

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1 About this Document

1.1 Intended Purpose

The purpose of the present document is to familiarize you with the described equipment and the tasks on safe and adequate installation and/or commissioning.

Observing the described instructions in this document will help you …

- to avoid dangerous situations,
- to keep installation and/or commissioning time at a minimum and
- to increase reliability and service life of the described equipment.

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.

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.)
(n)	referring to an item (such as order number, list item, etc.)
➔	denotes “see”, “see also”, “take note of” or “go to”

Table 1-1 Notations used in this Document

1.4 Symbols and Signs

Requirement / Note / Remark
Indicates an action you must perform prior continuing or refers to information on a particular item.

Best Practice
Gives advice on the easiest and best way to proceed.

Material Damage
Points out information particular to potential damage of equipment.

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
EtherCAT®	© EtherCAT Technology Group, DE-Nuremberg

Table 1-2 Brand Names and Trademark Owners

1.6 Sources for additional Information

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

#	Reference
[1]	ETG.1000: EtherCAT Specification ➔www.ethercat.org
[2]	IEC 61158-x-12: Industrial communication networks – Fieldbus specifications
[3]	IEC 61800-7: Adjustable speed electrical power drives systems
[4]	maxon motor: EPOS3 EtherCAT Communication Guide EPOS DVD or ➔www.maxonmotor.com

Table 1-3 Sources for additional Information

1.7 Copyright

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2 Introduction

2.1 Important Notice: Prerequisites for Permission to commence Installation

The EPOS3 EtherCAT Positioning Controllers are considered as partly completed machinery according to EU directive 2006/42/EC, Article 2, Clause (g) and therefore **are intended to be incorporated into or assembled with other machinery or other partly completed machinery or equipment**.

WARNING

Risk of Injury
Operating the device without the full compliance of the surrounding system with EU directive 2006/42/EC may cause serious injuries!

- *Do not operate the device, unless you have made sure that the other machinery fulfills the requirements stated in the EU directive!*
- *Do not operate the device, unless the surrounding system fulfills all relevant health and safety aspects!*
- *Do not operate the device, unless all respective interfaces have been established and fulfill the stated requirements!*

2.2 General Information

The present document provides you with the firmware details on the EPOS3 70/10 EtherCAT Positioning Controllers. It contains descriptions of the architecture, device states, operation modes, error handling and object dictionary.

maxon motor control's EPOS3 70/10 EtherCAT is a full digital, smart motion controller. Due to its flexible and high efficient power stage, the EPOS3 70/10 EtherCAT drives brushed DC motors with digital encoder as well as brushless EC motors with digital Hall sensors and encoder.

The sinusoidal current commutation by space vector control offers the possibility to drive brushless EC motors with minimal torque ripple and low noise. The integrated position, velocity and current control functionality allows sophisticated positioning applications. The EPOS3 70/10 EtherCAT is especially designed being commanded and controlled as a slave node in an EtherCAT network. In addition, the unit can be configured via USB interface.

Find the latest edition of the present document, as well as additional documentation and software to the EPOS3 70/10 EtherCAT Positioning Controllers also on the Internet: ➔www.maxonmotor.com

2.3 Documentation Structure

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:

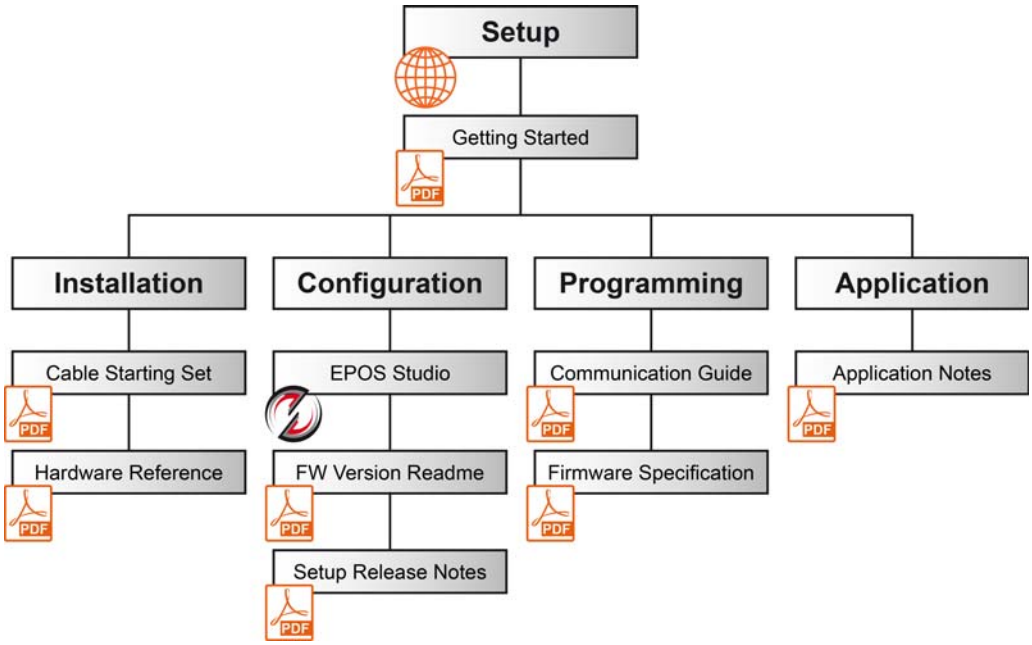

Figure 2-1 Documentation Structure

3 System Overview

3.1 Device Architecture

The EPOS3 EtherCAT's communication interface follows these specifications (numbers in brackets refer to respective items listed on ➔page 1-10):

- EtherCAT Technology Group (ETG)
  ETG.1000 EtherCAT Specification (➔[1])
- International Electrotechnical Commission (IEC)
  IEC 61158 Type 12 (➔[2])

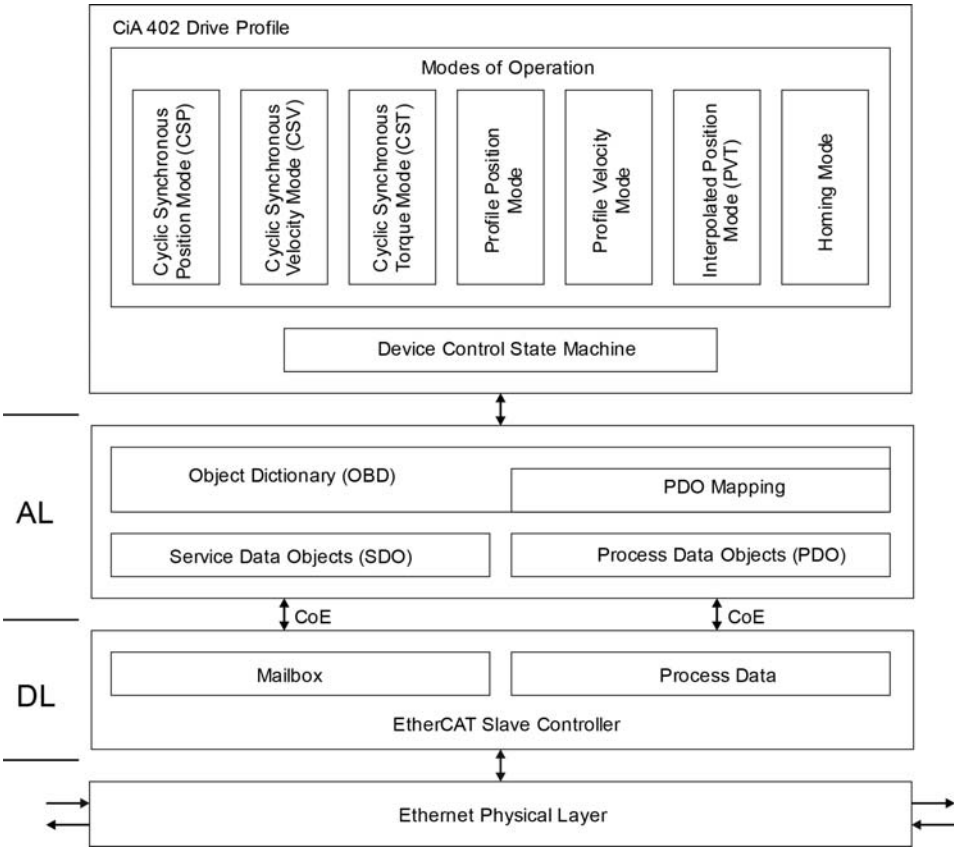

Figure 3-2 Communication Architecture

The physical layer of EtherCAT is based on an IEC 8802-3 (IEEE802.3) 100BASE-TX standard Ethernet physics. The data link layer (DL) is handled by the EtherCAT Slave Controller which splits the specific Ethernet data frames in process data and mailbox data. The application layer (AL) is connected via the CAN application protocol over EtherCAT (CoE) and can handle the service data objects as well as the cyclic process data objects. The drive functionality follows the CiA 402 Drive Profile based on IEC 61800-7-201 and IEC 61800-7-301.

Device Control

Starting and stopping of the drive and several mode-specific commands are executed by the state machine.

Modes of operation

The operating mode defines the behavior of the drive.

3.2 Device Control

The state machine describes the device state and the possible control sequence of the drive. A single state represents a special internal or external behavior. The state of the drive also determines which commands are accepted.

States may be changed using the ➔Controlword and/or according to internal events. The current state can be read using the ➔Statusword.

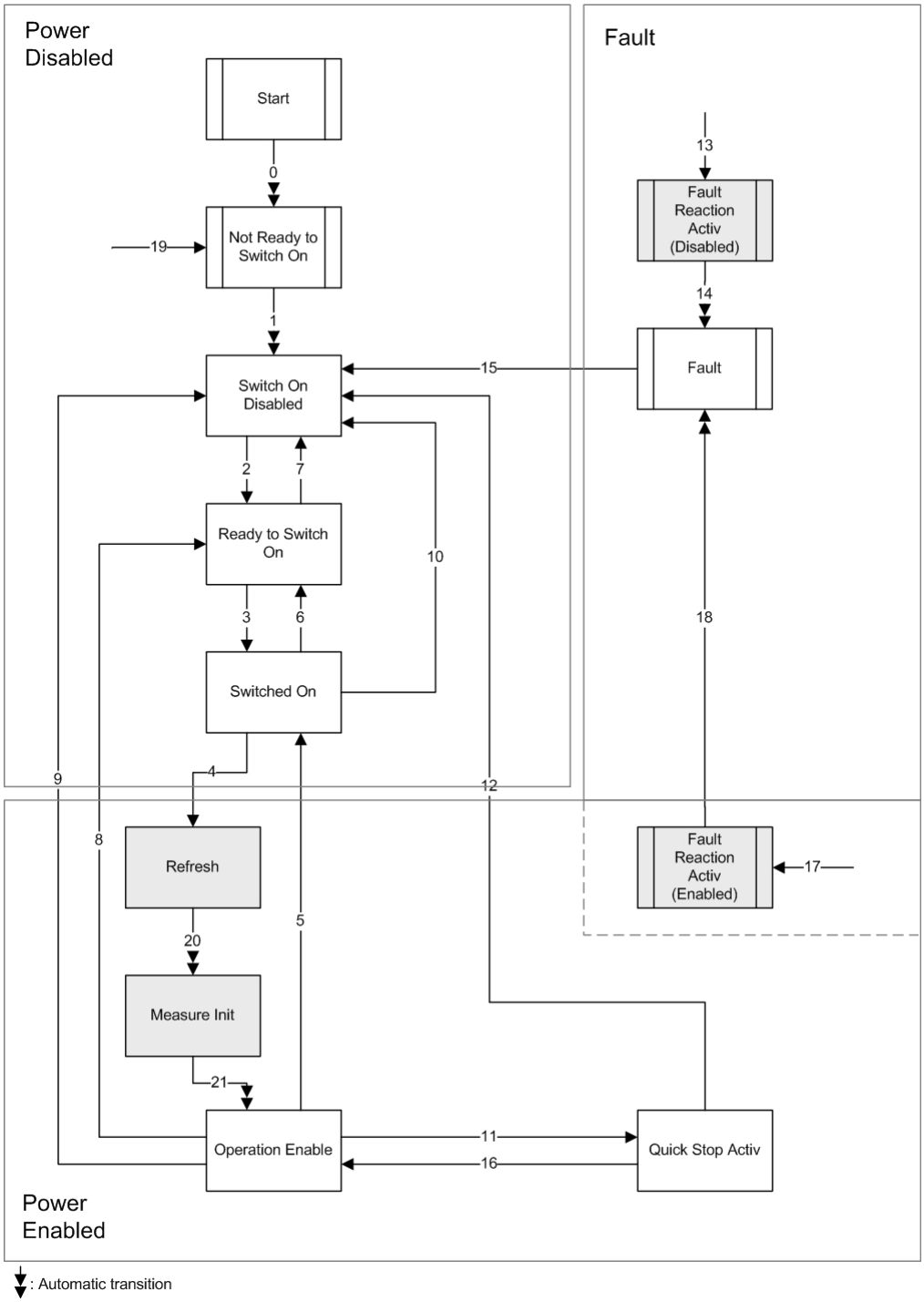

Figure 3-3 Device State Machine

3.2.1 State of the Drive

The following ➔Statusword bits indicate the current state of the drive.

State	Statusword [binary]	Description
Start	x0xx xxx0 x000 0000	Bootup
Not Ready to Switch On	x0xx xxx1 x000 0000	Current offset will be measured Drive function is disabled
Switch On Disabled	x0xx xxx1 x100 0000	Drive initialization is complete Drive parameters may be changed Drive function is disabled
Ready to Switch On	x0xx xxx1 x010 0001	Drive parameters may be changed Drive function is disabled
Switched On	x0xx xxx1 x010 0011	Drive function is disabled
Refresh	x1xx xxx1 x010 0011	Refresh of power stage
Measure Init	x1xx xxx1 x011 0011	Power is applied to the motor Motor resistance or commutation delay is measured
Operation Enable	x0xx xxx1 x011 0111	No faults have been detected Drive function is enabled and power is applied to the motor
Quickstop Active	x0xx xxx1 x001 0111	Quickstop function is being executed Drive function is enabled and power is applied to the motor
Fault Reaction Active (disabled)	x0xx xxx1 x000 1111	A fault has occurred in the drive Drive function is disabled
Fault Reaction Active (enabled)	x0xx xxx1 x001 1111	A fault has occurred in the drive Selected fault reaction is being executed
Fault	x0xx xxx1 x000 1000	A fault has occurred in the drive Drive parameters may be changed Drive function is disabled

Table 3-4 Device State Bits

3.2.2 State Transitions

State transitions are caused by internal events in the drive or by commands from the host via the ➔Controlword.

Note:
If a command is received which causes a change of state, this command will be processed completely and the new state attained before the next command can be processed.

Transition	Event	Action
0	Reset	Initialize drive
1	Drive has initialized successfully	Activate communication
2	«Shutdown» command received	
3	«Switch On» command received	
4	«Enable Operation» command received	Refresh power section
5	«Disable Operation» command received	Disable power section; disable drive function
6	«Shutdown» command received	
7	«Quickstop» or «Disable Voltage» command received	
8	«Shutdown» command received	Disable power section/drive function
9	«Disable Voltage» command received	Disable power section/drive function
10	«Quickstop» or «Disable Voltage» command received	
11	«Quickstop» command received	Setup Quickstop profile
12	«Disable Voltage» command received	Disable power section/drive function
13	A fault has occurred not during «Operation Enable» or «Quickstop» State	Disable power section/drive function
14	The fault reaction is completed	
15	«Fault Reset» command received	Reset fault condition if no fault is present
16	«Enable Operation» command received	Enable drive function
17	A fault has occurred during «Operation Enable» or «Quickstop» State	Execute selected fault reaction
18	The fault reaction is completed	
19	A Node Reset was received	Initialize drive
20	Refresh cycle finished	Enable power section
21	Measure Init cycle finished	Enable drive function

Table 3-5 Device State Transitions

3.2.3 Device Control Commands

Device control commands are triggered by the following bit patterns in the ➔Controlword.

Command	LowByte of Controlword [binary]	State Transition
Shutdown	0xxx x110	2, 6, 8
Switch On	0xxx x111	3
Switch On & Enable Operation	0xxx 1111	3, 4*1)
Disable Voltage	0xxx xx0x	7, 9, 10, 12
Quickstop	0xxx x01x	7, 10, 11
Disable Operation	0xxx 0111	5
Enable Operation	0xxx 1111	4, 16
Fault Reset	0xxx xxxx → 1xxx xxxx	15

Remark:

*1) Automatic transition to “Enable Operation” after executing “Switched On” functionality.

Table 3-6 Device Control Commands

3.3 System Units

3.3.1 Definition of Units

There is a need to interchange physical dimensions and sizes into device internal units. The physical dimensions for position, velocity and acceleration parameters are constant in this implementation (➔Table 3-7).

Dimension index and notation index can be read at ➔Position Notation Index, ➔Position Dimension Index, ➔Velocity Notation Index, ➔Velocity Dimension Index, ➔Acceleration Notation Index and ➔Acceleration Dimension Index (➔page 8-164 and following). Writing to these objects with other values will produce a value range failure.

Unit Dimension	Definition
Position units	steps (quadcounts = 4 x Encoder Counts / Revolution)
Velocity units	rpm (Revolutions per Minute)
Acceleration units	rpm/s (Velocity Unit / Second)

Table 3-7 Default Unit Dimensions

3.3.2 Factor Group Tables

Physical Dimension	Unit	Dimension index
Revolution / time	*rev/s*	*0xA3*
Revolution / time	rev/min	0xA4
Steps	steps	0xAC
Steps / revolution	*steps/rev*	*0xAD*

Table 3-8 Factor Group Dimension Indices

Prefix	Factor		Notation Index	
…	…	…	…	…
Mega	*10^6*	*1 000 000*	*0x06*	*6*
…	…	…	…	…
Kilo	*10^3*	*1 000*	*0x03*	*3*
Hecto	*10^2*	*100*	*0x02*	*2*
Deca	*10^1*	*10*	*0x01*	*1*
–	10^0	1	0x00	0
Deci	10^{-1}	0.1	0xFF	−1
Centi	10^{-2}	0.01	0xFE	−2
Milli	10^{-3}	0.001	0xFD	−3
…	…	…	…	…
Micro	*10^{-6}*	*0.000001*	*0xFA*	*−6*
…	…	…	…	…

Table 3-9 Factor Group Notation Indices

4 Error Handling

4.1 Device Errors

4.1.1 Overview

EPOS3 EtherCAT can detect a variety of device errors.

The reaction to an error depends on error type and option code. After execution of the fault reaction, the device changes to fault state and the drive will be disabled.

The ➔“Error History” on page 8-145 holds the error codes that occur. The ➔“Error Register” on page 8-87 holds all set error flags and provides a summary on possible errors.

For fault reaction codes, following notations will be used:

- a: Use ➔“Abort Connection Option Code” on page 8-148.
- f: Use ➔“Fault Reaction Option Code” on page 8-152.
- d: A secure movement is no longer possible.

Clearing certain error states (➔table below; column “Position Reset”) will cause a reset of the actual position data. This is due to the fact that the position data are no longer reliable if one of these error states was detected. We recommend to shut down the device and check sensors, wiring, and connectors prior restarting the motor.

Error Code	Error Register	Name	Fault Reaction Code	Position Reset
0x0000	0000 0000b	No Error	–	
0x1000	0000 0001b	➔Generic Error	d	
0x2310	0000 0010b	➔Overcurrent Error	d	
0x3210	0000 0100b	➔Overvoltage Error	d	
0x3220	0000 0100b	➔Undervoltage Error	d	
0x4210	0000 1000b	➔Overtemperature Error	d	
0x5113	0000 0100b	➔Logic Supply Voltage Too Low Error	d	
0x5114	0000 0100b	➔Supply Voltage Output Stage Too Low Error	d	
0x6100	0010 0000b	➔Internal Software Error	d	
0x6320	0010 0000b	➔Software Parameter Error	f	
0x7320	0010 0000b	➔Position Sensor Error	d	X
0x7580	0000 0001b	➔Inconsistent Firmware Detected Error	d	
0x7581	0000 0001b	➔Firmware Version Conflict Error	d	
0x7582	0001 0000b	➔Ethernet Module internal Communication Error	d	
0x7583	0001 0000b	➔Ethernet Module Initialization Error	d	
0x7584	0001 0000b	➔EtherCAT PDO Communication Error	a	
0x7585	0001 0000b	➔EtherCAT SDO Communication Error	a	
0x8180	0001 0000b	➔EtherCAT State Machine Error	a	
0x8611	0010 0000b	➔Following Error	f	
0xFF01	1000 0000b	➔Hall Sensor Error	d	X

Error Code	Error Register	Name	Fault Reaction Code	Position Reset
0xFF02	1000 0000b	➔Index Processing Error	d	X
0xFF03	1000 0000b	➔Encoder Resolution Error	d	X
0xFF04	1000 0000b	➔Hall Sensor not found Error	d	X
0xFF06	1000 0000b	➔Negative Limit Switch Error	f	
0xFF07	1000 0000b	➔Positive Limit Switch Error	f	
0xFF08	1000 0000b	➔Hall Angle Detection Error	f	X
0xFF09	1000 0000b	➔Software Position Limit Error	f	
0xFF0A	1000 0000b	➔Position Sensor Breach Error	d	X
0xFF0B	0010 0000b	➔System Overloaded Error	d	
0xFF0C	0010 0000b	➔Interpolated Position Mode Error	f	
0xFF0D	0010 0000b	➔Auto Tuning Identification Error	d	
0xFF0F	0010 0000b	➔Gear Scaling Factor Error	d	
0xFF10	0010 0000b	➔Controller Gain Error	f	
0xFF11	0010 0000b	➔Main Sensor Direction Error	d	
0xFF12	0010 0000b	➔Auxiliary Sensor Direction Error	d	
0xFF13	0010 0000b	➔CSP Interpolation Error	f	

Table 4-10 Error Codes – Overview

4.1.2 Generic Error

Error Code	0x1000
Error Register	0000 0001b
Cause	Unspecific error occurred
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword

4.1.3 Overcurrent Error

Error Code	0x2310
Error Register	0000 0010b
Cause	Short circuit in motor winding. Controller gains too high (➔Velocity Control Parameter Set, Position Control Parameter Set, Profile Acceleration) and/or deceleration too high (➔Profile Deceleration). Damaged power stage.
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword

4.1.4 Overvoltage Error

Error Code	0x3210
Error Register	0000 0100b
Cause	Power supply voltage too high
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	In most cases this error occurs at deceleration, where the motor works as a generator and the energy flows from motor to power supply (resulting in an increased voltage). Usually, a capacitor (e.g. 2200 µF) close to the device will solve the problem. If not, a shunt regulator will be necessary (maxon motor control order # 235811) to dissipate brake energy. Reset fault with ➔Controlword (only possible if supply voltage is in valid range).

4.1.5 Undervoltage Error

Error Code	0x3220
Error Register	0000 0100b
Cause	Supply voltage is too low for operation. Power supply cannot supply required acceleration current.
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword (only possible if supply voltage is in valid range)

4.1.6 Overtemperature Error

Error Code	0x4210
Error Register	0000 1000b
Cause	Temperature at device’s power stage too high
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword (only possible if temperature is in valid range)

4.1.7 Logic Supply Voltage Too Low Error

Error Code	0x5113
Error Register	0000 0100b
Cause	Overload on internally generated 5 V supply at Hall sensor connector or encoder connector
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword (only possible if supply voltage (+5V) is in valid range)

4.1.8 Supply Voltage Output Stage Too Low Error

Error Code	0x5114
Error Register	0000 0100b
Cause	Power supply of power stage too low. Power stage enable input is not activated while device is enabled.
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword (only possible output stage supply voltage is in valid range)

4.1.9 Internal Software Error

Error Code	0x6100
Error Register	0010 0000b
Cause	Internal software error occurred
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword

4.1.10 Software Parameter Error

Error Code	0x6320
Error Register	0010 0000b
Cause	➔Target Position too high with ➔Profile Velocity too low
Effect	Fault reaction defined in ➔Fault Reaction Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.11 Position Sensor Error

Error Code	0x7320
Error Register	0010 0000b
Cause	Detected position of position sensor is no longer valid due to… • changed Position Sensor Parameters • wrong Position Sensor Parameters • other errors that influence the absolute position detection (such as Hall Sensor Error, Encoder Index Error, …)
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword Actual position data is reset by clearing the error state
Error Recovery	Reset fault with ➔Controlword

4.1.12 Inconsistent Firmware Detected Error

Error Code	0x7580
Error Register	0000 0001b
Cause	The present firmware on the device is corrupt
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Perform firmware update

4.1.13 Firmware Version Conflict Error

Error Code	0x7581
Error Register	0000 0001b
Cause	Bad firmware version detected
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Perform firmware update

4.1.14 Ethernet Module internal Communication Error

Error Code	0x7582
Error Register	0001 0000b
Cause	Internal communication of the Ethernet module has failed
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword If the problem persists, perform firmware update or contact your supplier.

4.1.15 Ethernet Module Initialization Error

Error Code	0x7583
Error Register	0001 0000b
Cause	Initialization of the Ethernet module has failed
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset device. If the problem persists, perform firmware update or contact your supplier.

4.1.16 EtherCAT PDO Communication Error

Error Code	0x7584
Error Register	0001 0000b
Cause	EtherCAT Module detected an error at Process Data (PDO) communication
Effect	Fault reaction defined in ➔Abort Connection Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.17 EtherCAT SDO Communication Error

Error Code	0x7585
Error Register	0001 0000b
Cause	EtherCAT Module detected an error at Service Data (SDO) communication
Effect	Fault reaction defined in ➔Abort Connection Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.18 EtherCAT State Machine Error

Error Code	0x8180
Error Register	0001 0000b
Cause	EtherCAT State Machine detected an error (communication failed)
Effect	Fault reaction defined in ➔Abort Connection Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.19 Following Error

Error Code	0x8611
Error Register	0010 0000b
Cause	Difference between ➔Position Demand Value and ➔Position Actual Value higher than ➔Maximal Following Error
Effect	Fault reaction defined in ➔Fault Reaction Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.20 Hall Sensor Error

Error Code	0xFF01
Error Register	1000 0000b
Cause	Motor Hall sensors report an impossible signal combination due to… • incorrect wiring of Hall sensors • incorrect wiring of Hall sensor supply voltage • damaged Hall sensors • big Hall sensor signal noise
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword Actual position data is reset by clearing the error state
Error Recovery	Reset fault with ➔Controlword

4.1.21 Index Processing Error

Error Code	0xFF02
Error Register	1000 0000b
Cause	Encoder index signal was not found within two turns at start-up due to… • incorrect wiring of encoder cables • encoder without or with none working index channel • wrong sensor type (➔Sensor Configuration) • setting for encoder resolution (➔Sensor Configuration) too low Too many encoder index pulses were detected at unexpected positions due to… • big encoder signal noise • input frequency of encoder signals too high
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword Actual position data is reset by clearing the error state
Error Recovery	Reset fault with ➔Controlword

4.1.22 Encoder Resolution Error

Error Code	0xFF03
Error Register	1000 0000b
Cause	Encoder pulses counted between the first two index pulses does not fit to resolution. Setting of encoder resolution (➔Sensor Configuration) is wrong.
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword Actual position data is reset by clearing the error state
Error Recovery	Reset fault with ➔Controlword

4.1.23 Hall Sensor not found Error

Error Code	0xFF04
Error Register	1000 0000b
Cause	No Hall sensor 3 edge found within first motor turn due to… • wrong wiring of Hall sensors • defective Hall sensors • setting for encoder resolution (➔Sensor Configuration) too low
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword Actual position data is reset by clearing the error state
Error Recovery	Reset fault with ➔Controlword

4.1.24 Negative Limit Switch Error

Error Code	0xFF06
Error Register	1000 0000b
Cause	Negative limit switch was/is active. Wrong configuration of limit switch function in ➔Digital Input Functionalities.
Effect	Fault reaction defined in ➔Fault Reaction Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.25 Positive Limit Switch Error

Error Code	0xFF07
Error Register	1000 0000b
Cause	Negative limit switch was/is active. Wrong configuration of limit switch function in ➔Digital Input Functionalities.
Effect	Fault reaction defined in ➔Fault Reaction Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.26 Hall Angle Detection Error

Error Code	0xFF08
Error Register	1000 0000b
Cause	Angle difference measured between encoder and Hall sensors is too high due to… • wrong wiring of Hall sensors • defective Hall sensors • wrong wiring of encoder • defective encoder • wrong setting of encoder resolution or pole pairs (➔Sensor Configuration)
Effect	Fault reaction defined in ➔Fault Reaction Option Code Actual position data is reset by clearing the error state
Error Recovery	Reset fault with ➔Controlword

4.1.27 Software Position Limit Error

Error Code	0xFF09
Error Register	1000 0000b
Cause	Movement commanded or actual position runs out of software position limit (➔Software Position Limit)
Effect	Fault reaction defined in ➔Fault Reaction Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.28 Position Sensor Breach Error

Error Code	0xFF0A
Error Register	1000 0000b
Cause	Position sensor supervision has detected a bad working condition due to… • wrong/broken wiring of encoder • defective encoder • regulation parameter are not well tuned (➔Current Control Parameter Set)
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword Actual position data is reset by clearing the error state
Error Recovery	Reset fault with ➔Controlword. If error occurs frequently and none of above causes applies, position sensor supervision may be disabled by setting bit 0, respectively bit 1 TRUE in ➔Miscellaneous Configuration.

4.1.29 System Overloaded Error

Error Code	0xFF0B
Error Register	0010 0000b
Cause	Device has not enough free resources to process new target value
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword

4.1.30 Interpolated Position Mode Error

Error Code	0xFF0C
Error Register	0010 0000b
Cause	Fatal error during IPM execution. For detailed error cause ➔Interpolation Buffer.
Effect	Fault reaction defined in ➔Fault Reaction Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.31 Auto Tuning Identification Error

Error Code	0xFF0D
Error Register	0010 0000b
Cause	Error during identification process of Auto Tuning.
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword

4.1.32 Gear Scaling Factor Error

Error Code	0xFF0F
Error Register	0010 0000b
Cause	Product of gear ratio (➔Gear Configuration) and sensor resolutions ratio is out of range.
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword

4.1.33 Controller Gain Error

Error Code	0xFF10
Error Register	0010 0000b
Cause	Control function not possible due to controller gains of zero.
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword Fault reaction defined in ➔Fault Reaction Option Code
Error Recovery	Reset fault with ➔Controlword

4.1.34 Main Sensor Direction Error

Error Code	0xFF11
Error Register	0010 0000b
Cause	Position sensor supervision has detected a turn away of the motor in the opposite direction due to… • wrong setting of sensor polarity (➔Sensor Configuration) • wrong position sensor wiring • wrong motor wiring
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword If error occurs frequently and none of above causes applies, the software position sensor supervision may be disabled by setting bit 0 TRUE in ➔Miscellaneous Configuration.

4.1.35 Auxiliary Sensor Direction Error

Error Code	0xFF12
Error Register	0010 0000b
Cause	Position sensor supervision has detected a turn away of the motor in the opposite direction due to… • wrong setting of auxiliary sensor polarity (➔Sensor Configuration) • wrong position auxiliary sensor wiring • wrong motor wiring
Effect	Device disabled Red LED “ON” Error flag set in ➔Statusword
Error Recovery	Reset fault with ➔Controlword If error occurs frequently and none of above causes applies, the software position sensor supervision may be disabled by setting bit 0 TRUE in ➔Miscellaneous Configuration.

4.1.36 CSP Interpolation Error

Error Code	0xFF13
Error Register	0010 0000b
Cause	Fatal error during interpolation (missed interrupt from DC/SM). Verify Interpolation Time Period Value (0x60C2-01, ➔Interpolation Time Period)!
Effect	Fault reaction defined in ➔Fault Reaction Option Code
Error Recovery	Reset fault with ➔Controlword

4.2 Communication Errors (Abort Codes)

An abort object will be sent over the network instead of a response to a SDO request if the request was going wrong. The same abort code will be sent as part of the response to the USB transfer request.

Abort Code	Name	Cause
0x0000 0000	No Communication Error	Communication successful
0x0503 0000	Toggle Error	Toggle bit not alternated
0x0504 0000	SDO Time Out	SDO protocol timed out
0x0504 0001	Client / Server Specifier Error	Client / server command specifier not valid or unknown
0x0504 0005	Out of Memory Error	Out of memory
0x0601 0000	Access Error	Unsupported access to an object
0x0601 0001	Write Only	Read command to a write only object
0x0601 0002	Read Only	Write command to a read only object
0x0602 0000	Object does not exist Error	Last read or write command had wrong object index or subindex
0x0604 0041	PDO mapping Error	Object is not mappable to the PDO
0x0604 0042	PDO Length Error	Number and length of objects to be mapped would exceed PDO length
0x0604 0043	General Parameter Error	General parameter incompatibility
0x0604 0047	General internal Incompatibility Error	General internal incompatibility in device
0x0606 0000	Hardware Error	Access failed due to hardware error
0x0607 0010	Service Parameter Error	Data type does not match, length or service parameter does not match
0x0607 0012	Service Parameter too long Error	Data type does not match, length of service parameter too high
0x0607 0013	Service Parameter too short Error	Data type does not match, length of service parameter too low
0x0609 0011	Object Subindex Error	Last read or write command had wrong object subindex
0x0609 0030	Value Range Error	Value range of parameter exceeded
0x0609 0031	Value too high Error	Value of parameter written too high
0x0609 0032	Value too low Error	Value of parameter written too low
0x0609 0036	Maximum less Minimum Error	Maximum value is less than minimum value
0x0800 0000	General Error	General error
0x0800 0020	Transfer or store Error	Data cannot be transferred or stored
0x0800 0021	Local Control Error	Data cannot be transferred or stored to application because of local control
0x0800 0022	Wrong Device State	Data cannot be transferred or stored to application because of present device state
0x0800 0023	No Object Dictionary	Object dictionary dynamic generation fails or no object dictionary is present

Abort Code	Name	Cause
0x0F00 FFC0	Wrong EtherCAT State Error	Device is in wrong EtherCAT state
0x0F00 FFBF	Illegal Command Error	Command code is illegal (does not exist)
0x0F00 FFBE	Password Error	Password is incorrect
0x0F00 FFBC	Error Service Mode	Device is not in service mode

Table 4-11 Communication Errors

4.3 EtherCAT Emergency Request

Upon error in the EtherCAT State Machine (ESM), an EtherCAT Emergency Request will be sent.

Byte	0	1	2	3	4	5	6	7
Description	Emergency Error Code		Error Register	Additional error information				

Table 4-12 EtherCAT Emergency Request

Emergency Error Code	Description
0xA000	Transition PRE-OPERATIONAL to SAFE-OPERATIONAL not successful
0xA001	Transition SAFE-OPERATIONAL to OPERATIONAL not successful

Table 4-13 ESM Transition Error Codes

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5 Operating Modes

5.1 Operating Mode Selection Guide

The device behavior depends on the currently activated mode of operation.

- Choose desired mode (➔“Overview” on page 5-34).
- Select mode using (➔“Modes of Operation” on page 8-153).
- Read currently active mode from ➔“Modes of Operation Display” on page 8-153.

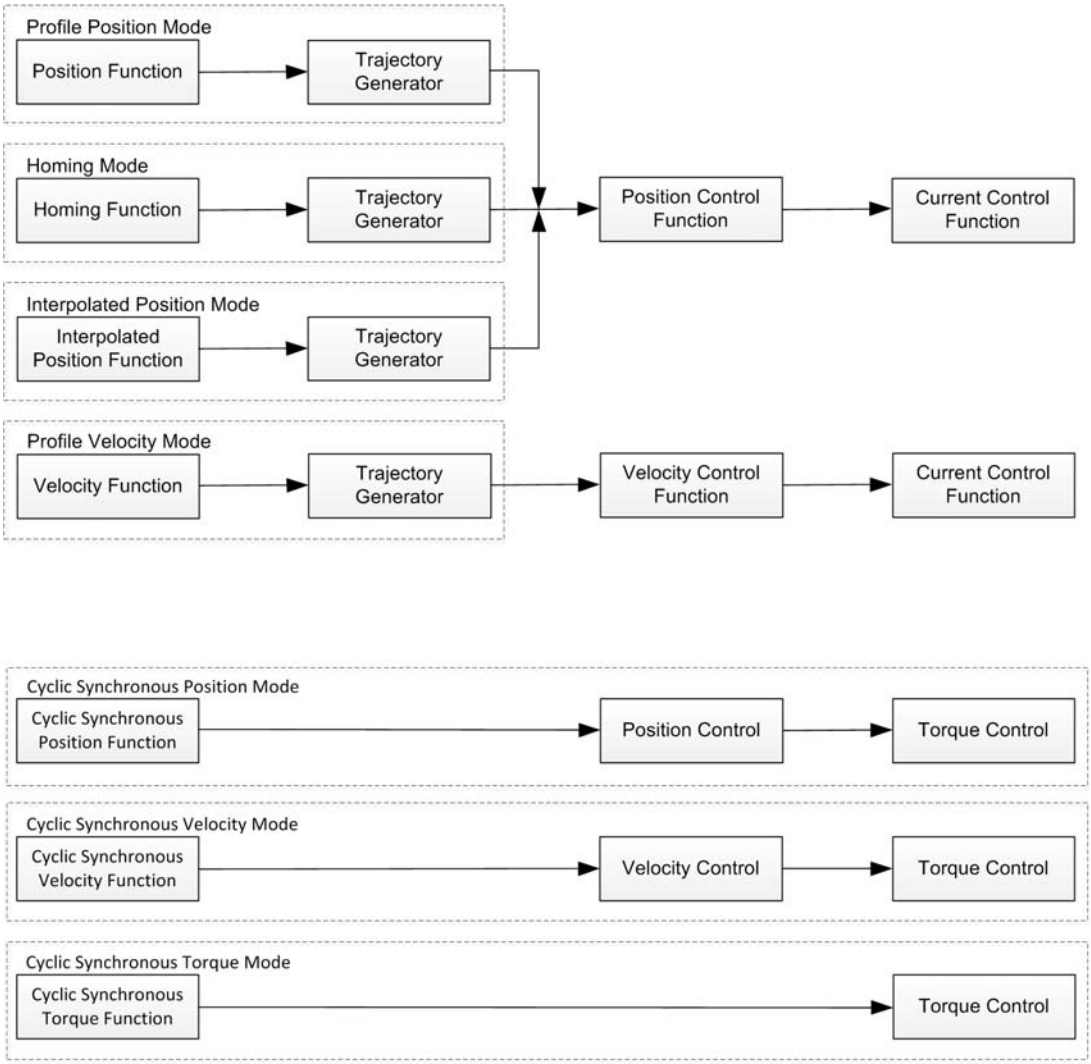


Figure 5-4 Functional Architecture

5.2 Overview

Profile Position Mode

Defines drive's positioning. Speed, position and acceleration can be limited, profiled moves using a Trajectory Generator can be executed.

Profile Velocity Mode

Used to control the velocity of the drive without particular focus on the position. It supplies limit functions and Trajectory Generation.

Homing Mode

Provides various methods to find a home position (also called reference point, zero point).

Interpolated Position Mode

The higher-level trajectory planner sends a set of interpolation points by PVT reference point. Each PVT reference point contains information on position, velocity, and time of a profile segment end point. The trajectory generator of EPOS3 performs a third order interpolation between the actual and the next reference point.

Cyclic Synchronous Position Mode

The trajectory generator is located in the control device (not in the drive device). In cyclic synchronous manner, it provides a target position to the drive device, which then performs position control, velocity control, and torque control.

Cyclic Synchronous Velocity Mode

The trajectory generator is located in the control device (not in the drive device). In cyclic synchronous manner, it provides a target velocity to the drive device, which then performs velocity control and torque control.

Cyclic Synchronous Torque Mode

The trajectory generator is located in the control device (not in the drive device). In cyclic synchronous manner, it provides a target torque to the drive device, which then performs torque control.

5.3 Profile Position Mode (PPM)

A target position is applied to the trajectory generator. It will generate a position demand value for the position control loop described in ➔"Cyclic Synchronous Position Mode (CSP)" on page 5-65. For the overall architecture of this mode ➔Figure 5-5).

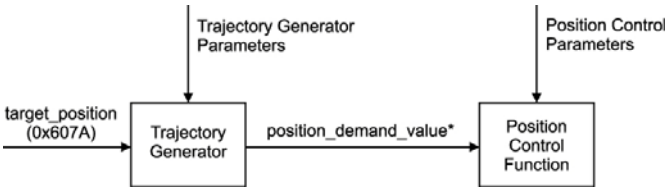


Figure 5-5 Profile Position Mode – Overview

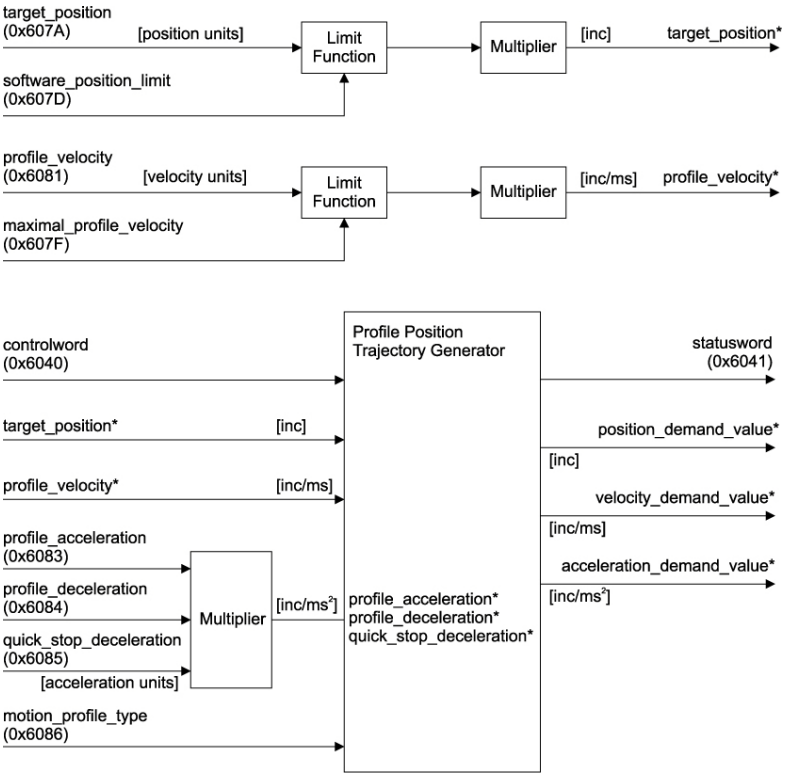


Figure 5-6 Profile Position Mode – Block Diagram

The «Target Reached Function» offers the possibility to define a position range (➔"Position Window" on page 8-155) around the ➔"Target Position" on page 8-160 to be reached as valid.

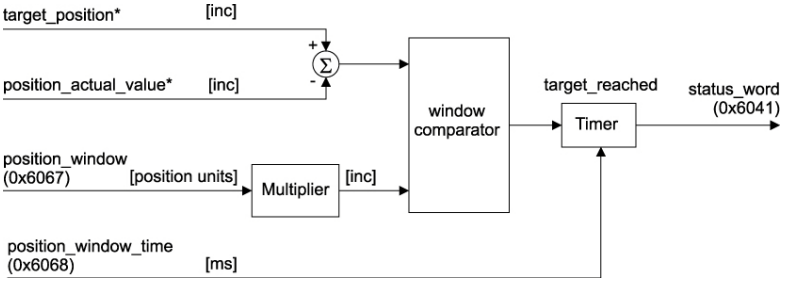


Figure 5-7 Profile Position Mode – Velocity Window

5.3.1 Profile Position Trajectory Generator

The trajectory generator supports different motion profile types.

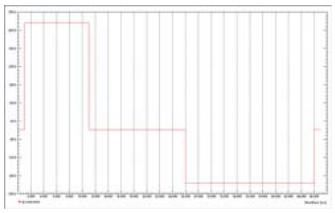
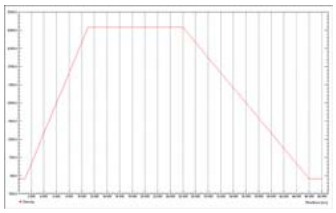
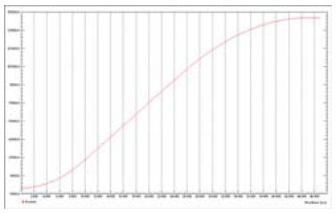
Acceleration	Velocity	Position
		
A_{max} = Profile acceleration A_{min} = Profile deceleration	V_{max} = Profile velocity	Absolute Movement P_{end} = Target position Relative Movement P_{end} = Position demand value + Target position

Figure 5-8 Profile Position Trajectory – Linear Ramp (trapezoidal Profile)

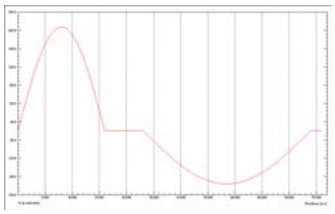
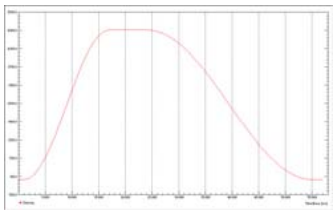
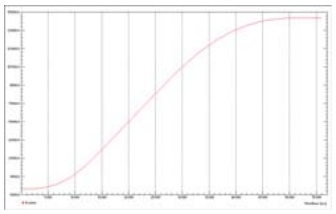
Acceleration	Velocity	Position
		
A_{max} = Profile acceleration A_{min} = Profile deceleration	V_{max} = Profile velocity	Absolute Movement P_{end} = Target position Relative Movement P_{end} = Position demand value + Target position

Figure 5-9 Profile Position Trajectory – Sin^2 Ramp (sinusoidal Profile)

5.3.2 How to use «Profile Position Mode»

5.3.2.1 Configuration Parameters

Parameter	Index	Description
➔Position Window	0x6067	Permits definition of a position range around a target position to be regarded as valid. If the drive is within this area for a specified time, the related Statusword control bit 10 «Target reached» is set.
➔Position Window Time	0x6068	Defines the time for the position window.
➔Software Position Limit	0x607D	Contains the sub-parameters «Minimal Position Limit» and «Maximal Position Limit» that define the absolute position limits or the position demand value. A new target position will be checked against these limits.
➔Maximal Profile Velocity	0x607F	Defines the maximal allowed speed.
➔Quickstop Deceleration	0x6085	Defines the deceleration ramp during a Quickstop.
➔Max Acceleration	0x60C5	Defines the maximal allowed acceleration.

Table 5-14 Profile Position Mode – Configuration Parameters

5.3.2.2 Commanding Parameters

Parameter	Index	Description
➔Controlword	0x6040	The mode will be controlled by a write access to the Controlword's mode-dependent bits.
➔Target Position	0x607A	The position, the drive is supposed to move using the current settings of motion control parameters, such as velocity, acceleration, motion profile type, etc. It will be interpreted as absolute or relative depending on the Controlword "abs / rel" flag.
➔Profile Velocity	0x6081	The velocity normally attained at the end of the acceleration ramp during a profiled move.
➔Profile Acceleration	0x6083	Defines the acceleration ramp during a movement.
➔Profile Deceleration	0x6084	Defines the deceleration ramp during a movement.
➔Motion Profile Type	0x6086	Selects the type of motion profile used for the movement: 0 = linear ramp (trapezoidal profile) 1 = $\sin^2$ ramp (sinusoidal profile)

Table 5-15 Profile Position Mode – Commanding Parameters

5.3.2.3 Controlword (Profile Position Mode-specific Bits)

Bit 15…9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3…0
➔ Table 8-111	Halt	➔ Table 8-111	Abs / rel	Change set immediately	New setpoint	➔ Table 8-111

Table 5-16 Profile Position Mode – Controlword

Name	Value	Description
New setpoint	0	Does not assume ➔Target Position
	1	Assume ➔Target Position
Change set immediately	0	Finish actual positioning, then start next positioning
	1	Interrupt actual positioning and start next positioning
Abs / rel	0	➔Target Position is an absolute value
	1	➔Target Position is a relative value
Halt	0	Execute positioning
	1	Stop axle with ➔Profile Deceleration

Table 5-17 Profile Position Mode – Controlword Bits

5.3.2.4 Output Parameters

Parameter	Index	Description
➔Statusword	0x6041	Mode state can be observed by the Statusword bits.
➔Position Demand Value	0x6062	The output of the trajectory generator – it is used as input for the position control function.

Table 5-18 Profile Position Mode – Output Parameters

5.3.2.5 Statusword (Profile Position Mode-specific Bits)

Bit 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9…0
➔ Table 8-112	Following error	setpoint acknowledge	➔ Table 8-112	Target reached	➔ Table 8-112

Table 5-19 Profile Position Mode – Statusword

Name	Value	Description
Target reached	0	Halt = 0: ➔Target Position not reached Halt = 1: Axle decelerates
	1	Halt = 0: ➔Target Position reached Halt = 1: Velocity of axle is 0
setpoint acknowledge	0	Trajectory generator has not (yet) assumed positioning value
	1	Trajectory generator has assumed positioning value
Following error	0	Not following error
	1	Following error

Table 5-20 Profile Position Mode – Statusword Bits

5.4 Profile Velocity Mode (PVM)

The profile velocity mode includes a velocity trajectory generator and a velocity control function.

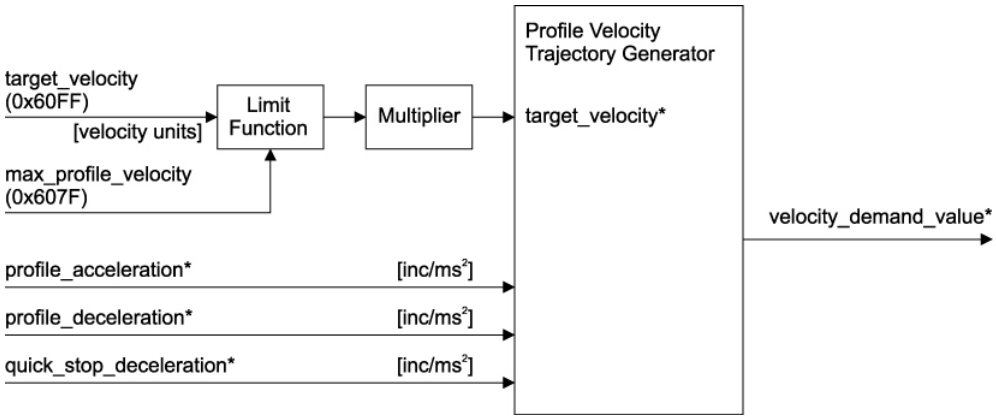


Figure 5-10 Profile Velocity Mode – Block Diagram

The target reached function offers the possibility to define a velocity range (➔"Velocity Window" on page 8-158) around the ➔"Target Velocity" on page 8-185 to be reached as valid.

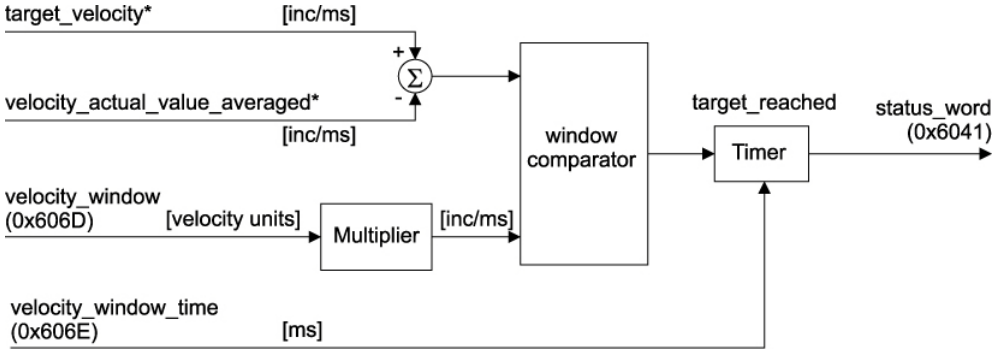


Figure 5-11 Profile Velocity Mode – Velocity Window

5.4.1 Profile Velocity Trajectory Generator

The trajectory generator supports different motion profile types.

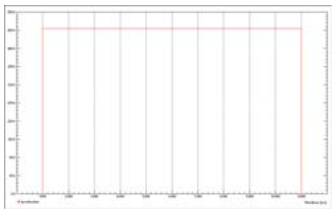
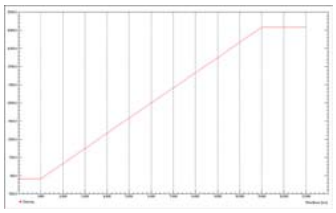
Acceleration	Velocity
	
A_{max} = Profile acceleration A_{min} = −Profile deceleration	V_{max} = Target velocity

Figure 5-12 Profile Velocity Trajectory – Linear Ramp (trapezoidal Profile)

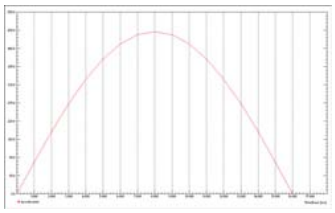
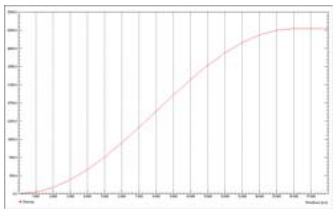
Acceleration	Velocity
	
A_{max} = Profile acceleration A_{min} = −Profile deceleration	V_{max} = Target velocity

Figure 5-13 Profile Velocity Trajectory – Sin^2 Ramp (sinusoidal Profile)

5.4.2 How to use «Profile Velocity Mode»

5.4.2.1 Configuration Parameters

Parameter	Index	Description
➔Velocity Window	0x606D	Permits the definition of a velocity range around a target velocity to be regarded as valid. If the drive is within this area for a specified time, the related Statusword control bit 10 «Target Reached» is set.
➔Velocity Window Time	0x606E	Defines the time for the velocity window.
➔Maximal Profile Velocity	0x607F	Defines the maximal allowed speed.
➔Quickstop Deceleration	0x6085	Defines the deceleration ramp during Quickstop.
➔Max Acceleration	0x60C5	Defines the maximal allowed acceleration.

Table 5-21 Profile Velocity Mode – Configuration Parameters

5.4.2.2 Commanding Parameters

Parameter	Index	Description
➔Controlword	0x6040	The mode will be controlled by a write access to the Controlword's mode-dependent bits.
➔Target Velocity	0x60FF	The speed the drive is supposed to reach.
➔Profile Acceleration	0x6083	Defines the acceleration ramp during a movement.
➔Profile Deceleration	0x6084	Defines the deceleration ramp during a movement.
➔Motion Profile Type	0x6086	Selects the type of motion profile used for the movement. 0 = linear ramp (trapezoidal profile) 1 = $\sin^2$ ramp (sinusoidal profile)

Table 5-22 Profile Velocity Mode – Commanding Parameters

5.4.2.3 Controlword (Profile Velocity Mode-specific Bits)

Bit 15…9	Bit 8	Bit 7	Bit 6…4	Bit 3…0
➔ Table 8-111	Halt	➔ Table 8-111	reserved	➔ Table 8-111

Table 5-23 Profile Velocity Mode – Controlword

Name	Value	Description
Halt	0	Execute motion
	1	Stop axle

Table 5-24 Profile Velocity Mode – Controlword Bits

5.4.2.4 Output Parameters

Parameter	Index	Description
➔Statusword	0x6041	Mode state can be observed by the Statusword bits.
➔Position Demand Value	0x6062	The output of the trajectory generator – it is used as input for the position control function.

Table 5-25 Profile Velocity Mode – Output Parameters

5.4.2.5 Statusword (Profile Velocity Mode-specific Bits)

Bit 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9…0
➔ Table 8-112	Not used	Speed	➔ Table 8-112	Target reached	➔ Table 8-112

Table 5-26 Profile Velocity Mode – Statusword

Name	Value	Description
Target reached	0	Halt = 0: Target velocity not (yet) reached Halt = 1: Axle decelerates
	1	Halt = 0: Target velocity reached Halt = 1: Axle has velocity 0
Speed	0	Speed is not equal 0
	1	Speed is equal 0

Table 5-27 Profile Velocity Mode – Statusword Bits

5.5 Homing Mode

«Homing» describes the procedure to which a drive seeks the home position (also called reference point or zero point). There are various methods to achieve this using limit switches at the both ends of travel or a home switch (zero point switch) in mid-travel. Most of the methods use the index (zero) pulse train of an incremental encoder.

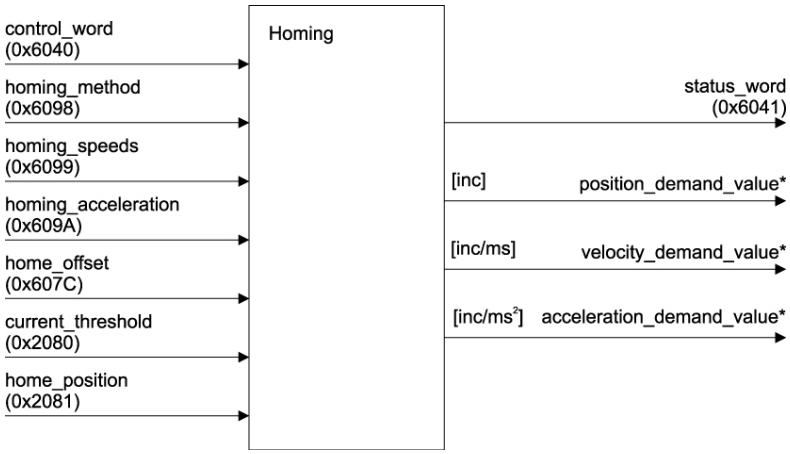


Figure 5-14 Homing Mode – Block Diagram

5.5.1 Homing Trajectory Generator

The trajectory generator supports different motion profile types. The movements are mode-dependent, the end positions will be calculated internally.

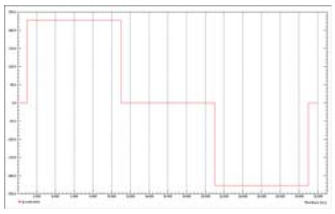
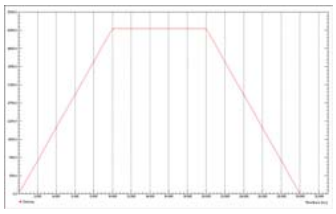
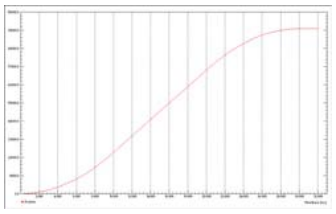
Acceleration	Velocity	Position
		
A_{max} = Homing acceleration A_{min} = −Homing acceleration	V_{max} = speed for switch search or speed for zero search	Absolute Movement: P_{end} = e.g. reference position + home offset

Figure 5-15 Homing Trajectory – Linear Ramp (trapezoidal Profile)

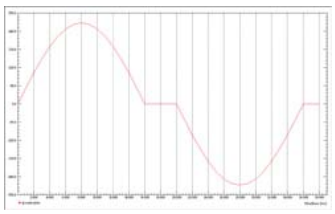
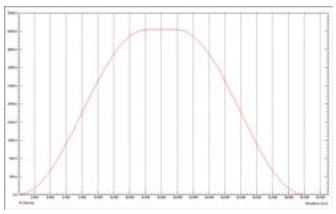
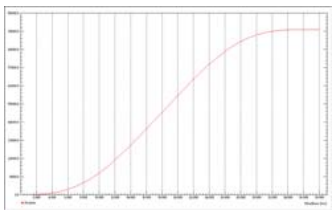
Acceleration	Velocity	Position
		
A_{max} = Homing acceleration A_{min} = −Homing acceleration	V_{max} = speed for switch search or speed for zero search	Absolute Movement: P_{end} = e.g. reference position + home offset

Figure 5-16 Homing Trajectory – Sin² Ramp (sinusoidal Profile)

5.5.2 How to use «Homing Mode»

5.5.2.1 Configuration Parameters

Parameter	Index	Description
➔Configuration of Digital Inputs	0x2070	Permits configuration of EPOS3 EtherCAT's digital inputs to Digital Input Functionalities. Especially useful for limit and homing switches used for «Homing».
➔Digital Input Functionalities	0x2071	Can be masked and changed in polarity by Digital Input Functionalities.
➔Motion Profile Type	0x6086	Selects the type of motion profile used for the movement. 0 = linear ramp (trapezoidal profile 1 = $\sin^2$ ramp (sinusoidal profile

Table 5-28 Homing Mode – Configuration Parameters

5.5.2.2 Commanding Parameters

Parameter	Index	Description
➔Controlword	0x6040	The mode will be controlled by a write access to the Controlword's mode-dependent bits.
➔Homing Method	0x6098	Defines the type of homing procedure.
➔Homing Speeds	0x6099	Specifies the two speeds used for Homing: In a typical cycle, the faster speed is used to find the home switch, the slower speed is used to find the index pulse.
➔Homing Acceleration	0x609A	Specifies the acceleration during Homing.
➔Home Offset	0x607C	The distance to move away from a detected position upon end of the homing sequence.
➔Current Threshold for Homing Mode	0x2080	The current threshold for current index homing methods.
➔Home Position	0x2081	Allows to displace zero in the user's coordinate system.

Table 5-29 Homing Mode – Commanding Parameters

5.5.2.3 Controlword (Homing Mode-specific Bits)

Bit 15…9	Bit 8	Bit 7	Bit 6, 5	Bit 4	Bit 3…0
➔ Table 8-111	Halt	➔ Table 8-111	reserved	Homing operation start	➔ Table 8-111

Table 5-30 Homing Mode – Controlword

Name	Value	Description
Homing operation start	0	Homing mode inactive
	0➔1	Start homing mode
	1	Homing mode active
Halt	0	Execute instruction of bit 4
	1	Stop axle with ➔Homing Acceleration

Table 5-31 Homing Mode – Controlword Bits

5.5.2.4 Output Parameters

Parameter	Index	Description
➔Statusword	0x6041	Mode state can be observed by the Statusword bits.

Table 5-32 Homing Mode – Output Parameters

5.5.2.5 Statusword (Homing Mode-specific Bits)

Bit 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9…0
➔ Table 8-112	Homing error	Homing attained	➔ Table 8-112	Target reached	➔ Table 8-112

Table 5-33 Homing Mode – Statusword

Name	Value	Description
Target reached	0	Halt = 0: Home position not reached Halt = 1: Axle decelerates
	1	Halt = 0: Home position reached Halt = 1: Velocity of axle is 0
Homing attained	0	Homing mode not yet completed
	1	Homing mode successfully terminated
Homing error	0	No homing error
	1	Homing error occurred Homing mode carried out not successfully For error cause read error code
Position in referenced to Home Position	0	Not referenced to home position
	1	The ➔Position Actual Value is referenced to home position

Table 5-34 Homing Mode – Statusword Bits

5.5.3 Homing Methods

5.5.3.1 Homing Method 1 (Negative Limit Switch & Index)

The initial direction of the movement is to the left (to negative position) if the negative limit switch is inactive (here shown as low).

a) The axis moves with speed for switch search (➔Homing Speeds) to the edge of negative limit switch (1).

b) The axis moves with speed for zero search (➔Homing Speeds) to the encoder index pulse (2).

c) Now, the axis moves the ➔Home Offset (3). This point will be used as reference for all further moves and is set to ➔Home Position (4).

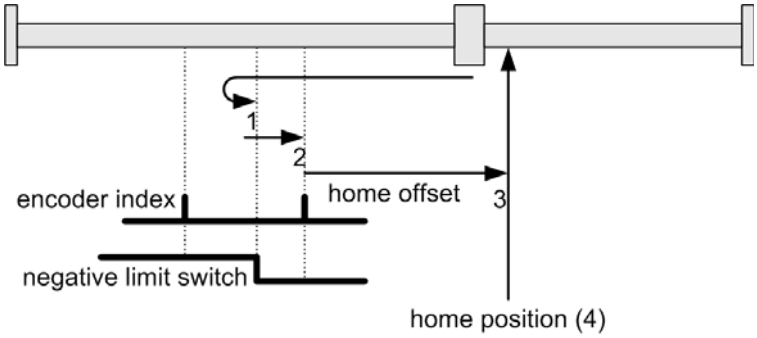


Figure 5-17 Homing Method 1

5.5.3.2 Homing Method 2 (Positive Limit Switch & Index)

The initial direction of movement is to the right (to positive positions) if the positive limit switch is inactive (here shown as low).

a) The axis moves with speed for switch search (➔Homing Speeds) to the edge of positive limit switch (1).

b) The axis moves with speed for zero search (➔Homing Speeds) to the encoder index pulse (2).

c) Now, the axis moves the ➔Home Offset (3). This point will be used as reference for all further moves and is set to ➔Home Position (4).

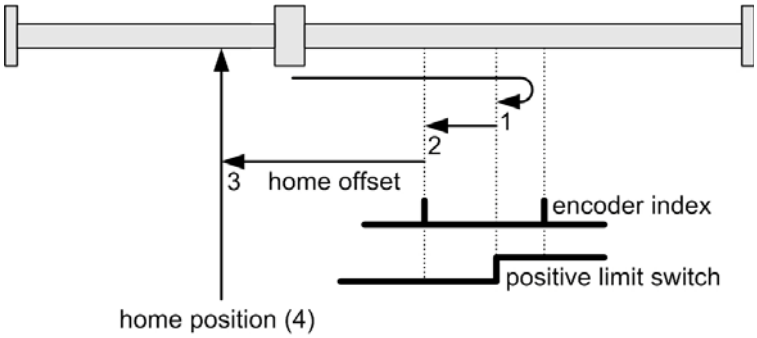


Figure 5-18 Homing Method 2

5.5.3.3 Homing Method 7 (Home Switch Positive Speed & Index)

Uses a home switch, which is active over only portion of the travel. In effect, the switch momentarily acts as the axle's position sweeps past the switch.

Using this method, the initial direction of movement is to the right (to positive position) except the home switch is already active at start of the motion.

a) The axis moves with speed for switch search (➔Homing Speeds) to the edge of home switch (1).

b) The axis moves with speed for zero search (➔Homing Speeds) to the encoder index pulse (2).

c) Now, the axis moves the ➔Home Offset (3). This point will be used as reference for all further moves and is set to ➔Home Position (4).

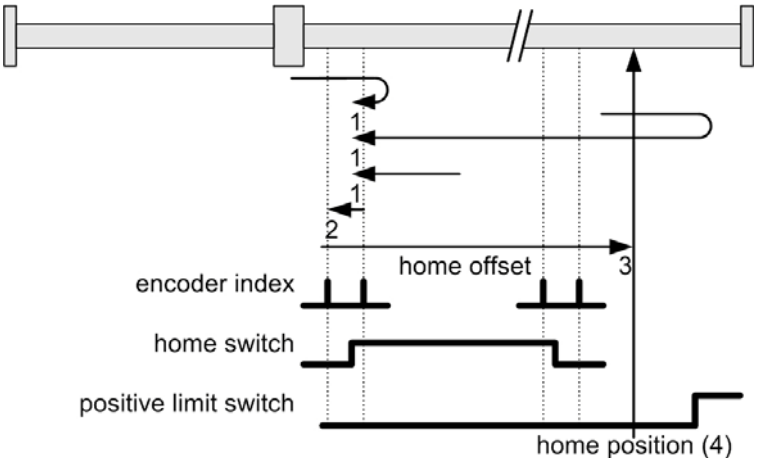


Figure 5-19 Homing Method 7

5.5.3.4 Homing Method 11 (Home Switch Negative Speed & Index)

Uses a home switch, which is active over only portion of the travel. In effect the switch has a momentary action as the axle's position sweeps past the switch.

Using this method, the initial direction of movement is to the left (to negative position) except if the home switch is already active at start of the motion.

a) The axis moves with speed for switch search ➔Homing Speeds) to the edge of home switch (1).

b) The axis moves with speed for zero search ➔Homing Speeds) to the encoder index pulse (2).

c) Now, the axis moves the ➔Home Offset (3). This point will be used as reference for all further moves and is set to ➔Home Position (4).

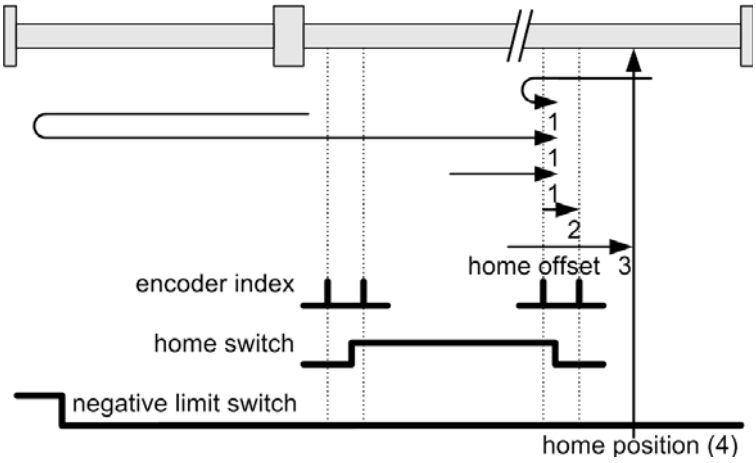


Figure 5-20 Homing Method 11

5.5.3.5 Homing Method 17 (Negative Limit Switch)

Similar to method 1 except that the Home position is not dependent on the index pulse but only on the negative limit switch.

5.5.3.6 Homing Method 18 (Positive Limit Switch)

Similar to method 2 except that the ➔Home Position is not dependent on the index pulse but only on the positive limit switch.

5.5.3.7 Homing Method 23 (Home Switch Positive Speed)

Similar to method 7 except that the ➔Home Position is not dependent on the index pulse but only on falling edge of the home switch.

5.5.3.8 Homing Method 27 (Home Switch Negative Speed)

Similar to method 11 except that the ➔Home Position is not dependent on the index pulse but only on falling edge of the home switch.

5.5.3.9 Homing Methods 33 and 34 (Index Negative / Positive Speed)

Direction for homing is negative (method 33) or positive, respectively (method 34).

a) The axis moves with speed for zero search (➔Homing Speeds) to the next encoder index pulse (33) or (34).

b) Now, the axis moves the ➔Home Offset (2). This point will be used as reference for all further moves and is set to ➔Home Position (4).

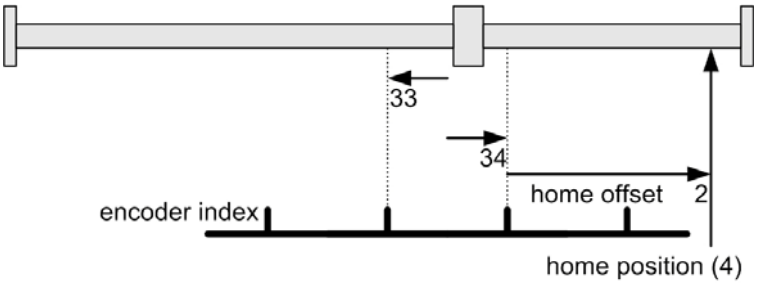


Figure 5-21 Homing Methods 33 and 34

5.5.3.10 Homing Method 35 (obsolete; Actual Position)

The current position is changed and considered as the future Home position.

5.5.3.11 Homing Method 37 (Actual Position)

The current position is changed and considered as the future Home position.

5.5.3.12 Homing Method −1 (Current Threshold Positive Speed & Index)

Uses a mechanical end stop on the right (positive) side. This border is detected when the output current rises above Current Threshold for Homing Mode.

a) The axis moves with positive speed for switch search (➔Homing Speeds) to the mechanical end stop (1).

b) The axis moves to the next encoder index pulse (2) with speed for zero search (➔Homing Speeds).

c) Now, the axis moves the ➔Home Offset (3). This point will be used as reference for all further moves and is set to ➔Home Position (4).

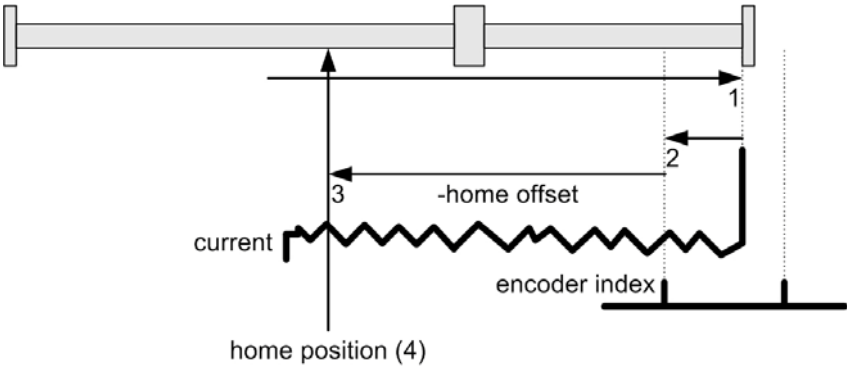


Figure 5-22 Homing Method −1

5.5.3.13 Homing Method −2 (Current Threshold Negative Speed & Index)

Uses a mechanical end stop on the left (negative) side. This border is detected when the output current rises above Current Threshold for Homing Mode.

a) The axis moves with negative speed for switch search (➔Homing Speeds) to the mechanical end stop (1).

b) The axis moves to the next encoder index pulse (2) with speed for zero search (➔Homing Speeds).

c) Now, the axis moves the ➔Home Offset (3). This point will be used as reference for all further moves and is set to ➔Home Position (4).

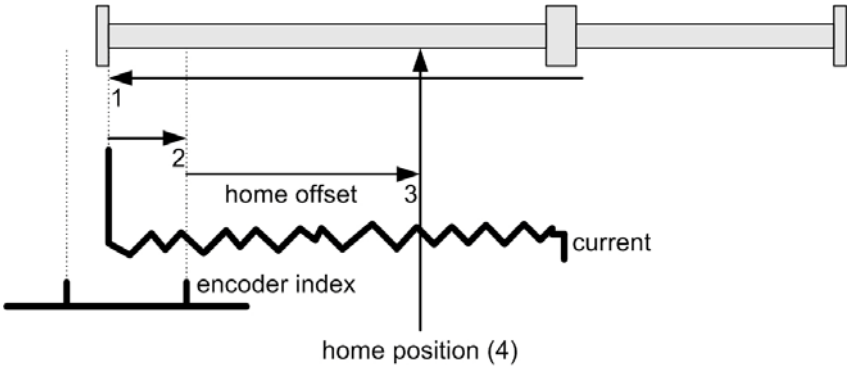


Figure 5-23 Homing Method −2

5.5.3.14 Homing Method −3 (Current Threshold Positive Speed)

Similar to method −1 except that the ➔Home Position is not dependent on the index pulse but only on mechanical end stop.

5.5.3.15 Homing Method −4 (Current Threshold Negative Speed)

Similar to method −2 except that the ➔Home Position is not dependent on the index pulse but only on mechanical end stop.

5.6 Interpolated Position Mode (PVT)

The Interpolated Position Mode described in the CANopen standard CiA 402 V3.0 is a general case. The objects are well-specified for a linear interpolation (PT). The interpolation type can also be extended by manufacturer-specific algorithms (selectable by «Interpolation Submode Selection», Object 0x60C0).

5.6.1 Spline Interpolation

For the Interpolated Position Mode, the interpolation type proposed by National Instruments is a cubic spline interpolation. The higher-level trajectory planner sends a set of interpolation points by PVT reference point. Each PVT reference point contains information on position, velocity and time of a profile segment end point. The trajectory generator of the drive performs a third order interpolation between the actual and the next reference point.

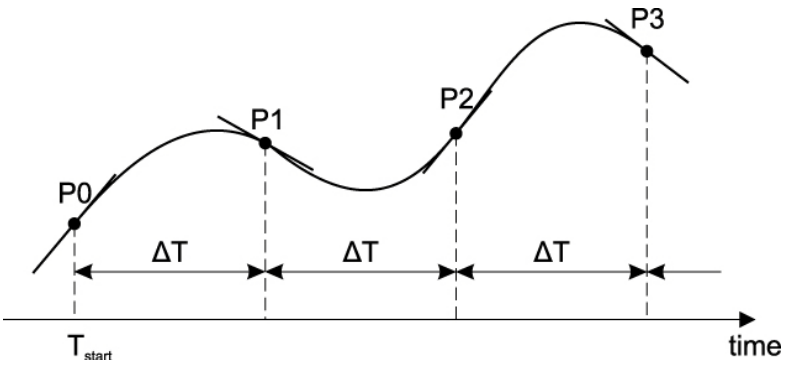


Figure 5-24 Interpolated Position Mode – PVT Principle

From two successive PVT reference points, the interpolation parameters a, b, c and d can be calculated:

```
d = P[t0] = P[n]
c = V[t0] = V[n]
b = T-2[n+1] * (3 * (P[n+1] – P[n]) – T[n+1] * (V[n+1] + 2 * V[n]))
a = T-3[n+1] * (–2 * (P[n+1] – P[n]) + T[n+1] * (V[n+1] + V[n]))
```

The interpolated values for position, velocity and (possibly also for) acceleration will be calculated as follows:

```
P(t) = a * (t – t0)3 + b * (t – t0)2 + c * (t – t0) + d
V(t) = 3a * (t – t0)2 + 2b * (t – t0) + c
A(t) = 6a * (t – t0) + 2b
```

The calculation shows that it is not mandatory that the time intervals are identical.

5.6.2 IPM Implementation by maxon

The Interpolated Position Mode is implemented in the EPOS3 EtherCAT as an additional operational mode (operating mode 7 as specified in CiA 402 V3.0).

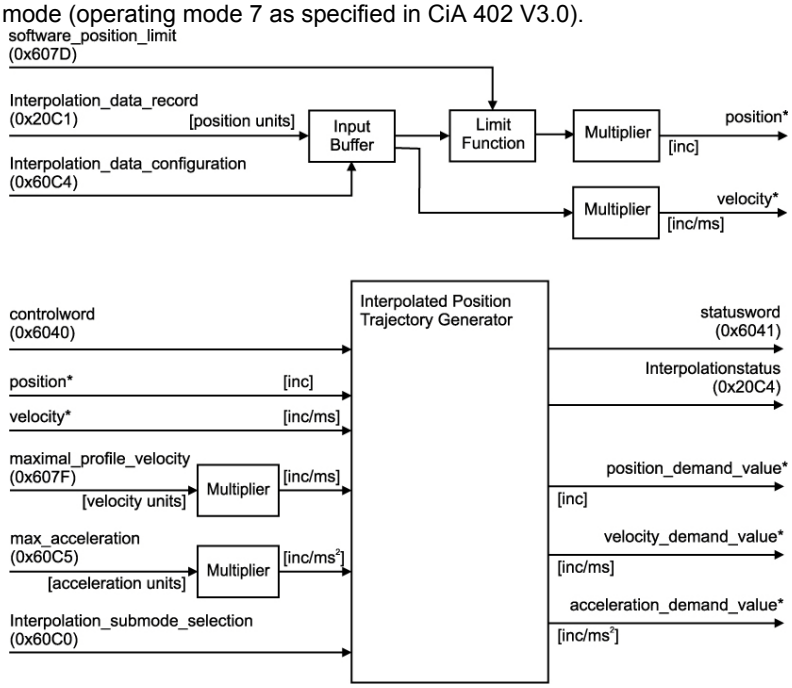


Figure 5-25 Interpolated Position Mode – Interpolation Controller

5.6.3 Interpolated Position Data Buffer

PVT reference points will be sent in a manufacturer-specific 64 bit data record of a complex data structure to a FIFO object. The FIFO will be implemented by a circular buffer with the length of 64 entries.

5.6.3.1 Definition of complex Data Structure 0x0040

MSB		LSB
Time (unsigned8)	Velocity (signed24)	Position (signed32)

Table 5-35 Interpolated Position Mode – IPM Data Buffer Structure

5.6.4 Interpolated Position Mode FSA

The interpolated position finite state automaton is a sub FSA of the Operation enable state (for description "*" ➔chapter "3.2 Device Control" on page 3-14).

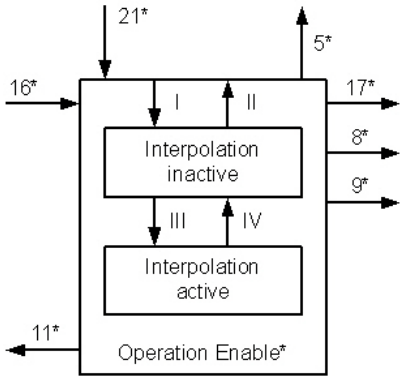


Figure 5-26 Interpolated Position Mode – FSA

FSA State	Function
Interpolation inactive	The drive device accepts input data and buffers it for interpolation calculations, but does not move the axis.
Interpolation active	The drive device accepts input data and moves the axis.

Table 5-36 Interpolated Position Mode – FSA States and supported Functions

Transition	Event		Action
I	ip mode selected (➔Modes of Operation)		clear data buffer
II	ip mode not selected (➔Modes of Operation)		none
III	enable ip mode:	set Controlword bit 4 to 1	none
IV	disable ip mode:	set Controlword bit 4 to 0 or ip data record with time = 0	none

Table 5-37 Interpolated Position Mode – Transition Events and Actions

5.6.4.1 Configuration Parameters

Parameter	Index	Description
➔Interpolation Sub Mode Selection	0x60C0	Indicates the actually chosen interpolation mode.
➔Interpolation Time Period	0x60C2	Indicates the configured interpolation cycle time.
➔Interpolation Data Configuration	0x60C4	Provides information on configuration and state of the buffer. It can also be used to clear the buffer.
➔Software Position Limit	0x607D	Contains the sub-parameters «Minimal Position Limit» and «Maximal Position Limit» that define the absolute position limits for the position demand value. A new target position will be checked against these limits
➔Position Window	0x6067	Permits definition of a position range around a target position to be regarded as valid. If the drive is within this area for a specified time, the related Statusword control bit 10 «Target reached» is set.
➔Position Window Time	0x6068	Defines the time or the position window.

Table 5-38 Interpolated Position Mode – Configuration Parameters

5.6.4.2 Commanding Parameters

Parameter	Index	Description
➔Controlword	0x6040	The mode will be controlled by a write access to the Controlword's mode-dependent bits.
➔Interpolation Data Record	0x20C1	Contains a FIFO to feed PVT reference points to the data buffer.

Table 5-39 Interpolated Position Mode – Commanding Parameters

5.6.4.3 Controlword (Interpolated Position Mode-specific Bits)

Bit 15…9	Bit 8	Bit 7	Bit 6, 5	Bit 4	Bit 3…0
➔ Table 8-111	Halt	➔ Table 8-111	reserved (0)	Enable ip mode	➔ Table 8-111

Table 5-40 Interpolated Position Mode – Controlword

Name	Value	Description
Enable ip mode	0	Interpolated position mode inactive
	1	Interpolated position mode active
Halt	0	Execute instruction of bit 4
	1	Stop axis with profile deceleration

Table 5-41 Interpolated Position Mode – Controlword Bits

5.6.4.4 Output Parameters

Parameter	Index	Description
➔Interpolation Buffer	0x20C4	Status
➔Statusword	0x6041	Mode state can be observed by Statusword bits.
➔Position Demand Value	0x6062	The output of the trajectory generator – it is used as input for the position control function.

Table 5-42 Interpolated Position Mode – Output Parameters

5.6.4.5 Statusword (Interpolated Position Mode-specific Bits)

Bit 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9…0
➔ Table 8-112	reserved	ip mode active	➔ Table 8-112	Target reached	➔ Table 8-112

Table 5-43 Interpolated Position Mode – Statusword

Name	Value	Description
Target reached	0	Halt = 0: ➔Target Position not (yet) reached Halt = 1: Axle decelerates
	1	Halt = 0: ➔Target Position reached Halt = 1: Velocity of axle is 0
ip mode active	0	ip mode inactive
	1	ip mode active

Table 5-44 Interpolated Position Mode – Statusword Bits

5.7 Position Control Function

Used for all position-based modes, such as «Profile Position Mode», «Position Mode», «Homing Mode», «Master Encoder Mode» and «Step/Direction Mode».

The control loop is fed with the «Position Demand Value» and «Position Actual Value» (the output of the position detection unit) like an encoder as input parameter. The behavior of the control may be influenced by externally applicable control parameters («Position Control Parameter Set»). The output of the controller is a current demand value, which serves as input for the current controller.

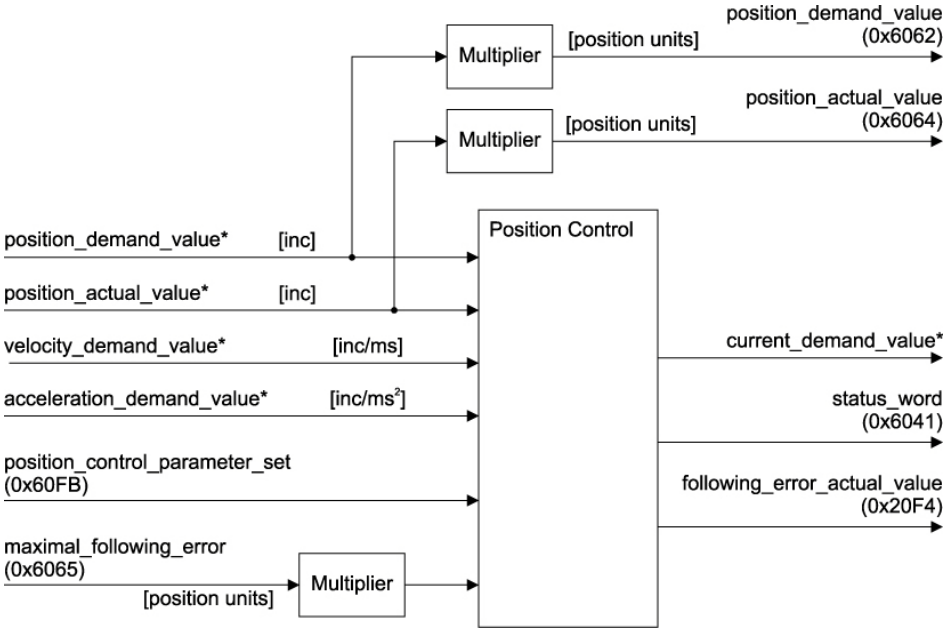


Figure 5-27 Position Control Function – Block Diagram

5.7.1 How to use «Position Control Function»

5.7.1.1 Configuration Parameters

Parameter	Index	Description
➔Maximal Following Error	0x6065	Defines the following error window. If the difference between Position Actual Value and Position Demand Value is bigger then the maximal following error, a following error will occur.
➔Position Control Parameter Set	0x60FB	Changes the behavior of the PID controller and the feed forward functionality.

Table 5-45 Position Control Function – Configuration Parameters

5.7.1.2 Commanding Parameters

There are no commanding parameters. This operating mode is directly commanded by all position-based operating modes (as Profile Position Mode, Position Mode, Homing Mode, Master Encoder Mode and Step/Direction Mode).

5.7.1.3 Output Parameters

Parameter	Index	Description
➔Position Demand Value	0x6062	The mode's output – it is used as input for the position control function.
➔Position Actual Value	0x6064	The actual position is absolute and referenced to system zero position in position units.

Table 5-46 Position Control Function – Output Parameters

5.8 Velocity Control Function

Used for all velocity-based modes, such as «Profile Velocity Mode and «Velocity Mode».

The control loop is fed with the «Demand Velocity» and «Position Actual Value» (the output of the position detection unit) like an encoder as input parameter. The behavior of the control may be influenced by externally applicable control parameters. The output of the controller is a current demand value, which serves as input for the current controller.

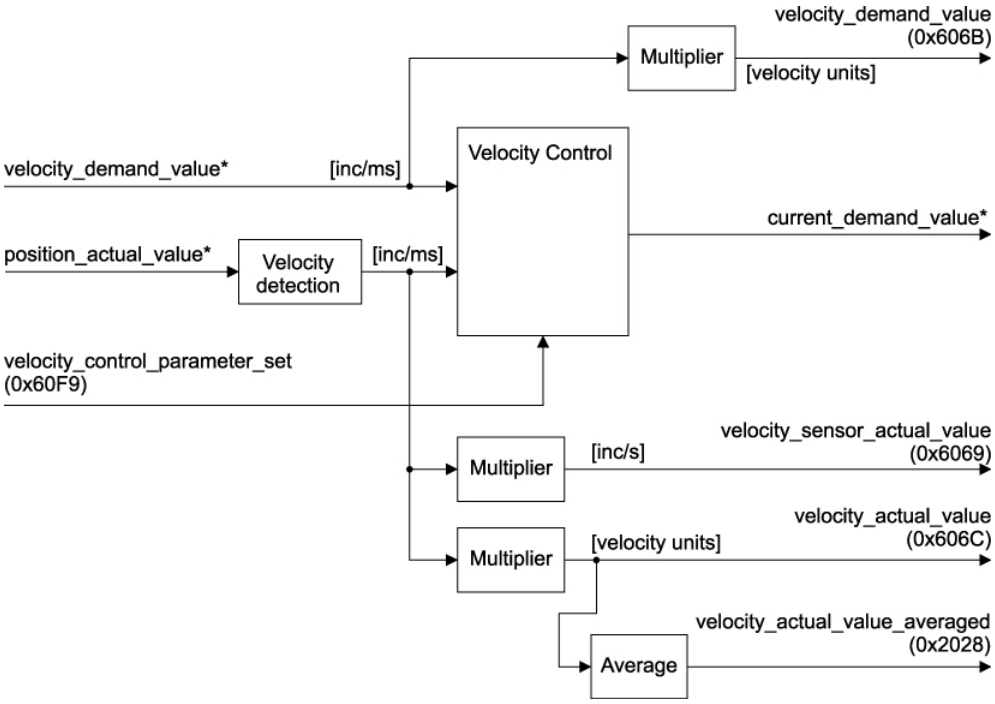


Figure 5-28 Velocity Control Function – Block Diagram

5.8.1 How to use «Velocity Control Function»

5.8.1.1 Configuration Parameters

Parameter	Index	Description
➔Velocity Control Parameter Set	0x60F9	Used to influence the behavior of the PI Control.

Table 5-47 Velocity Control Function – Configuration Parameters

5.8.1.2 Commanding Parameters

There are no commanding parameters. This operating mode is directly commanded by all velocity-based operating modes (as Profile Velocity Mode and Velocity Mode).

5.8.1.3 Output Parameters

Parameter	Index	Description
➔Velocity Demand Value	0x606B	The rescaled output of the trajectory generator.
➔Velocity Actual Value	0x606C	This actual velocity in velocity units.
➔Velocity Actual Value Averaged	0x2028	This averaged velocity in velocity units.
➔Velocity Sensor Actual Value	0x6069	Holds the internal calculated actual velocity.

Table 5-48 Velocity Control Function – Output Parameters

5.9 Current Control Function

Used for the other operating modes. The current demand value is received from a superordinate position or the velocity controller.

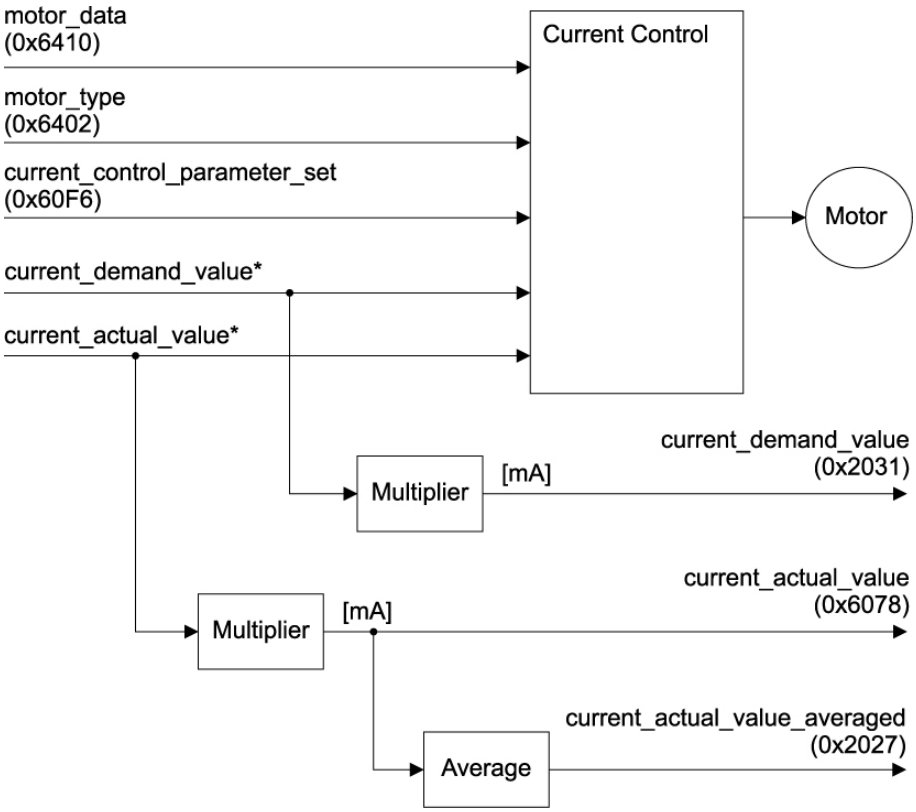


Figure 5-29 Current Control Function – Block Diagram

5.9.1 Output Current Limitation according I²t Method

With properly setup ➔Motor Data, EPOS3 EtherCAT will limit the output current according to I²t method with the parameters «Continuous Current Limit», «Output Current Limit» and «Thermal Time Constant Winding». The I²t method assumes an ambient temperature of 25 °C. If this condition is not fulfilled in the given application, the output current must be reduced by adjusting the above mentioned parameters to the actual ambient temperature.

The heating-up of the motor is given as follows:

$$\vartheta = P_V \cdot R_{th} \cdot \left(1 - e^{-\frac{t}{\tau_{th}}}\right) + \vartheta_a \cdot e^{-\frac{t}{\tau_{th}}}$$

ϑ	calculated actual winding temperature
P_V	thermal dissipation loss
R_{th}	thermal resistance
ϑ_a	temperature at beginning of measuring period
τ_{th}	thermal time constant winding

According to the actual EPOS3 EtherCAT internally calculated winding temperature [ϑ], «Continuous Current Limit», «Output Current Limit» and «Thermal Time Constant Winding» [τ_{th}], the EPOS3 EtherCAT limits the output current. With each measure interval [T_P], the EPOS3 EtherCAT calculates the thermal dissipation loss [P_V].

$$P_V = \frac{1}{T_P} \cdot \int_{t}^{(t+T_P)} i^2 R dt$$

T_P	measure interval
i	actual measured current
R	motor resistance

The measure interval is calculated at the start-up of the EPOS3 EtherCAT and is given with $T_P = 1/20$ thermal time constant winding.

If the I2t calculation reaches its limit based on the configured “Thermal time constant winding” (0x6410-05) and the motor's “Nominal current” (0x6410-01), the output current is reduced to the “Continuous Current Limit” (0x6410-01).

Use given scale to determine the time the EPOS3 EtherCAT can source a current (➔Figure 5-30).

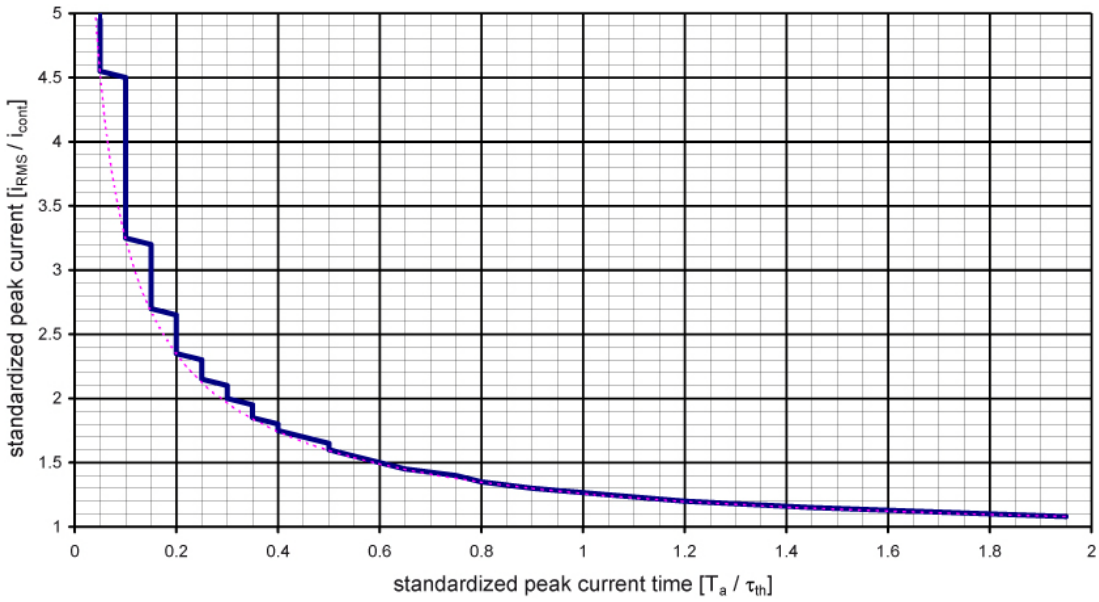


Figure 5-30 Standardized Peak Current vs. Standardized Peak Current Time

Example:

Given configuration (for details ➔"Motor Data" on page 8-221):

- «Current Limit»: 1470 mA
- «Output Current Limit»: 2940 mA
- «Thermal Time Constant Winding [τ_{th}]: 2.8

At acceleration time [T_a], the motor needs a higher acceleration current [I_a]. The EPOS3 EtherCAT current limiting method according to I²t fulfils this need.

For how long (maximal) does EPOS3 EtherCAT source the higher acceleration current [I_a] = 2940 mA?

- Standardized peak current = 2940 mA / 1470 mA = 2
- Standardized peak current time -> 0.3
- The resulting acceleration time T_P = 0.3 · thermal time constant winding = 0.3 · 2.8 s = 840 ms.

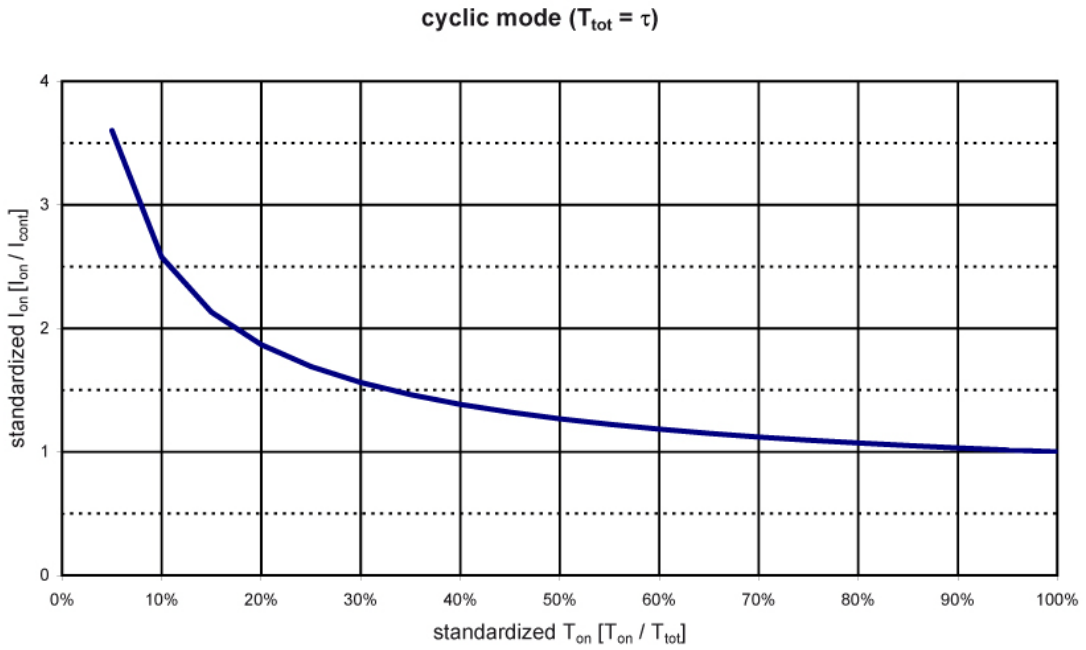


Figure 5-31 Cyclic Mode standardized I_{on} vs. Standardized T_{on}

- standardized T_{on} ratio of “ON time” vs. total time
- standardized I_{on} current at “ON time” standardized with «Continuous Current Limit»

Example:

Given configuration (for details ➔“Motor Data” on page 8-221):

- Application in “cyclic mode” – the current is switched on/off every 2.8 s.
- «Thermal Time Constant Winding»: 2.8 s
- «Continuous Current Limit»: 1470 mA

For the “ON time” of 280 ms (10%), a standardized output current of 2.6 is possible. Therefore, the possible output current I_{on} = 2.6 · «Continuous Current Limit» = 2.6 · 1470 mA = 3822 mA.

5.9.2 How to use «Current Control Function»

5.9.2.1 Configuration Parameters

Parameter	Index	Description
➔Current Control Parameter Set	0x60F6	Used to influence the behavior of the PI Control.
➔Motor Data	0x6410	Contains motor-dependent data.
➔Motor Type	0x6402	Used to define the type of motor.

Table 5-49 Current Control Function – Configuration Parameters

5.9.2.2 Commanding Parameters

There are no commanding parameters. This operating mode is directly commanded by the operating mode «Current Mode» or the control loops «Position Control Function» or «Velocity Control Function».

5.9.2.3 Output Parameters

Parameter	Index	Description
➔Current Demand Value	0x2031	Set value for current controller in current units [mA].
➔Current Actual Value	0x6078	Actual current value in current units [mA].
➔Current Actual Value Averaged	0x2027	Averaged actual current value in current units [mA].

Table 5-50 Current Control Function – Output Parameters

5.10 Cyclic Synchronous Position Mode (CSP)

With Cyclic Synchronous Position Mode, the trajectory generator is located in the control device (not in the drive device). It provides a target position to the drive device in cyclic synchronous manner, thus the drive position control and torque control.

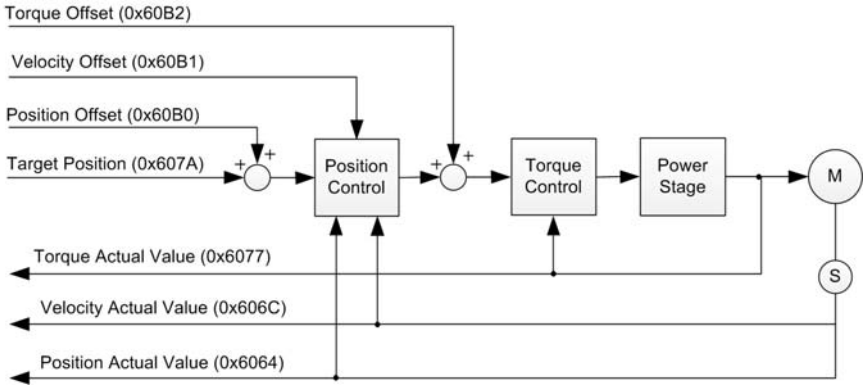


Figure 5-32 Cyclic Synchronous Position Mode – Overview

Cyclic Synchronous Position Mode is based on position control function. The inputs are «Target Position» and (optionally) «Position Offset». Furthermore, an optional velocity and torque offset are being used for feed forward control. The «Motor Data» input is used to define limitations for current value (torque). Other features specified in this mode are limit functions used to restrict the range of values to avoid unintended positions as well as monitoring of the following error. In this mode, the motor speed is not limited. Actual values for position, velocity, and torque are used as output to the control device.

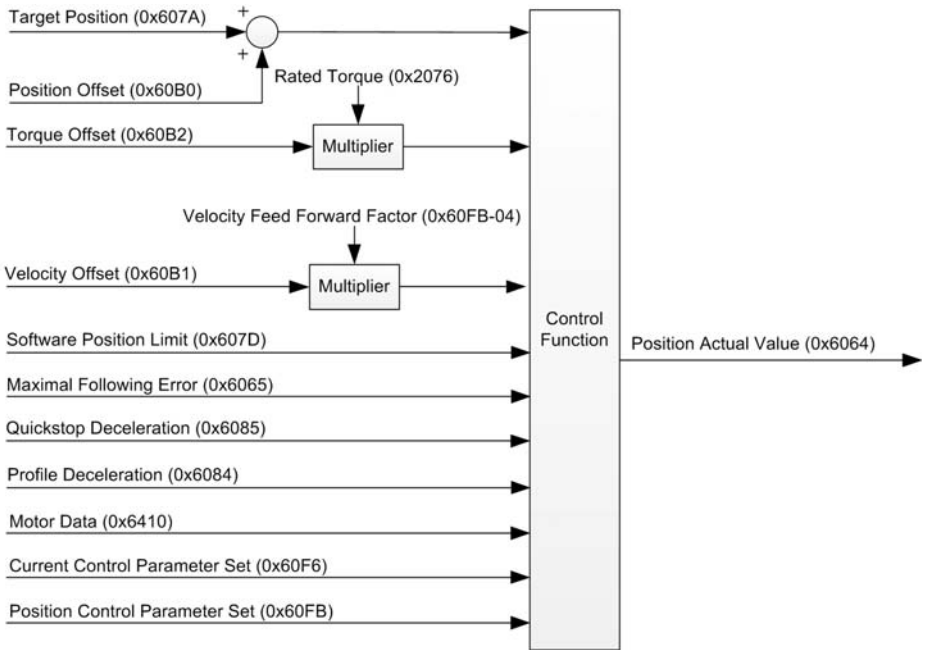


Figure 5-33 Cyclic Synchronous Position Mode – Block Diagram

Note:
The device-internal cycle time for linear interpolation is 1 ms. Adapt object 0x60C2 (➔Interpolation Time Period) to match the cycle time of the master.

5.10.1 How to use «Cyclic Synchronous Position Mode»

5.10.1.1 Configuration Parameters

Parameter	Index	Description
Nominal Current (➔Motor Data)	0x6410-01	Represents the maximal permissible continuous current of the motor.
Motor Torque Constant (➔Motor Data)	0x6410-06	Represents the torque constant of the motor.
➔Current Control Parameter Set	0x60F6	Represents the PI current controller gains.
➔Position Control Parameter Set	0x60FB	Represents of the PID position controller gains. *Note: Acceleration feed forward factor is irrelevant for this mode*.
➔Quickstop Deceleration	0x6085-00	Defines the deceleration for the quickstop ramp.
➔Profile Deceleration	0x6084-00	Defines the deceleration for the slowdown ramp.
➔Maximal Following Error	0x6065	The maximal allowed difference of position actual value to position demand value. If exceeded, following error is generated.
➔Software Position Limit	0x607D	Used to restrict the absolute position range. If the target position or the actual position exceeds the range, a software position limit error is generated.
➔Rated Torque (RO)	0x2076-00	Holds the value to which all torque objects are related to.

Table 5-51 Cyclic Synchronous Position Mode – Configuration Parameters

5.10.1.2 Commanding Parameters

Parameter	Index	Description
➔Target Position	0x607A-00	Position input value for the position controller.
➔Position Offset	0x60B0-00	Optional additive position value which is added to the target position.
➔Velocity Offset	0x60B1-00	Optional velocity feed forward input.
➔Torque Offset	0x60B2-00	Optional torque feed forward input.

Table 5-52 Cyclic Synchronous Position Mode – Commanding Parameters

5.10.1.3 Controlword

Cyclic Synchronous Position Mode uses no mode-specific controlword bits.

5.10.1.4 Output Parameters

Parameter	Index	Description
➔Torque Actual Value	0x6077-00	Actual motor torque value.
➔Velocity Actual Value	0x606C-00	Actual velocity value [velocity units].
➔Position Actual Value	0x6064-00	Actual position is absolute and referenced to system zero position.
➔Current Actual Value	0x6078-00	Actual motor current value.
➔Velocity Sensor Actual Value	0x6069-00	Actual velocity value [inc/s].
➔Current Demand Value	0x2031-00	Holds the actual set value for the current controller.
➔Position Demand Value	0x6062-00	Holds the actual set value for the position controller.
➔Following Error Actual Value	0x20F4-00	Represents the actual value of the following error.
➔Actual Values Averaged	0x202A-00	Represents the filtered average torque value.

Table 5-53 Cyclic Synchronous Position Mode – Output Parameters

5.10.1.5 Statusword (Cyclic Synchronous Position Mode-specific Bits)

Bit 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9…0
➔Table 8-112	following error	drive follows command value	➔Table 8-112	reserved	➔Table 8-112

Table 5-54 Cyclic Synchronous Position Mode – Statusword

Name	Value	Description
drive follows command	0	Drive does not follow the target value.
	1	Drive is in state operation enable and follows the target and setpoint values of the control device.
following error	0	No following error.
	1	Difference of position demand value and position actual value exceeds the defined maximal following error.

Table 5-55 Cyclic Synchronous Position Mode – Statusword Bits

5.11 Cyclic Synchronous Velocity Mode (CSV)

With Cyclic Synchronous Velocity Mode, the trajectory generator is located in the control device (not in the drive device). It provides a target velocity to the drive device in cyclic synchronous manner, thus the drive velocity control and torque control.

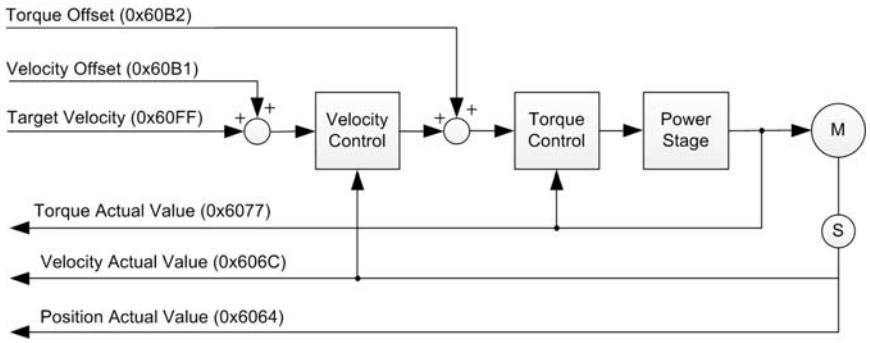


Figure 5-34 Cyclic Synchronous Velocity Mode – Overview

Cyclic Synchronous Velocity Mode is based on velocity control function. The inputs are «Target Velocity». Optionally, additive velocity and torque values may be provided by the control system in order to allow a second source for velocity and/or a torque feed forward control. The «Motor Data» input is used to define limitations for velocity and current values. Actual values for position, velocity, and torque are used as output to the control device.

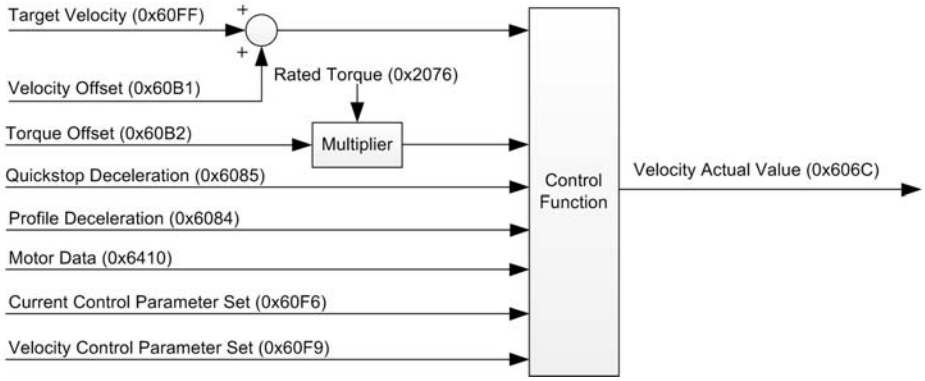


Figure 5-35 Cyclic Synchronous Velocity Mode – Block Diagram

5.11.1 How to use «Cyclic Synchronous Velocity Mode»

5.11.1.1 Configuration Parameters

Parameter	Index	Description
Nominal Current (➔Motor Data)	0x6410-01	Represents the maximal permissible continuous current of the motor.
Motor Torque Constant (➔Motor Data)	0x6410-06	Represents the torque constant of the motor.
Maximal Motor Speed (➔Motor Data)	0x6410-04	Indicates the configured maximal allowed speed for the motor.
➔Current Control Parameter Set	0x60F6	Represents the PI current controller gains.
➔Velocity Control Parameter Set	0x60F9	Represents the PI velocity controller gains. *Note: Velocity feed forward factors are irrelevant for this mode*.
➔Quickstop Deceleration	0x6085-00	Defines the deceleration for the quickstop ramp.
➔Profile Deceleration	0x6084-00	Defines the deceleration for the slowdown ramp.
➔Software Position Limit	0x607D	Used to restrict the absolute position range. If the actual position exceeds the defined range, a software position limit error is generated.
➔Rated Torque (RO)	0x2076-00	Holds the value to which all torque objects are related to.

Table 5-56 Cyclic Synchronous Velocity Mode – Configuration Parameters

5.11.1.2 Commanding Parameters

Parameter	Index	Description
➔Target Velocity	0x60FF-00	Velocity input value for the velocity controller.
➔Velocity Offset	0x60B1-00	Optional additive velocity value which is added to the target velocity.
➔Torque Offset	0x60B2-00	Optional torque feed forward input.

Table 5-57 Cyclic Synchronous Velocity Mode – Commanding Parameters

5.11.1.3 Controlword

Cyclic Synchronous Velocity Mode uses no mode-specific controlword bits.

5.11.1.4 Output Parameters

Parameter	Index	Description
➔Torque Actual Value	0x6077-00	Actual motor torque value.
➔Velocity Actual Value	0x606C-00	Actual velocity value [velocity units].
➔Position Actual Value	0x6064-00	Actual position is absolute and referenced to system zero position.
➔Current Actual Value	0x6078-00	Actual motor current value.
➔Velocity Sensor Actual Value	0x6069-00	Actual velocity value [inc/s].
➔Velocity Demand Value	0x606B-00	Holds the actual set value for the velocity controller.
➔Current Demand Value	0x2031-00	Holds the actual set value for the current controller.
➔Actual Values Averaged	0x202A-00	Represents the filtered average torque value.

Table 5-58 Cyclic Synchronous Velocity Mode – Output Parameters

5.11.1.5 Statusword (Cyclic Synchronous Velocity Mode-specific Bits)

Bit 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9…0
➔Table 8-112	reserved	drive follows command value	➔Table 8-112	reserved	➔Table 8-112

Table 5-59 Cyclic Synchronous Velocity Mode – Statusword

Name	Value	Description
drive follows command	0	Drive does not follow the target value.
	1	Drive is in state operation enable and follows the target and setpoint values of the control device.

Table 5-60 Cyclic Synchronous Velocity Mode – Statusword Bits

5.12 Cyclic Synchronous Torque Mode (CST)

With Cyclic Synchronous Torque Mode, the trajectory generator is located in the control device (not in the drive device). It provides a target torque to the drive device in cyclic synchronous manner, thus the drive performing torque control.

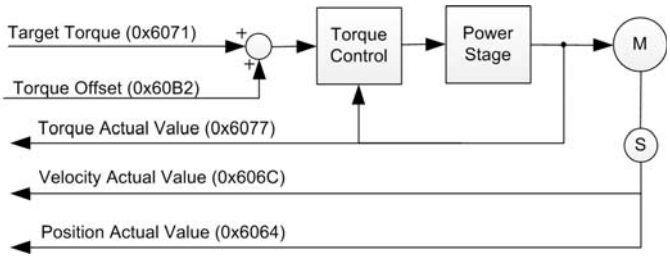


Figure 5-36 Cyclic Synchronous Torque Mode – Overview

Cyclic Synchronous Torque Mode is based on the current control function. The inputs are «Target Torque» and (optionally) «Torque Offset». The «Motor Data» input is used to define limitations for velocity and current values. Actual values for position, velocity, and torque are used as output to the control device.

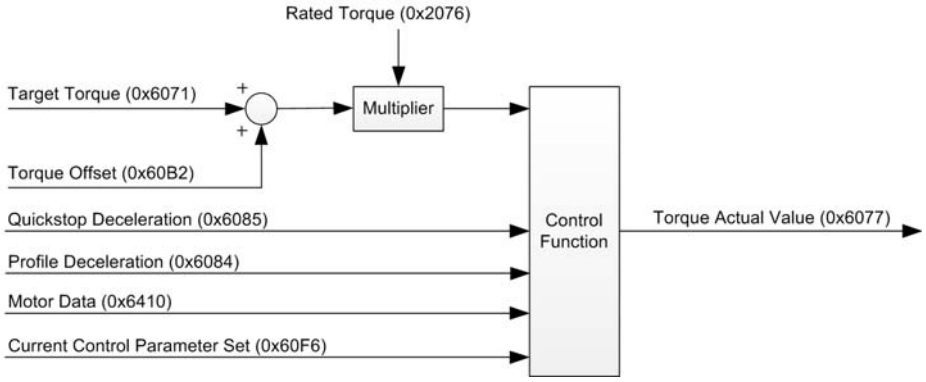


Figure 5-37 Cyclic Synchronous Torque Mode – Block Diagram

5.12.1 How to use «Cyclic Synchronous Torque Mode»

5.12.1.1 Configuration Parameters

Parameter	Index	Description
Nominal Current (➔Motor Data)	0x6410-01	Represents the maximal permissible continuous current of the motor.
Motor Torque Constant (➔Motor Data)	0x6410-06	Represents the torque constant of the motor.
Maximal Motor Speed (➔Motor Data)	0x6410-04	Indicates the configured maximal allowed speed for the motor.
➔Current Control Parameter Set	0x60F6	Represents the PI current controller gains.
➔Quickstop Deceleration	0x6085-00	Defines the deceleration for the quickstop ramp.
➔Profile Deceleration	0x6084-00	Defines the deceleration for the slowdown ramp.
➔Rated Torque (RO)	0x2076-00	Holds the value to which all torque objects are related to.
➔Software Position Limit	0x607D	Limits used to restrict the absolute position range. If the actual position exceeds the defined range, a software position limit error will be generated.

Table 5-61 Cyclic Synchronous Torque Mode – Configuration Parameters

5.12.1.2 Commanding Parameters

Parameter	Index	Description
➔Target Torque	0x6071-00	Torque input value for the torque controller.
➔Torque Offset	0x60B2-00	Optional additive torque which is added to the target torque value.

Table 5-62 Cyclic Synchronous Torque Mode – Commanding Parameters

5.12.1.3 Controlword

Cyclic Synchronous Torque Mode uses no mode-specific controlword bits.

5.12.1.4 Output Parameters

Parameter	Index	Description
➔Torque Actual Value	0x6077-00	Actual motor torque value.
➔Velocity Actual Value	0x606C-00	Actual velocity value [velocity units].
➔Position Actual Value	0x6064-00	Actual position is absolute and referenced to system zero position.
➔Current Actual Value	0x6078-00	Actual motor current value.
➔Velocity Sensor Actual Value	0x6069-00	Actual velocity value [inc/s].
➔Current Demand Value	0x2031-00	Holds the set value for the current controller.
➔Actual Values Averaged	0x202A-00	Represents the filtered average torque value.

Table 5-63 Cyclic Synchronous Torque Mode – Output Parameters

5.12.1.5 Statusword (Cyclic Synchronous Torque Mode-specific Bits)

Bit 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9…0
➔Table 8-112	reserved	drive follows command value	➔Table 8-112	reserved	➔Table 8-112

Table 5-64 Cyclic Synchronous Torque Mode – Statusword

Name	Value	Description
drive follows command	0	Drive does not follow the target value.
	1	Drive is in state operation enables and follows the target and setpoint values of the control device.

Table 5-65 Cyclic Synchronous Torque Mode – Statusword Bits

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6 Inputs and Outputs

6.1 Analog Inputs

The EPOS3 EtherCAT support two analog inputs. They may be used for general purpose process values like temperature, pressure, torque from an external sensor, etc. The output values are given in the object «Analog Inputs».

Output Data Description

For output values ➔“Analog Inputs” on page 8-126.

6.2 Analog Output

The device supports one analog output with a resolution of 12-bit (2.40 mV) and a bandwidth of 20 kHz.

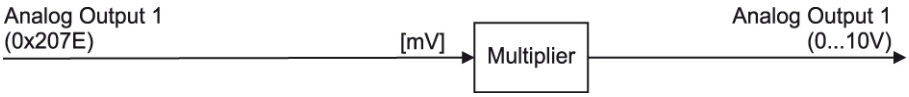

Figure 6-38 Analog Output – Block Diagram

Input Data Description

For input values ➔“Analog Output 1” on page 8-127.

6.3 Digital Inputs

There are predefined functions for digital inputs: «Home Switch», «Limit Switches, ➔“Position Marker” on page 8-118 and general purpose process inputs.

Configuration of the digital input functions is done with ➔“Configuration of Digital Inputs” on page 8-113. Configuration of polarity, execution and a general mask are given in ➔“Digital Input Functionalities” on page 8-115. The number of supported digital inputs depends on hardware used.

EPOS3 70/10 EtherCAT

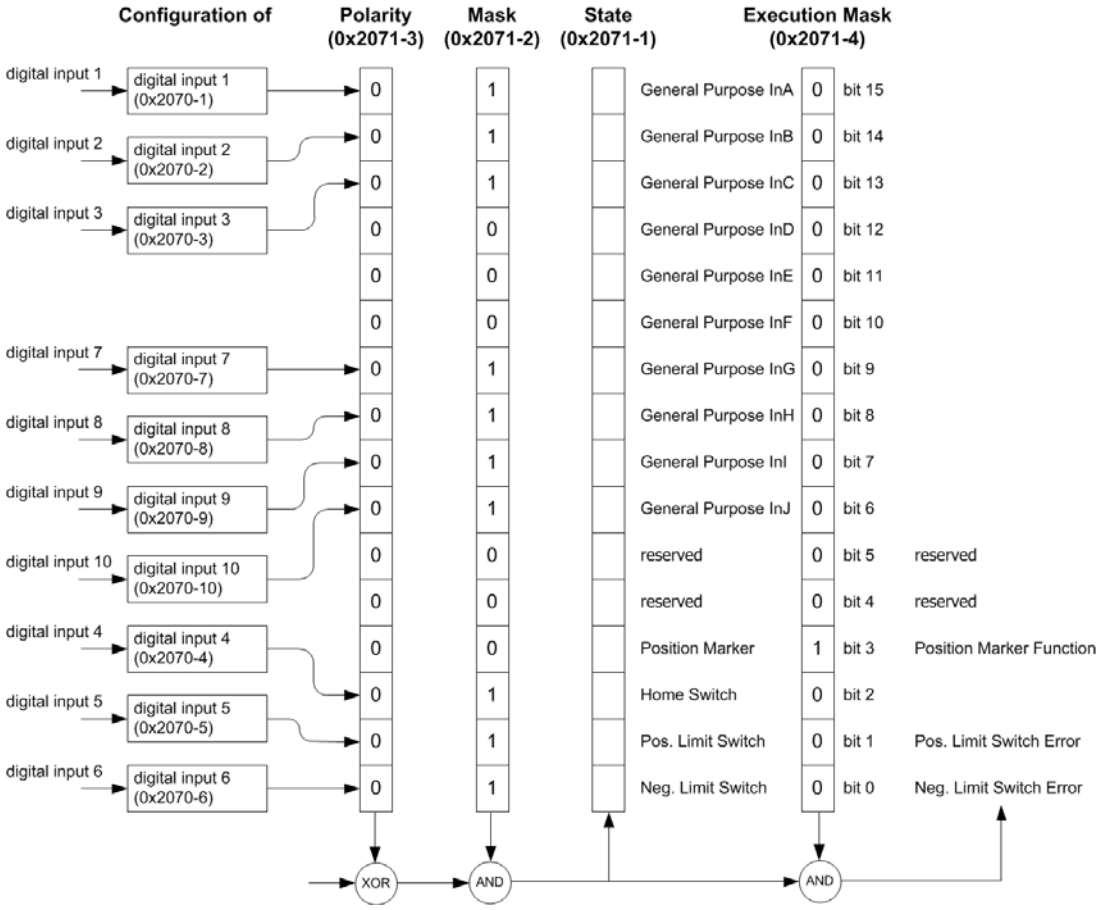

Figure 6-39 Digital Input Functionality – EPOS3 70/10 EtherCAT Overview (Default Configuration)

6.4 Digital Outputs

There are predefined functions for digital outputs: «Ready/Fault», «Position Compare», and «Holding Brake». If an output is configured with one of this functions, the hardware signal will be available whether a fault occurs or not. Also available are general purpose outputs for general process controlling, for example to illuminate a lamp.

Configuration is similar to that of digital inputs and is done with ➔"Configuration of Digital Inputs" on page 8-113 and ➔"Digital Input Functionalities" on page 8-115. The number of supported digital outputs depends on hardware used.

EPOS3 70/10 EtherCAT

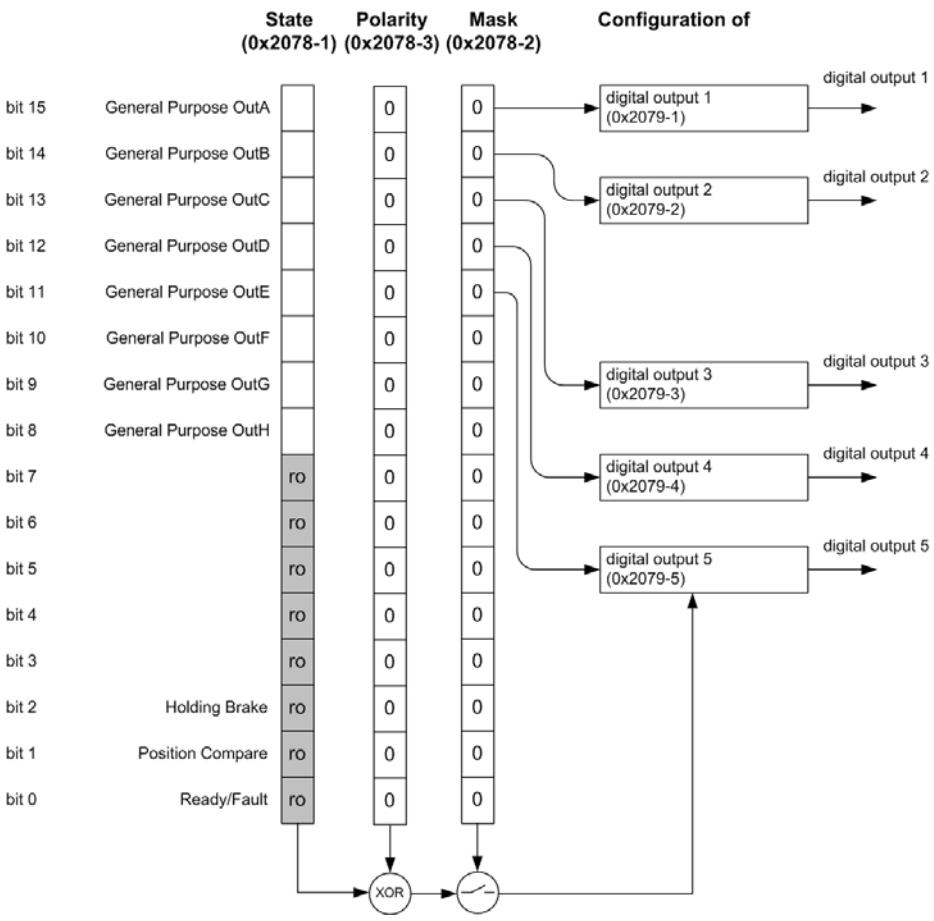

Figure 6-40 Digital Output Functionality – EPOS3 70/10 EtherCAT Overview (Default Configuration)

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7 Communication

The EPOS3 EtherCAT supports communication over EtherCAT and USB interface. For detailed information ➔separate document «EPOS3 EtherCAT Communication Guide» (for sources ➔chapter “1.6 Sources for additional Information” on page 1-10).

7.1 EtherCAT State Machine (ESM)

The EtherCAT State Machine coordinates both Master and Slave during startup and operation. Their interaction (Master ⇔ Slave) results in changes of states being related to writes to the Application Layer Controlword.

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 EPOS3 (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 ➔Figure 7-41, for further descriptions ➔as from Table 7-66.

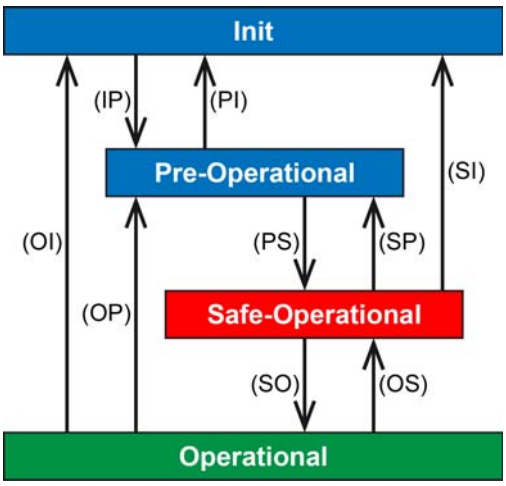

Figure 7-41 EtherCAT State Machine – Scheme

Condition	Description
Power ON	• EPOS3 is ON. • EPOS3 autonomously initializes and switches to state “Init”.
Init	• Master will synchronize the EtherCAT field bus. • Asynchronous communication between Master and Slave (Mailbox) will be established. At this time, no direct communication (Master ⇔ Slave) will yet take place. • When all devices have been connected to the field bus and have successfully passed configuration, state will be changed to “Pre-Operational”.

Condition	Description
Pre-Operational	• Asynchronous communication between Master and Slave (Mailbox) will be active. • Master will setup cyclic communication via PDOs and necessary parameterization via acyclic communication. • Upon successful completion, the Master will change to state “Safe-Operational”.
Safe-Operational	• 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. • Upon successful completion, the Master will change to state “Safe-Operational”.
Operational	• Acyclic as well as cyclic communication is active. • Master and Slave exchange setpoint and actual values. • EPOS3 be enabled and operated via the CoE protocol.

Table 7-66 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 ignorers 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.
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.

Table 7-67 EtherCAT State Machine – Transitions

Parameter	Address	Bit	Description
Status	0x120	3…0	0x01: Init Request 0x02: Pre-Operational Request 0x04: Safe-Operational Request 0x08: Operational Request
Acknowledgment	0x120	4	0x00: No error acknowledgment 0x01: Error acknowledgment at rising edge
Reserved	0x120	7…5	–
Application-specific	0x120	15…8	–

Table 7-68 EtherCAT State Machine – Control Register

7.2 Errors and Messages

For details on errors and emergency messages generated by EPOS3, ➔chapter “4 Error Handling” on page 4-19.

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8 Object Dictionary

8.1 Overview

8.1.1 Object Dictionary Overview

Note
Subindexes in brackets are persistent but will not be checked (➔"Verify Configuration" on page 8-147).

Index	Name	Data Type	Access Type	Subindex of persistent parameters
0x1000	➔Device Type	UNSIGNED32	RO	
0x1001	➔Error Register	UNSIGNED8	RO	
0x1008	➔Manufacturer Device Name	VISIBLE_STRING	CONST	
0x1018	➔Identity Object	RECORD	RO	
0x1600	➔Receive PDO 1 Mapping	RECORD	RO	0x01…0x08
0x1601	➔Receive PDO 2 Mapping	RECORD	RO	0x01…0x07
0x1602	➔Receive PDO 3 Mapping	RECORD	RO	0x01…0x06
0x1603	➔Receive PDO 4 Mapping	RECORD	RO	0x01…0x0a
0x1604	➔Receive PDO 5 Mapping	RECORD	RO	0x01…0x08
0x1A00	➔Transmit PDO 1 Mapping	RECORD	RO	0x01…0x09
0x1A01	➔Transmit PDO 2 Mapping	RECORD	RO	0x01…0x09
0x1A02	➔Transmit PDO 3 Mapping	RECORD	RO	0x01…0x09
0x1A03	➔Transmit PDO 4 Mapping	RECORD	RO	0x01…0x09
0x1A04	➔Transmit PDO 5 Mapping	RECORD	RO	0x01…0x08
0x1C00	➔Sync Manager Communication Type	ARRAY	RO	0x01…0x04
0x1C12	➔Sync Manager Channel 2 (Process Data Output)	ARRAY	RW	0x01
0x1C13	➔Sync Manager Channel 3 (Process Data Input)	ARRAY	RW	0x01
0x2003	➔Version	RECORD	RO	
0x2004	➔Serial Number	UNSIGNED64	CONST	
0x2006	➔USB Frame Timeout	UNSIGNED16	RW	(0x00)
0x2008	➔Miscellaneous Configuration	UNSIGNED16	RW	0x00
0x200C	➔Custom Persistent Memory	RECORD	RW	0x01…0x04
0x2020	➔Incremental Encoder 1 Counter	UNSIGNED32	RO	
0x2021	➔Incremental Encoder 1 Counter at Index Pulse	UNSIGNED32	RO	
0x2022	➔Hall Sensor Pattern	UNSIGNED32	RO	
0x2027	➔Current Actual Value Averaged	INTEGER16	RO	
0x2028	➔Velocity Actual Value Averaged	INTEGER32	RO	
0x2029	➔Auxiliary Velocity Actual Value Averaged	INTEGER32	RO	
0x202A	➔Actual Values Averaged	INTEGER16	RO	
0x2031	➔Current Demand Value	INTEGER16	RO	
0x2069	➔Auxiliary Velocity Sensor Actual Value	INTEGER32	RO	
0x206C	➔Auxiliary Velocity Actual Value	INTEGER32	RO	
0x2070	➔Configuration of Digital Inputs	RECORD	RW	0x01…0x10

Index	Name	Data Type	Access Type	Subindex of persistent parameters
0x2071	➔Digital Input Functionalities	RECORD	RO/RW	0x02…0x04
0x2074	➔Position Marker	RECORD	RO/RW	0x02, 0x03
0x2076	➔Rated Torque	UNSIGNED32	RO	
0x2078	➔Digital Output Functionalities	UNSIGNED16	RW	0x02, 0x03
0x2079	➔Configuration of Digital Outputs	RECORD	RW	0x01…0x05
0x207A	➔Position Compare	RECORD	RW	0x03…0x05
0x207C	➔Analog Inputs	RECORD	RO	
0x207E	➔Analog Output 1	UNSIGNED16	RW	
0x2080	➔Current Threshold for Homing Mode	UNSIGNED16	RW	0x00
0x2081	➔Home Position	UNSIGNED32	RW	(0x00)
0x2082	➔Home Position Displacement	INTEGER32	RO	
0x20C1	➔Interpolation Data Record	STRUCT	WO	
0x20C4	➔Interpolation Buffer	RECORD	RO/RW	0x02, 0x03
0x20F4	➔Following Error Actual Value	INTEGER16	RO	
0x2100	➔Holding Brake Configuration	RECORD	RW	0x01…0x03
0x2101	➔Standstill Window Configuration	RECORD	RW	0x01…0x03
0x2210	➔Sensor Configuration	RECORD	RW	0x01…0x04
0x2211	➔SSI Encoder Configuration	RECORD	RO/RW	0x01, 0x02, 0x04
0x2212	➔Incremental Encoder 2 Configuration	RECORD	RO/RW	0x01
0x2213	➔Sinus Incremental Encoder 2 Configuration	RECORD	RO/RW	0x01
0x2220	➔Controller Structure	UNSIGNED16	RW	0x00
0x2230	➔Gear Configuration	RECORD	RW	0x01…0x03
0x2F03	➔Number of Errors	UNSIGNED8	RW	
0x2F04	➔Error History	ARRAY	RO	
0x2F10	➔Store Parameters	ARRAY	RW	
0x2F11	➔Restore Default Parameters	ARRAY	RW	
0x2F20	➔Verify Configuration	ARRAY	RW	(0x01, 0x02)
0x6007	➔Abort Connection Option Code	INTEGER16	RW	0x00
0x6040	➔Controlword	UNSIGNED16	RW	
0x6041	➔Statusword	UNSIGNED16	RO	
0x605B	➔Shutdown Option Code	INTEGER16	RW	0x00
0x605C	➔Disable Operation Option Code	INTEGER16	RW	0x00
0x605E	➔Fault Reaction Option Code	INTEGER16	RW	0x00
0x6060	➔Modes of Operation	INTEGER8	RW	
0x6061	➔Modes of Operation Display	INTEGER8	RO	
0x6062	➔Position Demand Value	INTEGER32	RO	
0x6064	➔Position Actual Value	INTEGER32	RO	
0x6065	➔Maximal Following Error	UNSIGNED32	RW	0x00
0x6067	➔Position Window	UNSIGNED32	RW	0x00
0x6068	➔Position Window Time	UNSIGNED16	RW	0x00
0x6069	➔Velocity Sensor Actual Value	INTEGER32	RO	
0x606B	➔Velocity Demand Value	INTEGER32	RO	

Index	Name	Data Type	Access Type	Subindex of persistent parameters
0x606C	➔Velocity Actual Value	INTEGER32	RO	
0x606D	➔Velocity Window	UNSIGNED32	RW	0x00
0x606E	➔Velocity Window Time	UNSIGNED16	RW	0x00
0x6071	➔Target Torque	INTEGER16	RW	
0x6077	➔Torque Actual Value	INTEGER16	RO	
0x6078	➔Current Actual Value	INTEGER16	RO	
0x607A	➔Target Position	INTEGER32	RW	
0x607C	➔Home Offset	INTEGER32	RW	0x00
0x607D	➔Software Position Limit	ARRAY	RW	0x01, 0x02
0x607F	➔Maximal Profile Velocity	UNSIGNED32	RW	0x00
0x6081	➔Profile Velocity	UNSIGNED32	RW	(0x00)
0x6083	➔Profile Acceleration	UNSIGNED32	RW	(0x00)
0x6084	➔Profile Deceleration	UNSIGNED32	RW	(0x00)
0x6085	➔Quickstop Deceleration	UNSIGNED32	RW	(0x00)
0x6086	➔Motion Profile Type	INTEGER16	RW	0x00
0x6089	➔Position Notation Index	INTEGER8	RW	(0x00)
0x608A	➔Position Dimension Index	UNSIGNED8	RW	(0x00)
0x608B	➔Velocity Notation Index	INTEGER8	RW	(0x00)
0x608C	➔Velocity Dimension Index	UNSIGNED8	RW	(0x00)
0x608D	➔Acceleration Notation Index	INTEGER8	RW	(0x00)
0x608E	➔Acceleration Dimension Index	UNSIGNED8	RW	(0x00)
0x6098	➔Homing Method	INTEGER8	RW	0x00
0x6099	➔Homing Speeds	ARRAY	RW	0x01, 0x02
0x609A	➔Homing Acceleration	UNSIGNED32	RW	0x00
0x60B0	➔Position Offset	INTEGER32	RW	
0x60B1	➔Velocity Offset	INTEGER32	RW	
0x60B2	➔Torque Offset	INTEGER16	RW	
0x60B8	➔Touch Probe Function	UNSIGNED16	RW	
0x60B9	➔Touch Probe Status	UNSIGNED16	RO	
0x60BA	➔Touch Probe Position 1 Positive Value	INTEGER32	RO	
0x60BB	➔Touch Probe Position 1 Negative Value	INTEGER32	RO	
0x60C0	➔Interpolation Sub Mode Selection	INTEGER16	RW	
0x60C2	➔Interpolation Time Period	RECORD	RW	
0x60C4	➔Interpolation Data Configuration	RECORD	RO/RW/WO	
0x60C5	➔Max Acceleration	UNSIGNED32	RW	0x00
0x60D0	➔Touch Probe Source	INTEGER16	RO	
0x60D5	➔Touch Probe 1 Positive Edge Counter	UNSIGNED16	RO	
0x60D6	➔Touch Probe 1 Negative Edge Counter	UNSIGNED16	RO	
0x60E3	➔Supported Homing Methods	INTEGER16	RO	
0x60F6	➔Current Control Parameter Set	RECORD	RW	0x01, 0x02
0x60F9	➔Velocity Control Parameter Set	RECORD	RW	0x01…0x05
0x60FB	➔Position Control Parameter Set	RECORD	RW	0x01…0x05

Index	Name	Data Type	Access Type	Subindex of persistent parameters
0x60FF	➔Target Velocity	INTEGER32	RW	
0x6402	➔Motor Type	UNSIGNED16	RW	0x00
0x6410	➔Motor Data	RECORD	RW	0x01…0x06
0x6502	➔Supported Drive Modes	UNSIGNED32	CONST	
0xF000	➔Modular Device Profile	UNSIGNED8	RO	
0xF010	➔Module Profile List	UNSIGNED32	RO	
0xF050	➔Detected Module List	UNSIGNED8	RO	

Table 8-69 Object Dictionary Overview

8.1.2 Object Data Types

Type	Description	Size [Bits]	Range
INTEGER8	Signed Integer	8	−128…127
INTEGER16	Signed Integer	16	−32 768…32 767
INTEGER32	Signed Integer	32	−2 147 483 648…2 147 483 647
UNSIGNED8	Unsigned Integer	8	0…255
UNSIGNED16	Unsigned Integer	16	0…65 535
UNSIGNED32	Unsigned Integer	32	0…4 294 967 265
UNSIGNED64	Unsigned Integer	64	0…18 446 744 073 709 551 615
VISIBLE_STRING	Array of (8-Bit) characters	n * 8	–
RECORD	Structure of other types	–	–

Table 8-70 Object Data Types

8.1.3 Object Access Types

Attribute	Description
RW	read and write access
RO	read only access
CONST	read only access, value is constant

Table 8-71 Object Access Types

8.2 Objects

8.2.1 Device Type

Description

This constant describes the device type. The lower word of the device type stands for the supported device profile number. The value 0x0192 (402) means that the device follows the CiA 402 Device Profile Drives and Motion Control.

The higher word holds information about the drive type. The value 0x0002 means that the drive is a servo drive.

Name	Device Type	
Index	0x1000	
Subindex	0x00	
Type	UNSIGNED32	
Access	RO	
Default Value	0x00020192	
Value Range	–	–

8.2.2 Error Register

Description

An error register for the device. The device maps internal errors in this byte.

Name	Error Register	
Index	0x1001	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	0	
Value Range	–	–

Bit	Description
7	Motion error
6	reserved (always 0)
5	Device profile-specific
4	Communication error
3	Temperature error
2	Voltage error
1	Current error
0	Generic error

Table 8-72 Error Register Bits

8.2.3 Manufacturer Device Name

Description

The product name is “EPOS3”.

Name	Manufacturer Device Name	
Index	0x1008	
Subindex	0x00	
Type	VISIBLE_STRING	
Access	CONST	
Default Value	“EPOS3”	
Value Range	–	–

8.2.4 Identity Object

Description

The vendor identification of “maxon motor ag” assigned by the EtherCAT Technology Group (ETG) is 0x000000FB.

Related Objects

➔“Version” on page 8-103

Name	Identity Object	
Index	0x1018	
Number of entries	0x04	

Name	Vendor ID	
Index	0x1018	
Subindex	0x01	
Type	UNSIGNED32	
Access	RO	
Default Value	0x000000FB	
Value Range	–	–

Description

The high word contains the hardware version. The low word contains the application number of the version array (➔“Version” on page 8-103).

Name	Product Code	
Index	0x1018	
Subindex	0x02	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	–	–

Description

The high word contains the software version. The low word contains the application version of the version array (➔“Version” on page 8-103).

Name	Revision Number	
Index	0x1018	
Subindex	0x03	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	–	–

Description

Contains the last 8 digits of the device serial number in hex format.

Name	Serial Number	
Index	0x1018	
Subindex	0x04	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.5 Receive PDO 1 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Receive PDO 1 Mapping
Index	0x1600
Number of entries	–

Name	Number of mapped Application Objects in Receive PDO	
Index	0x1600	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	8	
Value Range	8	8

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60400010	➔Controlword
2nd	0x02	INTEGER32	RO	0x607A0020	➔Target Position
3rd	0x03	INTEGER32	RO	0x60B00020	➔Position Offset
4th	0x04	INTEGER32	RO	0x60B10020	➔Velocity Offset
5th	0x05	INTEGER16	RO	0x60B20010	➔Torque Offset
6th	0x06	INTEGER8	RO	0x60600008	➔Modes of Operation
7th	0x07	UNSIGNED16	RO	0x20780110	➔Digital Output Functionalities State
8th	0x08	UNSIGNED16	RO	0x60B80010	➔Touch Probe Function

Table 8-73 Receive PDO 1 Mapping – CSP (mapped Objects)

8.2.6 Receive PDO 2 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Receive PDO 2 Mapping
Index	0x1601
Number of entries	–

Name	Number of mapped Application Objects in Receive PDO	
Index	0x1601	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	7	
Value Range	7	7

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60400010	➔Controlword
2nd	0x02	INTEGER32	RO	0x60FF0020	➔Target Velocity
3rd	0x03	INTEGER32	RO	0x60B10020	➔Velocity Offset
4th	0x04	INTEGER16	RO	0x60B20010	➔Torque Offset
5th	0x05	INTEGER8	RO	0x60600008	➔Modes of Operation
6th	0x06	UNSIGNED16	RO	0x20780110	➔Digital Output Functionalities State
7th	0x07	UNSIGNED16	RO	0x60B80010	➔Touch Probe Function

Table 8-74 Receive PDO 2 Mapping – CSV (mapped Objects)

8.2.7 Receive PDO 3 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Receive PDO 3 Mapping
Index	0x1602
Number of entries	–

Name	Number of mapped Application Objects in Receive PDO	
Index	0x1602	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	6	
Value Range	6	6

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60400010	➔Controlword
2nd	0x02	INTEGER16	RO	0x60710010	➔Target Torque
3rd	0x03	INTEGER16	RO	0x60B20010	➔Torque Offset
4th	0x04	INTEGER8	RO	0x60600008	➔Modes of Operation
5th	0x05	UNSIGNED16	RO	0x20780110	➔Digital Output Functionalities State
6th	0x06	UNSIGNED16	RO	0x60B80010	➔Touch Probe Function

Table 8-75 Receive PDO 3 Mapping – CST (mapped Objects)

8.2.8 Receive PDO 4 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Receive PDO 4 Mapping
Index	0x1603
Number of entries	–

Name	Number of mapped Application Objects in Receive PDO	
Index	0x1603	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	10	
Value Range	10	10

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60400010	➔Controlword
2nd	0x02	INTEGER32	RO	0x607A0020	➔Target Position
3rd	0x03	INTEGER32	RO	0x60FF0020	➔Target Velocity
4th	0x04	INTEGER16	RO	0x60710010	➔Target Torque
5th	0x05	INTEGER32	RO	0x60B00020	➔Position Offset
6th	0x06	INTEGER32	RO	0x60B10020	➔Velocity Offset
7th	0x07	INTEGER16	RO	0x60B20010	➔Torque Offset
8th	0x08	INTEGER8	RO	0x60600008	➔Modes of Operation
9th	0x09	UNSIGNED16	RO	0x20780110	➔Digital Output Functionalities State
10th	0x0A	UNSIGNED16	RO	0x60B80010	➔Touch Probe Function

Table 8-76 Receive PDO 4 Mapping – CSP/CSV/CST (mapped Objects)

8.2.9 Receive PDO 5 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Receive PDO 5 Mapping
Index	0x1604
Number of entries	–

Name	Number of mapped Application Objects in Receive PDO	
Index	0x1604	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	8	
Value Range	8	8

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60400010	➔Controlword
2nd	0x02	INTEGER32	RO	0x607A0020	➔Target Position
3rd	0x03	INTEGER32	RO	0x60FF0020	➔Target Velocity
4th	0x04	UNSIGNED32	RO	0x60830020	➔Profile Acceleration
5th	0x05	UNSIGNED32	RO	0x60840020	➔Profile Deceleration
6th	0x06	UNSIGNED32	RO	0x60810020	➔Profile Velocity
7th	0x07	INTEGER8	RO	0x60600008	➔Modes of Operation
8th	0x08	UNSIGNED16	RO	0x20780110	➔Digital Output Functionalities State

Table 8-77 Receive PDO 5 Mapping – PPM/PVM/IPM (mapped Objects)

8.2.10 Transmit PDO 1 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Transmit PDO 1 Mapping
Index	0x1A00
Number of entries	–

Name	Number of mapped Application Objects in Transmit PDO	
Index	0x1A00	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	9	
Value Range	9	9

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60410010	➔Statusword
2nd	0x02	INTEGER32	RO	0x60640020	➔Position Actual Value
3rd	0x03	INTEGER32	RO	0x606C0020	➔Velocity Actual Value
4th	0x04	INTEGER16	RO	0x60770010	➔Torque Actual Value
5th	0x05	INTEGER8	RO	0x60610008	➔Modes of Operation Display
6th	0x06	UNSIGNED16	RO	0x20710110	➔Digital Input Functionalities State
7th	0x07	UNSIGNED16	RO	0x60B90010	➔Touch Probe Status
8th	0x08	INTEGER32	RO	0x60BA0020	➔Touch Probe Position 1 Positive Value
9th	0x09	INTEGER32	RO	0x60BB0020	➔Touch Probe Position 1 Negative Value

Table 8-78 Transmit PDO 1 Mapping – CSP (mapped Objects)

8.2.11 Transmit PDO 2 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Transmit PDO 2 Mapping
Index	0x1A01
Number of entries	–

Name	Number of mapped Application Objects in Transmit PDO	
Index	0x1A01	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	9	
Value Range	9	9

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60410010	➔Statusword
2nd	0x02	INTEGER32	RO	0x60640020	➔Position Actual Value
3rd	0x03	INTEGER32	RO	0x606C0020	➔Velocity Actual Value
4th	0x04	INTEGER16	RO	0x60770010	➔Torque Actual Value
5th	0x05	INTEGER8	RO	0x60610008	➔Modes of Operation Display
6th	0x06	UNSIGNED16	RO	0x20710110	➔Digital Input Functionalities State
7th	0x07	UNSIGNED16	RO	0x60B90010	➔Touch Probe Status
8th	0x08	INTEGER32	RO	0x60BA0020	➔Touch Probe Position 1 Positive Value
9th	0x09	INTEGER32	RO	0x60BB0020	➔Touch Probe Position 1 Negative Value

Table 8-79 Transmit PDO 2 Mapping – CSV (mapped Objects)

8.2.12 Transmit PDO 3 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Transmit PDO 3 Mapping
Index	0x1A02
Number of entries	–

Name	Number of mapped Application Objects in Transmit PDO	
Index	0x1A02	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	9	
Value Range	9	9

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60410010	➔Statusword
2nd	0x02	INTEGER32	RO	0x60640020	➔Position Actual Value
3rd	0x03	INTEGER32	RO	0x606C0020	➔Velocity Actual Value
4th	0x04	INTEGER16	RO	0x60770010	➔Torque Actual Value
5th	0x05	INTEGER8	RO	0x60610008	➔Modes of Operation Display
6th	0x06	UNSIGNED16	RO	0x20710110	➔Digital Input Functionalities State
7th	0x07	UNSIGNED16	RO	0x60B90010	➔Touch Probe Status
8th	0x08	INTEGER32	RO	0x60BA0020	➔Touch Probe Position 1 Positive Value
9th	0x09	INTEGER32	RO	0x60BB0020	➔Touch Probe Position 1 Negative Value

Table 8-80 Transmit PDO 3 Mapping – CST (mapped Objects)

8.2.13 Transmit PDO 4 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Transmit PDO 4 Mapping
Index	0x1A03
Number of entries	–

Name	Number of mapped Application Objects in Transmit PDO	
Index	0x1A03	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	9	
Value Range	9	9

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60410010	➔Statusword
2nd	0x02	INTEGER32	RO	0x60640020	➔Position Actual Value
3rd	0x03	INTEGER32	RO	0x606C0020	➔Velocity Actual Value
4th	0x04	INTEGER16	RO	0x60770010	➔Torque Actual Value
5th	0x05	INTEGER8	RO	0x60610008	➔Modes of Operation Display
6th	0x06	UNSIGNED16	RO	0x20710110	➔Digital Input Functionalities State
7th	0x07	UNSIGNED16	RO	0x60B90010	➔Touch Probe Status
8th	0x08	INTEGER32	RO	0x60BA0020	➔Touch Probe Position 1 Positive Value
9th	0x09	INTEGER32	RO	0x60BB0020	➔Touch Probe Position 1 Negative Value

Table 8-81 Transmit PDO 4 Mapping – CSP/CSV/CST (mapped Objects)

8.2.14 Transmit PDO 5 Mapping

Description

PDO mapping is static and cannot be changed.Thereby, subindex 0 represents the number of mapped objects, whereas subindex 0x01…0x0n represents the mapped objects.

Name	Transmit PDO 5 Mapping
Index	0x1A04
Number of entries	–

Name	Number of mapped Application Objects in Transmit PDO	
Index	0x1A04	
Subindex	0x00	
Type	UNSIGNED8	
Access	RO	
Default Value	8	
Value Range	8	8

Remarks

Upon the attempt to change a value via USB, EPOS Studio will display the error 0x06090030 (Value Range Error).

Static mapped Objects	Sub-index	Type	Access	Default Value	
1st	0x01	UNSIGNED16	RO	0x60410010	➔Statusword
2nd	0x02	INTEGER32	RO	0x60640020	➔Position Actual Value
3rd	0x03	INTEGER32	RO	0x606C0020	➔Velocity Actual Value
4th	0x04	INTEGER16	RO	0x60780010	➔Current Actual Value
5th	0x05	INTEGER16	RO	0x20F40010	➔Following Error Actual Value
6th	0x06	INTEGER8	RO	0x60610008	➔Modes of Operation Display
7th	0x07	UNSIGNED16	RO	0x20710110	➔Digital Input Functionalities State
8th	0x08	RECORD	RO	0x20C40010	➔Interpolation Buffer Status

Table 8-82 Transmit PDO 4 Mapping – PP/PV/IP (mapped Objects)

8.2.15 Sync Manager Communication Type

Description

The pre-configured read only object is used to read out the transfer mode of the EtherCAT Sync Manager's channels.

Name	Sync Manager Communication Type
Index	0x1C00
Number of entries	–

Name	Number of used Sync Manager Channels
Index	0x1C00
Subindex	0x00
Type	UNSIGNED8
Access	RO
Default Value	4
Value Range	4

Name	Communication Type Sync Channel 0
Index	0x1C00
Subindex	0x01
Type	UNSIGNED8
Access	RO
Default Value	1
Value Range	1: Mailbox Receive (Master → Slave)

Name	Communication Type Sync Channel 1
Index	0x1C00
Subindex	0x02
Type	UNSIGNED8
Access	RO
Default Value	2
Value Range	2: Mailbox Transmit (Master ← Slave)

Name	Communication Type Sync Channel 2
Index	0x1C00
Subindex	0x03
Type	UNSIGNED8
Access	RO
Default Value	3
Value Range	3: Process Data Output (Master → Slave)

Name	Communication Type Sync Channel 3
Index	0x1C00
Subindex	0x04
Type	UNSIGNED8
Access	RO
Default Value	4
Value Range	4: Process Data Input (Master ← Slave)

8.2.16 Sync Manager Channel 2 (Process Data Output)

Description

Used to configure a PDO for Sync channel 2 (Master → Slave). Subindex 0 defines the number of PDOs assigned to the Sync channel, subindex 1 carries the PDO's object. Prior, respective assigned objects must be configured as Receive PDOs.

Only one PDO can be defined, whereby only objects within the defined value range will be accepted. The EtherCAT Master must set the desired PDO.

In order to change a value in object "PDO Mapping Object Number of assigned RxPDO" (0x01), the object "Number of assigned PDOs" (0x00) must be set to "0" (zero) first.

Remarks

The values may only be altered via EtherCAT (not via i.e. USB).

Related Objects

➔"Receive PDO 1 Mapping" on page 8-90 thru "Receive PDO 5 Mapping" on page 8-94

Name	Sync Manager Channel 2 (Process Data Output)
Index	0x1C12
Number of entries	–

Name	Number of assigned PDOs
Index	0x1C12
Subindex	0x00
Type	UNSIGNED8
Access	RW
Default Value	1
Value Range	1: one PDO assigned to this channel

Name	PDO Mapping Object Number of assigned RxPDO	
Index	0x1C12	
Subindex	0x01	
Type	UNSIGNED16	
Access	RW	
Default Value	0x1600	
Value Range	0x1600: first Receive PDO 0x1601: second Receive PDO 0x1602: third Receive PDO	0x1603: fourth Receive PDO 0x1604: fifth Receive PDO

8.2.17 Sync Manager Channel 3 (Process Data Input)

Used to configure a PDO for Sync channel 3 (Master ← Slave). Subindex 0 defines the number of PDOs assigned to the Sync channel, subindex 1 carries the PDO's object. Prior, respective assigned objects must be configured as Transmit PDOs.

Only one PDO can be defined, whereby only objects within the defined value range will be accepted. The EtherCAT Master must set the desired PDO.

In order to change a value in object "PDO Mapping Object Number of assigned RxPDO" (0x01), the object "Number of assigned PDOs" (0x00) must be set to "0" (zero) first.

Related Objects

➔"Transmit PDO 1 Mapping" on page 8-95 thru "Transmit PDO 5 Mapping" on page 8-99

Name	Sync Manager Channel 3 (Process Data Input)
Index	0x1C13
Number of entries	–

Name	Number of assigned PDOs
Index	0x1C13
Subindex	0x00
Type	UNSIGNED8
Access	RW
Default Value	1
Value Range	1: one PDO assigned to this channel

Name	PDO Mapping Object Number of assigned TxPDO	
Index	0x1C13	
Subindex	0x01	
Type	UNSIGNED16	
Access	RW	
Default Value	0x1A00	
Value Range	0x1A00: first Transmit PDO 0x1A01: second Transmit PDO 0x1A02: third Transmit PDO	0x1A03: fourth Transmit PDO 0x1A04: fifth Transmit PDO

8.2.18 Version

Description

Contains the software version of the EPOS3 EtherCAT.

Name	Version
Index	0x2003
Number of entries	0x05

Name	Software Version	
Index	0x2003	
Subindex	0x01	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

Description

Contains the hardware version (and the device type).

Name	Hardware Version	
Index	0x2003	
Subindex	0x02	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	EPOS3 70/10 EtherCAT	0x6440

Description

If the value is not zero, an application-specific firmware is installed on this EPOS3 EtherCAT.

Name	Application Number	
Index	0x2003	
Subindex	0x03	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

Description

Used as version number of an application or as internal revision number.

Name	Application Version	
Index	0x2003	
Subindex	0x04	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

Description

Used internally and by GUI.

Name	Internal Object	
Index	0x2003	
Subindex	0x05	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.19 Serial Number

Description

The serial number of the EPOS3 can be read here. If “0” (zero), the serial number is unknown.

Name	Serial Number	
Index	0x2004	
Subindex	0x00	
Type	UNSIGNED64	
Access	CONST	
Default Value	–	
Value Range	–	–

8.2.20 USB Frame Timeout

Description

Defines the timeout over a USB communication frame. It is scaled in milliseconds.

Name	USB Frame Timeout	
Index	0x2006	
Subindex	0x00	
Type	UNSIGNED16	
Access	RW	
Default Value	500	
Value Range	–	–

8.2.21 Miscellaneous Configuration

Description

The configuration word can be used for various operations.

Remark

Changes are only supported in “Disable” state.

Name	Miscellaneous Configuration
Index	0x2008
Subindex	0x00
Type	UNSIGNED16
Access	RW
Default Value	0x0000
Value Range	➔Table 8-83

Bit	Description
15…9	reserved
8	Polarity Bit 0 = Normal: If demanded velocity or position is positive, direction of rotation is CCW 1 = Inverse: If demanded velocity or position is positive, direction of rotation is CW
7…5	reserved
4	1 = Measure auxiliary position sensor’s motor speed exacting by detecting encoder pulse time (only available for sensor type Hall, Incremental Encoder 1 and Incremental Encoder 2)
3	1 = Measure main position sensor’s motor speed exacting by detecting encoder pulse time (only available for sensor type Hall, Incremental Encoder 1 and Incremental Encoder 2)
2	0 = Measure (DC) motor resistance at first change to enable 1 = Measure (DC) motor resistance at every change to enable (used for position sensor supervision by software)
1	1 = Disable sensor supervision by hardware
0	1 = Disable sensor supervision by software

Table 8-83 Miscellaneous Configuration Bits

8.2.22 Custom Persistent Memory

Description

This persistent memory can be used to store custom values (e.g. axis numbers, identifications, …) on the EPOS3 EtherCAT. These values will not be evaluated by the firmware, but will be cleared by setting the default parameters.

Name	Custom Persistent Memory
Index	0x200C
Number of entries	4

Names	Custom Persistent Memory 1 Custom Persistent Memory 2	Custom Persistent Memory 3 Custom Persistent Memory 4
Index	0x200C	
Subindex	0x01…0x04	
Type	UNSIGNED32	
Access	RW	
Default Value	0x0000	
Value Range	–	–

8.2.23 Incremental Encoder 1 Counter

Description

Holds the internal counter register of the Incremental Encoder 1 multiplied by Polarity (➔“Miscellaneous Configuration” on page 8-105). It shows the actual encoder position in quadcounts.

Name	Incremental Encoder 1 Counter	
Index	0x2020	
Subindex	0x00	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.24 Incremental Encoder 1 Counter at Index Pulse

Description

Holds the Incremental Encoder 1 counter reached upon last detected encoder index pulse.

Name	Incremental Encoder 1 Counter at Index Pulse	
Index	0x2021	
Subindex	0x00	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.25 Hall Sensor Pattern

Description

Displays the actual state of the three Hall sensors as a pattern.

Name	Hall Sensor Pattern	
Index	0x2022	
Subindex	0x00	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

Bit	Hardware Signal
0	Hall sensor 1
1	Hall sensor 2
2	Hall sensor 3

Table 8-84 Hall Sensor Pattern

8.2.26 Current Actual Value Averaged

Description

Represents the current actual value filtered by 1st order digital low-pass filter with a cut-off frequency of 50 Hz. The value is given in [mA].

The linear difference equation is given with…

$$y[k] = (1-\lambda)\cdot y[k-1] + \lambda \cdot x[k]$$

…where the transfer function results in:

$$H(z) = \frac{Y(z)}{X(z)} = \frac{\lambda}{1-(1-\lambda)\times z^{-1}} \qquad \lambda = 2^{-5}$$

With the numerical values $\lambda = 2^{-5}$, sampling time $Ts = 0.1ms$ and $e^{j2\pi fTs}$, the following amplitude response will result:

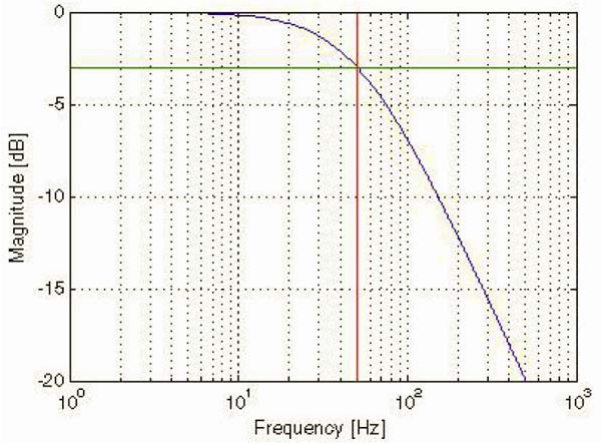

Figure 8-42 Current Actual Value Averaged – Amplitude Response

Related Objects

➔"Current Actual Value" on page 8-160

Name	Current Actual Value Averaged	
Index	0x2027	
Subindex	0x00	
Type	INTEGER16	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.27 Velocity Actual Value Averaged

Description

Represents the Velocity Actual Value [Velocity units] filtered by 1st order digital low-pass filter with a cut-off frequency of 5 Hz. For details on [Velocity units] ➔chapter “3.3.1 Definition of Units” on page 3-18.

The linear difference equation is given with…

$$y[k] = (1-\lambda)\cdot y[k-1] + \lambda \cdot x[k]$$

…where the transfer function results in:

$$H(z) = \frac{Y(z)}{X(z)} = \frac{\lambda}{1-(1-\lambda)\times z^{-1}} \qquad \lambda = 2^{-5}$$

With the numerical values $\lambda = 2^{-5}$, sampling time $Ts = 1ms$ and $e^{j2\pi fTs}$, the following amplitude response will result:

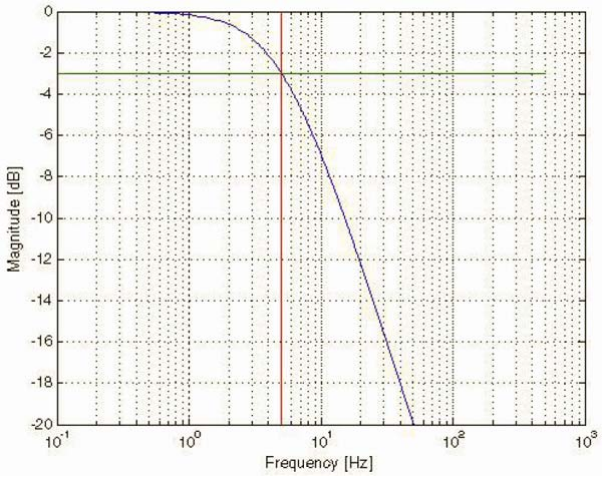

Figure 8-43 Velocity Actual Value Averaged – Amplitude Response

Remarks

The resolution of the short time velocity measurement (➔“Velocity Actual Value” on page 8-157 / “Velocity Sensor Actual Value” on page 8-156) is dependent on the encoder pulse number (➔“Sensor Configuration” on page 8-135) and the velocity measurement method (➔“Miscellaneous Configuration” on page 8-105, bit 3). To improve the short time velocity measurement resolution set the Miscellaneous configuration bit 3 to 1 or use a encoder with higher resolution.

For example the short time velocity resolution with a 500 pulse encoder and Miscellaneous configuration bit 3 = 0 is: 1 quadcount / ms = 60000 / (4 x 500) = 30 rpm.

Related Objects

➔“Velocity Actual Value” on page 8-157

Name	Velocity Actual Value Averaged	
Index	0x2028	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.28 Auxiliary Velocity Actual Value Averaged

Description

Represents the Auxiliary Velocity Actual Value [Velocity units] filtered by 1st order digital low-pass filter with a cut-off frequency of 5 Hz. For details on [Velocity units] ➔chapter “3.3.1 Definition of Units” on page 3-18.

For details on calculation and measurement ➔“Velocity Actual Value Averaged” on page 8-109.

Related Objects

➔“Auxiliary Velocity Actual Value” on page 8-112

Name	Auxiliary Velocity Actual Value Averaged	
Index	0x2029	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.29 Actual Values Averaged

Name	Actual Values Averaged
Index	0x202A
Number of entries	1

Description

Represents the Torque Actual Value filtered by 1st order digital low-pass filter with a cut-off frequency of 50 Hz. The value is given per thousand of Rated Torque (object 0x2076-00).

The linear difference equation is given with…

$$y[k] = (1-\lambda)\cdot y[k-1] + \lambda \cdot x[k]$$

…where the transfer function results in:

$$H(z) = \frac{Y(z)}{X(z)} = \frac{\lambda}{1-(1-\lambda)\times z^{-1}} \qquad \lambda = 2^{-5}$$

With the numerical values $\lambda = 2^{-5}$, sampling time $Ts = 0.1ms$ and $e^{j2\pi fTs}$, the following amplitude response will result:

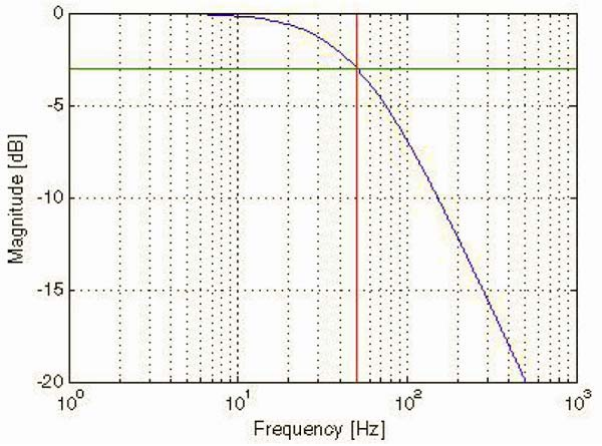

Figure 8-44 Torque Actual Value Averaged – Amplitude Response

Related Objects

➔"Torque Actual Value" on page 8-159

Name	Torque Actual Value Averaged	
Index	0x202A	
Subindex	0x01	
Type	INTEGER16	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.30 Current Demand Value

Description

The «Current Demand Value» is the set value [mA] for the current controller.

Name	Current Demand Value	
Index	0x2031	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.31 Auxiliary Velocity Sensor Actual Value

Description

Originates from the auxiliary sensor and is used as the auxiliary controller's input [inc/s]

Remarks

The short-time velocity measurement's resolution is dependent on the auxiliary encoder pulse number and the velocity measurement method (Miscellaneous Configuration bit 4).

To improve the short time velocity measurement resolution, set the Miscellaneous Configuration bit 4 to "1" or use an encoder with higher resolution (Incremental Encoder 1, Incremental Encoder 2 and Hall sensors, only).

If the auxiliary controller's sensor type is configured to unknown, the velocity actual value is always "0" (zero).

Related Object

➔"Miscellaneous Configuration" on page 8-105

Name	Auxiliary Velocity Sensor Actual Value	
Index	0x2069	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.32 Auxiliary Velocity Actual Value

Description

Representing the auxiliary velocity actual value scaling to [Velocity units] (➔page 3-18).

Remarks

The resolution of the short-time velocity measurement (Velocity actual value, ➔"Velocity Sensor Actual Value" on page 8-156) is dependent on the encoder pulse number (➔"Sensor Configuration" on page 8-135) and the velocity measurement method (➔"Miscellaneous Configuration" on page 8-105, bit 3). To improve the short time velocity measurement resolution set the Miscellaneous configuration bit 3 to 1 or use an encoder with higher resolution (Incremental Encoder 1, Incremental Encoder 2 and Hall sensors, only).

For example the short time velocity resolution with a 500-pulse encoder and Miscellaneous configuration Bit 3 = 0 is: 1 quadcount / ms = 60000 / (4 x 500) = 30 rpm.

Related Objects

➔"Velocity Actual Value Averaged" on page 8-109

Name	Auxiliary Velocity Actual Value	
Index	0x206C	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.33 Configuration of Digital Inputs

Description

Configures the functionality that will be assigned to digital input 1 to 10.

Related Objects

➔"Digital Input Functionalities" on page 8-115

Name	Configuration of Digital Inputs	
Index	0x2070	
Number of entries	10	
Names	Configuration of Digital Input 1 Configuration of Digital Input 2 Configuration of Digital Input 3 Configuration of Digital Input 4 Configuration of Digital Input 5	Configuration of Digital Input 6 Configuration of Digital Input 7 Configuration of Digital Input 8 Configuration of Digital Input 9 Configuration of Digital Input 10
Index	0x2070	
Subindex	0x01…0x10	
Type	UNSIGNED16	
Access	RW	
Default Value	➔Table 8-85	
Value Range	0	15

Digital Input	Default Value
1	15
2	14
3	13
4	2
5	1
6	0
7	9
8	8
9	7
10	6

Table 8-85 Digital Inputs – Default Values

Value	Functionality	Description
15	General purpose A	State can be read
14	General purpose B	State can be read
13	General purpose C	State can be read
12	General purpose D	State can be read
11	General purpose E	State can be read
10	General purpose F	State can be read
9	General purpose G	State can be read
8	General purpose H	State can be read
7	General purpose I	State can be read
6	General purpose J	State can be read
5	reserved	–
4	reserved	–
3	Position marker	Samples actual position
2	Home switch	Used in some homing modes
1	Positive limit switch	Generates Limit error / used in some homing modes
0	Negative limit switch	Generates Limit error / used in some homing modes

Table 8-86 Digital Inputs – Configuration

8.2.34 Digital Input Functionalities

Description

Displays the state of the digital input functionalities (after polarity correction and filtering by «Digital Input Functionalities Polarity» and «Digital Input Functionalities Mask»). If a bit is read as one the functionality is activated.

Name	Digital Input Functionalities
Index	0x2071
Number of entries	4

Name	Digital Input Functionalities State	
Index	0x2071	
Subindex	0x01	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

Bit	Description
15	General purpose A
14	General purpose B
13	General purpose C
12	General purpose D
11	General purpose E
10	General purpose F
9	General purpose G
8	General purpose H
7	General purpose I
6	General purpose J
5	reserved
4	reserved
3	Position marker
2	Home switch
1	Positive limit switch
0	Negative limit switch

Table 8-87 Digital Input Functionality – State

Description

Used to display the state of the digital input functionalities. If a bit is set to “1”, the functionality state will be displayed.

Remarks

For bit description ➔Table 8-87.

Name	Digital Input Functionalities Mask	
Index	0x2071	
Subindex	0x02	
Type	UNSIGNED16	
Access	RW	
Default Value	0xE007	
Value Range	–	–

Description

Used to set polarity of the digital input functionalities. If a bit is set to “0” (zero), the associated pin is high active.

Remarks

For bit description ➔Table 8-87.

Name	Digital Input Functionalities Polarity	
Index	0x2071	
Subindex	0x03	
Type	UNSIGNED16	
Access	RW	
Default Value	0x0000	
Value Range	–	–

Bit Value	Associated Pin
0	high active
1	low active

Table 8-88 Digital Input Functionality – Polarity

Description

Used to suppress execution of the digital input functionalities. The function (Negative or Positive Limit Switch Error Routine) will be executed when the associated bit in functionalities state register goes high and the bit in this execution mask is set.

Name	Digital Input Functionalities Execution Mask	
Index	0x2071	
Subindex	0x04	
Type	UNSIGNED16	
Access	RW	
Default Value	0x0008	
Value Range	–	–

Bit	Description
15	reserved
14	reserved
13	reserved
12	reserved
11	reserved
10	reserved
9	reserved
8	reserved
7	reserved
6	reserved
5	reserved
4	reserved
3	Position marker
2	reserved
1	Positive limit switch
0	Negative limit switch

Table 8-89 Digital Input Functionality – Execution Mask

8.2.35 Position Marker

Description

Holds the last captured position.

Remarks

Starting a homing sequence disables the «Position Marker» and resets the captured position. After the homing sequence, the «Position Marker» is enabled again.

Related Objects

➔“Configuration of Digital Inputs” on page 8-113 / ➔“Digital Input Functionalities” on page 8-115

Name	Position Marker
Index	0x2074
Number of entries	6

Name	Position Marker captured Position	
Index	0x2074	
Subindex	0x01	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

Remarks

The digital inputs are filtered by software additionally to the hardware input filter to suppress spikes. Due to this, even if a high speed input is used as position marker input, the level must be stable for more than 1 ms that a state change (edge) is detected as valid. A second capture edge must not occur earlier than 2 ms after a valid detection of both positions.

The high speed digital inputs are detected by an interrupt. Therefore the position can be captured exacting with this inputs (latency time shorter than 45 µs). For the other digital inputs, the latency time is longer due to polling of inputs (maximum 2 ms) plus the switching time for hardware filtering. For further details ➔separate documents «Hardware Reference» of respective controller.

Name	Position Marker Edge Type	
Index	0x2074	
Subindex	0x02	
Type	UNSIGNED8	
Access	RW	
Default Value	0	
Value Range	–	–

Value	Detection	Description
0	Both edges	«Digital Input Functionalities State» change from 0 to 1 or from 1 to 0
1	Rising edge	«Digital Input Functionalities State» change from 0 to 1
2	Falling edge	«Digital Input Functionalities State» change from 1 to 0

Table 8-90 Position Marker Edge Type

Description

Defines the position maker-capturing mode.

Name	Position Marker Mode	
Index	0x2074	
Subindex	0x03	
Type	UNSIGNED8	
Access	RW	
Default Value	1	
Value Range	0	3

Value	Capture	Description
0	Continuous	On every detected edge (of correct kind) the position will be captured
1	Single	Only the position at the first detected edge will be capture
2	Multiple	The positions at the detected edges will be captured until the history buffer is full (position marker counter = 3)
3	Single & Stop	Only the position at the first detected edge will be captured, the motor will be stopped with slow-down ramp.

Table 8-91 Position Marker Mode

Description

Counts the number of the detected edges. The counter and the captured positions can be cleared by writing “0” (zero) to this object.

Name	Position Marker Counter	
Index	0x2074	
Subindex	0x04	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	–	–

Description

If more than one position is captured in «Multiple Capture Mode» or «Continuous Capture Mode» the older captured positions will be shifted to this objects.

Remarks

If more than three positions are captured in «Continuous Capture Mode» the oldest marker positions are lost. Starting a homing sequence resets the «Position Marker History».

Names	Position Marker History [1]	Position Marker History [2]
Index	0x2074	
Subindex	0x05…0x06	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.36 Rated Torque

Description

Holds the value to which all torque objects are related to. The value is defined as Nominal Current (0x6410-01) multiplied by the Motor Torque Constant (0x6410-06) given in [µNm].

Related Objects

➔"Motor Data" on page 8-186

Names	Rated Torque	
Index	0x2076	
Subindex	0x00	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.37 Digital Output Functionalities

Description

Configures the state of ➔"Digital Outputs" on page 6-77.

Remarks

The bits 0 to 7 are read only. They will be modified by internal events or states. A write access has no effect on the state of these byte.

Related Objects

➔"Configuration of Digital Inputs" on page 8-113

Name	Digital Output Functionalities
Index	0x2078
Number of entries	3

Name	Digital Output Functionalities State	
Index	0x2078	
Subindex	0x01	
Type	UNSIGNED16	
Access	RW	
Default Value	–	
Value Range	–	–

Bit	Description
15	General purpose OutA
14	General purpose OutB
13	General purpose OutC
12	General purpose OutD
11	General purpose OutE
10	General purpose OutF
9	General purpose OutG
8	General purpose OutH
7	reserved
6	reserved
5	reserved
4	reserved
3	reserved
2	Holding brake (read only)
1	Position compare (read only)
0	Ready / Fault* (read only)

Table 8-92 Digital Output Functionality State

Description

Filters digital outputs. Only digital outputs will be modified that have set its bit to “1” in this register.

Remarks

For bit description ➔Table 8-92.

Name	Digital Output Functionalities Mask	
Index	0x2078	
Subindex	0x02	
Type	UNSIGNED16	
Access	RW	
Default Value	0x0000	
Value Range	–	–

Description

Permits change of polarity of digital outputs. If a bit is set to “1”, the associated output will be inverted. Thus, “1” in the «Digital Output Functionalities State» will set the output pin low.

Remarks

For bit description ➔Table 8-92.

Name	Digital Output Functionalities Polarity	
Index	0x2078	
Subindex	0x03	
Type	UNSIGNED16	
Access	RW	
Default Value	0x0000	
Value Range	–	–

8.2.38 Configuration of Digital Outputs

Description

Configures the output functionality that will be assigned to digital outputs 1 to 5.

Remarks

Changes for Holding Brake Configuration are only supported in “Disable” state.

Related Objects

➔“Position Compare” on page 8-123 / ➔“Holding Brake Configuration” on page 8-131

Name	Configuration of Digital Outputs	
Index	0x2079	
Number of entries	5	

Names	Configuration of Digital Output 1 Configuration of Digital Output 2 Configuration of Digital Output 3	Configuration of Digital Output 4 Configuration of Digital Output 5
Index	0x2079	
Subindex	0x01…0x05	
Type	UNSIGNED16	
Access	RW	
Default Value	➔Table 8-93	
Value Range	0	15

Digital Output	Default Value
1	15
2	14
3	13
4	12
5	11

Table 8-93 Digital Outputs – Default Values

Value	Functionality	Description
15	General purpose OutA	Can be written by state
14	General purpose OutB	Can be written by state
13	General purpose OutC	Can be written by state
12	General purpose OutD	Can be written by state
11	General purpose OutE	Can be written by state
10…8	not used	
7…3	reserved	
2	Holding Brake	Output functionality to drive a holding brake
1	Position compare	Trigger output of position compare
0	Ready / Fault*	Active on Device Ready / Inactive on Fault

Table 8-94 Digital Outputs – Configuration

8.2.39 Position Compare

Description

The «Position Compare» allows to trigger a digital output at configurable position values.

There are two different modes of operation:

- In single position mode, only one specific position will be compared.
- In position sequence mode, a sequence of positions consisting of a reference position and a number of interval offset positions is compared.

Further settings such as interval mode, direction dependency or pulse width are provided to configure «Position Compare».The «Position Compare» functionality can be mapped to any of the digital outputs. The accuracy of the signal depends on the type of the used output. The best accuracy can be attained if the high speed digital output is used due to the «Position Compare» is done directly by hardware (➔separate document «Hardware Reference» of respective controller. In contrast, the slower «General Purpose» digital outputs are handled by software and there higher switching delay affect the response time additionally.

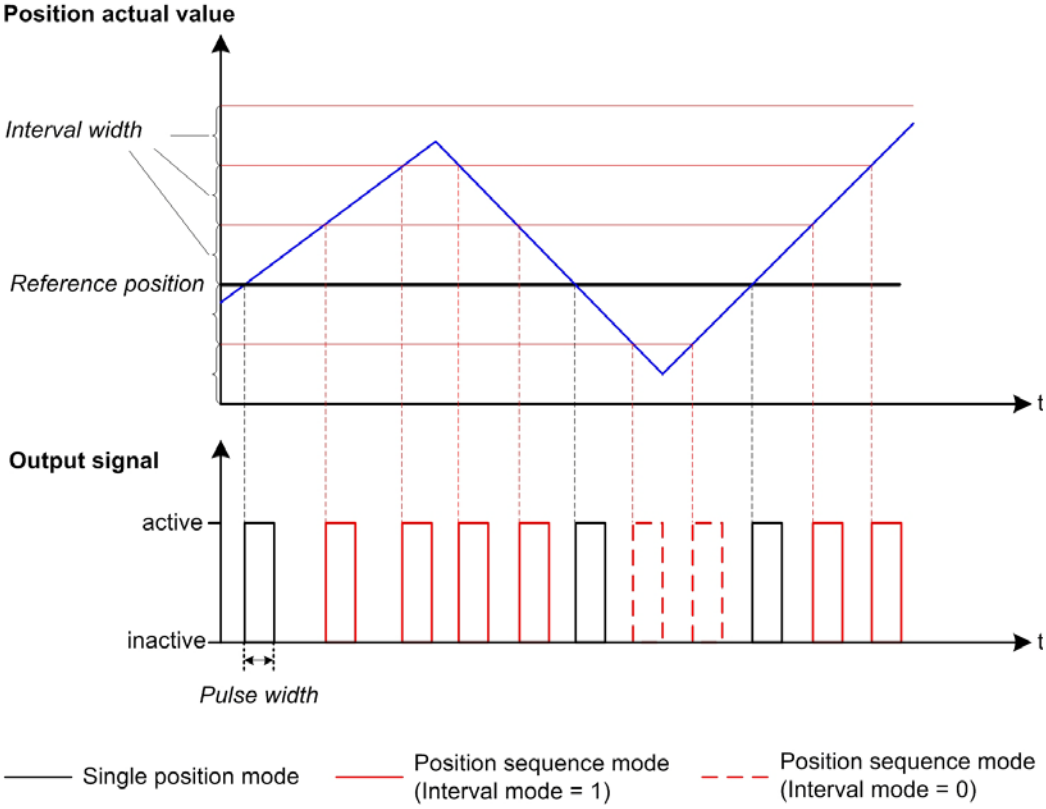

Figure 8-45 Position Compare – Overview

Name	Position Compare
Index	0x207A
Number of entries	0x05

Description

Used to configure «Position Compare» (e.g. enable/disable, mode selection, …).

Remarks

«Position Compare» is only available if the position sensor type is either set to “1” (Incremental Encoder with index) or to “2” (Incremental Encoder without index). For details ➔“Sensor Configuration” on page 8-135.

«Position Compare» will be disabled if «Homing Mode» is started or ➔“Position Actual Value” on page 8-154) overflows/underflows (goes from 2 247 483 647 to -2 147 483 648 or backwards).

Related Objects

➔“Configuration of Digital Outputs” on page 8-122 / ➔“Digital Output Functionalities” on page 8-120

Name	Position Compare Configuration	
Index	0x207A	
Subindex	0x01	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	➔Table 8-96	–

Bit 15…7	Bit 6…5	Bit 4…3	Bit 2…1	Bit 0
reserved (0)	Direction dependency	Interval mode	Operational mode	Enable

Table 8-95 Position Compare Configuration – Structure

Bit	Value	Description
Enable	0	Disable position compare
	1	Enable position compare
Operational mode	0	Single position mode
	1	Position sequence mode
	2	reserved
	3	reserved
Interval mode	0	Interval positions are set in negative direction relative to the position compare reference position
	1	Interval positions are set in positive direction relative to the position compare reference position
	2	Interval positions are set in positive and negative direction relative to the position compare reference position
	3	reserved
Direction dependency	0	Positions are compared only if actual motor direction is negative
	1	Positions are compared only if actual motor direction is positive
	2	Positions are compared regardless of the actual motor direction
	3	reserved

Table 8-96 Position Compare Configuration Bits

Description

Holds the position that is compared with ➔“Position Actual Value” on page 8-154. For [Position units] (➔page 3-18).

Remarks

In position sequence mode, this object represents the reference position of the sequence.

Name	Position Compare Reference Position	
Index	0x207A	
Subindex	0x02	
Type	INTEGER32	
Access	RW	
Default Value	0	
Value Range	–	–

Description

In position sequence mode, this object holds the width of the position intervals [Position units] (➔page 3-18).

Remarks

Not used in single position mode.

Name	Position Compare Interval Width	
Index	0x207A	
Subindex	0x03	
Type	INTEGER32	
Access	RW	
Default Value	0	
Value Range	0	2 147 483 647

Description

In position sequence mode, this object permits configuration of the number of position intervals to be considered by position compare (relative to the reference position). The value “0” (zero) stands for “infinite”.

Remarks

The value of this object is calculated from the reference position regardless of the interval mode. So the actual number of compare positions is the number of interval repetitions plus 1 (the reference position) and if the interval mode (Position Compare Configuration) is set to “2” (Intervals set in both directions), the real number of compare positions is even twice the number of interval repetitions plus 1.

Not used in single position mode.

Name	Position Compare Interval Repetitions	
Index	0x207A	
Subindex	0x04	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	–	–

Description

Configures the pulse width of the trigger output [µs].

Remarks

The object accepts any configuration value. In case of an invalid value, no configuration error is processed. The value will be internally rounded and automatically adjusted.

The minimum pulse width of standard digital outputs is 500 µs.

Pulse widths of 500…65 500 µs can be used for any digital output, that is for both standard and high-speed digital outputs.

Pulse widths of 500 µs and bigger always result (due to internal rounding) in an actual pulse width of multiples of 100 µs. For example…
– a configuration of 450…549 µs results in an actual pulse width of 500 µs
– a configuration of 550…649 µs results in an actual pulse width of 600 µs

High Speed Digital Outputs:
If the «Position Compare» functionality is assigned to a high-speed digital output (such as DigOUT5 of EPOS3 70/10 EtherCAT), a pulse width configuration of 1…164 µs is possible in addition and is processed precisely. But a configuration of 165…65 500 µs results in the same behavior as for any standard digital output, thus 500 µs is used as the minimum actual pulse width, then the configured value is internally rounded to 100 µs steps.

Related Objects

➔"Configuration of Digital Outputs" on page 8-122 / ➔"Digital Output Functionalities" on page 8-120

Name	Position Compare Pulse Width	
Index	0x207A	
Subindex	0x05	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	–	–

8.2.40 Analog Inputs

Description

The voltage measured at analog input 1 or 2 [mV].

Name	Analog Input
Index	0x207C
Number of entries	2

Names	Analog Input 1	Analog Input 2
Index	0x207C	
Subindex	0x01…0x02	
Type	INTEGER16	
Access	RO	
Default Value	–	
Value Range	+10 V	-10 V

8.2.41 Analog Output 1

Description

Used to set the voltage level of the analog output 1.The value is given in [mV]. Immediately after write to this object, the value is transferred to the analog output 1.

Name	Analog Output 1	
Index	0x207E	
Subindex	0x00	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	0	10 000

8.2.42 Current Threshold for Homing Mode

Description

This value is used for homing modes «-1», «-2», «-3» and «-4». A mechanical border will be detected when the measured motor current rises over this threshold [mA].

Name	Current Threshold for Homing Mode	
Index	0x2080	
Subindex	0x00	
Type	UNSIGNED16	
Access	RW	
Default Value	500	
Value Range	0	depending on hardware

8.2.43 Home Position

Description

The home position defines the position, which will be set to the absolute position counter at the zero position [Position units] (➔page 3-18).

Related Objects

➔“Home Position Displacement” on page 8-128

Name	Home Position	
Index	0x2081	
Subindex	0x00	
Type	INTEGER32	
Access	RW	
Default Value	0	
Value Range	-2 147 483 648	2 147 483 647

8.2.44 Home Position Displacement

Description

Shows the distance from the previous ➔“Home Position” on page 8-127 [Position units] (➔page 3-18). It will be reset to Home Position.

Related Objects

➔“Home Position” on page 8-127

Name	Home Position Displacement	
Index	0x2082	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.45 Interpolation Data Record

Description

Sets PVT reference points in the interpolated position mode in the cubic spline interpolation sub-mode. The position is given absolute in [Position units] (➔page 3-18, typically [qc]), the velocity is given in [Velocity units] (➔page 3-18, typically [rpm]), and the time is given in [ms]. The object structure is defined in ➔“Interpolated Position Data Buffer” on page 5-52.

Remarks

Normally used to feed PVT reference points to the drive while a PVT motion is executing.

In the Interpolation active state at least two data records have to be in the FIFO. Otherwise a Queue underflow Emergency will be launched and the drive changes to Fault reaction state.

A data record with time = 0 changes the state to Interpolation inactive without any error.

Name	Interpolation Data Record	
Index	0x20C1	
Subindex	0x00	
Type	complex data structure 0x0040	
Access	WO	
Default Value	–	
Value Range	–	–

8.2.46 Interpolation Buffer

Description

Provides access to status information on the IP input data buffer.

Name	Interpolation Buffer
Index	0x20C4
Number of entries	3

Name	Interpolation Buffer Status	
Index	0x20C4	
Subindex	0x01	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

Bit 15	Bit 14	Bit 13…12	Bit 11…8	Bit 7…4	Bit 3…0
IP Mode active	Buffer enabled	reserved (0)	IPM buffer errors	reserved (0)	IPM buffer warnings

Table 8-97 Interpolation Buffer Status Word

Name	Bit	Value	Description
Underflow Warning	0	0	No buffer underflow warning
		1	Buffer underflow warning level (0x20C4-2) is reached
Overflow Warning	1	0	No buffer overflow warning
		1	Buffer overflow warning level (0x20C4-3) is reached
Velocity Warning	2	0	No profile velocity violation detected
		1	IPM velocity greater than profile velocity (0x6081) detected
Acceleration Warning	3	0	No profile acceleration violation detected
		1	IPM acceleration greater than profile acceleration (0x6083) detected
Underflow Error	8	0	No buffer underflow error
		1	Buffer underflow error (trajectory abort)
Overflow Error	9	0	No buffer overflow error
		1	Buffer overflow error (trajectory abort)
Velocity Error	10	0	No maximal profile velocity error
		1	IPM velocity greater than maximal profile velocity (0x607F) detected
Acceleration Error	11	0	No maximal profile acceleration error
		1	IPM acceleration greater than maximal profile acceleration (0x60C5) detected
Buffer enabled	14	0	Disabled access to the input buffer
		1	Access to the input buffer enabled
IP Mode active	15	0	IP mode inactive (same as bit 12 in statusword)
		1	IP mode active

Table 8-98 Interpolation Buffer Status Bits

Description

Gives the lower signalization level of the data input FIFO. If the filling level is below this border the warning flag (bit 0) in the Interpolation buffer status will be set.

Name	Interpolation Buffer Underflow Warning	
Index	0x20C4	
Subindex	0x02	
Type	UNSIGNED16	
Access	RW	
Default Value	4	
Value Range	0	63

Description

Gives the higher signalization level of the data input FIFO. If the filling level is above this border the warning flag (bit 1) in the Interpolation buffer status will be set.

Name	Interpolation Buffer Overflow Warning	
Index	0x20C4	
Subindex	0x03	
Type	UNSIGNED16	
Access	RW	
Default Value	60	
Value Range	1	64

8.2.47 Following Error Actual Value

Description

Represents the actual value of the following error. It is given in internal position units [qc].

Name	Following Error Actual Value	
Index	0x20F4	
Subindex	0x00	
Type	INTEGER16	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.48 Holding Brake Configuration

Description

The holding brakes are designed to provide protection against unintentional drifting at standstill. They are activated when controller is in “Power Disable” state and deactivated in “Power Enabled” state.

The holding brake functionality can be mapped to any of the digital outputs. Thereby, take output current limit into account. As for EPOS3 70/10 EtherCAT, the brake should be connected to Digital Output 4 (for details ➔separate document «Hardware Reference» of respective controller); polarity set to “Low Active”, then the Digital Output state will indicate the brake state (“Active” output = activated brake, “Inactive” output = deactivated brake).

Design Characteristics of Holding Brake

- *The holding brake is not designed to brake loads. This is done by the controller.*
- *The holding brake or the motor may be damaged if the holding brake will activate before the motor has reached full standstill. This can be the case if the brake timeout is shorter than the time to reach motor’s standstill.*
- *The holding brake function will work not properly if the sensor configuration object 0x2210 is set to “0” (unknown sensor). The brake will be activated within the brake timeout since there is no available information on the motor speed, and thus there is no possibility to detect standstill.*

Name	Holding Brake Configuration
Index	0x2100
Number of entries	0x03

Description

Indicates the time needed between power-off and reaching the holding brake’s torque (➔Figure 8-46) given in multiple of milliseconds [ms].

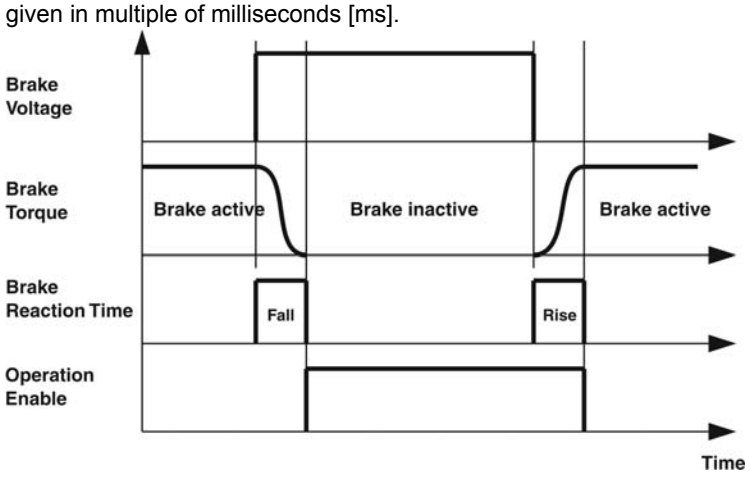

Figure 8-46 Brake Activation Timing

Name	Brake Reaction Rise Time	
Index	0x2100	
Subindex	0x01	
Type	UINT16	
Access	RW	
Default Value	10	
Value Range	0	65 535

Description

Indicates the time needed between power-on and releasing the holding brake's torque (➔Figure 8-46) given in multiple of milliseconds [ms].

Name	Brake Reaction Fall Time	
Index	0x2100	
Subindex	0x02	
Type	UINT16	
Access	RW	
Default Value	10	
Value Range	0	65 535

Description

Normally, the holding brake will be activated when the speed reaches standstill condition. If this will not happen within Brake Timeout, the holding brake will activate anyway. It is given in multiple of milliseconds [ms].

Remarks

The value "65535" will disable this timeout.

Name	Brake Timeout	
Index	0x2100	
Subindex	0x03	
Type	UINT16	
Access	RW	
Default Value	65535	
Value Range	0	65 535

8.2.49 Standstill Window Configuration

Used to detect that the motor has come to a standstill. This function is used in “Quickstop” active state, “Fault Reaction” active state as well as in the transition from “Operation Enable” to a “Disabled” state if a slowdown ramp (➔“Shutdown Option Code” on page 8-151 or “Disable Operation Option Code” on page 8-151) or a brake (➔“Holding Brake Configuration” on page 8-131?) is configurated.

Name	Standstill Window Configuration
Index	0x2101
Number of entries	0x03

Description

The standstill window defines a symmetric range of accepted velocity values relatively to zero. Standstill is reached, if the velocity’s actual average value is within the standstill window for the standstill window time. The standstill window is given in [rpm].

Remarks

The value “65535” switches the standstill window off and standstill is deemed to be reached at the end of the trajectory.

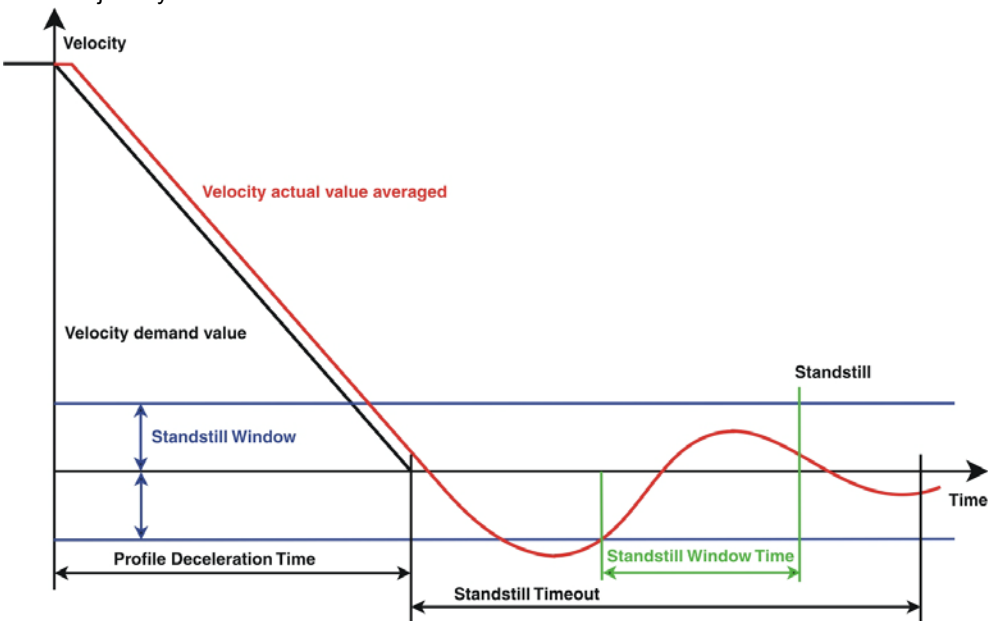

Figure 8-47 Standstill Window

Name	Standstill Window	
Index	0x2101	
Subindex	0x01	
Type	UINT16	
Access	RW	
Default Value	30	
Value Range	0	65 535

Description

Standstill is reached, if ➔“Velocity Actual Value Averaged” on page 8-109 is within the Velocity Window during the defined standstill window time. It is given in multiple of milliseconds [ms].

Name	Standstill Window Time	
Index	0x2101	
Subindex	0x02	
Type	UINT16	
Access	RW	
Default Value	50	
Value Range	0	65 535

Description

Defines the time where the standstill is supposed to be reached, even if the standstill conditions are not yet fulfilled. This timeout may be used to prevent “hangs” in the device state machine if the standstill window or the velocity controller parameters are set inauspicious. It is given in multiple of milliseconds [ms].

Remarks

Standstill time will be disabled if the “Disable” drive function (➔“Shutdown Option Code” on page 8-151 or “Disable Operation Option Code” on page 8-151) is configurated.

The value “65535” will disable timeout.

Name	Standstill Timeout	
Index	0x2101	
Subindex	0x03	
Type	UINT16	
Access	RW	
Default Value	1000	
Value Range	0	65 535

8.2.50 Sensor Configuration

Name	Sensor Configuration
Index	0x2210
Number of entries	4

Description

The pulse number must be set to the connected Incremental Encoder's number of pulses per revolution.

Remarks

Changes are only supported in "Disable" state.

The absolute position could be corrupt after changing this parameter.

If the Incremental Encoder 1 is used as encoder for sinus commutation the minimal resolution depends additionally on the number of pole pairs of the motor.

Pulse number Incremental Encoder 1 must be greater or equal to (16 * pole pair number). If this condition is not respected, a Position Sensor Error 0x7320 will be set at "Enable Operation" command.

Name	Pulse Number Incremental Encoder 1	
Index	0x2210	
Subindex	0x01	
Type	UNSIGNED32	
Access	RW	
Default Value	500	
Value Range	16	2 500 000

Description

Used to define the main and the auxiliary controller's sensor type.

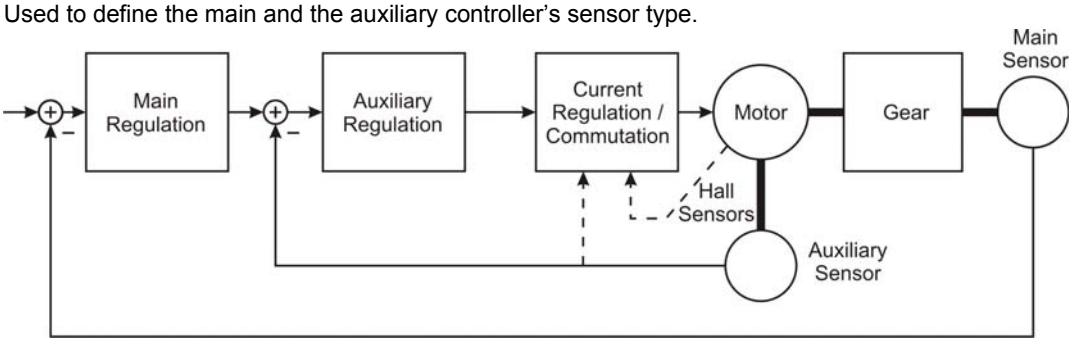

Figure 8-48 Regulation, Sensor and Gear Overview

Remarks

Can only be changed in "Disable" state.

The absolute position may be corrupted after changing this parameter. Therefore, ➔"Position Actual Value" on page 8-154 and the "Position referenced to home position" bit (➔"Statusword" on page 8-150) will be cleared.

An auxiliary sensor type can only be defined if the ➔"Controller Structure" on page 8-143 is set to dual loop. Otherwise, the auxiliary sensor type will be set to "Unknown sensor" (code 0).

Note that not all combinations of main and auxiliary controller sensor types will be supported (➔Table 8-101). For some Motor Type/Sensor combinations, a gear does not make sense and is therefore not permitted.

For main sensor type "Unknown sensor" (code 0), only «Current Mode» is supported. Therefore, in the "Regulation Tuning Wizard" for sensor type "Unknown Sensor", only current regulation tuning may be executed.

Consider that some homing modes will not work with an encoder without index since index can be detected.

If a gear has been configured, the main sensor must be mounted to the gear's output side. For this purpose, we strongly recommend to use a main sensor with higher resolution.

Name	Position Sensor Type
Index	0x2210
Subindex	0x02
Type	UNSIGNED16
Access	RW
Default Value	0x01
Value Range	➔Table 8-99 and Table 8-100

Bit	Description
15…12	reserved (0)
11…8	Sensor type of auxiliary controller
7…4	reserved (0)
3…0	Sensor type of main controller

Table 8-99 Position Sensor Type – Bits

Value	Description	Abbreviation
0	Unknown sensor (undefined)	–
1	Incremental Encoder 1 with index (3-channel)	Inc Enc1
2	Incremental Encoder 1 without index (2-channel)	
3	Hall Sensors (Remark: consider worse resolution)	Hall
4	Absolute encoder SSI	SSI
5	reserved	–
6	Incremental Encoder 2 with index (3-channel)	Inc Enc2
7	Incremental Encoder 2 without index (2-channel)	
8	Sinus Incremental Encoder 2	Sin Inc Enc2

Table 8-100 Supported Sensor Types

Legend:	*A)	Gear not permitted (➔"Gear Configuration" on page 8-144						
Motor	**Loop**	**Auxiliary Sensor**	**Main Sensor**					
			None	**Inc Enc1**	**Hall**	**SSI**	**Inc Enc2**	**Sin Inc Enc2**
DC motor (Motor Type 1)	Single	–	0x0000	0x0001 0x0002	–	0x0004	–	0x0008
	Dual	Inc Enc1	–	–	–	0x0104 0x0204	0x0107 0x0206	0x0108 0x0208
		Hall	–	–	–	–	–	–
		SSI	–	0x0401 0x0402	–	–	–	0x0408
		Inc Enc2	–	0x0602 0x0701	–	–	–	–
		Sin Inc Enc2	–	0x0801 0x0802	–	0x0804	–	–
EC motor, sinus commutation (Motor Type 10)	Single	–	0x0000	0x0001*A) 0x0002*A)	–	0x0004	0x0006 0x0007	0x0008
	Dual	Inc Enc1	–	–	–	0x0104 0x0204	0x0107 0x0206	0x0108 0x0208
		Hall	–	–	–	–	–	–
		SSI	–	–	–	–	–	–
		Inc Enc2	–	–	–	–	–	–
		Sin Inc Enc2	–	–	–	–	–	–
EC motor, block commutation (Motor Type 11)	Single	–	0x0000	0x0001 0x0002	0x0003*A)	0x0004	–	0x0008
	Dual	Inc Enc1	–	–	–	0x0104 0x0204	0x0107 0x0206	0x0108 0x0208
		Hall	–	0x0301 0x0302	–	0x0304	–	0x0308
		SSI	–	0x0401 0x0402	–	–	–	0x0408
		Inc Enc2	–	0x0602 0x0701	–	–	–	–
		Sin Inc Enc2	–	0x0801 0x0802	–	0x0804	–	–

Legend:	*A)	Gear not permitted (➔“Gear Configuration” on page 8-144					
Motor	**Loop**	**Auxiliary Sensor**	**Main Sensor**				
			None	**Inc Enc1**	**Hall**	**SSI**	**Inc Enc2**	**Sin Inc Enc2**
EC motor, sinus commutation (Motor Type 65535)	Single	–	0x0000	0x0001 0x0002	–	0x0004	–	0x0008*A)
	Dual	Inc Enc1	–	–	–	–	–	–
		Hall	–	–	–	–	–	–
		SSI	–	–	–	–	–	–
		Inc Enc2	–	–	–	–	–	–
		Sin Inc Enc2	–	0x0801 0x0802	–	0x0804	–	–

Table 8-101 Supported Motor Type/Sensor Type Combinations

Description

Used to change the position sensor polarity.

Remarks

Can only be changed in “Disable” state.

The absolute position may be corrupted after changing this parameter.

Name	Position Sensor Polarity
Index	0x2210
Subindex	0x04
Type	UNSIGNED16
Access	RW
Default Value	0x00
Value Range	➔Table 8-102

Bit	Value	Name	Description
0	0	Incremental Encoder 1	normal Enc1 polarity (CCW counts positive)
	1		inverted Enc1 polarity (or encoder mounted on motor shaft)
1	0	Hall sensors	normal Hall sensor polarity (maxon standard)
	1		inverted Hall sensor polarity
2	0	SSI Encoder	normal SSI polarity (CCW counts positive)
	1		inverted SSI polarity
3	0	Incremental Encoder 2	normal Enc2 polarity (CCW counts positive)
	1		inverted Enc2 polarity (or encoder mounted on motor shaft)
4	0	Sinus Incremental Encoder	normal Enc2Sin Encoder polarity (CCW counts positive)
	1		inverted Enc2Sin Encoder polarity
5…15	(0)	reserved	–

Table 8-102 Position Sensor Polarity

8.2.51 SSI Encoder Configuration

Description

Used to configure the interpretation of the SSI Encoder.

Remark

Changes are only supported in “Disable” state.

Name	SSI Encoder Configuration
Index	0x2211
Number of entries	4

Description

SSI data rate (SSI clock frequency) in [kbit/s].

Remark

The maximal data rate depends on the actual line length and the employed SSI encoders’ specifications. Typically are 400 kbit/s for cable lengths <50 m.

Name	SSI Encoder Datarate	
Index	0x2211	
Subindex	0x01	
Type	UNSIGNED16	
Access	RW	
Default Value	500	
Value Range	400	2 000

Description

Defines the number of multi-turn and single-turn bits. The maximal number of bits for both values combined is 32. The resolution is $2^{\text{number of bits single-turn}}$.

Name	SSI Encoder Number of Data Bits
Index	0x2211
Subindex	0x02
Type	UNSIGNED16
Access	RW
Default Value	3085 (0x0C0D)
Value Range	➔Table 8-103

Bit	Name	Value		
		Minimal	Maximal	Default
15…8	number of bits multi-turn	0	26	12
7…0	number of bits single-turn	6	23	13

Table 8-103 SSI Encoder Number of Data Bits

Description

Position received from encoder [Position units] (➔page 3-18).

Name	SSI Encoder Actual Position	
Index	0x2211	
Subindex	0x03	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

Description

Defines the SSI's encoding type.

Name	SSI Encoding Type
Index	0x2211
Subindex	0x04
Type	UNSIGNED16
Access	RW
Default Value	0
Value Range	➔Table 8-104

Value	Description
0	SSI Encoder binary type
1	SSI Encoder Gray coded

Table 8-104 SSI Encoding Type

8.2.52 Incremental Encoder 2 Configuration

Description

Used to configure the interpretation of the Incremental Encoder 2.

Remarks

Can only be changed in “Disable” state.

The absolute position may be corrupted after changing this parameter.

Name	Incremental Encoder 2 Configuration
Index	0x2212
Number of entries	3

Description

The encoder’s pulse number must be set to number of pulses per turn of the connected Incremental Encoder.

Name	Incremental Encoder 2 Pulse Number	
Index	0x2212	
Subindex	0x01	
Type	UNSIGNED32	
Access	RW	
Default Value	500	
Value Range	16	2 500 000

Description

Holds the internal counter register of the Incremental Encoder 2. It shows the actual encoder position in quad counts [qc].

Name	Incremental Encoder 2 Counter	
Index	0x2212	
Subindex	0x02	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	–	–

Description

Holds the Incremental Encoder 2 counter reached upon last detected encoder index pulse. It shows the actual encoder index position in quad counts [qc].

Name	Incremental Encoder 2 Counter at Index Pulse	
Index	0x2212	
Subindex	0x03	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.53 Sinus Incremental Encoder 2 Configuration

Description

Used to configure the Sinus Incremental Encoder 2 Configuration's interpretation.

Remarks

Can only be changed in "Disable" state.

The absolute position may be corrupted after changing this parameter.

Name	Sinus Incremental Encoder 2 Configuration
Index	0x2213
Number of entries	2

Description

Defines the resolution of "Sinus Incremental Encoder 2". The parameter pulses per turn must be set to the number of pulses per revolution of the connected Sinus Incremental Encoder.

This value multiplied by $2^{\text{number of interpolation bits}}$ is the total resolution of the Sinus Incremental Encoder.

The values are further limited as follows:

Max. resolution: $2^{\text{number of interpolation bits}} * \text{pulses per turn} \leq 10\,000\,000$

Min. resolution: $2^{\text{number of interpolation bits}} * \text{pulses per turn} \geq 64$

Name	Sinus Incremental Encoder 2 Resolution
Index	0x2213
Subindex	0x01
Type	UNSIGNED32
Access	RW
Default Value	0x00800006
Value Range	➔Table 8-105

Bit	Name	Value		
		Minimal	Maximal	Default
31…8	pulses per turn	1	2 500 000	2048
7…0	number of interpolation bits	2	10	4

Table 8-105 Encoder 2 Resolution

Description

Position received from Sinus Incremental Encoder [Position units] (➔page 3-18).

Name	Sinus Incremental Encoder 2 Actual Position	
Index	0x2213	
Subindex	0x02	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.54 Controller Structure

Description

Used to define the dual loop controller structure. Without auxiliary controller, the structure is single loop.

Remarks

If a controller structure will be set to a value that is in conflict with the actual position sensor type, the sensor type will be set to “0” (unknown sensor).

Can only be changed in “Disable” state.

Name	Controller Structure
Index	0x2220
Subindex	0x00
Type	UNSIGNED16
Access	RW
Default Value	–
Value Range	➔Table 8-106

Value	Description
0	no auxiliary controller
1	velocity auxiliary controller

Table 8-106 Controller Structure

8.2.55 Gear Configuration

Description

Defines the gear ratio (gear ratio numerator / gear ratio denominator).

Remarks

For some combinations of sensor type/motor type, a gear is not allowed. In this case, only gear numerator value “0” (zero: no gear) is permitted.

If the dual loop ➔Controller Structure is selected, the result of the calculation (Gear Ratio * Auxiliary Sensor Resolution / Main Sensor Resolution) must be within a range of 2^{-11} and 2^{15} (0.000488…32767).

Can only be changed in “Disable” state.

Name	Gear Configuration	
Index	0x2230	
Number of entries	3	

Name	Gear Ratio Numerator	
Index	0x2230	
Subindex	0x01	
Type	UNSIGNED32	
Access	RW	
Default Value	0	
Value Range	0	4 294 967 295

Name	Gear Ratio Denominator	
Index	0x2230	
Subindex	0x02	
Type	UNSIGNED16	
Access	RW	
Default Value	1	
Value Range	1	65 535

Description

Defines the maximal gear entry speed [rpm]. Together with the maximal motor speed, it limits the speed on the motor side. The maximal profile velocity on the load side will be calculated by dividing it additionally by the gear ratio.

Name	Gear Maximal Speed	
Index	0x2230	
Subindex	0x03	
Type	UNSIGNED32	
Access	RW	
Default Value	100 000	
Value Range	1	4 294 967 295

8.2.56 Number of Errors

Description

Contains the number of actual errors that are recorded in the ➔Error History. Writing a “0” (zero) deletes the error history (empties the array). Values higher than “0” (zero) are not permitted to write.

Name	Number of Errors	
Index	0x2F03	
Subindex	0x00	
Type	UNSIGNED8	
Access	RW	
Default Value	0	
Value Range	–	–

8.2.57 Error History

Description

Holds errors that have occurred on the device.

Name	Error History	
Index	0x2F04	
Number of entries	0x05	

Description

Every new error code is stored at subindex 1, the older ones move down the list. The error numbers are of type UNSIGNED32 and are composed of a 16-bit error code and 16-bit additional error information.

Names	Error History [1] Error History [2] Error History [3]	Error History [4] Error History [5]
Index	0x2F04	
Subindex	0x01…0x05	
Type	UNSIGNED32	
Access	RO	
Default Value	0	
Value Range	–	–

Bit	Description
31…16	Additional error information
15…0	Error code

Table 8-107 Error History Bits

8.2.58 Store Parameters

Description

All device parameters will be stored in a non-volatile memory, if the code “Save” is written to this object.

Name	Store Parameters
Index	0x2F10
Number of entries	0x01

Name	Save all Parameters	
Index	0x2F10	
Subindex	0x01	
Type	UNSIGNED32	
Access	RW	
Default Value	–	
Value Range	–	–

Byte	MSB			LSB
Character	‘e’	‘v’	‘a’	‘s’
Hex value	0x65	0x76	0x61	0x73

Table 8-108 Store Write Access Signature

8.2.59 Restore Default Parameters

Description

All device parameters will be restored with default values, if the code “Load” is written to this object.

Remarks

Restoring of the default parameters is permitted in state “Power Disable” and EtherCAT state “Pre-Operational” only. The default values are set valid after the device is reset or power cycled.

Name	Restore Default Parameters
Index	0x2F11
Number of entries	0x02

Name	Restore all Default Parameters	
Index	0x2F11	
Subindex	0x01	
Type	UNSIGNED32	
Access	RW	
Default Value	–	
Value Range	–	–

Byte	MSB			LSB
Character	‘d’	‘a’	‘o’	‘l’
Hex value	0x64	0x61	0x6F	0x6C

Table 8-109 Restore Default Parameters

8.2.60 Verify Configuration

Description

Indicates the downloaded configuration date/time and may be used by a network configuration tool to verify the EPOS3's configuration.

The configuration tool stores date/time in the object as well, for example, in the ENI file. Then, the configuration tool stores the EPOS3's configuration parameters with the object ➔"Store Parameters" on page 8-146. If any other command changes the configuration parameters, the EPOS3 will reset the object "Verify Configuration" to "0" (zero).

A EtherCAT master can verify that the device configuration has not changed by checking configuration date and time for the correct value. The column "Subindex of persistent Parameters" (except the subindexes in brackets) in the ➔"Overview" on page 8-83) indicates objects which will be checked by the firmware. Any change to them will reset the configuration time and date.

Related Objects

➔"Store Parameters" on page 8-146

Name	Verify Configuration
Index	0x2F20
Number of entries	0x02

Description

Configuration date must contain the number of days since January 1, 1984.

Name	Configuration Date	
Index	0x2F20	
Subindex	0x01	
Type	UNSIGNED32	
Access	RW	
Default Value	0x00000000	
Value Range	–	–

Description

Configuration time must contain the number of milliseconds [ms] after midnight.

Name	Configuration Time	
Index	0x2F20	
Subindex	0x02	
Type	UNSIGNED32	
Access	RW	
Default Value	0x00000000	
Value Range	–	–

8.2.61 Abort Connection Option Code

Description

Specifies what action is performed when one of the errors labeled with an “a” in the ➔“Device Errors” on page 4-19 will be detected. That contains all communication errors (e.g. bus-off error, heartbeat error, life guarding error, …).

Remarks

If the value is set to “1” (Fault signal only) the Emergency Message Frame is sent out and the Bit 7 of the ➔“Statusword” on page 8-150 (Warning Bit) is set to “1” if an error occurs. Changes to the value of this object always lead to a reset of the error history.

Related Objects

➔“Error Register” on page 8-87 / ➔“Fault Reaction Option Code” on page 8-152

Name	Abort Connection Option Code	
Index	0x6007	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	3	
Value Range	1	3

Value	Description
1	Fault signal only
2	Disable voltage command
3	Quickstop command

Table 8-110 Abort Connection Option Code

8.2.62 Controlword

Description

The controlword consist of bits for…

- the ➔“Device Control Commands” on page 3-17 (bits 0…3, 7),
- supervision of operating modes (bits 4…6, 8):
  ➔“Controlword (Profile Position Mode-specific Bits)” on page 5-38
  ➔“Controlword (Homing Mode-specific Bits)” on page 5-44
  ➔“Controlword (Interpolated Position Mode-specific Bits)” on page 5-54
  ➔“Controlword (Profile Velocity Mode-specific Bits)” on page 5-41

Related Objects

➔“Statusword” on page 8-150

Name	Controlword	
Index	0x6040	
Subindex	0x00	
Type	UNSIGNED16	
Access	RW	
Default Value	–	
Value Range	–	–

Bit	Description	PPM	PVM	HMM	IPM
15…11	reserved				
10, 9	reserved				
8	Operating mode-specific	Halt	Halt	Halt	Halt
7	Fault reset				
6	Operating mode-specific	Abs / rel	reserved	reserved	reserved
5	Operating mode-specific	Change set immediately	reserved	reserved	reserved
4	Operating mode-specific	New setpoint	reserved	Homing operation start	Enable IPM
3	Enable operation				
2	Quickstop				
1	Enable voltage				
0	Switch on				

Table 8-111 Controlword Bits

8.2.63 Statusword

Description

The statusword consist of bits for…

- Current ➔"State of the Drive" on page 3-15 (bits 0…6, 8 and 14)
- Operating state of the mode (bits 10, 12 and 13):
  ➔"Statusword (Profile Position Mode-specific Bits)" on page 5-38
  ➔"Statusword (Homing Mode-specific Bits)" on page 5-45
  ➔"Statusword (Interpolated Position Mode-specific Bits)" on page 5-55
  ➔"Statusword (Profile Velocity Mode-specific Bits)" on page 5-42
  ➔"Statusword (Cyclic Synchronous Position Mode-specific Bits)" on page 5-67
  ➔"Statusword (Cyclic Synchronous Velocity Mode-specific Bits)" on page 5-70
  ➔"Statusword (Cyclic Synchronous Torque Mode-specific Bits)" on page 5-73
- Position referenced to home position (bit 15: will be set on homing attained and will be cleared on a position counter overflow or a position sensor error)
- Internal limit active (bit 11: signals the Output Current Limitation according I2t Method)
- Remote (bit 9: will be set on ESM state "Safe-Operational" and "Operational")

Related Objects

➔"Controlword" on page 8-149

Name	Statusword	
Index	0x6041	
Subindex	0x00	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

Bit	Description	PPM	PVM	HMM	IPM	CSP	CST	CSV
15	Position referenced to home position							
14	Refresh cycle of power stage							
13	Operating mode-specific	Following error	Not used	Homing error	Not used	Following error		
12	Operating mode-specific	Setpoint ack	Speed	Homing attained	IPM active	Drive follows command value	Drive follows command value	Drive follows command value
11	Internal limit active							
10	Operating mode-specific	Target reached	Target reached	Target reached	Target reached			
9	Remote							
8	Offset current measured							
7	Warning							
6	Switch on disable							
5	Quickstop							
4	Voltage enabled (power stage on)							
3	Fault							
2	Operation enable							

Bit	Description	PPM	PVM	HMM	IPM	CSP	CST	CSV
1	Switched on							
0	Ready to switch on							

Table 8-112 Statusword Bits

8.2.64 Shutdown Option Code

Description

Indicates which action will be performed during a transition from “Operation Enabled” state to “Ready To Switch On” or “Switch On Disable” state. The slowdown ramp is the deceleration value of the used mode of operations (➔Table 8-113 for value definition).

Name	Shutdown Option Code	
Index	0x605B	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	0	
Value Range	0	1

Value	Description
0	Disable drive function (switch off the drive power stage)
1	Decelerate with slowdown ramp; disabling of the drive function

Table 8-113 Shutdown Option Code

8.2.65 Disable Operation Option Code

Description

Indicates which action will be performed during a transition from “Operation Enabled” state to “Switched On” state. The slowdown ramp is the deceleration value of the used mode of operations (➔Table 8-114 for value definition).

Name	Disable Operation Option Code	
Index	0x605C	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	1	
Value Range	0	1

Value	Description
0	Disable drive function (switch off the drive power stage)
1	Decelerate with slowdown ramp; disabling of the drive function

Table 8-114 Disable Operation Option Code

8.2.66 Fault Reaction Option Code

Description

Specifies what action is performed when one of the errors labeled with a “f” in the ➔“Device Errors” on page 4-19 will be detected. That contains most errors except communication errors (handled according to ➔“Abort Connection Option Code” on page 8-148).

Remarks

If the value is set to -1 (Fault signal only) the Emergency Message Frame is sent out and the Bit 7 of the ➔“Statusword” on page 8-150 (Warning Bit) is set to ❽1❾ if an error occurs.

Some critical errors (labeled with a “d” in the ➔“Device Errors” on page 4-19) always lead to a disable command even if fault reaction was not configured to do so.

Changes to the value of this object always lead to a reset of the error history.

Related Objects

➔“Error Register” on page 8-87 / ➔“Abort Connection Option Code” on page 8-148

Name	Fault Reaction Option Code	
Index	0x605E	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	2	
Value Range	-1	2

Value	Description
-1	Fault signal only
0	Disable drive function
1	Slow down on slow down ramp
2	Slow down on Quickstop ramp

Table 8-115 Fault Reaction Option Code

8.2.67 Modes of Operation

Description

The parameter mode of operation switches the actually chosen operating mode.

Remarks

We recommend to use “Modes of Operational Display” after changing the operation mode.

Related Objects

➔“Modes of Operation Display” on page 8-153

Name	Modes of Operation
Index	0x6060
Subindex	0x00
Type	INTEGER8
Access	RW
Default Value	1
Value Range	➔Table 8-116

Operation Mode	Description
7	➔Interpolated Position Mode (PVT)
6	➔Homing Mode
3	➔Profile Velocity Mode (PVM)
1	➔Profile Position Mode (PPM)
8	➔Cyclic Synchronous Position Mode (CSP)
9	➔Cyclic Synchronous Velocity Mode (CSV)
10	➔Cyclic Synchronous Torque Mode (CST)

Table 8-116 Modes of Operation

8.2.68 Modes of Operation Display

Description

The modes of operation display show the actual mode of operation. The meaning of the returned value corresponds to the code in the table «Modes of Operation».

Related Objects

➔“Modes of Operation” on page 8-153

Name	Modes of Operation Display
Index	0x6061
Subindex	0x00
Type	INTEGER8
Access	RO
Default Value	1
Value Range	➔Table 8-116

8.2.69 Position Demand Value

Description

Position demand value is generated by profile generator and is the set value of the position regulator [Position units] (➔page 3-18).

Name	Position Demand Value	
Index	0x6062	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	0	
Value Range	–	–

8.2.70 Position Actual Value

Description

The actual position is absolute and referenced to system zero position [Position units] (➔page 3-18).

Remarks

If the main controller's position sensor type is configured to unknown, the position actual value is always "0" (zero).

Name	Position Actual Value	
Index	0x6064	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.71 Maximal Following Error

Description

Maximal allowed difference of position actual value to position demand value. If difference of position demand value and position actual value is bigger, a following error occurs [Position units] (➔page 3-18).

Remarks

If the value of the Maximal Following Error is 2^{32}-1, the following control is switched off.

Name	Maximal Following Error	
Index	0x6065	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	2 000	
Value Range	0	4 294 967 295

8.2.72 Position Window

Description

In ➔Profile Position Mode (PPM), the position window defines a symmetrical range of accepted positions relatively to ➔"Target Position" on page 8-160. If the actual value of the position encoder is within the position window, this target position is regarded as reached.

Remarks

If the value of the position window is 4 294 967 295, the position window is switched off and the corresponding bit 10 target reached in the ➔"Statusword" on page 8-150 will be set to "1" at the end of the trajectory.

Related Objects

➔"Position Window Time" on page 8-156

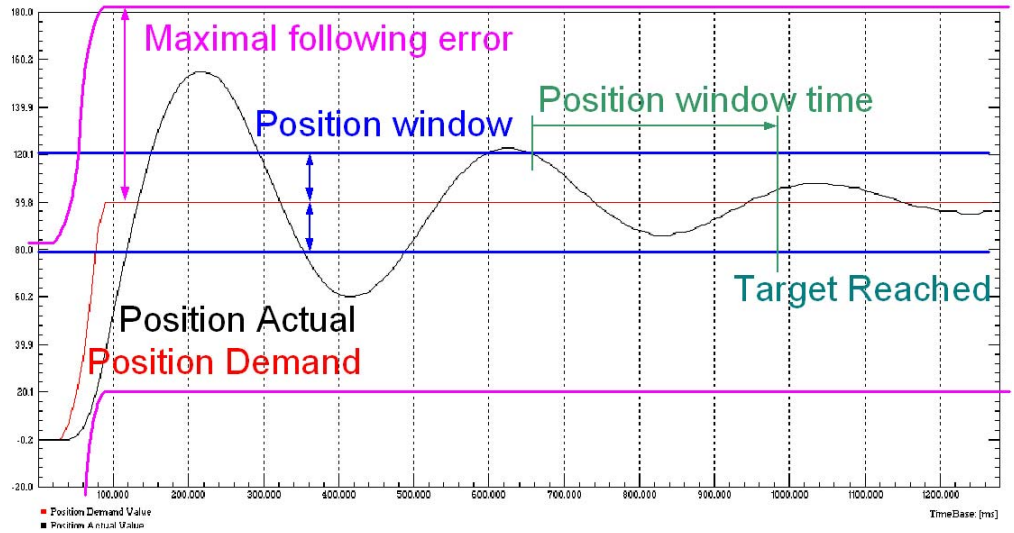

Figure 8-49 Position Window – Overview

Name	Position Window	
Index	0x6067	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	4 294 967 295	
Value Range	0	2 147 483 647 (and 4 294 967 295 for disable)

8.2.73 Position Window Time

Description

When the ➔“Position Actual Value” on page 8-154 is within the position window during the defined Position Window Time, which is given in multiples of milliseconds, the corresponding bit 10 target reached in the Statusword will be set to “1”.

Name	Position Window Time	
Index	0x6068	
Subindex	0x00	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	0	65 535

8.2.74 Velocity Sensor Actual Value

Description

The main sensor’s “Velocity Sensor Actual Value” is given in quadcounts per second [inc/s].

Remarks

The resolution of the short time velocity measurement (➔“Velocity Actual Value” on page 8-157, object Velocity Sensor Actual Value) is dependent on the encoder pulse number (➔“Sensor Configuration” on page 8-135) and the velocity measurement method (➔“Miscellaneous Configuration” on page 8-105, bit 3). To improve the short time velocity measurement resolution, set the Miscellaneous configuration bit 3 to “1” or use an encoder with higher resolution (Incremental Encoder 1, Incremental Encoder 2 and Hall sensors only).

Related Objects

➔“Velocity Actual Value” on page 8-157 / ➔“Velocity Actual Value Averaged” on page 8-109

Name	Velocity Sensor Actual Value	
Index	0x6069	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.75 Velocity Demand Value

Description

Velocity demand value is generated by profile generator and is the set value for the velocity controller given in [Velocity units] (➔page 3-18).

Name	Velocity Demand Value	
Index	0x606B	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.76 Velocity Actual Value

Description

Coupled to the velocity that is used as input to the main controller given in [Velocity units] (➔page 3-18).

Remarks

The resolution of the short-time velocity measurement (Velocity actual value, ➔"Velocity Sensor Actual Value" on page 8-156) is dependent on the encoder pulse number (➔"Sensor Configuration" on page 8-135) and the velocity measurement method (➔"Miscellaneous Configuration" on page 8-105, bit 3). To improve the short time velocity measurement resolution set the Miscellaneous configuration bit 3 to 1 or use an encoder with higher resolution (Incremental Encoder 1, Incremental Encoder 2 and Hall sensors, only).

For example the short time velocity resolution with a 500-pulse encoder and Miscellaneous configuration Bit 3 = 0 is: 1 quadcount / ms = 60000 / (4 x 500) = 30 rpm.

Related Objects

➔"Velocity Actual Value Averaged" on page 8-109

Name	Velocity Actual Value	
Index	0x606C	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.77 Velocity Window

Description

In ➔“Profile Velocity” on page 8-162, the velocity window defines a symmetrical range of accepted velocity values relatively to ➔“Target Velocity” on page 8-185. If the actual average value of the velocity is within the velocity window, this target velocity is regarded as reached. The velocity window is given in [Velocity units] (➔page 3-18).

Remarks

If the value of the velocity window is 2^{32}-1, the velocity window is switched off and the corresponding bit 10 target reached in the ➔“Statusword” on page 8-150 will be set to “1” at the end of the trajectory.

Related Objects

➔“Velocity Window Time” on page 8-159

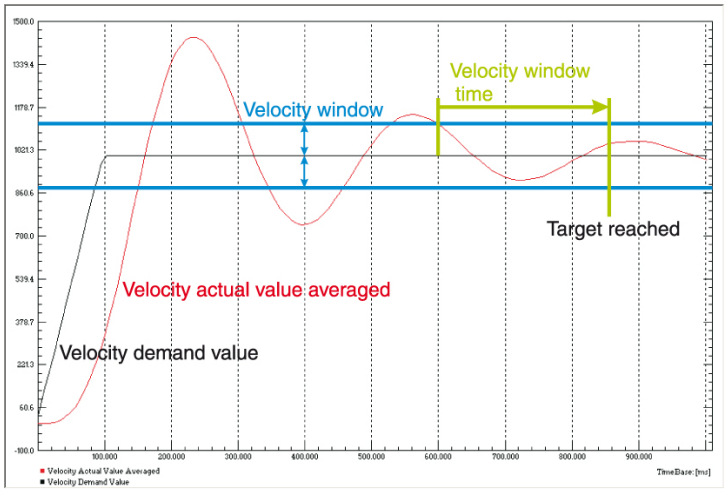

Figure 8-50 Velocity Window – Overview

Name	Velocity Window	
Index	0x606D	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	4 294 967 295	
Value Range	0	4 294 967 295

8.2.78 Velocity Window Time

Description

When ➔"Velocity Actual Value Averaged" on page 8-109 is within the Velocity Window (➔Figure 8-50) during the defined velocity window time, which is given in multiples of milliseconds, the corresponding bit 10 target reached in the ➔"Statusword" on page 8-150 will be set to "1".

Related Objects

➔"Velocity Window" on page 8-158

Name	Velocity Window Time	
Index	0x606E	
Subindex	0x00	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	–	–

8.2.79 Target Torque

Description

Indicates the configured input value for the torque controller in Cyclic Synchronous Torque Mode. The value is given per thousand of the Rated Torque (object 0x2076-00).

Related Objects

➔"Rated Torque" on page 8-120

Name	Target Torque	
Index	0x6071	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	0	
Value Range	–	–

8.2.80 Torque Actual Value

Description

Provides the actual value of the torque and corresponds to the motor's instantaneous torque. The value is given per thousand of the Rated Torque (object 0x2076-00).

Related Objects

➔"Rated Torque" on page 8-120

Name	Torque Actual Value	
Index	0x6071	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	0	
Value Range	–	–

8.2.81 Current Actual Value

Description

Actual measured current can be read in this object [mA].

Name	Current Actual Value	
Index	0x6078	
Subindex	0x00	
Type	INTEGER16	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.82 Target Position

Description

In Profile Position Mode, the target position is the position that the drive is supposed to move to in using the current settings of motion control parameters such as velocity, acceleration, and deceleration. The target position will be interpreted as absolute or relative depend on the controlword [Position units] (➔page 3-18).

Related Objects

➔“Controlword” on page 8-149

Name	Target Position	
Index	0x607A	
Subindex	0x00	
Type	INTEGER32	
Access	RW	
Default Value	–	
Value Range	–	–

8.2.83 Home Offset

Description

The home offset is a moving distance in homing procedure. It is useful to move away from a detected position e.g. mechanical border or limit switch at the end of the homing sequence. This move could prevent the axis from a border damage respectively limit switch error.

Related Objects

➔“Home Position” on page 8-127

Name	Home Offset	
Index	0x607C	
Subindex	0x00	
Type	INTEGER32	
Access	RW	
Default Value	0	
Value Range	-2 147 483 648	2 147 483 647

8.2.84 Software Position Limit

Description

Minimal position limit defines the absolute negative position limit for the position demand value [Position units] (➔page 3-18). If the desired or the actual position is lower then the negative position limit a software position limit Error will be launched.

Remarks

A value of -2 147 483 648 disables the minimal position limit check.

Name	Software Position Limit	
Index	0x607D	
Number of entries	0x02	

Name	Minimal Position Limit	
Index	0x607D	
Subindex	0x01	
Type	INTEGER32	
Access	RW	
Default Value	-2 147 483 648	
Value Range	-2 147 483 648	2 147 483 647

Description

Maximal position limit defines the absolute positive position limit for the position demand value [Position units] (➔page 3-18). If the desired or the actual position is higher than the positive position limit a software position limit Error will be launched.

Remarks

A value of 2 147 483 647 disables the maximum position limit check.

Name	Maximal Position Limit	
Index	0x607D	
Subindex	0x02	
Type	INTEGER32	
Access	RW	
Default Value	2 147 483 647	
Value Range	-2 147 483 648	2 147 483 647

8.2.85 Maximal Profile Velocity

Description

Used as velocity limit in a position (or velocity) move given in [Velocity units] (➔page 3-18).

Remarks

The maximum value range also depends on ➔“Velocity Notation Index” on page 8-165.

Related Objects

➔“Profile Velocity” on page 8-162 / ➔“Velocity Notation Index” on page 8-165 / ➔“Homing Speeds” on page 8-169 / ➔“Target Velocity” on page 8-185 / “Gear Maximal Speed in “Gear Configuration” on page 8-144 / ➔“Motor Type” on page 8-185 / ➔«Pole Pair Number» and «Maximal Motor Speed» in “Motor Data” on page 8-186

Name	Maximal Profile Velocity	
Index	0x607F	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	25 000	
Value Range	1	➔Table 8-117

“Maximal Profile Velocity” upper limit		**“Maximal Motor Speed” greater “Gear Maximal Speed”**	**“Maximal Motor Speed” lower or equal “Gear Maximal Speed”**
Gear	no	“Gear Maximal Speed”	“Maximal Motor Speed”
	yes	“Gear Maximal Speed” * “Gear Ratio Denominator” / “Gear Ratio Numerator”	“Maximal Motor Speed” * “Gear Ratio Denominator” / “Gear Ratio Numerator”

Table 8-117 Upper Limit of Maximum Profile Velocity

8.2.86 Profile Velocity

Description

The profile velocity is the velocity normally attained at the end of the acceleration ramp during a profiled move given in [Velocity units] (➔page 3-18).

Related Objects

➔“Maximal Profile Velocity” on page 8-162

Name	Profile Velocity	
Index	0x6081	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	1 000	
Value Range	1	➔Maximal Profile Velocity

8.2.87 Profile Acceleration

Description

This value is used as acceleration in a position (or velocity) profile move [Acceleration units] (➔page 3-18).

Related Objects

➔“Max Acceleration” on page 8-178

Name	Profile Acceleration	
Index	0x6083	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	10 000	
Value Range	1	➔Max Acceleration

8.2.88 Profile Deceleration

Description

This value is used as deceleration in a position (or velocity) profile move [Acceleration units] (➔page 3-18).

Related Objects

➔“Max Acceleration” on page 8-178

Name	Profile Deceleration	
Index	0x6084	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	10 000	
Value Range	1	➔Max Acceleration

8.2.89 Quickstop Deceleration

Description

Used with Quickstop command to determine the deceleration of the Quickstop profile. The deceleration is given in [Acceleration units] (➔page 3-18).

Related Objects

➔“Controlword” on page 8-149 / ➔“Max Acceleration” on page 8-178

Name	Quickstop Deceleration	
Index	0x6085	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	10 000	
Value Range	1	➔Max Acceleration

8.2.90 Motion Profile Type

Description

Selects the type of the motion profile for trajectories used in ➔Profile Position Mode (PPM), Homing Mode, or Profile Velocity Mode (PVM).

Name	Motion Profile Type	
Index	0x6086	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	0	
Value Range	➔Table 8-118	–

Value	Description
0	linear ramp (trapezoidal profile)
1	$\sin^2$ ramp (sinusoidal profile)

Table 8-118 Motion Profile Types – Definition

8.2.91 Position Notation Index

Description

Used to scale position objects.

Remark

Changes are only supported in “Disable” state.

Related Objects

➔“Factor Group Notation Indices” on page 3-18

Name	Position Notation Index	
Index	0x6089	
Subindex	0x00	
Type	INTEGER8	
Access	RW	
Default Value	0x00	
Value Range	0x00	0x00

8.2.92 Position Dimension Index

Description

Used to scale position objects.

Remark

Changes are only supported in “Disable” state.

Related Objects

➔“Factor Group Dimension Indices” on page 3-18

Name	Position Dimension Index	
Index	0x608A	
Subindex	0x00	
Type	UNSIGNED8	
Access	RW	
Default Value	0xAC	
Value Range	0xAC	0xAC

8.2.93 Velocity Notation Index

Description

Used to scale velocity objects.

Remark

Changes are only supported in “Disable” state.

Related Objects

➔“Factor Group Notation Indices” on page 3-18

Name	Velocity Notation Index	
Index	0x608B	
Subindex	0x00	
Type	INTEGER8	
Access	RW	
Default Value	0	
Value Range	-3	0

8.2.94 Velocity Dimension Index

Description

Used to scale velocity objects.

Remark

Changes are only supported in “Disable” state.

Related Objects

➔“Factor Group Dimension Indices” on page 3-18

Name	Velocity Dimension Index	
Index	0x608C	
Subindex	0x00	
Type	UNSIGNED8	
Access	RW	
Default Value	0xA4	
Value Range	0xA4	0xA4

8.2.95 Acceleration Notation Index

Description

Used to scale acceleration objects.

Remark

Changes are only supported in “Disable” state.

Related Objects

➔“Factor Group Notation Indices” on page 3-18

Name	Acceleration Notation Index	
Index	0x608D	
Subindex	0x00	
Type	INTEGER8	
Access	RW	
Default Value	0x00	
Value Range	0x00	0x00

8.2.96 Acceleration Dimension Index

Description

Used to scale acceleration objects.

Remark

Changes are only supported in “Disable” state.

Related Objects

➔“Factor Group Dimension Indices” on page 3-18

Name	Acceleration Dimension Index	
Index	0x608E	
Subindex	0x00	
Type	UNSIGNED8	
Access	RW	
Default Value	0xA4	
Value Range	0xA4	0xA4

8.2.97 Homing Method

Description

Used to select desired homing method.

Name	Homing Method	
Index	0x6098	
Subindex	0x00	
Type	INTEGER8	
Access	RW	
Default Value	7	
Value Range	–	–

Value	Description
37	➔Homing Method 37 (Actual Position)
35	➔Homing Method 35 (obsolete; Actual Position)
34	➔Homing Methods 33 and 34 (Index Negative / Positive Speed)
33	➔Homing Methods 33 and 34 (Index Negative / Positive Speed)
27	➔Homing Method 27 (Home Switch Negative Speed)
23	➔Homing Method 23 (Home Switch Positive Speed)
18	➔Homing Method 18 (Positive Limit Switch)
17	➔Homing Method 17 (Negative Limit Switch)
11	➔Homing Method 11 (Home Switch Negative Speed & Index)
7	➔Homing Method 7 (Home Switch Positive Speed & Index)
2	➔Homing Method 2 (Positive Limit Switch & Index)
1	➔Homing Method 1 (Negative Limit Switch & Index)
0	No homing operation required
-1	➔Homing Method −1 (Current Threshold Positive Speed & Index)
-2	➔Homing Method −2 (Current Threshold Negative Speed & Index)
-3	➔Homing Method −3 (Current Threshold Positive Speed)
-4	➔Homing Method −4 (Current Threshold Negative Speed)

Table 8-119 Homing Methods

8.2.98 Homing Speeds

Description

Used to search a limit switch in a homing sequence given in [Velocity units] (➔page 3-18).

Related Objects

➔“Maximal Profile Velocity” on page 8-162

Name	Homing Speeds
Index	0x6099
Number of entries	0x02

Name	Speed for Switch Search	
Index	0x6099	
Subindex	0x01	
Type	UNSIGNED32	
Access	RW	
Default Value	100	
Value Range	0	➔Maximal Profile Velocity

Description

Used to search the index in a homing sequence given in [Velocity units] (➔page 3-18).

Related Objects

➔“Maximal Profile Velocity” on page 8-162

Name	Speed for Zero Search	
Index	0x6099	
Subindex	0x02	
Type	UNSIGNED32	
Access	RW	
Default Value	10	
Value Range	0	➔Maximal Profile Velocity

8.2.99 Homing Acceleration

Description

Used to define acceleration and deceleration ramps in the homing profile [Acceleration units] (➔page 3-18).

Related Objects

➔“Max Acceleration” on page 8-178

Name	Homing Acceleration	
Index	0x609A	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	1 000	
Value Range	0	➔Max Acceleration

8.2.100 Position Offset

Description

Provides the offset of the target position in Cyclic Synchronous Position Mode [position units] (➔page 3-18).

Name	Position Offset	
Index	0x60B0	
Subindex	0x00	
Type	INTEGER32	
Access	RW	
Default Value	–	
Value Range	–	–

8.2.101 Velocity Offset

Description

Provides the offset of the velocity value [Velocity units] (➔page 3-18]. In Cyclic Synchronous Position Mode, this object contains the input value for velocity feed forward. In Cyclic Synchronous Velocity Mode, it contains the commanded offset of the drive device.

Remark

The value range also depends on ➔Velocity Notation Index.

Related Objects

➔“Velocity Notation Index” on page 8-165

Name	Velocity Offset	
Index	0x60B1	
Subindex	0x00	
Type	INTEGER32	
Access	RW	
Default Value	–	
Value Range	-100 000 [rpm]	+100 000 [rpm]

8.2.102 Torque Offset

Description

Provides the offset for the torque value given in per thousand of Rated Torque (0x2076-00).

- In Cyclic Synchronous Position Mode and Cyclic Synchronous Velocity Mode, the object contains the input value for torque feed forward.
- In Cyclic Synchronous Torque Mode, it contains the commanded additive torque of the drive, which is added to the Target Torque value.

Related Objects

➔“Rated Torque” on page 8-120 / “Target Torque” on page 8-159

Name	Torque Offset	
Index	0x60B2	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	–	
Value Range	–	–

8.2.103 Touch Probe Function

Description

Indicates the configured function of the touch probe. The definition of bit 3 is extended according to IEC 61800-7 to configure additional touch probes.

Name	Touch Probe Function
Index	0x60B8
Subindex	0x00
Type	UNSIGNED16
Access	RW
Default Value	0
Value Range	➔Table 8-120

Bit	Value	Definition
0	0	Switch off touch probe 1
	1	Enable touch probe 1
1	0	Trigger first event
	1	Continuous
2, 3	00	Trigger with touch probe 1 input
	01	Trigger with zero impulse signal or position encoder
	10	Touch probe source defined by object 0x60D0.1
	11	Reserved
4	0	Switch off sampling at positive edge of touch probe 1
	1	Enable sampling at positive edge of touch probe 1
5	0	Switch off sampling at negative edge of touch probe 1
	1	Enable sampling at negative edge of touch probe 1
6, 7	–	User-defined (e.g. for testing)
8…15	–	Not used

Table 8-120 Touch Probe Configuration

8.2.104 Touch Probe Status

Description

Provides the status of the touch probe.

Remarks

Status information of the touch probe shall first be evaluated by the control device to check whether the stored touch probe values (0x60BA…0x60BB) are valid.

Related Objects

➔"Touch Probe Position 1 Positive Value" on page 8-174 / ➔"Touch Probe Position 1 Negative Value" on page 8-174

Name	Touch Probe Status
Index	0x60B9
Subindex	0x00
Type	UNSIGNED16
Access	RO
Default Value	0
Value Range	➔Table 8-121

Bit	Value	Definition
0	0	Touch probe 1 is switched off
	1	Touch probe 1 is Enabled
1	0	Touch probe 1, no positive edge position stored
	1	Touch probe 1, positive edge position stored
2	0	Touch probe 1, no negative edge position stored
	1	Touch probe 1, negative edge position stored
3…5	0	Reserved
6, 7	–	User-defined (e.g. for testing)
8…15	–	Not used

Table 8-121 Touch Probe Status

8.2.105 Touch Probe Position 1 Positive Value

Description

Provides the position value of the touch probe 1 at positive edge detection.

Related Objects

➔"Touch Probe Status" on page 8-173

Name	Touch Probe Position 1 Positive Value	
Index	0x60BA	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.106 Touch Probe Position 1 Negative Value

Description

Provides the position value of the touch probe 1 at negative edge detection.

Related Objects

➔"Touch Probe Status" on page 8-173

Name	Touch Probe Position 1 Negative Value	
Index	0x60BB	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.107 Interpolation Sub Mode Selection

Description

Indicates the actually chosen interpolation mode.

Name	Interpolation Sub Mode Selection	
Index	0x60C0	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	-1	
Value Range	-1	-1

Value	Description
-32 768…-2	Manufacturer-specific (reserved)
-1	cubic spline interpolation (PVT)
0	Linear interpolation (not yet implemented)
1…32 767	reserved

Table 8-122 Interpolation Sub Mode Selection – Definition

8.2.108 Interpolation Time Period

Description

Indicates the configured interpolation cycle time. The interpolation time period (subindex 0x01) value is given in $10^{\text{interpolation time index}}$ per second. The interpolation time index (subindex 0x02) is dimensionless.

Name	Interpolation Time Period
Index	0x60C2
Number of entries	0x02

Note:
The device-internal cycle time for linear interpolation is 1 ms. Adapt object 0x60C2 to match the cycle time of the EtherCAT master.

Name	Interpolation Time Period Value	
Index	0x60C2	
Subindex	0x01	
Type	UNSIGNED8	
Access	RW	
Default Value	IPM: 1 CSP: 1	
Value Range	IPM: 1 CSP: 1	IPM: 1 CSP: 255

Name	Interpolation Time Index	
Index	0x60C2	
Subindex	0x01	
Type	INTEGER8	
Access	RW	
Default Value	-3	
Value Range	-3	-3

8.2.109 Interpolation Data Configuration

Description

Provides the maximal buffer size and is given in interpolation data records.

Name	Interpolation Data Configuration
Index	0x60C4
Number of entries	0x06

Name	Maximum Buffer Size	
Index	0x60C4	
Subindex	0x01	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	64	64

Description

Provides the actual free buffer size and is given in interpolation data records.

Name	Actual Buffer Size	
Index	0x60C4	
Subindex	0x02	
Type	UNSIGNED32	
Access	RO	
Default Value	–	
Value Range	0	64

Description

The value “0” (zero) indicates a FIFO buffer organization.

Name	Buffer Organization	
Index	0x60C4	
Subindex	0x03	
Type	UNSIGNED8	
Access	RW	
Default Value	0	
Value Range	0	0

Value	Description
0	FIFO buffer
1	Ring buffer (not supported)
2…255	reserved

Table 8-123 Buffer Organization – Definition

Description

Provides used buffer space and is given in interpolation data records. Writing to this object has no effect.

Name	Buffer Position	
Index	0x60C4	
Subindex	0x04	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	0	64

Description

Interpolation data record size is 8 bytes.

Name	Size of Data Record	
Index	0x60C4	
Subindex	0x05	
Type	UNSIGNED8	
Access	WO	
Default Value	–	
Value Range	8	8

Description

If “0” (zero) is written, the data buffer is cleared and the access to it is denied. If “1” is written, the access to the data buffer is enabled.

Related Objects

➔“Interpolation Buffer” on page 8-129

Name	Buffer Clear	
Index	0x60C4	
Subindex	0x06	
Type	UNSIGNED8	
Access	WO	
Default Value	0	
Value Range	0	1

Value	Description
0	Clear input buffer (and all data records) access disabled
1	Enable access to the input buffer for the drive functions
2…255	reserved

Table 8-124 Buffer Clear – Definition

8.2.110 Max Acceleration

Description

Permits to limit the acceleration to prevent mechanical damages. This value is the limit of the other acceleration/deceleration objects. The value is given in [Acceleration units] (➔page 3-18).

Remarks

Not supported in ➔Current Control Function.

Related Objects

➔“Profile Acceleration” on page 8-163 / ➔“Profile Deceleration” on page 8-163 / ➔“Quickstop Deceleration” on page 8-163 / ➔“Homing Acceleration” on page 8-169

Name	Max Acceleration	
Index	0x60C5	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	4 294 967 295	
Value Range	1	4 294 967 295

8.2.111 Touch Probe Source

Description

Defines the source of the touch probe functions.

Name	Touch Probe Source
Index	0x60D0
Number of entries	0x01

Name	Touch Probe 1 Source
Index	0x60D0
Subindex	0x01
Type	INTEGER16
Access	RO
Default Value	-1
Value Range	➔Table 8-125

Value	Description
-1	Position marker (manufacturer-specific)
+5	Hardware zero impulse signal of position encoder (manufacturer-specific)

Table 8-125 Touch Probe Source – Definition

8.2.112 Touch Probe 1 Positive Edge Counter

Description

Provides a continuous counter being incremented with each positive edge at touch probe 1. The counter is only valid if touch probe input is enabled.

Name	Touch Probe 1 Positive Edge Counter	
Index	0x60D5	
Subindex	0x00	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.113 Touch Probe 1 Negative Edge Counter

Description

Provides a continuous counter being incremented with each negative edge at touch probe 1. The counter is only valid if touch probe input is enabled.

Name	Touch Probe 1 Negative Edge Counter	
Index	0x60D6	
Subindex	0x00	
Type	UNSIGNED16	
Access	RO	
Default Value	–	
Value Range	–	–

8.2.114 Supported Homing Methods

Description

Defines the supported homing methods of the EPOS3.

Name	Supported Homing Methods
Index	0x60E3
Number of entries	16

Name	1st Supported Homing Method 2nd Supported Homing Method 3rd Supported Homing Method … 16th Supported Homing Method	
Index	0x60E3	
Subindex	0x01…0x10	
Type	INTEGER16	
Access	RO	
Default Value	➔Table 8-126	
Value Range	–	–

# of Supported Homing Method	Subindex	Default Value
1st	0x01	1
2nd	0x02	2
3rd	0x03	7
4th	0x04	11
5th	0x05	17
6th	0x06	18
7th	0x07	23
8th	0x08	27
9th	0x09	33
10th	0x0A	34
11th	0x0B	35
12th	0x0C	37
13th	0x0D	-1
14th	0x0E	-2
15th	0x0F	-3
16th	0x10	-4

Table 8-126 Supported Home Methods

8.2.115 Current Control Parameter Set

Description

Current control is done by a digital PI-Regulator.

Name	Current Control Parameter Set
Index	0x60F6
Number of entries	0x02

Description

Represents the proportional gain of the current controller.

Name	Current Regulator P-Gain	
Index	0x60F6	
Subindex	0x01	
Type	INTEGER16	
Access	RW	
Default Value	depending on hardware	
Value Range	0	32 767

Description

Represents the integral gain of the current controller.

Name	Current Regulator I-Gain	
Index	0x60F6	
Subindex	0x02	
Type	INTEGER16	
Access	RW	
Default Value	depending on hardware	
Value Range	0	32 767

8.2.116 Velocity Control Parameter Set

Description

Velocity control is done by a digital PI-Regulator.

Name	Velocity Control Parameter Set
Index	0x60F9
Number of entries	5

Description

Represents the proportional gain of the velocity controller.

Name	Velocity Regulator P-Gain	
Index	0x60F9	
Subindex	0x01	
Type	INTEGER16	
Access	RW	
Default Value	depending on hardware	
Value Range	0	32 767

Description

Represents the integral gain of the velocity controller.

Name	Velocity Regulator I-Gain	
Index	0x60F9	
Subindex	0x02	
Type	INTEGER16	
Access	RW	
Default Value	depending on hardware	
Value Range	0	32 767

Description

Represents the velocity feedforward factor of the speed controller.

Name	Velocity Feedforward Factor in Speed Regulator	
Index	0x60F9	
Subindex	0x04	
Type	INTEGER16	
Access	RW	
Default Value	0	
Value Range	0	65 535

Description

Represents the acceleration feedforward factor of the speed controller.

Name	Acceleration Feedforward Factor in Speed Regulator	
Index	0x60F9	
Subindex	0x05	
Type	INTEGER16	
Access	RW	
Default Value	0	
Value Range	0	65 535

8.2.117 Position Control Parameter Set

Description

Position control is done by a digital PID Regulator.

Name	Position Control Parameter Set
Index	0x60FB
Number of entries	0x05

Description

Represents the proportional gain of the position controller.

Name	Position Regulator P-Gain	
Index	0x60FB	
Subindex	0x01	
Type	INTEGER16	
Access	RW	
Default Value	depending on hardware	
Value Range	0	32 767

Description

Represents the integral gain of the position controller.

Name	Position Regulator I-Gain	
Index	0x60FB	
Subindex	0x02	
Type	INTEGER16	
Access	RW	
Default Value	depending on hardware	
Value Range	0	32 767

Description

Represents the differential gain of the position controller.

Name	Position Regulator D-Gain	
Index	0x60FB	
Subindex	0x03	
Type	INTEGER16	
Access	RW	
Default Value	depending on hardware	
Value Range	0	32 767

Description

Represents the velocity feed forward factor of the position controller.

Name	Velocity Feed Forward Factor	
Index	0x60FB	
Subindex	0x04	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	0	65 535

Description

Represents the acceleration feed forward factor of the position controller.

Name	Acceleration Feed Forward Factor	
Index	0x60FB	
Subindex	0x05	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value Range	0	65 535

8.2.118 Target Velocity

Description

In Profile Velocity Mode (PVM), the object indicates the configured target velocity and is used as input for the trajectory generator. In Cyclic Synchronous Velocity Mode (CSV), it indicates the configured input value for the velocity controller. Target velocity is given in [Velocity units] (➔page 3-18).

Related Objects

➔"Velocity Notation Index" on page 8-165

Name	Target Velocity	
Index	0x60FF	
Subindex	0x00	
Type	INTEGER32	
Access	RW	
Default Value	–	
Value Range	PVM: - ➔Maximal Profile Velocity CSV: -100 000 [rpm]	PVM: + ➔Maximal Profile Velocity CSV: +100 000 [rpm]

8.2.119 Motor Type

Description

The type of the motor driven by this controller must be selected.

Remarks

Changes are only supported in "Disable" state.

If a motor type will be set to a value which is in conflict with the actual position sensor type (➔"Sensor Configuration" on page 8-135), the sensor type will be set to "0" (zero, unknown sensor).

Name	Motor Type
Index	0x6402
Subindex	0x00
Type	UNSIGNED16
Access	RW
Default Value	10
Value Range	➔Table 8-127

Value	CiA 402 Motor Type	Description
1	Phase-modulated DC motor	brushed DC motor
10	Sinusoidal PM BL motor	EC motor sinus commutated with Hall sensors & Incremental Encoder 1
11	Trapezoidal PM BL motor	EC motor block commutated with Hall sensors, only
65535	Manufacturer-specific	EC motor sinus commutated with Hall sensors & Sinus Incremental Encoder 2

Table 8-127 Motor Types

8.2.120 Motor Data

Description

Represents the maximal permissible continuous current of the motor [mA]. Operation the motor continuously at this current level and at 25 °C ambient will cause the winding to ultimately reach the specified maximal winding temperature. This assumes no heat sinking. Depending how the motor is mounted, this value can be increased substantially.

Remarks

For detailed motor specifications ➔maxon motor catalogue.

Name	Motor Data
Index	0x6410
Number of entries	0x06

Name	Nominal Current			
Index	0x6410			
Subindex	0x01			
Type	UNSIGNED16			
Access	RW			
Default Value	EPOS3 70/10 EtherCAT	10 000		
Value Range	0		EPOS3 70/10 EtherCAT	10 000

Description

We recommend to set the output current limit to a value double of continuous current limit [mA].

Name	Output Current Limit			
Index	0x6410			
Subindex	0x02			
Type	UNSIGNED16			
Access	RW			
Default Value	EPOS3 70/10 EtherCAT	25 000		
Value Range	0		EPOS3 70/10 EtherCAT	25 000

Description

Number of magnetic pole pairs (number of poles divided by 2) of the rotor of a brushless DC motor.

Remarks

Changes are only supported in “Disable” state.

For EC motor with sinus commutation, the minimal pole pair number is additionally dependent on the encoder’s resolution used for commutation.

Encoder resolution [inc/rev] > (64 [inc/rev] * pole pair number)

If the pole pair number will be set to a value that is in conflict with the actual resolution of the encoder used for commutation, a Position Sensor Error 0x7320 will be set on “Enable Operation” command.

Name	Pole Pair Number	
Index	0x6410	
Subindex	0x03	
Type	UNSIGNED8	
Access	RW	
Default Value	1	
Value Range	1	255

Description

To prevent mechanical destroys in current mode it is possible to limit the velocity [rpm].

Remarks

Speed Regulator must be well tuned for correct function of speed limitation in current mode.

Related Objects

➔“Motor Type” on page 8-185 / ➔«Pole Pair Number» in “Motor Data” on page 8-186 / ➔“Maximal Profile Velocity” on page 8-162

Name	Maximal Motor Speed	
Index	0x6410	
Subindex	0x04	
Type	UNSIGNED32	
Access	RW	
Default Value	25 000	
Value Range	1	➔Table 8-128

Motor Type	Description	Maximum Velocity [rpm]
1	brushed DC motor	25 000
10	EC motor sinus commutated	25 000 / pole pair number
11	EC motor block commutated	100 000 / pole pair number
65535	EC motor sinus Inc2	25 000 / pole pair number

Table 8-128 Maximum Motor Speed

Description

The thermal time constant of motor winding is used to calculate the time how long the maximal output current is allowed for the connected motor [100 ms].

Remarks

Example: If a time constant of 4 seconds is desired a value of 40 must be set.

Name	Thermal Time Constant Winding	
Index	0x6410	
Subindex	0x05	
Type	UNSIGNED16	
Access	RW	
Default Value	40	
Value Range	1	5 400

Description

Defines the motor's torque constant and is only used in operation modes that take torque values into account. The value is given in [µNm/A].

Remarks

Changes are only supported in "Disable" state.

Name	Motor Torque Constant	
Index	0x6410	
Subindex	0x06	
Type	UNSIGNED32	
Access	RW	
Default Value	0	
Value Range	0	10 000 000

8.2.121 Supported Drive Modes

Description

Provides an overview of the implemented operating modes in the device. Supported are the following modes:

- ➔Profile Position Mode (PPM)
- ➔Profile Velocity Mode (PVM)
- ➔Homing Mode
- ➔Interpolated Position Mode (PVT),
- ➔Cyclic Synchronous Position Mode (CSP)
- ➔Cyclic Synchronous Velocity Mode (CSV)
- ➔Cyclic Synchronous Torque Mode (CST)

Name	Supported Drive Modes	
Index	0x6502	
Subindex	0x00	
Type	UNSIGNED32	
Access	CONST	
Default Value	0x00000365	
Value Range	–	–

Bit		Description
31…10	0	reserved
9	1	Cyclic Synchronous Torque (CST)
8	1	Cyclic Synchronous Velocity (CSV)
7	1	Cyclic Synchronous Position (CSP)
6	1	Interpolated Position Mode
5	1	Homing Mode
4	0	reserved
3	0	(Torque Mode, not implemented)
2	1	Profile Velocity Mode
1	0	(Velocity Mode, not implemented)
0	1	Profile position Mode

Table 8-129 Supported Drive Modes – Bits

8.2.122 Modular Device Profile

Description

Contains all information to interpret objects in the modules' object areas.

Name	Modular Device Profile
Index	0xF000
Number of entries	2

Description

Represents the index distance between two modules.

Name	Index Distance	
Index	0xF000	
Subindex	0x01	
Type	UNSIGNED16	
Access	RO	
Default Value	0x10	
Value Range	–	–

Description

Represents the maximum number of modules in the system.

Name	Maximum Number of Modules	
Index	0xF000	
Subindex	0x02	
Type	UNSIGNED16	
Access	RO	
Default Value	1	
Value Range	–	–

8.2.123 Module Profile List

Description

Contains the profile information of each module (such as Module Profile Number).

Name	Module Profile List	
Index	0xF010	
Number of entries	5	
Names	Module 1 Module 2 Module 3	Module 4 Module 5
Index	0xF010	
Subindex	0x01…0x05	
Type	UNSIGNED32	
Access	RO	
Default Value	Subindex 0x01: 0x001002E6 Subindex 0x02: 0x002002E6 Subindex 0x03: 0x003002E6	Subindex 0x04: 0x004002E6 Subindex 0x05: 0x005002E6
Value Range	–	–

8.2.124 Detected Module List

Description

Provides the number of detected modules.

Name	Detected Module List	
Index	0xF050	
Number of entries	1	

Description

Contains the first detected module.

Name	1st detected Module	
Index	0xF050	
Subindex	0x01	
Type	UNSIGNED32	
Access	RO	
Default Value	0x001002E6	
Value Range	–	–

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9 Firmware Version History

9.1 Version Overview

Date [dd.mm.yy]	Version		Application		Description
	Software	Hardware	#	Version	
11.11.2014	2211h	6440h	0000h	0000h	Bug fixes
21.01.2013	2210h	6440h	0000h	0000h	New features, bug fixes
20.06.2012	2200h	6440h	0000h	0000h	Initial release

Table 9-130 Version Overview

9.2 Software Version 2211h

2211h	Hardware	Firmware Filename
Binary Files	EPOS3 70/10 EtherCAT	Epos_2211h_6440h_0000h_0000h.bin

2211h	Description	
Changes	Homing	New homing method 37 (replaces obsolete method 35); new object 0x60E3 “Supported Homing Methods”
	SSI encoder	SSI homing offset value will now be cleared upon setting the position sensor type to SSI encoder. Clock frequency generation for bit rates below 600 kbit/s corrected.
	Bugfix	Interpolated Position Mode: sporadic clearing of velocity at very low IPM buffer level solved
	Bugfix	Cyclic Synchronous Position Mode: occasionally unexpected “Following Error” at re-enable fixed
	Bugfix	Behavior after Negative Limit Switch detection corrected
	Bugfix	Occasionally stuck-up at first movement after bootup of brushless EC motors with block commutation (Motor Type = 11) corrected
	Bugfix	Position sensor direction supervision improved to prevent untrue errors
	Bugfix	Writing of invalid “Mode of Operation” value 4 blocked
	Bugfix	Sporadic unexpected “Overvoltage Error” in case of short-circuit power supply voltage ($+V_{cc}$) solved
	Bugfix	Modular Device Profile (MDP) configuration corrected
	Bugfix	ESI device description file: various minor corrections
	EtherCAT communication	Various minor adaptations to improve test fulfillment of actual ETG EtherCAT Conformance Test Tool (CTT)

Table 9-131 Software Version 2220h

9.3 Software Version 2210h

2210h	Hardware	Firmware Filename
Binary Files	EPOS3 70/10 EtherCAT	Epos_2210h_6440h_0000h_0000h.bin

2210h	Description	
Changes	Cyclic Synchronous Position Mode (CSP)	Interpolation of Target Position improved.
	EtherCAT communication	Error handling for process data communication enhanced.
	Bugfix	PVM and CSV: calculation of speed signal filter cut-off frequency corrected.
	Bugfix	Sporadic “motor current” spikes on brushless EC motors with block commutation fixed.
	Bugfix	Output Current Limitation improved.
	Bugfix	Write access to Sync Manager objects 0x1C12, 0x1C13 corrected.
	Bugfix	EtherCAT SDO communication improved.
	Bugfix	Modular Device Profile configuration fixed.
	Bugfix	ESI device description file: various minor corrections.
	Bugfix	PPM trajectory calculation for acceleration time >32.7 s corrected.
New Features	Touch probe	Support of touch probe functionality

Table 9-132 Software Version 2210h

9.4 Software Version 2200h

2200h	Hardware	Firmware Filename
Binary Files	EPOS3 70/10 EtherCAT	Epos_2200h_6440h_0000h_0000h.bin

2200h	Description	
Changes	New	Initial release
New Features	–	–

Table 9-133 Software Version 2200h

LIST OF FIGURES

LIST OF TABLES

INDEX

G

H

I

L

M

N

O

P

Q

R

S

T

U

V

W

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