MAXPOS

Positioning Controllers

Communication Guide

maxpos.maxonmotor.com

Document ID: rel4896

PLEASE READD 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 MAXPOS 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 the 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!*

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1 About this Document

The present document provides you with information on the MAXPOS communication interfaces. It contains descriptions of the USB interface.

Find the latest edition of the present document, as well as additional documentation and software for the MAXPOS Positioning Controllers also on the Internet: ➔http://maxpos.maxonmotor.com.

1.1 Documentation Structure

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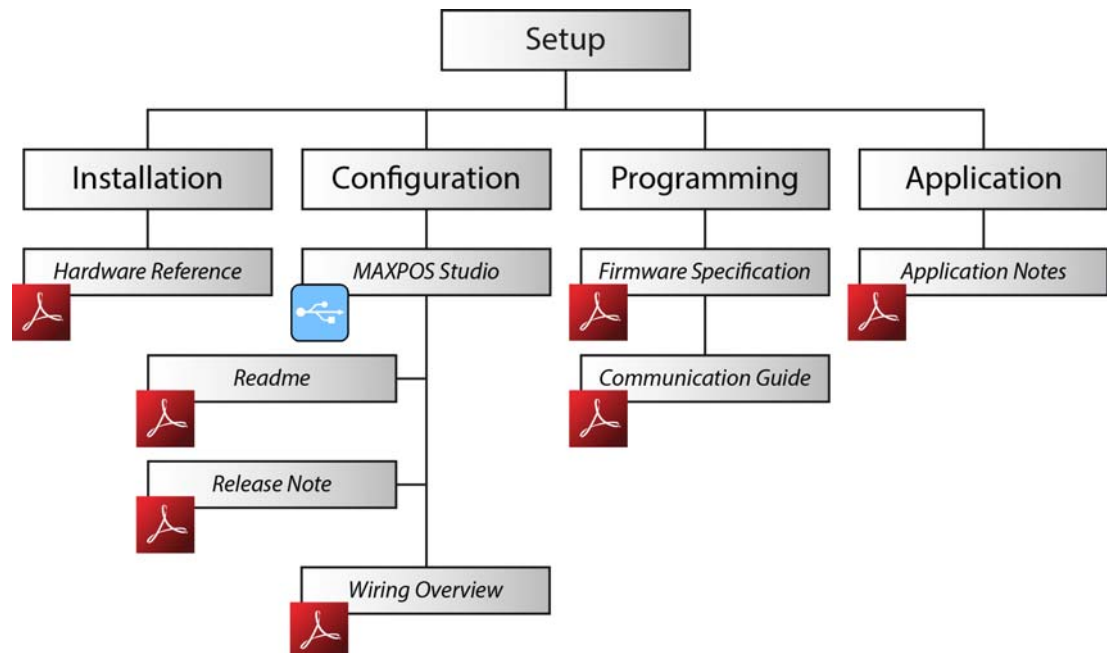

Figure 1-1   Documentation Structure

1.2 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.

1.3 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.

1.4 How to use

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

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

Table 1-1   Notations used in this Document

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
TwinCAT®	© Beckhoff Automation GmbH, DE-Verl

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:

Item	Reference
[1]	USB Implementers Forum: Universal Serial Bus Revision 2.0 Specification: ➔www.usb.org/developers/docs/usb20_docs/
[2]	Manufacturer-specific USB protocol: ➔www.microchip.com/mcp2210/

Table 1-3   Sources for additional Information

1.7 Copyright

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2   EtherCAT Interface

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

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

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

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

MAXPOS FIRMWARE SPECIFICATION

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

MAXPOS HARDWARE REFERENCE

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

2.1   Communication Specifications

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

Table 2-4   Communication Specifications

2.2 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: AL Ctrl (0x0120).

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

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

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

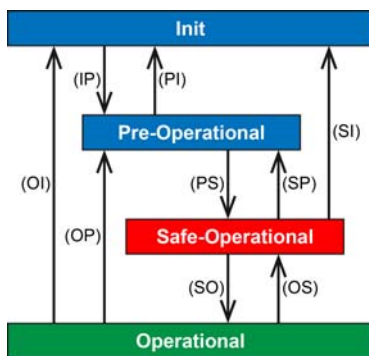For an overview of the EtherCAT State Machine ➜Figure 2-2, for further descriptions ➜as from Table 2-5.

Figure 2-2   EtherCAT State Machine – Scheme

Condition	Description
Power ON	• MAXPOS is ON • MAXPOS 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 n 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"
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 "Operational"
Operational	• Acyclic as well as cyclic communication is active • Master and Slave exchange setpoint and actual values • MAXPOS be enabled and operated via the CoE protocol

Table 2-5   EtherCAT State Machine – Conditions

Status Transition	Status	
IP	Start of acyclic communication (Mailbox)	
PI	Stop of acyclic communication (Mailbox)	
PS	Start of cyclic communication (Process Data) Slave sends actual values to Master Slave ignores setpoint values by the Master and uses default values	
SP	Stop of cyclic communication (Process Data) Slave ceases to send actual values to the Master	
SO	Slave evaluates actual setpoint values of the Master	
OS	Slave ignores setpoint values from Master and uses internal default values	
OP	Stop of cyclic communication (Process Data) Slave ceases to send actual values to the Master Master ceases to send actual values to the Slave	
SI	Stop of cyclic communication (Process Data) Stop of acyclic communication (Mailbox) Slave ceases to send actual values to the Master Master ceases to send actual values to the Slave	
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 2-6   EtherCAT State Machine – Transitions

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

Table 2-7   EtherCAT State Machine – Control Register

2.3   Integrating ESI Files

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

To integrate a MAXPOS EtherCAT axis into the Beckhoff Master System, copy the ESI (EtherCAT Slave Information) XML file to the following folder:

- For TwinCAT XAE use path "C:\TwinCAT\Config\Io\EtherCAT\".
- For TwinCAT2 use path "C:\TwinCAT\Io\EtherCAT\".

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2.4   Scanning the EtherCAT Slave Device

1)   Connect the MAXPOS to the EtherCAT Master and turn on power.

2)   Open the Beckhoff System Manager and create a new project using menu ¤File¤, then ¤New¤.

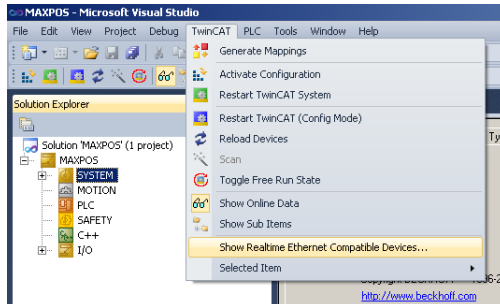3)   Open menu ¤Options¤, then select ¤Show Real Time Ethernet Compatible Devices¤.

Figure 2-3   TwinCAT System Manager – Create new Project

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

a) Click one of the listed network cards.

b) Click button ¤Install¤.
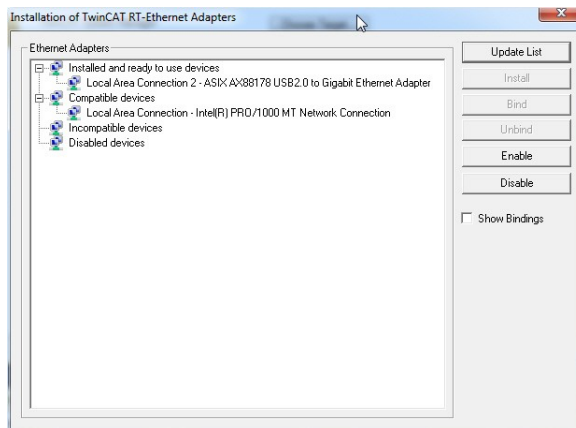
Figure 2-4   Installation of TwinCAT RT Ethernet Adapters

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5) In the TwinCAT System Manager navigation tree, click right on ¤I/O Devices¤, then select ¤Scan Devices¤.
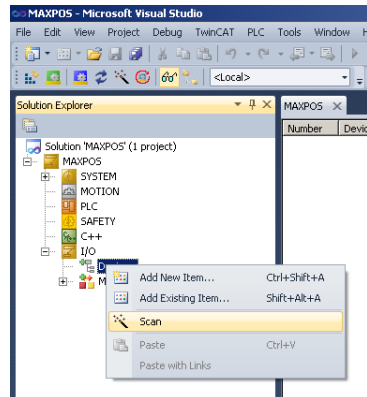
Figure 2-5   TwinCAT System Manager – Scan Devices

6) Click ¤OK¤ to confirm.
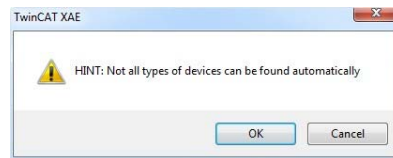
Figure 2-6   TwinCAT System Manager – Confirmation

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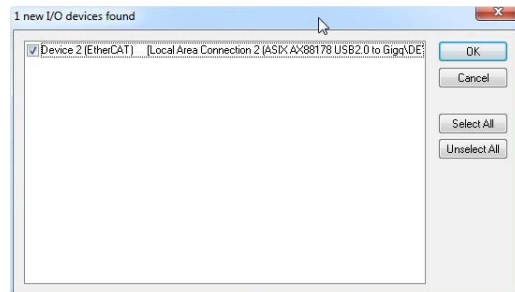Tick to select the network card to which the EtherCAT devices are connected to. Untick all others and click ¤OK¤.

Figure 2-7   TwinCAT System Manager – New I/O Devices found

8) Click ¤OK¤ to confirm.
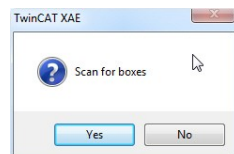
Figure 2-8   TwinCAT System Manager – Scan for Boxes Confirmation

9) The TwinCAT System Manager now searches for connected devices. If one or more controller were found, the following message will appear.
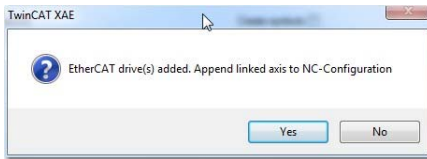
Figure 2-9   TwinCAT System Manager – Add Drives Message

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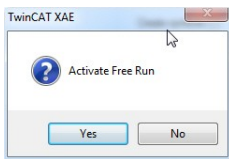
11) Click ¤Yes¤ to confirm.

Figure 2-10   TwinCAT System Manager – Activate Free Run Message

12) Save the project.
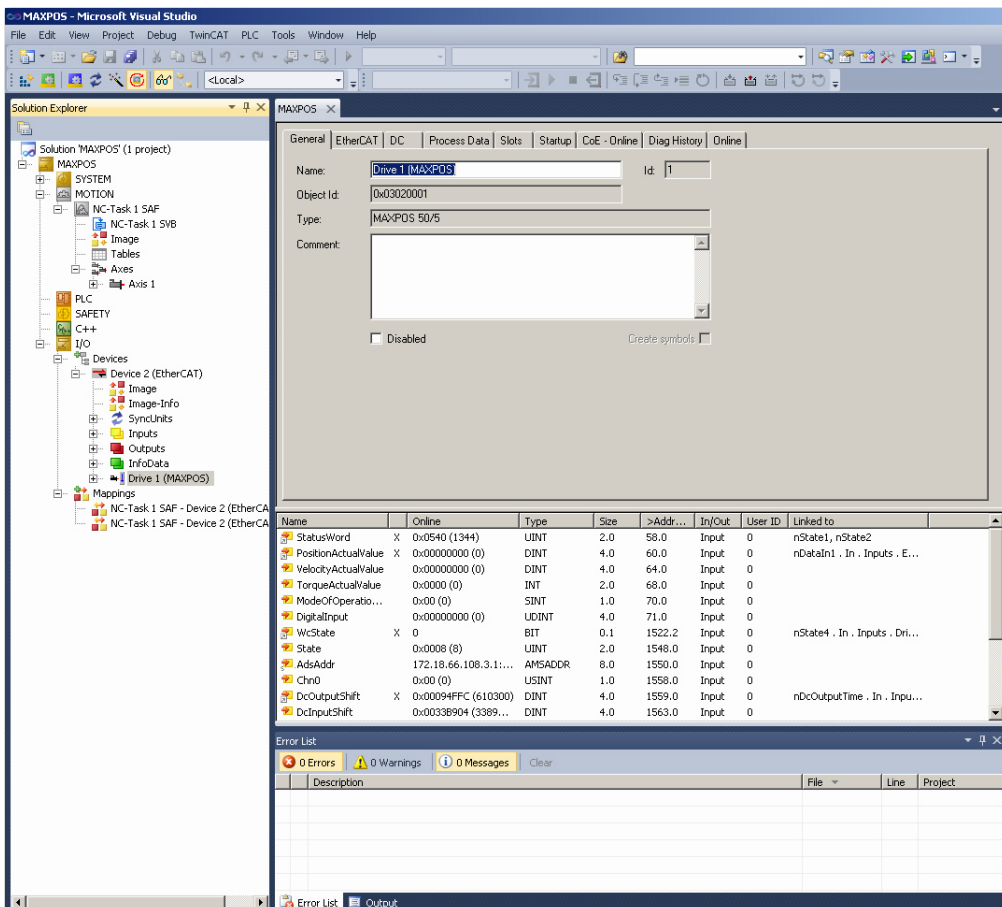
Figure 2-11   TwinCAT System Manager – Save Project

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2.5 Changing Operating Modes

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

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

If the controller will be operated in Cycle Synchronous Mode, PDO Mapping must be configured accordingly by defining "Slots".

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

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

1) Upon recognition of the involved axes, the structure tree (as to the following example) will be displayed.
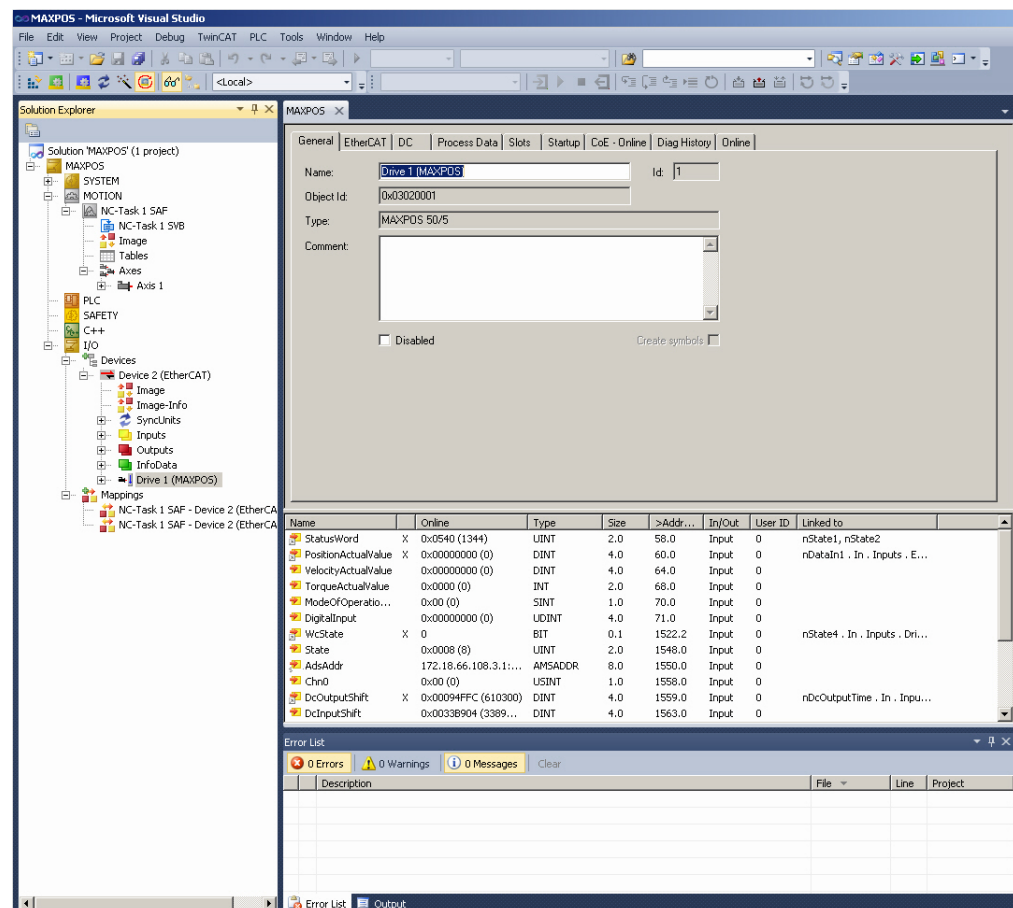
Figure 2-12   TwinCAT System Manager – Structure Tree

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2) Use the tab ¤Slots¤ to allocate the operating mode to be used:

a) Select a ¤Slot¤ from the left pane.

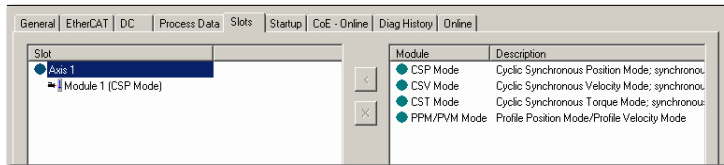b) Select the desired operating mode from the right pane ¤Module¤.

Figure 2-13   TwinCAT System Manager – Configuration of Slots

2.6   Verify CSP Settings

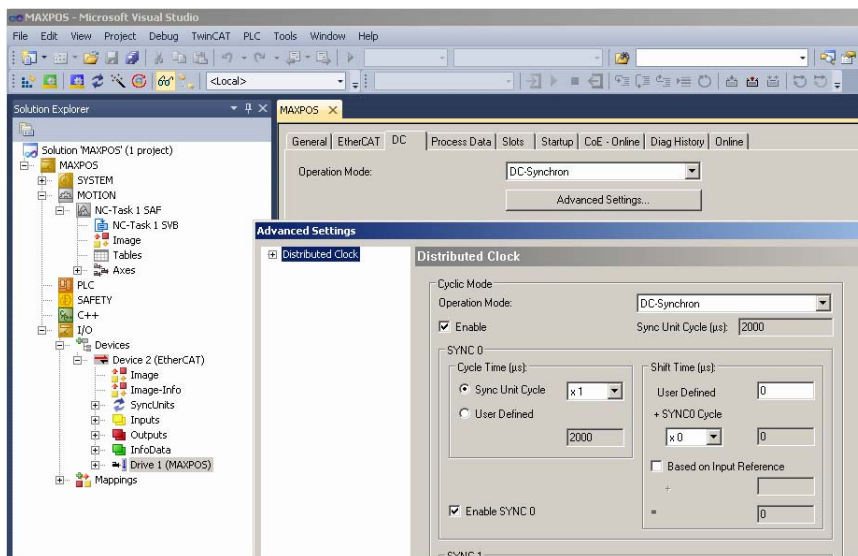1) Enable the Distributed Clock from the MAXPOS drive.

Figure 2-14   TwinCAT System Manager – Distributed Clock
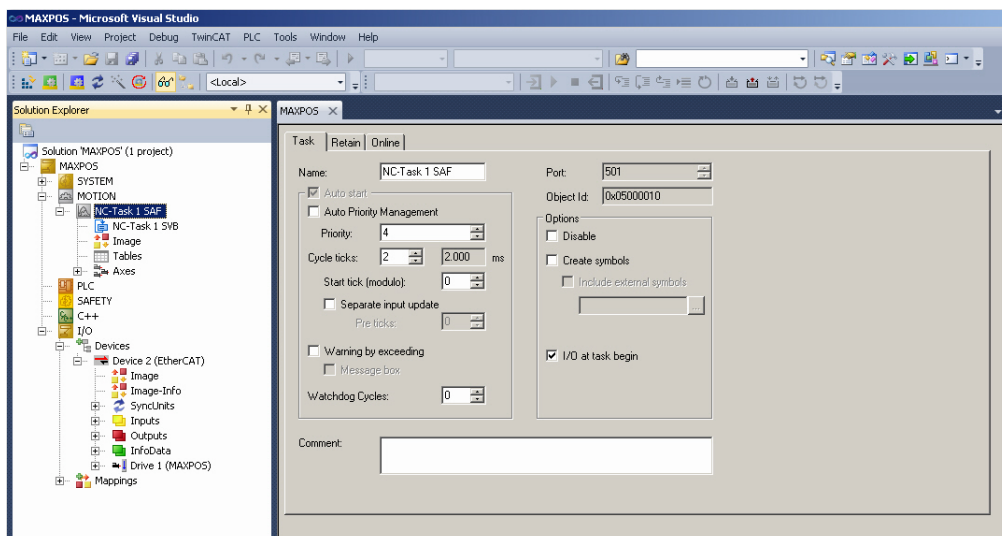
2) Set NC-Task 1 SAF cycle time to 1 ms.

Figure 2-15   TwinCAT System Manager – Cycle Ticks

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2.7 Configuration of the Axis

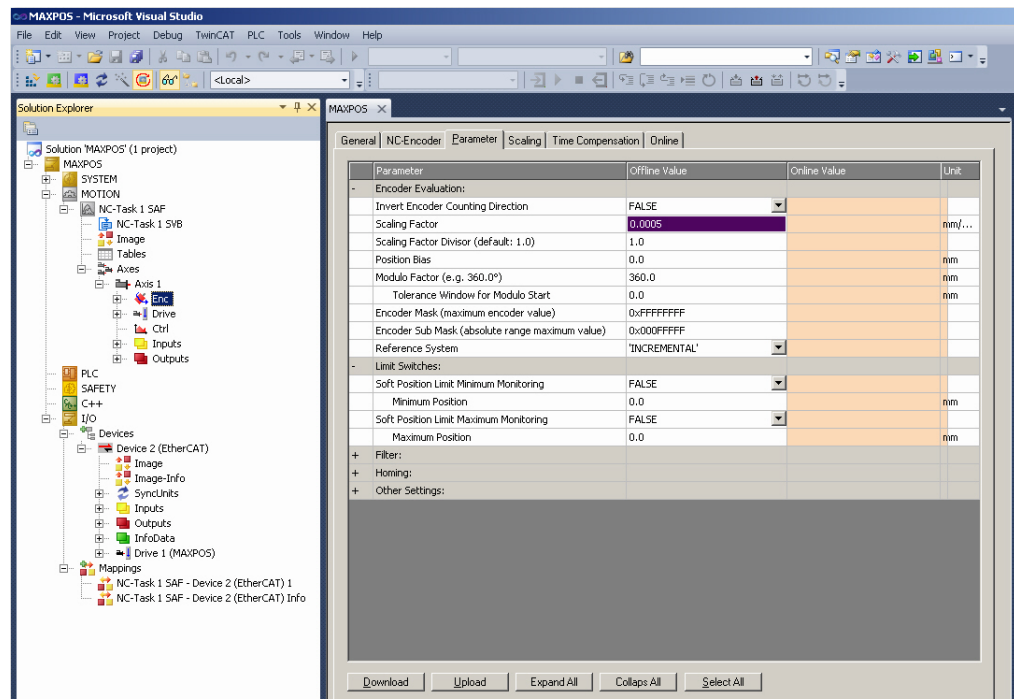1) Make sure to set the encoder resolution correctly.

Figure 2-16   TwinCAT System Manager – Encoder Settings

2) Set Dead Time Compensation to approximately three to four times the set NC-Task SAF Cycle ticks (➔"Verify CSP Settings" on page 2-14; step 2)
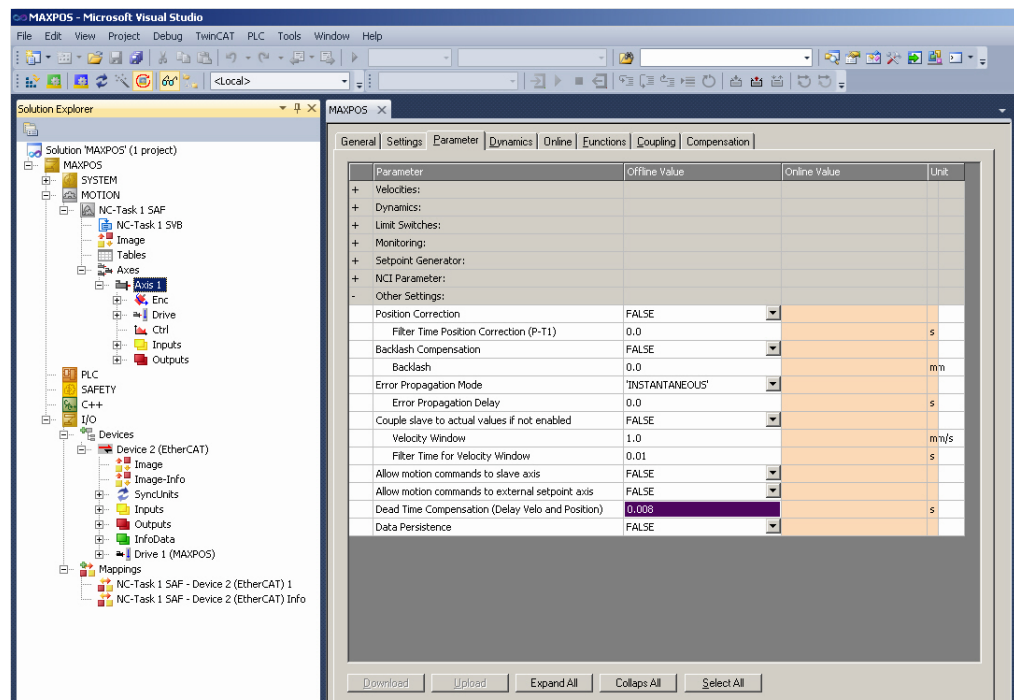

Figure 2-17   TwinCAT System Manager – Dead Time Compensation

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3)   Adjust the motor speed settings as to the motor's capability and to the supply voltage.
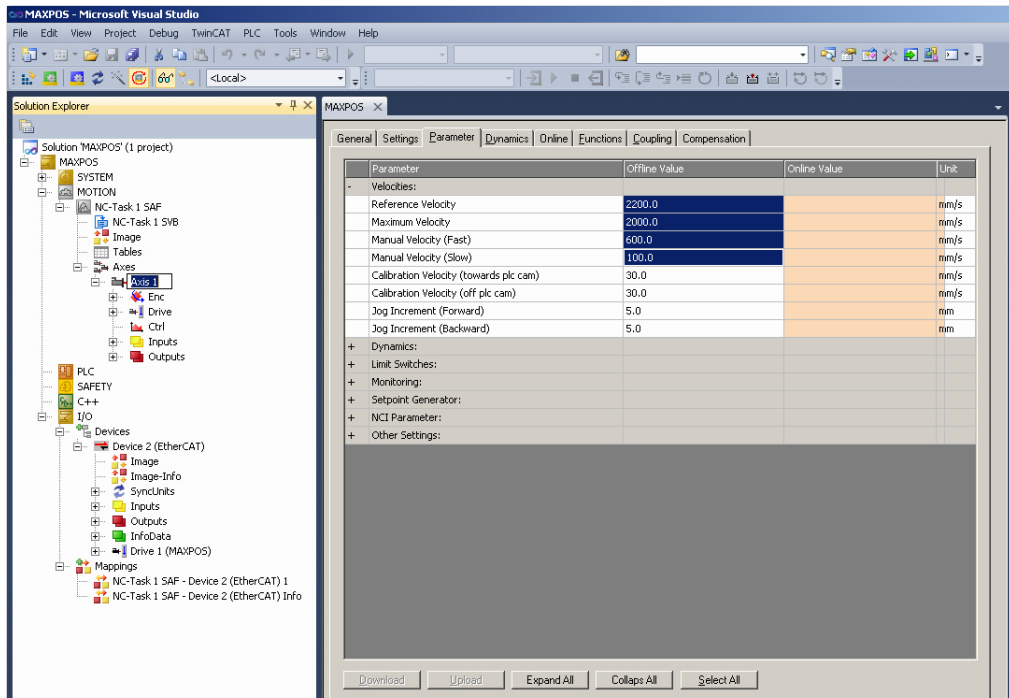

Figure 2-18   TwinCAT System Manager – Speed Settings

3 USB Interface

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

3.1 Physical Layer

ELECTRICAL STANDARD

maxon MAXPOS drives' USB interface follows the "Universal Serial Bus Revision 2.0 Specification". You may wish to download the file from the Internet (for URL ➔page 1-6, item [1]; full details are described in chapter "7.3 Physical Layer").

For further information on manufacturer-specific USB protocol ➔page 1-6, item [2].

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4 Error Code Definition

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

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