

# AKD™

## EtherCAT Communication



Edition: F, March 2012

Valid for Hardware Revision D

Part Number 903-200005-00

Original Documentation

# EtherCAT®

Keep all manuals as a product component during the life span of the product.  
Pass all manuals to future users and owners of the product.

**KOLLMORGEN**

*Because Motion Matters™*

## Record of Document Revisions:

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D	DA	01.06.xx.yyy	1.6.0.zzzzz	2.5.0.zzzzz	Control board revision 9, AKD PDMM Start revision

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## Current patents:

US Patent 5,646,496 (used in control card R/D and 1 Vp-p feedback interface)

US Patent 5,162,798 (used in control card R/D)

US Patent 6,118,241 (used in control card simple dynamic braking)

## Technical changes which improve the performance of the device may be made without prior notice!

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# 1 General

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## 1.1 About this Manual

This manual, *AKD EtherCAT Communication*, describes the installation, setup, range of functions, and software protocol for the EtherCAT AKD product series. All AKD EtherCAT drives have built-in EtherCAT functionality; therefore an additional option card is not required.

A digital version of this manual (pdf format) is available on the CD-ROM included with your drive. Manual updates can be downloaded from the Kollmorgen™ website.

Related documents for the AKD series include:

- *AKD Quick Start* (also provided in hard copy). This guide provides instructions for initial drive setup and connection to a network.
- *AKD Installation Manual* (also provided in hard copy for EU customers). This manual provides instructions for installation and drive setup.
- *AKD Users Manual*. This manual describes how to use your drive in common applications. It also provides tips for maximizing your system performance with the AKD.
- *AKD Parameter and Command Reference Guide*. This guide provides documentation for the parameters and commands used to program the AKD.
- *AKD CAN-BUS Communication*. This manual describes the CAN communication and delivers a lot of information for CAN over EtherCAT communication.
- *Accessories Manual*. This manual provides documentation for accessories like cables and regen resistors used with AKD. Regional versions of this manual exist.

Additionally, an EtherCAT XML file, entitled *AKD EtherCAT Device Description*, describes the drive SDO and PDO. This file is available on the Kollmorgen™ website (part of the firmware zip file):

<http://www.kollmorgen.com/en-us/products/drives/servo/akd/>

## 1.2 Target Group

This manual addresses personnel with the following qualifications:

- Installation: only by electrically qualified personnel.
- Setup: only by qualified personnel with extensive knowledge of electrical engineering and drive technology
- Programming: Software developers, project-planners

The qualified personnel must know and observe the following standards:

- ISO 12100, IEC 60364 and IEC 60664
- National accident prevention regulations

<b>⚠ WARNING</b>	<b>During operation there are deadly hazards, with the possibility of death, severe injury or material damage. The operator must ensure that the safety instructions in this manual are followed. The operator must ensure that all personnel responsible for working with the servo drive have read and understand the manual.</b>
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### 1.3 Symbols used

#### Warning Symbols

Symbol	Indication
	Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
	Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
	Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
	Indicates situations which, if not avoided, could result in property damage.
	This is not a safety symbol. This symbol indicates important notes.

#### Drawing symbols

Symbol	Description	Symbol	Description
	Signal ground		Diode
	Chassis ground		Relays
	Protective earth		Relays switch off delayed
	Resistor		Normal open contact
	Fuse		Normal closed contact

## 1.4 Abbreviations Used

Abbreviation	Meaning
AL	Application Layer: the protocol that directly used by the process entities.
Cat	Category – classification for cables that is also used in Ethernet.
DC	Distributed Clocks Mechanism to synchronize EtherCAT slaves and master
DL	Data Link(=Layer 2). EtherCAT uses Ethernet, which is standardized as IEEE 802.3.
FPGA	Field Programmable Gate Array
FTP	File Transfer Protocol
HW	Hardware
ICMP	Internet Control Message Protocol: Mechanisms for signaling IP errors.
IEC	International Electrotechnical Commission: The international standards
IEEE	Institute of Electrical and Electronics Engineers, Inc.
LLDP	Link Layer Discovery Protocol
MAC	Media Access Control
MII	Media Independent Interface: Standardized interface Ethernet controller <-> routing equipment.
MDI	Media Dependant Interface: Use of connector Pins and Signaling.
MDI-X	Media Dependant Interface (crossed): Use of connector Pins and Signaling with crossed lines.
OSI	Open System Interconnect
OUI	Organizationally Unique Identifier – the first 3 Bytes of an Ethernet-Address, that will be assign to companies or organizations and can be used for protocol identifiers as well (e.g. LLDP)
PDI	Physical Device Interface: set of elements that allows access to ESC from the process side.
PDO	Process Data Object
PDU	Protocol Data Unit: Contains protocol information transferred from a protocol instance of transparent data to a subordinate level
PHY	Physical interface that converts data from the Ethernet controller to electric or optical signals.
PLL	Phase Locked Loop
PTP	Precision Time Protocol in accordance with IEEE 1588
RSTP	Rapid Spanning Tree Protocol
RT	Real-time, can be run in Ethernet controllers without special support.
RX	Receive
RXPDO	Receive PDO
SNMP	Simple Network Management Protocol
SPI	Serial Peripheral Interface
Src Addr	Source Address: Source address of a message.
STP	Shielded Twisted Pair
TCP	Transmission Control Protocol
TX	Transmit
TXPDO	Transmit PDO
UDP	User Datagram Protocol: Non-secure multicast/broadcast frame.
UTP	Unshielded Twisted Pair
ZA ECAT	Access mode EtherCAT
ZA Drive	Access mode drive



## 2 Safety

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## 2.1 Safety Instructions

**⚠ DANGER** During operation there are deadly hazards, with the possibility of death, severe injury or material damage. Do not open or touch the equipment during operation. Keep all covers and cabinet doors closed during operation. Touching the equipment is allowed during installation and commissioning for properly qualified persons only.

- During operation, drives may have uncovered live components, depending on their level of enclosure protection.
- Control and power connections may be live, even though the motor is not rotating.
- Drives may have hot surfaces during operation. Heat sink can reach temperatures above 80°C.

**⚠ WARNING** Electronic equipment can fail. The user is responsible for ensuring that, in the event of a failure of the servo amplifier, the drive is set to a state that is safe for both machinery and personnel, for instance with the aid of a mechanical brake. Drives with servo amplifiers and EtherCAT are remote-controlled machines. They can start to move at any time without previous warning. Take appropriate measures to ensure that the operating and service personnel is aware of this danger. Implement appropriate protective measures to ensure that any unintended start-up of the machines cannot result in dangerous situations for personnel or machinery. Software limit-switches are not a substitute for the hardware limit-switches in the machine.

**NOTICE** Install the drive as described in the *Installation Manual*. Never break any of the electrical connections to the drive while it is live. This can result in destruction of the electronics

**NOTICE** Do not connect the Ethernet line for the PC with the set up software to the EtherCAT interface X5/X6. The set up Ethernet cable must be connected to the service interface on X11

## 2.2 Use as directed

Drives are components that are built into electrical plants or machines and can only be operated as integral components of these plants or machines. The manufacturer of the machine used with a drive must generate a risk assessment for the machine and take appropriate measures to ensure that unforeseen movements cannot cause personnel injury or property damage.

- Observe the chapters "Use as directed" and "Prohibited use" in the *AKD Installation Manual*.
- The EtherCAT interface serves only for the connection of the *AKD* to a master with EtherCAT connectivity.

## 2.3 Prohibited use

Other use than that described in chapter "Use as directed" is not intended and can lead to personnel injuries and equipment damage. The drive may not be used with a machine that does not comply with appropriate national directives or standards. The use of the drive in the following environments is also prohibited:

- potentially explosive areas
- environments with corrosive and/or electrically conductive acids, alkaline solutions, oils, vapors, dusts
- ships or offshore applications

The connectors X5 and X6 of the AKD EtherCAT drive may not be used for any ethernet protocol except EtherCAT (CoE, Can over EtherCAT).

## 3 Installation and Setup

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### 3.1 Safety Instructions

**⚠ DANGER** Never disconnect any electrical connections to the drive while the drive is live. There is a danger of electrical arcing with damage to contacts and serious personal injury. Wait at least seven minutes after disconnecting the drive from the main supply power before touching potentially live sections of the equipment (e.g. contacts) or undoing any connections. Capacitors can still have dangerous voltages present up to 7 minutes after switching off the supply power. To be sure, measure the voltage in the DC Bus link and wait until it has fallen below 40 V.  
Control and power connections can still be live, even if the motor is not rotating.

**⚠ WARNING** Electronic equipment can fail. The user is responsible for ensuring that, in the event of a failure of the servo amplifier, the drive is set to a state that is safe for both machinery and personnel, for instance with the aid of a mechanical brake.  
Drives with servo amplifiers and EtherCAT are remote-controlled machines. They can start to move at any time without previous warning. Take appropriate measures to ensure that the operating and service personnel is aware of this danger.  
Implement appropriate protective measures to ensure that any unintended start-up of the machines cannot result in dangerous situations for personnel or machinery. Software limit-switches are not a substitute for the hardware limit-switches in the machine.

**NOTICE** Install the drive as described in the *Installation Manual*. The wiring for the analog setpoint input and the positioning interface, as shown in the wiring diagram in the *Installation Manual*, is not required. Never break any of the electrical connections to the drive while it is live. This action can result in destruction of the electronics.

**NOTICE** The drive's status must be monitored by the PLC to acknowledge critical situations. Wire the FAULT contact in series into the emergency stop circuit of the installation. The emergency stop circuit must operate the supply contactor.

**NOTE** Use WorkBench to alter drive settings. Any other alterations will invalidate the warranty.

**NOTE** Because of the internal representation of the position-control parameters, the position controller can only be operated if the final limit speed of the drive does not exceed:

**rotary**

at sinusoidal<sup>2</sup> commutation: 7500 rpm

at trapezoidal commutation: 12000 rpm.

**linear**

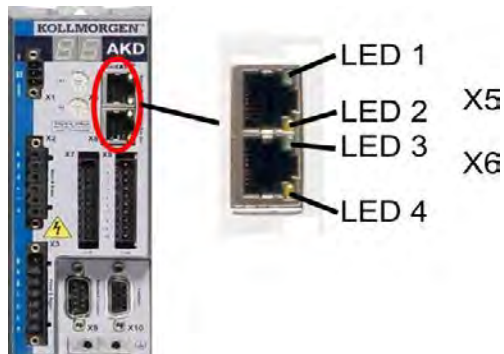
at sinusoidal<sup>2</sup> commutation: 4 m/s

at trapezoidal commutation: 6.25 m/s

**NOTE** All the data on resolution, step size, positioning accuracy etc. refer to calculatory values. Non-linearities in the mechanism (backlash, flexing, etc.) are not taken into account. If the final limit speed of the motor must be altered, then all the parameters that were previously entered for position control and motion blocks must be adapted.

### 3.2 EtherCAT Onboard

Connection to the EtherCAT Network via X5 (in port) and X6 (out port).



#### 3.2.1 LED functions

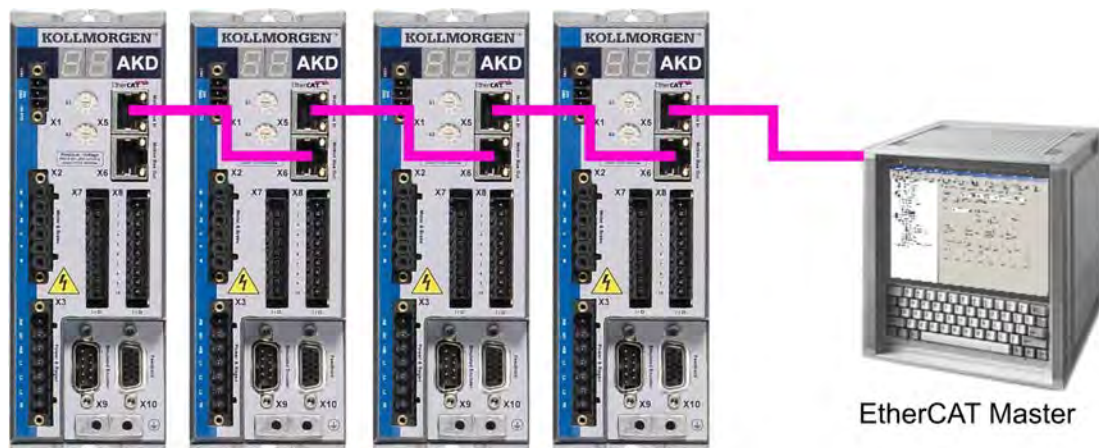
The communication status is indicated by the built-in LEDs.

Connector	LED#	Name	Function
X5	LED1	IN port Link	ON = active OFF = not active
	LED2	RUN	ON = running OFF = not running
X6	LED3	OUT port Link	ON = active OFF = not active
	LED4	-	-

#### 3.2.2 Connection technology

You can connect to the EtherCAT network using RJ-45 connectors.

#### 3.2.3 Network Connection Example



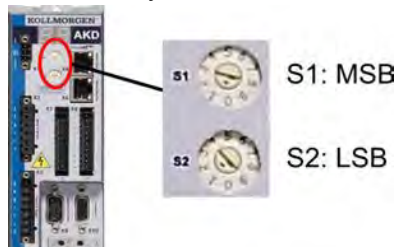
### 3.3 EtherCAT activation with AKD-CC models

AKD-CC drive models are Drives, which support EtherCAT and CAN fieldbus types within one common software. These CC drive models allow selecting a fieldbus support by setting the DRV.TYPE parameter to a certain value. CC drive models are delivered with EtherCAT set active. If you must change a drive from CANopen to EtherCAT, the DRV.TYPE parameter must be changed

1. by software: connect the PC to the AKD and change the parameter DRV.TYPE in the WorkBench terminal screen (see DRV.TYPE parameter documentation) or
2. by hardware: with the rotary switches S1 & S2 at the front and the button B1 on the top side of the Drive.

The following steps are needed for changing the fieldbus type from CAN to EtherCAT with the rotary switches.

1. Set the rotary switches on the front side of the AKD to the value of 89.



*Set S1 to 8 and S2 to 9*

2. Press the button B1 for about 3 seconds (starts DRV.NVSAVE).

Press B1 for 3 seconds



The seven segment display shows **En** during the process of changing DRV.TYPE to EtherCAT.  
**Do not switch off the 24[V] power supply while the seven segment shows En!**

3. Wait until the display goes back to the original state, now the drive is prepared for EtherCAT.
4. Power cycle the drive by switching the 24 V power supply **off** and then **on** again.

#### **NOTE**

The seven segment display shows **Er** (Error) in case that the DRV.TYPE instruction failed. In this case please power cycle the drive and contact the Kollmorgen™ customer support for further help.

### 3.4 Guide to Setup

#### **WARNING**

Only professional personnel with extensive knowledge of control and drive technology are allowed to setup the drive.

#### **CAUTION**

Make sure that any unintended movement of the drive cannot endanger machinery or personnel.

1. Check assembly/installation. Check that all the safety instructions in the product manual for the drive and this manual have been observed and implemented. Check the setting for the station address and baud rate.
2. Connect PC, start WorkBench. Use the setup software WorkBench to set the parameters for the drive.
3. Setup basic functions. Start up the basic functions of the drive and optimize the current, speed and position controllers. This section of the setup is described in the in the online help of the setup software.
4. Save parameters. When the parameters have been optimized, save them in the drive.

### 3.5 Setup via TwinCAT NC/PTP System Manager

Before you set up the drive, make sure the following have been completed:

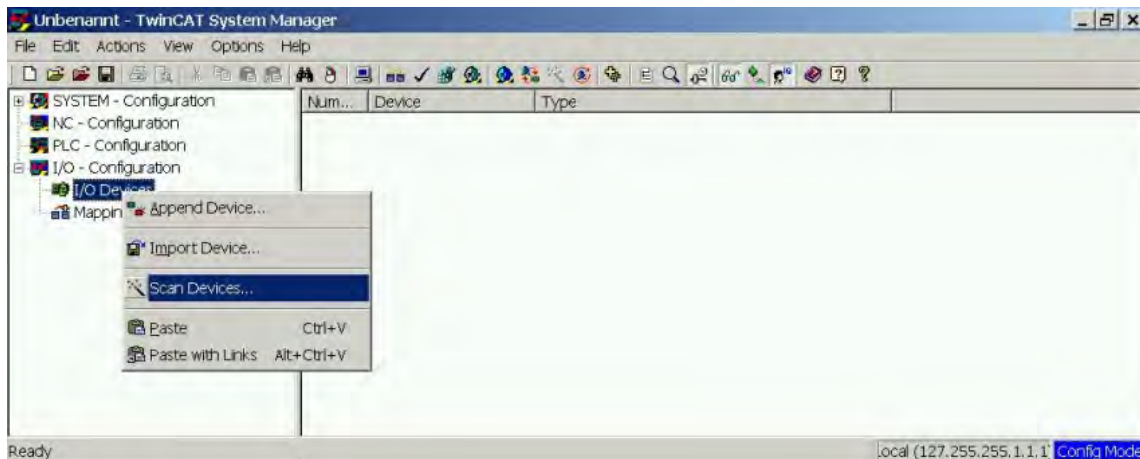
- The AKD is configured with WorkBench and the servomotor is able to move
- A correctly configured EtherCAT card is present in the master.
- TwinCAT software from Beckhoff (NC/PTP-Mode setup) is installed. Install first the TwinCAT System Manager, restart your PC, then install the option package NC/PTP-Mode.
- The XML description of the drive is available (the XML file on the CD-ROM or on the Kollmorgen™ website).
- An AKD EtherCAT slave is connected to the EtherCAT master PC.
- The TwinCAT system manager resides in Config-Mode. The current mode of the system manager is displayed of the bottom right side of the TwinCAT main-screen window.

Copy the XML description of the drive to the TwinCAT system (usually to the folder c:\TwinCAT\IO\EtherCAT) and restart the TwinCAT system since TwinCAT analyzes all device description files during start-up.

The following example explains the automatic EtherCAT network setup. The network setup can also be done manually; please refer to the TwinCAT manual for more details.

### 3.5.1 Scan devices

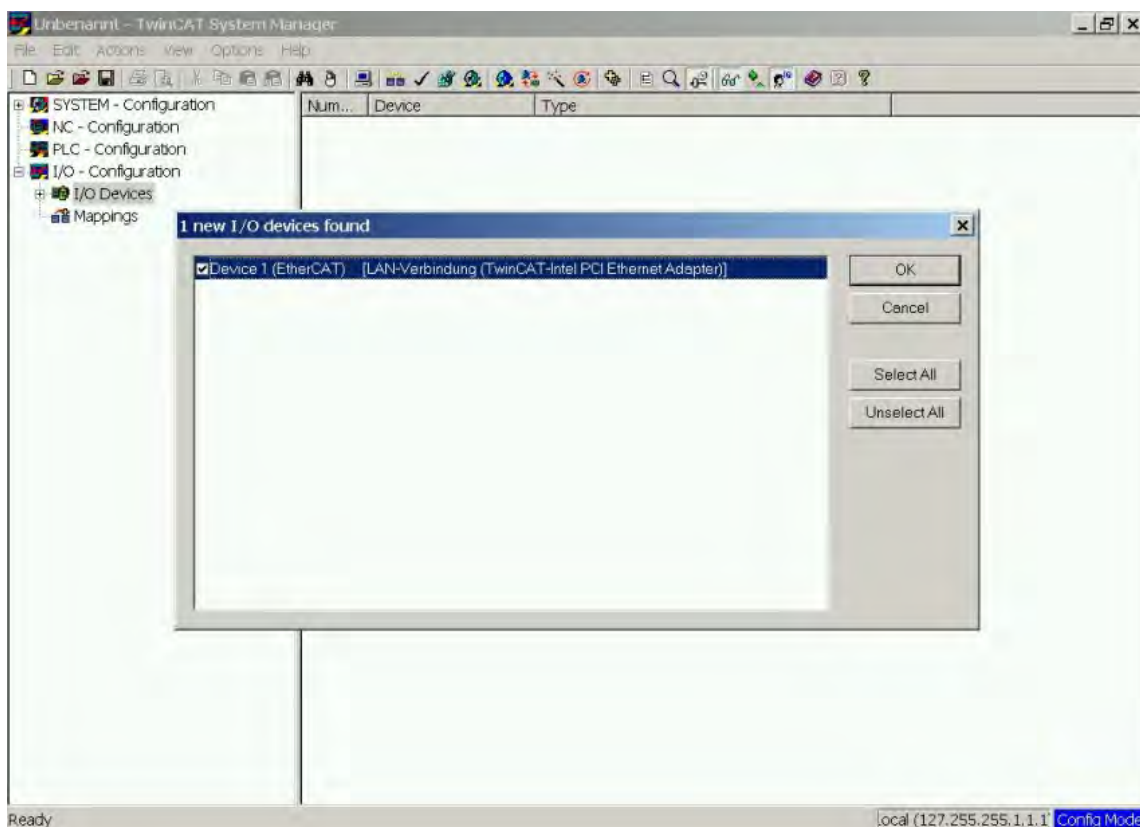
First ensure that the EtherCAT master is physically connected to the EtherCAT AKD. Create a new (empty) project. Right click I/O-Devices and scan for the devices. An example is included in the EtherCAT network card, which is plugged into the PC.



A pop-up window informs you that not all devices can be detected by the TwinCAT software. Click **OK** to continue.

### 3.5.2 Select the device

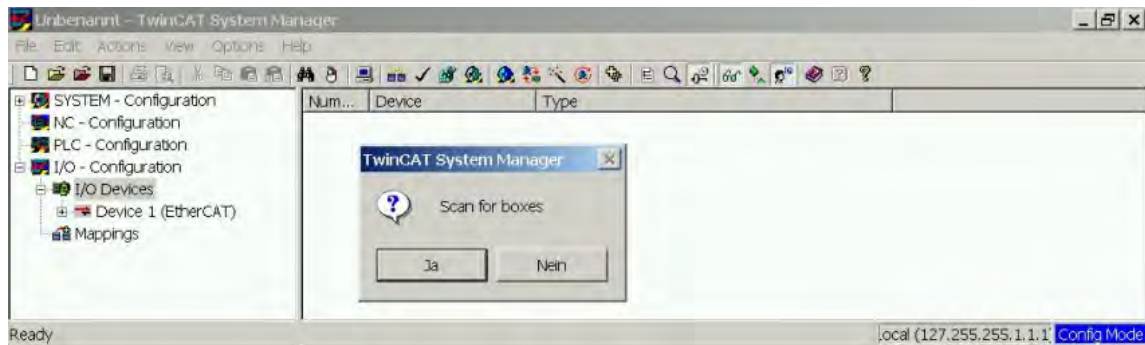
TwinCAT must be able to find the EtherCAT network card. An EtherCAT slave must be connected to the network card; otherwise TwinCAT will find a real-time EtherNET card instead of the EtherCAT card. Press the **OK** button.





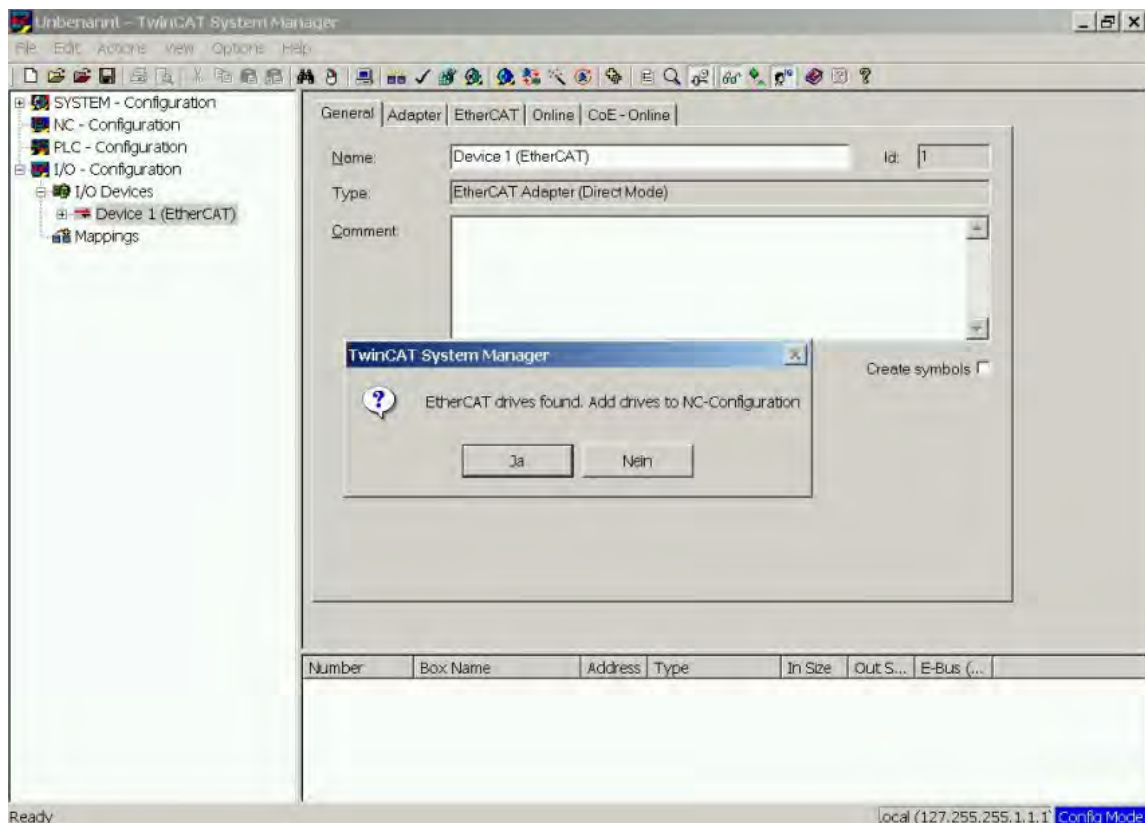
### 3.5.3 Scan for boxes

Click **Yes** to allow TwinCAT to scan for boxes. A *box* is an alias for a slave device and is always used in Beckhoff software products.






### 3.5.4 Add Slaves to NC tasks

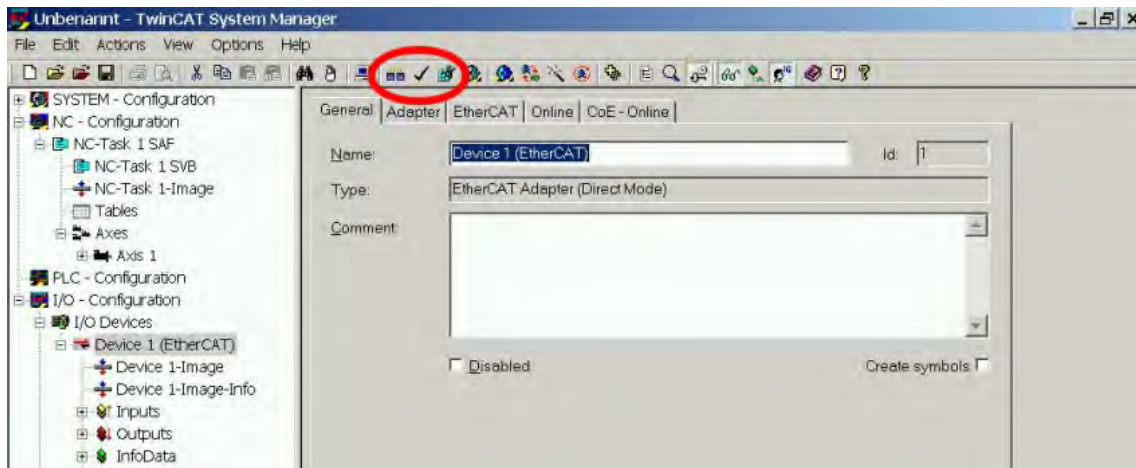
TwinCAT should now have identified the AKD according to the Device Description file. TwinCAT next asks if the slaves should be connected to NC tasks. Click **Yes** to continue. An NC task can, for example, contain a PLC program, which can be programmed by the user.



### 3.5.5 Enable the network configuration

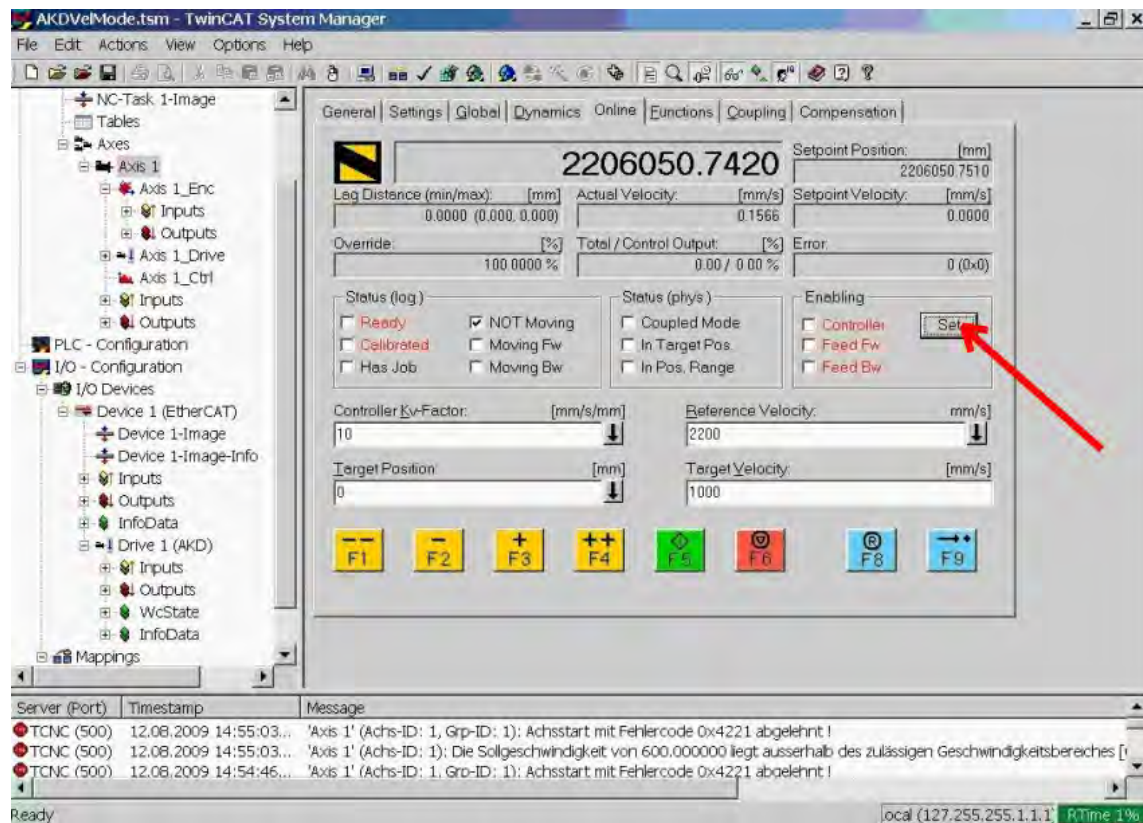
Confirm that the AKD appears in the device tree. Next, enable the network configuration. Press first the  button in order to generate the mappings, afterwards press the  button in order to let TwinCAT check the configuration and use finally the  button in order to step into run-mode.

Confirm afterwards that TwinCAT is allowed to jump into run-mode.



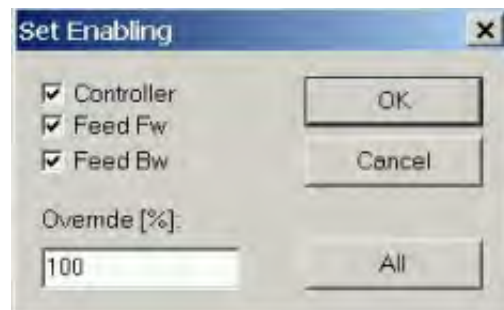
### 3.5.6 Enable the axis and move the axis

The Axis can be enabled by a mouse-click on the Set button within the Online window inside of each Axis, see also the next picture.



Afterwards a pop-up window appears.

The following setting enables the drive and allows command values in both directions.



Afterwards the motor should move in positive or negative direction as soon as the clicks on the following yellow buttons within the Online window:



### **3.6 Setup WorkBench over TwinCAT**

This chapter describes a quick start guide for a user to be able to setup a WorkBench over TwinCAT system and be able to make a motor spin under that system.

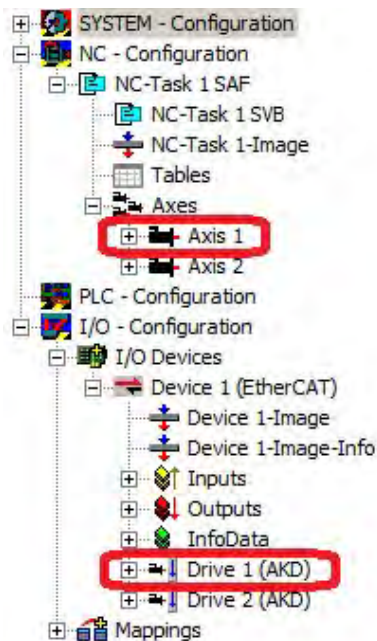
This chapter does not give any specific details on TwinCAT system or WorkBench alone but is giving guidelines and information on how TwinCAT master and WorkBench works together.

Main steps in configuring a WorkBench over TwinCAT system are:

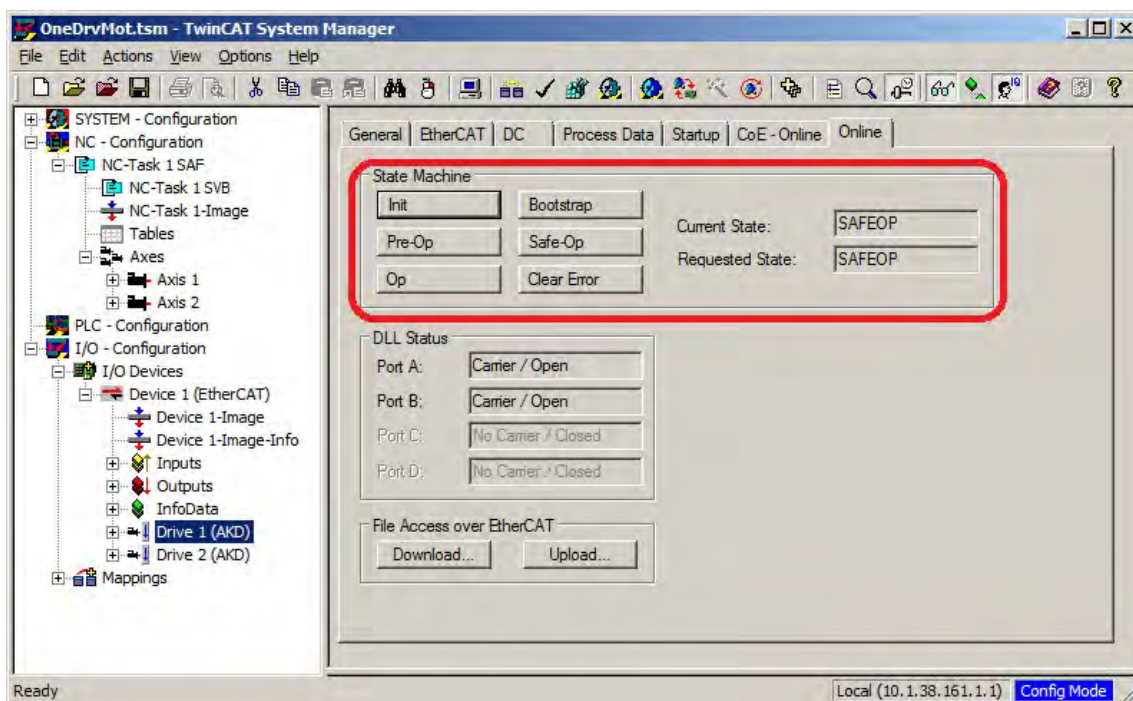
1. TwinCAT and WorkBench configuration
2. Connecting to a drive using WorkBench
3. Configuring and enabling a drive

### 3.6.1 TwinCAT and WorkBenchconfiguration

The EtherCAT network must be setup and managed using TwinCAT System Manager. To be able to connect to a drive and enable it, the drive must be loaded under the I/O Devices node in TwinCAT System Manager and axis must be added to NC - Configuration as shown in "Setup via TwinCAT NC/PTP System Manager" (=> p. 15)



In order to connect to the drives using WorkBench, the drives must be either in Pre-Op, Safe-Op or Op state. State machine for a drive can be accessed from the Online tab for the corresponding drive under the I/O Configuration → I/O Devices → Device [x] → Drive [x] node (see screenshot below).

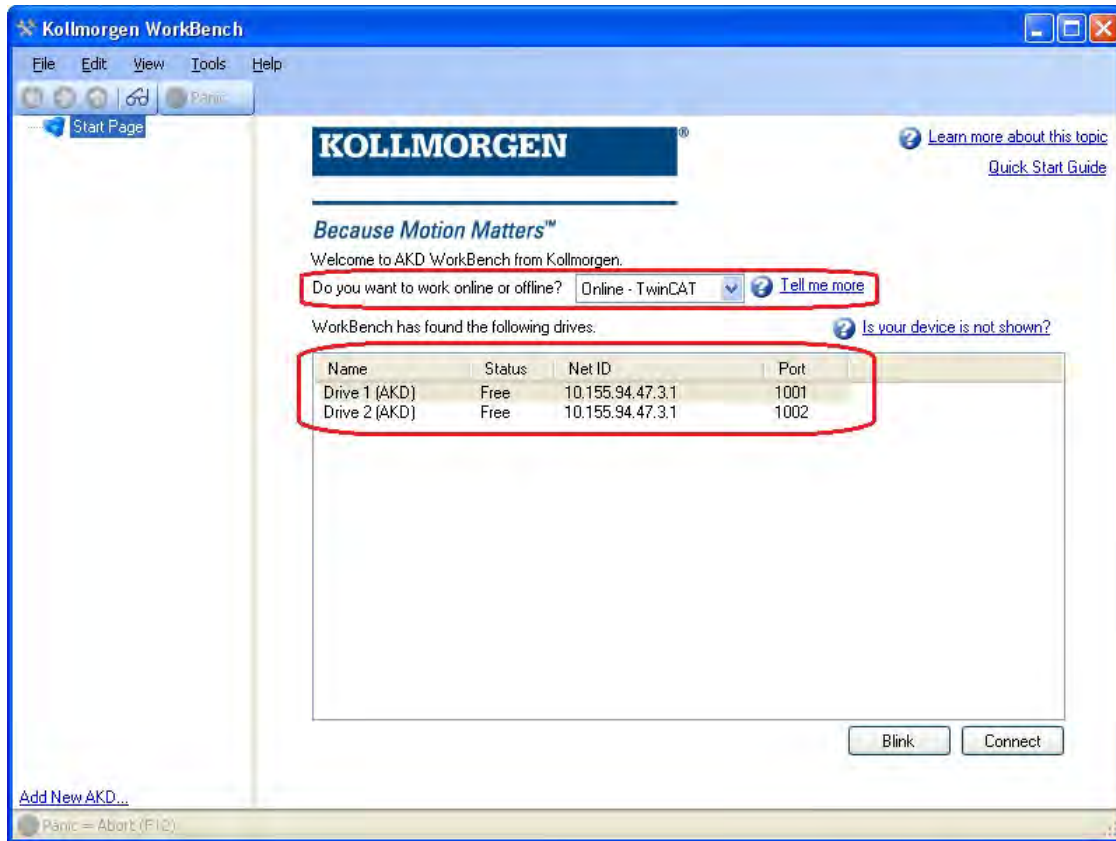


Installation process for WorkBench is the same process as normal, except that it must be installed on the same machine as TwinCAT. Communication to the drive is done thru TwinCAT master and it's not possible to connect WorkBench to the master remotely.



### 3.6.2 Connecting to a drive using WorkBench

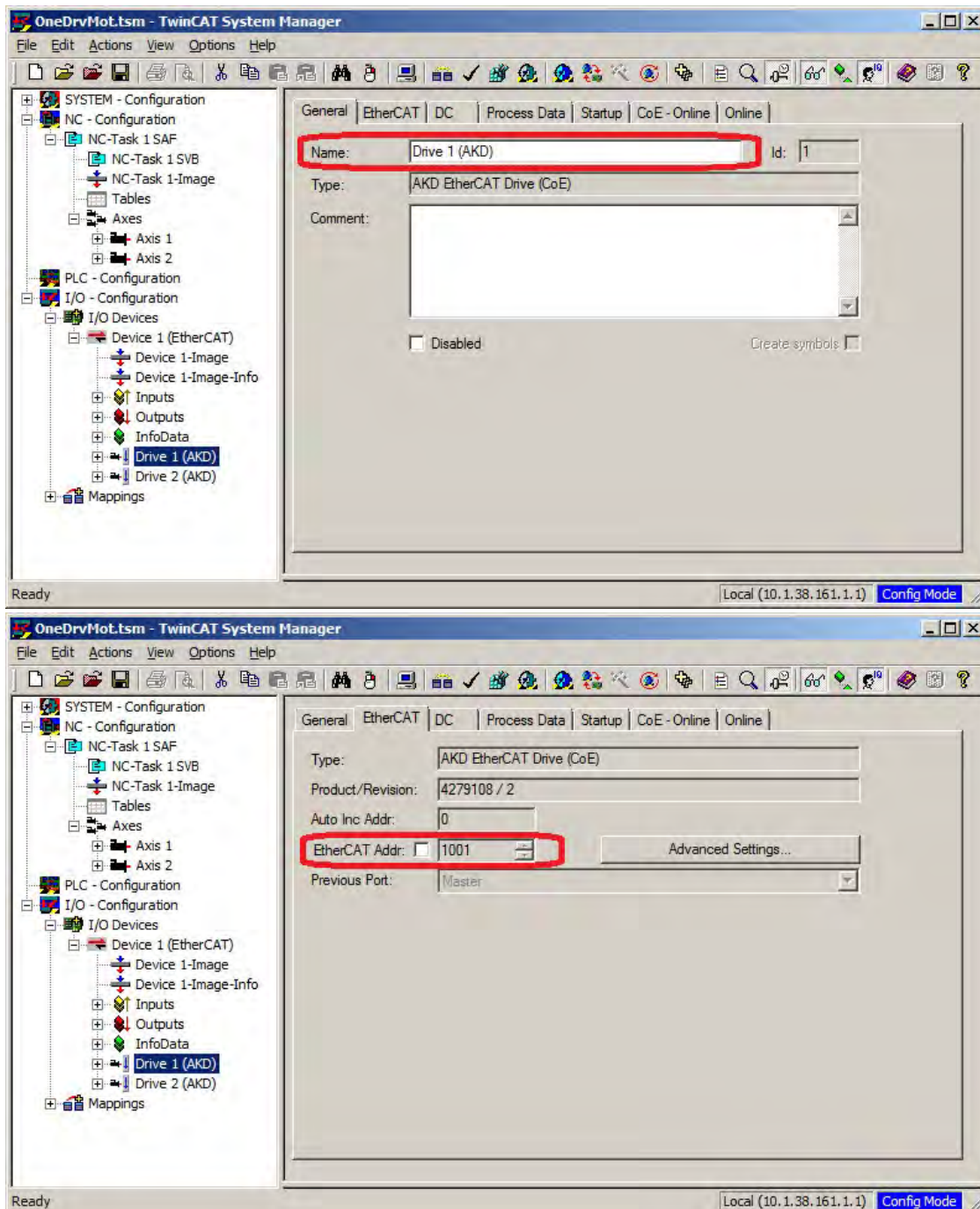
In order to connect to a drive, a TwinCAT device must be added in WorkBench. The start page of WorkBench can be used to do this. First, the type of drive (Online - TwinCAT) must be specified. Then, a list of available drives will be provided.



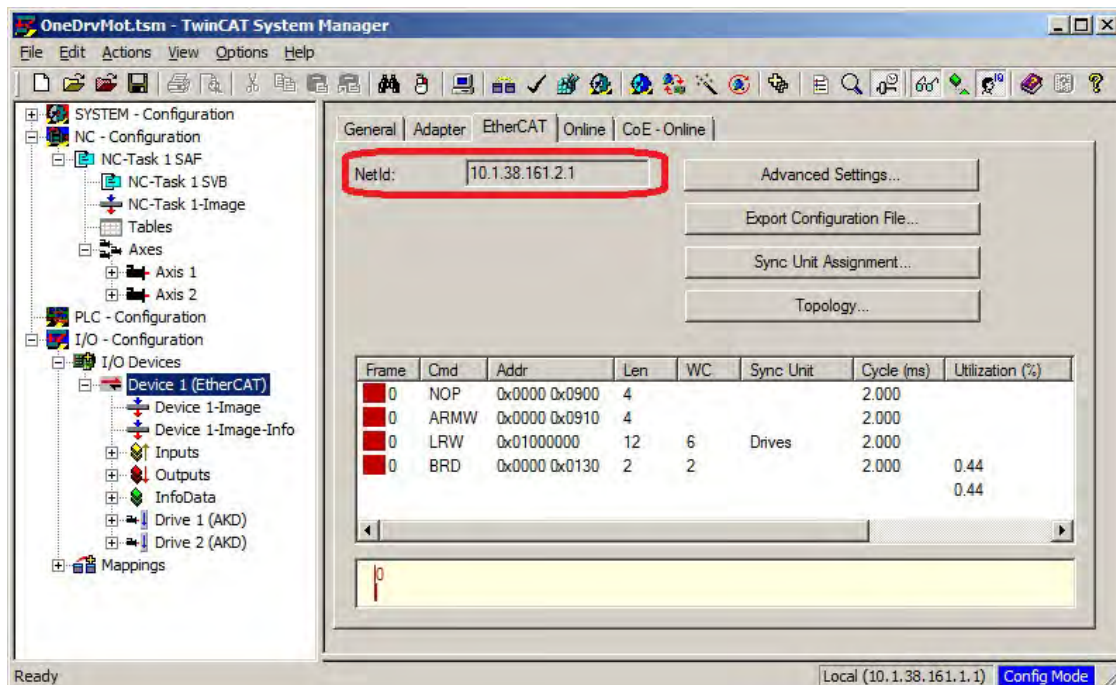
The information provided for a drive are it's name, status, Net ID and Port number. After selecting a drive from the list, clicking on the "Connect" button will create a device in the left frame of WorkBench and connect the device.

The name, Net ID and port number are information coming from the TwinCAT master configuration file (the name may be different than the drive name returned by the *DRV.NAME* command). While the status is an indicator that tells if there is already a device created within WorkBench which is already connected to that particular drive.

Using TwinCAT System Manager, the drive name and port number can be found in the General and EtherCAT tab respectively for the corresponding drive under the I/O Configuration → I/O Devices → Device [x] → Drive [x] node.



The Net ID can be found in the EtherCAT tab in the I/O Configuration → I/O Devices → Device [x] node.



It is important to understand that these information are coming from the TwinCAT master and its configuration file but not from the drive itself. Thus, if the TwinCAT configuration is not reflecting the actual network configuration, you may have a drive listed in WorkBench which is not be powered up or even connected in the EtherCAT network, or you have a drive powered up and connected to the TwinCAT network but not shown in the WorkBench list.



### 3.6.3 Configuring and enabling a drive

Once connected with WorkBench, a drive can be configured using all normal functionalities of WorkBench.

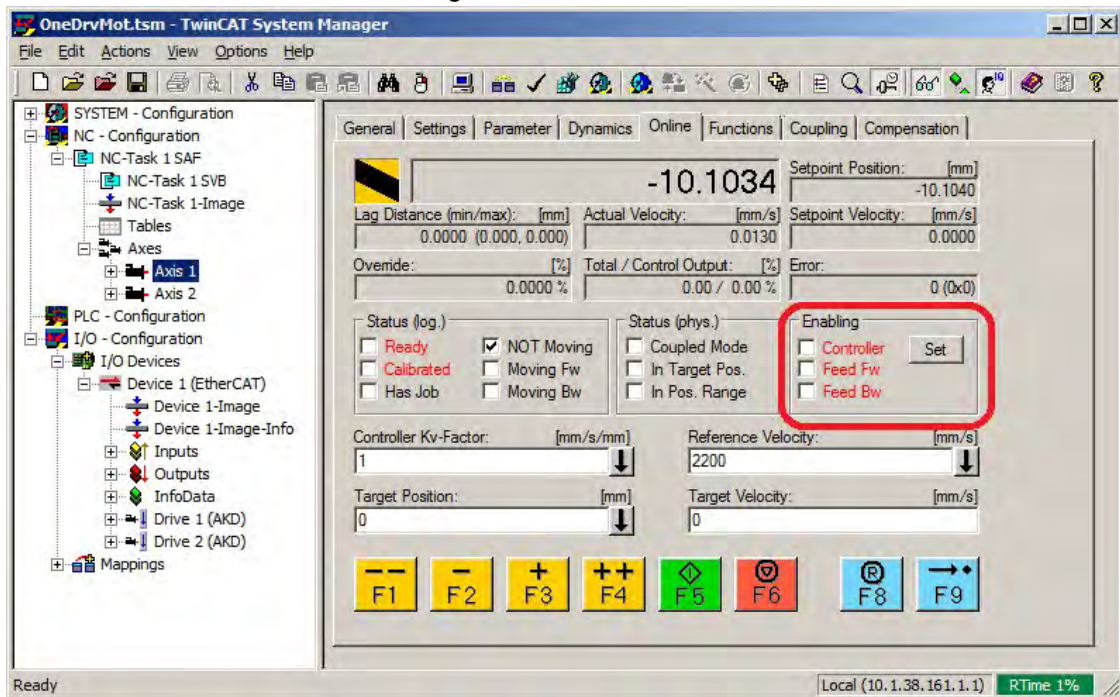
The only operation that is not possible to do using WorkBench over TwinCAT is the download of a new firmware in the drive. Downloading a new firmware in the drive must be performed using File over EtherCAT (FoE) feature of TwinCAT server.

#### NOTICE

If the cyclic communication of the TwinCAT master is enabled, it is possible that some commands sent by WorkBench using the ASCII channel are overwritten by the TwinCAT master. Typically, the drive enable command will have no effect if sent from WorkBench because the control word is usually mapped.

Using TwinCAT, enabling the drive can be done with the following procedure:

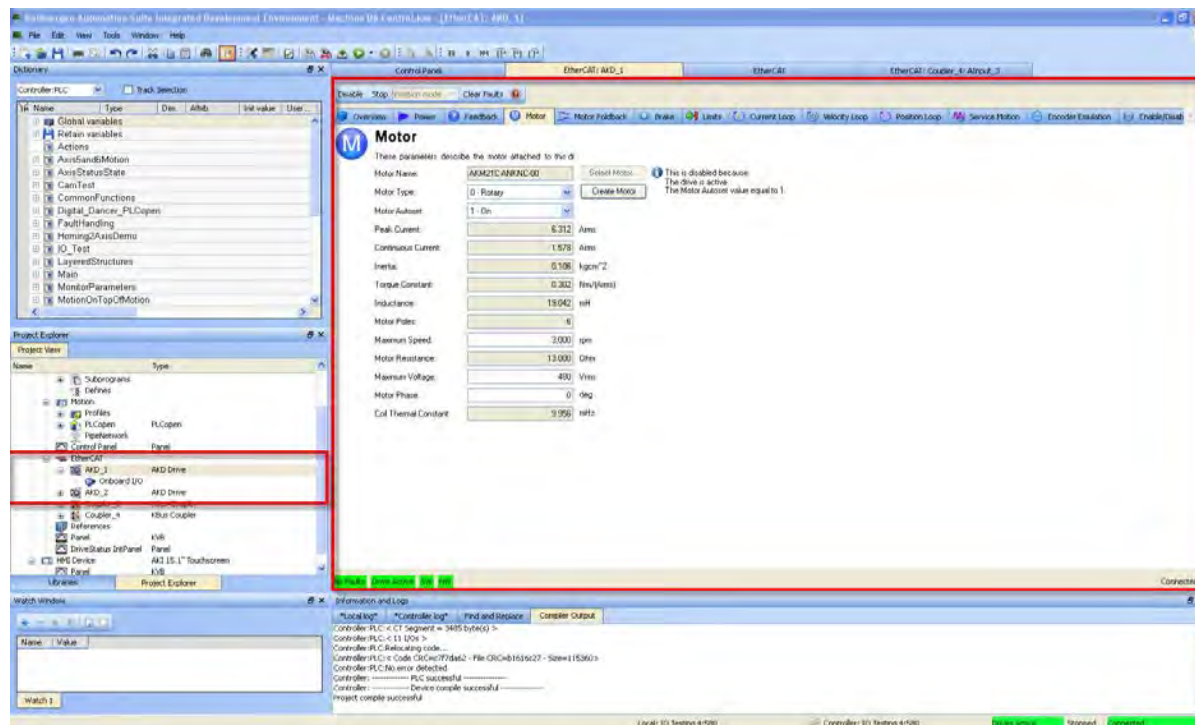
1. Under NC Configuration → Axes → Axis [x] node, choose the Online tab.
2. Press the Set button within the Enabling section.



3. In the pop-up dialog box, check the Controller checkbox to enable the drive (or un-check to disable the drive) and press on the OK button.

### 3.7 Setup via KAS IDE

If you are using a Kollmorgen Automation Suite (KAS) system, the AKD setup is completely integrated into the KAS Integrated Development Environment (IDE), as shown below:



For further information on the setup for a KAS system, see the following sections in the KAS documentation:

- *KAS IDE User Manual*: See section 4.2.3 Add and Configure Drive.
- *KAS Online Help*: See **Using the KAS IDE> Creating a Project> Step 3 - Add and Configure Drive**.

## 4 EtherCAT Profile

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#### 4.1 Slave Register

The table below gives the addresses of individual registers in the FPGA memory. The data is provided in little-endian format, with the 'least significant byte' occupying the lowest address. A detailed description of all registers and FPGA memory locations is available in the "EtherCAT Slave Controller" description of the EtherCAT user organization ([www.EtherCAT.org](http://www.EtherCAT.org)).

Address	Length (Byte)	Description	ZA ECAT*	ZA Drive*
0x0120	2	AL Control	R/W	R/O
0x0130	2	AL Status	R/O	R/W
0x0134	2	AL Status Code	R/O	R/W
0x0204	2	Interrupt Enable Register	R/O	R/W
0x0220	2	AL Event (IRQ Event)	R/W	R/O
0x0800	8	Sync Manager 0 (Mail Out Control Register)	R/W	R/O
0x0808	8	Sync Manager 1 (Mail In Control Register)	R/W	R/O
0x0810	8	Sync Manager 2 (Process data Output Control Register)	R/W	R/O
0x0818	8	Sync Manager 3 (Process data Input Control Register)	R/W	R/O
0x0820	8	Sync Manager 4	R/W	R/O
0x0828	8	Sync Manager 5	R/W	R/O
0x0830	8	Sync Manager 6	R/W	R/O
0x0838	8	Sync Manager 7	R/W	R/O
0x0840	8	Sync Manager 8	R/W	R/O
0x1100	Max. 64	ProOut Buffer (Process data Output, setpoints ECAT)	R/W	R/O
0x1140	Max. 64	ProIn (Process data Input, act. values ECAT)	R/O	R/W
0x1800	512	Mail Out Buffer (Object Channel Buffer ECAT, byte-length is specified in the device description file)	R/W	R/O
0x1C00	512	Mail In Buffer (Object Channel Buffer Drive, byte-length is specified in the device description file)	R/O	R/W

\* ZA ECAT = Access mode EtherCAT

\* ZA Drive = Access mode drive

## 4.2 AL Event (Interrupt Event) and Interrupt Enable

Communication between the drive and the EtherCAT FPGA can be interrupt-driven. The interrupt enable register and the AL event register are responsible for the EtherCAT interface interrupt functionality.

There are two events which lead also to a HW interrupt within the drive, the EEPROM emulation event and the SyncManager 2 event. The actual values of the drive (SyncManager 3 data) are written without any AL event request during each HW IRQ, e.g. triggered by a SyncManager 2 event. The Mailbox exchange between the master and the AKD is completely handled by polling the AL event register within the background task of the drive.

The drive activates individual EtherCAT interface events when the corresponding bit of the interrupt enable register is set to 1. When it is set to 0, the hardware interrupts for the specific events are deactivated.

### 4.2.1 Interrupt Enable Register (Address 0x0204:0x0205)

Parameter	Address	Bit	ZA Drive	ZA ECAT	Description
AL Control Event	0x204	0	R/W	R/O	Activation of AL control event for phase run-up
-	0x204	1	R/W	R/O	Reserved
Sync0 DC Distributed Clock	0x204	2	R/W	R/O	Activation of distributed clock (DC) sync 0 interrupts for entire communication
Sync1 DC Distributed Clock	0x204	3	R/W	R/O	Activation of distributed clock (DC) sync 1 interrupts for entire communication
SyncManager activation register change	0x204	4	R/W	R/O	Activation of 'SyncManager activation register change' IRQ.
EEPROM emulation event	0x204	5	R/W	R/O	Activation of the EEPROM emulation interrupts.
-	0x204	3 to 7	R/W	R/O	Reserved
Sync Manager 0 Event (Mail Out Event)	0x205	0	R/W	R/O	Activation of output event mailbox (SDO, Sync Manager 0) for object channel.
Sync Manager 1 Event (Mail In Event)	0x205	1	R/W	R/O	Activation of input event mailbox (SDO, Sync Manager 1) for object channel.
Sync Manager 2 Event (Pro Out Event)	0x205	2	R/W	R/O	Activation of output event process data (PDO, card's cyclical setpoints)
Sync Manager 3 Event (Pro In Event)	0x205	3	R/W	R/O	Activation of input event process data (PDO, drive's cyclical actual values)
-	0x205	4 to 7	R/W	R/O	Reserved

#### 4.2.2 AL Event Request (Address 0x0220:0x0221)

When the relevant bit of the AL event request register is set to 1, the EtherCAT interface tells the drive which event it should process by the AKD.

Parameter	Address	Bit	ZA Drive	ZA ECAT	Description
AL Control Event	0x220	0	R/O	R/W	Processing of AL control event for phase run-up
Sync0 Distributed Clock (DC) Event	0x220	2	R/O	R/W	Processing of a distributed clock (DC) event
Sync1 Distributed Clock (DC) Event	0x220	3	R/O	R/W	Processing of a distributed clock (DC) event
SyncManager activation register change	0x220	4	R/O	R/W	The content of the SyncManager activation register has been changed.
EEPROM emulation event	0x220	5	R/O	R/W	Processing of an EEPROM emulation event in order to identify the AKD within the network.
-	0x220	6 to 7	R/O	R/W	Reserved
Sync Manager 0 Event	0x221	0	R/O	R/W	Mailbox request (SDO, Sync Manager 0) for object channel.
Sync Manager 1 Event	0x221	1	R/O	R/W	Mailbox response (SDO, Sync Manager 1) for object channel.
Sync Manager 2 Event	0x201	2	R/O	R/W	Process data output (PDO, card's cyclical set-points)
Sync Manager 3 Event	0x201	3	R/O	R/W	Process data input (PDO, drive's cyclical actual values)
Sync Manager 4 –					
Sync Manager 7 Event	0x221	4 to 7	R/O	R/W	Reserved
Sync Manager 8 –					
Sync Manager 15 Event	0x222	0...7	R/O	R/W	Reserved

### 4.3 Phase Run-Up

The AL control, AL status and AL status code registers are responsible for communication phase run-up (also referred to as EtherCAT status change), for current status display and for any fault messages. The drive responds to every EtherCAT interface transition request made by the AL control register via the AL Status and AL Status Code registers. Any fault messages are displayed in the AL status code register.

A status change within the AL control register is polled within the AKD, which means that an AL control event does not lead to a HW interrupt within the drive.

#### 4.3.1 AL Control (Address 0x0120:0x0121)

Parameter	Address	Bit	ZA Drive	ZA ECAT	Description
Status	0x120	3 to 0	R/O	W/O	0x01: Init Request
0x02: PreOperational Request					
0x03: Bootstrap Mode Request					
0x04: Safe Operational Request					
0x08: Operational Request					
Acknowledgement	0x120	4	R/O	W/O	0x00: No fault acknowledgement 0x01: Fault acknowledgement (positive edge)
Reserved	0x120	7 to 5	R/O	W/O	-
Applic. specific	0x120	15 to 8	R/O	W/O	-

#### 4.3.2 AL Status (Address 0x0130:0x0131)

Parameter	Address	Bit	ZA Drive	ZA ECAT	Description
Status	0x130	3 to 0	W/O	R/O	0x01: Init
0x02: PreOperational					
0x03: Bootstrap Mode					
0x04: Safe Operational					
0x08: Operational					
Status change	0x130	4	W/O	R/O	0x00: Acknowledgement 0x01: Error, e.g. forbidden transition
Reserved	0x130	7 to 5	W/O	R/O	-
Applic. specific	0x130	15 to 8	W/O	R/O	-

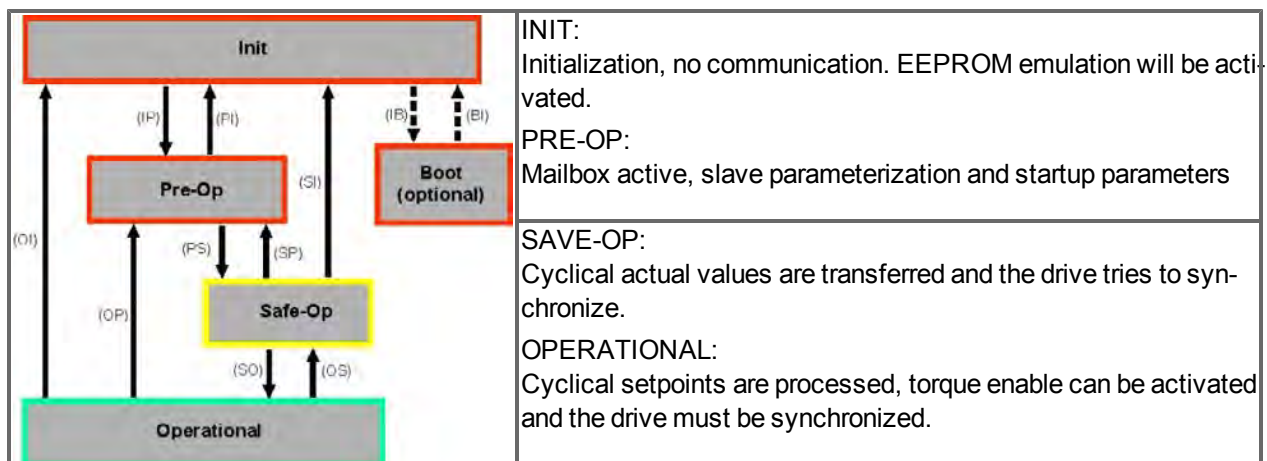
### 4.3.3 AL Status Code (Address 0x0134:0x0135)

Parameter	Address	Bit	ZA Drive	ZA ECAT	Description
Status	0x134	7 to 0	W/O	R/O	See table below
Status	0x135	7 to 0	W/O	R/O	See table below

Code	Description	Current Status (Status change)	Resulting Status
0x0000	No error	All	Current Status
0x0011	Invalid requested state change	I -> S, I -> O, P -> O, O -> B, S -> B, P -> B	Current Status + E
0x0017	Invalid sync manager configuration	I -> P, P -> S	Current Status + E

No other codes are supported.

### 4.3.4 EtherCAT communication phases



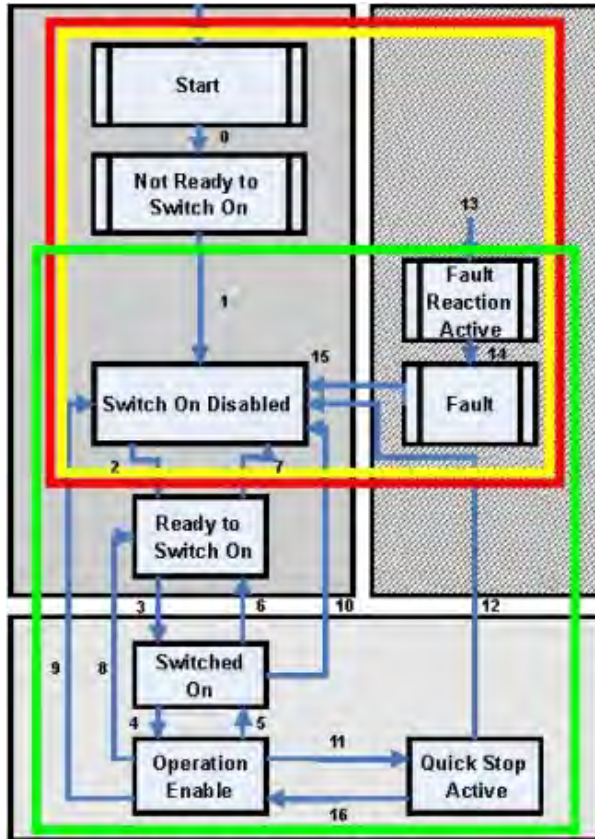
### Individual communication transitions

Transition	AL Control (Bit 3 to 0)	Description
(IB)	0x03	-
(BI)	-	-
(IP)	0x02	AKD reads the SyncManager 0 & 1 configuration and verifies the value of the start-address and the length. The AKD prepares itself for handling SyncManager 0 events.
(PI)	0x01	-
(PS)	0x04	AKD reads the SyncManager 2 & 3 configuration and verifies the value of the start-address and the length.
(SP)	0x02	-
(SI)	0x01	-
(SO)	0x08	The SyncManager 2 hardware interrupt will be enabled by the drive.
(OS)	0x04	Deactivation of SyncManager 2 hardware interrupt.
(OP)	0x02	Deactivation of SyncManager 2 hardware interrupt..
(OI)	0x01	Deactivation of SyncManager 2 hardware interrupt.



#### 4.4 CANopen over EtherCAT (CoE) Status Machine

The status machine for the control and status words corresponds to the CANopen status machine in accordance with DS402. CANopen control and status words are captured in every instance of fixed PDO mapping (see chapter entitled 'Fixed PDO Mapping', page ).



##### 4.4.1 Status Description

Status	Description
Not Ready to Switch On	The drive is not ready to switch on; the controller has not indicated readiness for service. The drive is still in the boot phase or in fault status.
Switch On Disable	In 'Switch On Disable' status, the amplifier cannot be enabled via the EtherCAT interface, because (for example) there is no connection to a power source.
Ready to Switch On	In 'Ready to Switch On' status, the drive can be enabled via the control word.
Switched On	In 'Switched On' status, the amplifier is enabled, but the setpoints of the EtherCAT-interface are not yet transferred. The amplifier is idle, and a positive edge in bit 3 of the control word activates setpoint transfer (transition to 'Operation Enable' status).
Operation Enable	In this status, the drive is enabled and setpoints are transferred from the EtherCAT interface.
Quick Stop Active	The drive follows a quick stop ramp.
Fault Reaction Active	The drive responds to a fault with an emergency stop ramp.
Fault	A fault is pending, the drive is stopped and disabled.

#### 4.4.2 Commands in the Control Word

##### Bit assignment in the control word

Bit	Name	Bit	Name
0	Switch on	8	Pause/halt
1	Disable Voltage	9	reserved
2	Quick Stop	10	reserved
3	Enable Operation	11	reserved
4	Operation mode specific	12	reserved
5	Operation mode specific	13	Manufacturer-specific
6	Operation mode specific	14	Manufacturer-specific
7	Reset Fault (only effective for faults)	15	Manufacturer-specific

##### Commands in the control word

Command	Bit 7 Fault Reset	Bit 3 Enable Operation	Bit 2 Quick Stop	Bit 1 Disable Voltage	Bit 0 Switch on	Transitions
Shutdown	X	X	1	1	0	2, 6, 8
Switch on	X	X	1	1	1	3
Disable Voltage	X	X	X	0	X	7, 9, 10, 12
Quick Stop	X	X	0	1	X	7, 10, 11
Disable Operation	X	0	1	1	1	5
Enable Operation	X	1	1	1	1	4, 16
Fault Reset	1	X	X	X	X	15

Bits labeled **X** are irrelevant. **0** and **1** indicate the status of individual bits.

##### Mode-dependent bits in the control word

The following table shows the mode-dependent bits in the control word. Only manufacturer-specific modes are supported at present. The individual modes are set by Object 6060h Modes of operation.

Operation mode	No.	Bit 4	Bit 5	Bit 6
Profile Position Mode (pp)	01h	new_setpoint	change_set_immediately	absolute/relative
Profile Velocity Mode (pv)	03h	reserved	reserved	reserved
Profile Torque Mode (tq)	04h	reserved	reserved	reserved
Homing Mode (hm)	06h	homing_operation_start	reserved	reserved
Interpolated Position Mode (ip)	07h		reserved	reserved
Cyclic synchronous position mode	08h	reserved	reserved	reserved

##### Description of the remaining bits in the control word

**Bit 8:** (Pause) If Bit 8 is set, then the drive halts (pauses) in all modes. The setpoints (speed for homing or jogging, motion task number, setpoints for digital mode) for the individual modes are retained.

**Bit 9,10:** These bits are reserved for the drive profile (DS402).

**Bit 13, 14, 15:** These bits are manufacturer-specific, and reserved at present.

#### 4.4.3 Status Machine Bits (status word)

##### Bit assignment in the status word

Bit	Name	Bit	Name
0	Ready to switch on	8	Manufacturer-specific (reserved)
1	Switched on	9	Remote (always 1)
2	Operation enable	10	Target reached
3	Fault	11	Internal limit active
4	Voltage enabled	12	Operation mode specific (reserved)
5	Quick stop	13	Operation mode specific (reserved)
6	Switch on disabled	14	Manufacturer-specific (reserved)
7	Warning	15	Manufacturer-specific (reserved)

##### States of the status machine

State	Bit 6 switch on disable	Bit 5 quick stop	Bit 3 fault	Bit 2 operation enable	Bit 1 switched on	Bit 0 ready to switch on
Not ready to switch on	0	X	0	0	0	0
Switch on disabled	1	X	0	0	0	0
Ready to switch on	0	1	0	0	0	1
Switched on	0	1	0	0	1	1
Operation enabled	0	1	0	1	1	1
Fault	0	X	1	0	0	0
Fault reaction active	0	X	1	1	1	1
Quick stop active	0	0	0	1	1	1

Bits labeled **X** are irrelevant. **0** and **1** indicate the status of individual bits.

##### Description of the remaining bits in the status word

**Bit 4:** voltage\_enabled The DC-link voltage is present if this bit is set.

**Bit 7:** warning There are several possible reasons for Bit 7 being set and this warning being produced. The reason for this warning can be revealed by using the Object 20subindex manufacturer warnings.

**Bit 9:** remote is always set to 1, i.e. the drive can always communicate and be influenced via the RS232 - interface.

**Bit 10:** target\_reached This is set when the drive has reached the target position.

**Bit 11:** internal\_limit\_active This bit specifies that a movement was or is limited. In different modes, different warnings cause the bit to be set.

## 4.5 Fixed PDO Mappings

Various ready-to-use mappings can be selected for cyclic data exchange via SDO's of the object 0x1C12 and 0x1C13. Using object 0x1C12 subindex 1 (Sync Manager 2 assignment), a fixed mapping for the cyclic command values can be set with the values 0x1701, 0x1702, 0x1703, 0x1720 to 0x1724. Using object 0x1C13 subindex 1 (Sync Manager 3 assignment), a fixed mapping for the cyclic actual values can be set via the data 0x1B01, 0x1B20 to 0x1B24.

The following sequence describes how to select the fixed command value mapping 0x1701 via SDO's:

1. SDO write access to object 0x1C12Sub0 Data:0x00
2. SDO write access to object 0x1C12Sub1 Data:0x1701
3. SDO write access to object 0x1C12Sub0 Data:0x01

The following fixed mappings are supported:

### Position interface:

0x1701	Position command value (4 bytes), Control word (2 bytes), total (6 bytes)
0x1720	Control Word (2 bytes), Interpolated position command value (4 bytes), Latch control word (2 bytes), Torque feed forward (2 bytes), Digital outputs (2 bytes)
0x1721	Interpolated position command value (4 bytes), Control Word (2 bytes), Torque feed forward (2 bytes)
0x1722	Control word (2 byte), Interpolated position command value (4 bytes), Latch control word (2 bytes), Torque feed forward (2 bytes), Digital outputs (2 bytes), max. torque (2 bytes)
0x1723	Control word (2 bytes), Interpolated position command value (4 bytes), Latch control word (2 bytes), Torque feed forward (2 bytes), Digital outputs (2 bytes), Reset of changed input information (2 bytes)
0x1724	Target position for cyclic synchronous position mode (4 bytes), Control word (2 byte), Torque feed forward (2 bytes)
0x1B01	Position actual value (4 bytes), Status word (2 bytes), total (6 bytes)
0x1B20	Position actual internal value (4 bytes), 2nd position feedback position (4 bytes), velocity actual value (4 bytes), digital inputs (4 bytes), following error (4 bytes), latch position positive (4 bytes), status word (2 bytes), torque actual value (2 bytes), latch status (2 bytes), analogue input value (2 bytes)
0x1B21	Position Actual Internal Value (4 bytes), Status word (2 bytes)
0x1B22	Position actual internal value (4 bytes), 2nd position feedback position (4 bytes), velocity actual value (4 bytes), digital inputs (4 bytes), following error (4 bytes), latch position negative (4 bytes), status word (2 bytes), torque actual value (2 bytes), latch status (2 bytes), analogue input value (2 bytes)
0x1B23	Position actual internal value (4 bytes), 2nd position feedback position (4 bytes), velocity actual value (4 bytes), digital inputs (4 bytes), following error (4 bytes), latch position positive / negative (4 bytes), status word (2 bytes), torque actual value (2 bytes), latch status (2 bytes), analogue input value (2 bytes)
0x1B24	Position actual value (4 bytes), status word (2 bytes)

### Velocity interface:

0x1702	Velocity command value (4 bytes), Control word (2 bytes), total (6 bytes)
0x1B02	Position actual value (4 bytes), Status word (2 bytes), total (6 bytes)

### Torque interface:

0x1703	Torque command value (2 bytes), Control word (2 bytes)
--------	--

## 4.6 Flexible PDO Mappings

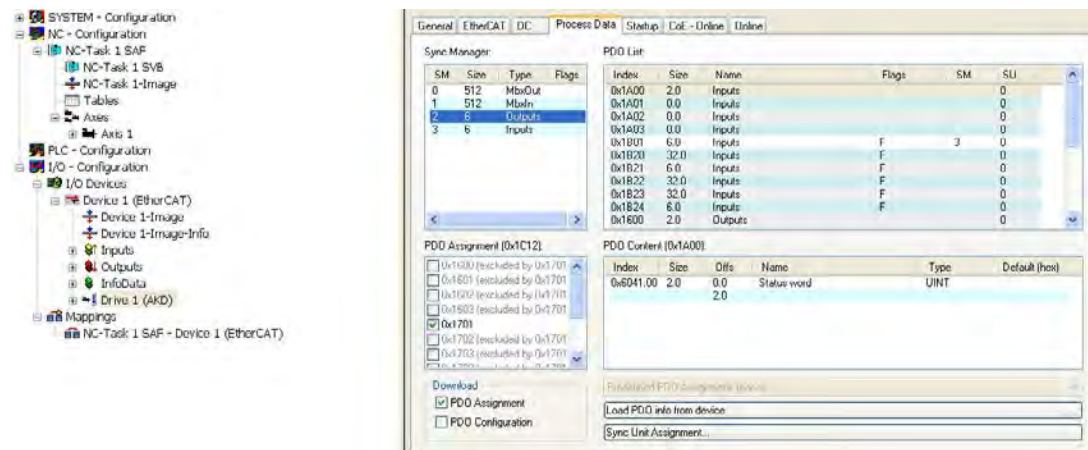
In addition to the fixed PDO - mapping the so-called flexible mapping of real-time objects is possible.

The configuration is similar to the described sequence for the fixed mappings:

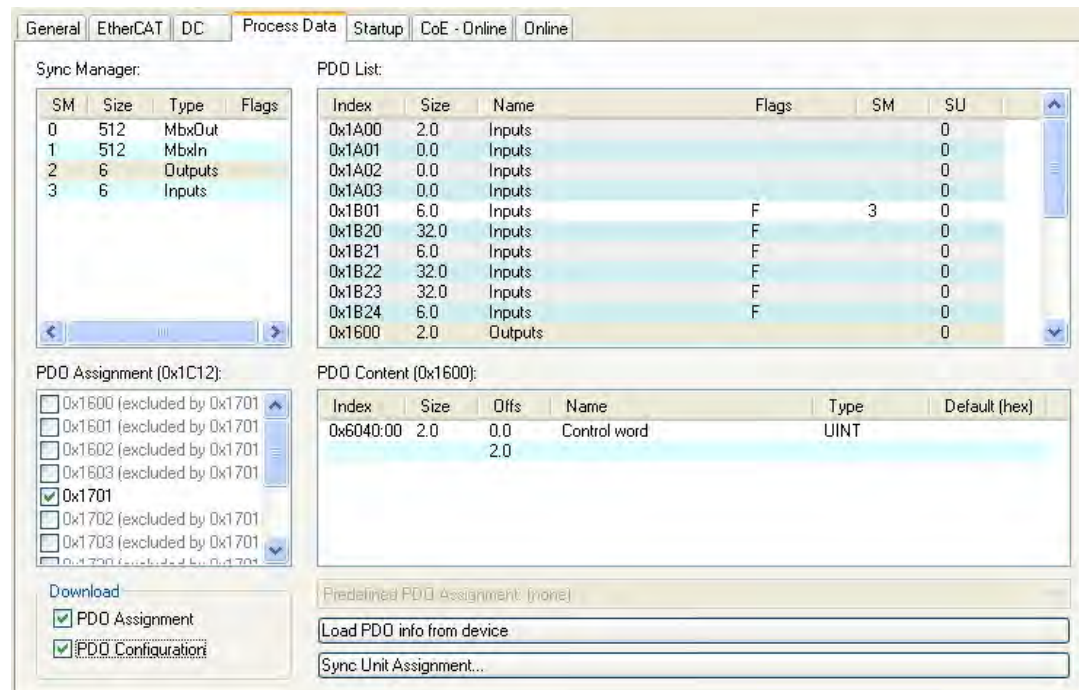
1. The mapping selection is cleared (write 0 to object 0x1C12 sub 0 and 1C13 sub 0)
2. As the AKD - implementation is based on CANopen the real-time data are build from up to 4 PDOs with 8 bytes in both directions. These PDOs are built in the same way as in a CAN-drive with the objects 0x1600 - 0x1603 and 0x1A00 - 0x1A03. Unused PDOs must be cleared with writing 0 to the subindex 0.
3. SDO write access to object 0x1C12 sub 1 .. 4 with the PDOs (0x1600 .. 0x1603), that should be used in receive direction of the AKD (set point values).
4. SDO write access to object 0x1C13 sub 1 .. 4 with the PDOs (0x1A00 .. 0x1A03), that should be used in transmit direction of the AKD (actual values).
5. SDO write access to the objects 0x1C12 sub 0 and 0x1C13 sub 0 with the number of mapped PDOs in this direction.

See an example in chapter "Flexible PDO Mappings" (=> p. 37) .

The cyclically used data are visible in the PDO-assignment window for the Inputs and Outputs of the Sync Managers. Default setting are the fixed PDOs 0x1701 and 0x1B01 (visible contents when selected in the PDO list).



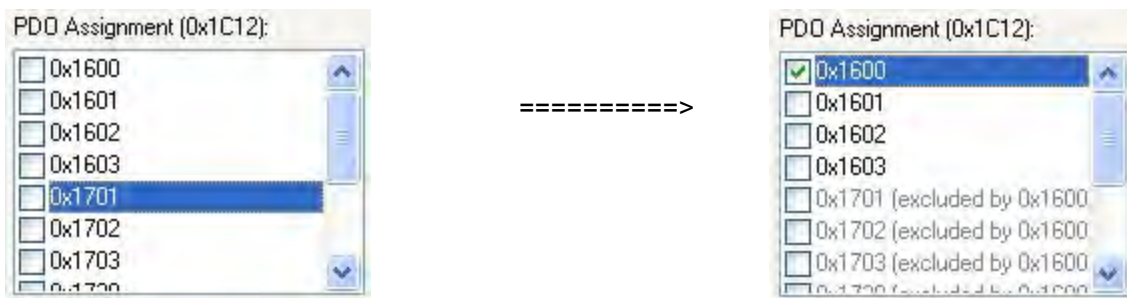
If the free mapping is required, the PDO configuration check box must be checked and changed.



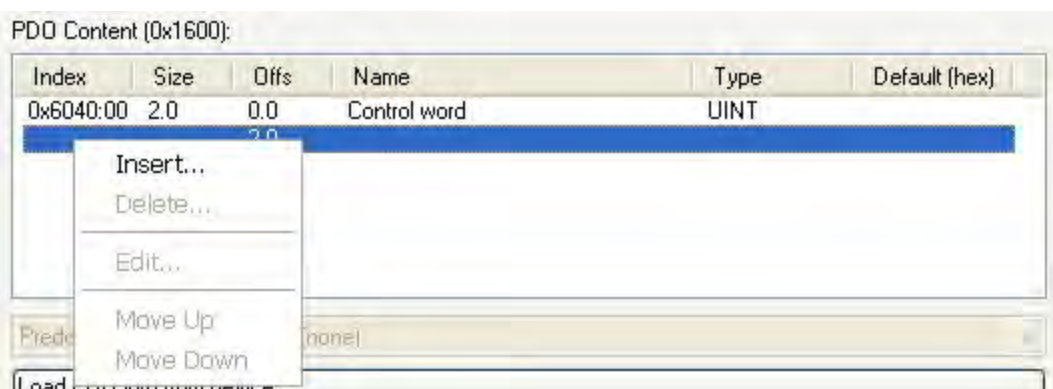


#### 4.6.1 Example: Free PDO Mapping

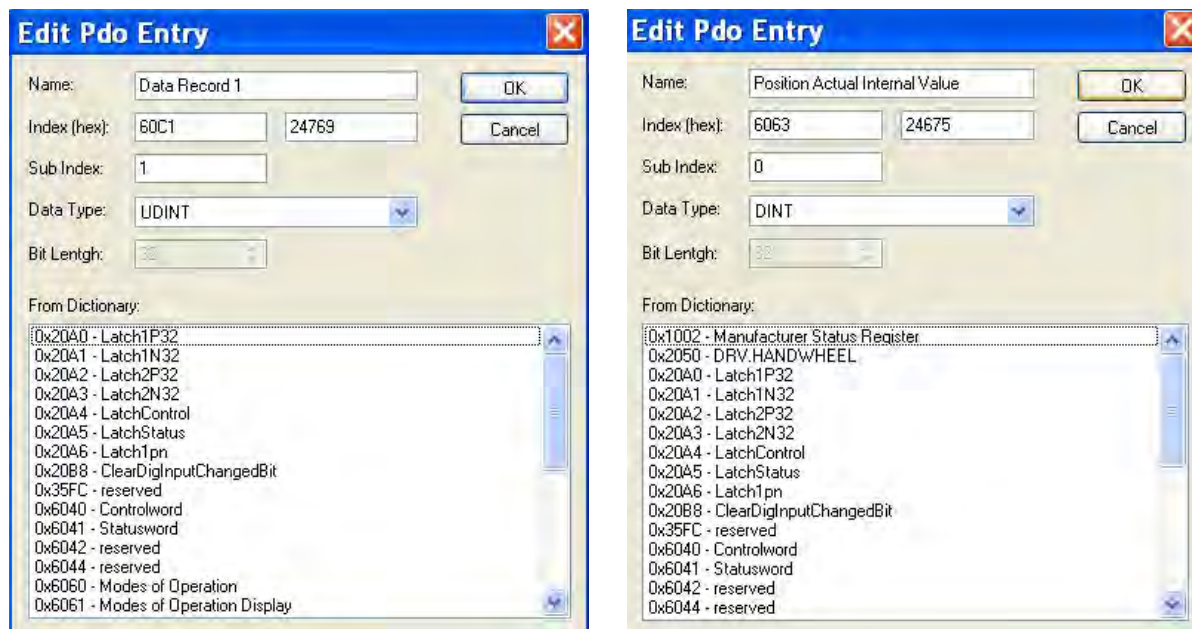
For the free mapping of the Outputs the fixed mapping 0x1701 has to be switched off and up to 4 free-mappable PDOs (0x1600-0x1603) can be used instead. The maximum number of bytes for each of these PDOs is 8.



After that the default mapping of e.g. the PDO 0x1600 can be extended:



A list of possible objects for the mapping will be shown and a new entry can be chosen.



In this case the setpoint for the interpolated position mode is selected.

The same is valid for the Tx-PDO-direction. Here the value of the actual internal position is selected.

This results in the startup-SDO-list for this sample free-mapped-configuration.

Transition	Protocol	Index	Data	Comment
<PS>	CoE	0x1C12:00	0x00 (0)	clear sm pdos (0x1C12)
<PS>	CoE	0x1C13:00	0x00 (0)	clear sm pdos (0x1C13)
<PS>	CoE	0x1A00:00	0x00 (0)	clear pdo 0x1A00 entries
<PS>	CoE	0x1A00:01	0x60410010 (1614872592)	download pdo 0x1A00 entry
<PS>	CoE	0x1A00:02	0x60630020 (1617100832)	download pdo 0x1A00 entry
<PS>	CoE	0x1A00:00	0x02 (2)	download pdo 0x1A00 entr...
<PS>	CoE	0x1A01:00	0x00 (0)	clear pdo 0x1A01 entries
<PS>	CoE	0x1A02:00	0x00 (0)	clear pdo 0x1A02 entries
<PS>	CoE	0x1A03:00	0x00 (0)	clear pdo 0x1A03 entries
<PS>	CoE	0x1600:00	0x00 (0)	clear pdo 0x1600 entries
<PS>	CoE	0x1600:01	0x60400010 (1614807056)	download pdo 0x1600 entry
<PS>	CoE	0x1600:02	0x60C10120 (1623261472)	download pdo 0x1600 entry
<PS>	CoE	0x1600:00	0x02 (2)	download pdo 0x1600 entr...
<PS>	CoE	0x1601:00	0x00 (0)	clear pdo 0x1601 entries
<PS>	CoE	0x1602:00	0x00 (0)	clear pdo 0x1602 entries
<PS>	CoE	0x1603:00	0x00 (0)	clear pdo 0x1603 entries
<PS>	CoE	0x1C12:01	0x1600 (5632)	download pdo 0x1C12:01 i...
<PS>	CoE	0x1C12:00	0x01 (1)	download pdo 0x1C12 count
<PS>	CoE	0x1C13:01	0x1B01 (6913)	download pdo 0x1C13:01 i...
<PS>	CoE	0x1C13:00	0x01 (1)	download pdo 0x1C13 count
PS	CoE	0x6060:00	0x07 (7)	Opmode
PS	CoE	0x60C2:01	0x02 (2)	Cycle time
PS	CoE	0x60C2:02	0xFD (253)	Cycle exp

If this shall be used in the NC, the interpolation set point position has to be linked from the axis to the NC-axis.

The screenshot shows the NC-Task 1 SVB configuration tree on the left. Under 'Axis 1', 'Axis 1\_Drive' is expanded, showing 'Inputs' and 'Outputs'. 'nOutData1' is highlighted under 'Outputs'. On the right, the 'Variable Properties' dialog for 'nOutData1' is open. It shows the variable is of type 'ARRAY [0..1] OF UINT', with a size of 4.0 and address 160 (hex). The 'Linked to...' field is empty.

The screenshot shows the 'Attach Variable nOutData1 (Output)' dialog. On the left, the 'I/O - Configuration' tree is shown, with 'Data Record 1' selected under 'Drive 1 (AKD)'. On the right, the 'Show Variables' section has 'Used' selected. The 'Show Variable Types' section has 'Matching Type' and 'Matching Size' checked. The 'Offset' section has 'Continuous' checked. The 'Variable Name' section has 'Hand over' checked. The 'OK' button is highlighted.

The screenshot shows the 'Linked to...' field filled with the path 'Data Record 1 . Outputs . Drive 1 (AKD) . Device 1 (EtherCAT) . I/O Device'. Below it, the 'Comment' field is empty.

After doing this configuration the mapping can be activated as seen before in this document:



Now the NC-screen should show a position in the online window, which changes a bit in the last digits.

General				Settings	Parameter	Dynamics	Online	Functions	Coupling	Compensation
				<b>165.7124</b>				Setpoint Position: [mm] 165.5651		
Lag Distance (min/max): [mm] 0.0010 (-0.025, 0.002)				Actual Velocity: [mm/s] -0.0168				Setpoint Velocity: [mm/s] 0.0000		
Override: [%] 100.0000 %				Total / Control Output: [%] 0.00 / 0.00 %				Error: 0 (0x0)		
<b>Status (log.)</b> <input type="checkbox"/> Ready <input type="checkbox"/> Calibrated <input type="checkbox"/> Has Job <input checked="" type="checkbox"/> NDT Moving <input type="checkbox"/> Moving Fw <input type="checkbox"/> Moving Bw				<b>Status (phys.)</b> <input type="checkbox"/> Coupled Mode <input type="checkbox"/> In Target Pos. <input type="checkbox"/> In Pos. Range				<b>Enabling</b> <input type="checkbox"/> Controller <input type="checkbox"/> Feed Fw <input type="checkbox"/> Feed Bw		
Controller Kv-Factor: [mm/s/mm] 1				Reference Velocity: [mm/s] 2200						
Target Position: [mm] 0				Target Velocity: [mm/s] 0						
<b>F1</b> <b>F2</b> <b>F3</b> <b>F4</b> <b>F5</b> <b>F6</b> <b>F8</b> <b>F9</b>										

After enabling the power stage with the All-button, the drive can be moved via the jog-buttons or via the functions in the function menu.

Set Enabling

☐ Controller  
☐ Feed Fw  
☐ Feed Bw

Override [%]:

100

OK

Cancel

All

+

++

F3

F4



## 4.7 Supported Cyclical Setpoint and Actual Values

### Supported cyclical setpoint values

Name	CANopen object number	Data type	Description
Position command value	0x60C1 sub 1	INT32	Interpolation data record in IP-mode
Velocity command value	0x60FF sub 0	INT32	
CANopen control-word	0x6040 sub 0	UINT16	CANopen control word.
Latch Control word	0x20a4 sub 0	UINT16	
Torque feed forward	0x60B2 sub 0	INT16	
Digital outputs	0x60FE sub 1	UINT32	

### Supported cyclical actual values

Name	CANopen object number	Data type	Description
Position actual internal value	0x6063 sub 0	INT32	
Velocity actual value	0x606c sub 0	INT32	
CANopen status-word	0x6041 sub 0	UINT16	CANopen status word.
Second position feedback	2050 sub 0	INT32	
Digital inputs	60FD sub 0	UINT32	
Following error actual value	60F4 sub 0	INT32	
Latch position positive edge	20a0 sub 0	INT32	
Torque actual value	6077 sub 0	INT16	
Latch status	20A5 sub 0	UINT16	
Analog input value	3470 sub 0	INT16	

## 4.8 Supported Operation Modes

CANopen mode of operation	AKD mode of operation	Description
Profile velocity	DRV.OPMODE 2 DRC.CMDSOURCE 1	0x6060Sub0 Data: 3 In this mode of operation the EtherCAT master sends cyclic velocity command values to the AKD.
Interpolated position	DRV.OPMODE 2 DRV.CMDSOURCE 1	0x6060Sub0 Data: 7 In this mode of operation the EtherCAT master sends cyclic position command values to the AKD. These command values are interpolated by the AKD according to the fieldbus sample rate.
Homing mode	DRV.OPMODE 2 DRV.CMDSOURCE 0	0x6060 sub 0 data : 6 In this mode an AKD-internal homing can be done.

#### 4.9 Adjusting EtherCAT Cycle Time

The cycle time to be used in the drive for the cyclical setpoints and actual values can either be stored in the FBUS.SAMPLEPERIOD parameter in the amplifier or configured in the startup phase.

This takes place via SDO mailbox access to CANopen objects 60C2 subindex 1 and 2.

Subindex 2, known as the interpolation time index, defines the power of ten of the time value (e.g. -3 means 10<sup>-3</sup> or milliseconds) while subindex 1, known as interpolation time units, gives the number of units (e.g. 4 means 4 units).

You can run a 2 ms cycle using various combinations. For example,

Index = -3, Units = 2

or

Index = -4, Units = 20 etc.

The FBUS.SAMPLEPERIOD parameter is counted in multiples of 62.5us microseconds within the device. This means, for example that 2 ms equates to FBUS.SAMPLEPERIOD value of 32.

#### 4.10 Maximum Cycle Times depending on operation mode

The minimum cycle time for the drive is largely dependent on the drive configuration (second actual position value encoder latch functionality enabled and so on)

Interface	Cycle time AKD
Position	≥ 0.25 ms (≥ 250 μs)
Velocity	≥ 0.25 ms (≥ 250 μs)
Torque	≥ 0.25 ms (≥ 250 μs)

## 4.11 Synchronization

On all drives, the internal PLL is theoretically able to even out an average deviation of up to 4800 ppm in the cycle time provided by the master. The drive checks once per fieldbus cycle a counter within the drive internal FPGA, which is cleared by a Sync0 (Distributed clock) event. Depending of the counter value, the drive extends or decreases the 62.5 µs MTS signal within the drive by a maximum of 300 ns.

The theoretical maximum allowed deviation can be calculated by using the following formula:

$$\max_{dev} = \frac{300[\text{ns}]}{62.5[\mu\text{s}]} \cdot 1,000,000 = 4800 [\text{ppm}]$$

The synchronization functionality within the drive can be enabled via setting bit 0 of the FBUS.PARAM02 parameter to high. Therefore FBUS.PARAM02 must be set to the value of 1. Furthermore the distributed clock functionality must be enabled by the EtherCAT master in order to activate cyclic Sync0 events.

### 4.11.1 Synchronization behavior with distributed clocks (DC) enabled

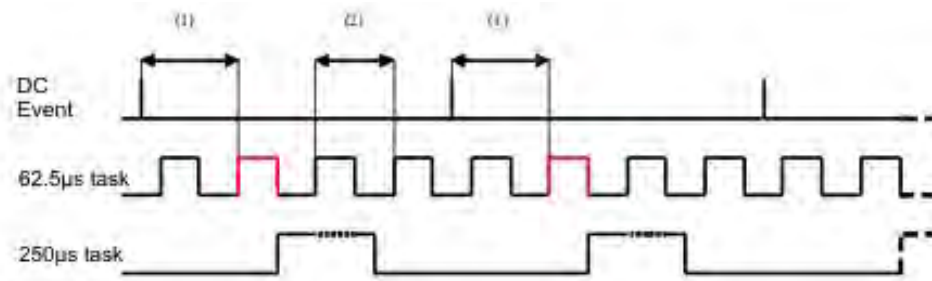
When the EtherCAT master enables distributed clocks, a distributed clock (DC) event is created in the AKD once per fieldbus cycle. An assigned 62.5 µs real-time task in the AKD monitors the elapsed time between the DC events and the AKD System time and extends or reduces the 62.5 µs strobe to the CPU as necessary.

The following fieldbus parameters are used for the synchronization feature:

1. FBUS.SYNCDIST = Expected time delay of the AKD PLL-code to the DC event.
2. FBUS.SYNCACT = Actual time delay of the AKD PLL-code to the DC event.
3. FBUS.PLLTHRESH = Number of consecutive successful synchronized PLL cycles of the AKD before the Drive is considered as synchronized.
4. FBUS.SYNCWND = Synchronization window in which the AKD is considered to be synchronized. The Drive is considered synchronized as long as the following statement is true is true for FBUS.PLLTHRESH consecutive cycles:  

$$\text{FBUS.SYNCDIST} - \text{FBUS.SYNCWND} < \text{FBUS.SYNCACT} < \text{FBUS.SYNCDIST} + \text{FBUS.SYNCWND}$$

Example with a 4kHz fieldbus sample rate:



Explanation:

The red-marked 62.5[µs] real-time task displays the AKD 62.5 µs real-time task within one fieldbus cycle which is responsible for calling the AKD PLL-code. The time delay (1) shows the actual delay to the previous DC event, which is ideally close to the adjusted FBUS.SYNCDIST parameter. Depending on (1) the AKD slightly extends or reduce the 62.5[µs] IRQ generation of the high-priority real-time task in order to either increase or decrease the measured time delay to the DC event (1) for the next PLL cycle. The time distance (2) shows the 62.5[µs] ± x[ms] realtime task of the AKD.

### 4.11.2 Synchronization behavior with distributed clocks (DC) disabled

The AKD fieldbus synchronization algorithm is similar to that used by Distributed Clocks. The difference is that the AKD synchronizes to a SyncManager2 event instead of the DC event. A SyncManager2 event is created when the EtherCAT Master sends a new package of command values to the drive while the network is in the Operational state. This occurs once per fieldbus cycle.

## 4.12 Latch Control Word and Latch Status Word

### Latch Control word (2 Byte)

Bit	Value (bin)	Value (hex)	Description
0	00000000 00000001	zz01	Enable extern latch 1 (positive rise)
1	00000000 00000010	zz02	Enable extern latch 1 (negative rise)
2	00000000 00000100	zz04	Enable extern latch 2 (positive rise)
3	00000000 00001000	zz08	Enable extern latch 2 (negative rise)
4			
5-7			Reserve
8-12	00000001 00000000	01zz	Read external latch 1 (positive rise)
	00000010 00000000	02zz	Read external latch 1 (negative rise)
	00000011 00000000	03zz	Read external latch 2 (positive rise)
	00000100 00000000	04zz	Read external latch 2 (negative rise)
13-15			Reserve

### Latch Status word (2 Byte)

Bit	Value (bin)	Value (hex)	Description
0	00000000 00000001	zz01	External latch 1 valid (positive rise)
1	00000000 00000010	zz02	External latch 1 valid (negative rise)
2	00000000 00000100	zz04	External latch 2 valid (positive rise)
3	00000000 00001000	zz08	External latch 2 valid (negative rise)
4			
5-7			Reserve
8-11	00000001 00000000	z1zz	Acknowledge value external latch 1 (positive rise)
	00000010 00000000	z2zz	Acknowledge value external latch 1 (negative rise)
	00000011 00000000	z3zz	Acknowledge value external latch 2 (positive rise)
	00000100 00000000	z4zz	Acknowledge value external latch 2 (negative rise)
12-15	00010000 00000000	1zzz	Zustand Digital Input 4
	00100000 00000000	2zzz	Zustand Digital Input 3
	01000000 00000000	4zzz	Zustand Digital Input 2
	10000000 00000000	8zzz	Zustand Digital Input 1

### 4.13 Mailbox Handling

With EtherCAT, acyclical data traffic (object channel or SDO channel) is called mailbox. This system is based around the master:

#### Mailbox Output:

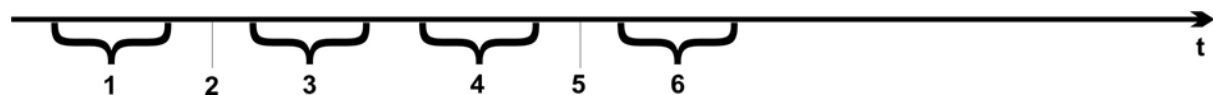
The master (EtherCAT controller) sends data to the slave (drive). This is essentially a (read/write) request from the master. Mailbox output operates via Sync Manager 0.

#### Mailbox Input:

The slave (drive) sends data to the master (EtherCAT controller). The master reads the slave's response. Mailbox input operates via Sync Manager 1.

#### Timing diagram

The timing diagram illustrates the mailbox access process:



1. The EtherCAT master writes the mailbox request to the mail-out buffer.
2. On the next interrupt, the EtherCAT interface activates a Sync Manager 0 event (mailbox output event) in the AL event register.
3. The drive reads 16 bytes from the mail-out buffer and copies them to the internal mailbox output array.
4. The drive identifies new data in the internal mailbox output array and performs an SDO access to the object requested by the EtherCAT interface. The response from the drive is written to an internal mailbox input array.
5. The drive deletes all data in the internal mailbox output array so that a new mailbox access attempt can be made.
6. The drive copies the response telegram from the internal mailbox input array to the mail-in buffer of the EtherCAT interface.

#### 4.13.1 Mailbox Output

An interrupt by the EtherCAT-interface with a Sync Manager 0 - Event starts a Mailbox Output Process. A 1 in the Mail Out Event-Bit of the AL Event register signalizes the drive, that the EtherCAT-interface wants to send a Mailbox message and that it has already stored the required data in the Mail Out Buffer. Now 16 Byte data are read by the drive with the IRQ process. The bytes are defined as follows

Address 0x1800								Address 0x180F							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CAN over EtherCAT specific data (CoE Header)								CAN specific data (standard CAN SDO)							
Byte 0	Length of the data (Low Byte)														
Byte 1	Length of the data (High Byte)														
Byte 2	Address (Low Byte)														
Byte 3	Address (High Byte)														
Byte 4	Bit 0 to 5: Channel Bit 6 to 7: Priority														
Byte 5	Bit 0 to 3: Type				1 = Reserved: ADS over EtherCAT 2 = Reserved: Ethernet over EtherCAT 3 = Can over EtherCAT...)										
	Bit 4 to 7: Reserved														
Byte 6	PDO Number (with PDO transmissions only, Bit 0 = LSB of the PDO number, see Byte 7 for MSB)														
Byte 7	Bit 0: MSB of the PDO number, see Byte 6														
	Bit 1 to 3: Reserved														
	Bit 4 to 7: CoE specific type				0: Reserved										
					1: Emergency message										
					2: SDO request										
					3: SDO answer										
					4: TxPDO										
					5: RxPDO										
					6: Remote transmission request of a TxPDO										
					7: Remote transmission request of a RxPDO										
					8...15: reserved										
Byte 8	Control-Byte in the CAN telegram:														
	write access:				0x23=4Byte, 0x27=3Byte, 0x2B=2Byte, 0x2F=1Byte										
	read access:				0x40										
Byte 9	Low Byte of the CAN object number (Index)														
Byte 10	High Byte of the CAN object number (Index)														
Byte 11	Subindex according to CANopen Specification for the drive														
Byte 12	Data with a write access (Low Byte)														
Byte 13	Data with a write access														
Byte 14	Data with a write access														
Byte 15	Data with a write access (High Byte)														

The drive answers every telegram with an answer in the Mailbox Input buffer.

#### 4.13.2 Mailbox Input

The drive answers every CoE telegram with a 16 byte answer telegram in the Mailbox Input buffer. The bytes are defined as follows:

Address 0x1C00								Address 0x1C0F							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CAN over EtherCAT specific data (CoE Header)								CAN specific data (standard CAN SDO)							
Byte 0	Length of the data (Low Byte)														
Byte 1	Length of the data (High Byte)														
Byte 2	Address (Low Byte)														
Byte 3	Address (High Byte)														
Byte 4	Bit 0 to 5: Channel Bit 6 to 7: Priority														
Byte 5	Bit 0 to 3: Type				1 = Reserved: ADS over EtherCAT 2 = Reserved: Ethernet over EtherCAT 3 = Can over EtherCAT...)										
	Bit 4 to 7: Reserved														
Byte 6	PDO Number (with PDO transmissions only, Bit 0 = LSB of the PDO number, see Byte 7 for MSB)														
Byte 7	Bit 0: MSB of the PDO number, see Byte 6														
	Bit 1 to 3: Reserved														
	Bit 4 to 7: CoE specific type				0: Reserved										
					1: Emergency message										
					2: SDO request										
					3: SDO answer										
					4: TXPDO										
					5: RxPDO										
					6: Remote transmission request of a TxPDO										
					7: Remote transmission request of a RxPDO										
					8...15: reserved										
Byte 8	Control-Byte in the CAN telegram:														
	write access OK:				0x60										
	read access OK + length of answer:				0x43 (4 Byte), 0x47 (3 Byte), 0x4B (2Byte), 0x4F (1Byte)										
	error with read- or write access:				0x80										
Byte 9	Low Byte of the CAN object number (Index)														
Byte 10	High Byte of the CAN object number (Index)														
Byte 11	Subindex according to CANopen Specification for Kollmorgen™ drive														
Byte 12	Data (Low Byte)														
Byte 13	Data				error code Fehlercode according to CANopen Specification in case of an error										
Byte 14	Data				data value of the object in case of successfull read access										
Byte 15	Data (High Byte)														



#### 4.13.3 Example: Mailbox Access

In the example below, PDOs 0x1704 are mapped (see Chapter # “Fixed PDO Mappings”):

The master sends this mailbox output message:

<b>Byte 0</b>	0x0A	The next 10 Bytes contain data (Byte 2 to Byte 11)
<b>Byte 1</b>	0x00	The next 10 Bytes contain data (Byte 2 to Byte 11)
<b>Byte 2</b>	0x00	Address 0
<b>Byte 3</b>	0x00	Address 0
<b>Byte 4</b>	0x00	Channel 0 and Priority 0
<b>Byte 5</b>	0x03	CoE Object
<b>Byte 6</b>	0x00	PDO Number 0
<b>Byte 7</b>	0x20	PDO Number 0 and SDO-Request
<b>Byte 8</b>	0x2B	2 Byte write access
<b>Byte 9</b>	0x12	SDO-Object 0x1C12
<b>Byte 10</b>	0x1C	SDO-Object 0x1C12
<b>Byte 11</b>	0x01	Subindex 1
<b>Byte 12</b>	0x04	Data value 0x00001704
<b>Byte 13</b>	0x17	Data value 0x00001704
<b>Byte 14</b>	0x00	Data value 0x00001704
<b>Byte 15</b>	0x00	Data value 0x00001704

The drive returns the following message:

<b>Byte 0</b>	0x0E	The next 14 Bytes contain data (Byte 2 to Byte 15)
<b>Byte 1</b>	0x00	The next 14 Bytes contain data (Byte 2 to Byte 15)
<b>Byte 2</b>	0x00	Address 0
<b>Byte 3</b>	0x00	Address 0
<b>Byte 4</b>	0x00	Channel 0 and Priority 0
<b>Byte 5</b>	0x03	CoE Object
<b>Byte 6</b>	0x00	PDO Number 0
<b>Byte 7</b>	0x20	PDO Number 0 and SDO-Answer
<b>Byte 8</b>	0x60	Successful write access
<b>Byte 9</b>	0x12	SDO-Object 0x1C12
<b>Byte 10</b>	0x1C	SDO-Object 0x1C12
<b>Byte 11</b>	0x01	Subindex 1
<b>Byte 12</b>	0x00	Data value 0x00000000
<b>Byte 13</b>	0x00	Data value 0x00000000
<b>Byte 14</b>	0x00	Data value 0x00000000
<b>Byte 15</b>	0x00	Data value 0x00000000

#### 4.14 Fieldbus Parameters

The AKD holds several fieldbus-specific, general purpose parameters. Some of them contain the following EtherCAT relevant data:

- **FBUS.PARAM02:** This parameter activates the synchronization feature of the AKD. The DC feature must be activated in order to allow the AKD to get synchronized with the master. A value of 1 enables the drive internal PLL functionality, a value of 0 deactivates this feature.
- **FBUS.PARAM03:** This parameter contains the Configured Station Alias address of the AKD. An EEPROM emulation write access to the Configured Station Alias address forces the AKD to store the drive parameters automatically using the DRV.NVSAVE command.
- **FBUS.PARAM04:** This parameter enables (1) or disables(0) the synchronization supervision of the CANOpen or EtherCAT fieldbus.

Default values for this parameter are as follows:

CANopen drive: disabled (0)

EtherCAT drive: enabled (1)

Synchronization supervision is active when FBUS.PARAM 04 = 1 and the first CANOpen Sync message or first EtherCAT frame is received. When more than three CANOpen sync messages or seven EtherCAT frames have not been received and the drive is enabled, fault F125 ("Synchronization lost"), occurs.

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## About KOLLMORGEN

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