CoE Programming

TECHNOSOFT

MOTION TECHNOLOGY

User Manual

P091.064.UM.1224

Read This First

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About This Manual

This manual describes how to program the Technosoft intelligent drives equipped with **EtherCAT®** communication interface. These drives support **CAN application protocol over EtherCAT® (CoE)** in conformance with **CiA 402** device profile. The manual presents the object dictionary associated with this profile. The manual also explains how to combine the Technosoft Motion Language and the **CoE** commands in order to distribute the application between the **EtherCAT®** master and the Technosoft drives.

In order to operate the Technosoft drives with EtherCAT® communication, you need to pass through 3 steps:

- ❑ **Step 1 Hardware installation**
- ❑ **Step 2 Drive setup** using Technosoft **EasyMotion Studio II** software for drive commissioning and later, via an **EtherCAT®** master
- ❑ **Step 3 Motion programming** using one of the options:
  A. An **EtherCAT®** master
  B. The drives **built-in motion controller** executing a Technosoft Motion Language (**TML**) program developed using Technosoft **EasyMotion Studio II** software
  C. A **distributed control** approach which combines the above options, like for example a master calling motion functions programmed on the drives in TML

This manual covers an introductory part of **Step 2** and **Step 3** / **Motion programming using the CoE protocol** in detail. For Step 1, please consult the drive User Manual, where a detailed hardware installation is described.

Scope of This Manual

This manual applies to the iPOS and Micro family of Technosoft intelligent drives having an EtherCAT® communication interface.

Notational Conventions

This document uses the following conventions:

AL – Application Layer
CoE - CAN application protocol over EtherCAT®
TML – Technosoft Motion Language
iPOS – a Technosoft drive family, the code is usually iPOSxx0x xx-CAN
Micro – a Technosoft drive family, the code is usually Micro48xx xx-CAT
GUI – Graphical User Interface
IU – drive/motor internal units
IP – Interpolated Position
RegisterY.x- bit x or register Y; **Example: Controlword.5** – bit 5 of Controlword data
cs – command specifier
CSP – Cyclic Synchronous Position
CSV – Cyclic Synchronous Velocity
CST – Cyclic Synchronous Torque
RO – read only
RW – read and write
SW – software
H/W or HW – hardware
***X1** – Subindex 1 of object 60C1h - Interpolation data record*
***X2** – Subindex 2 of object 60C1h - Interpolation data record*

Trademarks

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Related Documentation

EasyMotion Studio II – Quick Setup and Programming Guide (P091.034.ESM II - Quick.Setup.and.Programming.Guide.xxxx) – describes the compatible software installation, drive software setup commissioning, introduction to TML motion programming and motion evaluation tools.

Technical Reference Manual of each iPOS or Micro drive version – describes the hardware including the technical data, the connectors, the wiring diagrams needed for installation and detailed setup information.

If you Need Assistance …

If you want to …	**Contact Technosoft at …**
Visit Technosoft online	World Wide Web: http://www.technosoftmotion.com/
Receive general information or assistance (see Note)	World Wide Web: http://www.technosoftmotion.com/ Email: sales@technosoftmotion.com
Ask questions about product operation or report suspected problems (see Note)	Tel: +41 (0)32 732 5500 Email: support@technosoftmotion.com
Make suggestions about, or report errors in documentation.	Mail: Technosoft SA Avenue des Alpes 20 Ch-2000 Neuchatel, NE Switzerland

1 Getting Started

1.1 Setting up the drive using EasyMotion Studio II

1.1.1 What is EasyMotion Studio II?

Technosoft provides the **EasyMotion Studio II** software to facilitate the commissioning and programming of its iPOS and Micro drive families. This application is available in two versions: **LITE** and **FULL**, each tailored to address specific commissioning and motion programming needs.

The **LITE version** is designed to simplify the setup process for Technosoft drives, offering a quick and straightforward solution for commissioning. It enables users to generate setup data that can be saved directly into the drive's EEPROM (non-volatile memory) or stored as a file on a PC. Upon power-up, the drive automatically initializes using the setup data from the EEPROM, ensuring a seamless startup process. Furthermore, this version allows users to retrieve setup configurations from previously programmed drives, providing flexibility for system diagnostics and modifications. The LITE version is available as a free download from the Technosoft website and is particularly suited for applications where motion programming is handled externally, such as via a **EtherCAT®** master.

The **FULL version,** in addition to the capabilities of the LITE version**,** supports the development of complex motion programs using the Technosoft Motion Language (TML), which is executed directly by the drive's integrated motion controller. The software includes a Motion Wizard, a user-friendly graphical tool that generates TML instructions automatically, eliminating the need for users to manually write code.

Using TML, users can:

- ❑ Set various motion modes
- ❑ Change the motion modes and/or the motion parameters
- ❑ Execute homing sequences
- ❑ Control the program flow through:
  - o Conditional jumps and calls of TML functions
  - o Interrupts generated on pre-defined or programmable conditions (protections triggered, transitions of limit switch or capture inputs, etc.)
  - o Waits for programmed events to occur
- ❑ Handle digital I/O and analogue input signals
- ❑ Execute arithmetic and logic operations

The output from EasyMotion Studio II, in both versions, includes the setup data required for commissioning and, in the case of the FULL version, the TML motion program. This application data can be loaded into the drive's EEPROM or saved for later use. The FULL version also facilitates distributed intelligence by allowing users to program drives to perform complex tasks autonomously, reducing the workload on the master and enabling efficient multitasking in advanced systems.

Both versions of EasyMotion Studio II include powerful evaluation tools such as a Data Logger for capturing and analyzing drive performance, Control Panels for real-time interaction, and a Command Interpreter for executing and testing individual commands.

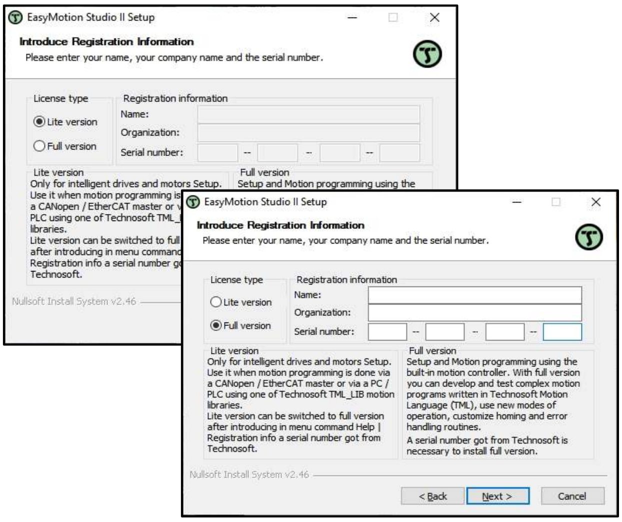
It is important to note that the LITE version can be upgraded to the FULL version by entering a license key obtained from Technosoft. This flexibility allows users to start with the LITE version and scale up to the advanced capabilities of the FULL version as their system requirements evolve.

1.1.2 Installing EasyMotion Studio II

The **EasyMotion Studio II** is available as a free download from the **Technosoft website** (link). It can be installed as either the LITE version (free) or the FULL version (requires a serial number for activation).

The **LITE version** provides all the necessary tools for drive and motor commissioning. It includes features such as the Data Logger, Scope, and Control Panels, which are essential for evaluating performance or debugging applications as needed.

The **FULL version**, in addition to the capabilities of the LITE version, enables the downloading of TML programs to the drive. This unlocks the full potential of the drive's built-in motion controller, allowing users to implement complex motion applications directly at the drive level or distribute intelligence between the master and the drive for advanced control systems.



EasyMotion Studio II Setup

Introduce Registration Information

Please enter your name, your company name and the serial number.

License type

○ Lite version

● Full version

Registration information

Name:

Organization:

Serial number: -- -- --

Lite version

Only for intelligent drives and motors Setup. Use it when motion programming is done via a CANopen / EtherCAT master or via a PC / PLC using one of Technosoft TML_LIB motion libraries.

Lite version can be switched to full version after introducing in menu command Help | Registration info a serial number got from Technosoft.

Full version

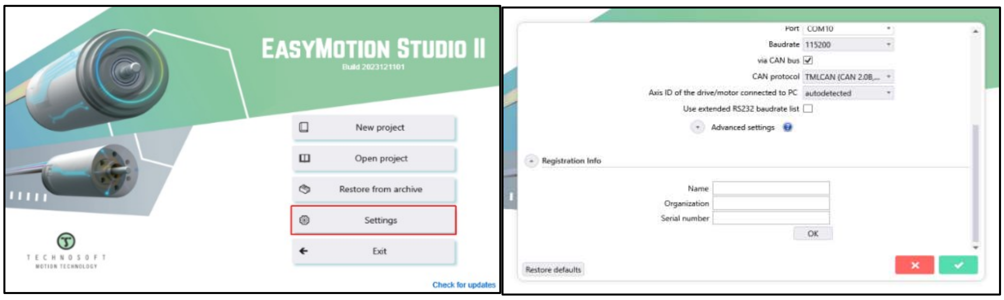
Setup and Motion programming using the built-in motion controller. With full version you can develop and test complex motion programs written in Technosoft Motion Language (TML), use new modes of operation, customize homing and error handling routines.

A serial number got from Technosoft is necessary to install full version.

Nullsoft Install System v2.46

Figure 1.1.1. *EasyMotion Studio II – Version selection*

The Full version can be activated any time by entering the Registration info in the Settings dialogue that can be opened from the EasyMotion Studio II splash screen.



Port COM10

Baudrate 115200

via CAN bus ☑

CAN protocol TMLCAN (CAN 2.0B,...

Axis ID of the drive/motor connected to PC autodetected

Use extended RS232 baudrate list □

Advanced settings

Registration Info

Name

Organization

Serial number

Figure 1.1.2 – Registration info in the Settings window

The Registration info window can also be accessed through the Help menu in the project window.

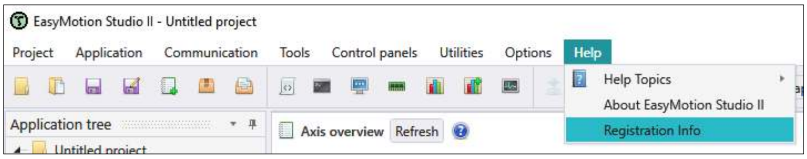


Figure 1.1.3 – Access the Registration info window via the Help menu

EasyMotion Studio II includes an **Update via Internet** tool. This feature allows users to check if their software is up-to-date and, if updates are available, download and install the latest version.

1.1.3 Establishing serial communication with the drive

EasyMotion Studio II establishes communication with the drive using one of the following interfaces: RS-232 serial link, USB, or EoE. The appropriate interface depends on the specific drive model and its supported communication protocols. For detailed information about the supported protocols, refer to the Drive Technical Reference Manual.

1.1.3.1 Connecting via RS-232

To connect to a drive using **EasyMotion Studio II**, begin by creating a **New project**. During this process, you'll select the communication channel and configure the necessary parameters. Once your settings are in place, use the **Scan Ports** option to refresh the list of available ports and choose the correct one for your setup.

If your PC doesn't have a built-in serial port, a USB-to-RS232 adapter can be used. For drives or Starter Kit boards equipped with a 9-pin serial port, simply connect the drive to your PC using a standard 9-wire, non-inverting serial cable.

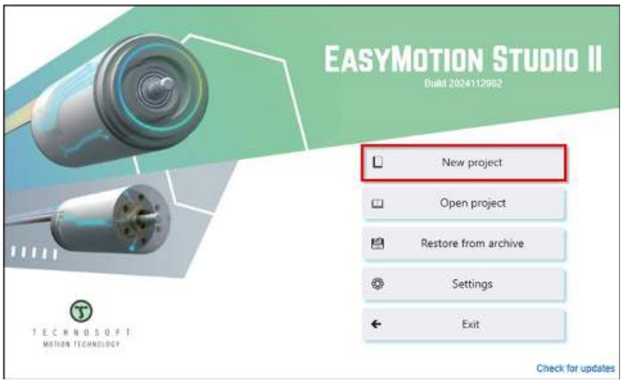
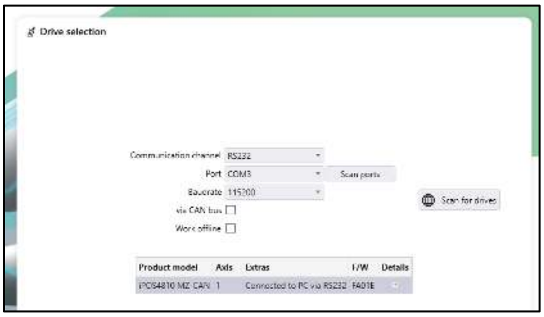


Figure 1.1.4. *EasyMotion Studio II - Opening window*

Once the physical connection is established, click **Scan for Drives** to initiate the detection process. EasyMotion Studio II will search for connected drives and display their details in a table, including the drive name, Axis ID, and firmware version. If no drive is detected, the software will display an error message, prompting you to double-check your connections and configuration settings before trying again.

If you don't have a drive connected, EasyMotion Studio II offers the flexibility to work offline. By selecting the Work Offline option, you can choose a model from a predefined list and continue configuring your project without needing a physical connection.



Communication channel RS232
Port COM3
Baudrate 115200
via CAN bus □
Work offline □

Product model	Axis	Extras	F/W	Details
iPOS4810 MZ-CAN	1	Connected to PC via RS232	FA01E	

Figure 1.1.5. *EasyMotion Studio II – Scan results*

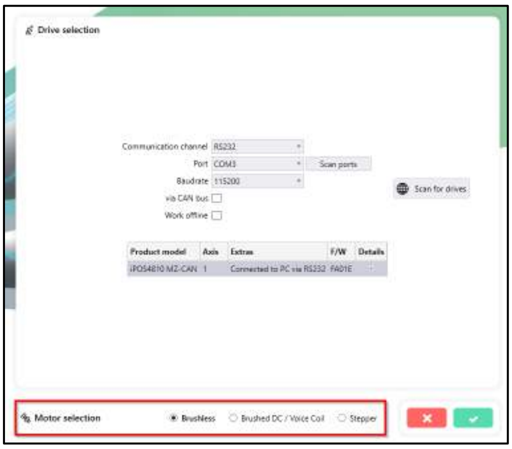
Technosoft drives utilize a unique **AxisID** (address) for serial communication. Additional information on selecting the AxisID can be found in Understanding EtherCAT® addressing modes supported.

To open an existing project in EasyMotion Studio II, click the **Open Project** button to browse and select a project from a specific location. If you need to restore a project archive, including one created with the earlier version of EasyMotion Studio II, use the arrow next to the **Restore from Project Archive** option to access and import the desired file.

Note: The file extension for EasyMotion Studio I archives is `*.m.zip`, while EasyMotion Studio II archives use the `*.e2p` extension.

1.1.4 Choosing the the drive and motor configuration

Once the drive has been successfully identified, key information such as its name, AxisID, and firmware version will be displayed. At this point, you can select the desire motor technology. After finalizing the drive and motor technology selection, simply click the green tick button in the Motor Selection group box to proceed. This action concludes the selection wizard and transitions you to the project window, where you can continue with advanced configuration and programming tasks.



Communication channel RS232
Port COM3
Baudrate 115200
via CAN bus □
Work offline □

Product model	Axis	Extras	F/W	Details
iPOS4810 MZ-CAN	1	Connected to PC via RS232	FA01E	

Motor selection ● Brushless ○ Brushed DC / Voice Coil ○ Stepper

Figure 1.1.6. *EasyMotion Studio II – Drive and Motor selection*

When you start a new project in EasyMotion Studio II, the software automatically creates an initial application as a starting point. Additional applications can be added later using the **New** or **Duplicate** options available in the **Application** menu.

Each application is organized into three main branches:

- **Setup** – Dedicated to configuring the drive and motor settings.
- **Motion** – Reserved for application development, accessible only in the full version of EasyMotion Studio II.
- **Memory Settings** – Provides an overview of memory usage and tools for configuring memory-related parameters.

The **Setup** branch, essential for initializing the drive and motor, will be detailed in the following chapters.

1.1.5 Commissioning the drive

The **Setup** branch is designed to guide you through the drive commissioning process, offering two modes: **Quick Setup** and **Advanced Setup**. You can select your preferred mode using the radio button located at the top of the Setup tree section.

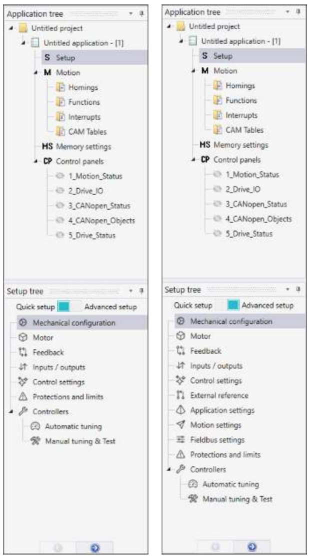
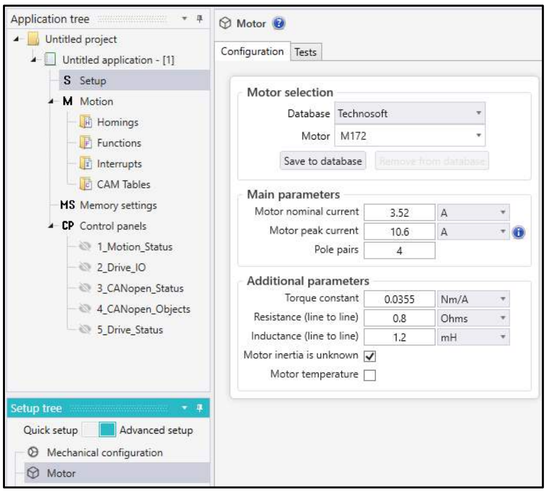


Figure 1.1.7. *EasyMotion Studio II – Quick Setup vs. Advanced setup*

The **Quick Setup** mode is ideal for scenarios where all connections have already been validated and the motor and feedback parameters are well understood. This simplified approach enables rapid commissioning, saving time in well-prepared environments. However, for new projects, it is strongly recommended to use the **Advanced Setup** mode. This mode provides a comprehensive framework for conducting various tests to validate the motor, feedback, and drive connections. It ensures that all components are functioning correctly, reducing the risk of errors during operation.

Regardless of the selected setup structure (quick or advanced), the drive commissioning procedure assumes checking all the Setup tree branches (one by one, from top to the bottom), set the needed parameters and enable/disable the application related options.

The **Mechanical Configuration** section, available in both Quick and Advanced Setup modes, defines the motor-to-load transmission type and ratio, including configurations for rotary-to-rotary, rotary-to-linear, or linear-to-linear systems. If the motor includes an electromechanical brake, this section allows configuring its control.



Motor selection

Database Technosoft

Motor M172

Main parameters

Motor nominal current 3.52 A

Motor peak current 10.6 A

Pole pairs 4

Additional parameters

Torque constant 0.0355 Nm/A

Resistance (line to line) 0.8 Ohms

Inductance (line to line) 1.2 mH

Motor inertia is unknown ☑

Motor temperature □

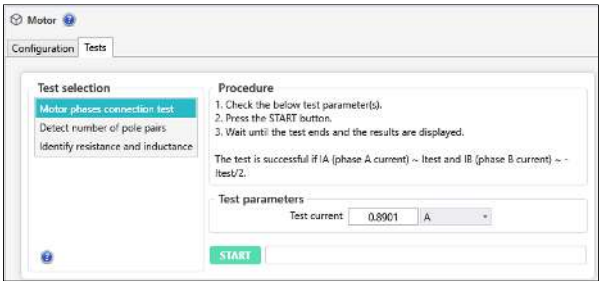
Figure 1.1.8. *EasyMotion Studio II – Motor Setup*

The **Motor Setup** page provides two main tabs: **Configuration** and **Tests**.

In the **Configuration** tab, you can:

- **Select the Motor**: Load parameters from a predefined database or save custom configurations for future use.
- **Set Main Parameters**: Define values such as nominal and peak current, as well as the number of motor pole pairs, in line with the motor data sheet.
- **Add Additional Parameters**: Optionally input data like torque constant, phase resistance, inductance, rotor inertia, and temperature sensor type. Built-in tests can identify these if not available from the motor data sheet.

The **Tests** tab allows testing the motor phases connection, detect the number of the motor pole pairs and identify the motor winding resistance and inductance.


Motor
Configuration
Tests
Test selection
Motor phases connection test
Detect number of pole pairs
Identify resistance and inductance
START

Procedure

1. Check the below test parameter(s).
2. Press the START button.
3. Wait until the test ends and the results are displayed.

The test is successful if IA (phase A current) ~ Itest and IB (phase B current) ~ -Itest/2.

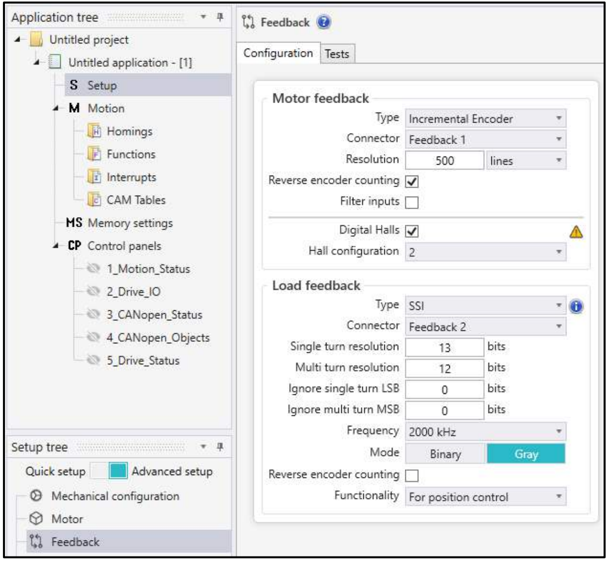
Test parameters

Test current 0.8901 A

Figure 1.1.9.*EasyMotion Studio II – Motor Tests*

The **Feedback Setup** page is used to configure motor and load feedback sensors.

- The Configuration tab adapts to the selected feedback type and guides users to input sensor-specific parameters, referencing the sensor's data sheet.
- The Tests tab (Advanced Setup mode) allows you to validate sensor connections and detect sensor characteristics, such as resolution or alignment.



Motor feedback

Type Incremental Encoder

Connector Feedback 1

Resolution 500 lines

Reverse encoder counting ☑

Filter inputs ☐

Digital Halls ☑

Hall configuration 2

Load feedback

Type SSI

Connector Feedback 2

Single turn resolution 13 bits

Multi turn resolution 12 bits

Ignore single turn LSB 0 bits

Ignore multi turn MSB 0 bits

Frequency 2000 kHz

Mode Binary [✓ Gray]

Reverse encoder counting ☐

Functionality For position control

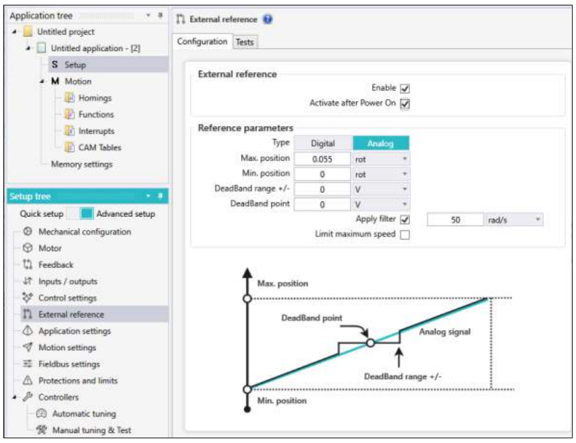
Figure 1.1.10.*EasyMotion Studio II – Feedback Setup*

The **Inputs/Outputs** page in EasyMotion Studio II simplifies configuring the drive's input and output signals. By default, Technosoft drives include general-purpose inputs/outputs and some with specialized functions. These specialized functions can be disabled by setting them to "General Purpose Input/Output." Additionally, the Analog Inputs group box allows the drive to read analog voltage signals, configurable for 0–5 V or ±10 V ranges.

The **Control Settings** section enables selecting the desired control mode — Position, Speed, or Torque — and configuring the control structure, such as position control with or without an active speed controller.

In Position mode, the drive activates internal current and position loops, supporting various position profiles like trapezoidal, S-curve, PT and PVT. Speed mode engages the current and speed loop, enabling precise speed profile execution. For Torque mode, only the current controller remains active, providing direct control of the motor's torque output.

The **External Reference** section, available only in Advanced Setup mode, allows the drive to interpret an external signal (digital or analog) and convert it into a position, speed, or torque reference.



External reference

Enable ☑

Activate after Power On ☑

Reference parameters

Type: Digital [✓ Analog]

Max. position: 0.055 rot

Min. position: 0 rot

DeadBand range +/-: 0 V

DeadBand point: 0 V

Apply filter ☑ 50 rad/s

Limit maximum speed ☐

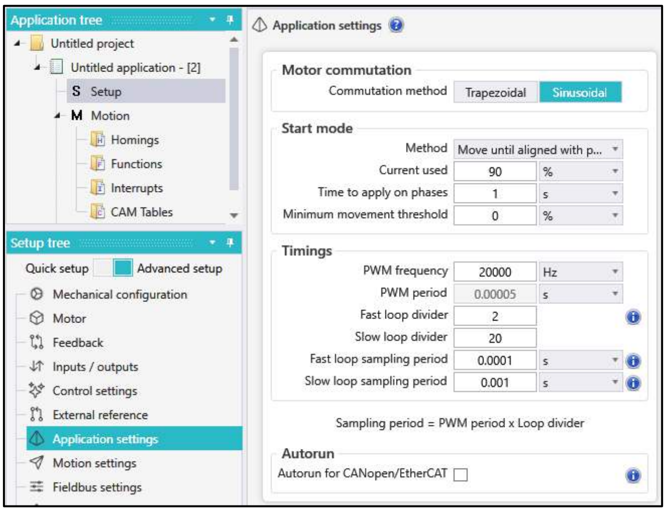
Figure 1.1.11.*EasyMotion Studio II – Analog external reference settings*

When **Digital Reference** is selected, the drive can process Pulse & Direction signals or a quadrature incremental encoder input, calculating the reference using a programmable gear ratio.

When **Analog Reference** is selected, the drive reads a voltage signal, either 0 V to 5 V or ±10 V (refer to the user manual for supported ranges), and converts it into a position, speed, or torque reference based on the selected control mode.

Enabling the Automatically Activated After Power On option ensures that external reference mode is automatically engaged upon power-up, provided AUTORUN mode is enabled and no application program is stored in the drive's memory.

The **Application Settings** section, available in Advanced Setup mode, provides tools for configuring commutation methods, startup modes, timing adjustments, and autorun functionality for EtherCAT.



Motor commutation

Commutation method: Trapezoidal [✓ Sinusoidal]

Start mode

Method: Move until aligned with p...

Current used: 90 %

Time to apply on phases: 1 s

Minimum movement threshold: 0 %

Timings

PWM frequency: 20000 Hz

PWM period: 0.00005 s

Fast loop divider: 2

Slow loop divider: 20

Fast loop sampling period: 0.0001 s

Slow loop sampling period: 0.001 s

Sampling period = PWM period x Loop divider

Autorun

Autorun for CANopen/EtherCAT ☐

Figure 1.1.12.*EasyMotion Studio II – Application Settings*

You can select the **commutation method** based on the desired motor control strategy:

- ❑ In **Trapezoidal mode**, the motor functions as a brushless DC motor, with Hall sensors managing commutation.
- ❑ **Sinusoidal mode** treats the motor as a Permanent Magnet Synchronous Motor (PMSM), using Field-Oriented Control (FOC). This mode requires precise rotor position detection, performed during startup.

The FOC algorithm is possible only if the rotor position is precisely known. The drive checks it after Power On or Reset, through a start method. This method can be selected / configured though the **Start mode** group box.

Within the **timings section**, you can adjust:

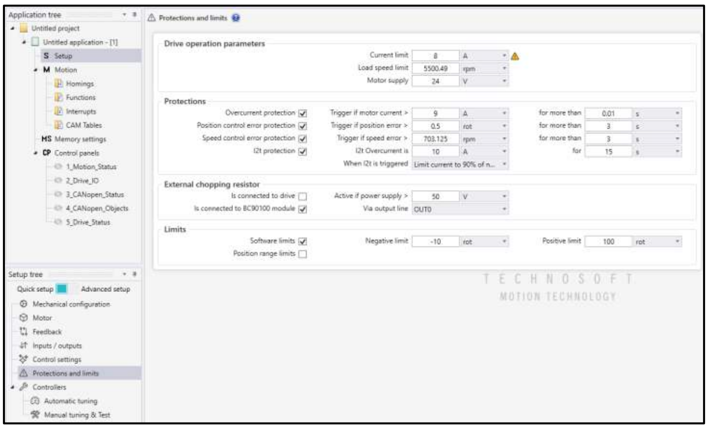
- ❑ **PWM frequency**, which should remain within the safe range of 20 kHz to 80 kHz.
- ❑ **Sampling periods**, with defaults set to 0.1 ms for the fast loop and 1 ms for the slow loop, ensuring optimal control system performance.

The **Autorun for EtherCAT** feature allows the drive to automatically execute the TML program at power-on or reset, streamlining operations and reducing the need for manual intervention.

The **Fieldbus Settings** section, available exclusively in the Advanced setup, includes the configurations of:

- ❑ **Axis ID:** Ranging from 1 to 255, equivalent to the Configured Station Alias address, can be set either through hardware (as detailed in the drive’s user manual) or using software in EasyMotion Studio II.
- ❑ **Factor Group:** Allows selecting the desired physical unit for position, speed, acceleration and jerk values. For more details, consult chapter Factor group.

The **Protections and limits** section covers motor protections and operational limits to prevent system damage during tests or normal operation.



Protections and limits

Drive operation parameters

Current limit: 8 A
Load speed limit: 5500.49 rpm
Motor supply: 24 V

Protections

Overcurrent protection ☑ Trigger if motor current > 9 A for more than 0.01 s
Position control error protection ☑ Trigger if position error > 0.5 rot for more than 3 s
Speed control error protection ☑ Trigger if speed error > 703.125 rpm for more than 3 s
I2t protection ☑ I2t Overcurrent is 10 A for 15 s
When I2t is triggered: Limit current to 90% of n...

External chopping resistor

Is connected to drive ☐ Active if power supply > 50 V
Is connected to BC90100 module ☑ Via output line: OUT0

Limits

Software limits ☑ Negative limit -10 rot Positive limit 100 rot
Position range limits ☐

__Figure 1.1.13.__EasyMotion Studio II – Protections and limits settings

Drive Operation Parameters:

- ❑ **Current Limit:** Sets the maximum current applied to the motor, typically slightly higher than the motor's nominal current but lower than its peak current to avoid prolonged overloads.
- ❑ **Load Speed Limit:** Restricts the load speed to protect the mechanical system and operators from unsafe speeds.
- ❑ **Motor Supply:** Represents the voltage applied to the motor’s “Vmot” input.

Protections:

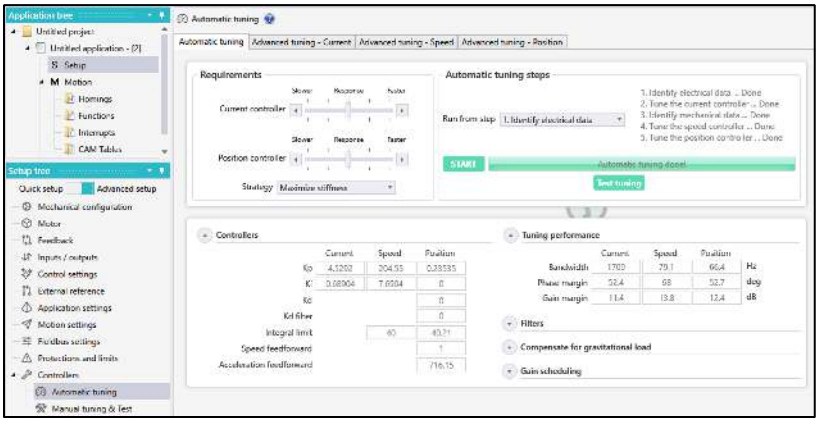
- ❑ **Over Current:** Triggers if motor current exceeds the limit for a specified time. The current value is set slightly above the limit but below the motor's peak current.
- ❑ **Control Error:** Monitors position or speed errors and triggers if they exceed the set limits for too long.
- ❑ **I^{2}t Thermal Protection:** Prevents motor damage from prolonged over-current operation. The drive calculates the I^{2}t value to ensure safe operation, limiting current if necessary.

External Chopping Resistor: Protects against overvoltage caused by energy transferred during braking or reversing by dissipating the excess energy through a resistor.

Limits:

- ❑ **Software Limit Switches:** The software limits switches act like the hardware limit switches, when the positive or negative limits are reached.
- ❑ **Position Range Limits:** Uses software limits to restrict the movement using a specified position range.

The **Controllers Section** in EasyMotion Studio II provides tools for configuring controller parameters, detecting system inertia (available in Advanced setup mode), and tuning controllers either automatically or manually.



Automatic tuning

Requirements

Current controller
Position controller
Strategy: Maximize stiffness

Automatic tuning steps

Run from step: 1. Identify electrical data

1. Identify electrical data ... Done
2. Tune the current controller ... Done
3. Identify mechanical data ... Done
4. Tune the speed controller ... Done
5. Tune the position controller ... Done

Automatic tuning done!

Controllers

	Current	Speed	Position
Kp	4.5202	204.55	0.23535
Ki	0.08904	7.0904	0
Kd			0
Kd filter			0
Integral limit		60	40.21
Speed feedforward			1
Acceleration feedforward			716.15

Tuning performance

	Current	Speed	Position	
Bandwidth	1700	79.1	66.4	Hz
Phase margin	52.4	68	52.7	deg
Gain margin	11.4	13.8	12.4	dB

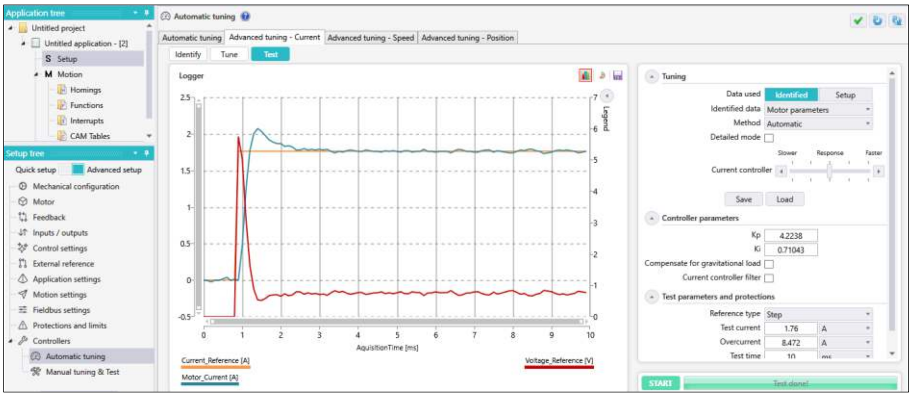
***Figure 1.1.14.** EasyMotion Studio II – Automatic tuning page*

The **Automatic Tuning** option simplifies parameter configuration based on the desired system response. Pressing the **START** button initiates the tuning process. Once completed successfully, a **"Automatic tuning done!"** message appears in the progress bar, along with the detected or computed parameters displayed in the Controllers and Tuning Performances section.
If tuning fails, a **"Automatic tuning failed"** message will appear, and hovering over the progress bar provides additional information about the issue.

Advanced Tuning Tabs:

- ❑ **Identify:** Displays detected data used for tuning and allows modifications to identification methods for repeating the process.
- ❑ **Tune:** Shows computed parameters and the estimated controller response, enabling parameter adjustments or re-tuning as needed.
- ❑ **Test:** Allows testing the controller's response and refining parameters for optimal performance.

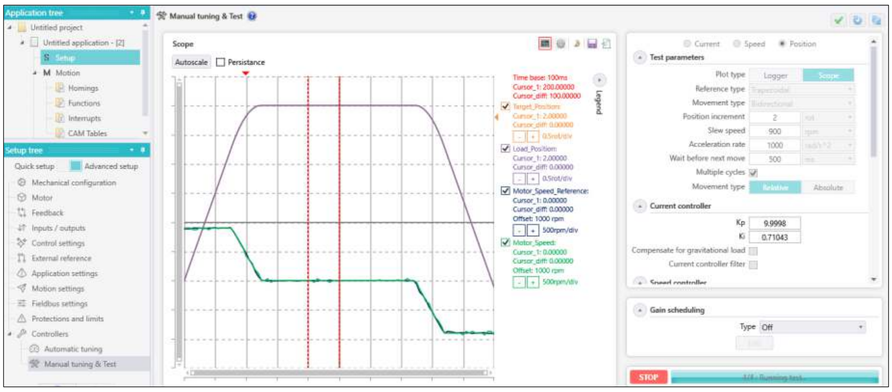
Note: To achieve the best system performance, ensure the load is connected to the motor during the tuning process.



Data used: Identified / Setup
Identified data: Motor parameters
Method: Automatic
Detailed mode □
Current controller
Kp 4.2238
Ki 0.71043
Compensate for gravitational load □
Current controller filter □
Reference type: Step
Test current: 1.76 A
Overcurrent: 8.472 A
Test time: 10 ms

***Figure 1.1.15.** EasyMotion Studio II – Advanced tuning tabs*

The **Manual Tuning & Test** section enables users to run current, speed, or position profiles while fine-tuning active controller parameters. This process allows real-time monitoring and analysis of system behaviour using integrated tools such as the logger and scope.



Autoscale □ Persistance
Time base: 100ms
Cursor_1: 200.00000
Cursor_diff: 100.00000
☑ Target_Position
Cursor_1: 2.00000
Cursor_diff: 0.00000
0.5rot/div
☑ Load_Position
Cursor_1: 2.00000
Cursor_diff: 0.00000
0.5rot/div
☑ Motor_Speed_Reference
Cursor_1: 0.00000
Cursor_diff: 0.00000
Offset: 1000 rpm
500rpm/div
☑ Motor_Speed
Cursor_1: 0.00000
Cursor_diff: 0.00000
Offset: 1000 rpm
500rpm/div
○ Current ○ Speed ● Position
Plot type: Logger / Scope
Reference type: Trapezoidal
Movement type: Bidirectional
Position increment: 2 rot
Slew speed: 900 rpm
Acceleration rate: 1000 rad/s^2
Wait before next move: 500 ms
Multiple cycles ☑
Movement type: Relative / Absolute
Kp 9.9998
Ki 0.71043
Compensate for gravitational load □
Current controller filter □
Type: Off

***Figure 1.1.16.** EasyMotion Studio II – Manual tuning page*

***Note:** For detailed instructions and additional options, refer to the Help menu or click the "?" icon within the interface.*

1.1.6 Downloading setup data to drive/motor. Saving setup data.

The configured setup can be transferred to the drive using the Write Setup to Drive option, accessible from the Application menu or via the ribbon button highlighted with a red square in the image below.

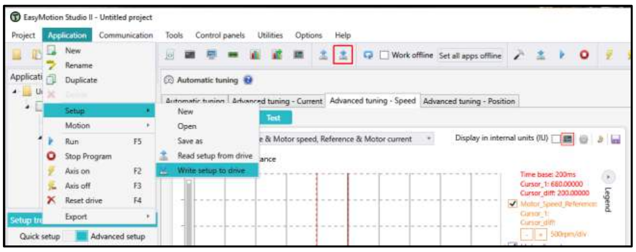


Figure 1.1.17. *EasyMotion Studio II - Write the setup parameters to the drive memory*

Once the setup is successfully written to the drive's non-volatile memory (EEPROM), a reset is required to activate it. The new settings will take effect at the next power-on, as the setup data is loaded into the active RAM memory used during runtime.

You can also save the setup data to your PC for future use, making it convenient to access and reuse when needed.

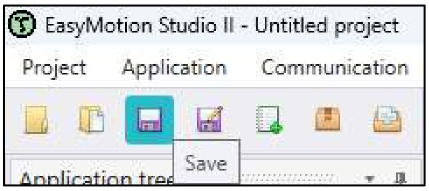


Figure 1.1.18. *EasyMotion Studio II – Save project*

In summary, you can create, modify, or load setup data in the following ways:

- Create New Setup Data: Configure a setup by completing the motor and drive dialogues.
- Use Previously Saved Data: Load setup data that was previously saved on your PC.
- Upload Data from EEPROM: Retrieve setup data stored in the drive or motor's EEPROM memory.

1.1.7 Creating a .sw file with the setup data

After validating your setup, you can export a software file (.sw) containing all the setup data to be written into the drive's EEPROM. This can be done via the menu command **Application | Export | EEPROM File**.

The .sw file is a text file that can be opened with any text editor and contains blocks of data formatted for EEPROM programming. Each block begins with a start address, followed by sequential data values to be written to consecutive memory locations. The structure of the file:

- Start address: Indicates where the block begins in the EEPROM.
- Data values: Ordered sequentially, specifying what to write at each consecutive address starting from the block's start address.
- The data values are 16-bit hexadecimal numbers (maximum of 4 digits) written in right-justified format. For example: A value of 92 is represented as 0x0092.
- Each data value is listed on a separate line, and blocks are separated by an empty line for clarity.

The .sw file can be programmed into a drive using the following methods:

- Via EtherCAT® Master: Use communication objects to write data into the drive EEPROM. For detailed instructions, refer to Downloading an image file (.sw) to the drive using CoE objects example.
- Via EtherCAT® Master: Utilize the File over EtherCAT (FoE) protocol, available only with firmware version FA0xx, F515F or newer. See Writing a FoE (File over EtherCAT) Setup data file using TwinCAT 3 example for more information.
- Using the EEPROM Programmer Tool: Available in the EasyMotion Studio II installation package, this tool enables fast and efficient programming of .sw files into Technosoft drives. Access the tool via Utilities | EEPROM Programmer.

1.1.8 Checking and updating setup data via .sw files with an EtherCAT® master

You can configure an EtherCAT® master to automatically verify, after power-up, whether all Technosoft drives on the EtherCAT® network have the correct setup data stored in their EEPROM. This verification process involves comparing the contents of each drive's EEPROM with the corresponding reference .sw file for its axis, which must first be loaded into the EtherCAT® master.

The fastest way to perform this comparison is by checking the checksums. The EtherCAT® master calculates the checksum for the .sw file data and compares it with the checksum calculated by the drive for the same address range in its EEPROM. If a mismatch is detected, the EtherCAT® master must reload the correct reference .sw file into the drive. For detailed examples of programming a .sw file into a drive and verifying its consistency against a reference .sw file, see Writing a FoE (File over EtherCAT) Setup data file using TwinCAT 3 example.

1.1.9 Testing and monitoring the drive behavior

EasyMotion Studio II provides several pre-defined **control panels** for monitoring and diagnosing system parameters, such as motion, drive I/O, and CANopen status. Users can customize panel content, create new panels, or import/export existing configurations. However, for real-time data, the **Logger** or **Scope** tools are recommended.

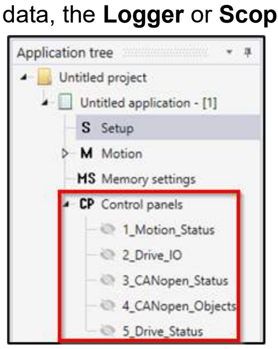


Figure 1.1.19. *EasyMotion Studio II – Predefined Control Panels*

Users can modify the default content of control panels by right-clicking on the panel surface and selecting the Customize option. Additionally, they can create new control panels or import/export existing ones via the Control Panels menu.

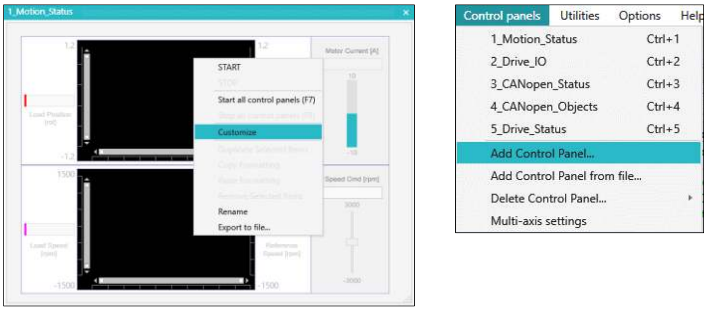


Figure 1.1.20. *EasyMotion Studio II – Control Panels Options*

The **Logger** allows users to configure, capture, and analyse data by selecting variables and setting acquisition parameters through the Logger ribbon or by right-clicking on the Logger interface. Data is stored in the drive's RAM, ensuring high accuracy but limiting the number of points due to memory constraints.

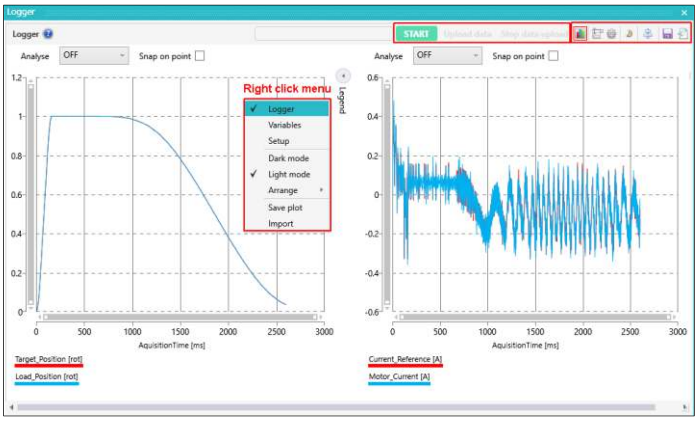
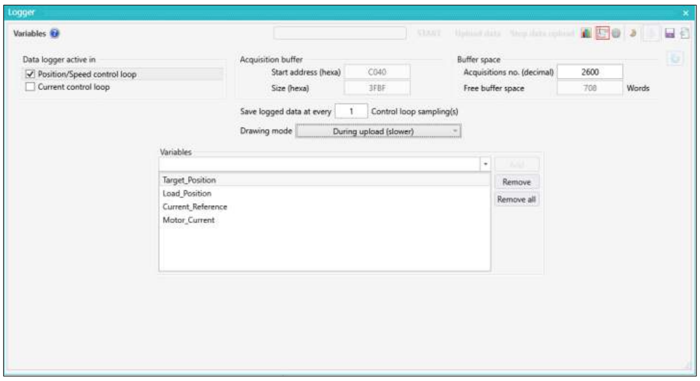


Figure 1.1.21. *EasyMotion Studio II – Logger*

The first step in using the Logger consist in choosing the variables and setting the acquisition parameters.


Logger

Variables

Data logger active in

☑ Position/Speed control loop

☐ Current control loop

Acquisition buffer

Start address (hexa) C040

Size (hexa) 3FBF

Buffer space

Acquisitions no. (decimal) 2600

Free buffer space 708 Words

Save logged data at every 1 Control loop sampling(s)

Drawing mode During upload (slower)

Variables

Target_Position

Load_Position

Current_Reference

Motor_Current

Figure 1.1.22. *EasyMotion Studio II – Logger acquisition menu*

The data acquisition starts automatically when running the TML application but can also be triggered manually, using the **Start** button in the Logger ribbon.

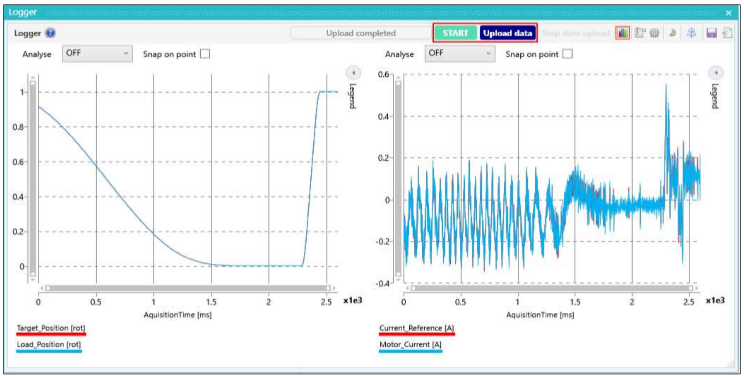


Figure 1.1.23. *EasyMotion Studio II – Logger operation options*

The **Upload data** button in the Logger ribbon will start the plotting process, while the **Stop data upload** option stops the uploading process, keeping on the Logger just the portion of the recording that was already plotted.

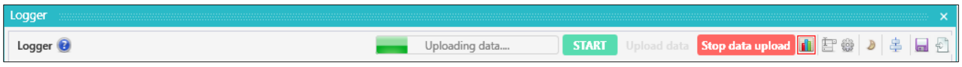
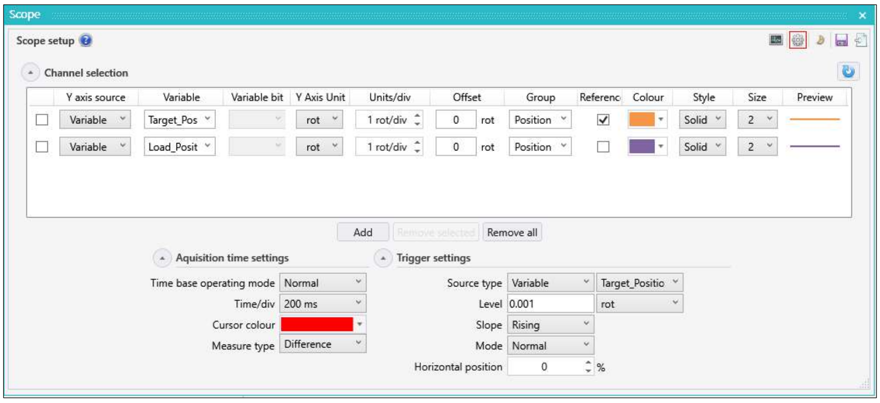


Figure 1.1.24.** EasyMotion Studio II* – ***Logger uploading cancelation

The plots can be saved, using the **Save** button in the Logger ribbon, as a Logger files (*.lgs), a text file ("*.txt"), an image ("*.png") or as an Excel files ("*.csv").

The **Scope** functions as a 4-channel oscilloscope, enabling real-time monitoring of variables, parameters, registers, or input/output statuses.

The Scope setup page can be accessed through the button in the Scope ribbon or using the right click menu and allows configuring the 4 available channels and setting the acquisition and triggering parameters.



	Y axis source	Variable	Variable bit	Y Axis Unit	Units/div	Offset		Group	Referenc	Colour	Style	Size	Preview
☐	Variable	Target_Pos		rot	1 rot/div	0	rot	Position	☑	🟧	Solid	2	
☐	Variable	Load_Posit		rot	1 rot/div	0	rot	Position	☐	🟪	Solid	2	

Aquisition time settings

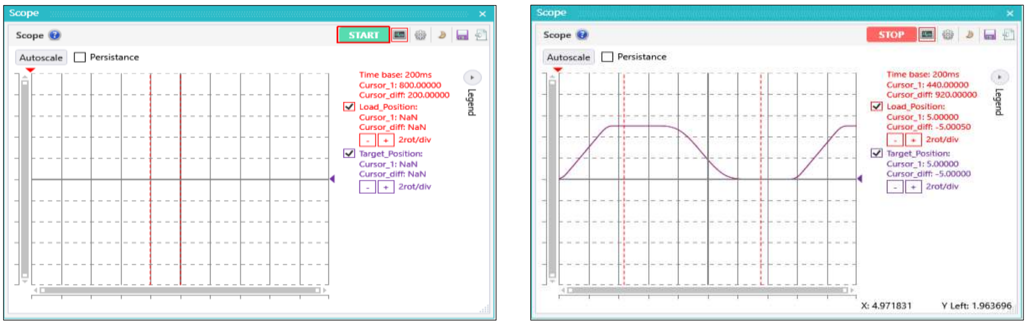
Time base operating mode: Normal
Time/div: 200 ms
Cursor colour: 🟥
Measure type: Difference

Trigger settings

Source type: Variable, Target_Positio
Level: 0.001 rot
Slope: Rising
Mode: Normal
Horizontal position: 0 %

***Figure 1.1.25.** EasyMotion Studio II – Scope Setup window*

The data acquisition starts when pressing the **START** button, in the Scope ribbon, and the information is updated continuously until the acquisition is stopped, using the **STOP** button in the Scope ribbon.



Time base: 200ms
Cursor_1: 800.00000
Cursor_diff: 200.00000
☑ Load_Position:
Cursor_1: NaN
Cursor_diff: NaN
2rot/div
☑ Target_Position:
Cursor_1: NaN
Cursor_diff: NaN
2rot/div

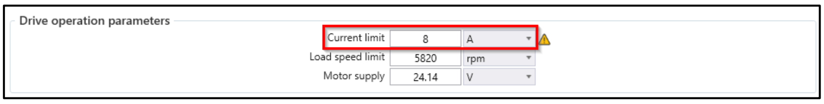
Time base: 200ms
Cursor_1: 440.00000
Cursor_diff: 920.00000
☑ Load_Position:
Cursor_1: 5.00000
Cursor_diff: -5.00050
2rot/div
☑ Target_Position:
Cursor_1: 5.00000
Cursor_diff: -5.00000
2rot/div
X: 4.971831 Y Left: 1.963696

***Figure 1.1.26.** EasyMotion Studio II – Motion evaluation using the Scope*

Note: For detailed instructions and additional options, refer to the Help menu or click the "?" icon within the interface.

1.2 Setting the current limit

One of the key protections to configure is the **Current Limit** (accessible via **Setup | Protections and Limits**), which defines the maximum current supplied to the motor. This value is typically set slightly above the motor's nominal current but below its peak current to prevent prolonged overloads. Alternatively, the current limit can be configured using Object 207F$_h$: Current limit.



Drive operation parameters

Current limit: 8 A
Load speed limit: 5820 rpm
Motor supply: 24.14 V

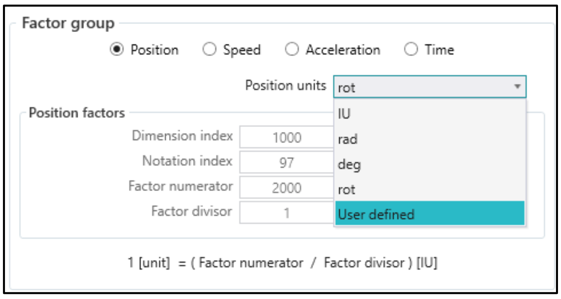
***Figure 1.2.1.**EasyMotion Studio II – Setting the current limit*

1.3 Factor group setting

The factor group settings currently implemented are complying with:
- CiA-402-2 and later versions – starting with F515K / FA0xx firmware versions
- CiA-402 – for other firmware versions

1.3.1 Factor group setting - CiA-402 (obsolete)

The Fieldbus Settings opens an interface that allows access to the scaling factors for position, speed, acceleration and time objects. These settings are linked directly to the objects 6089h, 608Ah, 608Bh, 608Ch, 608Dh, 608Eh, 206Fh,2070h, 6093h, 6094h, 6097h and 2071h. This means that these settings can be chosen either from Setup or by later setting the objects themselves. The factor group dialogue can select the units to be used when writing or reading the Position, Velocity or Acceleration objects. These settings already have a list standard units defined in the standard CiA402 and there is the option of customization.



Factor group
● Position ○ Speed ○ Acceleration ○ Time
Position units: rot
Position factors
Dimension index: 1000
Notation index: 97
Factor numerator: 2000
Factor divisor: 1
1 [unit] = (Factor numerator / Factor divisor) [IU]

Figure 1.3.1. Factor group dialogue in compliance with CiA-402

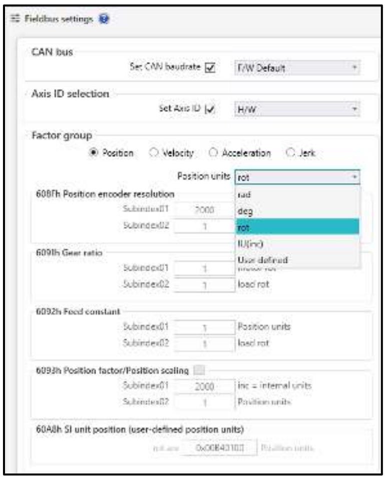
In the last case, the user can set the factor numerator and divisor in order to obtain the needed scaling. The dimension and notation index (and their linked objects) have no influence over any scaling. Their purpose is only to define an [SI] unit name like rpm, rad, deg, etc. The factor group settings are stored in the setup table. By default, the drive uses its internal units. The correspondence between the drive internal units and the [SI] units is presented in the drives user manual.
For the [SI] dimension and notation index list, see ***Dimension/Notation Index Table.***
Remarks:

- the dimension and notation index objects (6089h, 608Ah, 608Bh, 608Ch, 608Dh, 608Eh, 206Fh and 2070h) have been classified as obsolete by the CiA 402 standard. They are now used only for legacy purposes, on EtherCAT masters which still need them.
- because the iPOS drives work with Fixed 32 bit numbers (not floating point), some calculation round off errors might occur when using objects 6093h, 6094h, 6097h and 2071h. If the EtherCAT® master supports handling the scaling calculations on its side, it is recommended to use them instead of using the "*Factor*" scaling objects.

1.3.2 Factor group setting - CiA-402-2

The Fieldbus Settings opens an interface which allows to select the desired physical unit for position, speed, acceleration and jerk values. These settings are linked directly to the objects presented in chapter Factor group objects - CiA-402-2. The factor group that complies with CiA-402-2 is available starting with firmware version **F515K / FA0xx**.

The factor group settings can be modified either in the Setup part of the project, or by changing the factor group objects directly using EtherCAT protocol. If the settings are changed in the Setup part, once the desired unit is selected, EasyMotion Studio II automatically computes the scaling factors according to each mechanical setup.In this case, the settings are stored in the non volatile memory and remain active regardless of the drive state (reset, power lost, etc.).



Fieldbus settings
CAN bus
Set CAN baudrate ☑ F/W Default
Axis ID selection
Set Axis ID ☑ H/W
Factor group
● Position ○ Velocity ○ Acceleration ○ Jerk
Position units: rot
608Fh Position encoder resolution
Subindex01: 2000
Subindex02: 1
6091h Gear ratio
Subindex01: 1
Subindex02: 1 load rot
6092h Feed constant
Subindex01: 1 Position units
Subindex02: 1 load rot
6093h Position factor/Position scaling □
Subindex01: 2000 inc = internal units
Subindex02: 1 Position units
60A8h SI unit position (user-defined position units)
0x00B43100 Position units

Figure 1.3.2. Factor group dialogue in compliance with CiA-402-2

The Factor Group should be adjusted once before any type of movement is realised and not changed during the movement.

In the Fieldbus Settings section can be found all the objects that corresponds to the specific unit and the scalling factors computed by EasyMotion Studio II according to the feedback, transmission and slow loop period.

If other units than the standardized option are needed, the scaling can be obtained also in the setup part if “User defined” option is selected.

By default, the drive uses its internal units (IU). The correspondence between the drive internal units and the [SI] units is presented in the Help menu of EasyMotion Studio II.

1.4 Using the built-in Motion Controller and TML

One of the key advantages of the Technosoft drives is their capability to execute complex motions without requiring an external motion controller. This is possible because Technosoft drives offer in a single compact package both a state of art digital drive and a powerful motion controller.

1.4.1 Technosoft Motion Language Overview

Programming motion directly on a Technosoft drive requires to create and download a TML (Technosoft Motion Language) program into the drive memory. The TML allows you to:

- Set various motion modes (profiles, PVT, PT, electronic gearing or camming, etc.)
- Change the motion modes and/or the motion parameters
- Execute homing sequences
- Control the program flow through:
  - Conditional jumps and calls of TML functions
  - Interrupts generated on pre-defined or programmable conditions (protections triggered, transitions of limit switch or capture inputs, etc.)
  - Waits for programmed events to occur
- Handle digital I/O and analogue input signals
- Execute arithmetic and logic operations

In order to program a motion using TML you need EasyMotion Studio II software platform.

Chapter *18* describes in detail how the TML features can be combined with the CoE programming.

1.5 Setting up EtherCAT® communication. Example with TwinCAT3

This section explains how to set up EtherCAT® communication using Beckhoff TwinCAT3 software on a PC. It also provides examples for programming the drive in various modes of operation, such as **Position Profile** and **Cyclic Synchronous Position**. Additionally, an example is included on how to map objects in **TxPDOs** and **RxPDOs**.

The examples presented use the **7-day free version** of TwinCAT v3.1.4022.29, which can be downloaded from Beckhoff's website www.beckhoff.de.

1.5.1 Adding the XML file

The .xml file can be found on the Technosoft web page of each EtherCAT drive. After TwinCAT installation is complete, copy the appropriate .xml file for your product in:

TwinCAT2 installation folder \Io\EtherCAT. The default location is “C:\TwinCAT\Io\EtherCAT”

TwinCAT3 installation folder \3.1\Config\Io\EtherCAT. The default location is “C:\TwinCAT\3.1\Config\Io\EtherCAT”

TwinCAT will need a restart in order to load the new file.

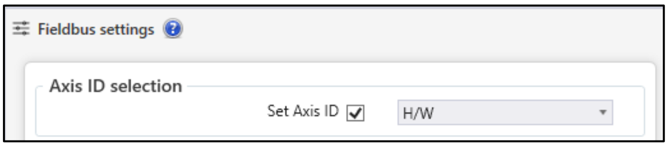
1.5.2 Understanding EtherCAT® addressing modes supported

There are three device addressing modes available in EtherCAT®: auto-increment addressing, configured station address, and broadcast. EtherCAT® devices support up to two configured station addresses:

1. **Configured Station Address**: Assigned by the EtherCAT® master.
2. **Configured Station Alias Address**: Optional and can be assigned by the drive. This alias address is loaded from the drive only after a power-on or reset event.

When the device addressing mode is based on node address, the EtherCAT® drive sets the Configured Station Alias Address to match its **AxisID** value. The AxisID is determined after power-on through one of the following methods:

1. **By Hardware**: For details, refer to the drive's user manual.
2. **By Software**: The AxisID can be explicitly set in the range 1–255 using the EasyMotion Studio II software.



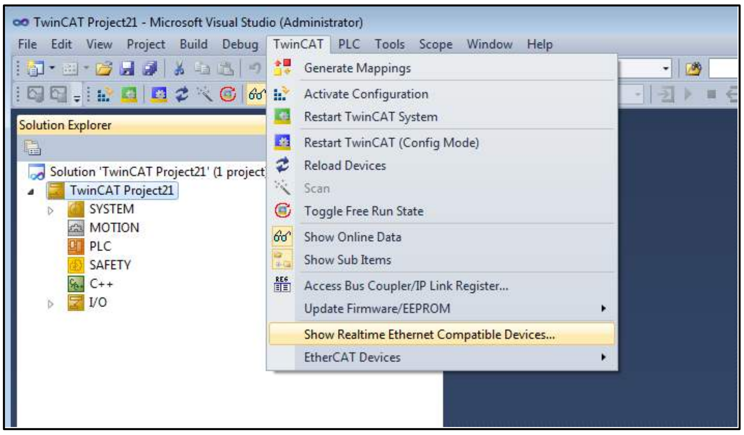
Set Axis ID ☑ H/W

***Figure 1.5.1** EasyMotion Studio II – Setting the Axis ID*

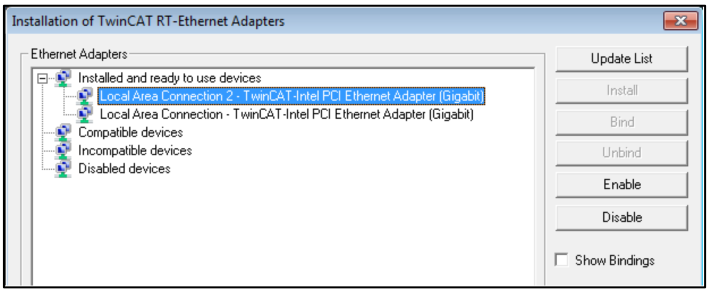
1.5.3 Detecting the drive with TwinCAT3

Once all connections are made and the system is powered on, ensure that the **link** and **activity** LEDs on the EtherCAT® drive are illuminated.

1. **Start TwinCAT XAE** and create a new project.
2. Go to the menu and select **TwinCAT -> Show Real-Time Ethernet Compatible Devices...**

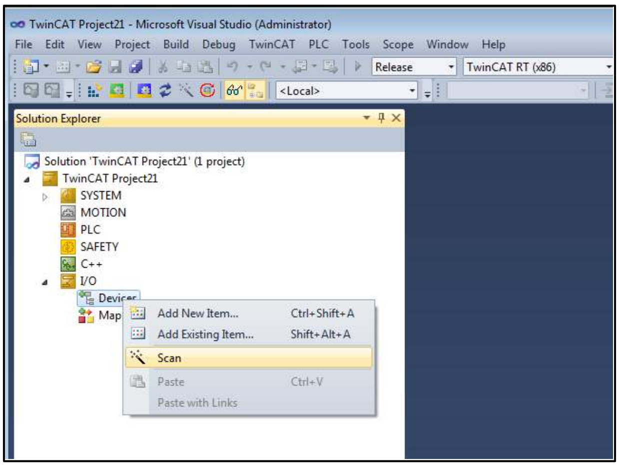

TwinCAT Project21 - Microsoft Visual Studio (Administrator)
File Edit View Project Build Debug TwinCAT PLC Tools Scope Window Help
Solution Explorer
Solution 'TwinCAT Project21' (1 project
TwinCAT Project21
SYSTEM
MOTION
PLC
SAFETY
C++
I/O
Generate Mappings
Activate Configuration
Restart TwinCAT System
Restart TwinCAT (Config Mode)
Reload Devices
Scan
Toggle Free Run State
Show Online Data
Show Sub Items
Access Bus Coupler/IP Link Register...
Update Firmware/EEPROM
Show Realtime Ethernet Compatible Devices...
EtherCAT Devices

- If no network card appears under **Installed and ready to use devices**, you will need to install one with an EtherCAT® driver.
  - Select a Network Ethernet Card (NIC) from the **Compatible Devices** list and click **Install**.
  - **Note**: In most cases, this step is performed automatically during TwinCAT installation.


Installation of TwinCAT RT-Ethernet Adapters
Ethernet Adapters
Installed and ready to use devices
Local Area Connection 2 - TwinCAT-Intel PCI Ethernet Adapter (Gigabit)
Local Area Connection - TwinCAT-Intel PCI Ethernet Adapter (Gigabit)
Compatible devices
Incompatible devices
Disabled devices
Update List
Install
Bind
Unbind
Enable
Disable
Show Bindings

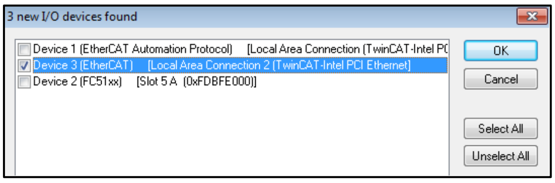
3. In the **Solution Explorer** (left panel), expand the **I/O Configuration** tree.

- Right-click on **Devices** and select **Scan**.
- Confirm the dialog that appears by clicking **OK**.


TwinCAT Project21 - Microsoft Visual Studio (Administrator)
File Edit View Project Build Debug TwinCAT PLC Tools Scope Window Help
Release
TwinCAT RT (x86)
<Local>
Solution Explorer
Solution 'TwinCAT Project21' (1 project)
TwinCAT Project21
SYSTEM
MOTION
PLC
SAFETY
C++
I/O
Devices
Map
Add New Item... Ctrl+Shift+A
Add Existing Item... Shift+Alt+A
Scan
Paste Ctrl+V
Paste with Links

4. From the list of detected I/O interfaces, select the ones you want to add and click **OK**.

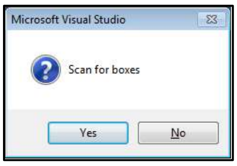
- **Note**: If you attempt to scan too soon after powering up the drive, it may not be detected. Wait **10–20 seconds** after powering up before scanning for new devices.



3 new I/O devices found

- □ Device 1 (EtherCAT Automation Protocol) [Local Area Connection (TwinCAT-Intel PC
- ☑ Device 3 (EtherCAT) [Local Area Connection 2 (TwinCAT-Intel PCI Ethernet)]
- □ Device 2 (FC51xx) [Slot 5 A (0xFDBFE000)]

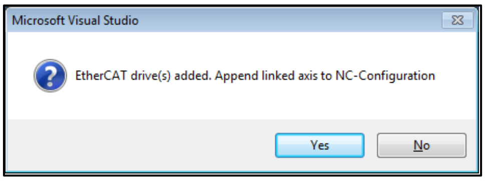
5. A confirmation dialog will appear. Click **Yes** to proceed.



Microsoft Visual Studio

Scan for boxes

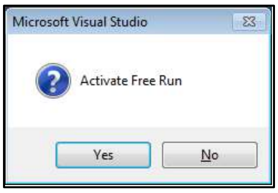
6. In the next dialog, click **Yes** to add the drives to the **NC-Configuration**.



Microsoft Visual Studio

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

7. Finally, confirm **Free Run** mode by clicking **Yes** in the subsequent dialog.



Microsoft Visual Studio

Activate Free Run

Note: Free Run mode is used in the following examples to simplify the setup process, as it avoids the need for an additional PLC layer.

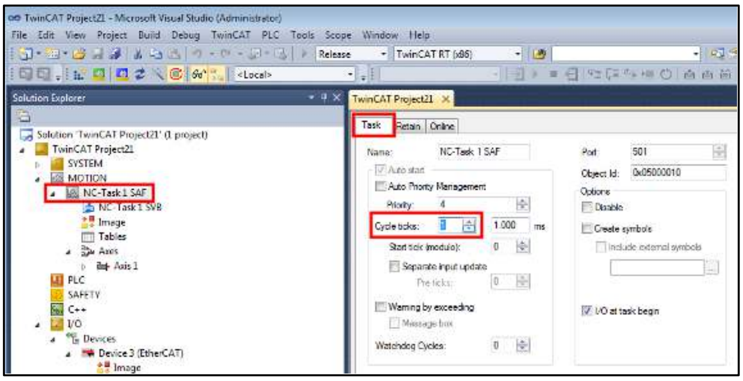
1.5.4 Configuring Technosoft EtherCAT drives for NC PTP compatibility (CSP example)

After the instructions from chapter **0** are complete, do the following:

1.5.4.1 Setting the communication cycle time for RUN mode

Double-click on the **NC-Task** to configure the communication cycle time. In the **Task** tab, set the cycle ticks to **1** to achieve a communication cycle time of **1 ms**, which matches the drive's slow loop for optimal performance.

Note: If the drive's slow loop time is set to a value other than 1 ms, the communication cycle time must be equal to or a multiple of the slow loop period. You can modify the slow loop period in the **Application Settings** section during setup using **EasyMotion Studio II**.



TwinCAT Project21 - Microsoft Visual Studio (Administrator)

Name: NC-Task 1 SAF

☑ Auto start

□ Auto Priority Management

Priority: 4

Cycle ticks: 1 1.000 ms

Start tick (modulo): 0

□ Separate input update

Pre ticks: 0

□ Warning by exceeding

□ Message box

Watchdog Cycles: 0

Port: 501

Object Id: 0x05000010

Options

□ Disable

□ Create symbols

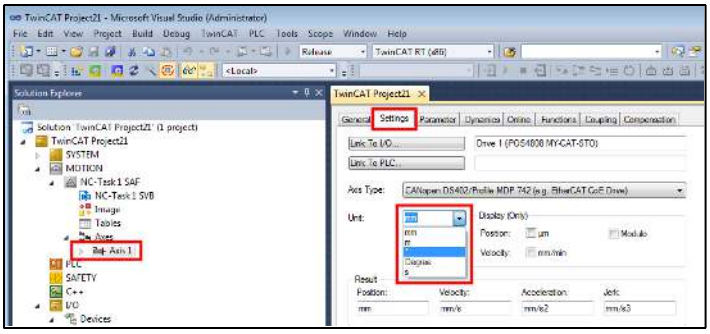
□ Include external symbols

☑ I/O at task begin

1.5.4.2 Setting the interface factor group settings

Setting the Interface Factor Group:

- Click on **Axis 1**.
- Go to the **Settings** tab and select the appropriate unit:
  - Choose **°** if your motor is rotary.
  - Choose **mm** if your motor is linear.



Drive 1 (POS4808 MY-CAT-STO)

Axis Type: CANopen DS402/Profile MDP 742 (e.g. EtherCAT CoE Drive)

Unit: mm (options: mm, m, °, Degrees, s)

Display (Only): Position: □ µm □ Modulo; Velocity: □ mm/min

Result: Position: mm; Velocity: mm/s; Acceleration: mm/s2; Jerk: mm/s3

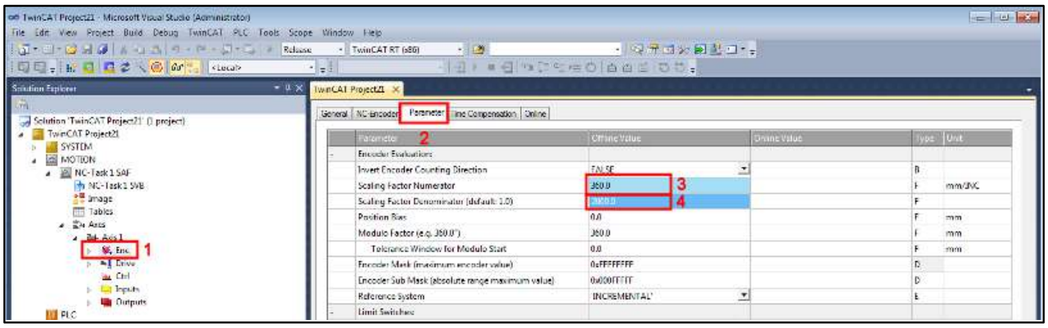
Setting the Scaling Factor:

- Click on **Axis 1_Enc(1)** and open the **Parameter** tab.
- Enter the scaling factor for your encoder using the formula:

$$ScalingFactor = 360° = \frac{360°}{\text{Number of Encoder Counts for One Full Motor Rotation}}$$

- For example, if the encoder has **500 lines** in quadrature, it generates **2000 counts per rotation**. In this case, the scaling factor would be:

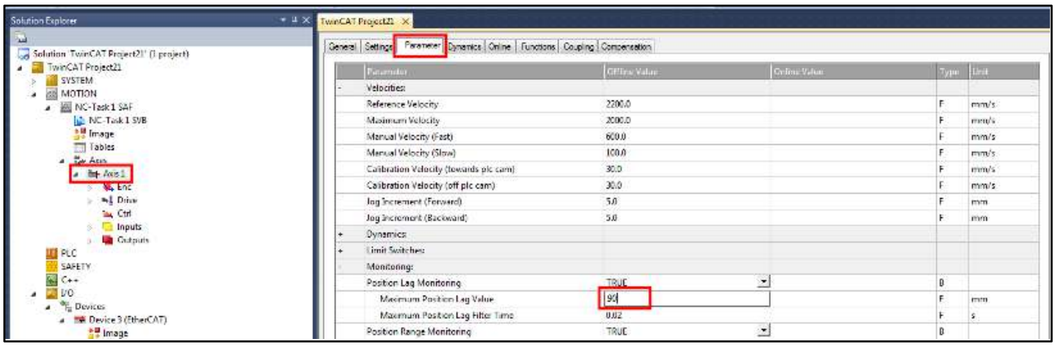
$$\frac{360}{2000} = 0.18$$



	Parameter	Offline Value	Online Value	Type	Unit
-	Encoder Evaluation:				
	Invert Encoder Counting Direction	FALSE		B	
	Scaling Factor Numerator	360.0		F	mm/INC
	Scaling Factor Denominator (default: 1.0)	2000.0		F	
	Position Bias	0.0		F	mm
	Modulo Factor (e.g. 360.0°)	360.0		F	mm
	Tolerance Window for Modulo Start	0.0		F	mm
	Encoder Mask (maximum encoder value)	0xFFFFFFFF		D	
	Encoder Sub Mask (absolute range maximum value)	0x000FFFFF		D	
	Reference System	'INCREMENTAL'		E	
-	Limit Switches				

1.5.4.3 Choosing a position lag value

Double-click on Axis 1 and navigate to the Parameter tab. Set a higher value for the Maximum Position Lag, such as 90. This adjustment is for demonstration purposes only and prevents the drive from triggering a position control error too quickly in cases of poor motor tuning.



	Parameter	Offline Value	Online Value	Type	Unit
-	Velocities:				
	Reference Velocity	2200.0		F	mm/s
	Maximum Velocity	2000.0		F	mm/s
	Manual Velocity (Fast)	600.0		F	mm/s
	Manual Velocity (Slow)	100.0		F	mm/s
	Calibration Velocity (towards plc cam)	30.0		F	mm/s
	Calibration Velocity (off plc cam)	30.0		F	mm/s
	Jog Increment (Forward)	5.0		F	mm
	Jog Increment (Backward)	5.0		F	mm
+	Dynamics:				
+	Limit Switches:				
-	Monitoring:				
	Position Lag Monitoring	TRUE		B	
	Maximum Position Lag Value	90		F	mm
	Maximum Position Lag Filter Time	0.02		F	s
	Position Range Monitoring	TRUE		B	

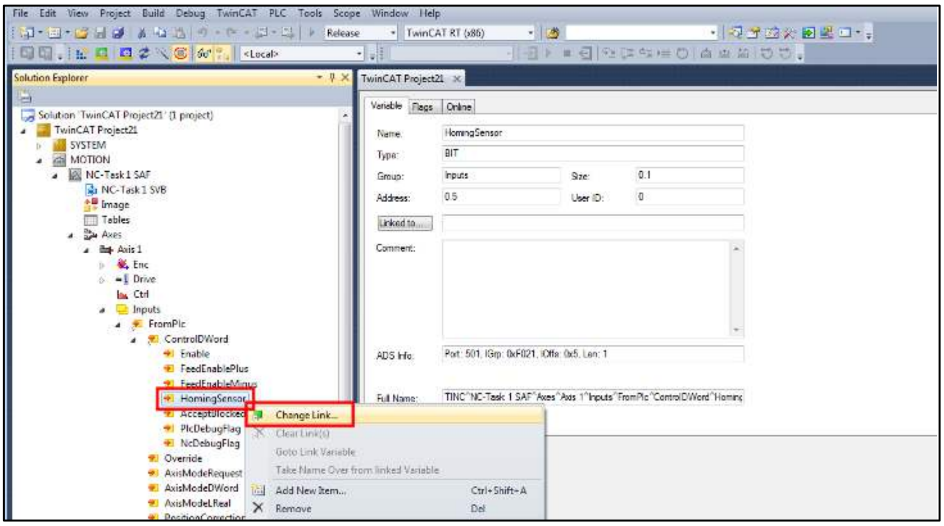
***Note:** Position lag protection is available on all drives and can also be configured using EasyMotion Studio II under the Protections and Limits section.*

1.5.4.4 Mapping a digital input as the home switch for the NC-PTP interface

Configuring the Homing Sensor Input

1. In the left panel, navigate to **NC – Configuration/Axes/Axis1/Inputs**.

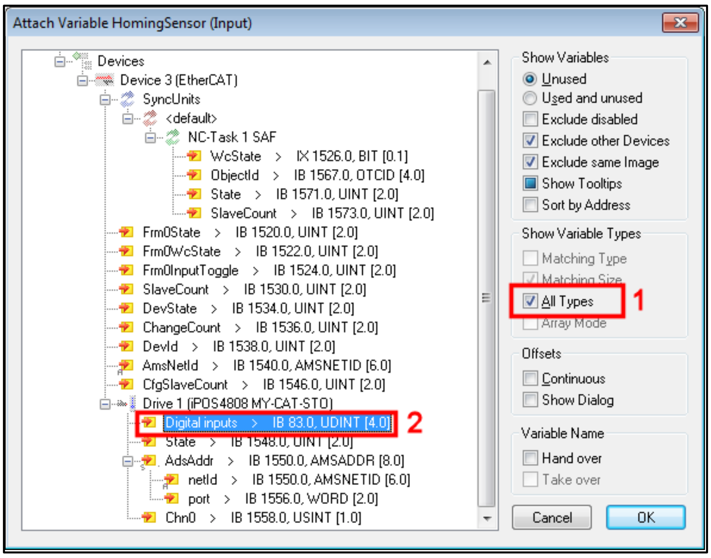
2. Expand **Axis1_FromPLC**, then expand **ControlDWord**, and select the variable **HomingSensor**.
3. Right-click on the **HomingSensor** variable and choose **Change Link...**.



Name: HomingSensor
Type: BIT
Group: Inputs   Size: 0.1
Address: 0.5   User ID: 0
Comment:
ADS Info: Port: 501, IGrp: 0xF021, IOffs: 0x5, Len: 1
Full Name: TINC^NC-Task 1 SAF^Axes^Axis 1^Inputs^FromPlc^ControlDWord^Homing

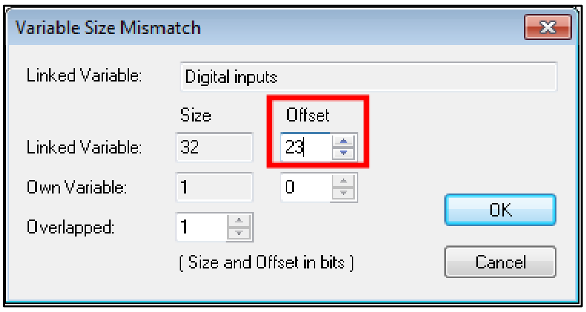
In the dialog box that appears:

- Check the **All Types** checkbox (1).
- Select the variable **Digital Inputs** (2) and click **OK**.


Attach Variable HomingSensor (Input)
Devices
Device 3 (EtherCAT)
SyncUnits
<default>
NC-Task 1 SAF
WcState > IX 1526.0, BIT [0.1]
ObjectId > IB 1567.0, OTCID [4.0]
State > IB 1571.0, UINT [2.0]
SlaveCount > IB 1573.0, UINT [2.0]
Frm0State > IB 1520.0, UINT [2.0]
Frm0WcState > IB 1522.0, UINT [2.0]
Frm0InputToggle > IB 1524.0, UINT [2.0]
SlaveCount > IB 1530.0, UINT [2.0]
DevState > IB 1534.0, UINT [2.0]
ChangeCount > IB 1536.0, UINT [2.0]
DevId > IB 1538.0, UINT [2.0]
AmsNetId > IB 1540.0, AMSNETID [6.0]
CfgSlaveCount > IB 1546.0, UINT [2.0]
Drive 1 (iPOS4808 MY-CAT-STO)
Digital inputs > IB 83.0, UDINT [4.0]
State > IB 1548.0, UINT [2.0]
AdsAddr > IB 1550.0, AMSADDR [8.0]
netId > IB 1550.0, AMSNETID [6.0]
port > IB 1556.0, WORD [2.0]
Chn0 > IB 1558.0, USINT [1.0]
Show Variables
● Unused
○ Used and unused
☐ Exclude disabled
☑ Exclude other Devices
☑ Exclude same Image
☑ Show Tooltips
☐ Sort by Address
Show Variable Types
☐ Matching Type
☑ Matching Size
☑ All Types
☐ Array Mode
Offsets
☐ Continuous
☐ Show Dialog
Variable Name
☐ Hand over
☐ Take over
Cancel
OK
1
2

A new menu will appear prompting you to specify the **offset**.

- Since **Digital Inputs Status** is a 32-bit variable and the **HomingSensor** is a **BOOLEAN** (1-bit) variable, set the **offset** to **23** to map it to the **IN0 input**.
- Click **OK** to confirm.



Linked Variable: Digital inputs

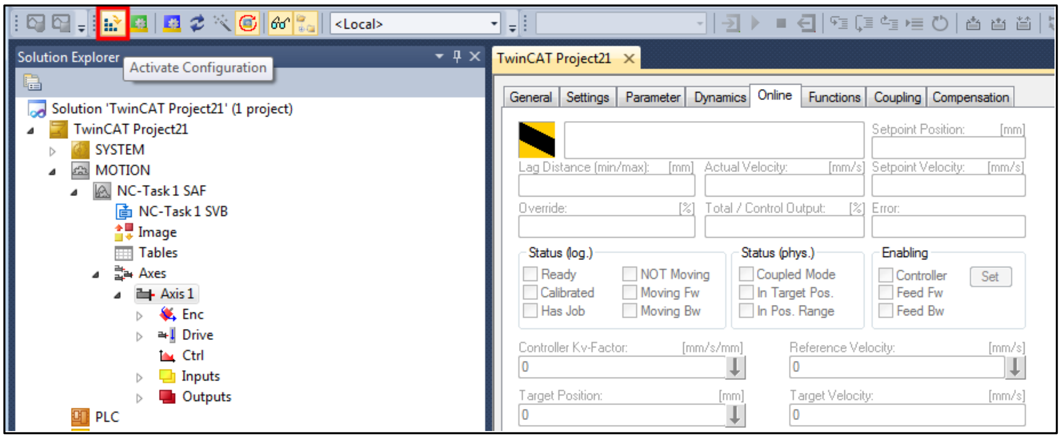
	Size	Offset
Linked Variable:	32	23
Own Variable:	1	0
Overlapped:	1	

(Size and Offset in bits)

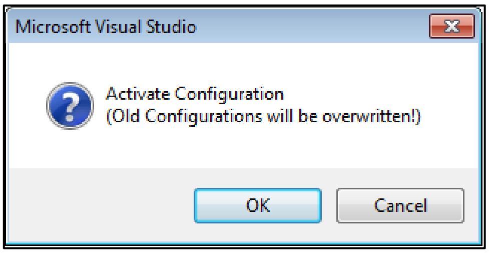
1.5.4.5 Running the NC-PTP interface

Activate Configuration:

- Click the **Activate Configuration** button to enter **PLC Run** mode.

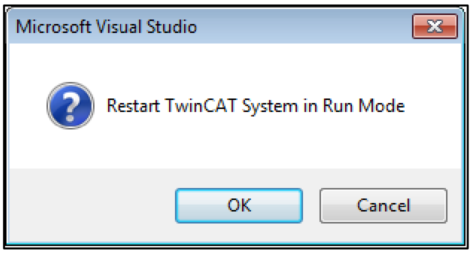


- Confirm any prompts by clicking **OK**.



Microsoft Visual Studio

Activate Configuration
(Old Configurations will be overwritten!)

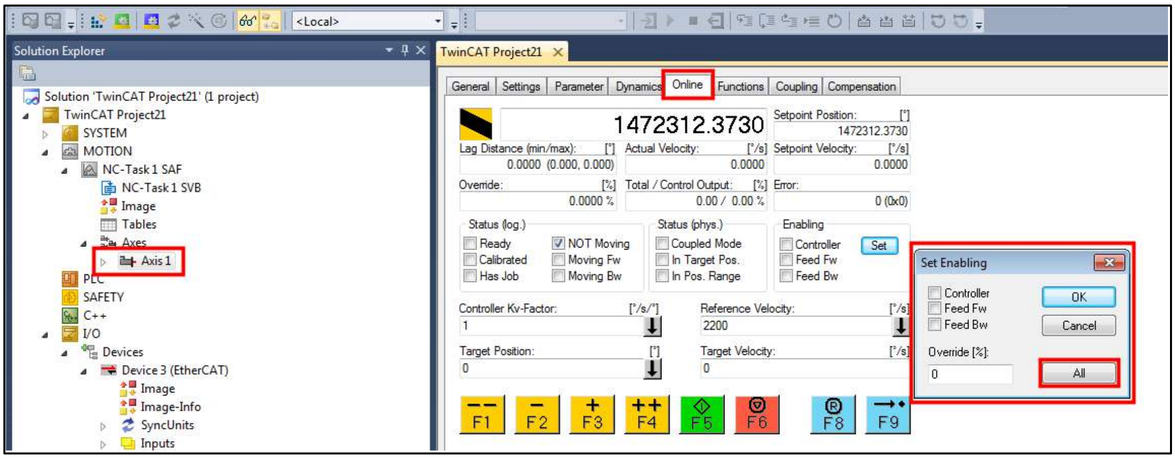


Microsoft Visual Studio

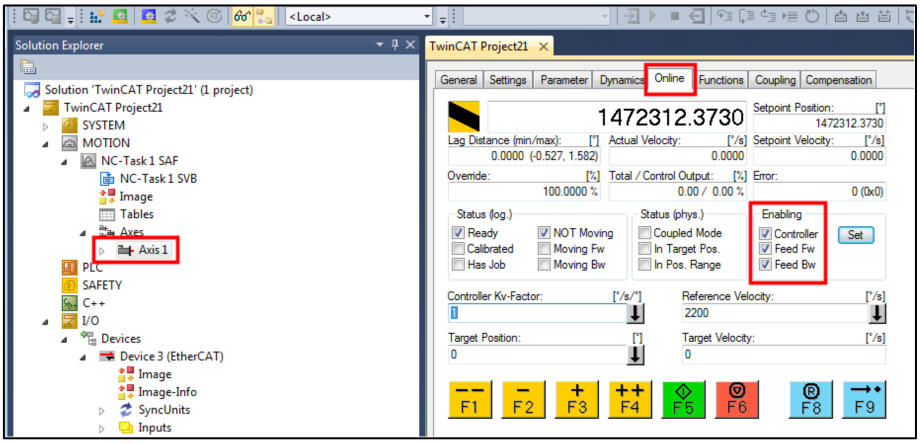
Restart TwinCAT System in Run Mode

Powering the Motor:

- Select **Axis 1** and open the **Online** tab.

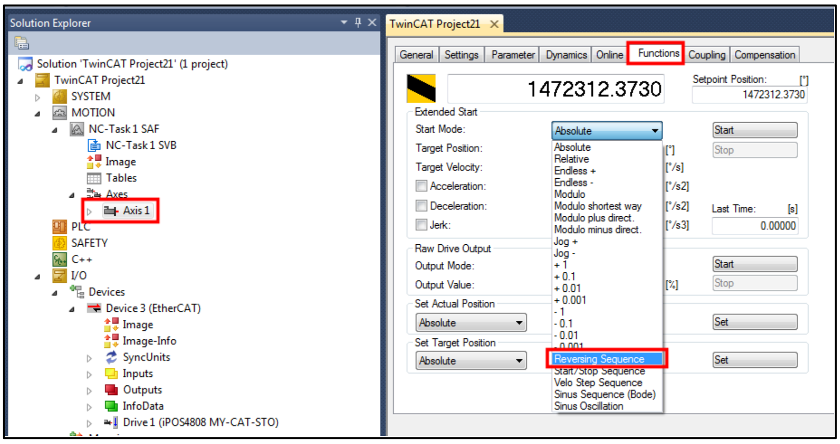


- Click the **Set** button. In the window that appears, click **All** to activate power to the motor.
- If the configuration is correct, all checkboxes under **Enabling** will turn **ON**, and the motor will begin holding its position.
- **Debugging Tip**: Use the yellow **F1–F4** buttons to manually move the motor for testing purposes.



Running a Reversing Sequence:

- Go to the **Functions** tab and select **Reversing Sequence**.



1472312.3730

Setpoint Position: [°] 1472312.3730

Extended Start

Start Mode: Absolute

Target Position: [°]

Target Velocity: [°/s]

□ Acceleration: [°/s2]

□ Deceleration: [°/s2]

□ Jerk: [°/s3]

Last Time: [s] 0.00000

Raw Drive Output

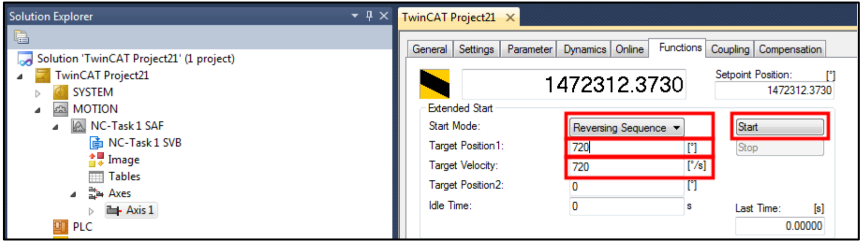
Output Mode:

Output Value: [%]

Set Actual Position: Absolute

Set Target Position: Absolute

- Enter the following parameters:
  - ○ **Target Position 1**: **720** (to rotate the motor twice).
  - ○ **Velocity**: **720°/s** (equivalent to 2 revolutions per second).
- Click the **Start** button. The motor should rotate smoothly back and forth for two full rotations without shaking.



1472312.3730

Setpoint Position: [°] 1472312.3730

Extended Start

Start Mode: Reversing Sequence

Target Position1: 720 [°]

Target Velocity: 720 [°/s]

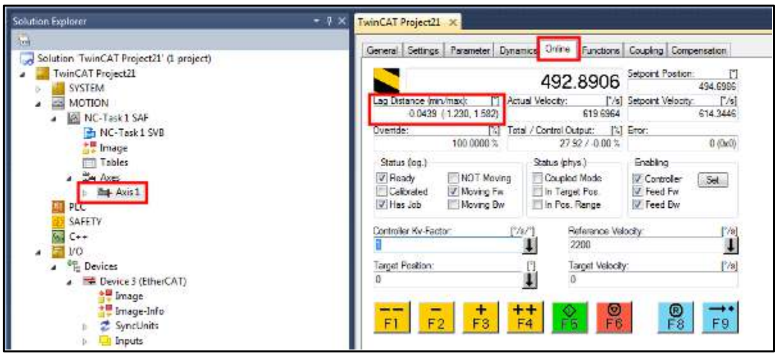
Target Position2: 0 [°]

Idle Time: 0 s

Last Time: [s] 0.00000

Monitoring Position Error:

- Return to the **Online** tab and observe the **Lag Distance** (position error) displayed in TwinCAT.



492.8906

Setpoint Position: [°] 494.6986

Lag Distance (min/max): [°] 0.0429 (-1.230, 1.582)

Actual Velocity: [°/s] 619.6964

Setpoint Velocity: [°/s] 614.3446

Override: [%] 100.0000 %

Total / Control Output: [%] 27.92 / -0.00 %

Error: 0 (0x0)

Status (log.): ☑ Ready □ Calibrated ☑ Has Job □ NOT Moving ☑ Moving Fw □ Moving Bw

Status (phys.): □ Coupled Mode □ In Target Pos. □ In Pos. Range

Enabling: ☑ Controller ☑ Feed Fw ☑ Feed Bw

Controller Kv-Factor: [°/s/°] 1

Reference Velocity: [°/s] 2200

Target Position: [°] 0

Target Velocity: [°/s] 0

Once these settings are complete, the configuration will be fully compatible with **PLCopen Motion Blocks** in the PLC Control program, enabling automated script execution.

1.5.4.6 Checking and updating the XML file stored in the drive

The XML file data is stored in the **EtherCAT ASIC EEPROM**, not in the drive itself. The EtherCAT EEPROM can only be written through the Ethernet port. The XML file also contains information about the supported CoE objects. When firmware updates introduce new objects, the XML file may also need to be updated.

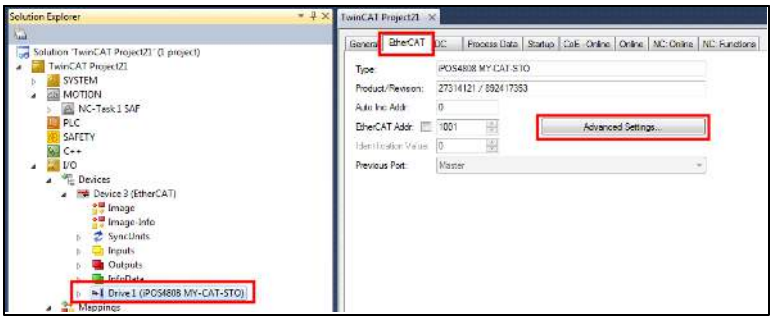
To correctly identify your product, you can:

- **Read the label on the drive**, or
- **Check Object 1018h, sub-index 2**, which displays the correct Product Code.

Technosoft Drive name	**Product code in 1018$_h$, sub 02$_h$**
iPOS360x VX-CAT	28002021
iPOS4808 MY-CAT-STO	27314121
iPOS4808 BX-CAT-STO	27314221

1.5.4.7 Steps to Write a New XML File

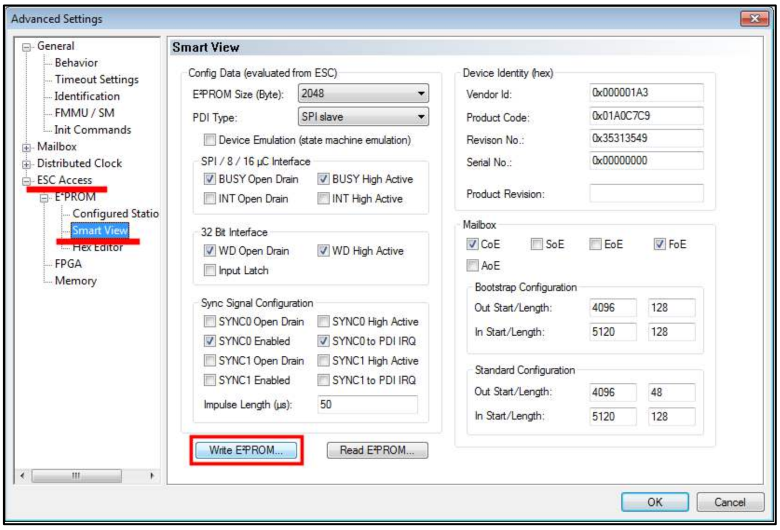
1. **Ensure the XML file is in the correct folder**:
   - For **TwinCAT2**, the default location is: C:\TwinCAT\Io\EtherCAT
   - For **TwinCAT3**, the default location is: C:\TwinCAT\3.1\Config\Io\EtherCAT
2. **Open TwinCAT System Manager**:
   - If you know the product ID of the drive, select the target drive from the left-hand menu.
   - Go to the **EtherCAT** tab and click **Advanced Settings...**



Type: iPOS4808 MY-CAT-STO
Product/Revision: 27314121 / 892417353
Auto Inc Addr: 0
EtherCAT Addr: 1001
Identification Value: 0
Previous Port: Master

3. **Write to the EEPROM**:

- In the **Advanced Settings** window, navigate to **ESC Access/E2PROM/Smart View** in the left-side tree.
- Click the **Write E2PROM...** button.

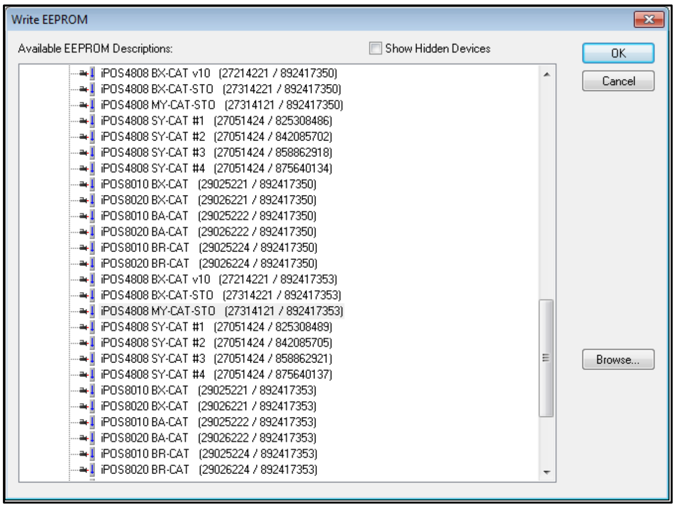


Config Data (evaluated from ESC)
E²PROM Size (Byte): 2048
PDI Type: SPI slave
☐ Device Emulation (state machine emulation)
SPI / 8 / 16 µC Interface
☑ BUSY Open Drain ☑ BUSY High Active
☐ INT Open Drain ☐ INT High Active
32 Bit Interface
☑ WD Open Drain ☑ WD High Active
☐ Input Latch
Sync Signal Configuration
☐ SYNC0 Open Drain ☐ SYNC0 High Active
☑ SYNC0 Enabled ☑ SYNC0 to PDI IRQ
☐ SYNC1 Open Drain ☐ SYNC1 High Active
☐ SYNC1 Enabled ☐ SYNC1 to PDI IRQ
Impulse Length (µs): 50

Device Identity (hex)
Vendor Id: 0x000001A3
Product Code: 0x01A0C7C9
Revison No.: 0x35313549
Serial No.: 0x00000000
Product Revision:
Mailbox
☑ CoE ☐ SoE ☐ EoE ☑ FoE
☐ AoE
Bootstrap Configuration
Out Start/Length: 4096 128
In Start/Length: 5120 128
Standard Configuration
Out Start/Length: 4096 48
In Start/Length: 5120 128

4. **Select the Correct XML File**:

- If the XML file has been added correctly (refer to Section 1.5.1 Adding the XML file), a list of available product descriptions will appear.
- The current XML file on the drive will already be selected.
- Choose your correct drive name with the **highest revision number** (the number shown on the right) and click **OK**.



Available EEPROM Descriptions: ☐ Show Hidden Devices

```
iPOS4808 BX-CAT v10   (27214221 / 892417350)
iPOS4808 BX-CAT-STO   (27314221 / 892417350)
iPOS4808 MY-CAT-STO   (27314121 / 892417350)
iPOS4808 SY-CAT #1   (27051424 / 825308486)
iPOS4808 SY-CAT #2   (27051424 / 842085702)
iPOS4808 SY-CAT #3   (27051424 / 858862918)
iPOS4808 SY-CAT #4   (27051424 / 875640134)
iPOS8010 BX-CAT   (29025221 / 892417350)
iPOS8020 BX-CAT   (29026221 / 892417350)
iPOS8010 BA-CAT   (29025222 / 892417350)
iPOS8020 BA-CAT   (29026222 / 892417350)
iPOS8010 BR-CAT   (29025224 / 892417350)
iPOS8020 BR-CAT   (29026224 / 892417350)
iPOS4808 BX-CAT v10   (27214221 / 892417353)
iPOS4808 BX-CAT-STO   (27314221 / 892417353)
iPOS4808 MY-CAT-STO   (27314121 / 892417353)
iPOS4808 SY-CAT #1   (27051424 / 825308489)
iPOS4808 SY-CAT #2   (27051424 / 842085705)
iPOS4808 SY-CAT #3   (27051424 / 858862921)
iPOS4808 SY-CAT #4   (27051424 / 875640137)
iPOS8010 BX-CAT   (29025221 / 892417353)
iPOS8020 BX-CAT   (29026221 / 892417353)
iPOS8010 BA-CAT   (29025222 / 892417353)
iPOS8020 BA-CAT   (29026222 / 892417353)
iPOS8010 BR-CAT   (29025224 / 892417353)
iPOS8020 BR-CAT   (29026224 / 892417353)
```

The first number refers to the drive **Product Number**, while the second represents the **Revision Number**, which indicates the current firmware version. The revision number can be converted into hexadecimal and then into ASCII characters. For example, if the current firmware is **F515I**, the revision number will be:

- **ASCII**: 515I
- **Hexadecimal**: 0x35313149
- **Decimal**: 892417353

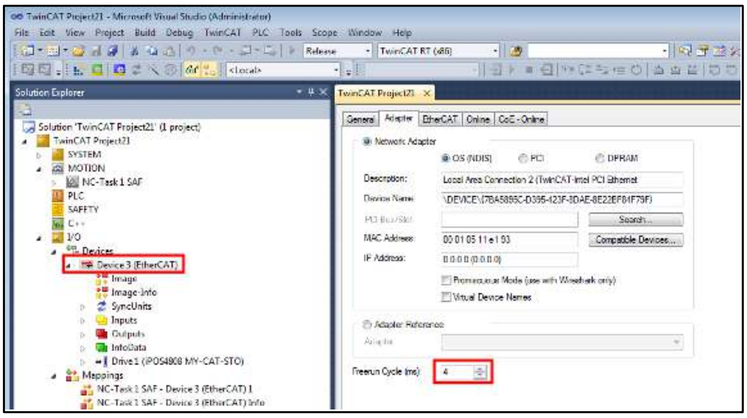
Note: Newer firmware versions are compatible with older XML file information, so there is no need to update the XML in the EtherCAT® adapter for every firmware update. In some cases, newer firmware does not include new CoE objects or functionalities and, therefore, does not require an updated XML file. For instance, firmware **F515G** works seamlessly with the XML file created for **F515F**.

Once the writing process is complete, reset the drive and rescan the devices on the network. The correct device description will then be automatically detected.

1.5.5 Setting the free run communication cycle

In the left panel, under **I/O Devices**, select **Device 3 (EtherCAT)**. On the right side, go to the **Adapter** tab and set the **Freerun Cycle** (ms), for example, to **1 ms**.

Note: When TwinCAT is running in **Freerun** mode, this is the only setting required to define the communication cycle time.


TwinCAT Project21 - Microsoft Visual Studio (Administrator)
File Edit View Project Build Debug TwinCAT PLC Tools Scope Window Help
Release
TwinCAT RT (x86)
<Local>
Solution Explorer
Solution 'TwinCAT Project21' (1 project)
TwinCAT Project21
SYSTEM
MOTION
NC-Task 1 SAF
PLC
SAFETY
C++
I/O
Devices
Device 3 (EtherCAT)
Image
Image-Info
SyncUnits
Inputs
Outputs
InfoData
Drive 1 (iPOS4808 MY-CAT-STO)
Mappings
NC-Task 1 SAF - Device 3 (EtherCAT) 1
NC-Task 1 SAF - Device 3 (EtherCAT) Info
TwinCAT Project21
General
Adapter
EtherCAT
Online
CoE - Online
Search...
Compatible Devices...

● Network Adapter

● OS (NDIS) ○ PCI ○ DPRAM

Description: Local Area Connection 2 (TwinCAT-Intel PCI Ethernet

Device Name: \DEVICE\{7BA5895C-D395-423F-9DAE-8E22EF84F79F}

PCI Bus/Slot:

MAC Address: 00 01 05 11 e1 93

IP Address: 0.0.0.0 (0.0.0.0)

□ Promiscuous Mode (use with Wireshark only)

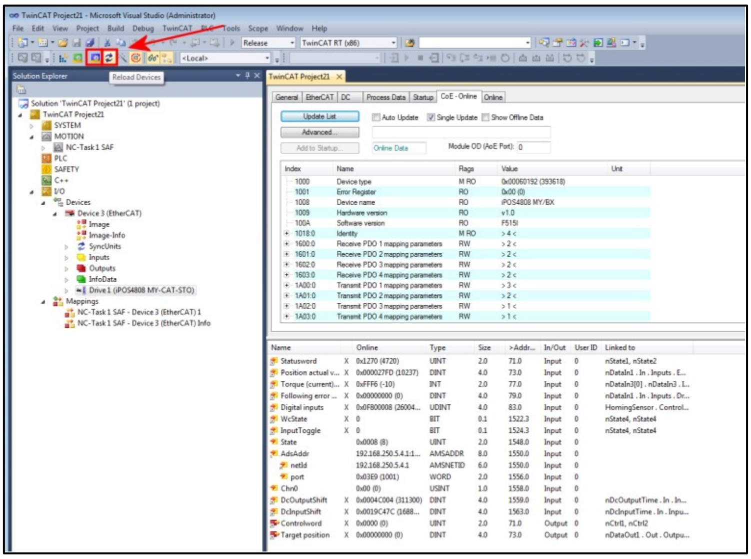
□ Virtual Device Names

○ Adapter Reference

Adapter:

Freerun Cycle (ms): 4

To apply all the changes made (including any updates to PDO mapping), click the **Reload I/O Devices (F4)** button. This will also activate the **SYNC 0** signal, if it has been enabled.



□ Auto Update ☑ Single Update □ Show Offline Data

Module OD (AoE Port): 0

Index	Name	Flags	Value	Unit
1000	Device type	M RO	0x00060192 (393618)	
1001	Error Register	RO	0x00 (0)	
1008	Device name	RO	iPOS4808 MY/BX	
1009	Hardware version	RO	v1.0	
100A	Software version	RO	F515I	
+ 1018:0	Identity	M RO	> 4 <	
+ 1600:0	Receive PDO 1 mapping parameters	RW	> 2 <	
+ 1601:0	Receive PDO 2 mapping parameters	RW	> 2 <	
+ 1602:0	Receive PDO 3 mapping parameters	RW	> 2 <	
+ 1603:0	Receive PDO 4 mapping parameters	RW	> 2 <	
+ 1A00:0	Transmit PDO 1 mapping parameters	RW	> 3 <	
+ 1A01:0	Transmit PDO 2 mapping parameters	RW	> 2 <	
+ 1A02:0	Transmit PDO 3 mapping parameters	RW	> 1 <	
+ 1A03:0	Transmit PDO 4 mapping parameters	RW	> 1 <	

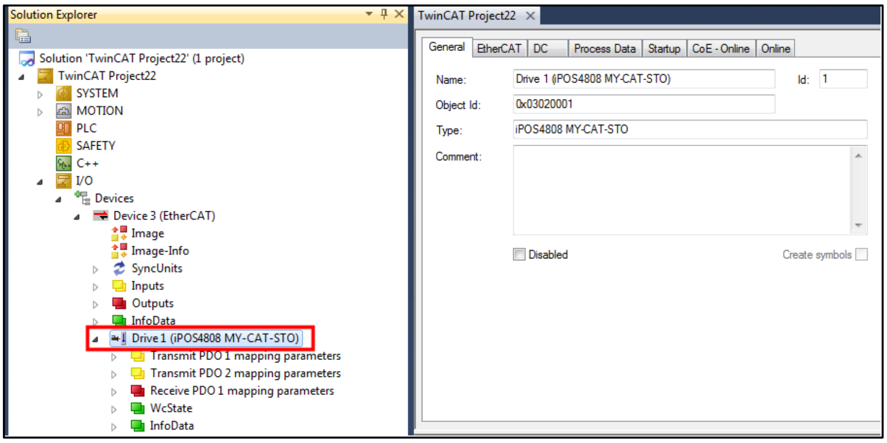
Name		Online	Type	Size	>Addr...	In/Out	User ID	Linked to
Statusword	X	0x1270 (4720)	UINT	2.0	71.0	Input	0	nState1, nState2
Position actual v...	X	0x000027FD (10237)	DINT	4.0	73.0	Input	0	nDataIn1 . In . Inputs . E...
Torque (current)...	X	0xFFF6 (-10)	INT	2.0	77.0	Input	0	nDataIn3[0] . nDataIn3 . I...
Following error ...	X	0x00000000 (0)	DINT	4.0	79.0	Input	0	nDataIn1 . In . Inputs . Dr...
Digital inputs	X	0x0F800008 (26004...	UDINT	4.0	83.0	Input	0	HomingSensor . Control...
WcState	X	0	BIT	0.1	1522.3	Input	0	nState4, nState4
InputToggle	X	0	BIT	0.1	1524.3	Input	0	nState4, nState4
State		0x0008 (8)	UINT	2.0	1548.0	Input	0	
AdsAddr		192.168.250.5.4.1:1...	AMSADDR	8.0	1550.0	Input	0	
netId		192.168.250.5.4.1	AMSNETID	6.0	1550.0	Input	0	
port		0x03E9 (1001)	WORD	2.0	1556.0	Input	0	
Chn0		0x00 (0)	USINT	1.0	1558.0	Input	0	
DcOutputShift	X	0x0004C004 (311300)	DINT	4.0	1559.0	Input	0	nDcOutputTime . In . In...
DcInputShift	X	0x0019C47C (1688...	DINT	4.0	1563.0	Input	0	nDcInputTime . In . Inpu...
Controlword	X	0x0000 (0)	UINT	2.0	71.0	Output	0	nCtrl1, nCtrl2
Target position	X	0x00000000 (0)	DINT	4.0	73.0	Output	0	nDataOut1 . Out . Outpu...

1.6 Controlling the drive using CoE commands. Examples

1.6.1 Starting a position profile with CoE commands in TwinCAT

Assuming the motor has been connected to the drive, it has a valid setup downloaded (see **1.1**) and it has been identified in TwinCAT (see **0**), the next steps describe a positive trapezoidal motion in position profile mode:

1. In the left tree, at *I/O Devices*, click on Drive 1.



Solution Explorer

- Solution 'TwinCAT Project22' (1 project)
  - TwinCAT Project22
    - SYSTEM
    - MOTION
    - PLC
    - SAFETY
    - C++
    - I/O
      - Devices
        - Device 3 (EtherCAT)
          - Image
          - Image-Info
          - SyncUnits
          - Inputs
          - Outputs
          - InfoData
          - Drive 1 (iPOS4808 MY-CAT-STO)
            - Transmit PDO 1 mapping parameters
            - Transmit PDO 2 mapping parameters
            - Receive PDO 1 mapping parameters
            - WcState
            - InfoData

TwinCAT Project22

General | EtherCAT | DC | Process Data | Startup | CoE - Online | Online

Name: Drive 1 (iPOS4808 MY-CAT-STO)   Id: 1

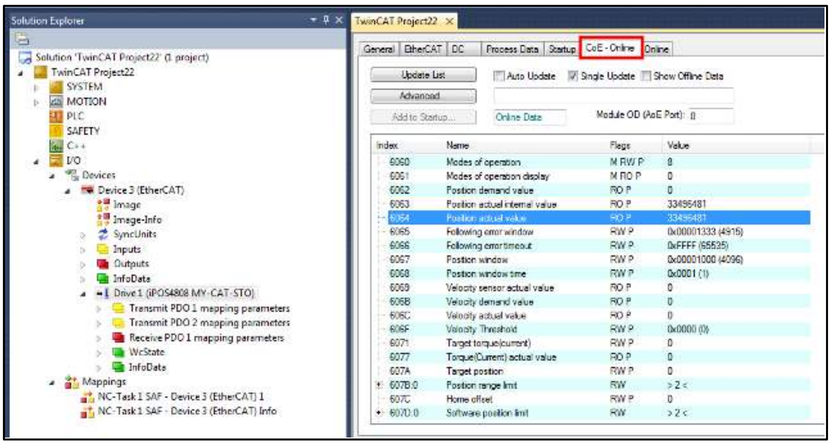
Object Id: 0x03020001

Type: iPOS4808 MY-CAT-STO

Comment:

□ Disabled   Create symbols □

Click on *CoE – Online* tab on the right side. If the provided .xml file matches the characteristics of the drive, the CoE objects will have an associated name, like Object 6064h: Position actual value. Else, all CoE objects will be read directly from the drive without anything in the name column.



Solution Explorer

- Solution 'TwinCAT Project22' (1 project)
  - TwinCAT Project22
    - SYSTEM
    - MOTION
    - PLC
    - SAFETY
    - C++
    - I/O
      - Devices
        - Device 3 (EtherCAT)
          - Image
          - Image-Info
          - SyncUnits
          - Inputs
          - Outputs
          - InfoData
          - Drive 1 (iPOS4808 MY-CAT-STO)
            - Transmit PDO 1 mapping parameters
            - Transmit PDO 2 mapping parameters
            - Receive PDO 1 mapping parameters
            - WcState
            - InfoData
      - Mappings
        - NC-Task 1 SAF - Device 3 (EtherCAT) 1
        - NC-Task 1 SAF - Device 3 (EtherCAT) Info

TwinCAT Project22

General | EtherCAT | DC | Process Data | Startup | CoE - Online | Online

Update List   □ Auto Update   ☑ Single Update   □ Show Offline Data

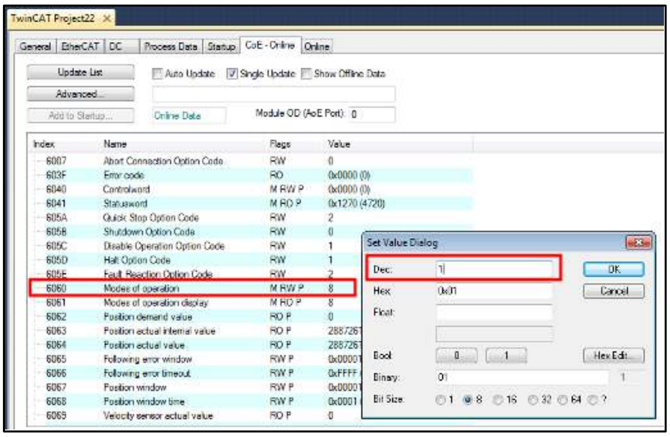
Advanced...

Add to Startup...   Online Data   Module OD (AoE Port): 0

Index	Name	Flags	Value
6060	Modes of operation	M RW P	8
6061	Modes of operation display	M RO P	0
6062	Position demand value	RO P	0
6063	Position actual internal value	RO P	33496481
6064	Position actual value	RO P	33496481
6065	Following error window	RW P	0x00001333 (4915)
6066	Following error timeout	RW P	0xFFFF (65535)
6067	Position window	RW P	0x00001000 (4096)
6068	Position window time	RW P	0x0001 (1)
6069	Velocity sensor actual value	RO P	0
606B	Velocity demand value	RO P	0
606C	Velocity actual value	RO P	0
606F	Velocity Threshold	RW P	0x0000 (0)
6071	Target torque(current)	RW P	0
6077	Torque(Current) actual value	RO P	0
607A	Target position	RW P	0
+ 607B:0	Position range limit	RW	> 2 <
607C	Home offset	RW P	0
+ 607D:0	Software position limit	RW	> 2 <

2. In the CoE online list, search for Object 6060h: Modes of Operation and double click it. In the new window, write the value 1. This step writes with an SDO command into object 6060h the value 1 to set the modes of operation object into position profile.

Remark: if the drive is reset, object 6060h will be re-initialized with 8 (CSP mode). This happens because this command is defined in the Startup tab (the one beside the CoE-Online tab) and is added if the Technosoft XML is present.



TwinCAT Project22

General | EtherCAT | DC | Process Data | Startup | CoE - Online | Online

Update List   □ Auto Update   ☑ Single Update   □ Show Offline Data

Advanced...

Add to Startup...   Online Data   Module OD (AoE Port): 0

Index	Name	Flags	Value
6007	Abort Connection Option Code	RW	0
603F	Error code	RO	0x0000 (0)
6040	Controlword	M RW P	0x0000 (0)
6041	Statusword	M RO P	0x1270 (4720)
605A	Quick Stop Option Code	RW	2
605B	Shutdown Option Code	RW	0
605C	Disable Operation Option Code	RW	1
605D	Halt Option Code	RW	1
605E	Fault Reaction Option Code	RW	2
6060	Modes of operation	M RW P	8
6061	Modes of operation display	M RO P	8
6062	Position demand value	RO P	0
6063	Position actual internal value	RO P	288726
6064	Position actual value	RO P	288726
6065	Following error window	RW P	0x0000
6066	Following error timeout	RW P	0xFFFF
6067	Position window	RW P	0x0000
6068	Position window time	RW P	0x0001
6069	Velocity sensor actual value	RO P	0

Set Value Dialog

Dec: 1   OK

Hex: 0x01   Cancel

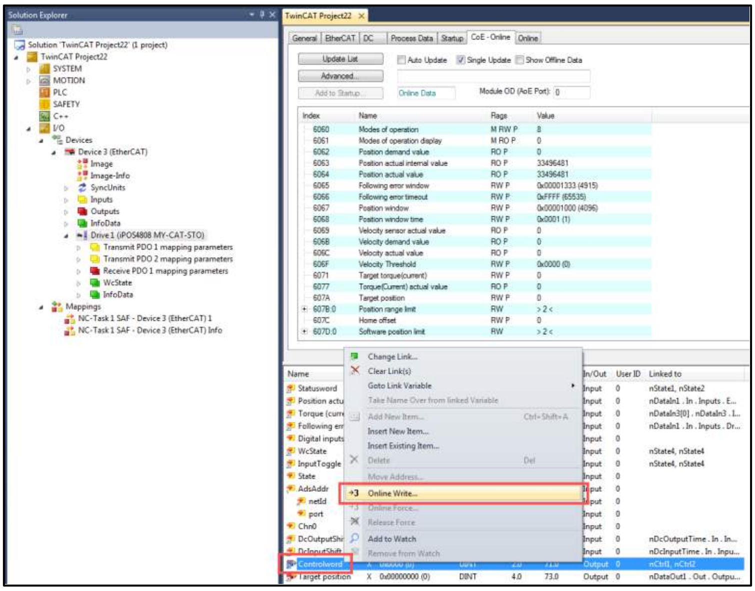
Float:

Bool: 0 | 1   Hex Edit...

Binary: 01   1

Bit Size: ○ 1 ● 8 ○ 16 ○ 32 ○ 64 ○ ?

3. Right click on *Control word* variable, and choose *Online Write..* .



☐ Auto Update ☑ Single Update ☐ Show Offline Data

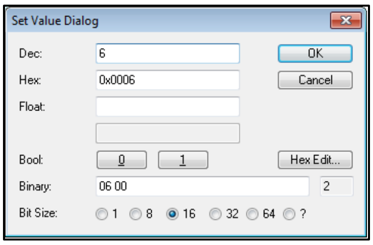
Online Data

Module OD (AoE Port): 0

Index	Name	Flags	Value
6060	Modes of operation	M RW P	8
6061	Modes of operation display	M RO P	0
6062	Position demand value	RO P	0
6063	Position actual internal value	RO P	33496481
6064	Position actual value	RO P	33496481
6065	Following error window	RW P	0x00001333 (4915)
6066	Following error timeout	RW P	0xFFFF (65535)
6067	Position window	RW P	0x00001000 (4096)
6068	Position window time	RW P	0x0001 (1)
6069	Velocity sensor actual value	RO P	0
606B	Velocity demand value	RO P	0
606C	Velocity actual value	RO P	0
606F	Velocity Threshold	RW P	0x0000 (0)
6071	Target torque(current)	RW P	0
6077	Torque(Current) actual value	RO P	0
607A	Target position	RW P	0
+ 607B:0	Position range limit	RW	> 2 <
607C	Home offset	RW P	0
+ 607D:0	Software position limit	RW	> 2 <

Name						In/Out	User ID	Linked to
Statusword						Input	0	nState1, nState2
Position actu						Input	0	nDataIn1 . In . Inputs . E...
Torque (curr						Input	0	nDataIn3[0] . nDataIn3 . I...
Following er						Input	0	nDataIn1 . In . Inputs . Dr...
Digital inputs						Input	0	
WcState						Input	0	nState4, nState4
InputToggle						Input	0	nState4, nState4
State						Input	0	
AdsAddr						Input	0	
netId						Input	0	
port						Input	0	
Chn0						Input	0	
DcOutputShi						Input	0	nDcOutputTime . In . In...
DcInputShift						Input	0	nDcInputTime . In . Inpu...
Controlword	X	0x0000 (0)	UINT	2.0	71.0	Output	0	nCtrl1, nCtrl2
Target position	X	0x00000000 (0)	DINT	4.0	73.0	Output	0	nDataOut1 . Out . Outpu...

4. To enter in **Ready to switch** on state, write in the hex field 0x0006 and click OK.



Set Value Dialog

Dec: 6

Hex: 0x0006

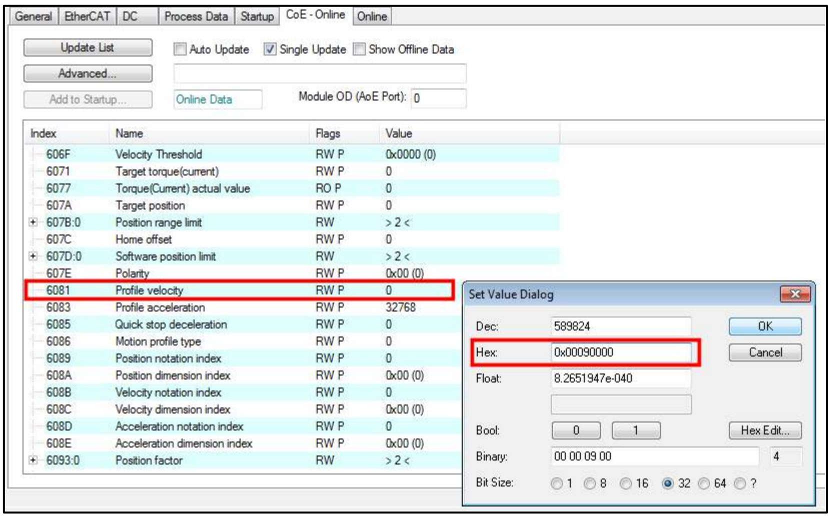
Float:

Bool: 0 1

Binary: 06 00 2

Bit Size: ○ 1 ○ 8 ● 16 ○ 32 ○ 64 ○ ?

5. Repeat Step 4 and send **Switch** On (0x0007) into *Control word*.
6. Do the same as Step 4 for the PDO *Target position* and write 80000 into Dec field. The drive will finally execute 80000 internal position units (encoder counts) after the start motion command is given.
7. In the CoE object list choose the object with index *0x6081 Profile velocity* and double click on it just like step 3. Write the hex value 0x00090000 in the Hex field and click *OK*. The profile will be executed with a velocity of 9.0 IU (encoder counts)/ms.



☐ Auto Update ☑ Single Update ☐ Show Offline Data

Online Data

Module OD (AoE Port): 0

Index	Name	Flags	Value
606F	Velocity Threshold	RW P	0x0000 (0)
6071	Target torque(current)	RW P	0
6077	Torque(Current) actual value	RO P	0
607A	Target position	RW P	0
+ 607B:0	Position range limit	RW	> 2 <
607C	Home offset	RW P	0
+ 607D:0	Software position limit	RW	> 2 <
607E	Polarity	RW P	0x00 (0)
6081	Profile velocity	RW P	0
6083	Profile acceleration	RW P	32768
6085	Quick stop deceleration	RW P	0
6086	Motion profile type	RW P	0
6089	Position notation index	RW P	0
608A	Position dimension index	RW P	0x00 (0)
608B	Velocity notation index	RW P	0
608C	Velocity dimension index	RW P	0x00 (0)
608D	Acceleration notation index	RW P	0
608E	Acceleration dimension index	RW P	0x00 (0)
+ 6093:0	Position factor	RW	> 2 <

Set Value Dialog

Dec: 589824

Hex: 0x00090000

Float: 8.2651947e-040

Bool: 0 1

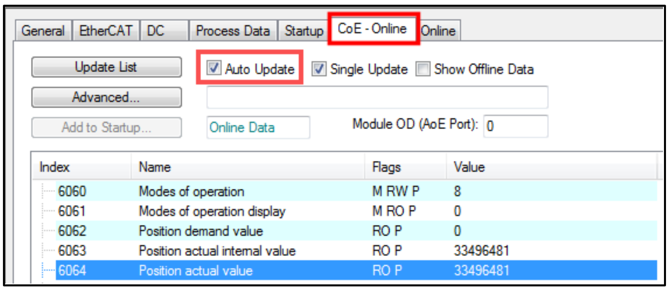
Binary: 00 00 09 00 4

Bit Size: ○ 1 ○ 8 ○ 16 ● 32 ○ 64 ○ ?

Remark: if the object you need to write is also mapped as a RxPDO, writing in it via SDO protocol is useless because the PDO data comes each communication cycle and overwrites the data in the object. For example, object 607Ah is mapped by default to an RxPDO. Writing in it via the CoE Online list will be overwritten by the PDO value. That is why in Step 7, the PDO data is changed for Target position and not written with SDO protocol.

8. Repeat Step 4 and send **Operation Enable** (0F 00) into *Control word*. After this command, the drive will apply voltage to the motor and will keep its current position.
9. To start the motion, write in *Control word* variable (0x001F) as in Step 4.

10. To follow the actual position of the motor, scroll to the object index *0x6064 Position actual value* and click the check box *Auto Update*. The motor actual value shall update automatically by reading continuously through SDO protocol.

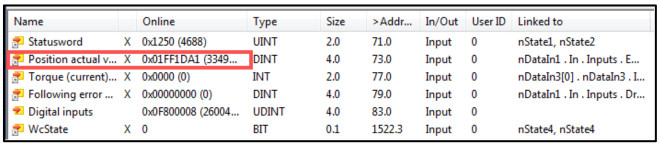


☑ Auto Update ☑ Single Update □ Show Offline Data

Module OD (AoE Port): 0

Index	Name	Flags	Value
6060	Modes of operation	M RW P	8
6061	Modes of operation display	M RO P	0
6062	Position demand value	RO P	0
6063	Position actual internal value	RO P	33496481
6064	Position actual value	RO P	33496481

An alternative is to watch the TxPDO value where this object is mapped.



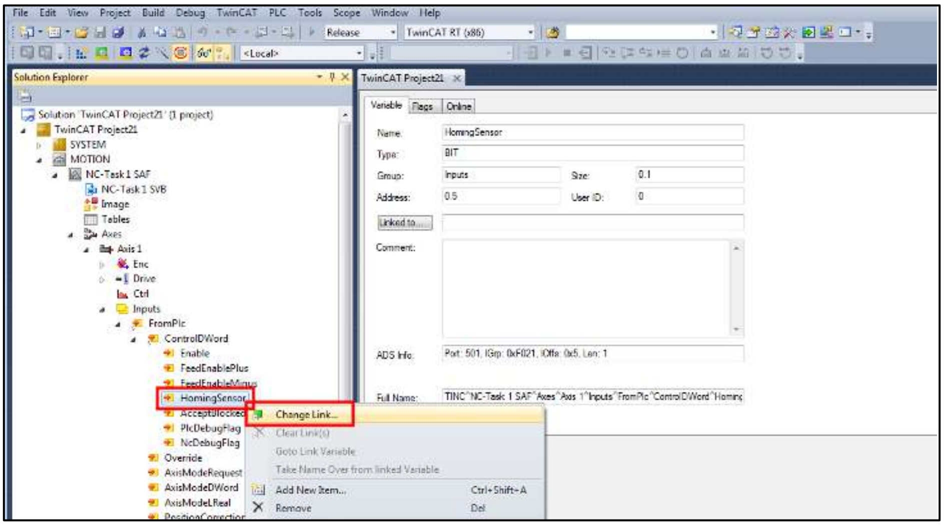
Name		Online	Type	Size	>Addr...	In/Out	User ID	Linked to
Statusword	X	0x1250 (4688)	UINT	2.0	71.0	Input	0	nState1, nState2
Position actual v...	X	0x01FF1DA1 (3349...	DINT	4.0	73.0	Input	0	nDataIn1 . In . Inputs . E...
Torque (current)...	X	0x0000 (0)	INT	2.0	77.0	Input	0	nDataIn3[0] . nDataIn3 . I...
Following error ...	X	0x00000000 (0)	DINT	4.0	79.0	Input	0	nDataIn1 . In . Inputs . Dr...
Digital inputs		0x0F800008 (26004...	UDINT	4.0	83.0	Input	0	
WcState	X	0	BIT	0.1	1522.3	Input	0	nState4, nState4

11. After reaching 80000 counts, the motor will stop and hold its position until it receives new motion commands.
12. To issue a new motion command, reset bit 4 of control word to 0. Like in step 4, write the value 0x000F into control word. It was previously set to 0x001F.
13. As in step 7, right click the Target position PDO value and change it from 80000 to 40000.
14. Right click the control word and set it to 0x001F again to start a new motion.

1.6.2 Starting a Cyclic Synchronous Position mode (CSP) (manual commands)

Remark: The cyclic synchronous position mode is the one used by the TwinCAT software in chapter *0 Configuring the Homing Sensor* **Input**

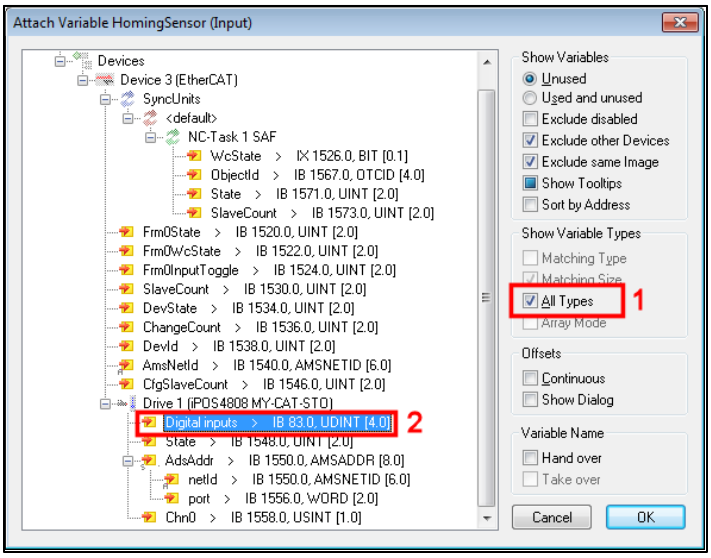
4. In the left panel, navigate to **NC – Configuration/Axes/Axis1/Inputs**.
5. Expand **Axis1_FromPLC**, then expand **ControlDWord**, and select the variable **HomingSensor**.
6. Right-click on the **HomingSensor** variable and choose **Change Link...**.



Name: HomingSensor
Type: BIT
Group: Inputs Size: 0.1
Address: 0.5 User ID: 0
Comment:
ADS Info: Port: 501, IGrp: 0xF021, IOffs: 0x5, Len: 1
Full Name: TINC^NC-Task 1 SAF^Axes^Axis 1^Inputs^FromPlc^ControlDWord^Homing

In the dialog box that appears:

- Check the **All Types** checkbox (1).
- Select the variable **Digital Inputs** (2) and click **OK**.



Attach Variable HomingSensor (Input)

```
Devices
  Device 3 (EtherCAT)
    SyncUnits
      <default>
        NC-Task 1 SAF
          WcState  >  IX 1526.0, BIT [0.1]
          ObjectId  >  IB 1567.0, OTCID [4.0]
          State  >  IB 1571.0, UINT [2.0]
          SlaveCount  >  IB 1573.0, UINT [2.0]
    Frm0State  >  IB 1520.0, UINT [2.0]
    Frm0WcState  >  IB 1522.0, UINT [2.0]
    Frm0InputToggle  >  IB 1524.0, UINT [2.0]
    SlaveCount  >  IB 1530.0, UINT [2.0]
    DevState  >  IB 1534.0, UINT [2.0]
    ChangeCount  >  IB 1536.0, UINT [2.0]
    DevId  >  IB 1538.0, UINT [2.0]
    AmsNetId  >  IB 1540.0, AMSNETID [6.0]
    CfgSlaveCount  >  IB 1546.0, UINT [2.0]
    Drive 1 (iPOS4808 MY-CAT-STO)
      Digital inputs  >  IB 83.0, UDINT [4.0]
      State  >  IB 1548.0, UINT [2.0]
      AdsAddr  >  IB 1550.0, AMSADDR [8.0]
        netId  >  IB 1550.0, AMSNETID [6.0]
        port  >  IB 1556.0, WORD [2.0]
      Chn0  >  IB 1558.0, USINT [1.0]
```

Show Variables
- ● Unused
- ○ Used and unused
- □ Exclude disabled
- ☑ Exclude other Devices
- ☑ Exclude same Image
- ■ Show Tooltips
- □ Sort by Address

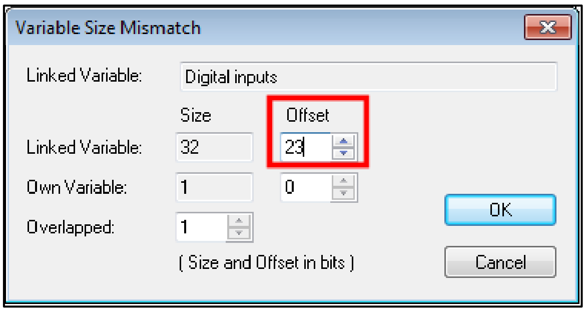
Show Variable Types
- □ Matching Type
- ☑ Matching Size
- ☑ All Types
- □ Array Mode

Offsets
- □ Continuous
- □ Show Dialog

Variable Name
- □ Hand over
- □ Take over

A new menu will appear prompting you to specify the **offset**.

- Since **Digital Inputs Status** is a 32-bit variable and the **HomingSensor** is a **BOOLEAN** (1-bit) variable, set the **offset** to **23** to map it to the **IN0 input**.
- Click **OK** to confirm.



Variable Size Mismatch

Linked Variable: Digital inputs

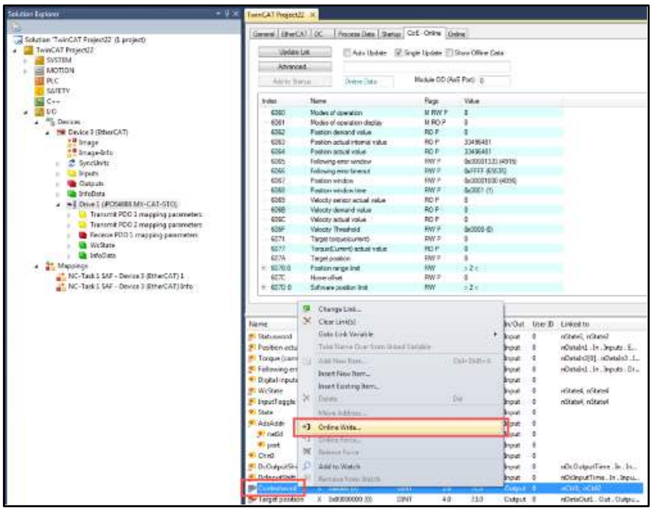
	Size	Offset
Linked Variable:	32	23
Own Variable:	1	0
Overlapped:	1	

(Size and Offset in bits)

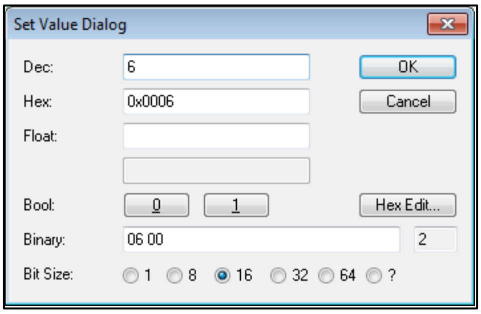
Running the NC-PTP interface. This example shows the manual steps that are behind this operation mode.

To write in a mapped RPDO variable, right click on the variable and choose *Online Write…*

First Edit the Control Word (which is the variable for object 6040h Controlword)



Write inside the Controlword 06 and then click *OK*.



Set Value Dialog

Dec: 6

Hex: 0x0006

Float:

Bool: 0 1

Binary: 06 00 2

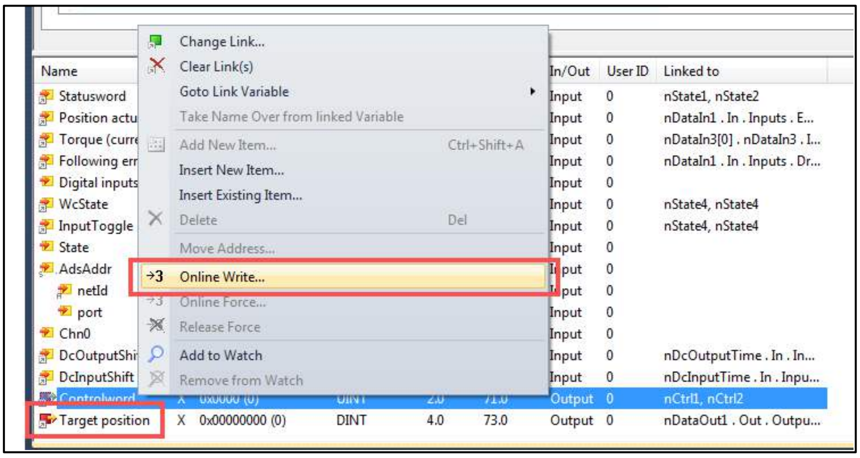
Bit Size: ○ 1 ○ 8 ● 16 ○ 32 ○ 64 ○ ?

Using the same method, write 07 and then 0x000F. After 0x000F, the drive should be in Operation Enable.

6060h should already be set to the value 08 if the XML file is loaded. If it is not 08, then modify Modes of operation object 6060h value 08 via SDO write. This value sets the drive in Cyclic synchronous position mode.

Finally write a small value into RPDO variable Target position (which is object 607Ah). Maximum 20-200 encoder counts.

The data in the target position will be updated every free run cycle (which was previously set to 1ms). Every time the data inside the Target position changes, the motor will move to that destination within that communication cycle time value.

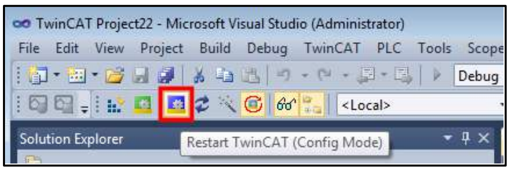


Name						In/Out	User ID	Linked to
Statusword						Input	0	nState1, nState2
Position actu						Input	0	nDataIn1 . In . Inputs . E...
Torque (curre						Input	0	nDataIn3[0] . nDataIn3 . I...
Following err						Input	0	nDataIn1 . In . Inputs . Dr...
Digital inputs						Input	0	
WcState						Input	0	nState4, nState4
InputToggle						Input	0	nState4, nState4
State						Input	0	
AdsAddr						Input	0	
netId						Input	0	
port						Input	0	
Chn0						Input	0	
DcOutputShi						Input	0	nDcOutputTime . In . In...
DcInputShift						Input	0	nDcInputTime . In . Inpu...
Controlword	X	0x0000 (0)	UINT	2.0	71.0	Output	0	nCtrl1, nCtrl2
Target position	X	0x00000000 (0)	DINT	4.0	73.0	Output	0	nDataOut1 . Out . Outpu...

1.6.3 Mapping objects to TxPDOs and RxPDOs in TwinCAT System Manager

1.6.3.1 Mapping objects to RxPDO2

- Set the drive in Config mode. The drive can be with free run mode activated or not.

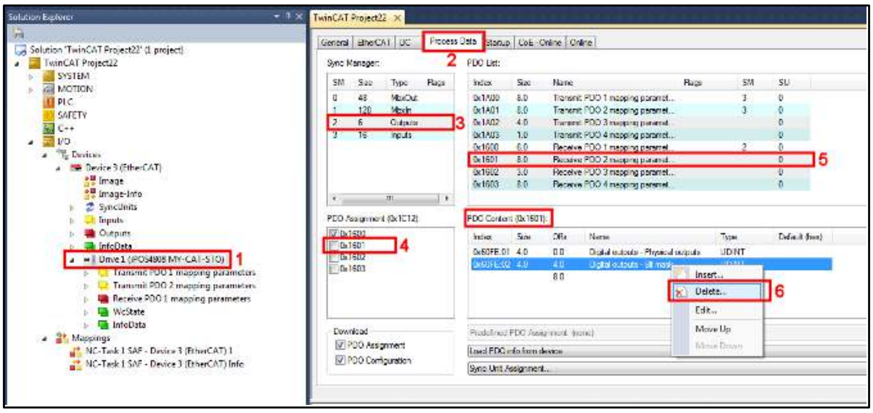


TwinCAT Project22 - Microsoft Visual Studio (Administrator)
File Edit View Project Build Debug TwinCAT PLC Tools Scope
Debug
<Local>
Solution Explorer
Restart TwinCAT (Config Mode)

- To map new RxPDO data follow the steps:

1. Select or double-click Drive 1 on the left.
2. Select Process Data tab to the upper right of the screen
3. In Sync Manager, select the Outputs to enable or disable RxPDO1 to 4.
4. Under PDO Assignment (0x1C12), select which RxPDOs objects should be active. In this case, check 0x1601 to activate RxPDO2.
5. Under PDO List, select object 0x1601 (Receive PDO 2) by clicking on it.

   Below, in the PDO content window, the default mapped objects are shown.
6. First clear the existing objects by right click and delete on them.



Sync Manager:

SM	Size	Type	Flags
0	48	MbxOut	
1	120	MbxIn	
2	6	Outputs	
3	16	Inputs	

PDO List:

Index	Size	Name	Flags	SM	SU
0x1A00	8.0	Transmit PDO 1 mapping paramet...		3	0
0x1A01	8.0	Transmit PDO 2 mapping paramet...		3	0
0x1A02	4.0	Transmit PDO 3 mapping paramet...			0
0x1A03	1.0	Transmit PDO 4 mapping paramet...			0
0x1600	6.0	Receive PDO 1 mapping paramet...		2	0
0x1601	8.0	Receive PDO 2 mapping paramet...			0
0x1602	3.0	Receive PDO 3 mapping paramet...			0
0x1603	8.0	Receive PDO 4 mapping paramet...			0

PDO Assignment (0x1C12):

☑ 0x1600
□ 0x1601
□ 0x1602
□ 0x1603

PDO Content (0x1601):

Index	Size	Offs	Name	Type	Default (hex)
0x60FE:01	4.0	0.0	Digital outputs - Physical outputs	UDINT	
0x60FE:02	4.0	4.0	Digital outputs - Bit mask	UDINT	
		8.0			

Download

☑ PDO Assignment

☑ PDO Configuration

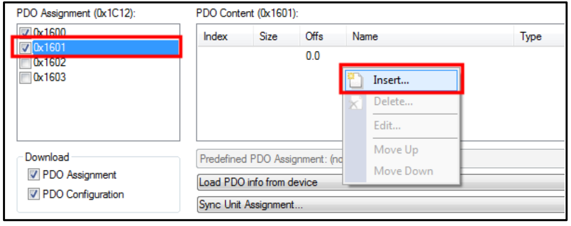
Predefined PDO Assignment: (none)

Load PDO info from device

Sync Unit Assignment...

Do this step until all objects are deleted.

- After current objects are deleted from PDO 0x1601, right click on the white space and choose Insert...



PDO Assignment (0x1C12):

☑ 0x1600
☑ 0x1601
□ 0x1602
□ 0x1603

PDO Content (0x1601):

Index	Size	Offs	Name	Type
		0.0		

Download

☑ PDO Assignment

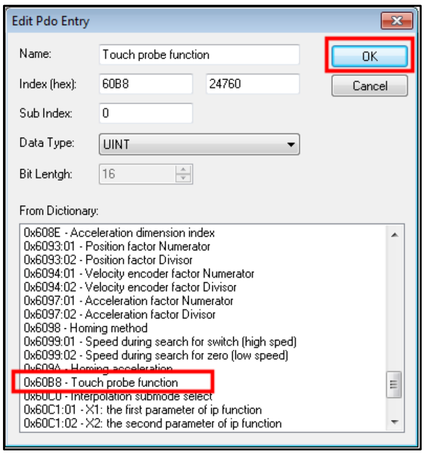
☑ PDO Configuration

Predefined PDO Assignment: (nc

Load PDO info from device

Sync Unit Assignment...

- A new list of mappable objects will open. Choose for this example, object 60B8h – Touch probe function and click Ok.



Name: Touch probe function

Index (hex): 60B8 24760

Sub Index: 0

Data Type: UINT

Bit Length: 16

From Dictionary:

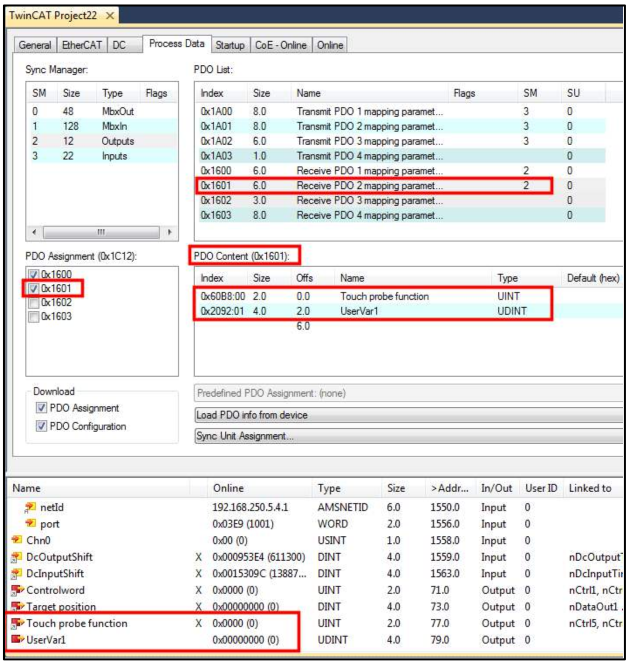
0x608E - Acceleration dimension index
0x6093:01 - Position factor Numerator
0x6093:02 - Position factor Divisor
0x6094:01 - Velocity encoder factor Numerator
0x6094:02 - Velocity encoder factor Divisor
0x6097:01 - Acceleration factor Numerator
0x6097:02 - Acceleration factor Divisor
0x6098 - Homing method
0x6099:01 - Speed during search for switch (high sped)
0x6099:02 - Speed during search for zero (low speed)
0x609A - Homing acceleration
0x60B8 - Touch probe function
0x60C0 - Interpolation submode select
0x60C1:01 - X1: the first parameter of ip function
0x60C1:02 - X2: the second parameter of ip function

- Repeat the same step as before and add/insert object 2092h UserVar1

Remark: each RxPDO or TxPDO can support up to 64 bits of data. This means that the sum of the size of all objects mapped into a PDO must not exceed 64 bits. TwinCAT actually allows in the GUI to map more objects, exceeding 64 bits. When the drive will be re-initialized with the new settings, it will send an emergency message that it ignored the PDO mapping.

Remark: the more data is mapped into the PDOs, the more data is transferred to and from the drive each communication cycle. The data transfer time is increased and leads to decreased performance like bad synchronization during CSP mode. It is recommended to map only the data that is used most often and leave one-time configuration objects like 6060_h Modes of operation to be written into only once using SDO protocol.

- Because 0x1601 is checked under PDO Assignment, the newly mapped objects names will be visible in the PDO list below



Sync Manager:

SM	Size	Type	Flags
0	48	MbxOut	
1	128	MbxIn	
2	12	Outputs	
3	22	Inputs	

PDO List:

Index	Size	Name	Flags	SM	SU
0x1A00	8.0	Transmit PDO 1 mapping paramet...		3	0
0x1A01	8.0	Transmit PDO 2 mapping paramet...		3	0
0x1A02	6.0	Transmit PDO 3 mapping paramet...		3	0
0x1A03	1.0	Transmit PDO 4 mapping paramet...			0
0x1600	6.0	Receive PDO 1 mapping paramet...		2	0
0x1601	6.0	Receive PDO 2 mapping paramet...		2	0
0x1602	3.0	Receive PDO 3 mapping paramet...			0
0x1603	8.0	Receive PDO 4 mapping paramet...			0

PDO Assignment (0x1C12):

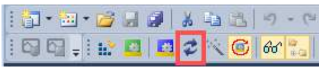
☑ 0x1600
☑ 0x1601
☐ 0x1602
☐ 0x1603

PDO Content (0x1601):

Index	Size	Offs	Name	Type	Default (hex)
0x60B8:00	2.0	0.0	Touch probe function	UINT	
0x2092:01	4.0	2.0	UserVar1	UDINT	
		6.0			

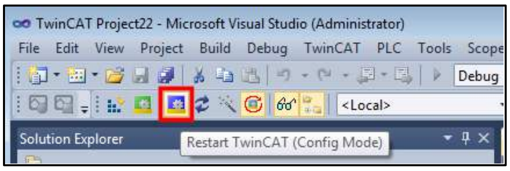
Name		Online	Type	Size	>Addr...	In/Out	User ID	Linked to
netId		192.168.250.5.4.1	AMSNETID	6.0	1550.0	Input	0	
port		0x03E9 (1001)	WORD	2.0	1556.0	Input	0	
Chn0		0x00 (0)	USINT	1.0	1558.0	Input	0	
DcOutputShift	X	0x000953E4 (611300)	DINT	4.0	1559.0	Input	0	nDcOutput
DcInputShift	X	0x0015309C (13887...	DINT	4.0	1563.0	Input	0	nDcInputTi
Controlword	X	0x0000 (0)	UINT	2.0	71.0	Output	0	nCtrl1, nCtr
Target position	X	0x00000000 (0)	DINT	4.0	73.0	Output	0	nDataOut1 .
Touch probe function	X	0x0000 (0)	UINT	2.0	77.0	Output	0	nCtrl5, nCtr
UserVar1		0x00000000 (0)	UDINT	4.0	79.0	Output	0	

- To activate the new PDO setup, click Reload I/O devices button.



1.6.3.2 Mapping objects to TxPDO3

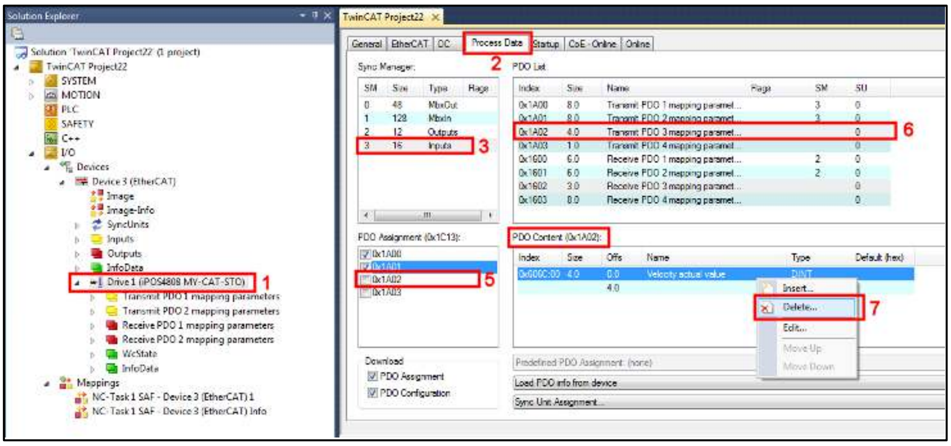
- Set the drive in Config mode if not already.


TwinCAT Project22 - Microsoft Visual Studio (Administrator)
File
Edit
View
Project
Build
Debug
TwinCAT
PLC
Tools
Scope
Debug
<Local>
Solution Explorer
Restart TwinCAT (Config Mode)

- To map new RxPDO data follow the steps:

1. Select or double-click Drive 1 in the left.
2. Select Process Data tab to the upper right of the screen
3. In Sync Manager, select the Inputs to enable or disable TxPDO1 to 4.
4. Under PDO Assignment (0x1C13), select which TxPDOs objects should be active. In this case, check 0x1A02 to activate TxPDO3.
5. Under PDO List, select object 0x1A02 (Transmit PDO 3) by clicking on it.

   Below, in the PDO content window, the default mapped objects are shown.
6. First clear the existing objects by right click and delete on them.



Sync Manager:

SM	Size	Type	Flags
0	48	MbxOut	
1	128	MbxIn	
2	12	Outputs	
3	16	Inputs	

PDO List

Index	Size	Name	Flags	SM	SU
0x1A00	8.0	Transmit PDO 1 mapping paramet...		3	0
0x1A01	8.0	Transmit PDO 2 mapping paramet...		3	0
0x1A02	4.0	Transmit PDO 3 mapping paramet...			0
0x1A03	1.0	Transmit PDO 4 mapping paramet...			0
0x1600	6.0	Receive PDO 1 mapping paramet...		2	0
0x1601	6.0	Receive PDO 2 mapping paramet...		2	0
0x1602	3.0	Receive PDO 3 mapping paramet...			0
0x1603	8.0	Receive PDO 4 mapping paramet...			0

PDO Assignment (0x1C13):

☑ 0x1A00
☑ 0x1A01
☐ 0x1A02
☐ 0x1A03

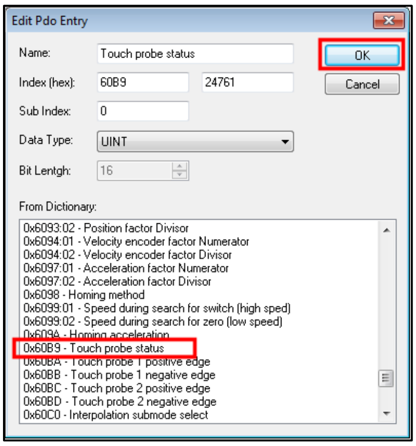
PDO Content (0x1A02):

Index	Size	Offs	Name	Type	Default (hex)
0x606C:00	4.0	0.0	Velocity actual value	DINT	
		4.0			

Do this step until all objects are deleted.

- After current objects are deleted from PDO 0x1A02, right click on the white space and choose Insert...

- A new list of mappable objects will open. Choose for this example, object 60B9$_h$ – Touch probe status and click Ok.



Edit Pdo Entry

Name: Touch probe status

Index (hex): 60B9 24761

Sub Index: 0

Data Type: UINT

Bit Lentgh: 16

From Dictionary:

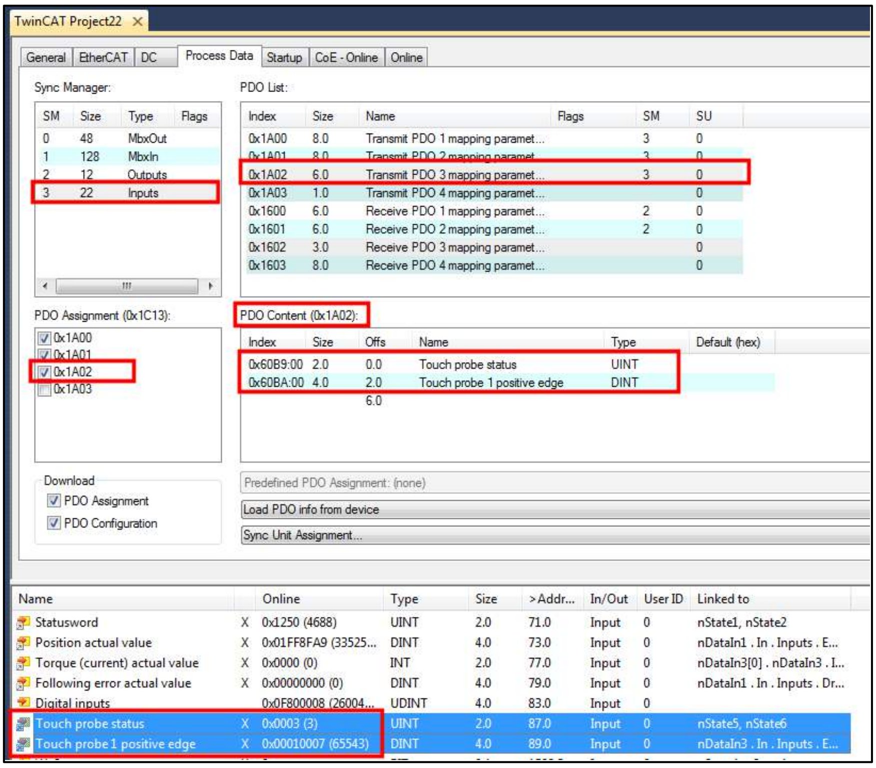
0x6093:02 - Position factor Divisor
0x6094:01 - Velocity encoder factor Numerator
0x6094:02 - Velocity encoder factor Divisor
0x6097:01 - Acceleration factor Numerator
0x6097:02 - Acceleration factor Divisor
0x6098 - Homing method
0x6099:01 - Speed during search for switch (high sped)
0x6099:02 - Speed during search for zero (low speed)
0x609A - Homing acceleration
0x60B9 - Touch probe status
0x60BA - Touch probe 1 positive edge
0x60BB - Touch probe 1 negative edge
0x60BC - Touch probe 2 positive edge
0x60BD - Touch probe 2 negative edge
0x60C0 - Interpolation submode select

- Repeat the same step as before and add/insert object 0x60BA – Touch probe 1 positive edge

Remark: each RxPDO or TxPDO can support up to 64 bits of data.

Remark: the more data is mapped into the PDOs, the data transfer time is increased and leads to decreased performance.

- Because 0x1A02 is checked under PDO Assignment, the newly mapped objects names will be visible in the PDO list below



Sync Manager:

SM	Size	Type	Flags
0	48	MbxOut	
1	128	MbxIn	
2	12	Outputs	
3	22	Inputs	

PDO List:

Index	Size	Name	Flags	SM	SU
0x1A00	8.0	Transmit PDO 1 mapping paramet...		3	0
0x1A01	8.0	Transmit PDO 2 mapping paramet...		3	0
0x1A02	6.0	Transmit PDO 3 mapping paramet...		3	0
0x1A03	1.0	Transmit PDO 4 mapping paramet...			0
0x1600	6.0	Receive PDO 1 mapping paramet...		2	0
0x1601	6.0	Receive PDO 2 mapping paramet...		2	0
0x1602	3.0	Receive PDO 3 mapping paramet...			0
0x1603	8.0	Receive PDO 4 mapping paramet...			0

PDO Assignment (0x1C13):

☑ 0x1A00
☑ 0x1A01
☑ 0x1A02
☐ 0x1A03

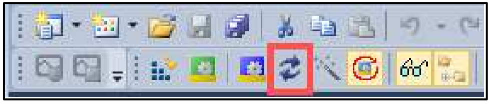
PDO Content (0x1A02):

Index	Size	Offs	Name	Type	Default (hex)
0x60B9:00	2.0	0.0	Touch probe status	UINT	
0x60BA:00	4.0	2.0	Touch probe 1 positive edge	DINT	
		6.0			

Download
☑ PDO Assignment
☑ PDO Configuration

Name		Online	Type	Size	>Addr...	In/Out	User ID	Linked to
Statusword	X	0x1250 (4688)	UINT	2.0	71.0	Input	0	nState1, nState2
Position actual value	X	0x01FF8FA9 (33525...	DINT	4.0	73.0	Input	0	nDataIn1 . In . Inputs . E...
Torque (current) actual value	X	0x0000 (0)	INT	2.0	77.0	Input	0	nDataIn3[0] . nDataIn3 . I...
Following error actual value	X	0x00000000 (0)	DINT	4.0	79.0	Input	0	nDataIn1 . In . Inputs . Dr...
Digital inputs		0x0F800008 (26004...	UDINT	4.0	83.0	Input	0	
Touch probe status	X	0x0003 (3)	UINT	2.0	87.0	Input	0	nState5, nState6
Touch probe 1 positive edge	X	0x00010007 (65543)	DINT	4.0	89.0	Input	0	nDataIn3 . In . Inputs . E...

- To activate the new PDO setup, click Reload I/O devices button.



2 CAN application protocol over EtherCAT® (CoE protocol)

EtherCAT® (Ethernet for Control Automation Technology) is an open high performance Ethernet-based fieldbus system used in automation control systems. The CAN application protocol over EtherCAT® (CoE) enables the complete CANopen profile family to be used via EtherCAT® and it specifies how various types of devices can use the EtherCAT® network.

2.1 EtherCAT® Architecture

EtherCAT® fieldbus accepts different network topologies, the most commonly used being presented in

Figure 2.1.1.

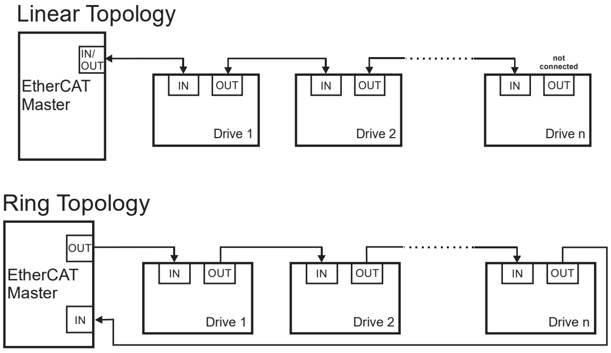


Figure 2.1.1. *EtherCAT® Architecture*

Technosoft has extended the concept of distributed motion application allowing splitting the motion application between the Technosoft drives and the EtherCAT® master. Using TML the user can build complex motion applications locally, on each drive, leaving on the EtherCAT® master only a high level motion application and thus reducing the network master complexity. The master has the vision of the motion application, specific tasks being executed on the Technosoft drives.

2.2 Accessing EtherCAT® devices

An EtherCAT® device is controlled through read/write operations to/from objects performed by an EtherCAT® master.

2.2.1 CoE elements

Table 2.2.1 describes the Mailbox Header and CoE Header.

Table 2.2.1 *– CoE elements*

Frame part	Data Field	Data Type	Value/Description
Mailbox Header	Length	WORD	Length of the Mailbox Service Data
	Address	WORD(32 Bit)	Station Address of the source, if a master is client, Station Address of the destination, if a slave is client
	Channel	Unsigned6	0x00 (Reserved for future)
	Priority	Unsigned2	0x00: lowest priority … 0x03: highest priority
	Type	Unsigned4	0x03: CoE
	Cnt	Unsigned3	Counter of the mailbox services (0 is the start value, next value after 7 is 1)
	Reserved	Unsigned1	0x00
CANopen Header	Number	Unsigned9	Depending on the CANopen service
	Reserved	Unsigned3	0x00
	Service	Unsigned4	0x01: Emergency 0x02: SDO Request 0x03: SDO Response 0x04: TxPDO 0x05: RxPDO 0x06: TxPDO remote request 0x07: RxPDO remote request 0x08: SDO Information

2.2.2 Object dictionary

The Object Dictionary is a group of objects that describe the complete functionality of a device by way of communication objects and is the link between the communication interface and the application. All communication objects of a device (application data and configuration parameters) are described in the Object Dictionary in a standardized way.

2.2.3 Object access using index and sub-index

The objects defined for a device are accessed using a 16-bit index and an 8-bit sub-index. In case of arrays and records there is an additional sub-index for each element of the array or record.

2.2.4 Service Data Objects (SDO)

Service Data Objects are used by the EtherCAT® master to access any object from the drive's Object Dictionary.

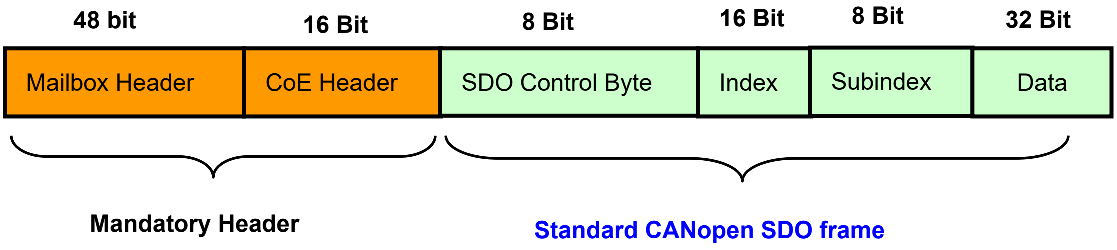


Figure 2.2.1. *EtherCAT®* message SDO structure

Standard CANopen SDO frames can be used:

– Initiate SDO Download

– Download SDO Segment

– Initiate SDO Upload

– Upload SDO Segment

– Abort SDO Transfer

The SDOs are typically used for drive configuration after power-on, for PDO mapping and for infrequent low priority communication.

SDO transfers are confirmed services. In case of an error, an Abort SDO message is transmitted with one of the codes listed below**.**

Table 2.2.2 *– SDO Abort Codes*

Abort code	Description
0503 0000h	Toggle bit not changed
0504 0000h	SDO protocol timeout
0504 0001h	Client/server command specifier not valid or unknown
0504 0005h	Out of memory
0601 0000h	Unsupported access to an object.
0601 0001h	Attempt to read to a write only object
0601 0002h	Attempt to write to a read only object
0602 0000h	Object does not exist in the object dictionary.
0604 0041h	Object cannot be mapped to the PDO.
0604 0042h	The number and length of the objects to be mapped would exceed PDO length.
0604 0043h	General parameter incompatibility reason.
0604 0047h	General internal incompatibility error in the device.
0606 0000h	Access failed due to a hardware error
0607 0010h	Data type does not match, length of service parameter does not match
0607 0012h	Data type does not match, length of service parameter too high
0607 0013h	Data type does not match, length of service parameter too low
0609 0011h	Sub-index does not exist.
0609 0030h	Value range of parameter exceeded (only for write access).
0609 0031h	Value of parameter written too high.
0609 0032h	Value of parameter written too low.
0609 0036h	Maximum value is less than minimum value
0800 0000h	General error
0800 0020h	Data cannot be transferred or stored to the application.
0800 0021h	Data cannot be transferred or stored to the application because of local control.
0800 0022h	Data cannot be transferred or stored to the application because of the present device state.
0800 0023h	Object dictionary dynamic generation fails or no object dictionary is present

2.2.5 Process Data Objects (PDO)

Process Data Objects are used for high priority, real-time data transfers between the EtherCAT® master and the drives. The PDOs are unconfirmed services and are performed with no protocol overhead. Transmit PDOs are used to send data from the drive, and receive PDOs are used to receive data. The Technosoft drives accept 4 transmit PDOs and 4 receive PDOs. The contents of the PDOs can be set according with the application needs through the dynamic PDO-mapping. This operation can be done during the drive configuration phase using SDOs.

The mapping PDO object contains the descriptions of the objects mapped into the PDO, i.e. the index, sub-index and size of the mapped objects.

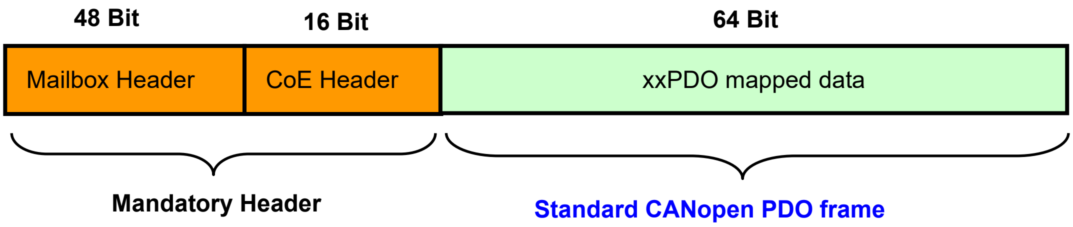


Figure 2.2.2. *EtherCAT®* message PDO structure

2.3 Objects that define SDOs and PDOs

2.3.1 Object 1600$_h$: Receive PDO1 Mapping Parameters

This object contains the mapping parameters of the receive PDO1. The sub-index 00$_h$ contains the number of valid entries within the mapping record. This number of entries is also the number of the objects that shall be transmitted/received with the corresponding PDO. The sub-indices from 01$_h$ to the number of entries contain the information about the mapped objects. These entries describe the PDO contents by their index, sub-index and length. The length entry contains the length of the mapped object in bits and is used to verify the overall mapping length.

The structure of the entries from sub-index 01$_h$ to the number of entries is as follows:

MSB		**LSB**
Index (16 bits)	Sub-index (8 bits)	Object length (8 bits)

In order to change the PDO mapping, first the PDO has to be disabled - the object 160x$_h$ sub-index 00$_h$ has to be set to 0. Now the objects can be remapped. If a wrong mapping parameter is introduced (object does not exist, the object cannot be mapped or wrong mapping length is detected) the SDO transfer will be aborted with an appropriate error code (0602 0000$_h$ or 0604 0041$_h$). After all objects are mapped, sub-index 00$_h$ has to be set to the valid number of mapped objects thus enabling the PDO.

If data types (index 01$_h$ - 07$_h$) are mapped, they serve as “dummy entries”. The corresponding data is not evaluated by the drive. This feature can be used to transmit data to several drives using only one PDO, each drive using only a part of the PDO. This feature is only valid for receive PDOs.

Object description:

Index	1600$_h$
Name	RPDO1 Mapping Parameters
Object code	RECORD
Data type	PDO Mapping

Entry description:

Sub-index	00$_h$
Description	Number of mapped objects
Access	RW
PDO mapping	No
Value range	0: Mapping disabled 1 – 64: Sub-index 1 to x is valid
Default value	2

Sub-index	01$_h$
Description	1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60400010$_h$ – Controlword

Sub-index	02_h
Description	2nd mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	$607A0020_h$ – Target position

2.3.2 Object 1601_h: Receive PDO2 Mapping Parameters

This object contains the mapping parameters of the receive PDO2. The sub-index 00_h contains the number of valid entries within the mapping record. This number of entries is also the number of the objects that shall be transmitted/received with the corresponding PDO.

Object description:

Index	1601_h
Name	RPDO2 Mapping Parameter
Object code	RECORD
Data type	PDO Mapping

Entry description:

Sub-index	00_h
Description	Number of mapped objects
Access	RW
PDO mapping	No
Value range	0: Mapping disabled 1 – 64: Sub-index 1 to x is valid
Default value	2

Sub-index	01_h
Description	1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	$60FE0120_h$ – Digital outputs - Physical outputs

Sub-index	02_h
Description	2nd mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	$60FE0220_h$ – Digital outputs - Bit mask

2.3.3 Object 1602_h: Receive PDO3 Mapping Parameters

This object contains the mapping parameters of the receive PDO3. The sub-index 00_h contains the number of valid entries within the mapping record. This number of entries is also the number of the objects that shall be transmitted/received with the corresponding PDO.

Object description:

Index	1602_h
Name	RPDO3 Mapping Parameter
Object code	RECORD
Data type	PDO Mapping

Entry description:

Sub-index	00_h
Description	Number of mapped objects
Access	RW
PDO mapping	No
Value range	0: Mapping disabled 1 – 64: Sub-index 1 to x is valid
Default value	2

Sub-index	01_h
Description	1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60600008_h – Modes of operation

Sub-index	02$_h$
Description	2nd mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60710010$_h$ – Target torque

2.3.4 Object 1603$_h$: Receive PDO4 Mapping Parameters

This object contains the mapping parameters of the receive PDO4. The sub-index 00$_h$ contains the number of valid entries within the mapping record. This number of entries is also the number of the objects that shall be transmitted/received with the corresponding PDO.

Object description:

Index	1603$_h$
Name	RPDO4 Mapping Parameters
Object code	RECORD
Data type	PDO Mapping

Entry description:

Sub-index	00$_h$
Description	Number of mapped objects
Access	RW
PDO mapping	No
Value range	0: Mapping disabled 1 – 64: Sub-index 1 to x is valid
Default value	2

Sub-index	01$_h$
Description	1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60810020$_h$ – Profile velocity

Sub-index	02$_h$
Description	2nd mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60830020$_h$ – Profile acceleration

2.3.5 Object 1A00$_h$: Transmit PDO1 Mapping Parameters

This object contains the mapping parameters of the transmit PDO1. For detailed description see object 1600$_h$ (Receive PDO1 mapping parameters)

Object description:

Index	1A00$_h$
Name	TPDO1 Mapping Parameters
Object code	RECORD
Data type	PDO Mapping

Entry description:

Sub-index	00$_h$
Description	Number of mapped objects
Access	RW
PDO mapping	No
Value range	0: Mapping disabled 1 – 64: Sub-index 1 to x is valid
Default value	3

Sub-index	01$_h$
Description	1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60410010$_h$ – Statusword

Sub-index	02$_h$
Description	2nd mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60640020$_h$ – Position actual value

Sub-index	03$_h$
Description	3rd mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60770010$_h$ – Torque actual value

2.3.6 Object 1A01$_h$: Transmit PDO2 Mapping Parameters

This object contains the mapping parameters of the transmit PDO2. For detailed description see object 1600$_h$ (Receive PDO1 mapping parameters)

Object description:

Index	1A01$_h$
Name	TPDO2 Mapping Parameter
Object code	RECORD
Data type	PDO Mapping

Entry description:

Sub-index	00$_h$
Description	Number of mapped objects
Access	RW
PDO mapping	No
Value range	0: Mapping disabled 1 – 64: Sub-index 1 to x is valid
Default value	2

Sub-index	01$_h$
Description	1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60F40020$_h$ – Following error actual value

Sub-index	02$_h$
Description	2nd mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60FD0020$_h$ – Digital inputs

2.3.7 Object 1A02$_h$: Transmit PDO3 Mapping Parameters

This object contains the mapping parameters of the transmit PDO3. For detailed description see object 1600$_h$ (Receive PDO1 mapping parameters). By default, this PDO is disabled with object 1802$_h$ Sub-index 01 by setting Bit31 to 1.

Object description:

Index	1A02$_h$
Name	TPDO3 Mapping Parameter
Object code	RECORD
Data type	PDO Mapping

Entry description:

Sub-index	00$_h$
Description	Number of entries
Access	RW
PDO mapping	No
Value range	0: Mapping disabled 1 – 64: Sub-index 1 to x is valid
Default value	1

Sub-index	01$_h$
Description	1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	606C0020$_h$ – Velocity actual value

2.3.8 Object 1A03$_h$: Transmit PDO4 Mapping Parameters

This object contains the mapping parameters of the transmit PDO4. For detailed description see object 1600$_h$ (Receive PDO1 mapping parameters). By default, this PDO is disabled with object 1803$_h$ Sub-index 01 by setting Bit31 to 1.

Object description:

Index	1A03$_h$
Name	TPDO4 Mapping Parameter
Object code	RECORD
Data type	PDO Mapping

Entry description:

Sub-index	00$_h$
Description	Number of entries
Access	RW
PDO mapping	No
Value range	0: Mapping disabled 1 – 64: Sub-index 1 to x is valid
Default value	1

Sub-index	01$_h$
Description	1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	60610008$_h$ – Modes of operation display

2.3.9 Object 1C00$_h$: Sync Manager Communication type

Object description:

Index	1C00$_h$
Name	Sync Manager Com. type
Object code	ARRAY
Data type	UNSIGNED 8

Entry description:

Sub-index	00$_h$
Description	Number of entries
Access	RO
PDO mapping	No
Default value	4

Sub-index	01$_h$
Description	Communication Type Sync Manager 0
Access	RO
PDO mapping	No
Value range	UNSIGNED8 1 : mailbox receive (master to slave)
Default value	1

Sub-index	02$_h$
Description	Communication Type Sync Manager 1
Access	RO
PDO mapping	No
Value range	UNSIGNED8 2 : mailbox send (slave to master)
Default value	2

Sub-index	03$_h$
Description	Communication Type Sync Manager 2
Access	RO
PDO mapping	No
Value range	UNSIGNED8 0: unused 3 : process data output (master to slave)
Default value	3

Sub-index	04_h
Description	Communication Type Sync Manager 3
Access	RO
PDO mapping	No
Value range	UNSIGNED8 0: unused 1 : mailbox receive (master to slave) 2 : mailbox send (slave to master) 3 : process data output (master to slave) 4: process data input (slave to master)
Default value	3

2.3.10 Object 1C12$_h$: Sync Manager Channel 2 (Process Data Output)

Assigns the RxPDO. This object can be modified only when State Machine is in Pre Operational and Subindex 0 = 0. After configuration is done, set in Subindex 0 the number of configured RxPDOs.

Object description:

Index	1C12$_h$
Name	Sync Manager Channel 2
Object code	ARRAY
Data type	UNSIGNED8

Entry description:

Sub-index	00_h
Description	Number of entries
Access	RO
PDO mapping	No
Value Range	UNSIGNED8 1-4
Default value	1

Sub-index	01_h
Description	PDO Mapping object index of assigned RxPDO : 1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED16 0x1600 (RxPDO1) 0x1601 (RxPDO2) 0x1602 (RxPDO3) 0x1603 (RxPDO4)
Default value	0x1600 (RxPDO1)

2.3.11 Object 1C13h: Sync Manager Channel 3 (Process Data Input)

Assigns the TxPDO. This object can be modified only when State Machine is in Pre Operational and Subindex 0 = 0. After configuration is done, set in Subindex 0 the number of configured TxPDOs.

Object description:

Index	1C13$_h$
Name	Sync Manager Channel 3
Object code	ARRAY
Data type	UNSIGNED8

Entry description:

Sub-index	00_h
Description	Number of entries
Access	RO
PDO mapping	No
Value Range	UNSIGNED8 0-4
Default value	2

Sub-index	01_h
Description	PDO Mapping object index of assigned TxPDO : 1st mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED16 0x1A00 – 0x1A03 (TxPDO1 - TxPDO4)
Default value	0x1A00 (TxPDO1)

Sub-index	02_h
Description	PDO Mapping object index of assigned TxPDO : 2nd mapped object
Access	RW
PDO mapping	No
Value range	UNSIGNED16 0x1A00 – 0x1A03 (TxPDO1 - TxPDO4)
Default value	0x1A01 (TxPDO2)

2.3.12 Object 1C32h: Output Sync Manager Parameter

This object gives the specifications of the EtherCAT communications mode for Sync Manager for output process data.

Object description:

Index	$1C32_h$
Name	Output Sync Manager Parameter
Object code	RECORD
Data type	UNSIGNED8

Entry description:

Sub-index	00_h
Description	Number of entries
Access	RO
PDO mapping	No
Value Range	UNSIGNED8 0-32
Default value	32

Sub-index	01_h	
Description	Synchronization Type	
Access	RO	
PDO mapping	No	
Value range	UNSIGNED16	
Default value	0x0002	
Value description	Value	Current synchronization mode:
	0	Free Run
	2	DC-Mode - Synchronization with SYNC0 Event

Sub-index	02_h	
Description	Cycle Time	
Access	RO	
PDO mapping	No	
Value range	UNSIGNED32	
Default value	0x000F4240	
Value description	Free Run	Cycle time of the local timer (ns)
	DC-Mode	SYNC0 Cycle Time (ns)

Sub-index	04_h		
Description	Synchronization Types supported		
Access	RO		
PDO mapping	No		
Value range	UNSIGNED16		
Default value	0x0005		
Value description	Bit	Value	Supported synchronization modes:
	0	1	Free run is supported
	2:4	001	DC SYNC0 mode is supported
	5:6	00	No Output Shift supported

Sub-index	05_h
Description	Minimum Cycle Time
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00000000
Value description	Gives the minimum Cycle Time that is supported by the slave (ns).

Sub-index	06$_h$
Description	Calc and Copy Time
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00000000
Value description	Minimum time between SYNC0 and SYNC1 event (ns, DC mode only)

Sub-index	09$_h$
Description	Delay Time
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00000000
Value description	Time between SYNC1 event and output of the outputs (ns, DC mode only)

Sub-index	0B$_h$
Description	SM-Event Missed Counter
Access	RO
PDO mapping	No
Value range	UNSIGNED16
Default value	0x00000000
Value description	The error counter increases whenever a SM event is expected but does not arrive within the expected time frame.

Sub-index	0C$_h$
Description	Cycle Time Too Small Counter
Access	RO
PDO mapping	No
Value range	UNSIGNED16
Default value	0x00000000
Value description	The error counter increases when the cycle time is too small so the local cycle was not completed in time.

Sub-index	20$_h$	
Description	Sync Error	
Access	RO	
PDO mapping	No	
Value range	BOOL	
Default value	FALSE	
Value description	The synchronization was not correct in the last cycle	
	FALSE	No Synchronization error in the last cycle
	TRUE	Synchronization error in the last cycle

If the communication cycle time is configured to be less than the "Minimum Cycle Time" (specified in sub-index 5$_h$), the system will detect an error. Specifically:

1. The Sync Error flag (sub-index 20$_h$) will be set to TRUE, indicating a synchronization issue.
2. The Cycle Time Too Small Counter (sub-index C$_h$) will increment, tracking the number of occurrences of this issue.
3. As a result of this error, the EtherCAT state machine will not transition to the Safe-Operational state, preventing the system from operating.

2.3.13 Object 1C33h: Input Sync Manager Parameter

This object gives the specifications of the EtherCAT communications mode for Sync Manager for input process data.

Object description:

Index	1C33$_h$
Name	Input Sync Manager Parameter
Object code	RECORD
Data type	UNSIGNED8

Entry description:

Sub-index	00$_h$
Description	Number of entries
Access	RO
PDO mapping	No
Value Range	UNSIGNED8 0-32
Default value	32

Sub-index	01$_h$	
Description	Synchronization Type	
Access	RO	
PDO mapping	No	
Value range	UNSIGNED16	
Default value	0x0002	
Value description	Value	Current synchronization mode:
	0	Free Run
	2	DC-Mode - Synchronized with SYNC0 Event

Sub-index	02$_h$	
Description	Cycle Time	
Access	RO	
PDO mapping	No	
Value range	UNSIGNED32	
Default value	0x000F4240	
Value description	Free Run	Cycle time of the local timer (ns)
	DC-Mode	SYNC0 Cycle Time (ns)

Sub-index	04$_h$		
Description	Synchronization Types supported		
Access	RO		
PDO mapping	No		
Value range	UNSIGNED16		
Default value	0x0005		
Value description	Bit	Value	Supported synchronization modes:
	0	1	Free run is supported
	2:4	001	DC SYNC0 mode is supported
	5:6	00	No Output Shift supported

Sub-index	05$_h$
Description	Minimum Cycle Time
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00000000
Value description	Gives the minimum Cycle Time that is supported by the slave (ns).

Sub-index	06$_h$
Description	Calc and Copy Time
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00000000
Value description	Minimum time between SYNC0 and SYNC1 event (ns, DC mode only)

Sub-index	09$_h$
Description	Delay Time
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00000000
Value description	Time between SYNC1 event and output of the outputs (ns, DC mode only)

Sub-index	0B$_h$
Description	SM-Event Missed Counter
Access	RO
PDO mapping	No
Value range	UNSIGNED16
Default value	0x00000000
Value description	The error counter increases whenever a SM event is expected but does not arrive within the expected time frame.

Sub-index	0C$_h$
Description	Cycle Time Too Small Counter
Access	RO
PDO mapping	No
Value range	UNSIGNED16
Default value	0x00000000
Value description	The error counter increases when the cycle time is too small so the local cycle was not completed in time.

Sub-index	20$_h$	
Description	Sync Error	
Access	RO	
PDO mapping	No	
Value range	BOOL	
Default value	FALSE	
Value description	The synchronization was not correct in the last cycle	
	FALSE	No Synchronization error in the last cycle
	TRUE	Synchronization error in the last cycle

If the communication cycle time is configured to be less than the "Minimum Cycle Time" (specified in sub-index 5$_h$), the system will detect an error. Specifically:

1. The Sync Error flag (sub-index 20$_h$) will be set to TRUE, indicating a synchronization issue.
2. The Cycle Time Too Small Counter (sub-index C$_h$) will increment, tracking the number of occurrences of this issue.
3. As a result of this error, the EtherCAT state machine will not transition to the Safe-Operational state, preventing the system from operating.

2.3.14 Object 207D$_h$: Dummy

This object may be used to fill a RPDO up to a length matching the EtherCAT® master requirements.

Object description:

Index	207D$_h$
Name	Dummy
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RW
PDO mapping	Possible
Value range	0 … 255
Default value	0

2.4 PDOs mapping general example

Follow the next steps to change the default mapping of a PDO:

1. **Set the drive into Pre-Operational.**
2. **Disable the Sync Manager Channels 2 and 3** for the RxPDOs and the TxPDOs: write 0 in sub-index 0 of objects 1C12$_h$ and 1C13$_h$
3. **Disable the PDO**. In the PDO's mapping object (index 1600$_h$-1603$_h$ for RxPDOs and 1A00$_h$-1A03$_h$ for TxPDOs) set the first sub-index (the number of mapped objects) to 0. This will disable the PDO.
4. **Map the new objects**. Write in the PDO's mapping object (index 1600$_h$-1603$_h$ for RxPDOs and 1A00$_h$-1A03$_h$ for TxPDOs) sub-indexes (1-8) the description of the objects that will be mapped.
5. **Enable the PDO**. In sub-index 0 of the PDO's associated mapping object (index 1600$_h$-1603$_h$ for RxPDOs and 1A00$_h$-1A03$_h$ for TxPDOs) write the number of mapped objects.
6. **Map the enabled PDOs intro Sync Manager Channels 2 and 3**. Set in sub-index 1-4 the hex value of the enabled PDOs (1A00$_h$-1A03$_h$ for TxPDOs in 1C13$_h$ and 1600$_h$-1603$_h$ for RxPDOs in 1C12$_h$).
7. **Enable the Sync Manager channels.** Set in their sub-index 0 the number of enabled Tx/Rx PDOs.
8. **Set the drive into Operational** state.

2.5 PDOs size

Our drives support the configuration of up to 8 PDOs in total. The size of these PDOs depends on the firmware version of the drive:

- Firmware Version **F515K**

- RPDO1/TPDO1: 32 bytes (256 bits)
- RPDO2/TPDO2, RPDO3/TPDO3, RPDO4/TPDO4: 8 bytes (64 bits each)

- Firmware Version **F515J or Earlier**

- RPDO1/TPDO1, RPDO2/TPDO2, RPDO3/TPDO3, RPDO4/TPDO4: 8 bytes (64 bits each)

- Firmware Versions **FA00x or FA02x**

- RPDO1/TPDO1: 64 bytes (512 bits)
- RPDO2/TPDO2, RPDO3/TPDO3, RPDO4/TPDO4: 8 bytes (64 bits each)

2.6 RxPDOs mapping example

Remark: for a TwinCAT example about mapping RxPDOs see paragraph *1.6.3.1.*

Map the receive PDO3 with **ControlWord** (index 6040h) and **Modes of Operation** (index 6060h).

1. **Set the drive to Pre-Operational.**
2. **Disable the Sync manager with RxPDOs**. Write zero in object 1C12h sub-index 0, this will disable the PDO.
3. **Disable RxPDO3 mapping PDO**. Write 0 in object 1602h sub-index 0, this will disable the PDO's mapping.

   Send the following message: SDO access to object 1602h sub-index 0, 8-bit value 0.
4. **Map the new objects**.

   a. Write in object 1602h sub-index 1 the description of the Controlword:

Index	Sub-index	Length	Resulting data
6040h	**00h**	**10h**	**60400010h**

   Send the following message: SDO access to object 1602h sub-index 1, 32-bit value 60400010h.

   b. Write in object 1602h sub-index 2 the description of the Modes of Operation:

Index	Sub-index	Length	Resulting data
6060h	**00h**	**08h**	**60600008h**

   Send the following message: SDO access to object 1602h sub-index 2, 32-bit value 60600008h.
5. **Enable the RxPDO3 mapped objects**. Set the object 1602h sub-index 0 with the value 2 to enable both mapped objects.

   Send the following message: SDO access to object 1602h sub-index 0, 8-bit value 2.
6. **Add the new TPDO to the Sync Manager**.

   -Write in object 1C12h sub-index 3 the RPDO3 mapping parameter object number:

   Send the following message: SDO access to object 1C12h sub-index 3, 16-bit value 1602h.

   -Write 03 h in object 1C12h sub-index 0, this will enable the Sync. Manager.

   Send the following message: SDO access to object 1C12h sub-index 0, 8-bit value 03h.

   Note: if using TwinCAT System Manager, enter in Configuration Mode, select the drive, select Process Data tab, uncheck the PDO Assignment and PDO Configuration boxes. Click Load PDO info from device button to load the new PDO configuration. Reload the IO devices and enter in Operation state.
7. **Set the drive to Safe-Operational**.
8. **Set the drive to Operational.**

2.7 TxPDOs mapping example

Remark: for a TwinCAT example about mapping TxPDOs see paragraph *1.6.3.2.*

Map the transmit PDO4 with **Position actual value** (index 6064h) and **Digital inputs** (index 60FDh).

1. **Set the drive to Pre-Operational.**
2. **Disable the Sync manager with TxPDOs**. Write zero in object 1C13h sub-index 0, this will disable the PDO.

3. **Disable RxPDO4 mapping PDO**. Write 0 in object 1A03$_h$ sub-index 0, this will disable the PDO's mapping.

   Send the following message: SDO access to object 1A03$_h$ sub-index 0, 8-bit value 0.

4. **Map the new objects**.

   a. Write in object 1A03$_h$ sub-index 1 the description of the Position actual value:

Index	Sub-index	Length	Resulting data
6064$_h$	**00$_h$**	**20$_h$**	**60640020$_h$**

   Send the following message (SDO access to object 1A03$_h$ sub-index 1, 32-bit value 60640020$_h$).

   b. Write in object 1A03$_h$ sub-index 2 the description of the Digital inputs:

Index	Sub-index	Length	Resulting data
60FD$_h$	**00$_h$**	**20$_h$**	**60FD0020$_h$**

   Send the following message (SDO access to object 1A03$_h$ sub-index 2, 32-bit value 60FD0020$_h$).

5. **Enable the RxPDO3 mapped objects**. Set the object 1A03$_h$ sub-index 0 with the value 2 to enable both mapped objects.

   Send the following message: SDO access to object 1A03$_h$ sub-index 0, 8-bit value 2.

6. **Add the new TPDO to the Sync Manager**.

   -Write in object 1C13$_h$ sub-index 4 the TPDO4 mapping parameter object number:

   Send the following message: SDO access to object 1C13$_h$ sub-index 4, 16-bit value 1A03$_h$.

   -Write 04 $_h$ in object 1C13$_h$ sub-index 0, this will enable the Sync. Manager.

   Send the following message: SDO access to object 1C13$_h$ sub-index 0, 8-bit value 04$_h$.

   Note: if using TwinCAT System Manager, enter in Configuration Mode, select the drive, select Process Data tab, uncheck the PDO Assignment and PDO Configuration boxes. Click Load PDO info from device button to load the new PDO configuration. Reload the IO devices and enter in Operation state.

7. **Set the drive to Safe-Operational**.

8. **Set the drive to Operational.**

3 EtherCAT® State Machine (ESM)

3.1 Overview

The EtherCAT® State Machine (ESM) is responsible for the coordination of master and slave at start up and during operation. State changes are mainly caused by interactions between master and slave. They are primarily related to writes to Application Layer Controlword.

After Initialization of Data Layer and Application Layer the machine enters the **INIT** State. The 'Init' state defines the root of the communication relationship between the master and the slave in application layer. No direct communication between the master and the slave on application layer is possible. The master uses the 'Init' state to initialize a set of configuration register. The corresponding sync manager configurations are also done in the 'Init' state.

The '**Pre-Operational**' state can be entered if the settings of the mailbox have been set. Both the master and the slave can use the mailbox and the appropriate protocols to exchange application specific initializations and parameters.

No process data communication is possible in this state.

The '**Safe-Operational**' state can be entered if the settings of the input buffer have been updated. The application of the slave shall deliver actual input data without processing the output data. The real outputs of the slave will be set to their "safe state".

The '**Operational**' state can be entered if the settings of the output buffer have been done and actual outputs have been delivered to the slave (provides outputs of the slave will be used).

The application of the slave shall deliver actual input data and the application of the master will provide output data.

The '**Bootstrap**' state can be entered only to update the firmware via FoE protocol. Entering this state will disable all other communication channels (including RS232).

The ESM defines four states, which are supported:

- Init
- Pre-Operational
- Safe-Operational
- Operational
- Bootstrap (only with F515F or newer)

3.1.1 Device control

All state changes are possible except for the 'Init' state, where only the transition to the 'Pre Operational' state is possible and for the 'Pre-Operational' state, where no direct state change to 'Operational' exists.

State changes are normally requested by the master. The master requests a write to the Application Layer Control register which results in a Register Event 'Application Layer Control' indication in the slave. The slave will respond to the change in Application Layer Control through a local Application Layer Status write service after a successful or a failed state change. If the requested state change failed, the slave will respond with the error flag set.

ESM is specified in *Figure 3.1.1*.

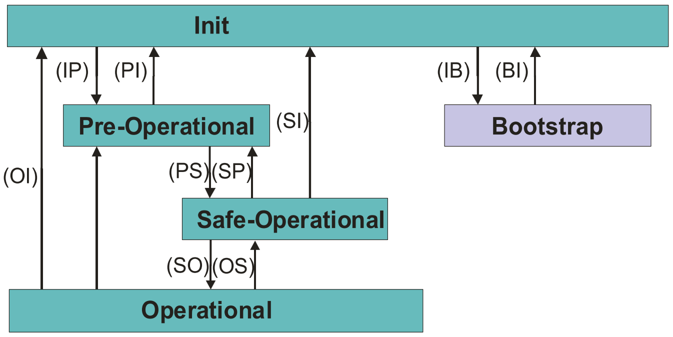


Figure 3.1.1. *EtherCAT®* State Machine Diagram

The local management services are related to the transitions in the ESM, as specified in *Table 3.1.1*. If there is more than one service related to the transition, the slave's application will process all of the related services.

***Table 3.1.1** – State transitions and local management services*

State transition	Local management services
(IP)	Start Mailbox Communication
(PI)	Stop Mailbox Communication
(PS)	Start Input Update
(SP)	Stop Input Update
(SO)	Start Output Update
(OS)	Stop Output Update
(OP)	Stop Output Update, Stop Input Update
(SI)	Stop Input Update, Stop Mailbox Communication
(OI)	Stop Output Update, Stop Input Update, Stop Mailbox Communication
(IB)	Init to Bootstrap
(BI)	Bootstrap to Init

***Table 3.1.2** – AL Control Description*

Parameter	Data Type	Value
State	Unsigned4	1: Init 3: Bootstrap 2: Pre-Operational 4: Safe-Operational 8: Operational
Acknowledge	Unsigned1	0: Parameter Change of the **AL** Status Register will be unchanged 1: Parameter Change of the **AL** Status Register will be reset
Reserved	Unsigned3	Shall be zero
Application Specific	Unsigned8	

3.1.2 EtherCAT® State Machine and CANopen State Machine

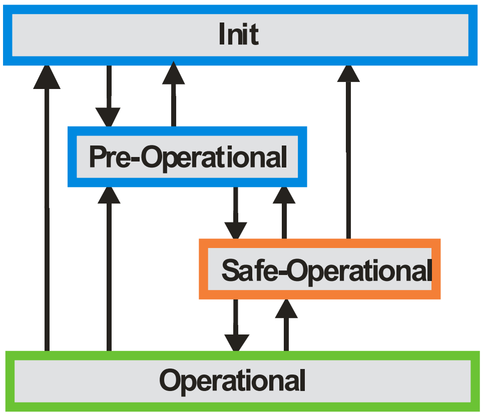


***Figure 3.1.2.** EtherCAT®* State Machine

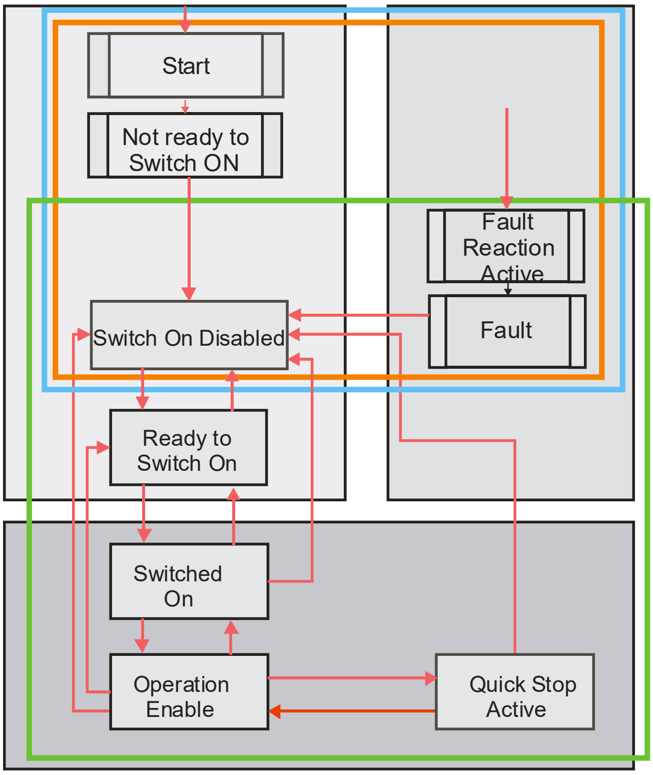


***Figure 3.1.3.** Drive State-machine based on CANopen (DS402).*

3.1.3 Emergency messages

A drive sends an emergency message (EMCY) when a drive internal error occurs. An emergency message is transmitted only once per ‘error event’. As long as no new errors occur, the drive will not transmit further emergency messages.

The emergency error codes supported by the Technosoft drives are listed in **Table 3.1.3**. Details regarding the conditions that may generate emergency messages are presented at object Motion Error Register index 2000h.

***Table 3.1.3** – Emergency Error Codes*

Error code (hex)	Description
00xx	Error Reset or No Error
1000	Generic Error; sent when a communication error occurs on CAN (object 2000$_h$ bit0=1; usually followed by EMCY code 0x7500
2310	Continuous over-current
2340	Short-circuit
30xx	Voltage
3210	DC-link over-voltage
3220	DC-link under-voltage
33xx	Output Voltage
4280	Over temperature motor
4310	Over temperature drive
5441	Drive disabled due to enable or STO input
5442	Negative limit switch active
5443	Positive limit switch active
6100	Invalid setup data
7300	Sensor error; this emergency message also contains other data; see its description at the end of this table
7500	Communication error
8100	EtherCAT® communication error
8210	PDO not processed due to length error
8220	PDO length exceeded
8331	I2t protection triggered
8580	Position wraparound / or hall sensor error
8611	Control error / Following error
9000	Command error
A0xx	ESM Transition Error
F0xx	Additional Functions
FF01	Generic interpolated position mode error (PVT / PT error)
FF02	Change set acknowledge bit wrong value
FF03	Specified homing method not available
FF04	A wrong mode is set in object 6060$_h$, modes_of_operation
FF05	Specified digital I/O line not available
FF06	Positive software position limit triggered
FF07	Negative software position limit triggered
FF08	Enable/STO circuit hardware error

3.1.3.1 Emergency message structures

The Emergency message contains 8 data bytes having the following contents:

Most EMCY messages:

0	1	2	3	7
Emergency Error Code		Error Register (Object 1001$_h$)	Manufacturer specific error field	

0x7300 Sensor error:

0	1	2	3	4	5	7
Emergency Error Code		Error Register (Object 1001$_h$)	Detail Error Register 2 (Object 2009$_h$)		Manufacturer specific error field	

0xFF01 Generic interpolated position mode error (PVT / PT error):

0	1	2	3	4	5	7
Emergency Error Code (0xFF01)		Error Register (Object 1001$_h$)	Interpolated position (Object 2072$_h$)	status	Manufacturer specific error field	

To disable the sending of PVT emergency message with ID 0xFF01, the setup variable PVTSENDOFF must be set to 1.

To disable the automatic sending of some of the emergency messages, use *Object 2001h: Motion Error Register Mark*.

3.2 EtherCAT® Synchronization

3.2.1 Overview

The drive uses the SYNC 0 signal in order to synchronize with the EtherCAT® master and the network. The SYNC 0 signal must have the period equal or multiple than the drive slow control loop which is by default at 1ms.

The synchronization assures the good functioning of modes like Cyclic Synchronous Position, Cyclic Synchronous Velocity and Cyclic Synchronous Torque.

3.2.2 Synchronization signals

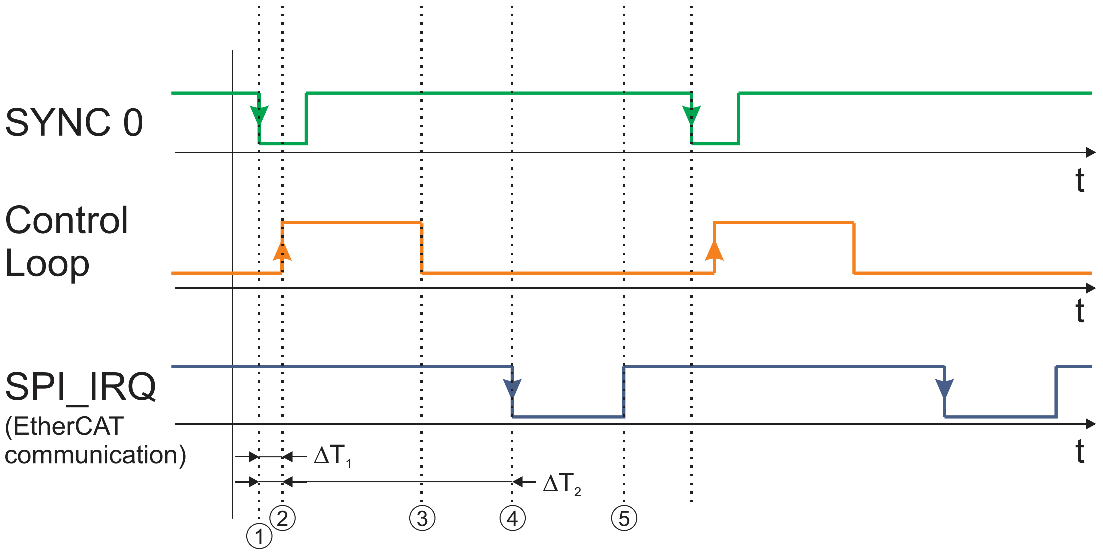


Figure 3.2.1. *Synchronization signal and control loop timing*

Time moments description:

1 – SYNC0 descending edge. Everything is synchronized with this event

2 – Control loop start. Actual position Pi is read, immediately after entering in the control loop

3 – Control loop end. At this moment the actual position Pi is stored in the EtherCAT slave ASIC as TxPDO, so it will be transmitted on next EtherCAT communication cycle

4 – A new EtherCAT frame is received. It puts in the ASIC in RxPDO the reference Ri+1 for next control loop and reads from the ASIC from TxPDO the actual position Pi

5 – The EtherCAT data processing is finalized. The new reference Ri+1 is stored in the drive internal variables which are used by the control loops

In order to work correctly the synchronization, the following conditions shall be respected:

a) communication cycle shall be a multiple of the SYNC0 cycle

b) SYNC0 shall be a multiple of control loop

c) time moment 3 shall be before time moment 4

d) time moment 5 shall be before time moment 1 of the next cycle

Remarks:

the minimum jitter between SYNC0 and the control loop is obtained when both have the cycle tine

it is possible to have different values for control loop, SYNC0 and communication cycle as long as conditions a) and b) are respected. Example: control loop at 1ms; SYNC0 at 2 ms and communication cycle at 4ms

On Beckhoff EtherCAT masters, the delay ΔT_2 between time moments 1 and 5 can be adjusted. By default, the Beckhoff master tries to place the communication cycle to minimize the time interval between time moment 5 and time moment 1 of next cycle. In many cases the "default" settings are not correct and moment 5 is superposed with 1. So, the "default" "shift time" in the Beckhoff master needs to be changed in order to reduce ΔT_2 (increase the time interval between time moment 5 and next SYNC0).

Object 2109h: Sync offset can also adjust the ΔT1 time. Although it is recommended to modify only the sync0 shift time form the EtherCAT master.

Important:

Technosoft drives can be configured to generate on 3 outputs the above mentioned key signals:

- SYNC0 on OUT0; Object 2089_h bit0=1;
- Control loop on Ready/OUT3; Object 2089_h bit1=1;
- EtherCAT Communication processing on Error/OUT2; Object 2089_h bit2=1;

This feature can be activated by writing via SDO value 7 in object 2089_h. It can be deactivated via reset or by writing 0 in object 2089_h.

In order to preserve the synchronization when changing ΔT1 and ΔT2, conditions c) and d) shall be checked with an oscilloscope to make sure that a safe margin exists considering the worst case jitter of the control loop and the EtherCAT communication processing time

3.2.3 Object 2089_h: Synchronization test config

This object enables the visualization of SYNC0, Control Loop and EtherCAT communication signals over the drive digital outputs.

Object description:

Index	2089_h
Name	Synchronization test config
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	No
Value range	0-7
Default value	No

Table 3.2.1 *–Bit Assignment in Synchronization test config*

Bit	Value	Description
3-15	-	Reserved
2	1	Trigger EtherCAT communication on Error/OUT2
1	1	Trigger Control Loop on Ready/OUT3
0	1	View SYNC0 on OUT0

Remarks:

- Before activating this feature, disconnect any other device connected to the 3 outputs;
- Ready and Error outputs are also connected to the green and red LEDs. These will flicker when this feature is activated. This case shall not be treated as an error condition!
- SYNC0 signal on OUT0 is generated by the drive starting from SYNC0 signal generated by the EtherCAT ASIC. OUT0 goes down almost simultaneously with the SYNC0 generated by the ASIC, but it rises much faster. So SYNC0 from OUT0 will be shorter than the real signal.

3.2.4 Object 2109h: Sync offset

This object adjusts the ΔT_1 time from *3.2.2 Synchronization* signals. This time represents the difference between the sync0 signal start time and the Control loop start time.

Remark:

- Use this object only if sync0 offset cannot be adjusted from the EtherCAT master.
- Some EtherCAT masters start the communication loop immediately after the sync0 signal. If the communication loop is active while the control loop is active, the synchronization will not work and vibrations in the motor will be noticed while moving in CSP mode.
- If the sync0 offset cannot be adjusted, this object will offset the control loop start.

Object description:

Index	2109_h
Name	Sync offset
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Value range	0 … 55000 (not higher)
Default value	1000

The default value for this object can be changed by editing the parameter "SLSyncOffset" found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

3.2.5 Object 210Ah: Sync rate

This object adjusts the timing corrections applied to the internal clock in order to sync faster.

Remark:

Use this object only for fine tuning the synchronization signals. It should be adjusted only by viewing the sync signals with the oscilloscope and observing the results while modifying it.

Object description:

Index	$210A_h$
Name	Sync rate
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	No
Value range	0..32767
Default value	3

3.2.6 Object 2112_h: TML priority[1]

By changing the default value of the object, the TML language will have an increased priority, therefore changes of Modes of operations (6060_h) and Controlword (6040_h) objects are not allowed. Any TML commands that the drive receives will be executed.

Object description:

Index	2112_h
Name	TML priority
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Default value	0

***Table 3.2.2** – TML priority description*

Value	Description
0	Default value.
1…65535	Writing or Changing Modes of operations (6060_h) and Controlword (6040_h) objects is not allowed

[1] Available only for FA0xx firmware version.

4 Drive control and status

4.1 CiA402 State machine and command coding

The state machine from **Drives and motion control device profile** (CiA 402) describes the drive status and the possible control sequences of the drive. The drive has to pass through the described states in order to control the motor. The drive states can be changed by the object 6040h **(Controlword)** and/or by internal events. The drive current state is reflected in the object **6041h (Statusword)**. **Figure 4.1.1** describes the state machine of the drive along with Controlword and Statusword values for each transition. **Table 4.1.1** describes each transition present in the state machine.

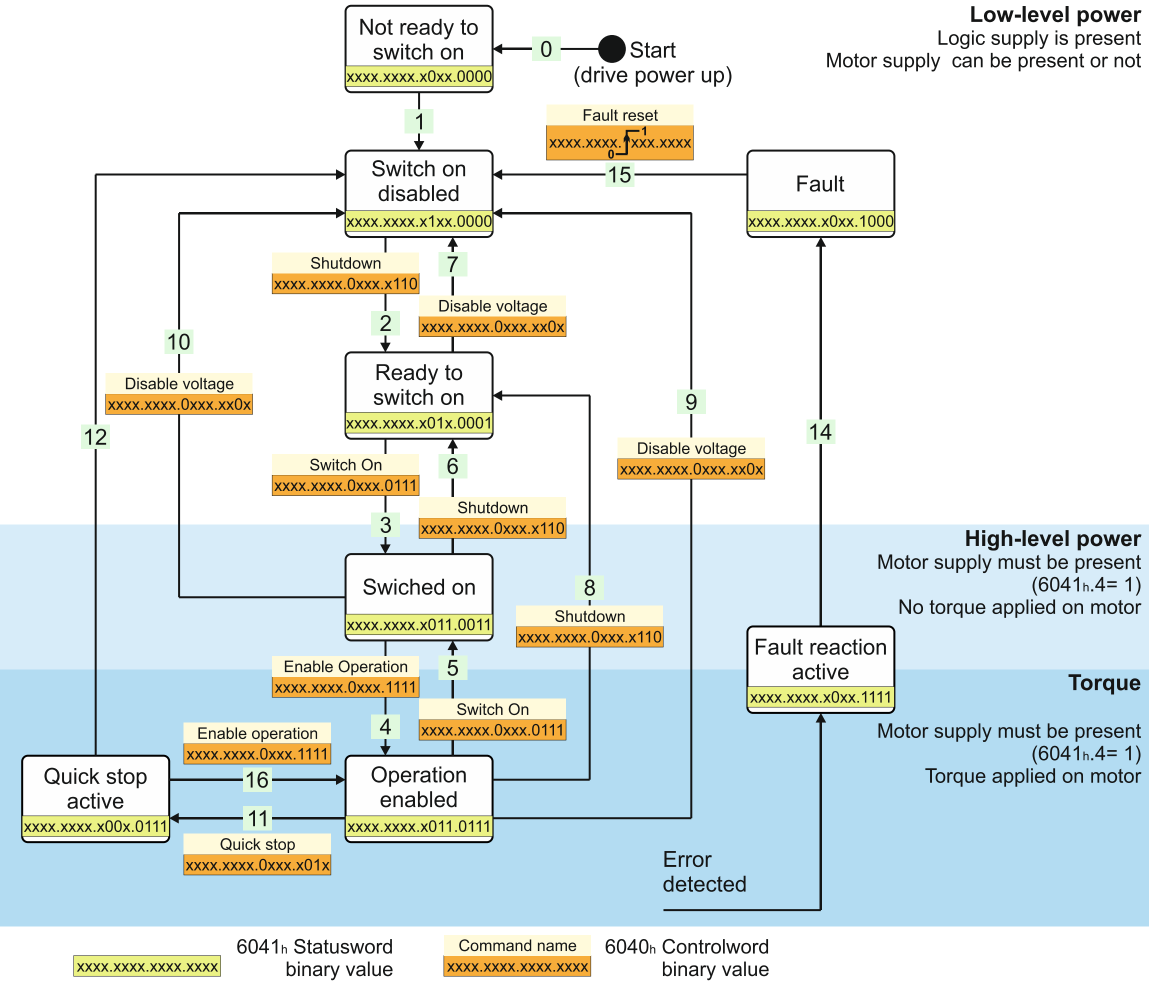


Figure 4.1.1. *Drive's status machine. States and transitions*

Table 4.1.1 *– Drive State Transitions*

Transition	Event	Action
0	Automatic transition after power-on or reset application	Hardware Initialization
1	Automatic transition.	Initialization completed successfully. Communication is active
2	Bits 1 and 2, are set in Controlword (*Shutdown* command). Motor voltage may be present.	None
3	Bits 0,1 and 2 are set in Controlword (*Switch On* command)	Motor supply voltage must be present (6041h bit 4=1). The undervoltage protection is active. The motor will not be powered and have no torque.
4	Bits 0,1,2 and 3 are set in Controlword (*Enable Operation* command)	Motion function and power stage are enabled, assuming the enable or STO input is also enabled. Depending on the mode of operation that is set, the motor will apply torque and keep its current position or velocity to 0. Depending on the motor start mode, this transition may take more than a few ms to finish. Example: When using the start mode "Move till aligned with phase A" which is the default method, the first executed Enable operation transition takes 2 seconds.

5	Bit 3 is cancelled in Controlword (*Disable Operation* command)	Motion function is inhibited. The drive will execute the instructions from Object 605Ch: Disable operation option code and finally transition into *Switched On* state. The motor has no torque.
6	Bit 0 is cancelled in Controlword (*Shutdown* command)	Motor supply may be disabled. Motor has no torque.
7	Bit 1 or 2 is cancelled in Controlword (*Quick Stop* or *Disable Voltage* command)	None
8	Bit 0 is cancelled in Controlword (*Shutdown* command)	The drive will execute the instructions from Object 605Bh: Shutdown option code and finally transition into *Ready to switch on* state. The motor has no torque.
9	Bit 1 is cancelled in Controlword (*Disable Voltage* command)	The drive will execute the instructions from Object 605Ch: Disable operation option code and finally transition into *Switch on disabled* state. The motor has no torque.
10	Bit 1 or 2 is cancelled in Controlword (*Quick Stop* or *Disable Voltage* command)	Motor supply may be disabled. Drive has no torque.
11	Bit 2 is cancelled in Controlword (*Quick Stop* command)	The drive will execute the instructions from Object 605Ah: Quick stop option code.
12	*Quick Stop* is completed or bit 1 is cancelled in Controlword (*Disable Voltage* command)	Output stage is disabled. Motor has no torque.
13	Fault signal	Execute specific fault treatment routine from Object 605Eh: Fault reaction option code
14	The fault treatment is complete	The drive function is disabled
15	Bit 7 is set in Controlword (*Reset Fault* command)	Some of the bits from *4.4.2 Object 2000h: Motion Error Register* are reset. If all the error conditions are reset, the drive returns to Switch On Disabled status. After leaving the state *Fault* bit 7, *Fault Reset* of the Controlword has to be cleared by the host.
16	Bit 2 is set in Controlword (*Enable Operation* command). This transition is possible if *Quick-Stop-Option-Code* is 5, 6, 7 or 8	Drive exits from Quick Stop state. Drive function is enabled.

***Table 4.1.2** – Drive States*

State	Description
Not Ready to switch on	The drive performs basic initializations after power-on. The drive function is disabled The transition to this state is automatic.
Switch On Disabled	The drive basic initializations are done and the green led must turn-on if no error is detected. The drive is not Ready to switch on; any drive parameters can be modified, including a complete update of the whole EEPROM data (setup table, TML program, cam files, etc.) The motor supply can be switched on, but the motion functions cannot be carried out yet. The transition to this state is automatic.
Ready to switch on	The motor supply voltage may be switched on, most of the drive parameter settings can still be modified, and motion functions cannot be carried out yet.
Switched On (Operation Disabled)	The motor supply voltage must be applied. The power stage is switched off. The motion functions cannot be carried out yet.
Operation Enabled	No fault present, power stage is switched on, motion functions are enabled. If the operation mode set performs position control, the motor is held in position. If the operation mode set performs speed control, the motor is kept at zero speed. If the operation mode is torque external, the motor is kept with zero torque. From this state, the motor can execute motion commands.
Quick Stop Active	Drive has been stopped with the quick stop deceleration. The power stage is enabled. If the drive was operating in position control when quick stop command was issued, the motor is held in position. If the drive was operating in speed control, the motor is kept at zero speed. If the drive was operating in torque control, the motor is kept at zero torque.
Fault Reaction Active	The drive performs a default reaction to the occurrence of an error condition
Fault	The motor power is turned off. The drive remains in fault condition, until it receives a Reset Fault command. If following this command, all the bits from the Motion Error Register are reset, the drive exits the fault state

4.2 Drive control and status objects

4.2.1 Object 6040_h: Controlword

The object controls the status of the drive. It is used to enable/disable the power stage of the drive, start/halt the motions and to clear the fault status. The status machine is controlled through the Controlword.

Object description:

Index	6040_h
Name	Controlword
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Yes
Units	-
Value range	0 … 65535
Default value	No

***Table 4.2.1** – Bit Assignment in Controlword*

Bit	Value	Meaning
15	0	Registration mode inactive
	1	Activate registration mode
14	0	When an update is performed, keep unchanged the demand values for speed and position (TML command TUM1;)
	1	When an update is performed, update the demand values for speed and position with the actual values of speed and position (TML command TUM0;)
13		When it is set, it cancels the execution of the TML function called through object 2006_h. The bit is automatically reset by the drive when the command is executed.
12	0	No action
	1	If bit 14 = 1 – Force *position demand value* to 0 If bit 14 = 0 – Force *position actual value* to 0 This bit is valid regardless of the status of the drive or other bits in Controlword
11		Manufacturer Specific - Operation Mode Specific. The meaning of this bit is detailed further in this manual for each operation mode
10-9		Reserved. Writes have no effect. Read as 0
8	0	No action
	1	Halt command – the motor will slow down on slow down ramp
7	0	No action
	1	Reset Fault. The faults are reset on 0 to 1 transition of this bit. After a Reset Fault command, the master has to reset this bit.
4-6		Operation Mode Specific. The meaning of these bits is detailed further in this manual for each operation mode
3		Enable Operation
2		Quick Stop
1		Enable Voltage
0		Switch On

The following table lists the bit combinations for the Controlword that lead to the corresponding state transitions. An X corresponds to a bit state that can be ignored. The single exception is the fault reset: The transition is only started by a bit transition from 0 to 1.

***Table 4.2.2** – Command coding in Controlword*

Command	Bit in object 6040_h					Transition
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	X	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Disable voltage	0	X	X	0	X	7,9,10,12
Quick stop	0	X	0	1	X	7,10,11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4,16
Fault reset	0↑1	X	X	X	X	13

For the command coding values see also *Figure 4.1.1. Drive's status machine. States and transitions.*

4.2.2 Object 6041$_h$: Statusword

Object description:

Index	6041$_h$
Name	Statusword
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Yes
Units	-
Value range	0 … 65535
Default value	No

The Statusword has the following bit assignment:

***Table 4.2.3** – Bit Assignment in Statusword*

Bit	Value	Description
15	0	Axis off. Power stage is disabled. Motor control is not performed
	1	Axis on. Power stage is enabled. Motor control is performed
14	0	No event set or the programmed event has not occurred yet
	1	Last event set has occurred
13..12		Operation Mode Specific. The meaning of these bits is detailed further in this manual for each operation mode
11		Internal Limit Active – see ***Remark 1*** below
10		Target reached
9	0	Remote – drive is in local mode and will not execute the command message.
	1	Remote – drive parameters may be modified via ECAT messages and the drive will execute the command message.
8	0	No TML function or homing is executed. The execution of the last called TML function or homing is completed.
	1	A TML function or homing is executed. Until the function or homing execution ends or is aborted, no other TML function / homing may be called
7	0	No Warning
	1	Warning. A TML function / homing was called, while another TML function / homing is still in execution. The last call is ignored.
6		Switch On Disabled.
5		Quick Stop. When this bit is zero, the drive is performing a quick stop
4	0	Motor supply voltage is absent See ***Remark 2*** below
	1	Motor supply voltage is present
3		Fault. If set, a fault condition is or was present in the drive.
2		Operation Enabled
1		Switched On
0		Ready to switch on

The drive state can be identified when Statusword coding is the following:

***Table 4.2.4** – State coding in Statusword*

Statusword	Drive state
xxxx xxxx x0xx 0000$_b$	Not Ready to switch on
xxxx xxxx x1xx 0000$_b$	Switch on disabled
xxxx xxxx x01x 0001$_b$	Ready to switch on
xxxx xxxx x01x 0011$_b$	Switched on
xxxx xxxx x01x 0111$_b$	Operation enabled
xxxx xxxx x00x 0111$_b$	Quick stop active
xxxx xxxx x0xx 1111$_b$	Fault reaction active
xxxx xxxx x0xx 1000$_b$	Fault

For the state coding values see also *Figure 4.1.1. Drive's status machine. States and transitions.*

Remark 1: Bit11 internal limit active is set when either the Positive or Negative limit switches is active. If the internal register LSACTIVE = 1 or object 60B8$_h$ bit 6 = 1, this bit will not be set and the emergency messages for the active limit switches will be disabled.

Remark 2: Bit 4 shows whether the +Vmot Input is supplied. The state machine cannot transition to states Switched On and Operation enabled without this bit being set first. If this bit transitions to 0 while in Operation enabled or Switched On states (+Vmot input is not present), the drive will enter fault state due to undervoltage error. If in a lower state than switch On, the absence of +Vmot in will not trigger an undervoltage error.

4.2.3 Object 6060h: Modes of Operation

The object selects the mode of operation of the drive.

Object description:

Index	6060h
Name	Modes of Operation
Object code	VAR
Data type	INTEGER8

Entry description:

Access	RW
PDO mapping	Yes
Units	-
Value range	-128 … 127
Default value	No

Data description:

Value	**Description**
-128…-1	Reserved
0	No mode change/no mode assigned
1	Profile Position Mode
2	Reserved
3	Profile Velocity Mode
4	Profile Torque Mode[1]
5	Reserved
6	Homing Mode
7	Interpolated Position Mode
8	Cyclic sync Position Mode (CSP)
9	Cyclic sync Velocity Mode (CSV)
10	Cyclic sync Torque Mode (CST)
11…127	Reserved

Remark: *The actual mode is reflected in object 6061h (Modes of Operation Display).*

4.2.4 Object 6061h: Modes of Operation Display

The object reflects the actual mode of operation set with object Modes of Operation (index 6060h).

If the drive is in an inferior state than Operation enabled and object 6060h Modes of operation is changed, object 6061h will take the value of 6060h only after the drive reached Operation enabled state.

Object description:

Index	6061h
Name	Modes of Operation Display
Object code	VAR
Data type	INTEGER8

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	-128 … 127
Default value	-

Data description: Same as for object 6060h Modes of Operation.

4.3 Limit Switch functionality explained

4.3.1 Hardware limit switches LSP and LSN functionality

All iPOS drives have two limit switch inputs:

- LSP – positive limit switch
- LSN – negative limit switch

Triggering a limit switch during a motion causes the drive to automatically stop using the deceleration value defined in Object 6085h: Quick stop deceleration. After the motor stops, it will continue to hold its position and wait until a new motion command is received in the opposite direction of the active limit switch. A new motion in the opposite direction will be accepted only after the motor ends its deceleration, signaled by Statusword 6041h bit 10.

[1] This mode is available starting with firmware versions F515K / FA00x.

While the motor stops due to an activated limit switch, the Statusword will still report the Operation enabled state and NOT actually enter Quick stop state (where Statusword = xxxx xxxx x00x 0111_b). *Object 605Ah: Quick stop option code* will have no effect if a limit switch is activated.

If during a positive motion LSP is activated, the motor will stop.

If during a negative motion LSN is activated, the motor will stop.

If during a positive motion LSN is activated, nothing will happen.

If during a negative motion LSP is activated, nothing will happen.

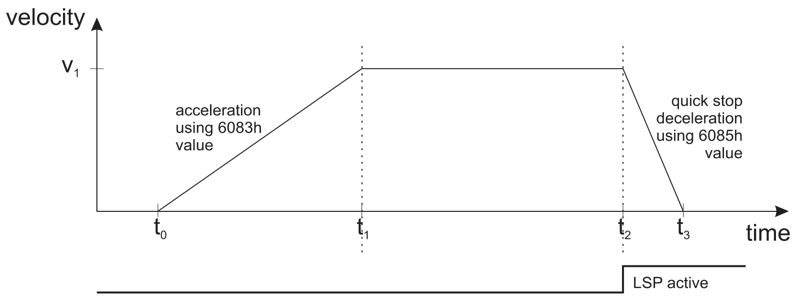


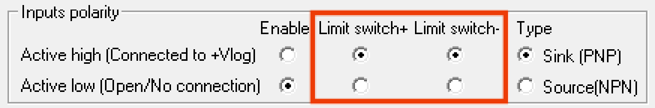
***Figure 4.3.1.** Stopping a motion on the positive limit switch*

Figure 4.3.1 depicts a positive motion where the speed increases from t0 until t1 using the acceleration value defined in Object 6081h: Profile velocity. At moment t2, the positive limit switch is activated and the drive automatically stops and it decelerates using the value defined in Object 6085h: Quick stop deceleration.

While the positive limit switch is active, no new positive motion will be accepted by the drive. Only a negative motion is accepted while LSP is active.

While the negative limit switch is active, no new negative motion will be accepted by the drive. Only a positive motion is accepted while LSN is active.

A limit switch can be defined as active while the input is in the low or high state in Drive setup:



Inputs polarity

	Enable	Limit switch+	Limit switch-	Type
Active high (Connected to +Vlog)	○	●	●	● Sink (PNP)
Active low (Open/No connection)	●	○	○	○ Source(NPN)

***Figure 4.3.2.** Configuring the limit witch active state in Drive setup.*

Status word Bit11 (internal limit active) is set when either the Positive or Negative limit switch is active. If the internal parameter LSACTIVE = 1 or object $60B8_h$ bit 6 = 1, status word bit11 will not be set and the emergency messages for the active limit switches will be disabled. If the limit switches inputs are disabled, they can be used as regular digital inputs.

If the positive limit switch is activated, the emergency error code 0x5443 will be sent automatically and object 2000_h bit 6 will be 1.

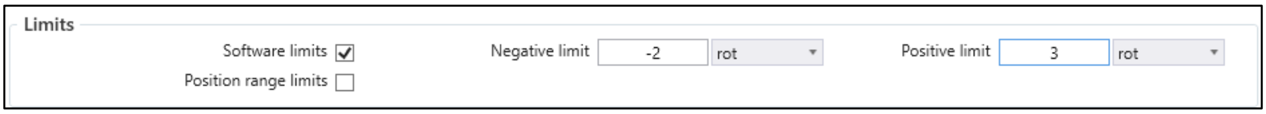
If the negative limit switch is activated, the emergency error code 0x5442 will be sent automatically and object 2000_h bit 7 will be 1.

When a limit switch becomes inactive, the emergency error code 0x0000 will be sent automatically and object 2000_h bit 6 or 7 will return to 0.

All iPOS drives can also use the limit switch inputs in order to capture the motor or load position. This function is configurable through Object 60B8h: Touch probe function and Object 2104h: Auxiliary encoder function. If the feedback type is incremental encoder, the position is captured within several µs. If the feedback type is SSI/BiSS/Resolver/Linear halls or Sin/Cos, the captured position is the latest one computed in the position loop, so by default it may be up to 1 ms old.

4.3.2 Software limit switches functionality

The software limit switches work just like the hardware limit switches (LSP, LSN) in terms of functionality. An individual position value is chosen for the negative and positive limits and when those values are reached, the drive will quick stop. A new motion will be accepted only if the motion is opposite the active software or hardware limit switch.



Limits

Software limits ☑

Position range limits □

Negative limit -2 rot

Positive limit 3 rot

***Figure 4.3.3.** Configuring the software limit switches position values.*

The software limit switches can also be configured through Object 607Dh: Software position limit.

If the positive software limit switch is activated, the emergency error code 0xFF06 will be sent automatically and object 2002h bit 6 will be 1.

If the negative software limit switch is activated, the emergency error code 0xFF07 will be sent automatically and object 2002h bit 7 will be 1.

When a limit switch becomes inactive, the emergency error code 0x0000 will be sent automatically and object 2002h bit 6 or 7 will return to 0.

4.4 Error monitoring

4.4.1 Object 1001$_h$: Error Register

This object is an error register for the device. The device can map internal errors in this byte. This entry is mandatory for all devices. It is a part of an Emergency object.

Object description:

Index	1001$_h$
Name	Error register
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RO
PDO mapping	No
Value range	UNSIGNED8
Default value	No

Table 4.4.1 *– Bit description of object* ***1001$_h$***

Bit	Description
0	Generic error
1	Current
2	Voltage
3	Temperature
4	Communication error
5	Device profile specific
6	Reserved (always 0)
7	Manufacturer specific.

Valid bits while an error occurs – bit 0 and bit 4. The other bits will remain 0.

4.4.2 Object 2000$_h$: Motion Error Register

The Motion Error Register displays all the drive possible errors. A bit set to 1 signals that a specific error has occurred. When the error condition disappears or the error is reset using a Fault Reset command, the corresponding bit is reset to 0.

The Motion Error Register is continuously checked for changes of the bits status. When a bit is set (e.g. an error has occurred), if the corresponding bit from Motion Error Register Mask (2001$_h$) is set to 1, an emergency message with the specific error code is sent. When a bit is reset, if the corresponding bit from Motion Error Register Mask (2001$_h$) is set to 1, an emergency message for error reset is sent.

Object description:

Index	2000$_h$
Name	Motion Error Register
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	0 … 65535
Default value	0

Table 4.4.2 *– Bit Assignment in Motion Error Register*

Bit	Description
15	Drive disabled due to enable or STO input. Set when enable or STO input is on disable state. Reset when enable or STO input is on enable state
14	Command error. This bit is set in several situations and acts as a warning. They can be distinguished either by the associated emergency code, or in conjunction with other bits from the DER (2002h) register.
13	Under-voltage. Set when protection is triggered. Reset by a Reset Fault command. Can be triggered only in Switch On or Operation enabled states. If in a lower state, the drive will not fault if no motor voltage input is present.
12	Over-voltage. Set when protection is triggered. Reset by a Reset Fault command
11	Over temperature drive. Set when protection is triggered. Reset by a Reset Fault command.
10	Over temperature motor. Set when protection is triggered. Reset by a Reset Fault command. This protection may be activated if the motor has a PTC or NTC temperature contact.
9	I^2T protection. Set when protection is triggered. Reset by a Reset Fault command
8	Over current. Set when protection is triggered. Reset by a Reset Fault command
7	Negative limit switch active. Set when LSN input is in active state. Reset when LSN input is inactive state
6	Positive limit switch active. Set when LSP input is in active state. Reset when LSP input is inactive state
5	For F515F and newer: Feedback error. Details found in DER2 (2009h) bits. Set when protection is triggered. Reset by a Reset Fault command. For F510x/511x; it represents either digital Hall sensor missing or position wraparound.
4	Communication error. Set when protection is triggered. Reset by a Reset Fault command
3	Control error (position/speed error too big). Set when protection is triggered. Reset by a Reset Fault command
2	Invalid setup data. Set when the EEPROM stored setup data is not valid or not present.
1	Short-circuit. Set when protection is triggered. Reset by a Reset Fault command
0	EtherCAT® communication error. Reset by a Reset Fault command or by Clear Error in the EtherCAT® State Machine.

4.4.3 Object 2001h: Motion Error Register Mark

The Motion Error Register Mask offers the possibility to choose which of the errors set or reset in the Motion Error Register to be signaled via emergency messages. The Motion Error Register Mask has the same bit codification as the Motion Error Register (see Table 4.2.2 – Command coding in Controlword) and the following meaning:

1 – Send an emergency message when the corresponding bit from the Motion Error Register is set

0 – Don't send an emergency message when the corresponding bit from the Motion Error Register is set.

Object description:

Index	2001h
Name	Motion Error Register Mask
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	0 … 65535
Default value	0

4.4.4 Object 2002h: Detailed Error Register (DER)

The Detailed Error Register displays detailed information about the errors signaled with command Error bit from Motion Error Register. Not all bits represent errors. This register also displays the status of software limit switches and lock EEPROM status. A bit set to 1 signals that a specific error has occurred. When the error condition disappears or the error is reset using a Fault Reset command, the corresponding bit is reset to 0.

Object description:

Index	2002h
Name	Detailed Error Register
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	0 … 65535
Default value	0

Table 4.4.3 – Bit Assignment in Detailed Error Register

Bit	Description
15	EEPROM is Locked. The EEPROM can be locked via object 2091h or by Easy Motion Studio II – Select Communication – EEPROM write protection.
14	STO or Enable circuit hardware error
13	Self-check error. The ECAT adapter EEPROM memory is not programmed with the XML/ESI file data or has errors.
12	reserved
11	Start mode failed; Motionless start or pole lock minimum movement failed
10	Encoder broken wire; On a brushless motor, either the digital halls or the incremental encoder signal was interrupted
9	Update ignored for S-curve
8	S-curve parameters caused an invalid profile. UPD instruction was ignored.
7	Negative software limit switch is active.
6	Positive software limit switch is active.
5	Cancelable call instruction received while another cancelable function was active.
4	UPD instruction received while AXISON was executed. The UPD instruction was ignored and it must be sent again when AXISON is completed.
3	A call to an inexistent function was received.
2	A call to an inexistent homing routine was received.
1	A RET/RETI instruction was executed while no function/ISR was active.
0	The number of nested function calls exceeded the length of TML stack. Last function call was ignored.

4.4.5 Object 2009$_h$: Detailed Error Register 2 (DER2)[1]

The Detailed Error Register 2 mostly displays detailed information about the errors signaled with command Feedback error bit 5 from Motion Error Register (2000$_h$). A bit set to 1 signals that a specific error has occurred. When the error condition disappears or the error is reset using a Fault Reset command, the corresponding bit is reset to 0.

Object description:

Index	2009$_h$
Name	Detailed Error Register 2
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	0 … 65535
Default value	0

Table 4.4.4 – Bit Assignment in Detailed Error Register 2

Bit	Description
15	Output frequency. The imposed speed exceeds the DUAL USE European regulation limit.
14..6	reserved
6	Position wraparound. The position 2^{31} was exceeded. It does not represent a Fault condition.
5	Hall sensor missing; can be either Digital or Linear analogue hall error.
4	Absolute Encoder Interface (AEI) interface error; applies only to iPOS80x0 BA drives
3	BiSS sensor missing; No BiSS sensor communication detected.
2	BiSS data error bit is set. The BiSS protocol includes an error bit in its data.
1	BiSS data warning bit is set. If ASR2.10 = 1, this error will represent a Fault condition.
0	BiSS data CRC error. BiSS data stream CRC does not match computed CRC.

4.4.6 Object 603Fh: Error code

This object provides the error code of the last error which occurred in the drive device. These error codes are always transmitted as Emergency messages. The error codes are described in *3.1.3 Emergency messages*.

Object description:

Index	603F$_h$
Name	Error Code
Object code	VAR
Data type	UNSIGNED16

[1] Available only with F515x firmwares

Entry description:

Access	RO
PDO mapping	Yes
Units	-
Value range	0 … 65535
Default value	0

4.4.7 Object 605Ah: Quick stop option code

This object determines what action should be taken if the quick stop function is executed. The slow down ramp is a deceleration value set by the Profile acceleration object, index 6083h. The quick stop ramp is a deceleration value set by the Quick stop deceleration object, index 6085h.

Object description:

Index	605Ah
Name	Quick stop option code
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	No
Value range	-32768 … 32767
Default value	2

Data description:

Value	Description
-32768…-1	Manufacturer specific
0	Disable drive function
1	Slow down on slow down ramp and transit into Switch On Disabled
2	Slow down on quick stop ramp and transit into Switch On Disabled
3	Reserved
4	Reserved
5	Slow down on slow down ramp and stay in Quick Stop Active
6	Slow down on quick stop ramp and stay in Quick Stop Active
7…32767	Reserved

4.4.8 Object 605Bh: Shutdown option code

This object determines what action is taken if when there is a transition from Operation Enabled state to Ready to Switch On state. The slowdown ramp is a deceleration value set by the Profile acceleration object, index 6083h.

Object description:

Index	605Bh
Name	Shutdown option code
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	No
Value range	-32768 … 32767
Default value	0

Data description:

Value	Description
-32768…-1	Manufacturer specific
0	Disable drive function (switch-off the drive power stage)
1	Slow down on slowdown ramp and disable the drive function
2…32767	Reserved

4.4.9 Object 605C$_h$: Disable operation option code

This object determines what action is taken if when there is a transition from Operation Enabled state Switched On state. The slowdown ramp is a deceleration value set by the Profile acceleration object, index 6083$_h$.

Object description:

Index	605C$_h$
Name	Disable operation option code
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	No
Value range	-32768 … 32767
Default value	1

Data description:

Value	Description
-32768…-1	Manufacturer specific
0	Disable drive function (switch-off the drive power stage)
1	Slow down on slow down ramp and disable the drive function
2…32767	Reserved

4.4.10 Object 605D$_h$: Halt option code

This object determines what action is taken if when the halt command is executed. The slowdown ramp is a deceleration value set by

Object 6083h: Profile acceleration. The quick stop ramp is a deceleration value set by Object 6085h: Quick stop deceleration.

Object description:

Index	605D$_h$
Name	Halt option code
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	No
Value range	-32768 … 32767
Default value	1

Data description:

Value	Description
-32768…-1	Manufacturer specific
0	Reserved
1	Slow down on slow down ramp and stay in Operation Enabled
2	Slow down on quick stop ramp and stay in Operation Enabled
3…32767	Reserved

4.4.11 Object 605E$_h$: Fault reaction option code

This object determines what action should be taken if a non-fatal error occurs in the drive. The non-fatal errors are by default the following:

- Under-voltage
- Over-voltage
- I^2t error[1] –when the internal register ASR bit1 is 0 in setup.
- Drive over-temperature
- Motor over-temperature
- Communication error (when object 6007$_h$ option 1 is set)

[1] Starting with firmware version FA00G / FA02G, I^2t is no longer a "non-fatal error" that can be configured through object 605E$_h$.

Remark: the under-voltage protection is monitored while in Switched On and Operation enabled states. If in a lower state, the drive will not fault if no motor voltage input is present.

Object description:

Index	605E$_h$
Name	Fault reaction option code
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	No
Value range	-32768 … 32767
Default value	2

Data description:

Value	**Description**
-32768…-2	Manufacturer specific
-1	No action
0	Disable drive, motor is free to rotate
1	Reserved
2	Slow down with quick stop ramp
3…32767	Reserved

4.4.12 Object 6007$_h$: Abort connection option code

The object sets the action performed by the drive when a communication error occurs.

Object description:

Index	6007$_h$
Name	Abort connection option code
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Yes
Value range	-32768…32767
Default value	1

Table 4.4.5 *– Abort connection option codes values*

Option code	**Description**
-32768…-1	Manufacturer specific (reserved)
0	No action
+1	Fault signal - Execute specific fault routine set in Object 605Eh: Fault reaction option code
+2	Disable voltage command
+3	Quick stop command
+4…+32767	Reserved

The default value for this object can be changed by editing the parameter “x6007” found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

4.4.13 Object 2114$_h$: Fault Override Option Code[1]

This object serves as a mean to define a custom action routine when specific errors are triggered. Once activated, the custom routine has a higher priority in comparison to the actions defined in objects 6007$_h$: Abort connection option code and 605E$_h$: Fault reaction option code.

Each bit within this object corresponds to an error found in Object 2000$_h$: Motion Error Register, and by setting the corresponding bit to 1, the fault routine can be customized using the options described in object 2113$_h$: Detailed Option Code.

Object description:

Index	2114E$_h$
Name	Override Option Code

[1] Available starting with FA00G / FA02G firmware versions or newer

Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Value range	0 … 65535
Default value	32768

Data description:

Bit	Description
0	Communication error
1	Short-Circuit
2	Reserved
3	Control error
4…7	Reserved
8	Over current
9	Reserved
10	Over temperature - Motor
11	Over temperature - Drive
12	Over voltage
13	Under voltage
14	Reserved
15	Enable / STO inactive

4.4.14 Object 2113h: Detailed Option Code[1]

This object establishes the available actions for customizing a fault routine associated with each error described in Object 2114h: Fault Override Option Code. These designated options will be implemented only when the corresponding bit in Object 2114h is activated; otherwise, the settings will remain inactive.

Object description:

Index	2113Eh
Name	Detailed Option Code
Object code	VAR
Data type	UNISGNED16

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	1…15
Default value	15

Sub-index	1
Description	Short-Circuit option code*
Access	RW
PDO mapping	NO
Value range	UNSIGNED16
Default value	0

Sub-index	2
Description	Reserved

Sub-index	3
Description	Control error option code
Access	RW
PDO mapping	NO
Value range	UNSIGNED16
Default value	0

Sub-index	4
Description	Communication error option code
Access	RW
PDO mapping	NO
Value range	UNSIGNED16

[1] Available starting with FA00G / FA02G firmware versions or newer

Default value	0

Sub-index	5, 6, 7
Description	Reserved

Sub-index	8
Description	Over current option code
Access	RW
PDO mapping	NO
Value range	UNSIGNED16
Default value	0

Sub-index	9
Description	Reserved

Sub-index	10
Description	Over temperature – Motor option code
Access	RW
PDO mapping	NO
Value range	UNSIGNED16
Default value	0

Sub-index	11
Description	Over temperature – Drive option code
Access	RW
PDO mapping	NO
Value range	UNSIGNED16
Default value	0

Sub-index	12
Description	Over voltage option code
Access	RW
PDO mapping	NO
Value range	UNSIGNED16
Default value	0

Sub-index	13
Description	Under voltage option code
Access	RW
PDO mapping	NO
Value range	UNSIGNED16
Default value	0

Sub-index	14
Description	Reserved

Sub-index	15
Description	Enable / STO inactive* option code
Access	RW
PDO mapping	NO
Value range	UNSIGNED16
Default value	32768

***Table 4.6** – Sub-index bit description*

Bit	Value	Description
15	0	Do not generate a TML interrupt
	1	Generate a TML interrupt
8…14	0	Reserved
0…7	0	Disable drive
	2	Quick stop
	-1	No action

* For the Short circuit and Enable/STO inactive option codes, only the customization of bit 15 is possible.

4.5 Digital I/O control and status objects

4.5.1 Object 60FD$_h$: Digital inputs

The object contains the actual value of the digital inputs available on the drive. Each bit from the object corresponds to a digital input (manufacturer specific or device profile defined). If a bit is SET, then the status of the corresponding input is logical ‘1’ (high). If the bit is RESET, then the corresponding drive input status is logical ‘0’ (low).

Remarks:

- *The device profile defined inputs (limit switches, home input and interlock) are mapped also on the manufacturer specific inputs. Hence, when one of these inputs changes the status, then both bits change, from the manufacturer specific list and from the device profile list.*
- *The number of available digital inputs is product dependent. Check the drive user manual for the available digital inputs.*

Object description:

Index	60FD$_h$
Name	Digital inputs
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RO
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0

	Bit	Value	Description
Manufacturer specific	31		IN15 status
	30		IN14 status
	29		IN13 status
	28		IN12 status
	27		IN11 status
	26		IN10 status
	25		IN9 status
	24		IN8 status
	23		IN7 status
	22		IN6 status
	21		IN5 status
	20		IN4 status
	19		IN3 status
	18		IN2 status
	17		IN1 status
	16		IN0 status
Device profile defined	15..4		Reserved
	3	0	Interlock (Drive enable/ STO input) deactivated; drive may not apply power to motor. Enter *Switch on disabled* state.
		1	Interlock (Drive enable/ STO input) activated; drive may apply power to motor.
	2	0	Home switch input status is low
		1	Home switch input status is high
	1	0	Positive limit switch is inactive
		1	Positive limit switch is active
	0	0	Negative limit switch is inactive
		1	Negative limit switch is active

4.5.2 Object 208F$_h$: Digital inputs 8bit

This object has 2x8 bit sub-indexes that show the same data as object 60FD$_h$ Digital inputs. Mapping shorter data to a PDO decreases the total communication bus load and processing time.

Remark:

The number of available digital inputs is product dependent. Check the drive user manual for the available digital inputs.

Object description:

Index	208F$_h$
Name	Digital inputs 8bit
Object code	ARRAY
Data type	UNSIGNED8

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	1…2
Default value	2

Sub-index	1
Description	Device profile defined inputs
Access	RO
PDO mapping	Possible
Value range	UNSIGNED8
Default value	no
Sub-index	2
Description	Manufacturer specific inputs
Access	RO
PDO mapping	Possible
Value range	UNSIGNED8
Default value	no

Table 4.5.1 *– Sub-index 1 bit description*

	Bit	Value	Description
$208F_h$:01 Device profile defined input	4..7		Reserved
	3	0	Interlock (Drive enable/STO input) activated; drive may apply power to motor
		1	Interlock (Drive enable/STO input) deactivated; drive may not apply power to motor. Enter *Switch on disabled* state.
	2	0	Home switch input status is low
		1	Home switch input status is high
	1	0	Positive limit switch is inactive
		1	Positive limit switch is active
	0	0	Negative limit switch is inactive
		1	Negative limit switch is active

Table 4.5.2 *– Sub-index 2 bit description*

	Bit	Value	Description
$208F_h$:02 Manufacturer specific inputs	7		IN7 status
	6		IN6 status
	5		IN5 status
	4		IN4 status
	3		IN3 status
	2		IN2 status
	1		IN1 status
	0		IN0 status

4.5.3 Object 60FE$_h$: Digital outputs

The object is responsible for controlling the digital outputs of the drive. Its functionality is defined through two sub-indices:

1. **Sub-index 1**: Specifies the desired state of the outputs (high or low).
2. **Sub-index 2**: Acts as a mask, defining which outputs are allowed to be controlled. Only the outputs permitted by this mask can be manipulated.

All drive outputs are of the **NPN type**, which means they function as follows:

- **Output Bit Set to 1 (Logical High)**: The corresponding output on the drive switches to a logical ‘1’ (high), disconnecting the load from the ground (GND).
- **Output Bit Reset to 0 (Logical Low)**: The corresponding output switches to a logical ‘0’ (low), connecting the load to the ground (GND).

Remarks:

The actual number of available digital outputs is product dependent. Check the drive user manual for the available digital outputs.

If an unavailable digital output is selected in sub-index 2, the drive will issue an emergency message with ID 0xFF05.

Object description:

Index	60FE$_h$
Name	Digital outputs
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	1…2
Default value	2

Sub-index	1
Description	Physical outputs
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0

Sub-index	2
Description	Bit mask
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0

***Table 4.5.3** – Bit mask description*

	Bit	Description
Manufacturer Specific	31	OUT15 command
	30	OUT14 command
	29	OUT13 command
	28	OUT12 command
	27	OUT11 command
	26	OUT10 command
	25	OUT9 command
	24	OUT8 command
	23	OUT7 command
	22	OUT6 command
	21	OUT5 command
	20	OUT4 command
	19	OUT3 command
	18	OUT2 command
	17	OUT1 command
	16	OUT0 command
Device profile Defined	15…0	Reserved

4.5.3.1 Example for setting the digital outputs

The example will Set OUT0 to 0(connect to GND) and OUT1 to 1 (disconnect from GND).

1. **Set sub-index 1 with the needed outputs states.** Set bit 16 (OUT0) to 0 and bit17 (OUT1) to 1.

   Set in **60FE$_h$ sub-index1** to 0x00020000.

2. **Set sub-index 2 bit mask only with the output values that need to be changed.** Set bit 16 and 17 to 1 to allow the change of OUT0 and OUT1 states.

   Set in **60FE$_h$ sub-index2** to 0x00030000.

After the second sub-index is set, the selected outputs will switch their state to the values defined in sub-index 1.

4.5.4 Object 2090$_h$: Digital outputs 8bit

Has the same functionality as object 60FE$_h$ digital outputs, only that its two sub-indexes are 8 bit instead of 32bit. Mapping shorter data to a PDO decreases the total communication bus load and processing time.

Object description:

Index	2090$_h$
Name	Digital outputs 8bit
Object code	ARRAY
Data type	UNSIGNED8

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	1…2
Default value	2

Sub-index	1
Description	Physical outputs 8bit
Access	RW
PDO mapping	Possible
Value range	UNSIGNED8
Default value	0
Sub-index	2
Description	Bit mask 8bit
Access	RW
PDO mapping	Possible
Value range	UNSIGNED8
Default value	0

Table 4.5.4 *– Sub-index 1&2 Bit description*

	Bit	Description
Manufacturer Specific Outputs	7	OUT7 command
	6	OUT6 command
	5	OUT5 command
	4	OUT4 command
	3	OUT3 command
	2	OUT2 command
	1	OUT1 command
	0	OUT0 command

4.5.5 Object 2045$_h$: Digital outputs status

The actual status of the drive outputs can be monitored using this object.

Object description:

Index	2045$_h$
Name	Digital outputs status
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	UNSIGNED16
Default value	No

Data description:

Bit	Meaning	Bit	Meaning
15	OUT15 status	7	OUT7 status
14	OUT14 status	6	OUT6 status
13	OUT13 status	5	OUT5 status
12	OUT12 status	4	OUT4 status
11	OUT11 status	3	OUT3 status
10	OUT10 status	2	OUT2 status
9	OUT9 status	1	OUT1 status
8	OUT8 status	0	OUT0 status

If the any of the bits is **SET**, then the corresponding drive output status is logical ‘1’ (high). If the bit is **RESET**, then the corresponding drive output status is logical ‘0’ (low).

4.5.6 Object 2102$_h$: Brake status

The object shows the status for the digital output assigned to operate a mechanical brake on the motor. When bit1 is SET (=1), the brake output is active. This object will show an inactive brake depending on the brake release delay parameter set in the Motor Setup. The brake will start to deactivate when the command Switch On is received in Control Word and it may still be active even when the drive reaches the Operation Enabled state is Status Word. In case a mechanical brake is used, the CoE master should not send a motion command until this object is 0.

Object description:

Index	2102$_h$
Name	Brake status
Object code	VAR
Data type	USINT8

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	0 or 1
Default value	No

4.5.7 Object 2046$_h$: Analogue input: Reference

The object contains the actual value of the analog reference applied to the drive. Through this object, one can supervise the analogue input dedicated to receive the analogue reference in the external control modes.

Object description:

Index	2046$_h$
Name	Analogue input: Reference
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	0 … 65520
Default value	No

4.5.8 Object 2047$_h$: Analogue input: Feedback

The object contains the actual value of the analogue feedback applied to the drive.

Object description:

Index	2047$_h$
Name	Analogue input: Feedback
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	0 … 65520
Default value	No

4.5.9 Object 2055$_h$: DC-link voltage

The object contains the actual value of the DC-link voltage. The object is expressed in internal voltage units.

Object description:

Index	2055$_h$
Name	Analogue input: DC-link voltage
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Units	DC-VU
Value range	0 … 65520
Default value	No

The computation formula for the voltage [IU] in [V] is:

$$Voltage\_measured[V] = \frac{VDCMaxMeasurable[V]}{65520} \cdot Voltage\_measured[IU]$$

where *VDCMaxMeasurable* is the maximum measurable DC voltage expressed in [V]. This value can be read in the "Drive Info" dialogue, which can be opened from the "Drive Setup".

4.5.10 Object 2058$_h$: Drive Temperature

The object contains the actual drive temperature. The object is expressed in temperature internal units.

Object description:

Index	2058$_h$
Name	Analogue input for drive temperature
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	0 … 65535
Default value	No

Note: if the drive does not have a temperature sensor, this object should not be used.

The computation formula for the temperature [IU] in [°C] is:

$$\mathrm{Temp}[°\mathrm{C}] = \frac{3.3}{\mathrm{DriveTempSensorGain*65520}} * \left(\mathrm{Temp[IU]} - \frac{\mathrm{DriveTempOutAt0oC*65520}}{3.3}\right)$$

where DriveTempSensorGain and DriveTempOutAt0°C parameters are available as Sensor Gain and Output at 0 °C, respectively, in the Protections and Limits section within the Drive Data dialog.

4.5.11 Object 208B$_h$[1]: Sin AD signal from Sin/Cos encoder

The object contains the actual value of the analogue sine signal of a Sin/Cos encoder.

Object description:

Index	208B$_h$
Name	Sin AD signal from Sin/Cos encoder
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	-32768 … 32767
Default value	No

4.5.12 Object 208C$_h$[2]: Cos AD signal from Sin/Cos encoder

The object contains the actual value of the analogue cosine signal of a Sin/Cos encoder.

Object description:

Index	208C$_h$
Name	Cos AD signal from Sin/Cos encoder
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RO
PDO mapping	Possible
Units	-
Value range	-32768 … 32767
Default value	No

[1] Object 208B$_h$ is available only on firmware F515x.

[2] Object 208C$_h$ is available only on firmware F515x.

4.6 Protections Setting Objects

4.6.1 Object 607Dh: Software position limit

The object sets the maximal and minimal software position limits. If the actual position is lower than the negative position limit or higher than the positive one, a software position limit emergency message will be launched. If either of these limits is passed, the motor will start decelerating using the value set in *Object 6085h: Quick stop deceleration*. Once it has decelerated, the motor will stand still until a new command is given to travel within the space defined by the limits.

Remarks:

A value of -2147483648 for Minimal position limit and 2147483647 for Maximal position limit disables the position limit check.

Object description:

Index	607D$_h$
Name	Software position limit
Object code	ARRAY
Data type	INTEGER32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Minimal position limit
Access	RW
PDO mapping	Possible
Value range	INTEGER32
Default value	0x80000000

Sub-index	2
Description	Maximal position limit
Access	RW
PDO mapping	Possible
Value range	INTEGER32
Default value	0x7FFFFFFF

4.6.2 Object 2050h: Over-current protection level

The Over-Current Protection Level object together with object Over-Current Time Out (2051$_h$) defines the drive over-current protection limits. The object defines the value of current in the drive, over which the over-current protection will be activated, if lasting more than a time interval that is specified in object 2051$_h$. It is set in current internal units.

Object description:

Index	2050$_h$
Name	Over-current protection level
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Units	CU
Value range	0 … 32767
Default value	No

The computation formula for the current [IU] in [A] is:

$$current[A] = \frac{2 \cdot Ipeak}{65520} \cdot current[IU]$$

where *Ipeak* is the peak current supported by the drive and *current[IU]* is the command value for object 2050$_h$.

4.6.3 Object 2051h: Over-current time out

The Over-Current time out object together with object Over-Current Protection Limit (2050$_h$) defines the drive over-current protection limits. The object sets the time interval after which the over-current protection is triggered if the drive current exceeds the value set through object 2050$_h$. It is set in time internal units.

Object description:

Index	2051_h
Name	Over-current time out
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Possible
Units	TU
Value range	0 … 65535
Default value	No

4.6.4 Object 2052_h: Motor nominal current

The object sets the maximum motor current RMS value for continuous operation. This value is used by the I2t motor protection and one of the start methods. It is set in current internal units. See object 2053_h for more details about the I2t motor protection.

Object description:

Index	2052_h
Name	Motor nominal current
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Units	CU
Value range	0 … 32767
Default value	No

The computation formula for the current [IU] in [A] is:

$$current[A] = \frac{2 \cdot Ipeak}{65520} \cdot current[IU]$$

where *Ipeak* is the peak current supported by the drive and *current[IU]* is the read value from object 2052_h.

4.6.5 Object 2053_h: I2t protection integrator limit

Objects 2053_h and 2054_h contain the parameters of the I^2t protection (against long-term motor over-currents). Their setting must be coordinated with the setting of the object 2052_h, motor nominal current. Select a point on the I^2t motor thermal protection curve, which is characterized by the points I_I2t (current, [A]) and t_I2t: (time, [s]) (see **Figure 4.6.1**)

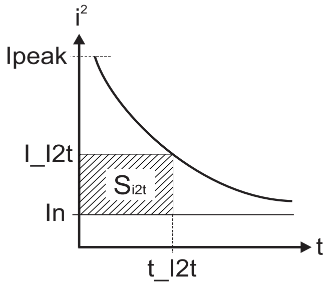


Figure 4.6.1.*I2t motor thermal protection curve*

The points I_I2t and t_I2t on the motor thermal protection curve together with the nominal motor current **In** define the surface S_{I2t}. If the motor instantaneous current is greater than the nominal current In and the I2t protection is activated, the difference between the square of the instantaneous current and the square of the nominal current is integrated and compared with the SI2t value (see **Figure 4.6.2**). When the integral equals the SI2t surface, the I2t protection is triggered.

Object description:

Index	2053_h
Name	I2t protection integrator limit
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	No
Units	-
Value range	0 … 2^{31}-1
Default value	No

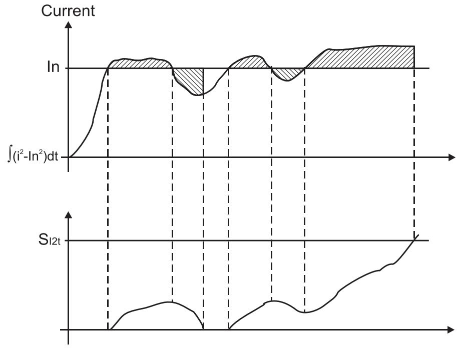


Figure 4.6.2. *I2t protection implementation*

The computation formula for the i2t protection integrator limit (I2TINTLIM) is

$$I2TINTLIM = \frac{(I\_I2t)^2 - (In)^2}{32767^2} \cdot 2^{26}$$

where I_I2t and In are represented in current units (CU).

4.6.5.1 I2t protection explained

The behavior of the I²t protection depends on **bit 1** of the **ASR register** found in the parameters.xml file. By default, all templates have **ASR.1=1**.

- **If ASR.1=0**:
  - The drive enters a **fault state**, and motor power is turned OFF.
  - When the I²t protection is triggered, the **Software Protections Interrupt** will be executed.
- **If ASR.1=1**:
  - The motion continues, but the current limit is reduced to **90% of the nominal current** until the I²t integral returns to 0.
  - The **Software Protections Interrupt** will not be executed when the I²t protection is triggered.

4.6.6 Object 2054$_h$: I2t protection scaling factor

Object description:

Index	2054$_h$
Name	I2t protection scaling factor
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Units	-
Value range	0 … 65535
Default value	No

The computation formula for the i2t protection scaling factor (SFI2T) is

$$SFI2T = 2^{26} \cdot \frac{Ts\_S}{t\_I2t}$$

where Ts_S is the sampling time of the speed control loop [s], and t_I2t is the I2t protection time corresponding to the point on the graphic in **Figure 4.6.1**.

4.6.7 Object 207F$_h$: Current limit

The object defines the maximum current that will pass through the motor. This object is valid only for the configurations using: brushless, DC brushed and stepper closed loop motor. The value is set in current internal units.

Object description:

Index	207F$_h$
Name	Current limit
Object code	VAR
Data type	Unsigned16

Entry description:

Access	RW
PDO mapping	YES
Units	-
Value range	0 … 65535
Default value	No

The computation formula for the current_limit [A] to [IU] is:

$$Current\_Limit[IU] = 32767 - \frac{Current\_Limit[A] \cdot 65520}{2 \cdot Ipeak}$$

where *Ipeak* is the peak current supported by the drive, C*urrent_Limit[A]* is the target current in [A] and C*urrent_Limit[IU]* is the target value to be written in object 207F$_h$.

4.7 Step Loss Detection for Stepper Open Loop configuration

In a stepper open-loop configuration, the command resolution can exceed that of a standard closed-loop configuration. For instance, with a motor featuring 200 steps per revolution and 256 microsteps per step, the position command achieves a resolution of 51,200 Internal Units per revolution. By comparison, a 1,000-line quadrature encoder provides feedback at 4,000 Internal Units per revolution.

When step-loss detection is employed, an encoder monitors the open-loop stepper motor to identify any lost steps. If the protection mechanism is triggered, the drive transitions to a Fault state, signaling a Control Error. To activate this protection, select the Stepper Open Loop + Encoder on Motor configuration and set an appropriate Control Error Protection value.

4.7.1 Object 2083$_h$: Encoder Resolution for step loss protection

Sets the number of encoder increments for one full motor rotation. For example, if an encoder has 2000 increments/revolution, then 2000 must be written into the object.

Remark: The value for this object is automatically calculated in the setup when choosing a Stepper Open Loop with feedback on motor configuration.

Object description:

Index	2083$_h$
Name	Encoder resolution for step loss protection
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Yes
Value range	UNSIGNED32
Default value	-

The value for this object can be changed by editing the parameter “ENCRESLONG” found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

4.7.2 Object 2084$_h$: Stepper Resolution for step loss protection

Sets the number of microsteps the step motor does for one full rotation. For example, if the motor has 100 steps / revolution (see **Figure 4.7.1**) and is controlled with 256 microsteps / step (see **Figure 4.7.2**), the value 100x256=25600 should be found into this object.

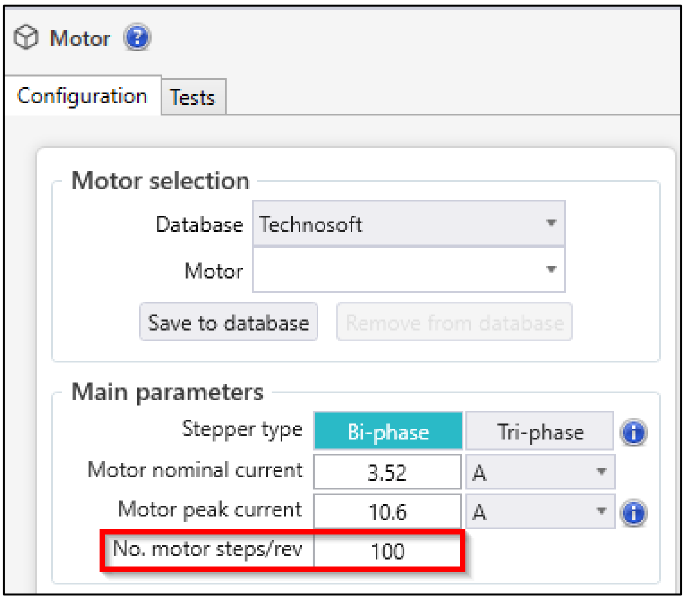
Remark: The value for this object is automatically calculated in the setup when choosing a Stepper Open Loop with feedback on motor configuration.

Object description:

Index	2084$_h$
Name	Stepper resolution for step loss protection
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Yes
Value range	UNSIGNED32
Default value	-



Motor selection

Database: Technosoft

Motor:

Main parameters

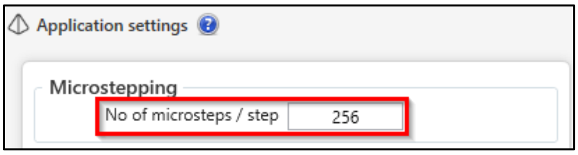
Stepper type: Bi-phase

Motor nominal current: 3.52 A

Motor peak current: 10.6 A

No. motor steps/rev: 100

Figure 4.7.1. *Motor steps / revolution*



Microstepping

No of microsteps / step: 256

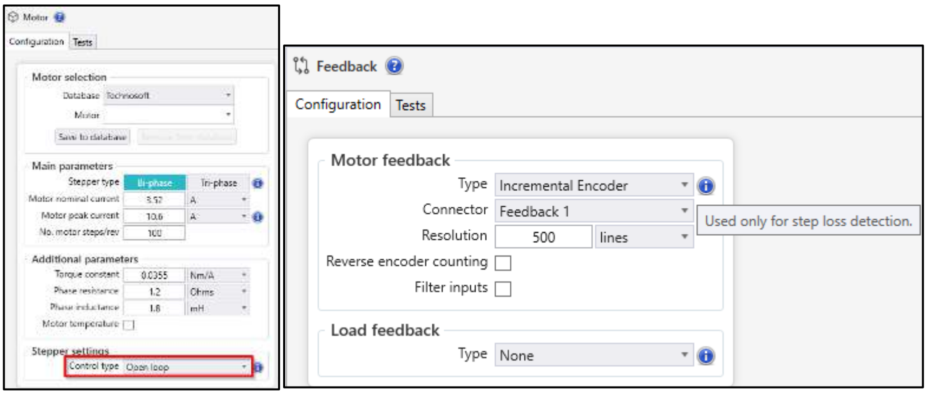
Figure 4.7.2. *Motor microsteps / step*

The value for this object can be changed by editing the parameter "STEPRESLONG" found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

4.7.3 Enabling step loss detection protection

Before enabling the step loss detection protection, the *Encoder resolution* in object 2083h and the *Stepper resolution* in object 2084h must be set correctly. These two objects should already be set automatically if the correct setup parameters were introduced. In addition, the feedback sensor must be set on motor in the Feedback setup:



Motor selection

Database: Technosoft

Motor:

Main parameters

Stepper type: Bi-phase

Motor nominal current: 3.52 A

Motor peak current: 10.6 A

No. motor steps/rev: 100

Additional parameters

Torque constant: 0.0355 Nm/A

Phase resistance: 1.2 Ohms

Phase inductance: 1.8 mH

Motor temperature □

Stepper settings

Control type: Open loop

Motor feedback

Type: Incremental Encoder

Connector: Feedback 1

Resolution: 500 lines

Used only for step loss detection.

Reverse encoder counting □

Filter inputs □

Load feedback

Type: None

Figure 4.7.3. *Configuring the feedback sensor for step loss detection*

The step loss detection protection parameters are actually the control error parameters: object Object 6066h: Following error time out and object Object 6065h: Following error window. The protection is triggered if the error between the commanded position and the position measured via the encoder is greater than the value set in object 6065h for a time interval greater than the value set in object 6066h.

The following error window is expressed in microsteps. The Following error time is expressed in multiples of position/speed control loops (1ms by default for stepper configurations).

To enable the step loss detection protection, set first the Object 6065h: Following error window, then set the Object 6066h: Following error time out to a value different from 65535 (0xFFFF). To disable this protection, set a 65535 value in object 6066h.

Example: Following error window is set to 1000 and *Following error time* is set to 20. The step motor has 100 steps/rev and is controlled with 256 microsteps/step. The step loss protection will be triggered if the difference between the commanded position and the measured position is bigger than 1000 microsteps (i.e. 1000/(100*256) rev = 14,06 degrees) for a time interval bigger or equal than 20 control loops of 1ms each i.e. 20ms.

Remark: the actual value of the error between the commanded position and the measured position can be read from object 60F4h. It is expressed in microsteps.

4.7.4 Step loss protection setup

The following steps are recommended for optimal setup of the step loss protection parameters:

Move your motor with the highest velocity and load planned to be used in your application

During the movement at maximal speed, read object 60F4h - *Following error actual value* as often as possible to determine its highest value.

> **Remark:** *Following error actual value can be read at every control loop using EasyMotion Studio II by logging the TML variable POSERR.*

Add a margin of about 25% to the highest error value determined at previous step and set the new obtained value into object 6065h - *Following error window*.

Activate the step loss detection by writing a non-zero value in object 6066h - *Following error time out.* Recommended values are between 1 and 10.

4.7.5 Recovering from step loss detection fault

When the step loss detection protection is triggered, the drive enters in Fault state. The EtherCAT® master will receive an emergency message from the drive with control error/following error code. In order to exit from Fault state and restart a motion, the following steps must be performed:

- Send fault reset command to the drive. The drive will enter in Switch On Disabled state;
- Send Disable voltage command into Controlword.
- Send Switch On command into Controlword.
- Send Enable operation into Controlword. At this moment, voltage is applied to the motor and it will execute the phase alignment procedure again. The position error will be reset automatically.
- Start a homing procedure to find again the motor zero position.

4.7.6 Remarks about Factor Group settings when using step the loss detection

When the drive controls stepper motors in open loop, if the factor group settings are activated they are automatically configured for correspondence between motor position in user units and microsteps as internal units. Because the motor position is read in encoder counts, it leads to incorrect values reported in objects 6064h Position actual value and 6062h Position demand value.

Only object 6063h *Position actual internal value* will always show the motor position correctly in encoder counts.

If the factor group settings are not used, i.e. all values reported are in internal units (default), both 6064h *Position actual value* and 6062h *Position demand value* will provide correct values.

4.8 Drive info objects

4.8.1 Object 1000h: Device Type

The object contains information about drive type and its functionality. The 32-bit value contains 2 components of 16-bits: the 16 LSB describe the CiA standard that is followed.

Object description:

Index	1000h
Name	Device type
Object code	VAR
Data type	UNSIGNED32

Value description:

Access	RO
PDO mapping	NO
Value range	UNSIGNED32
Default value	60192h for iPOS family

4.8.2 Object 6502_h: Supported drive modes

This object gives an overview of the operating modes supported on the Technosoft drives. Each bit from the object has assigned an operating mode. If the bit is set then the drive supports the associated operating mode.

Object description:

Index	6502_h
Name	Supported drive modes
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RO
PDO mapping	Possible
Value range	UNSIGNED32
Default value	$001C03E5_h$ - iPOS-CAT drives

The modes of operation supported by the Technosoft drives, and their corresponding bits, are the following:

Data description:

MSB **LSB**

0	0	x	…	x	0		0	1	1	0	0	1	0	1
Manufacturer specific					rsvd			ip	hm	rsvd	tq	pv	vl	pp
31	21	20	…	16	15	...	7	6	5	4	3	2	1	0

Data description – manufacturer specific:

Bit	Description
31 … 21	Reserved
20	External Reference Torque Mode
19	External Reference Speed Mode
18	External Reference Position Mode
17	Electronic Gearing Position Mode
16	Electronic Camming Position Mode

4.8.3 Object 1008_h: Manufacturer Device Name

The object contains the manufacturer device name in ASCII form, maximum 15 characters.

Object description:

Index	1008_h
Name	Manufacturer device name
Object code	VAR
Data type	Visible String

Entry description:

Access	Const
PDO mapping	No
Value range	No
Default value	iPOS

4.8.4 Object $100A_h$: Manufacturer Software Version

The object contains the firmware version programmed on the drive in ASCII form with the maximum length of 15 characters.

Object description:

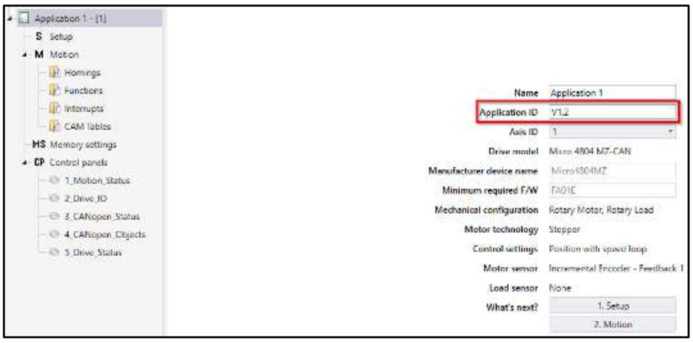
Index	$100A_h$
Name	Manufacturer software version
Object code	VAR
Data type	Visible String

Entry description:

Access	Const
PDO mapping	No
Value range	No
Default value	Product dependent

4.8.5 Object 2060$_h$: Software version of a TML application

By inspecting this object, the user can find out the software version of the TML application (setup plus eventually cam tables) that is stored in the EEPROM memory of the drive. The object shows a string of the first 4 elements written in the TML application field, grouped in a 32-bit variable. If more character are written, only the first 4 will be displayed. Each byte represents an ASCII character.



Name: Application 1
Application ID: V1.2
Axis ID: 1
Drive model: Micro 4804 MZ-CAN
Manufacturer device name: Micro4804MZ
Minimum required F/W: FA01E
Mechanical configuration: Rotary Motor, Rotary Load
Motor technology: Stepper
Control settings: Position with speed loop
Motor sensor: Incremental Encoder - Feedback 1
Load sensor: None
What's next?

Object description:

Index	2060_h
Name	Software version of TML application
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RO
PDO mapping	No
Units	-
Value range	No
Default value	No

Example:

If object 2060_h contains the value 0x322E3156, then the software version of the TML application is read as:

0x56 – ASCII code of letter **V**

0x31 – ASCII code of number **1**

0x2E – ASCII code of character . (point)

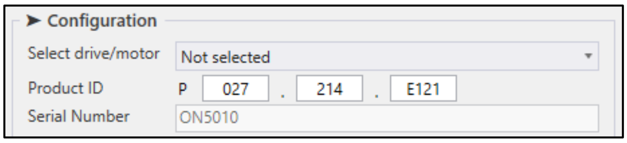
0x32 – ASCII code of number **2**

Therefore, the version is **V1.2**.

4.8.6 Object 1018$_h$: Identity Object

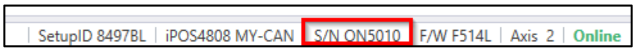
This object provides general information about the device.

- ❑ Sub-index 01_h shows the unique Vendor ID allocated to Technosoft ($1A3_h$).
- ❑ Sub-index 02_h contains the Technosoft drive product ID. It can be found physically on the drive label or using the EEPROM programmer tool found under the Utilities tab. If the Technosoft product ID is P027.214.E121, sub-index 02_h will be read as the number 27214121 in decimal.



➤ Configuration
Select drive/motor: Not selected
Product ID: P 027 . 214 . E121
Serial Number: ON5010

- ❑ Sub-index 03_h shows the Revision number.
- ❑ Sub-index 04h displays the drive's serial number. This serial number can be retrieved using the EEPROM Programmer tool or viewed in the bottom-right corner of EasyMotion Studio II when the drive is connected online.



SetupID 8497BL | iPOS4808 MY-CAN | S/N ON5010 | F/W F514L | Axis 2 | Online

For example, the serial number 0x4C451158 is interpreted as follows:

- 0x4C corresponds to the ASCII character "L"
- 0x45 corresponds to the ASCII character "E"
- 0x1158 represents the numerical value 1158

Thus, the full serial number is LE1158.

Object description:

Index	1018_h
Name	Identity Object
Object code	RECORD
Data type	Identity

Entry description:

Sub-index	00_h
Description	Number of entries
Access	RO
PDO mapping	No
Value range	1..4
Default value	1

Sub-index	01_h
Description	Vendor ID
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	$000001A3_h$

Sub-index	02_h
Description	Product Code
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	Product dependent

Sub-index	03_h
Description	Revision number
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	0x30313030 (ASCII 0100)

Sub-index	04_h
Description	Serial number
Access	RO
PDO mapping	No
Value range	UNSIGNED32
Default value	Unique number

4.9 Miscellaneous Objects

4.9.1 Object 2025_h: Stepper current in open-loop operation

In this object, one can set the level of the current to be applied when controlling a stepper motor in open loop operation at runtime.

Object description:

Index	2025_h
Name	Stepper current in open-loop operation
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Possible
Units	IU
Value range	-32768 … 32767
Default value	No

The computation formula for the current [IU] in [A] is:

$$current[A] = \frac{2 \cdot Ipeak}{65520} \cdot curent[IU]$$

where *Ipeak* is the peak current supported by the drive and *current[IU]* is the commanded value in object 2025_h.

4.9.2 Object 2026_h: Stand-by current for stepper in open-loop operation

In this object, one can set the level of the current to be applied when controlling a stepper motor in open loop operation in stand-by.

Object description:

Index	2026$_h$
Name	Stand-by current for stepper in open-loop operation
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Possible
Units	CU
Value range	-32768 … 32767
Default value	No

4.9.3 Object 2027$_h$: Timeout for stepper stand-by current

In this object, one can set the amount of time after the value set in object 2026$_h$, *stand-by current for stepper in open-loop operation* will activate as the reference for the current applied to the motor after the reference has reached the target value.

Object description:

Index	2027$_h$
Name	Timeout for stepper stand-by current
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Possible
Units	TU
Value range	0 … 65535
Default value	No

4.9.4 Object 2075$_h$: Position triggers

This object is used in order to define a set of four position values. If the *position actual value* is the value set as a position trigger, then the corresponding bit in *SRH – Status Register High (bits 1…4)* will be set.

Object description:

Index	2075$_h$
Name	Position triggers
Object code	ARRAY
Data type	INTEGER32

Entry description:

Sub-index	00$_h$
Description	Number of sub-indexes
Access	RO
PDO mapping	No
Default value	4

Sub-index	01$_h$ – 04$_h$
Description	Position trigger 1 - 4
Access	RW
PDO mapping	Possible
Value range	INTEGER32
Default value	No

4.9.5 Object 2085$_h$: Position triggered outputs

The object controls the digital outputs 0, 1 and 5 in concordance with the position triggers 1, 2 and 4 status from the *SRH – Status Register High (bits 1, 2 and 4)*.

Object description:

Index	2085$_h$
Name	Position triggered outputs
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Units	-
Value range	0 … 65535
Default value	No

The *Position triggered outputs* object has the following bit assignment:

Table 4.9.1 *– Bit Assignment in Position triggered outputs*

Bit	Value	Meaning
12-15	0	Reserved.

11	0	OUT5 = 1 when Position trigger 4 = 0
		OUT5 = 0 when Position trigger 4 = 1

	1	OUT5 = 0 when Position trigger 4 = 0
		OUT5 = 1 when Position trigger 4 = 1

10	0	Reserved.

9	0	OUT1 = 1 when Position trigger 2 = 0
		OUT1 = 0 when Position trigger 2 = 1

	1	OUT1 = 0 when Position trigger 2 = 0
		OUT1 = 1 when Position trigger 2 = 1

8	0	OUT0 = 1 when Position trigger 1 = 0
		OUT0 = 0 when Position trigger 1 = 1

	1	OUT0 = 0 when Position trigger 1 = 0
		OUT0 = 1 when Position trigger 1 = 1

4-7	0	Reserved
3[1]	1	Enable position trigger 4 control of OUT5
	0	Disable position trigger 4 control of OUT5
2	0	Reserved
1	1	Enable position trigger 2 control of OUT1
	0	Disable position trigger 2 control of OUT1
0	1	Enable position trigger 1 control of OUT0
	0	Disable position trigger 1 control of OUT0

Note: Some drives may not have some outputs available. The object will control only the ones that exist.

4.9.6 Object 2076$_h$: Save current configuration

This object is used in order to enable saving the current configuration of the operating parameters of the drive. These parameters are the ones that are set when doing the setup of the drive. The purpose of this object is to be able to save the new values of these parameters in order to be re-initialized at subsequent system re-starts.

Writing any value in this object will trigger the save in the non-volatile EEPROM memory of the current drive operating parameters.

Object description:

Index	2076$_h$
Name	Save current configuration
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	WO
PDO mapping	No
Value range	UNSIGNED16
Default value	-

4.9.7 Object 208A$_h$: Save setup status

This object is used in order to monitor the parameters saving process. Bit 0 will be set to 1 when the 2076$_h$ object can be activated or the save function has been completed. It will stay 0 while the save function is ongoing.

Object description:

Index	208A$_h$
Name	Save setup status
Object code	VAR
Data type	UNSIGNED16

[1] Some outputs may not be available on all drives.

Entry description:

Access	RO
PDO mapping	Yes
Value range	INTEGER16
Default value	0

4.9.8 Object 2080h: Reset drive

This object is used to reset the drive by writing any non-zero value in it.

Remark: it resets only the drive; it does not reset the ECAT interface.

Object description:

Index	2080h
Name	Reset drive
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	WO
PDO mapping	No
Value range	USIGNED16
Default value	0

4.9.9 Object 2082h: Sync on fast loop

This object is used to synchronize the drive on the fast or slow loop sample period. The Distributed Clock time (SYNC 0) must be set accordingly with the time of the chosen sample loop in this object.

By default, the fast loop period for all configurations is set to 0.1 ms, the slow loop period 1ms.

Object description:

Index	2082h
Name	Sync on fast loop
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Value range	0: synchronize on slow loop 1: synchronize on fast loop
Default value	0

4.9.10 Object 2108h: Filter variable 16bit

This object applies a first order low pass filer on a 16 bit variable value. It does not affect the motor control when applied. It can be used only for sampling filtered values of one variable like the motor current.

Object description:

Index	2108h
Name	Filter variable 16bit
Object code	Record
Data type	Filter variable record

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	3
Default value	3

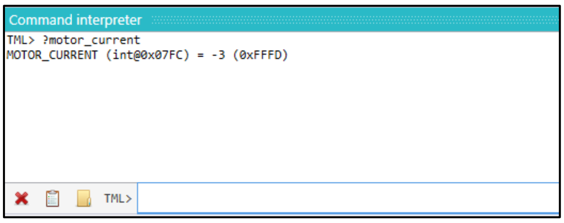
Sub-index	1
Description	16 bit variable address
Access	RW
PDO mapping	Possible
Value range	UNSIGNED16
Default value	0x0230 (address. or motor current)

Sub-index	2
Description	Filter strength
Access	RW
PDO mapping	Possible
Value range	UNSIGNED16
Default value	50

Sub-index	3
Description	Filtered variable 16bit
Access	RO
PDO mapping	Possible
Value range	0 -32767
Default value	-

How it works:

Sub-index 1 sets the filtered variable address. To find a variable address, in EasyMotion Studio II, click Tools | Command Interpreter. The communication must be online with the drive. Write the desired variable name with a ? in front and press Enter.



```
TML> ?motor_current
MOTOR_CURRENT (int@0x07FC) = -3 (0xFFFD)
```

The variable address can be found between the parenthesis.

Sub-index 2 sets the filter strength. The filter is strongest when Sub-index 2 = 0 and weakest when it is 32767. A strong filter increases the time lag between the unfiltered variable change and the filtered value reaching that value.

Sub-index 3 shows the filtered value of the 16 bit variable whose address is declared in Sub-index 1.

4.9.11 Object 208E$_h$: Auxiliary Settings Register

This object is used as a configuration register that enables various advanced control options.

Object description:

Index	208E$_h$
Name	Auxiliary Settings Register
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Value range	UNSIGNED16
Default value	0x0100

***Table 4.9.2** – Bit Assignment in Auxiliary Settings Register*

Bit	Value	Description
9-15	0	Reserved.
8	0	Set interpolation mode compatible with PT and PVT (legacy)
	1	Set interpolation mode (when 6060=7) as described in the CiA402 standard
4-7	0	Reserved
3	0	When 6040 bit 14 = 1, at the next *update*[1], the Target Speed Starting Value is the Actual Speed
	1	When 6040 bit 14 = 1, at the next *update*, the Target Speed Starting Value is zero.
0-2	0	Reserved.

4.9.12 Object 210B$_h$: Auxiliary Settings Register2

This object is used as a configuration register that enables various advanced control options. The bits in this object are linked to the internal register ASR2.

[1] *update* can mean a 0 to 1 transition of bit4 in Controlword or setting a new value into object 60FF$_h$ while in velocity mode

Object description:

Index	210Bh
Name	Auxiliary Settings Register2
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Value range	UNSIGNED16
Default value	0x0000

***Table 4.9.3** – Bit Assignment in Auxiliary Settings Register2*

Bit	Value	Description
13-15	0	Reserved.
12	0	Set actual position to the value of the homing offset 607Ch at the end of the homing procedure
	1	After finishing a homing procedure, do not reset the actual position. Homing ends keeping position on home switch.
0-11	0	Reserved

4.9.13 Object 20A0h: Load Position and Speed monitoring[1]

This object shows the position and speed of the load sensor, when its functionality is set as only monitoring (not used in position control). The load sensor functionality can be selected using the Feedback section during the setup part. The object is not affected by Factor Group settings – it will always return values in IU.

Object description:

Index	20A0h
Name	Load Position and Speed monitoring
Object code	VAR
Data type	INTEGER32

Entry description:

Sub-index	00h
Description	Number of sub-indexes
Access	RO
PDO mapping	Yes
Default value	3

Sub-index	01h
Description	Reserved
Access	RO
PDO mapping	-
Default value	-

Sub-index	02h
Description	Load Position Monitor
Access	RO
PDO mapping	Yes
Default value	-

Sub-index	03h
Description	Load Speed Monitor
Access	RO
PDO mapping	Yes
Default value	-

4.9.14 Object 2100h: Number of steps per revolution

This object shows the number of motor steps per revolution in case a stepper motor is used. This number is defined automatically in Setup part when configuring the motor data, under Main Parameters section.

Object description:

[1] Object 20A0h is available only in F515K / FA00C firmware or newer.

Index	2100$_h$
Name	Number of steps per revolution
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RO
PDO mapping	Yes
Value range	INTEGER16
Default value	-

4.9.15 Object 2101$_h$: Number of microsteps per step

This object shows the number of motor microsteps per step in case a stepper open loop configuration is used. This number is defined automatically when configuring Drive Setup.

Object description:

Index	2101$_h$
Name	Number of microsteps per step
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RO
PDO mapping	Yes
Value range	INTEGER16
Default value	-

4.9.16 Object 2103$_h$: Number of encoder counts per revolution

This object shows the number of encoder counts for one full motor rotation.

For example, if this object indicates 4000 and a 4000IU position command is given, the motor will rotate 1 full mechanical rotation.

Remark: this object will not indicate a correct number in case a Brushed DC motor is used.

Object description:

Index	2103$_h$
Name	Number of encoder counts per revolution
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Yes
Value range	INTEGER32
Default value	-

4.9.17 Object 2091$_h$: Lock EEPROM[1]

This object can be used to lock/unlock the EEPROM data from being written. By reading it, it also acts as a status.

Once TML or Setup data is written into the drive memory, it can be protected from being overwritten by using this object.

If the EEPROM memory is already locked, it can be unlocked using this object in order to write new setup data.

Object description:

Index	2091$_h$
Name	Lock EEPROM
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RW
PDO mapping	NO
Value range	UNSIGNED8
Default value	0

[1] Object 2091$_h$ is available only on firmware F515x

Table 4.9.4 *– Bit Assignment in Lock EEPROM*

Bit	Value	Meaning
2-7	0	Reserved.
0	0	EEPROM is unlocked.
	1	EEPROM is locked.

4.9.18 Object 2092$_h$: User Variables[1]

This object contains 4x sub-indexes, each a 32bit User Variable. These variables are directly linked to parameters present in the template and their values can be saved using object 2076$_h$ *Save current configuration*.

The variables are named: *UserVar1, UserVar2, UserVar3* and *UserVar4*. They are linked to sub-index 1 to 4 of this object.

Object description:

Index	2092$_h$
Name	User Variables
Object code	ARRAY
Data type	ULONG32

Entry description:

Sub-index	00$_h$
Description	Number of sub-indexes
Access	RO
PDO mapping	No
Default value	4

Sub-index	01$_h$ – 04$_h$
Description	UserVar1 - 4
Access	RW
PDO mapping	Possible
Value range	ULONG32
Default value	No

[1] Object 2092$_h$ is available only on firmware F515x

5 Factor group

The iPOS and Micro families offers the possibility to interchange physical dimensions and sizes into the device internal units. This chapter describes the factors that are necessary to do the interchanges.

The factors defined in Factor Group set up a relationship between device internal units and physical units.

The factor group settings currently implemented are complying with:

- Factor group objects - CiA 402-2 and later versions – starting with firmware version F515K / FA0xx
- **Factor group objects - CiA-402 (obsolete)** – for other firmware versions

5.1 Factor group objects - CiA-402 (obsolete)

The actual factors used for scaling are the *position factor* (object 6093h), the *velocity encoder factor* (object 6094h), the *acceleration factor* (object 6097h) and the *time encoder factor* (object 2071h). Writing a non-zero value into the respective dimension index objects validates these factors. The notation index objects are used for status only and can be set by the user depending on each user-defined value for the factors.

Because the drives work with Fixed 32 bit numbers (not floating point), some calculation round off errors might occur when using objects 6093h, 6094h, 6097h and 2071h. If the ECAT master supports handling the scaling calculations on its side, it is recommended to use them instead of using the "*Factor*" scaling objects.

5.1.1 Object 607Eh: Polarity

This object is used to multiply by 1 or -1 position and velocity objects. The object applies only to position profile, velocity profile, CSP and CSV in modes of operation.

Object description:

Index	607Eh
Name	Polarity
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RW
PDO mapping	Possible
Value range	0..256
Default value	0

The *Polarity* object has the following bit assignment:

***Table 5.1.1** – Bit Assignment in Polarity object*

Bit	Bit name	Value	Meaning
7	Position polarity	0	Multiply by 1 the values of objects 607Ah, 6062h and 6064h
		1	Multiply by -1 the values of objects 607Ah, 6062h and 6064h
6	Velocity polarity	0	Multiply by 1 the values of objects 60FFh, 606Bh and 606Ch
		1	Multiply by -1 the values of objects 60FFh, 606Bh and 606Ch
5-0	reserved	0	Reserved

The default value for this object can be changed by editing the parameter "POLARITY" found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

5.1.2 Object 6089h: Position notation index

The *position notation index* is used to define the position into [SI] units. Its purpose is purely informative for EtherCAT masters which still use it and has no influence over the actual unit scaling. In the CiA 402 standard, the dimension and notion index objects have been declared as obsolete. In case a custom position scaling is used, set it to 1 instead of 0. For position scaling, use Object 6093h: Position factor.
A list of predefined values can be found in the Dimension/Notation Index Table.

Object description:

Index	6089$_h$
Name	Position notation index
Object code	VAR
Data type	INTEGER8

Entry description:

Access	RW
PDO mapping	Possible
Value range	-128 … 127
Default value	0

5.1.3 Object 608A$_h$: Position dimension index

The *position dimension index* is used to define the position into [SI] units. Its purpose is purely informative for EtherCAT masters which still use it and has no influence over the actual unit scaling. In the CiA 402 standard, the dimension and notion index objects have been declared as obsolete. In case a custom position scaling is used, set it to 1 instead of 0. For position scaling, use Object 6093h: Position factor.

A list of predefined values can be found in the Dimension/Notation Index Table.

Object description:

Index	608A$_h$
Name	Position dimension index
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RW
PDO mapping	Possible
Value range	0 … 255
Default value	0

5.1.4 Object 608B$_h$: Velocity notation index

The *velocity notation index* is used to define the velocity into [SI] units. Its purpose is purely informative for EtherCAT masters which still use it and has no influence over the actual unit scaling. In the CiA 402 standard, the dimension and notion index objects have been declared as obsolete. In case a custom velocity scaling is used, set it to 1 instead of 0. For velocity scaling, use Object 6094h: Velocity encoder factor.

A list of predefined values can be found in the Dimension/Notation Index Table.

Object description:

Index	608B$_h$
Name	Velocity notation index
Object code	VAR
Data type	INTEGER8

Entry description:

Access	RW
PDO mapping	Possible
Value range	-128 … 127
Default value	0

5.1.5 Object 608C$_h$: Velocity dimension index

The *velocity dimension index i*s used to define the velocity into [SI] units. Its purpose is purely informative for EtherCAT masters which still use it and has no influence over the actual unit scaling. In the CiA 402 standard, the dimension and notion index objects have been declared as obsolete. In case a custom velocity scaling is used, set it to 1 instead of 0. For velocity scaling, use Object 6094h: Velocity encoder factor.

A list of predefined values can be found in the Dimension/Notation Index Table.

Object description:

Index	608C$_h$
Name	Velocity dimension index
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RW
PDO mapping	Possible
Value range	0 … 255
Default value	0

5.1.6 Object 608Dh: Acceleration notation index

The *acceleration notation index i*s used to define the acceleration into [SI] units. Its purpose is purely informative for EtherCAT masters which still use it and has no influence over the actual unit scaling. In the CiA 402 standard, the dimension and notion index objects have been declared as obsolete. In case a custom acceleration scaling is used, set it to 1 instead of 0. For acceleration scaling, use Object 6097h: Acceleration factor.

A list of predefined values can be found in the Dimension/Notation Index Table.

Object description:

Index	608Dh
Name	Acceleration notation index
Object code	VAR
Data type	INTEGER8

Entry description:

Access	RW
PDO mapping	Possible
Value range	-128 … 127
Default value	0

5.1.7 Object 608Eh: Acceleration dimension index

The *acceleration dimension index i*s used to define the acceleration into [SI] units. Its purpose is purely informative for EtherCAT masters which still use it and has no influence over the actual unit scaling. In the CiA 402 standard, the dimension and notion index objects have been declared as obsolete. In case a custom acceleration scaling is used, set it to 1 instead of 0. For acceleration scaling, use Object 6097h: Acceleration factor.

A list of predefined values can be found in the Dimension/Notation Index Table.

Object description:

Index	608Eh
Name	Acceleration dimension index
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RW
PDO mapping	Possible
Value range	0 … 255
Default value	0

5.1.8 Object 206Fh: Time notation index

The *time dimension index i*s used to define the time into [SI] units. Its purpose is purely informative for EtherCAT masters which still use it and has no influence over the actual unit scaling. In the CiA 402 standard, the dimension and notion index objects have been declared as obsolete. In case a custom time scaling is used, set it to 1 instead of 0. For time scaling, use Object 2071h: Time factor.

Object description:

Index	206Fh
Name	Time notation index
Object code	VAR
Data type	INTEGER8

Entry description:

Access	RW
PDO mapping	Possible
Value range	-128 … 127
Default value	0

5.1.9 Object 2070h: Time dimension index

The *time dimension index i*s used to define the time into [SI] units. Its purpose is purely informative for EtherCAT masters which still use it and has no influence over the actual unit scaling. In the CiA 402 standard, the dimension and notion index objects have been declared as obsolete. In case a custom time scaling is used, set it to 1 instead of 0. For time scaling, use Object 2071h: Time factor.

Object description:

Index	2070h
Name	Time dimension index
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RW
PDO mapping	Possible
Value range	0 … 255
Default value	0

5.1.10 Object 6093h: Position factor

The *position factor* converts the drive internal position units (increments) to the desired position (in position units) into the internal format (in increments) for the drive to use.

Writing any non-zero value into the respective dimension and notation index objects activates this object.

$$Position[IU] = Position[UserUnits] \times \frac{PositionFactor.Numerator}{PositionFactor.Divisor}$$

It scales the following objects*:*

6064h Position actual value; 6062h Position demand value; 607Ah Target position; 6067h Position window; 6068h Following error window; 60F4h Following error actual value

Object description:

Index	6093h
Name	Position factor
Object code	ARRAY
Number of elements	2
Data type	UNSIGNED32

Entry description:

Sub-index	01h
Description	Numerator
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	1

Sub-index	02h
Description	Divisor
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	1

5.1.10.1 Setting the numerator and divisor in a factor group object. Example

Important: when small values are used, errors may occur due to the internal calculation round off errors. In order to avoid this, use larger values giving the same desired ratio Example = 6093.1 = 0x20000 and 6093.2 = 0x10000. This will mean a factor of 2:1. In case 6093.1 = 0x2 and 0x6093.2 = 0x1, the position would not be computed correctly. As a general rule, the bigger the numerator and denominator values are, the more precise is the fraction calculation.

Example

The desired user position units are radians. The drive internal position units are encoder counts. The load is connected directly to the motor shaft and the motor has a 500-lines incremental encoder.

The conversion between user and internal units is:

$$Position[rad] \times \frac{(4 \times 500)}{(2 \times \pi)} = Position[UserUnits]$$

Hence (6093.2/6093.1) = 2 * pi / (4 x 500) = 0.0031415926535897932384626433832795…

How to set the 2 numbers? Being a number less than 1, the denominator (6093.1) is bigger than the numerator (6093.2). Hence set the denominator to the largest integer value for 32 bits i.e. 0xFFFF FFFF = 4294967295 and the numerator to

0.0031415926535897932384626433832795 x 4294967295 = 13493037.701380426305009189410434, rounded to integer i.e. = 13493038.

In conclusion: 6093.1 = 4294967295 (0xFFFF FFFF) and 6093.2 = 13493038 i.e. user position [rad] * 4294967295 / 13493038 = internal position [counts]

5.1.11 Object 6094$_h$: Velocity encoder factor

The *velocity encoder factor* converts the desired velocity (in velocity units) into the internal format (in increments) for the drive to use.

Writing any non-zero value into the respective dimension and notation index objects activates this object.

$$Velocity[IU] = Velocity[UserUnits] \times \frac{VelocityEncoderFactor.Numerator}{VelocityEncoderFactor.Divisor}$$

It scales the following objects:

606C$_h$ Velocity actual value; 606B$_h$ Velocity demand value; 606F$_h$ Velocity threshold; 60FF$_h$ Target velocity; 60F8$_h$ Max slippage; 6081$_h$ Profile velocity

To configure the object with optimal values, see *Setting the numerator and divisor in a factor group object. Example*.

Object description:

Index	6094$_h$
Name	Velocity encoder factor
Object code	ARRAY
Number of elements	2
Data type	UNSIGNED32

Entry description:

Sub-index	01$_h$
Description	Numerator
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	1

Sub-index	02$_h$
Description	Divisor
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	1

5.1.12 Object 6097$_h$: Acceleration factor

The *acceleration factor* converts the velocity (in acceleration units/sec^2) into the internal format (in increments/sampling^2) for the drive to use.

Writing any non-zero value into the respective dimension and notation index objects activates this object.

$$Acceleration[IU] = Acceleration[UserUnits] \times \frac{AccelerationFactor.Numerator}{AccelerationFactor.Divisor}$$

It scales the following objects:

6083$_h$ Profile acceleration; 6085$_h$ Quick stop deceleration

To configure the object with optimal values, see *Setting the numerator and divisor in a factor group object. Example*.

Object description:

Index	6097$_h$
Name	Acceleration factor
Object code	ARRAY
Number of elements	2
Data type	UNSIGNED32

Entry description:

Sub-index	01_h
Description	Numerator
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	1

Sub-index	02_h
Description	Divisor
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	1

5.1.13 Object 2071$_h$: Time factor

The *time factor* converts the desired time values (in time units) into the internal format (in speed / position loop samplings) for the drive to use.

Writing any non-zero value into the respective dimension and notation index objects activates this object.

$$Time[IU] = Time[UserUnits] \times \frac{TimeFactor.Numerator}{TimeFactor.Divisor}$$

It scales the following objects*:*

6066$_h$ Following error time out; 6068$_h$ Position window time; 2023$_h$ Jerk time; 2005$_h$ Max slippage time out; 2051$_h$ Over-current time out

To configure the object with optimal values, see *Setting the numerator and divisor in a factor group object. Example*.

Object description:

Index	2071_h
Name	Time factor
Object code	ARRAY
Number of elements	2
Data type	UNSIGNED32

Entry description:

Sub-index	01_h
Description	Numerator
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	1

Sub-index	02_h
Description	Divisor
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	1

5.2 Factor group objects - CiA-402-2

The user-defined units are translated to internal units (IU) by the factor / scaling objects: 6093ₕ (Position factor), 6094ₕ (Velocity encoder factor), 210Fₕ (Acceleration encoder factor) and 2110ₕ (Jerk encoder factor). For the calculation of the respective values (and their physical units) specific formulas presented in the chapter are used.

***Remark:** This feature is available starting with firmware versions F515K / FA0xx.*

All units are specified using a 32-bit notation index[1] that have no influence over any scaling. Their purpose is only to define an [SI] unit name (rpm, rad, deg, etc) and their exponent (prefix). The SI unit objects are: 60A8ₕ (SI unit position), 60A9ₕ (SI unit velocity), 60AAₕ (SI unit acceleration) and 60ABₕ (SI unit jerk).

Table 5.2 – SI Objects Structure

MSB **LSB**

Prefix			SI numerator			SI denominator			Profile-specific		
31	…	24	23	…	16	15	...	8	7	...	0

If the SI base unit is used, the bit field SI numerator contains the notation index of the base unit. The SI denominator is not used and its bit field is equal to 1. If SI derived units are used, the SI numerator bit field contains the notation index corresponding to the numerator of the unit and the SI denominator contains the notation index corresponding to the denominator of the unit. Additionally, the parameter definition may contain notation index for profile specific units.

Listed in the following table are the possible exponents (prefixes) and their values:

Table 5.3 – Prefix Representation[1]

Prefix	Factor	Symbol	Notation Index
kilo	10^3	k	03
-	10^0	-	00
milli	10^{-3}	m	FD
micro	10^{-6}	μ	FA

Listed in the following table all default units for the SI numerator field:

Table 5.4 – Notation Index for SI Numerator [1]

Name	Symbol	Notation Index	Description
Internal Unit	IU(inc)	B5	Encoder counts. Dependent on the used sensor configuration. It’s value can be found also in object 2103ₕ: Number of encoder counts per revolution.
Step	IU(step)	AC	Available only for step motors. The value can be computed as object 2100ₕ: Number of steps per revolution multiplied by object 2101ₕ: Number of microsteps per step.
Radian	rad	10	Radian
Degree	deg	41	Degrees
Mechanical Revolution	rot	B4	Revolution
Meter	m	01	Available only if transmission type is rotary to linear or linear to linear.
Dimensionless	-	00	Dimensionless length unit

Listed in the following table are all default units for the SI denominator:

Table 5.5 – Notation Index for SI Denominator[1]

Name	Symbol	Notation Index
Second	s	03
Minute	min	47
Square Second	s^2	57
Cubic second	s^3	A0

[1] Specified in CiA-303-2 v.1.5.0/27.04.2015 Recommendation – “Part 2: Representation of SI units and prefixes”

If needed, the full list of notation indexes is specified in CiA-303-2 v.1.5.0/27.04.2015 Recommendation – “Part 2: Representation of SI units and prefixes”.

5.2.1 Object 60A8$_h$: SI unit position

This object indicates the user-defined position units. The object structure is defined in table Table 5.2 – *SI Objects Structure*. The profile specific field (bit 0 to bit 7) of this object is reserved (00$_h$).

Object description:

Index	60A8$_h$
Name	SI unit position
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00B50100

Example:

- If the object is configured in deg:

MSB **LSB**

Prefix	SI numerator	SI denominator	Profile-specific
00$_h$ (means 10^0)	41$_h$(means deg)	01$_h$(default)	00$_h$(default)
31 … 24	23 … 16	15 ... 8	7 ... 0

- If the object is configured in mm:

MSB **LSB**

Prefix	SI numerator	SI denominator	Profile-specific
FD$_h$ (means 10^{-3})	01$_h$(means m)	01$_h$(default)	00$_h$(default)
31 … 24	23 … 16	15 ... 8	7 ... 0

5.2.2 Object 6093$_h$: Position Factor / Position Scaling

The object converts all values of length of the application from position internal units (IU) to position units (PU). Its value takes into consideration three objects: Position Encoder Resolution - 608F$_h$, Gear Ratio - 6091$_h$ and Feed Constant - 6092$_h$.

The calculation of the position factor is done using the following equation:

$$Position\ Internal\ Units\ (IU)\ = \frac{Position\ Units\ (PU) \times Position\ Encoder\ Resolution\ \times Gear\ Ratio}{Feed\ Constant}$$

The Position Units are computed automatically by EasyMotion Studio II for each mechanical setup (rot-rot / rot-lin / lin-lin transmission) and each position sensor configuration (type, on motor or on load).

Object description:

Index	6093$_h$
Name	Position Factor / Position Scaling
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Position internal units (IU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

Sub-index	2
Description	Position units (PU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

5.2.3 Object 608F$_h$: Position Encoder Resolution

The object indicates the configured encoder increments and the number of motor revolutions. The position encoder resolution is calculated as follows:

$$Position\ Encoder\ Resolution = \frac{Encoder\ Increments}{Motor\ Rotation}$$

Object description:

Index	608F$_h$
Name	Position encoder resolution
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Encoder increments
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x000007D0 (2000 IU)

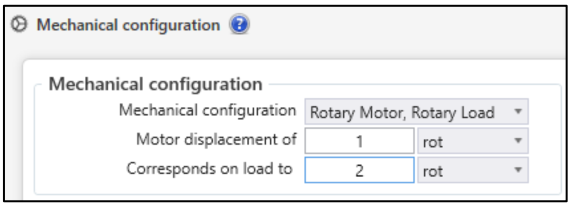
Sub-index	2
Description	Motor rotation
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

5.2.4 Object 6091$_h$: Gear Ratio

The object indicates the configured number of load rotations corresponding to the number of motor rotations. The gear ratio is calculated as follows:

$$Gear\ Ratio = \frac{Motor\ Rotation}{Load\ Rotation}$$

In EasyMotion Studio II, this object is automatically configured in the Mechanical Configuration section:



Mechanical configuration

Mechanical configuration

Mechanical configuration: Rotary Motor, Rotary Load

Motor displacement of: 1 rot

Corresponds on load to: 2 rot

Object description:

Index	6091$_h$
Name	Gear Ratio
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Motor rotation
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

Sub-index	2
Description	Load rotation
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

5.2.5 Object 6092$_h$: Feed Constant

The object indicates the measurement distance per one rotation of the driving shaft of the gearbox. The feed constant is calculated as follows:

$$Feed\ Constant = \frac{Feed}{Driving\ Shaft\ Rotation}$$

The feed is given in user-defined position units, and the driving shaft revolutions value is dimensionless.

Object description:

Index	6092$_h$
Name	Feed Constant
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Feed
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

Sub-index	2
Description	Shaft Rotations
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

5.2.6 Object 60A9$_h$: SI unit velocity

This object indicates the user-defined velocity units. The object structure is defined in Table 5.2 – *SI Objects Structure*. The profile specific field (bit 0 to bit 7) of this object is reserved (00$_h$).

Object description:

Index	60A9$_h$
Name	SI unit velocity
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00000000

Example:

- If the object is configured in rpm:

MSB **LSB**

Prefix	SI numerator	SI denominator	Profile-specific
00$_h$ (means 10^0)	B4$_h$(means rot)	47$_h$(means min)	00$_h$(default)
31 … 24	23 … 16	15 ... 8	7 ... 0

- If the object is configured in mm/s:

MSB **LSB**

Prefix	SI numerator	SI denominator	Profile-specific
FD$_h$ (means 10^{-3})	01$_h$(means m)	03$_h$(means s)	00$_h$(default)
31 … 24	23 … 16	15 ... 8	7 ... 0

5.2.7 Object 6094$_h$: Velocity encoder factor

The object converts all values of speed of the application from velocity internal units (IU) to velocity units (VU). Its value takes into consideration two objects: Position Factor / Position Scaling - 6093$_h$ and Velocity Factor - 6096$_h$.

The calculation of the position factor is done using the following equation:

$$Velocity\ Internal\ Units\ (IU) = \frac{Velocity\ Units\ (VU) \times Position\ Factor}{Velocity\ Factor} \times T\ \times 2^{16}\ \ where\ T = slow\ loop\ period$$

The Velocity Units are computed automatically by EasyMotion Studio II for each mechanical setup (rot-rot / rot-lin / lin-lin transmission), position sensor configuration (type, on motor or on load) and slow loop period.

Object description:

Index	6094$_h$
Name	Velocity encoder factor
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Velocity internal units (IU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001
Sub-index	2
Description	Velocity units (VU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

5.2.8 Object 6096$_h$: Velocity Factor

The object converts PU (position units) per second into VU (velocity units). The calculation of the velocity factor is done using the following equation:

$$Velocity\ Factor = \frac{Velocity\ Units\ (VU)}{\frac{Position\ Units\ (PU)}{s}}$$

For example, if the user defined position unit is radian (rad) and the user defined velocity unit is rpm, the velocity factor will be 60/2/π. If the user defined position unit is radian (rad) and the user defined velocity unit is rad/s, the velocity factor will be 1.

Object description:

Index	6096$_h$
Name	Velocity Factor
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Velocity units (VU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

Sub-index	2
Description	Position units (PU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

5.2.9 Object 60AA$_h$: SI unit acceleration

This object indicates the user-defined acceleration units. The object structure is defined in Table 5.2 – *SI Objects Structure*. The profile specific field (bit 0 to bit 7) of this object is reserved (00$_h$).

Object description:

Index	60AA$_h$
Name	SI unit acceleration
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00000000

Example:

- If the object is configured in deg/s^2:

MSB **LSB**

Prefix	SI numerator	SI denominator	Profile-specific
00$_h$ (means 10^0)	41$_h$(means rad)	57$_h$(means s^2)	00$_h$(default)
31 … 24	23 … 16	15 ... 8	7 ... 0

- If the object is configured in krad/s^2:

MSB **LSB**

Prefix	SI numerator	SI denominator	Profile-specific
03$_h$ (means 10^3)	10$_h$(means rad)	57$_h$(means s^2)	00$_h$(default)
31 … 24	23 … 16	15 ... 8	7 ... 0

5.2.10 Object 210F$_h$: Acceleration encoder factor

The object converts all values of acceleration of the application from acceleration internal units (IU) to acceleration units (AU). Its value takes into consideration two objects: Velocity Encoder Factor - 6094$_h$ and Acceleration Factor - 6097$_h$.

The calculation of the position factor is done using the following equation:

$$Acceleration\ Internal\ Units\ (IU) = \frac{Acceleration\ \ Units\ (AU) \times Velocity\ Encoder\ Factor}{Acceleration\ Factor} \times\ T\ \ where\ T = slow\ loop\ period$$

The Acceleration Units are computed automatically by EasyMotion Studio II for each mechanical setup (rot-rot / rot-lin / lin-lin transmission), position sensor configuration (type, on motor or on load) and slow loop period.

Object description:

Index	210F$_h$
Name	Acceleration encoder factor
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Acceleration internal units (IU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

Sub-index	2
Description	Acceleration units (AU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

5.2.11 Object 6097$_h$: Acceleration Factor

The object converts VU (velocity units) per second into AU (acceleration units). The calculation of the acceleration factor is done using the following equation:

$$Acceleration\ Factor = \frac{Acceleration\ Units\ (AU)}{\frac{Velocity\ Units\ (VU)}{s}}$$

For example, if the user defined velocity unit is rad/s and the user defined acceleration unit is krad/s^2, the acceleration factor will be 0.001. If the user defined velocity unit is rad/s and the user defined acceleration unit is rad/s^2, the acceleration factor will be 1.

Object description:

Index	6097$_h$
Name	Acceleration Factor
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Acceleration units (AU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

Sub-index	2
Description	Velocity units (VU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

5.2.12 Object 60AB$_h$: SI unit jerk

This object indicates the user-defined jerk units. The object structure is defined in Table 5.2 – *SI Objects Structure*. The profile specific field (bit 0 to bit 7) of this object is reserved (00$_h$).

Object description:

Index	60AB$_h$
Name	SI unit jerk
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	0x00000000

Example:

- If the object is configured in deg/s^3:

MSB **LSB**

Prefix	SI numerator	SI denominator	Profile-specific
00$_h$ (means 10^0)	41$_h$(means rad)	A0$_h$(means s^3)	00$_h$(default)
31 … 24	23 … 16	15 ... 8	7 ... 0

- If the object is configured in krad/s^3:

MSB **LSB**

Prefix	SI numerator	SI denominator	Profile-specific
03$_h$ (means 10^3)	10$_h$(means rad)	A0$_h$(means s^3)	00$_h$(default)
31 … 24	23 … 16	15 ... 8	7 ... 0

5.2.13 Object 2110$_h$: Jerk encoder factor

The object converts all values of jerk of the application from jerk internal units (IU) to jerk units (JU). Its value takes into consideration two objects: Acceleration Encoder Factor – 210F$_h$ and Jerk Factor – 60A2$_h$.

The calculation of the position factor is done using the following equation:

$$Jerk\ Internal\ Units\ (IU) = \frac{Jerk\ Units\ (JU) \times Acceleration\ Encoder\ Factor}{Jerk\ Factor} \times T \quad where\ T = slow\ loop\ period$$

The Jerk Units are computed automatically by EasyMotion Studio II for each mechanical setup (rot-rot / rot-lin / lin-lin transmission), position sensor configuration (type, on motor or on load) and slow loop period.

Object description:

Index	2110$_h$
Name	Jerk encoder factor
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Jerk internal units (IU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

Sub-index	2
Description	Jerk units (JU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

5.2.14 Object $60A2_h$: Jerk Factor

The object converts AU (acceleration units) per second into JU (jerk units). The calculation of the jerk factor is done using the following equation:

$$Acceleration\ Factor = \frac{Jerk\ Units\ (JU)}{\frac{Acceleration\ Units\ (AU)}{s}}$$

For example, if the user defined acceleration unit is rad/s^2 and the user defined jerk unit is krad/s^3, the jerk factor will be 0.001. If the user defined acceleration unit is rad/s^2 and the user defined jerk unit is rad/s^3, the jerk factor will be 1.

Object description:

Index	$60A2_h$
Name	Jerk Factor
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Jerk Units (JU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

Sub-index	2
Description	Acceleration Units (AU)
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00000001

6 Homing Mode

6.1 Overview

Homing is the method by which a drive seeks the home position. There are various methods to achieve this position using the four available sources for the homing signal: limit switches (negative and positive), home switch (IN0) and encoder index pulse.

Remark: on a Micro, iPOS drive or iMOT intelligent motor, the "home switch" is always the digital input IN0.

A homing move is started by setting bit 4 of the *Controlword* object 6040h. The results of a homing operation can be accessed in the *Statusword* (index 0x6041).

After the physical home position is found, the drive actual position (object 6064h or internal variable APOS) will be set with the value of

Object 607Ch: Home offset.

A homing mode is chosen by writing a value to homing method (object 6098h) which will clearly establish:

1. the used homing signal (positive limit switch, negative limit switch, home switch or index pulse)
2. the initial direction of motion
3. the position of the index pulse (if used).

The user can specify the home method, the home offset, two homing speeds and the acceleration.

The **home offset** (object 607Ch) is the difference between the zero position for the application and the machine home position. During homing, the home position is found. Once the homing is completed, the zero position is offset from the home position by adding the home offset to the home position. This is illustrated in the following diagram.

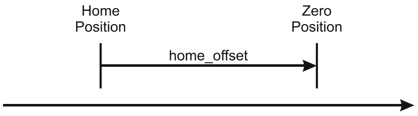


Figure 6.1.1. *Home Offset*

In other words, after the home position has been found, the drive will set the actual position (object 6064h) with the value found in object 607Ch.

There are two **homing speeds:** a fast speed (which is used for the initial motion to find the home switch), and a slow speed (which is used after the home switch transition, when the motion is reversed).

The **homing acceleration** establishes the acceleration to be used for all accelerations and decelerations with the standard homing modes.

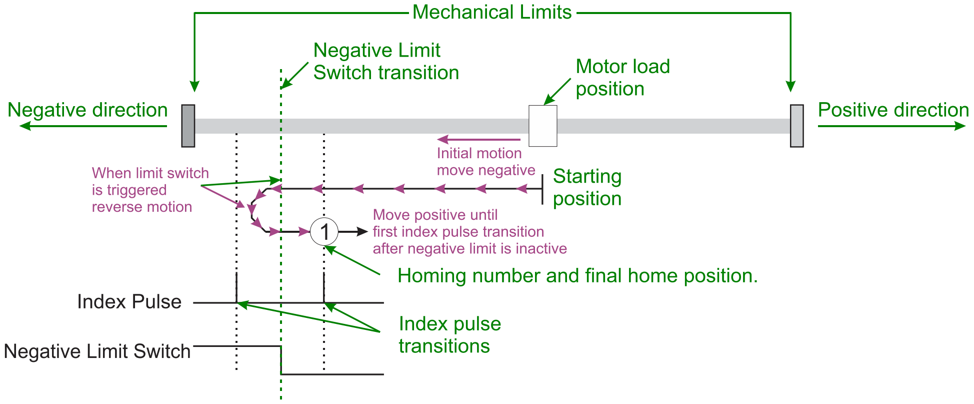
The homing method descriptions in this document are based on those in the Profile for Drives and Motion Control (CiA402 or IEC61800 Standard).

The figure below explains the homing method 1 diagram in detail. The other homing method diagrams are similar and the explanation below applied to all of them.

The colors **black** and **grey** represent the original homing diagram as explained in the CiA 402 standard.

The **green** color represents the explanation for the various elements in the diagram.

The **purple** color represents the motion explanation for the current homing method diagram.



Mechanical Limits
Negative Limit Switch transition
Motor load position
Negative direction
Positive direction
Initial motion move negative
When limit switch is triggered reverse motion
Starting position
1
Move positive until first index pulse transition after negative limit is inactive
Homing number and final home position.
Index Pulse
Index pulse transitions
Negative Limit Switch

Figure 6.1.2. *Homing method 1 diagram explained*

6.2 Homing methods

6.2.1 Method 1: Homing on the Negative Limit Switch and Index Pulse

If the negative limit switch is inactive (low) the initial direction of movement is leftward (negative sense). After negative limit switch is reached the motor will reverse the motion, moving in the positive sense with slow speed. The home position is at the first index pulse to the right of the position where the negative limit switch becomes inactive.

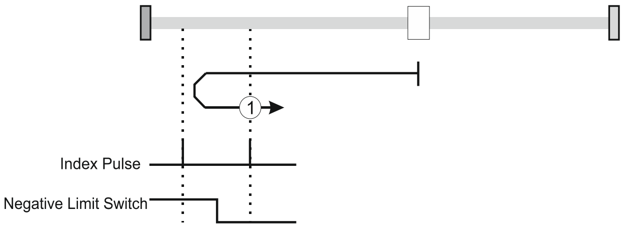


Figure 6.2.1. *Homing on the Negative Limit Switch and Index Pulse*

6.2.2 Method 2: Homing on the Positive Limit Switch and Index Pulse

If the positive limit switch is inactive (low) the initial direction of movement is rightward (negative sense). After positive limit switch is reached the motor will reverse the motion, moving in the negative sense with slow speed. The home position is at the first index pulse to the left of the position where the positive limit switch becomes inactive.

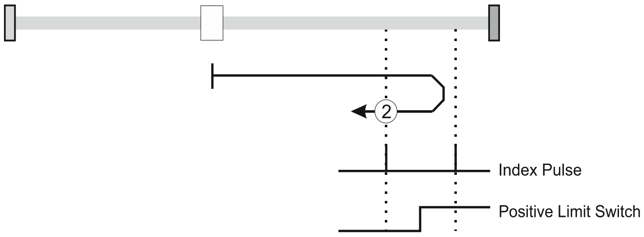


Figure 6.2.2. *Homing on the Positive Limit Switch and Index Pulse*

6.2.3 Methods 3 and 4: Homing on the Positive Home Switch and Index Pulse.

The home position is at the index pulse either after home switch high-low transition (method 3) or after home switch low-high transition (method 4).

The diagram shows two initial movements for each type of method. This is because the initial direction of movement is dependent on the state of the home switch (if low - move positive, if high - move negative).

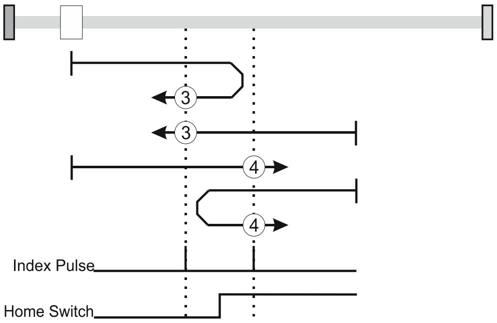


Figure 6.2.3. *Homing on the Positive Home Switch and Index Pulse*

For **method 3**, if home input is high the initial direction of movement will be negative, or positive if home input is low, and reverse (with slow speed) after home input low-high transition. The motor will stop at first index pulse after home switch high-low transition.

For **method 4**, if home input is low the initial direction of movement will be positive, or negative if home input is high, and reverse (with slow speed) after home input high-low transition. The motor will stop at first index pulse after home switch low-high transition.

In all cases after home switch transition, the speed of the movement is slow.

6.2.4 Methods 5 and 6: Homing on the Negative Home Switch and Index Pulse.

The home position is at the index pulse either after home switch high-low transition (method 5) or after home switch low-high transition (method 6).

The initial direction of movement is dependent on the state of the home switch (if high - move positive, if low - move negative).

In all cases after home switch transition, the speed of the movement is slow.

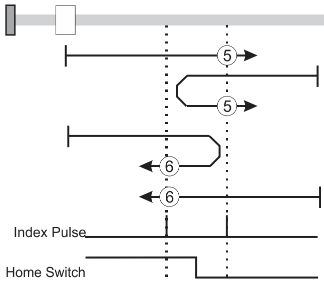


***Figure 6.2.4.** Homing on the Negative Home Switch and Index Pulse*

For **method 5**, if home input is high the initial direction of movement will be positive, or negative if home input is low, and reverse (with slow speed) after home input low-high transition. The motor will stop at first index pulse after home switch high-low transition.

For **method 6**, if home input is low the initial direction of movement will be negative, or positive if home input is high, and reverse (with slow speed) after home input high-low transition. The motor will stop at first index pulse after home switch low-high transition.

6.2.5 Methods 7 to14: Homing on the Home Switch using limit switches and Index Pulse.

These methods use a home switch that is active over only a portion of the travel distance; in effect the switch has a ‘momentary’ action as the axle’s position sweeps past the switch.

Using methods 7 to 10 the initial direction of movement is to the right (positive), and using methods 11 to 14 the initial direction of movement is to the left (negative), except the case when the home switch is active at the start of the motion (initial direction of motion is dependent on the edge being sought – the rising edge or the falling edge).

The home position is at the index pulse on either side of the rising or falling edges of the home switch, as shown in the following two diagrams.

If the initial direction of movement leads away from the home switch, the drive will reverse on encountering the relevant limit switch (negative limit switch for methods 7 to 10, or positive limit switch for methods 11 to 14).

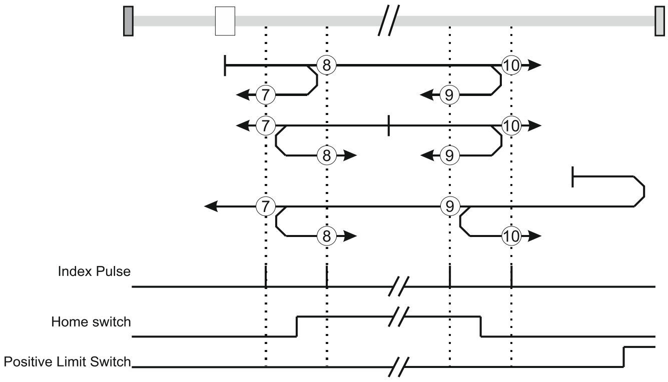


***Figure 6.2.5.** Homing on the Home Switch using limit switches and Index Pulse – Positive Initial Move*

Using **method 7** the initial move will be positive if home input is low and reverse after home input low-high transition, or move negative if home input is high. Reverse also if the positive limit switch is reached. Stop at first index pulse after home switch active region ends (high-low transition). In all cases after high-low home switch transition the motor speed will be slow.

Using **method 8** the initial move will be positive if home input is low, or negative if home input is high and reverse after home input high-low transition. Reverse also if the positive limit switch is reached. Stop at first index pulse after home switch active region starts (low-high transition). In all cases after low-high home switch transition the motor speed will be slow.

Using **method 9** the initial move will be positive and reverse (slow speed) after home input high-low transition. Reverse also if the positive limit switch is reached. Stop at first index pulse after home switch active region starts (low-high transition).

Using **method 10** the initial move will be positive. Reverse if the positive limit switch is reached, then reverse once again after home input low-high transition. Stop at first index pulse after home switch active region ends (high-low transition). In all cases after high-low home switch transition the motor speed will be slow.

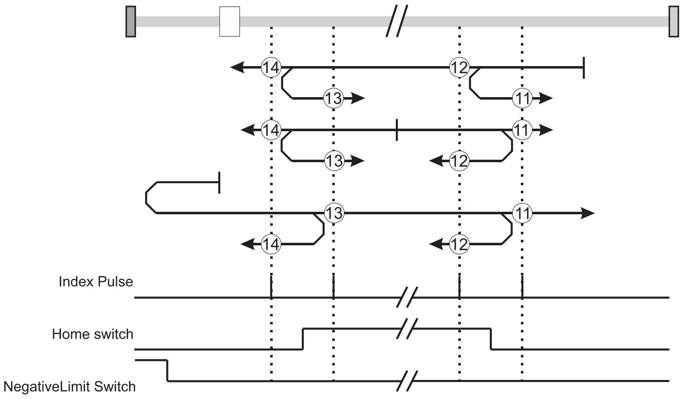


Figure 6.2.6. *Homing on the Home Switch using limit switches and Index Pulse – Negative Initial Move*

Using **method 11** the initial move will be negative if home input is low and reverse after home input low-high transition. Reverse also if the negative limit switch is reached. If home input is high move positive. Stop at first index pulse after home switch active region ends (high-low transition). In all cases after high-low home switch transition the motor speed will be slow.

Using **method 12** the initial move will be negative if home input is low. If home input is high move positive and reverse after home input high-low transition. Reverse also if the negative limit switch is reached. Stop at first index pulse after home switch active region starts (low-high transition). In all cases after low-high home switch transition the motor speed will be slow.

Using **method 13** the initial move will be negative and reverse after home input high-low transition. Reverse also if the negative limit switch is reached. Stop at first index pulse after home switch active region starts (low-high transition). In all cases after high-low home switch transition the motor speed will be slow.

Using **method 14** the initial move will be negative. Reverse if the negative limit switch is reached, then reverse once again after home input low-high transition. Stop at first index pulse after home switch active region ends (high-low transition). In all cases after high-low home switch transition the motor speed will be slow.

Methods 15 and 16: Reserved

6.2.6 Methods 17 to 30: Homing without an Index Pulse

These methods are similar to methods 1 to 14 except that the home position is not dependent on the index pulse but only on the relevant home or limit switch transitions.

6.2.7 Method 17: Homing on the Negative Limit Switch

Using **method 17** if the negative limit switch is inactive (low) the initial direction of movement is leftward (negative sense). After negative limit switch reached the motor will reverse the motion, moving in the positive sense with slow speed. The home position is at the right of the position where the negative limit switch becomes inactive.

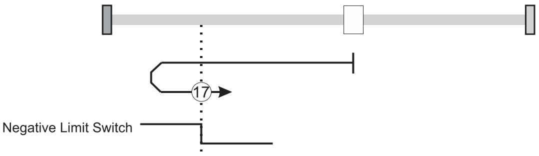


Figure 6.2.7. *Homing on the Negative Limit Switch*

6.2.8 Method 18: Homing on the Positive Limit Switch

Using **method 18** if the positive limit switch is inactive (low) the initial direction of movement is rightward (negative sense). After positive limit switch reached the motor will reverse the motion, moving in the negative sense with slow speed. The home position is at the left of the position where the positive limit switch becomes inactive.

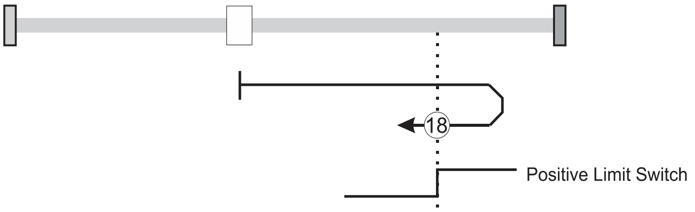


Figure 6.2.8. *Homing on the Positive Limit Switch*

6.2.9 Methods 19 and 20: Homing on the Positive Home Switch

The home position is at the home switch high-low transition (method 19) or low-high transition (method 20).

The diagram shows two initial movements for each type of method. This is because the initial direction of movement is dependent on the state of the home switch (if low - move positive, if high - move negative).

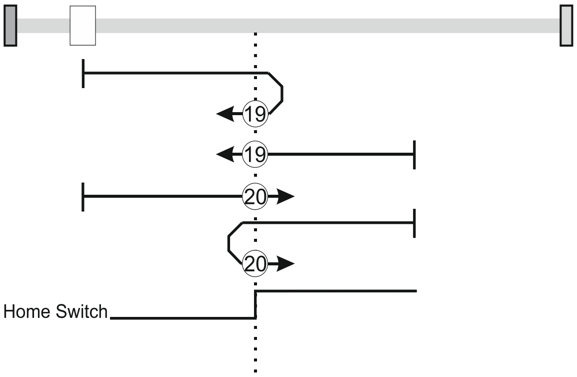


Figure 6.2.9. *Homing on the Positive Home Switch*

Using **method 19**, if home input is high, the initial direction of movement will be negative, or positive if home input is low, and reverse (with slow speed) after home input low-high transition. The motor will stop right after home switch high-low transition.

Using **method 20**, if home input is low, the initial direction of movement will be positive, or negative if home input is high, and reverse (with slow speed) after home input high-low transition. The motor will stop after right home switch low-high transition.

6.2.10 Methods 21 and 22: Homing on the Negative Home Switch

The home position is at the home switch high-low transition (method 21) or after home switch low-high transition (method 22).

The initial direction of movement is dependent on the state of the home switch (if high - move positive, if low - move negative).

In all cases after home switch transition, the speed of the movement is slow.

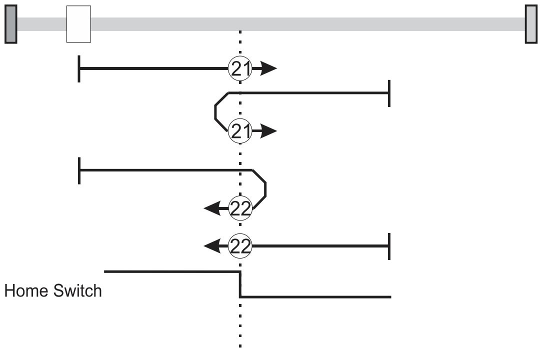


Figure 6.2.10. *Homing on the Negative Home Switch*

Using **method 21**, if home input is high, the initial direction of movement will be positive, or negative if home input is low, and reverse (with slow speed) after home input low-high transition. The motor will stop right after home switch high-low transition.

Using **method 22**, if home input is low, the initial direction of movement will be negative, or positive if home input is high, and reverse (with slow speed) after home input high-low transition. The motor will stop right after home switch low-high transition.

6.2.11 Methods 23 to30: Homing on the Home Switch using limit switches

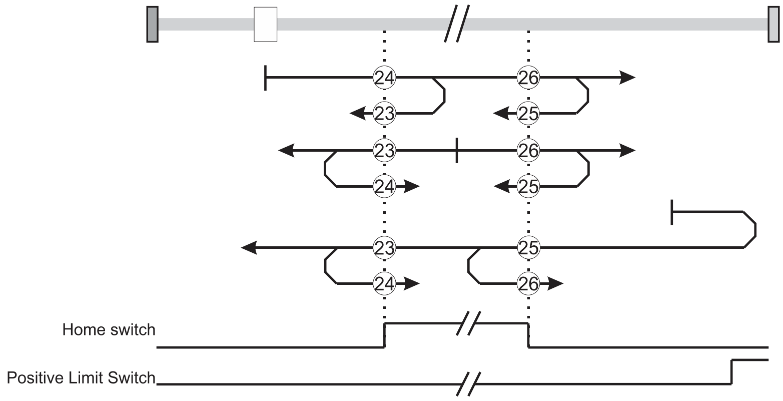


Figure 6.2.11. *Homing on the Home Switch using limit switches – Positive Initial Move*

Using **method 23** the initial move will be positive if home input is low and reverse after home input low-high transition, or move negative if home input is high. Reverse also if the positive limit switch is reached. Stop right after home switch active region ends (high-low transition).

Using **method 24** the initial move will be positive if home input is low, or negative if home input is high and reverse after home input high-low transition. Reverse also if the positive limit switch is reached. Stop right after home switch active region starts (low-high transition).

Using **method 25** the initial move will be positive and reverse after home input high-low transition. Reverse also if the positive limit switch is reached. Stop right after home switch active region starts (low-high transition).

Using **method 26** the initial move will be positive. Reverse if the positive limit switch is reached, then reverse once again after home input low-high transition. Stop right after home switch active region ends (high-low transition).

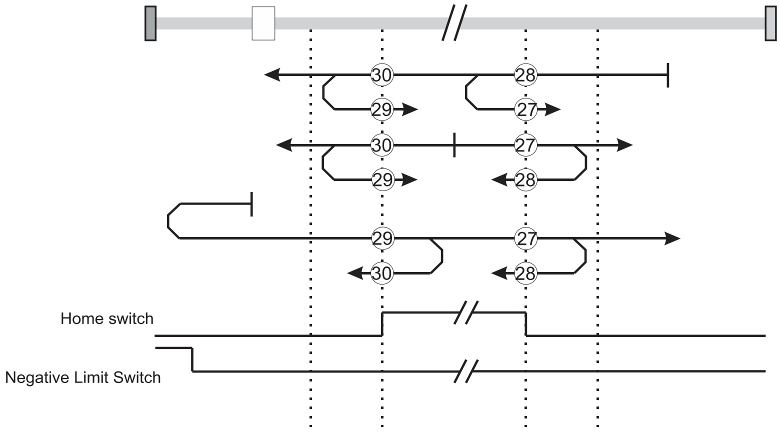


Figure 6.2.12. *Homing on the Home Switch using limit switches – Negative Initial Move*

Using **method 27** the initial move will be negative if home input is low and reverse after home input low-high transition. Reverse also if the negative limit switch is reached. If home input is high move positive. Stop right after home switch active region ends (high-low transition).

Using **method 28** the initial move will be negative if home input is low. If home input is high move positive and reverse after home input high-low transition. Reverse also if the negative limit switch is reached. Stop right after home switch active region starts (low-high transition).

Using **method 29** the initial move will be negative and reverse after home input high-low transition. Reverse also if the negative limit switch is reached. Stop right after home switch active region starts (low-high transition).

Using **method 30** the initial move will be negative. Reverse if the negative limit switch is reached, then reverse once again after home input low-high transition. Stop right after home switch active region ends (high-low transition).

Methods 31 and 32: Reserved

6.2.12 Methods 33 and 34: Homing on the Index Pulse

Using **methods 33** or **34** the direction of homing is negative or positive respectively. During these procedures, the motor will move only at slow speed. The home position is at the index pulse found in the selected direction.

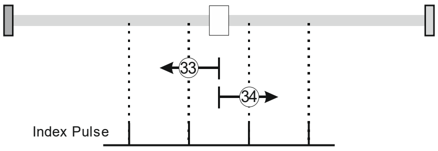


Figure 6.2.13. *Homing on the Index Pulse*

6.2.13 Method 35: Homing on the Current Position

In **method 35** the current position set with the value of home position (object 607Ch).

Remark: see also *Object 2081h: Set/Change the actual motor position* which can be used to obtain the same outcome as in Method 35.

6.2.14 Method -1: Homing on the Negative Mechanical Limit and Index Pulse

6.2.14.1 Method -1 based on motor current increase

This method applies to all closed loop motor configurations. It does not apply to Stepper Open Loop configurations. Move negative until the "Current threshold" is reached for a specified amount of time, then reverse and stop at the first index pulse. When the motor current is greater than the *Homing Current Threshold* (index 0x207B) for a specified amount of time in the *Homing Current Threshold Time* object (index207Ch), the motor will reverse direction. The home position is at the first index pulse to the right of the negative mechanical limit. At the end of the procedure, the reported motor position will be the one set in *Home offset* (index 0x607C).

Warning!	The value of *Homing Current Threshold* must be lower than the drive current limit. Otherwise, the homing will not complete successfully (no homing error will be issued). The current limit is set during setup. See Paragraph 1.2. Setting the current limit. *Current Threshold < current limit*

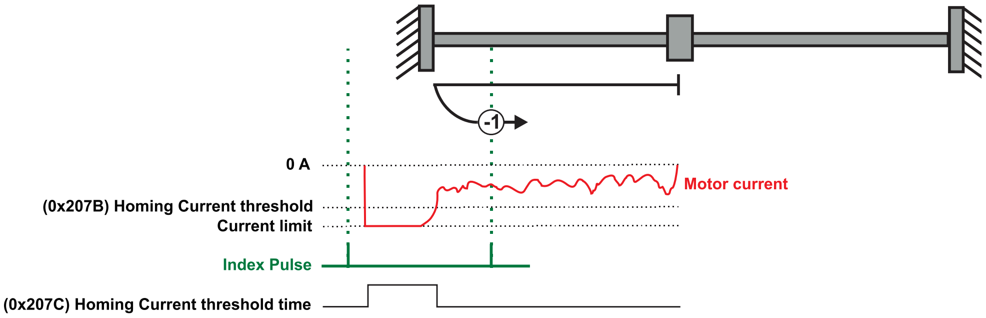

-1
0 A
(0x207B) Homing Current threshold
Current limit
Motor current
Index Pulse
(0x207C) Homing Current threshold time

Figure 6.2.14. *Homing on the Negative Mechanical Limit and Index Pulse detecting the motor current increase*

6.2.14.2 Method -1 based on step loss detection

This method applies only to Stepper Open Loop with Encoder on motor (step loss detection) or Encoder on Load. It does not apply to Closed loop configurations or Stepper Open Loop without an incremental encoder present.
If a Stepper Open Loop with Encoder on motor (step loss detection) or Encoder on Load configuration is selected, this homing method will detect a Position control error when reaching the mechanical limit. The homing Position Control Error parameters are set in the objects 6065h *Following error window* and 207Ch *Homing current threshold time.*
Move negative until a control error is detected, then reverse and stop at the first index pulse. The home position is at the first index pulse to the right of the negative mechanical limit. At the end of the procedure, the reported motor position will be the one set in *Home offset* (index 0x607C).

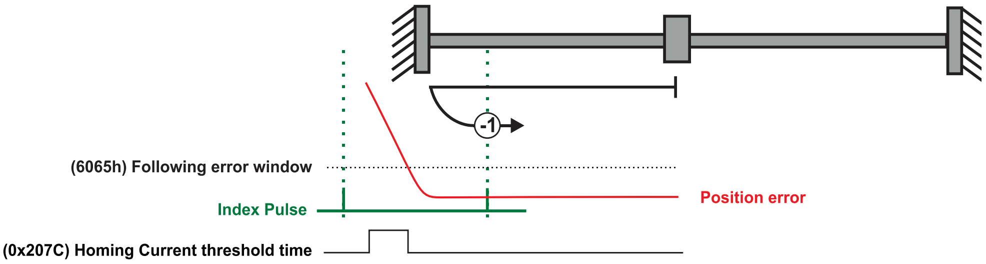

-1
(6065h) Following error window
Position error
Index Pulse
(0x207C) Homing Current threshold time

Figure 6.2.15. *Homing on the Negative Mechanical Limit and Index Pulse detecting a control error*

6.2.15 Method -2: Homing on the Positive Mechanical Limit and Index Pulse

6.2.15.1 Method -2 based on motor current increase

This method applies to all closed loop motor configurations. It does not apply to Stepper Open Loop configurations.

Move positive until the “Current threshold” is reached for a specified amount of time, then reverse and stop at the first index pulse. When the motor current is greater than the *Homing Current Threshold* (index 0x207B) for a specified amount of time in the *Homing Current Threshold Time* object (index 207C$_h$), the motor will reverse direction. The home position is at the first index pulse to the left of the positive mechanical limit. At the end of the procedure, the reported motor position will be the one set in *Home offset* (index 0x607C).

Warning! The value of *Homing Current Threshold* must be lower than the drive current limit. Otherwise, the homing will not complete successfully (no homing error will be issued). The current limit is set during setup. See Paragraph 1.2. Setting the current limit. *Current Threshold < current limit*

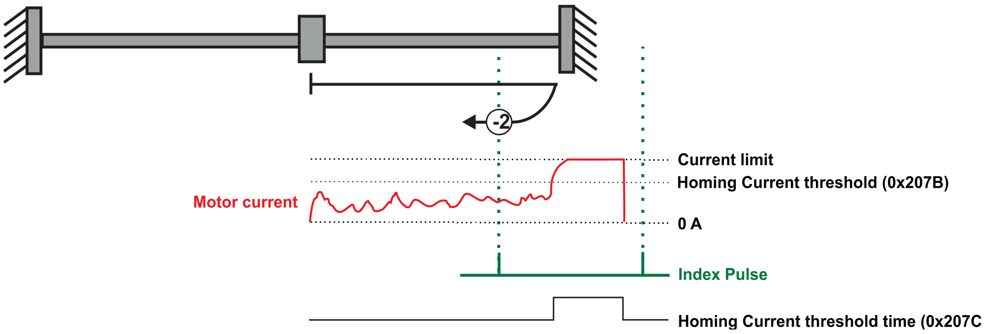

-2
Current limit
Homing Current threshold (0x207B)
Motor current
0 A
Index Pulse
Homing Current threshold time (0x207C

Figure 6.2.16. *Homing on the Positive Mechanical Limit and Index Pulse detecting the motor current increase*

6.2.15.2 Method -2 based on step loss detection

This method applies only to Stepper Open Loop with Encoder on motor (step loss detection) or Encoder on Load. It does not apply to Closed loop configurations or Stepper Open Loop without an incremental encoder present.

If a Stepper Open Loop with Encoder on motor (step loss detection) or Encoder on Load configuration is selected, this homing method will detect a Position control error when reaching the mechanical limit. The homing Position Control Error parameters are set in the objects 6065$_h$ *Following error window* and 207C$_h$ *Homing current threshold time.*

Move positive until a control error is detected, then reverse and stop at the first index pulse. The home position is at the first index pulse to the left of the positive mechanical limit. At the end of the procedure, the reported motor position will be the one set in *Home offset* (index 0x607C).

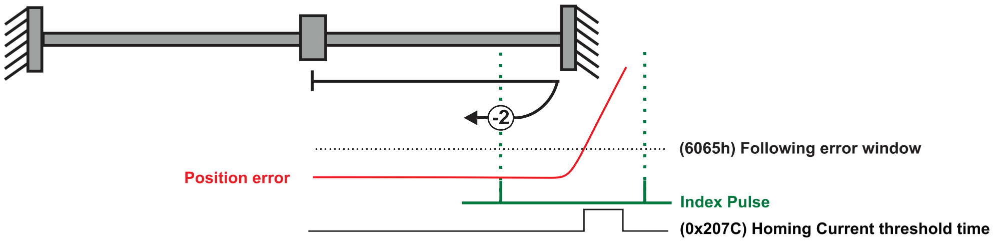

-2
(6065h) Following error window
Position error
Index Pulse
(0x207C) Homing Current threshold time

Figure 6.2.17. *Homing on the Positive Mechanical Limit and Index Pulse detecting a control error*

6.2.16 Method -3: Homing on the Negative Mechanical Limit without an Index Pulse.

6.2.16.1 Method -3 based on motor current increase

This method applies to all closed loop motor configurations. It does not apply to Stepper Open Loop configurations.

Move negative until the “Current threshold” is reached for a specified amount of time, then reverse and stop at the position set in “Home position”. When the motor current is greater than the *Homing Current Threshold* (index 0x207B) for specified amount of time set in the *Homing Current Threshold Time* object (index 207C$_h$), the motor will reverse direction and stop after it has travelled the value set in *Home offset* (index 0x607C). At the end of the procedure, the reported motor position will be the one set in *Home offset* (index 0x607C).

Warning! The value of *Homing Current Threshold* must be lower than the drive current limit. Otherwise, the homing will not complete successfully (no homing error will be issued). The current limit is set during setup. See Paragraph 1.2. Setting the current limit. *Current Threshold < current limit*

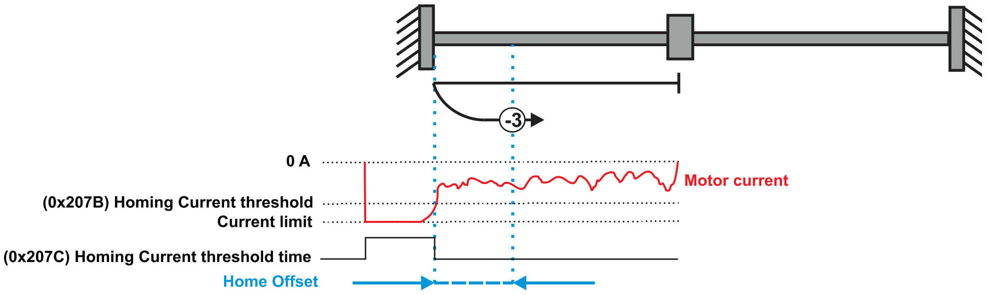

-3
0 A
Motor current
(0x207B) Homing Current threshold
Current limit
(0x207C) Homing Current threshold time
Home Offset

Figure 6.2.18. *Homing on the Positive Mechanical Limit without an Index Pulse detecting the motor current increase*

6.2.16.2 Method -3 based on step loss detection

This method applies only to Stepper Open Loop with Encoder on motor (step loss detection) or Encoder on Load. It does not apply to Closed loop configurations or Stepper Open Loop without an incremental encoder present.

If a Stepper Open Loop with Encoder on motor (step loss detection) or Encoder on Load configuration is selected, this homing method will detect a Position control error when reaching the mechanical limit. The homing Position Control Error parameters are set in the objects 6065_h *Following error window* and $207C_h$ *Homing current threshold time.*

Move negative until a control error is detected, then reverse and stop at the position set in “Home position”. The motor will reverse direction and stop after it has travelled the value set in *Home offset* (index 0x607C). At the end of the procedure, the reported motor position will be the one set in *Home offset* (index 0x607C).

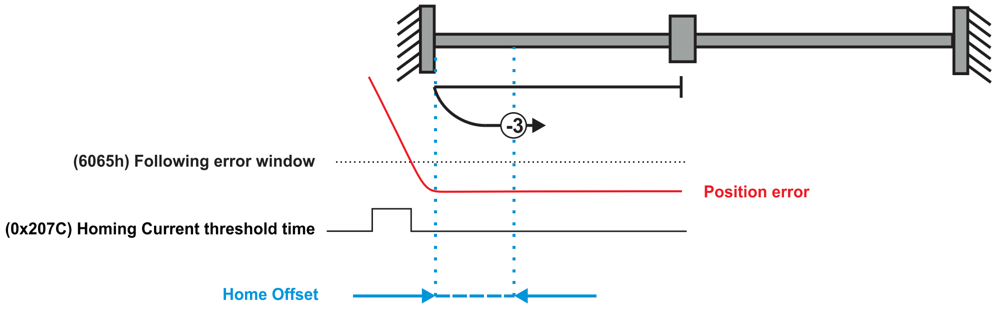

-3
(6065h) Following error window
Position error
(0x207C) Homing Current threshold time
Home Offset

Figure 6.2.19. *Homing on the Positive Mechanical Limit without an Index Pulse detecting a control error*

6.2.17 Method -4: Homing on the Positive Mechanical Limit without an Index Pulse.

6.2.17.1 Method -4 based on motor current increase

This method applies to all closed loop motor configurations. It does not apply to Stepper Open Loop configurations.

Move positive until the “Current threshold” is reached for a specified amount of time, then reverse and stop at the position set in “Home position”. When the motor current is greater than the *Homing Current Threshold* (index 0x207B) for specified amount of time set in the *Homing Current Threshold Time* object (index $207C_h$), the motor will reverse direction and stop after it has travelled the absolute value set in *Home offset* (index 0x607C). At the end of the procedure, the reported motor position will be the one set in *Home offset* (index 0x607C).

⚠ **Warning!** The value of *Homing Current Threshold* must be lower than the drive current limit. Otherwise, the homing will not complete successfully (no homing error will be issued). The current limit is set during setup. See Paragraph 1.2. Setting the current limit. *Current Threshold < current limit*

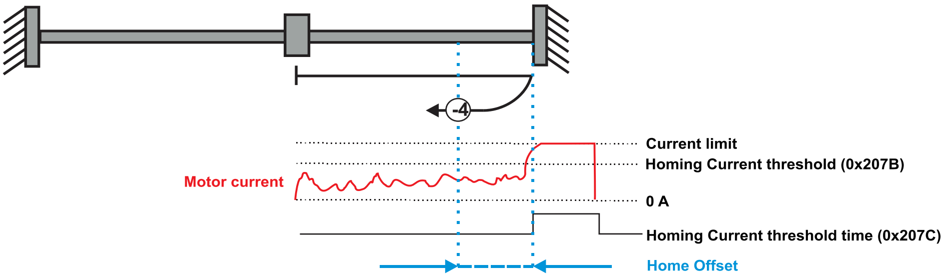

-4
Current limit
Homing Current threshold (0x207B)
Motor current
0 A
Homing Current threshold time (0x207C)
Home Offset

Figure 6.2.20. *Homing on the Positive Mechanical Limit without an Index Pulse detecting the motor current increase*

6.2.17.2 Method -4 based on step loss detection

This method applies only to Stepper Open Loop with Encoder on motor (step loss detection) or Encoder on Load. It does not apply to Closed loop configurations or Stepper Open Loop without an incremental encoder present.

If a Stepper Open Loop with Encoder on motor (step loss detection) or Encoder on Load configuration is selected, this homing method will detect a Position control error when reaching the mechanical limit. The homing Position Control Error parameters are set in the objects 6065_h *Following error window* and $207C_h$ *Homing current threshold time.*

Move positive until a control error is detected, then reverse and stop at the position set in "Home position". The motor will reverse direction and stop after it has travelled the value set in *Home offset* (index 0x607C). At the end of the procedure, the reported motor position will be the one set in *Home offset* (index 0x607C).

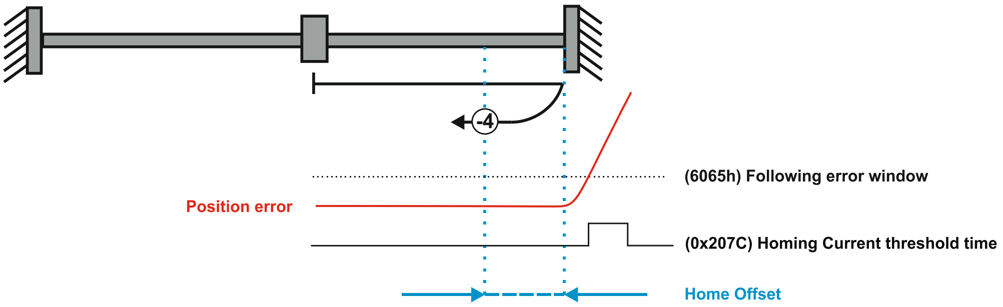

-4
(6065h) Following error window
Position error
(0x207C) Homing Current threshold time
Home Offset

Figure 6.2.21. *Homing on the Positive Mechanical Limit without an Index Pulse detecting the motor current increase*

6.3 Homing Mode Objects

This chapter describes the method by which the drive seeks the home position. There are 35 built-in homing methods, as described in **paragraph 6.1**. Using the EasyMotion Studio II software, one can alter each of these homing methods to create a custom homing method.

You can select which homing method to be used by writing the appropriate number in the object 6098_h *homing method*.

The user can specify the speeds and acceleration to be used during the homing. There is a further object *homing offset* that allows the user to displace zero in the user's coordinate system from the home position.

In the homing mode, the bits in *Controlword* and *Statusword* have the following meaning:

6.3.1 Controlword in homing mode

MSB **LSB**

See 6040_h	Halt	See 6040_h	Reserved	Homing operation start	See 6040_h
15 9	8	7	6 5	4	3 0

Table 6.3.1 *– Controlword bits description for Homing Mode*

Bit	Name	Value	Description
4	Homing operation start	0 -> 1	Only a 0 to 1 transition will start homing mode
8	Halt	0	Execute the instruction of bit 4
		1	Stop drive with *homing acceleration*

6.3.2 Statusword in homing mode

MSB LSB

See 6041_h	Homing error	Homing attained	See 6041_h	Target reached	See 6041_h
15 14	13	12	11	10	9 0

Table 6.3.2 *– Statusword bits description for Homing Mode*

Bit	Name	Value	Description
13	Homing error	0	No homing error
		1	Homing error occurred; homing mode not carried out successfully.
12	Homing attained	0	Homing mode not yet completed
		1	Homing mode carried out successfully
10	Target reached	0	Halt = 0: Home position not reached Halt = 1: Drive decelerates
		1	Halt = 0: Home position reached Halt = 1: Velocity of drive is 0

***Table 6.3.3** – Definition of Statusword bit 10,bit 12 and bit 13 in homing mode*

Bit 13	Bit 12	Bit 10	Definition
0	0	0	Homing procedure is in progress
0	0	1	Homing procedure is interrupted or not started
0	1	0	Homing is attained, but target is not reached
0	1	1	Homing procedure is completed successfully
1	0	0	Homing error occurred, velocity is not 0
1	0	1	Homing error occurred, velocity is 0
1	1	X	reserved

6.3.3 Object 607Ch: Home offset

The *home offset* will be set as the new drive position (reported in object 6064h) after a homing procedure is finished. An exception applies only to the homing motions -3 and -4. See their description for more details.

If Object 210Bh: Auxiliary Settings Register2 bit 12 is set to 1, then after the homing ends, the actual position (6064h) will not be reset to the value of 607Ch. This option is useful when using an absolute encoder, and only the absolute position of the home sensor is needed. The homing will end the positioning right on the home sensor.

Object description:

Index	607Ch
Name	Home offset
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RW
PDO mapping	Possible
Units	PU
Value range	INTEGER32
Default value	0

The default value for this object can be changed by editing the parameter “HOME_OFFSET_607C” found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

6.3.4 Object 6098h: Homing method

The *homing method* determines the method that will be used during homing.

Object description:

Index	6098h
Name	Homing method
Object code	VAR
Data type	INTEGER8

Entry description:

Access	RW
PDO mapping	Possible
Value range	INTEGER8
Default value	0

Data description:

Value	Description
-128 … -5	Reserved
-4..-1	Methods -4 to -1
0	No homing operation will be executed
1 … 14	Methods 1 to 14
15,16	reserved
17..30	Methods 17 to 30
31,32	reserved
33..35	Methods 33 to 35
36 … 127	reserved

There are 35 built-in homing methods, conforming to DSP402 device profile. Using the EasyMotion Studio II software, one can customize each of these homing methods.

The default value for this object can be changed by editing the parameter “HOME_NR_6098” found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

6.3.5 Object 6099$_h$: Homing speeds

This object defines the speeds used during homing. It is given in velocity units. There are 2 homing speeds; in a typical cycle the faster speed is used to find the home switch and the slower speed is used to find the index pulse.

Object description:

Index	6099$_h$
Name	Homing speeds
Object code	ARRAY
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	2
Default value	2

Sub-index	1
Description	Speed during search for switch
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00010000 (1.0 IU)

Sub-index	2
Description	Speed during search for zero
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0x00010000 (1.0 IU)

The default value for sub-index 1 can be changed by editing the parameter “HOME_HSPD_6099_01” found in parameters.xml of the project file.
The default value for sub-index 2 can be changed by editing the parameter “HOME_LSPD_6099_02” found in parameters.xml of the project file.
Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

6.3.6 Object 609A$_h$: Homing acceleration

The *homing acceleration* establishes the acceleration to be used for all the accelerations and decelerations with the standard homing modes and is given in acceleration units.

Object description:

Index	609A$_h$
Name	Homing acceleration
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Possible
Units	AU
Value range	UNSIGNED32
Default value	0x0000199A (0.1 IU)

The default value for this object can be changed by editing the parameter “HOME_ACC_609A” found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

6.3.7 Object 207B$_h$: Homing current threshold

The Homing Current Threshold Level object together with object Homing current threshold time (207C$_h$) defines the protection limits when reaching a mechanical stop during homing methods -1,-2,-3 and -4. The object defines the value of current in the drive, over which the homing procedure determines that the mechanical limit has been reached when it lasts more than the time interval specified in object 207C$_h$. The current is set in internal units.

Warning! The value of *Homing Current Threshold* must be lower than the drive current limit. Otherwise, the homing will not complete successfully (no homing error will be issued). The current limit is set during setup. See Paragraph *1.2. Setting the current limit*. *Current Threshold < current limit*

Object description:

Index	207Bh
Name	Homing current threshold
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Possible
Units	IU
Value range	-32768 … 32767
Default value	0

The default value for this object can be changed by editing the parameter "HOME_CRT_207B" found in parameters.xml of the project file. Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

6.3.8 Object 207Ch: Homing current threshold time

The Homing current threshold time object together with object Homing current threshold (207Bh) defines the protection limits when reaching a mechanical stop during homing methods -1,-2,-3 and -4. The object sets the time interval after the homing current threshold is exceeded. After this time is completed without the current dropping below the threshold, the next step in the homing shall be executed. It is set in time internal units.

In case a Stepper Open Loop with Step loss detection is used, this object will set the control error time detection when methods -1 to -4 are used.

Object description:

Index	207Ch
Name	Homing current threshold time
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Possible
Units	TU
Value range	0 … 65535
Default value	0

The default value for this object can be changed by editing the parameter "HOME_TIME_207C" found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

6.4 Homing example

Execute homing method number 18.

1. **Start remote node**.

   Enter **Pre-Operational** state.

   Enter **Safe-Operational** state.

   Enter **Operational** state.

2. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06h.

3. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07h.

4. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

   Set in **Control Word** mapped in RPDO1 the value 0Fh.

5. **Homing speed during search for zero.** Set the speed during search for zero to 150 rpm. By using a 500 lines incremental encoder and 1ms sample rate for position/speed control the corresponding value of object 6099h sub-index 2 expressed in encoder counts per sample is 50000h.

   Send the following message: SDO access to object 6099h sub-index 2, 32-bit value 00050000h.

6. **Homing speed during search for switch.** Set the speed during search for switch to 600 rpm. By using a 500 lines incremental encoder and 1ms sample rate for position/speed control the corresponding value of object 6099h sub-index 1 expressed in encoder counts per sample is 140000h.

   Send the following message: SDO access to object 6099h sub-index 1, 32-bit value 00140000h.

7. **Homing acceleration.** The homing acceleration establishes the acceleration to be used with the standard homing moves. Set this value at 5 rot/s^2. By using a 500 lines incremental encoder and 1ms sample rate for position/speed control the corresponding value of object 609A$_h$ expressed in encoder counts per square sample is 28F$_h$.

   Send the following message: SDO access to object 609A$_h$, 32-bit value 0000028F$_h$.

8. **Home offset.** Set the home offset to 1 rotation. By using a 500 lines incremental encoder the corresponding value of object 607C$_h$ expressed in encoder counts is 7D0$_h$.

   Send the following message: SDO access to object 607C$_h$, 32-bit value 000007D0$_h$.

9. **Homing method.** Select homing method number 18.

   Send the following message: SDO access to object 6098$_h$, 8-bit value 12$_h$.

10. **Modes of operation.** Select homing mode.

    Set in **Modes of Operation** mapped in RPDO1 the value 06$_h$.

11. **Start the homing.**

    Set in **Control Word** mapped in RPDO1 the value 001F$_h$.

12. **Press for 5s the LSP button.**

13. **Wait for homing to end.**

    When Status Word (object 6040$_h$) bit13=0, bit12=1 and bit10=1, means homing procedure is completed successfully.

14. **Check the value of motor actual position.**

Read by SDO protocol the value of object 6064$_h$.

The node will return the value of motor actual position that should be the same with the value of home offset (plus or minus few encoder counts depending on your position tuning).

7 Position Profile Mode

7.1 Overview

In Position Profile Mode, the drive controls the position.

The Position Profile Mode supports 2 motion modes:

- **Trapezoidal profile**. The built-in reference generator computes the position profile with a trapezoidal shape of the speed, due to a limited acceleration. The EtherCAT® master specifies the absolute or relative **Target Position** (index 607A$_h$), the **Profile Velocity** (index 6081$_h$) and the **Profile Acceleration** (6083$_h$)

  In relative mode, the position to reach can be computed in 2 ways: standard (default) or additive. In standard relative mode, the position to reach is computed by adding the position increment to the instantaneous position in the moment when the command is executed. In the additive relative mode, the position to reach is computed by adding the position increment to the previous position to reach, independently of the moment when the command was issued. Bit 11 of *Controlword* activates the additive relative mode.

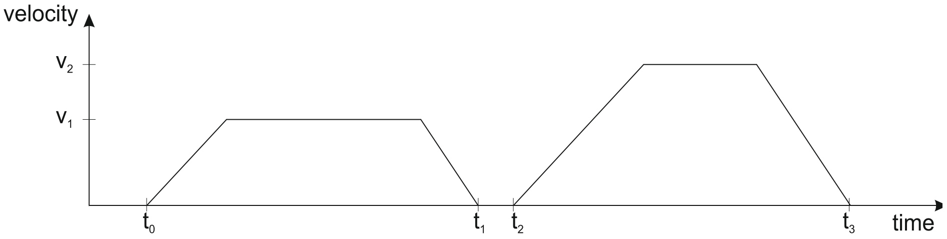
- **S-curve profile** the built-in reference generator computes a position profile with an S-curve shape of the speed. This shape is due to the jerk limitation, leading to a trapezoidal or triangular profile for the acceleration and an S-curve profile for the speed. The EtherCAT® master specifies the absolute or relative **Target Position** (index 607A$_h$), the **Profile Velocity** (index 6081$_h$), the **Profile Acceleration** (6083$_h$) and the jerk rate. The jerk rate is set indirectly via the **Jerk time** (index 2023$_h$), which represents the time needed to reach the maximum acceleration starting from zero.

There are two different ways to apply *target positions* to a drive, controlled by the *change set immediately* bit in Controlword:

7.1.1 Discrete motion profile (*change set immediately* = 0)

After reaching the *target position* the drive unit signals this status to a EtherCAT® master and then receives a new set-point. After reaching a *target position* the velocity normally is reduced to zero before starting a move to the next set-point.

After the *target position* is sent to the drive, the EtherCAT® master has to set the *new set-point* bit in *Controlword*. The drive responds with bit *set-point acknowledge* set in *Statusword*. After that, the master has to reset bit *new set-point* to 0. Following this action, the drive will signalize that it can accept a new set-point by resetting *set-point acknowledge* bit in *Statusword* after the reference generator has reached the designated demand position.



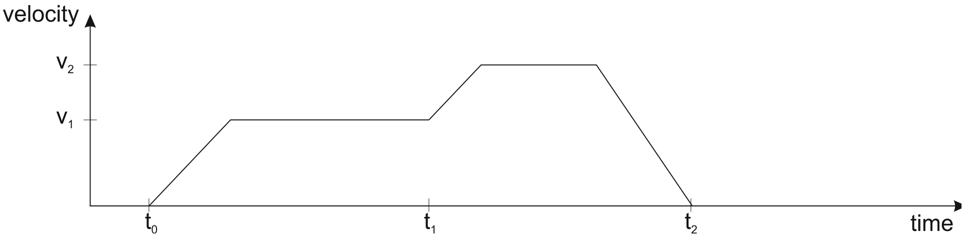
7.1.2 Continuous motion profile (*change set immediately = 1*)

The drive unit immediately processes the next *target position*, even if the actual movement is not completed. The drive readapts the actual move to the new target position.

In this case, the handshake presented for *change set immediately* = 0 is not necessary. By setting the *new set-point* bit, the master will trigger the immediate update of the target position. In this case, if the *target position* is set as relative, also bit 11 is taken into consideration (with or without additive movement).

Remark:

In case object 6086$_h$ (Motion Profile Type) is set to 3 (jerk-limited ramp = S-curve profile), then *change set immediately* bit must be 0, else a command error is issued.



7.1.3 Controlword in profile position mode

MSB **LSB**

See 6040$_h$	Operation Mode	See 6040$_h$	Halt	See 6040$_h$	Abs/rel	Change set immediately	New set-point	See 6040$_h$
15 12	11	10 9	8	7	6	5	4	3 0

Table 7.1.1 *– Controlword bits description for Position Profile Mode*

Name	Value	Description
Operation Mode	0	Trapezoidal profile - In case the movement is relative, do not add the new target position to the old demand position S-curve profile – Stop the motion with S-curve profile (jerk limited ramp)
	1	Trapezoidal profile - In case the movement is relative, add the new target position to the old demand position to obtain the new target position S-curve profile – Stop the motion with trapezoidal profile (linear ramp)
New set-point	0 -> 1	Only a 0 to 1 transition will start a new motion
Change set immediately	0	Finish the actual positioning and then start the next positioning
	1	Interrupt the actual positioning and start the next positioning. Valid only for linear ramp profile.
Abs / rel	0	*Target position* is an absolute value
	1	*Target position* is a relative value
Halt	0	Execute positioning
	1	Stop drive with *profile acceleration*

7.1.4 Statusword in profile position mode

MSB **LSB**

See 6041$_h$	Following error	Set-point acknowledge	See 6041$_h$	Target reached	See 6041$_h$
15 14	13	12	11	10	9 0

Table 7.1.2 *– Statusword bits description for Position Profile Mode*

Name	Value	Description

Target reached	0	Halt = 0: *Target position* not reached
		Halt = 1: Drive decelerates

	1	Halt = 0: *Target position* reached Halt = 1: Velocity of drive is 0
Set-point acknowledge	0	Trajectory generator will accept a new set-point
	1	Trajectory generator will not accept a new set-point.
Following error	0	No following error
	1	Following error

7.2 Position Profile Mode Objects

7.2.1 Object 607A$_h$: Target position

The *target position* is the position that the drive should move to in position profile mode using the current settings of motion control parameters such as velocity, acceleration, and *motion profile type* etc. It is given in position units.

The position units are user defined. The value can be converted into position increments using the *position factor* (see Chapter Factor group).

If Controlword bit 6 = 0 (e.g. absolute positioning), represents the position to reach.

If Controlword bit 6 = 1 (e.g. relative positioning), represents the position displacement to do. When Controlword bit 14 = 0, the new position to reach is computed as: motor actual position (6064$_h$) + displacement. When Controlword bit 14 = 1, the new position to reach is computed as: actual demand position (6062$_h$) + displacement.

Object description:

Index	607A$_h$
Name	Target position
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RW
PDO mapping	Yes
Value range	$-2^{31} \dots 2^{31}-1$
Default value	No

7.2.2 Object 6081h: Profile velocity

In a position profile, it represents the maximum speed to reach at the end of the acceleration ramp. The *profile velocity* is given in speed units.

The speed units are user defined. The value can be converted into internal units using the *velocity encoder factor* (see Chapter Factor group).

By default, the velocity value is given in internal units. They are encoder increments/Sample loop. The default Sample loop is 1ms. The velocity variable is 32 bits long and it receives 16.16 data. The MSB takes the integer part and the LSB takes the factionary part.

Example: for a target speed of 50.00 IU, 0x00320000 must be set in 6081h if no factor group is chosen.

Object description:

Index	6081h
Name	Profile velocity
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	-

7.2.3 Object 6083h: Profile acceleration

In position or speed profiles, represents the acceleration and deceleration rates used to change the speed between 2 levels. The same rate is used when *Quick Stop* or *Disable Operation* commands are received. The *profile acceleration* is given in acceleration units.

The acceleration units are user defined. The value can be converted into internal units using the *acceleration factor* (see Chapter Factor group).

If no factor is applied, the same description as object 6081h applies. So 65536 IU = 1 encoder increment / sample^2.

Object description:

Index	6083h
Name	Profile acceleration
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Possible
Value range	0..(2^{32}-1)
Default value	-

7.2.4 Object 6085h: Quick stop deceleration

The *quick stop deceleration* is the deceleration used to stop the motor if the *Quick Stop* command is received and the *quick stop option code* object (index 605Ah) is set to 2 or 6.

It is also used when:

- the *fault reaction option code* object (index 605Eh) and the *halt option code* object (index 605Dh) is 2.

- a limit switch is active. See also *4.3 Limit Switch functionality explained*.

The quick stop deceleration is given in user-defined acceleration units.

Object description:

Index	6085h
Name	Quick stop deceleration
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Possible
Value range	0..(2^{32}-1)
Default value	-

7.2.5 Object 2023h: Jerk time

In this object, you can set the time to use for S-curve profile (jerk-limited ramp set in Object 6086h – Motion Profile Type). The time units are given in ms.

Object description:

Index	2023_h
Name	Jerk time
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Possible
Value range	0 … 65535
Default value	-

7.2.6 Object 6086_h: Motion profile type

Object description:

Index	6086_h
Name	Motion profile type
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Possible
Value range	INTEGER16
Default value	0

Data description:

Profile code	Profile type
-32768 … -1	Manufacturer specific (reserved)
0	Linear ramp (trapezoidal profile)
1,2	Reserved
3	Jerk-limited ramp (S-curve)
4 … 32767	Reserved

7.2.7 Object 6062_h: Position demand value

This object represents the output of the trajectory generation. The *position demand value* is given in user-defined position units.

Object description:

Index	6062_h
Name	Position demand value
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Possible
Value range	-2^{31} … 2^{31}-1
Default value	-

7.2.8 Object 6063_h: Position actual internal value

This object represents the actual value of the position measurement device in increments.

Object description:

Index	6063_h
Name	Position actual value
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Possible
Units	increments
Value range	-2^{31} … 2^{31}-1
Default value	-

7.2.9 Object 6064h: Position actual value

This object represents the actual value of the position measurement device. The *position actual value* is given in user-defined position units.

Remarks:

1. When using a stepper open loop motor with no encoder this object reports the value of object 6062h Position demand value. In this case, object 6063h will report the value 0, as there is no feedback device.
2. When using a stepper open loop motor with no encoder with encoder on motor configuration (for step loss detection), based on the internal register ASR bit 11, this object reports:
   - ASR.11=0 (default) - the value of object 6062h Position demand value. In this case, object 6063h will show the actual encoder value in increments.
   - [1]ASR.11=1 – the value of the feedback device scaled into microsteps which are the same value that is used for position commands in 607Ah

Object description:

Index	6064h
Name	Position actual value
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Yes
Value range	$-2^{31} \ldots 2^{31}-1$
Default value	-

7.2.10 Object 6065h: Following error window

This object defines a range of tolerated position values symmetrically to the *position demand value*, expressed in position units. If the *position actual value* is above the *following error window* for a period larger than the one defined in *following error time out*, a following error occurs. If the value of the *following error window* is 2^{32}-1, the following control is switched off.

The maximum value allowed for the *following error window* parameter, expressed in increments, is:

- 2^{32}-1 for F515x or newer firmware
- 32767 for F510x/511x firmware

Object description:

Index	6065h
Name	Following error window
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	-

This object is automatically set in the Setup part by modifying the Position control error.

The value for this object can be changed by editing the parameter:

- “ERRMAXL” for F515x
- “ERRMAX” for F510x/511x

found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

7.2.11 Object 6066h: Following error time out

See 6065h, *following error window*. The value is given in control loop time which is by default 1ms.

Remark: By default, without the Factor Group set, the time units are equal to the drive Slow/Control Loop time value.

Object description:

Index	6066h
Name	Following error time out
Object code	VAR
Data type	UNSIGNED16

[1] ASR.11=1 implementation is available only of F515x firmwares.

Entry description:

Access	RW
PDO mapping	Possible
Units	TU
Value range	0 … 65535
Default value	-

The value for this object can be changed by editing the parameter “TERRMAX” found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

7.2.12 Object 6067$_h$: Position window

The *position window* defines a symmetrical range of accepted positions relative to the *target position*. If the *position actual value* is within the *position window* for a time period defined inside the *position window time* object, this *target position* is regarded as reached. The *position window* is given in position units. If the value of the *position window* is 2^{32}-1, the position window control is switched off and the target position will be regarded as reached when the position reference is reached.

The maximum value allowed for the *position window* parameter, expressed in increments, is 32767.

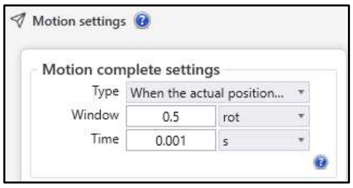
Object description:

Index	6067$_h$
Name	Position window
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	-

This object is automatically set in Setup part by modifying the Band in Motion complete settings in Motion Settings section.



Motion settings

Motion complete settings

Type: When the actual position...

Window: 0.5 rot

Time: 0.001 s

The value for this object can be changed by editing the parameter “POSOKLIM” found in parameters.xml of the project file.

Activating *Object* 2076h: Save current configuration, will set its current values as the a new default.

7.2.13 Object 6068$_h$: Position window time

See description of Object 6067h: Position window.

Remark: By default, without the Factor Group set, the time units are equal to the drive Slow/Control Loop time value.

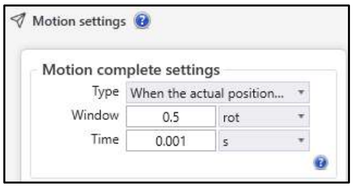
Object description:

Index	6068$_h$
Name	Position window time
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Possible
Units	TU
Value range	0 … 65535
Default value	-

This object is automatically set in Setup part by modifying the Band in Motion complete settings in Motion Settings section.



Motion settings

Motion complete settings

Type: When the actual position...

Window: 0.5 rot

Time: 0.001 s

The value for this object can be changed by editing the parameter "TONPOSOK" found in parameters.xml of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

7.2.14 Object 607B$_h$: Position range limit

This object indicates the configured maximal and minimal position range limits. It limits the numerical range of the input value. On reaching or exceeding these limits, the input value shall wrap automatically to the other end of the range. Wrap-around of the input value may be prevented by setting software position limits as defined in software position limit object (607D$_h$). To disable the position range limits, the min position range limit (sub-index 01h) and max position range limit (sub-index 02h) must be set to 0. The values are given in user-defined position units.

Object description:

Index	607B$_h$
Name	Position range limit
Object code	ARRAY
Data type	INTEGER32

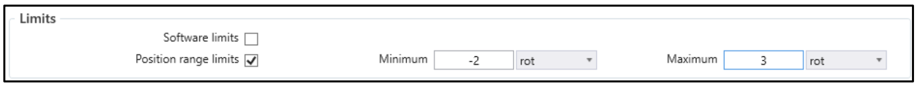
Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Default value	2

Sub-index	1
Description	Min position range limit
Access	RW
PDO mapping	Possible
Value range	INTEGER32
Default value	No

Sub-index	2
Description	Max position range limit
Access	RW
PDO mapping	Possible
Value range	INTEGER32
Default value	No

This object and its values can be defined directly in Setup part under the Protections and Limits section.



Limits

Software limits □

Position range limits ☑

Minimum: -2 rot

Maximum: 3 rot

Also, activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

7.2.15 Object 60F2$_h$: Positioning option code

This object configures the positioning behavior as for the profile positioning mode or the interpolated positioning mode.

Object description:

Index	60F2$_h$
Name	Positioning option code
Object code	VAR
Data type	UNSIGNED16

Entry description:

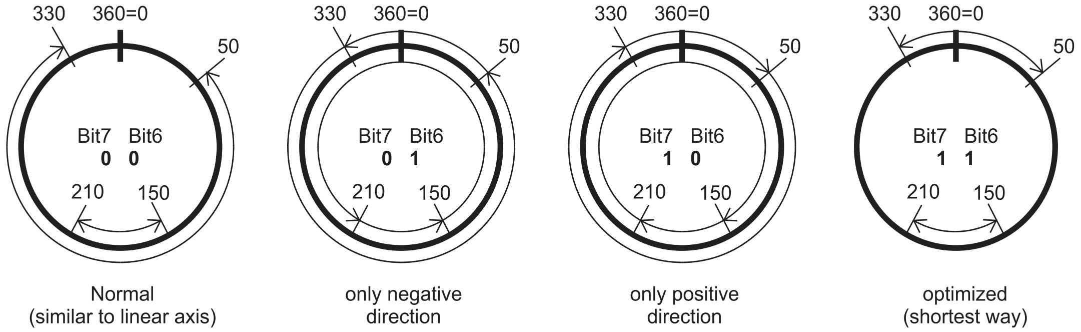
Access	RW
PDO mapping	Possible
Value range	UNSIGNED16
Default value	0000h

MSB					LSB
Reserved		rado		Reserved	
15	8	7	6	5	0

***Table 7.2.1** – Positioning option code bits description*

Name	bit 7	bit 6	Description
rado	0	0	Normal positioning similar to linear axis; If reaching or exceeding the Position range limits (607Bh) the input value shall wrap automatically to the other end of the range. Positioning can be relative or absolute. Only with this bit combination, the movement greater than a modulo value is possible.
	0	1	Positioning only in negative direction; if target position is higher than actual position, axis moves over the min position limit (607Dh, sub-index 01h) to the target position.
	1	0	Positioning only in positive direction; if target position is lower than actual position, axis moves over the max position limit (607Bh, sub-index 02h) to the target position.
	1	1	Positioning with the shortest way to the target position. NOTE: If the difference between actual value and target position in a 360° system is 180°, the axis moves in positive direction.

The figure below shows movement examples depending on settings of the bits 6 and 7. Here the min position range limit (607Bh, sub-index 01h) is 0° and the max position range limit (607Bh, sub-index 02h) is 360°.



Normal (similar to linear axis)

only negative direction

only positive direction

optimized (shortest way)

***Figure 7.2.1.** Rotary axis positioning example*

A movement greater than a modulo value with more than 360° (bit 6 and 7 in this object are set to 0) on a rotary axis can be done with relative and absolute values depending on the bit 6 in the controlword. There are positive and negative values possible.

The figure below shows an example for absolute positioning in a 360° system. The actual position is 90° and absolute target position is 630°. The axis will move in positive direction one time via the max position limit to 270°. To move in negative direction, the negative sign for target position shall be used.

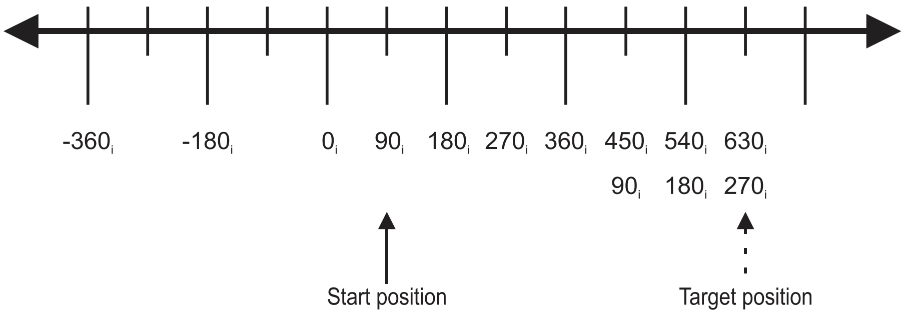


***Figure 7.2.2.** Example for absolute movement greater than modulo value*

The figure below shows an example for relative positioning in a 360° system. The actual position is 300° and relative target position is 500°. The axis will move in positive direction two times via the max position limit to 80°. To move in negative direction, the negative sign for target position is used. The difference between min and max position range limits (see object 607Bh) are representable in multiples of encoder increments.

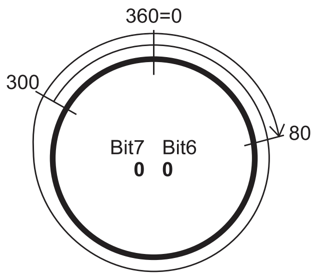


Figure 7.2.3. *Example for relative movement greater than modulo value*

The default value for this object can be changed by editing the parameter “POSOPTCODE” found in parameters.xml of the project file.
Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

7.2.16 Object 60F4h: Following error actual value

This object represents the actual value of the following error, given in user-defined position units.

Object description:

Index	60F4h
Name	Following error actual value
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Possible
Value range	INTEGER32
Default value	-

7.2.17 Object 60FCh: Position demand internal value

This output of the trajectory generator in profile position mode is an internal value using position increments as units. It can be used as an alternative to *position demand value* (6062h).

Object description:

Index	60FCh
Name	Position demand internal value
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Possible
Units	Increments
Value range	$-2^{31} \ldots 2^{31}-1$
Default value	-

7.2.18 Object 2022h: Control effort

This object can be used to visualize the control effort of the drive (the reference for the current controller). It is available in internal units.

Object description:

Index	2022h
Name	Control effort
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RO
PDO mapping	Yes
Value range	INTEGER16
Default value	-

7.2.19 Object 2081$_h$: Set/Change the actual motor position

This object sets the motor position to the value written in it. It affects object 6064$_h$, 6063$_h$ and 6062$_h$.

The object is not affected by the Factor Group and it receives its value in Internal Units.

Object description:

Index	2081$_h$
Name	Set actual position
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RW
PDO mapping	No
Value range	$-2^{31}\ldots2^{31}-1$
Default value	-

7.2.20 Object 2088$_h$[1]: Actual internal position from sensor on motor

This object shows the position value read from the encoder on the motor in increments, in case a dual loop control method is used.

The factor group objects have no effect on it.

Object description:

Index	2088$_h$
Name	Actual internal position from sensor on motor
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Possible
Units	increments
Value range	$-2^{31} \ldots 2^{31}-1$
Default value	-

7.2.21 Object 208D$_h$[2]: Auxiliary encoder position

This object represents the actual value of the auxiliary position measurement device, expressed in internal units, when operating in the digital external reference mode (signal type set to Encoder). The factor group objects have no effect on it.

Object description:

Index	208D$_h$
Name	Auxiliary encoder value
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Possible
Units	increments
Value range	$-2^{31} \ldots 2^{31}-1$
Default value	-

7.3 Position Profile Examples

7.3.1 Relative trapezoidal example

Execute an absolute trapezoidal profile with limited speed. First perform 4 rotations, wait motion complete and then set the target position of 16 rotations.

1. **Start remote node**.

   Enter **Pre-Operational** state.

[1] Object 2088$_h$ applies only to drives which have a secondary feedback

[2] Object 208D$_h$ is available only drives which have a secondary feedback

Enter **Safe-Operational** state.

Enter **Operational** state.

2. **Modes of operation.** Select position mode.

   Set in **Modes of Operation** mapped in RPDO1 the value 01h.

3. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06h.

4. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07h.

5. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

   Set in **Control Word** mapped in RPDO1 the value 0Fh.

6. **Target position.** Set the target position to 20 rotations. By using a 500 lines incremental encoder the corresponding value of object 607Ah expressed in encoder counts is 9C40h.

   Set in **Target position** mapped in RPDO2 the value 00009C40h.

7. **Target speed.** Set the target speed normally attained at the end of acceleration ramp to 500 rpm. By using a 500 lines incremental encoder and 1ms sample rate for position/speed control the corresponding value of object 6081h expressed in encoder counts per sample is 10AAACh.

   Send the following message: SDO access to object 6081h, 32-bit value 0010AAACh.

8. **Start the profile.**

   Set in **Control Word** mapped in RPDO1 the value 005Fh. If Controlword bit 6 is set (Controlword.6 = 1), a relative positioning will start.

9. **Wait movement to finish.**

   Wait for Bit10 to become 1 in Status Word.

10. **Reset the set point.**

    Set in **Control Word** mapped in RPDO1 the value 000Fh.

11. **Target position.** Set the target position to 200 rotations. By using a 500 lines incremental encoder the corresponding value of object 607Ah expressed in encoder counts is 61A80h.

    Send the following message: SDO access to object 607Ah 32-bit value 00061A80h.

12. **Start the profile.**

    Set in **Control Word** mapped in RPDO1 the value 005Fh.

13. **Wait movement to finish.**

    Wait for Bit10 to become 1 in Status Word.

14. **Check the value of motor actual position.**

    Read by SDO protocol the value of object 6064h.

15. **Check the value of position demand value.**

    Read by SDO protocol the value of object 6062h.

At the end of movement the motor position actual value should be equal with position demand value (plus or minus few encoder counts depending on your position tuning) and the motor should rotate 220 times.

7.3.2 Absolute trapezoidal example

Execute an absolute trapezoidal profile with limited speed. First perform 4 rotations, wait motion complete and then set the target position of 16 rotations.

16. **Start remote node**.

    Enter **Pre-Operational** state.

    Enter **Safe-Operational** state.

    Enter **Operational** state.

17. **Modes of operation.** Select position mode.

    Set in **Modes of Operation** mapped in RPDO1 the value 01h.

18. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

    Set in **Control Word** mapped in RPDO1 the value 06h.

19. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

    Set in **Control Word** mapped in RPDO1 the value 07h.

20. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

    Set in **Control Word** mapped in RPDO1 the value 0Fh.

21. **Target position.** Set the target position to 4 rotations. By using a 500 lines incremental encoder the corresponding value of object 607A$_h$ expressed in encoder counts is 1F40$_h$.

    Set in **Target position** mapped in RPDO2 the value 00001F40$_h$.

22. **Target speed.** Set the target speed normally attained at the end of acceleration ramp to 500 rpm. By using a 500 lines incremental encoder and 1ms sample rate for position/speed control the corresponding value of object 6081$_h$ expressed in encoder counts per sample is 10AAAC$_h$.

    Send the following message: SDO access to object 6081$_h$, 32-bit value 0010AAAC$_h$.

23. **Start the profile.**

    Set in **Control Word** mapped in RPDO1 the value 001F$_h$.

24. **Wait movement to finish.**

    Wait for Bit10 to become 1 in Status Word.

25. **Reset the set point.**

    Set in **Control Word** mapped in RPDO1 the value 000F$_h$.

26. **Target position.** Set the target position to 16 rotations. By using a 500 lines incremental encoder the corresponding value of object 607A$_h$ expressed in encoder counts is 7D00$_h$.

    Send the following message: SDO access to object 607A$_h$ 32-bit value 00007D00$_h$.

27. **Start the profile.**

    Set in **Control Word** mapped in RPDO1 the value 001F$_h$.

28. **Wait movement to finish.**

    Wait for Bit10 to become 1 in Status Word.

29. **Check the value of motor actual position.**

    Read by SDO protocol the value of object 6064$_h$.

30. **Check the value of position demand value.**

    Read by SDO protocol the value of object 6062$_h$.

At the end of movement the motor position actual value should be equal with position demand value (plus or minus few encoder counts depending on your position tuning) and the motor should rotate 16 times.

7.3.3 Relative Jerk-limited ramp profile example

Execute an absolute Jerk-limited ramp profile.

1. **Start remote node**.

   Enter **Pre-Operational** state.

   Enter **Safe-Operational** state.

   Enter **Operational** state.

2. **Modes of operation.** Select position mode.

   Set in **Modes of Operation** mapped in RPDO1 the value 01$_h$.

3. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06$_h$.

4. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07$_h$.

5. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

   Set in **Control Word** mapped in RPDO1 the value 0F$_h$.

6. **Motion profile type.** Select Jerk-limited ramp.

   Send the following message: SDO access to object 6086$_h$, 16-bit value 0003$_h$.

7. **Target position.** Set the target position to 10 rotations. By using a 500 lines incremental encoder the corresponding value of object 607A$_h$ expressed in encoder counts is 4E20$_h$.

   Set in **Target position** mapped in RPDO2 the value 00004E20$_h$.

8. **Target speed.** Set the target speed to 450 rpm. By using a 500 lines incremental encoder and 1ms sample rate for position/speed control the corresponding value of object 6081$_h$ expressed in encoder counts per sample is 000F0000$_h$.

   Send the following message: SDO access to object 6081$_h$, 32-bit value 000F0000$_h$.

9. **Jerk time.** Set the time to use for Jerk-limited ramp. For more information related to this parameter, see the EMS help

   Send the following message: SDO access to object 2023$_h$, 16-bit value 1F4B$_h$.

10. **Start the profile.** If Controlword bit 6 is set (Controlword.6 = 1), a relative positioning will start.

    Set in **Control Word** mapped in RPDO1 the value 005F$_h$.

11. **Wait movement to finish.**

    Wait for Bit10 to become 1 in Status Word.

12. **Check the value of motor actual position.**

    Read by SDO protocol the value of object 6064$_h$.

13. **Check the value of position demand value.**

    Read by SDO protocol the value of object 6062$_h$.

At the end of movement the motor position actual value should be equal with position demand value (plus or minus few encoder counts depending on your position tuning).

7.3.4 Absolute Jerk-limited ramp profile example

Execute an absolute Jerk-limited ramp profile.

14. **Start remote node**.

    Enter **Pre-Operational** state.

    Enter **Safe-Operational** state.

    Enter **Operational** state.

15. **Modes of operation.** Select position mode.

    Set in **Modes of Operation** mapped in RPDO1 the value 01$_h$.

16. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

    Set in **Control Word** mapped in RPDO1 the value 06$_h$.

17. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

    Set in **Control Word** mapped in RPDO1 the value 07$_h$.

18. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

    Set in **Control Word** mapped in RPDO1 the value 0F$_h$.

19. **Motion profile type.** Select Jerk-limited ramp.

    Send the following message: SDO access to object 6086$_h$, 16-bit value 0003$_h$.

20. **Target position.** Set the target position to 5 rotations. By using a 500 lines incremental encoder the corresponding value of object 607A$_h$ expressed in encoder counts is 2710$_h$.

    Set in **Target position** mapped in RPDO2 the value 00002710$_h$.

21. **Target speed.** Set the target speed to 150 rpm. By using a 500 lines incremental encoder and 1ms sample rate for position/speed control the corresponding value of object 6081$_h$ expressed in encoder counts per sample is 00050000$_h$.

    Send the following message: SDO access to object 6081$_h$, 32-bit value 00050000$_h$.

22. **Jerk time.** Set the time to use for Jerk-limited ramp. For more information related to this parameter, see the EMS help

    Send the following message: SDO access to object 2023$_h$, 16-bit value 13B$_h$.

23. **Start the profile.**

    Set in **Control Word** mapped in RPDO1 the value 001F$_h$.

24. **Wait movement to finish.**

    Wait for Bit10 to become 1 in Status Word.

25. **Check the value of motor actual position.**

    Read by SDO protocol the value of object 6064$_h$.

26. **Check the value of position demand value.**

    Read by SDO protocol the value of object 6062$_h$.

At the end of movement the motor position actual value should be equal with position demand value (plus or minus few encoder counts depending on your position tuning).

8 Torque Profile Mode

8.1 Overview

The profile torque mode allows to control the motor in torque mode by transmitting the target torque and torque slope values, which are processed via the trajectory generator.

Remark: *This mode is available starting with firmware versions F515K / FA00x.*

8.1.1 Controlword in profile torque mode

MSB **LSB**

See 6040$_h$	Halt	See 6040$_h$	Reserved	See 6040$_h$
15 9	8	7	6 4	3 0

Table 8.1 *– Controlword bits description for Torque Profile Mode*

Name	Value	Description
Halt	0	Execute torque profile
	1	Stop drive according to the halt option code (605D$_h$)

8.1.2 Statusword in profile torque mode

MSB **LSB**

See 6041$_h$	Reserved	See 6041$_h$	Target reached	See 6041$_h$
15 14	13 12	11	10	9 0

Table 8.2 *– Statusword bits description for Torque Profile Mode*

Name	Value	Description

Target reached	0	Halt = 0: *Target torque* not reached
		Halt = 1: Drive decelerates

	1	Halt = 0: *Target torque* reached Halt = 1: Velocity of drive is 0

8.2 Torque Profile Mode Objects

8.2.1 Object 6071$_h$: Target torque

This parameter specifies the input value configured for the torque controller when operating in Torque Profile mode. The unit for this object is given in IU, except for FA00x and FA02x firmware versions, where Object 2115$_h$: ASR4 bit 0 controls the unit in which the object is given:

- If ASR4.0 = 0, the unit for this object is given in IU
- If ASR4.0 = 1, the unit is in thousandths (‰) of the motor's rated current specified in object 6075$_h$. Example:
- If the target torque is set to 500, it represents 50.0% (500 ‰) of the motor's rated current.
- If the target torque is set to 255, it represents 25.5% (255 ‰) of the motor's rated current.

Remarks:
1. When object 2115$_h$ is set to 1, the target torque can exceed 100% (equivalent to 1000 ‰) of the motor's rated current, as defined by object 6075$_h$.
2. The current limit is set through Object 207F$_h$: Current limit. This value acts as a safety threshold and will restrict the maximum current, regardless of the value specified in object 6071$_h$.

Object description:

Index	6071$_h$
Name	Target torque
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Yes
Value range	INTEGER16
Default value	0000$_h$

The computation formula for the current [IU] in [A] is:

$$curent[IU] = \frac{65520 \cdot current[A]}{2 \cdot Ipeak}$$

where I_{peak} is the peak current supported by the drive and *current[IU]* is the command value for object 6071h.

8.2.2 Object 6075h: Motor rated current

The motor rated current is the motor's nominal current which needs to be expressed in mA.

Object description:

Index	6075h
Name	Motor rated current
Object code	VAR
Data type	UNSIGNED32

Entry description:

Sub-index	00h
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	Motor nominal current specified in the setup part.

8.2.3 Object 6087h: Torque slope

The torque slope indicate the rate of change of current. The value needs to be given in in units of per thousand of rated current specified in object 6075h per second.

The rate of change of current is calculated as follows:

$$\frac{Rated\ Current\ (6075_h)}{1000} \times Torque\ Slope\ (6087_h)/s$$

Example: If the Rated Current specified in object 6075h is set to 2000mA and the Torque Slope specified in object 6087h is set to 1000, the rate of change of current is 2A/s.

Object description:

Index	6087h
Name	Torque slope
Object code	VAR
Data type	UNSIGNED32

Entry description:

Sub-index	00h
Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0

8.3 Torque Profile Example

Execute a torque profile.

1. **Start remote node**.

   Enter **Pre-Operational** state.

   Enter **Safe-Operational** state.

   Enter **Operational** state.

2. **Modes of operation.** Select position mode.

   Set in **Modes of Operation** mapped in RPDO1 the value 04h.

3. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06h.

4. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07h.

5. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

   Set in **Control Word** mapped in RPDO1 the value 0Fh.

6. **Motor rated current.** Define the motor nominal(rated) current of 1000mA using object 6075h. Send the following message: SDO access to object 6075h, 32-bit value 03E8h

7. **Target slope.** Define a target slope of 1000mA using object 6087$_h$. Send the following message: SDO access to object 6087$_h$, 32-bit value 03E8h

8. **Configure the formatting and representation of object 6071h[1].** To define the unit as thousandths (‰) of the motor's rated current (specified in object 6075$_h$), set bit 0 of object 2115$_h$ to 1. Send the following message: SDO access to object 2115$_h$, 32-bit value 1$_h$.

9. **Target torque.** Define a target torque of 50.0% of the motor rated current. Send the following message: SDO access to object 6071$_h$, 16-bit value 01F4$_h$. The motor will move positive and reach a current of 50.0% of the motor rated current (500mA).

10. **Set a new Target torque value.** Define a target torque of -120.0% of the motor rated current. Send the following message: SDO access to object 6071$_h$, 16-bit value FB50$_h$. The motor will move negative and reach a current of -120.0% of the motor rated current (-1200mA).

[1] Only for FA00x and FA02x firmware versions.

9 Interpolated Position Mode

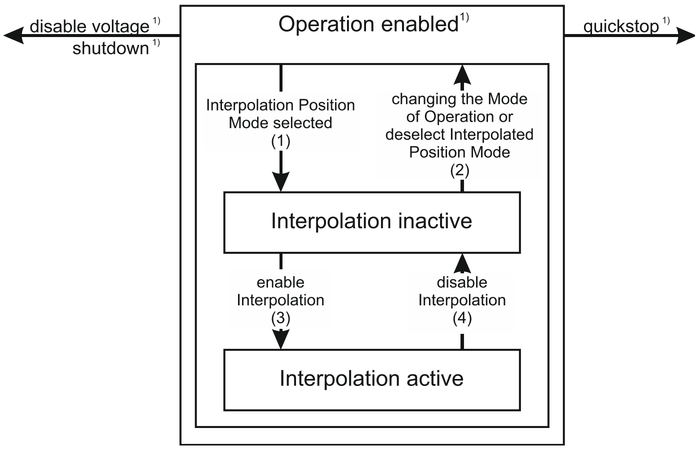
9.1 Overview

The interpolated Position Mode is used to control multiple coordinated axis or a single on with the need for time-interpolation of set-point data. The Interpolated Position Mode can use the time synchronization mechanism for a time coordination of the related drive units.

The Interpolated Position Mode allows a host controller to transmit a stream of interpolation data to a drive unit. The interpolation data is better sent in bursts because the drive supports an input buffer. The buffer size is the number of *interpolation data records* that may be sent to the drive to fill the input buffer.

The interpolation algorithm can be defined in the *interpolation sub mode select*. Linear (PT – Position Time) interpolation is the default interpolation method.

9.1.1 Internal States



disable voltage 1)
shutdown 1)
Operation enabled1)
quickstop 1)
Interpolation Position Mode selected (1)
changing the Mode of Operation or deselect Interpolated Position Mode (2)
Interpolation inactive
enable Interpolation (3)
disable Interpolation (4)
Interpolation active

Figure 9.1.1. *Internal States for the Interpolated Position Mode*

[1] See state machine Operation enabled[1]

Interpolation inactive: This state is entered when the device is in state Operation enabled and the Interpolated Position Mode is selected. The drive will accept input data and will buffer it for interpolation calculations, but it does not move the motor.

Interpolation active: This state is entered when a device is in state Operation enabled and the Interpolation Position Mode is selected and enabled. The drive will accept input data and will move the motor.

State Transitions of the Internal States

State Transition 1: NO IP-MODE SELECTED => IP-MODE INACTIVE

Event: Select ip-mode with *modes of operations* while inside Operation enable

State Transition 2: IP-MODE INACTIVE => NO IP-MODE SELECTED

Event: Select any other mode while inside Operation enable

State Transition 3: IP-MODE INACTIVE => IP-MODE ACTIVE

Event: Set bit *enable ip mode* (bit4) of the *Controlword* while in ip-mode and Operation enable

State Transition 4: IP-MODE ACTIVE => IP-MODE INACTIVE

Event: Reset bit *enable ip mode* (bit4) of the *Controlword* while in ip-mode and Operation enable

9.1.2 Controlword in interpolated position mode

MSB LSB

See 6040h	Stop option	See 6040h	Halt	See 6040h	Abs / rel	Reserved	Enable ip mode	See 6040h
15 12	11	10 9	8	7	6	5	4	3 0

Table 9.1.1 *– Controlword bits description for Interpolated Position Mode*

Name	6040h bit	Value	Description
Enable ip mode	4	0	Interpolated position mode inactive
		1	Interpolated position mode active
Abs / rel	6	0	Set position is an absolute value
		1	Set position is a relative value (similar to Cyclic Synchronous Velocity)
Halt	8	0	Execute the instruction of bit 4
		1	Stop drive with (*profile acceleration*)
Stop option	11	0	On transition to inactive mode, stop drive immediately using *profile acceleration*
		1	On transition to inactive mode, stop drive after finishing the current segment.

9.1.3 Statusword in interpolated position mode

MSB **LSB**

See 6041$_h$	Reserved	ip mode active	See 6041$_h$	Target reached	See 6041$_h$
15 14	13	12	11	10	9 0

***Table 9.1.2** – Statusword bits description for Interpolated Position Mode*

Name	Value	Description
Target reached	0	Halt = 0: Final position not reached Halt = 1: Drive decelerates
	1	Halt = 0: Final position reached Halt = 1: Velocity of drive is 0
ip mode active	0	Interpolated position mode inactive
	1	Interpolated position mode active

9.2 Interpolated Position Objects

9.2.1 Object 60C0$_h$: Interpolation sub mode select

In the Interpolated Position Mode the drive supports three interpolation modes:

1. **Linear interpolation** as described in the CiA 402 standard (when object 208E$_h$ bit8=1); This mode is almost identical with Cyclic Synchronous Position mode, only that it receives its position data into 60C1$_h$ sub-index 01 instead of object 607A$_h$. No interpolation point buffer will be used.
2. **PT (Position – Time)** linear interpolation (legacy) (when object 208E$_h$ bit8=0)
3. **PVT (Position – Velocity – Time)** cubic interpolation (legacy) (when object 208E$_h$ bit8=0).

The interpolation mode is selected with Interpolation sub-mode select object. The sub-mode can be changed only when the drive is in Interpolation inactive state.

Each change of the interpolation mode will trigger the reset of the buffer associated with the interpolated position mode (because the physical memory available is the same for both the sub-modes, size of each data record is different).

Object description:

Index	60C0$_h$
Name	Interpolation sub mode select
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Possible
Value range	$-2^{15} \ldots 2^{15}-1$
Default value	0

Data description:

Profile code	Profile type
-32768 … -2	Manufacturer specific (reserved)
-1	PVT (Position – Velocity – Time) cubic interpolation
0	Linear Interpolation or PT (Position – Time)
+1…+32767	Reserved

9.2.2 Object 60C1$_h$: Interpolation data record

The **Interpolation Data Record** contains the data words that are necessary to perform the interpolation algorithm. The number of data words in the record is defined by the *interpolation data configuration.*

Object description:

Index	60C1$_h$
Name	Interpolation data record
Object code	ARRAY
Number of elements	2
Data Type	Interpolated Mode dependent

Entry description

Sub-index	01$_h$
Description	X1: the first parameter of ip function
Access	RW
PDO mapping	Possible
Value range	Interpolated Mode dependent
Default value	-

Sub-index	02$_h$
Description	X2: the second parameter of ip function
Access	RW
PDO mapping	Possible
Value range	Interpolated Mode dependent
Default value	-

Description of the sub-indexes:

X1 and X2 form a 64-bit data structure as defined below:

9.2.2.1 a) For linear interpolation (standard DS402 implementation)

To work with this mode, object 208E$_h$ bit8 must be 1. The default value of this bit is 1 with the current iPOS templates.

There are 2 parameters in this mode:

Position – a 32-bit long integer value representing the target position (relative or absolute). Unit - position increments.

– the **Linear interpolation** position command is received in object 60C1$_h$ sub-index1; sub-index2 is not used

Time – the time is defined in object 60C2$_h$.

The position points should be sent in a synchronous RxPDO at fixed time intervals defined in object 60C2$_h$.

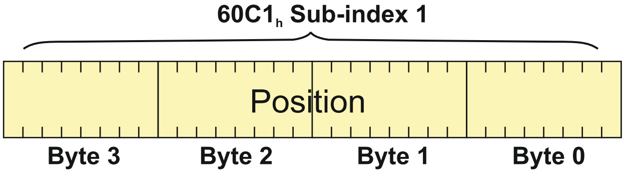


Figure 9.2.1. *Linear interpolation point 32-bit data structure*

9.2.2.2 b) For PT (Position –Time) linear interpolation (legacy).

To work with this mode, object 208E$_h$ bit8 must be 0. The default value of this bit is 1 with the current iPOS templates.

There are 3 parameters in this mode:

Position – a 32-bit long integer value representing the target position (relative or absolute). Unit - position increments.

Time – a 16-bit unsigned integer value representing the time of a PT segment. Unit - position / speed loop samplings.

Counter – a 7-bit unsigned integer value representing an integrity counter. It can be used in order to have a feedback of the last point sent to the drive and detect errors in transmission.

In the example below Position[7…0] represents bits 0..7 of the position value.

Byte 0	Position [7...0]	
Byte 1	Position [15...8]	
Byte 2	Position [23...16]	
Byte 3	Position [31...24]	
Byte 4	Time [7...0][1]	
Byte 5	Time [15...8][1]	
Byte 6	Reserved	
Byte 7	Counter[6…0]	Reserved

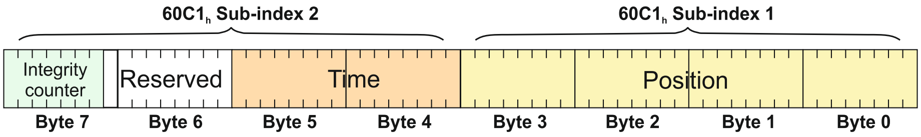


Figure 9.2.2. *PT interpolation point 64-bit data structure*

Remarks:

- The integrity counter is written in byte 3 of 60C1$_h$ Sub-index 2, on the most significant 7 bits (bit 1 to bit 7).

- The integrity counter is 7 bits long, so it can have a value up to 127. When the integrity counter reaches 127, the next value is 0

[1] If object 207A$_h$ Interpolated position 1st order time is used, these bits will we overwritten with the value defined in it

9.2.2.3 c) For PVT (Position – Velocity – Time) cubic interpolation

To work with this mode, object 208E$_h$ bit8 must be 0. The default value of this bit is 1 with the current iPOS templates. There are 4 parameters in this mode:
Position – a 24-bit long integer value representing the target position (relative or absolute). Unit - position increments.
Velocity – a 24-bit fixed value representing the end point velocity (16 MSB integer part and 8 LSB fractional part). Unit - increments / sampling
Time – a 9-bit unsigned integer value representing the time of a PVT segment. Unit - position / speed loop samplings.
Counter – a 7-bit unsigned integer value representing an integrity counter. It can be used in order to have a feedback of the last point sent to the drive and detect errors in transmission.
In the example below Position 0 [7…0] represents bits 0..7 of the position value.

Byte 0	Position 0 [7...0]			
Byte 1	Position 1 [15...8]			
Byte 2	Velocity 0 [15...8]			
Byte 3	Position 2 [23...16]			
Byte 4	Velocity 1 [23...16]			
Byte 5	Velocity 2 [31...24]			
Byte 6	Time [7...0]			
Byte 7	Counter[6…0]			Time[8]
	bit7	- - - -	bit1	bit0

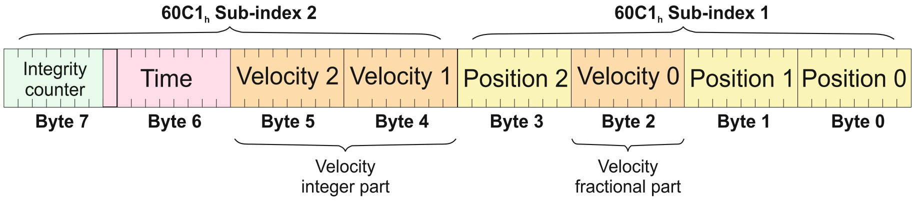


Figure 9.2.3. *PVT interpolation point 64-bit data structure*

Remarks:
- The integrity counter is written in byte 3 of 60C1$_h$ Sub-index 2, on the most significant 7 bits (bit 1 to bit 7).
- The integrity counter is 7 bits long, so it can have a value up to 127. When the integrity counter reaches 127, the next value is 0.

9.2.3 Object 2072$_h$: Interpolated position mode status

The object provides additional status information for the interpolated position mode.

Object description:

Index	2072$_h$
Name	Interpolated position mode status
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Possible
Value range	UNSIGNED16
Default value	-

Table 9.2.1 *– Interpolated position mode status bit description*

Bit	Value	Description
15	0	Buffer is not empty
	1	Buffer is empty – there is no point in the buffer.
14	0	Buffer is not low
	1	Buffer is low – the number of points from the buffer is equal or less than the low limit set using object 2074$_h$.
13	0	Buffer is not full
	1	Buffer is full – the number of points in the buffer is equal with the buffer dimension.
12	0	No integrity counter error
	1	Integrity counter error. If integrity counter error checking is enabled and the integrity counter sent by the master does not match the integrity counter of the drive.
11	0	Valid only for PVT (cubic interpolation): Drive has maintained interpolated position mode after a buffer empty condition (the velocity of the last point was 0).
	1	Valid only for PVT (cubic interpolation): Drive has performed a quick stop after a buffer empty condition because the velocity of the last point was different from 0
10 … 7		Reserved
6 … 0		Current integrity counter value

Remark: *when a status bit changes from this object, an emergency message with the code 0xFF01 will be generated. This emergency message will have mapped object 2072h data onto bytes 3 and 4.*

The Emergency message contains of 8 data bytes having the following contents:

0-1	2	3-4	5-7
Emergency Error Code (0xFF01)	Error Register (Object 1001h)	Interpolated position status (Object 2072h)	Manufacturer specific error field

To disable the sending of PVT emergency message with ID 0xFF01, the setup variable PVTSENDOFF must be set to 1.

9.2.4 Object 2073h: Interpolated position buffer length

Through **Interpolated position buffer length** object you can change the default buffer length. When writing in this object, the buffer will automatically reset its contents and then re-initialize with the new length. The length of the buffer is the maximum number of interpolation data that can be queued, and does not mean the number of data locations physically available.

Remark: *It is NOT allowed to write a "0" into this object.*

Object description:

Index	2073h
Name	Interpolated position buffer length
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	WO
PDO mapping	No
Value range	UNSIGNED16
Default value	7

9.2.5 Object 2074h: Interpolated position buffer configuration

Through this object you can control more in detail the behavior of the buffer.

Object description:

Index	2074h
Name	Interpolated position buffer configuration
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	WO
PDO mapping	No
Value range	UNSIGNED16
Default value	-

Table 9.2.2 *– Interpolated position buffer configuration*

Bit	Value	Description
15	0	Nothing
	1	Clear buffer and reinitialize buffer internal variables
14	0	Enable the integrity counter error checking
	1	Disable the integrity counter error checking
13	0	No change in the integral integrity counter
	1	Change internal integrity counter with the value specified in bits 0 to 6
12	0	If absolute positioning is set (bit 6 of *Controlword* is 0), the initial position is read from object 2079h. It is used to compute the distance to move up to the first PVT point.
	1	If absolute positioning is set (bit 6 of *Controlword* is 0), the initial position is the current *position demand value*. It is used to compute the distance to move up to the first PVT point.
11 ... 8		New parameter for buffer low signaling. When the number of entries in the buffer is equal or less than buffer low value, bit 14 of object 2072h will set.
7	0	No change in the buffer low parameter
	1	Change the buffer low parameter with the value specified in bits 8 to 11
6 … 0		New integrity counter value

9.2.6 Object 2079$_h$: Interpolated position initial position

Through this object, you can set an initial position for absolute positioning in order to be used to compute the distance to move up to the first point. It is given in position units.

Object description:

Index	2079$_h$
Name	Interpolated position initial position
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RW
PDO mapping	Possible
Value range	INTEGER32
Default value	0

9.2.7 Object 207A$_h$: Interpolated position 1st order time

Through this object, you can set the time in a PT (Position – Time) Linear Interpolation mode. By setting a value in this object, there is no need to send the time together with the position and integrity counter in **Object** 60C1h: Interpolation data record. This object is disabled when it is set with 0. It is given in IU which is by default 1ms.

Remark: By default, without the Factor Group set, the time units are equal to the drive Slow/Control Loop time value.

Object description:

Index	207A$_h$
Name	Interpolated position 1st order time
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Yes
Value range	UNSIGNED16
Default value	0

9.2.8 Loading the interpolated points

The points can be loaded only in Legacy interpolation mode (object 208E$_h$ bit8 must be 0 and its default is 1).

If the integrity counter is enabled, the drive considers and loads a valid IP point when it receives a new valid integrity counter number. If the drive receives interpolation data with the same integrity number, it will ignore the point and send an emergency message with the code 0xFF01. If it receives a lower or a +2 higher integrity number, it will ignore the data and send an emergency message with code 0xFF01 and

Object 207Ah: Interpolated position 1st order time mapped on bytes 4 and 5 showing and integrity counter error. This error will be automatically reset when the data with correct integrity number will be received. The 7 bit integrity counter can have values between 0 and 127. Therefore, when the counter reaches the value 127, the next logical value is 0.

After receiving each point, the drive calculates the trajectory it has to execute. Because of this, the points must be loaded after the absolute/relative bit is set in Controlword.

A correct interpolated PT/PVT motion would be like this:

- Enter mode 07 in Modes of Operation
- set the IP (Interpolated Position) buffer size
- Clear the buffer and reinitialize the integrity counter
- Set in Controlword the bit for absolute or relative motion
- If the motion is absolute, set in 2079$_h$ the actual position of the drive (read from object 6063$_h$)
- If the motion is PT, set in object 207A$_h$ a fixed time interval if not supplied in 60C1$_h$ sub-index2
- Load the first IP points
- Start the motion by toggling from 0 to 1 bit4 in Controlword
- Monitor the interpolated status for buffer low warning (an emergency message will be sent automatically containing the interpolated status when one of the status bits changes)
- Load more points until buffer full bit is active
- Return to monitoring the buffer status and load points until the profile is finished

9.3 Linear interpolation example

To work with this mode, object 208E$_h$ bit8 must be 1. The default value of this bit is 1, so there is no need to change it. This example is identical with the *Cyclic Synchronous Position Mode basic* example with the following changes:

- the modes of operation 6060$_h$ must be set = 7 instead of 8
- object 60C1$_h$ sub-index 1 must be used instead of object 607A$_h$.

All the other commands and behavior is the same.

9.4 PT absolute movement example

Execute an absolute PT movement.

***Remarks:** Because this is a demo for a single axis, the synchronization mechanism is not used here.*

To work with this mode, object 208E$_h$ bit8 must be 0. The default value of this bit is 1

1. **Start remote node**.

Enter **Pre-Operational** state.

2. **Disable the RPDO3**. Write zero in object 1602$_h$ sub-index 0, this will disable the PDO.

Send the following message: SDO access to object 1602$_h$ sub-index 0, 8-bit value 0.

3. **Map the new objects**:
   a. Write in object 1602$_h$ sub-index 1 the description of the interpolated data record sub-index 1:

   Send the following message: SDO access to object 1602$_h$ sub-index 1, 32-bit value 60C10120$_h$.

   b. Write in object 1602$_h$ sub-index 2 the description of the interpolated data record sub-index 2:

   Send the following message: SDO access to object 1602$_h$ sub-index 2, 32-bit value 60C10220$_h$.

4. **Enable the RPDO3**. Set the object 1602$_h$ sub-index 0 with the value 2.

Send the following message: SDO access to object 1602$_h$ sub-index 0, 8-bit value 2.

5. **Add the new TPDO to the Sync Manager**:
   a. Write zero in object 1C12$_h$ sub-index 0, this will disable the Sync. Manager.

   Send the following message: SDO access to object 1C12$_h$ sub-index 0, 8-bit value 00$_h$.

   b. Write in object 1C12$_h$ sub-index 3 the RPDO3 mapping parameter object number:

   Send the following message: SDO access to object 1C12$_h$ sub-index 3, 16-bit value 1602$_h$.

   c. Write 03$_h$ in object 1C12$_h$ sub-index 0, this will enable the Sync. Manager.

   Send the following message: SDO access to object 1C12$_h$ sub-index 0, 8-bit value 03$_h$.

Note: if using TwinCAT System Manager, enter in Configuration Mode, select the drive, select Process Data tab, uncheck the PDO Assignment and PDO Configuration boxes. Click Load PDO info from device button to load the new DO configuration. Press F4 to reload the IO devices and enter in Operation state.

6. Enter **Safe-Operational** state.
7. Enter **Operational** state.
8. **Ready to switch on.** Set in **Control Word** mapped in RPDO1 the value 06$_h$.
9. **Switch on.** Set in **Control Word** mapped in RPDO1 the value 07$_h$.
10. **Enable Operation.** Set in **Control Word** mapped in RPDO1 the value 0F$_h$. For relative motion, set 4F$_h$.
11. Set in **Modes of operation** mapped in RPDO1 the value 7 to enable Interpolated mode.
12. **Interpolation sub mode select**. Select PT interpolation position mode.

    Send the following message: SDO access to object 60C0$_h$, 16-bit value 0000$_h$.

13. **Interpolated position buffer length**.

    Send the following message: SDO access to object 2073$_h$, 16-bit value 000C$_h$. The maximum is 000F$_h$.

14. **Interpolated position buffer configuration**. By setting the value A001$_h$, the buffer is cleared and the integrity counter will be set to 1.

    Send the following message: SDO access to object 2074$_h$, 16-bit value A001$_h$.

15. **Interpolated position initial position**. Set the initial position to 0.5 rotations. By using a 500 lines incremental encoder the corresponding value of object 2079$_h$ expressed in encoder counts is (1000$_d$) 3E8$_h$. By using the settings done so far, if the final position command were to be 0, the drive would travel to (Actual position – 1000).

    Send the following message: SDO access to object 2079$_h$, 32-bit value 3E8$_h$.

16. **Loading the PT points.** Assuming X1 and X2 are object 60C1$_h$'s sub index 01 and 02, which were recently mapped, send the following data:
17. **Send the 1st PT point**.

    Position= 20000 IU (0x00004E20) 1IU = 1 encoder pulse

    Time = 1000 IU (0x03E8) 1IU = 1 control loop = 1ms by default

    IC = 1 (0x01) IC=Integrity Counter

The drive motor will do 10 rotations (20000 counts) in 1000 milliseconds.

Set X1=00004E20$_h$; X2=020003E8$_h$;

18. **Send the 2nd PT point**.

    Position= 30000 IU (0x00007530)

    Time = 2000 IU (0x07D0)

    IC = 2 (0x02)

Set X1=00007530$_h$; X2=040007D0$_h$;

19. **Send the 3rd PT point**.

    Position= 2000 IU (0x000007D0)

    Time = 1000 IU (0x03E8)

    IC = 3 (0x03)

Set X1=000007D0h; X2=060003E8 h;

20. **Send the last PT point**.

Set X1=00000000 h (0 counts); X2=080001F4 (IC=4 (0x08), time =500 (0x01F4))

    Position= 0 IU (0x00000000)

    Time = 500 IU (0x01F4)

    IC = 4 (0x04)

Set X1=00000000h; X2=080001F4h;

21. **Start an absolute motion**.

    Set in **Control Word** mapped in RPDO1 the value 1Fh.

After the sequences are executed, if the drive actual position before starting the motion was 0, now it should be -1000 counts because of Step 15.

9.5 PVT absolute movement example

Execute an absolute PVT movement. The PVT position points will be given as absolute positions.

Remarks: *Because this is a demo for a single axis the synchronization mechanism is not used here.*

To work with this mode, object 208Eh bit8 must be 0. The default value of this bit is 1.

1. **Start remote node**.

    Enter **Pre-Operational** state.

2. **Disable the RPDO3**. Write zero in object 1602h sub-index 0, this will disable the PDO.

    Send the following message: SDO access to object 1602h sub-index 0, 8-bit value 0.

3. **Map the new objects**:

    - Write in object 1602h sub-index 1 the description of the interpolated data record sub-index 1:

      Send the following message: SDO access to object 1602h sub-index 1, 32-bit value 60C10120h.

    - Write in object 1602h sub-index 2 the description of the interpolated data record sub-index 2:

      Send the following message: SDO access to object 1602h sub-index 2, 32-bit value 60C10220h.

4. **Enable the RPDO3**. Set the object 1602h sub-index 0 with the value 2.

    Send the following message: SDO access to object 1602h sub-index 0, 8-bit value 2.

5. **Add the new TPDO to the Sync Manager**:

    - Write zero in object 1C12h sub-index 0, this will disable the Sync. Manager.

      Send the following message: SDO access to object 1C12h sub-index 0, 8-bit value 00h.

    - Write in object 1C12h sub-index 3 the RPDO3 mapping parameter object number:

      Send the following message: SDO access to object 1C12h sub-index 3, 16-bit value 1602h.

    - Write 03 h in object 1C12h sub-index 0, this will enable the Sync. Manager.

      Send the following message: SDO access to object 1C12h sub-index 0, 8-bit value 03h.

    Note: if using TwinCAT System Manager, enter in Configuration Mode, select the drive, select Process Data tab, uncheck the PDO Assignment and PDO Configuration boxes. Click Load PDO info from device button to load the new PDO configuration. Press F4 to reload the IO devices and enter in Operation state.

6. Enter **Safe-Operational** state.
7. Enter **Operational** state.
8. **Ready to switch on.** Set in **Control Word** mapped in RPDO1 the value 06h.
9. **Switch on.** Set in **Control Word** mapped in RPDO1 the value 07h.
10. **Enable Operation and set an absolute motion.** Set in **Control Word** mapped in RPDO1 the value 0Fh.
11. Set in **Modes of operation** mapped in RPDO1 the value 7 to enable Interpolated mode.
12. **Interpolation sub mode select**. Select PVT interpolation position mode.

    Send the following message: SDO access to object 60C0h, 16-bit value FFFFh.

13. **Interpolated position buffer length**.

    Send the following message: SDO access to object 2073h, 16-bit value 000Fh. The maximum is 000Fh.

14. **Interpolated position buffer configuration**. By setting the value B001h, the buffer is cleared and the integrity counter will be set to 1.

    Send the following message: SDO access to object 2074h, 16-bit value B001h.

15. **Loading the PVT points.** Assuming X1 and X2 are 60C1 sub index 01 and 02 which were recently mapped, send the following data:

16. **Send the 1st PVT point**.

    Position = 88 IU (0x000058) 1IU = 1 encoder pulse

    Velocity = 3.33 IU (0x000354) 1IU = 1 encoder pulse/ 1 control loop

    Time = 55 IU (0x37) 1IU = 1 control loop = 1ms by default

    IC = 1 (0x01) IC=Integrity Counter

Set X1=00540058$_h$; X2=02370003$_h$;

17. **Send the 2nd PVT point**.

    Position = 370 IU (0x000172)

    Velocity = 6.66 IU (0x0006A8)

    Time = 55 IU (0x37)

    IC = 2 (0x02)

Set X1=00A80172$_h$; X2=04370006$_h$;

18. **Send the 3rd PVT point**.

    Position = 2982 IU (0x000BA6)

    Velocity = 6.66 IU (0x0006A8)

    Time = 390 IU (0x186)

    IC = 3 (0x03)

Set X1=00A80BA6$_h$; X2=07860006$_h$;

19. **Send the 4th PVT point**.

    Position = 5631 IU (0x0015FF)

    Velocity = 6.66 IU (0x0006A8)

    Time = 400 IU (0x190)

    IC = 4 (0x04)

Set X1=00A815FF$_h$; X2=09900006$_h$;

20. **Send the 5th PVT point**.

    Position = 5925 IU (0x001725)

    Velocity = 3.00 IU (0x000300)

    Time = 60 IU (0x3C)

    IC = 5 (0x05)

Set X1=00001725$_h$; X2=0A3C0003$_h$;

21. **Send the 6th PVT point**.

    Position = 6000 IU (0x001770)

    Velocity = 0.00 IU (0x000000)

    Time = 50 IU (0x32)

    IC = 6 (0x06)

Set X1=00001770$_h$; X2=0C320000$_h$;

22. **Send the 7th PVT point**.

    Position = 5127 IU (0x001407)

    Velocity = -7.5 IU (0xFFF880)

    Time = 240 IU (0xF0)

    IC = 7 (0x07)

Set X1=00801407$_h$; X2=0EF0 FFF8$_h$;

23. **Send the 8th PVT point**.

    Position = 3115 IU (0x000C2B)

    Velocity = -13.33 IU (0xFFF2AB)

    Time = 190 IU (0xBE)

    IC = 8 (0x08)

Set X1=00AB0C2B $_h$; X2=10BEFFF2$_h$;

24. **Send the 9th PVT point**.

    Position = -1686 IU (0xFFF96A)

    Velocity = -13.33 IU (0xFFF2AB)

    Time = 360 IU (0x168)

    IC = 9 (0x09)

Set X1=FFABF96A h; X2=1368FFF2h;

25. **Send the 10nth PVT point**.

Position = -7145 IU (0xFFE417)

Velocity = -13.33 IU (0xFFF2AB)

Time = 410 IU (0x19A)

IC = 10 (0x0A)

Set X1=FFABE417 h; X2=159AFFF2h;

26. **Send the 11th PVT point**.

Position = -9135 IU (0xFFDC51)

Velocity = -7.4 IU (0xFFF899)

Time = 190 IU (0xBE)

IC = 11 (0x0B)

Set X1=FF990C2B h; X2=16BEFFF8h;

27. **Send the 12th PVT point. The last.**

Position = -10000 IU (0xFFD8F0)

Velocity = -7.4 IU (0x000000)

Time = 240 IU (0xF0)

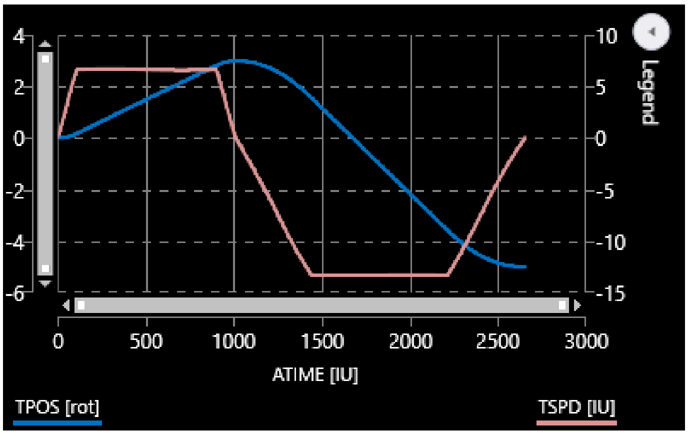
IC = 12 (0x0C)

Set X1=FF00D8F0 h; X2=18F00000h;

28. **Start an absolute PVT motion**.

Set in **Control Word** mapped in RPDO1 the value 1Fh.

The PVT motion should be like the one below.



The motor should rotate 3 positive rotations and another 8 negatively (for a 500 lines encoder). If the initial position before the motion was 0, the final position should be -10000 IU (-5 rotations). All points should be executed within 2.64s, considering the default time base is 1ms.

9.6 PVT relative movement example

Execute a relative PVT movement. The PVT position points will be given as a difference between next and last position.

Remarks: *Because this is a demo for a single axis the synchronization mechanism is not used here.*

To work with this mode, object 208Eh bit8 must be 0. The default value of this bit is 1.

1. **Start remote node**.

Enter **Pre-Operational** state.

2. **Disable the RPDO3**. Write zero in object 1602h sub-index 0, this will disable the PDO.

Send the following message: SDO access to object 1602h sub-index 0, 8-bit value 0.

3. **Map the new objects**:

- Write in object 1602h sub-index 1 the description of the interpolated data record sub-index 1:

Send the following message: SDO access to object 1602h sub-index 1, 32-bit value 60C10120h.

- Write in object 1602h sub-index 2 the description of the interpolated data record sub-index 2:

Send the following message: SDO access to object 1602h sub-index 2, 32-bit value 60C10220h.

4. **Enable the RPDO3**. Set the object 1602h sub-index 0 with the value 2.

   Send the following message: SDO access to object 1602h sub-index 0, 8-bit value 2.

5. **Add the new TPDO to the Sync Manager**:
   - Write zero in object 1C12h sub-index 0, this will disable the Sync. Manager.

     Send the following message: SDO access to object 1C12h sub-index 0, 8-bit value 00h.
   - Write in object 1C12h sub-index 3 the RPDO3 mapping parameter object number:

     Send the following message: SDO access to object 1C12h sub-index 3, 16-bit value 1602h.
   - Write 03 h in object 1C12h sub-index 0, this will enable the Sync. Manager.

     Send the following message: SDO access to object 1C12h sub-index 0, 8-bit value 03h.

   Note: if using TwinCAT System Manager, enter in Configuration Mode, select the drive, select Process Data tab, uncheck the PDO Assignment and PDO Configuration boxes. Click Load PDO info from device button to load the new PDO configuration. Press F4 to reload the IO devices and enter in Operation state.

6. Enter **Safe-Operational** state.
7. Enter **Operational** state.
8. **Ready to switch on.** Set in **Control Word** mapped in RPDO1 the value 06h.
9. **Switch on.** Set in **Control Word** mapped in RPDO1 the value 07h.
10. **Enable Operation and set a relative motion.** Set in **Control Word** mapped in RPDO1 the value 4Fh. For an absolute motion, set 0Fh but the example points will not apply.
11. Set in **Modes of operation** mapped in RPDO1 the value 7 to enable Interpolated mode.
12. **Interpolation sub mode select**. Select PVT interpolation position mode.

    Send the following message: SDO access to object 60C0h, 16-bit value FFFFh.

13. **Interpolated position buffer length**.

    Send the following message: SDO access to object 2073h, 16-bit value 000Ch. The maximum is 000Fh.

14. **Interpolated position buffer configuration**. By setting the value A001h, the buffer is cleared and the integrity counter will be set to 1.

    Send the following message: SDO access to object 2074h, 16-bit value A001h.

15. **Loading the PVT points.** Assuming X1 and X2 are 60C1 sub index 01 and 02 which were recently mapped, send the following data:
16. **Send the 1st PVT point**.

    Position = 400 IU (0x000190) 1IU = 1 encoder pulse

    Velocity = 3.00 IU (0x000300) 1IU = 1 encoder pulse/ 1 control loop

    Time = 250 IU (0xFA) 1IU = 1 control loop = 1ms by default

    IC = 1 (0x01) IC=Integrity Counter

Set X1=00000190h; X2=02FA0003h;

17. **Send the 2nd PVT point**.

    Position = 1240 IU (0x0004D8)

    Velocity = 6.00 IU (0x000600)

    Time = 250 IU (0xFA)

    IC = 2 (0x02)

Set X1=000004D8h; X2=04FA0006h;

18. **Send the 3rd PVT point**.

    Position = 1674 IU (0x00068A)

    Velocity = 6.00 IU (0x000600)

    Time = 250 IU (0xFA)

    IC = 3 (0x03)

Set X1=0000068Ah; X2=06FA0006h;

19. **Send the 4th PVT point**.

Position = 1666 IU (0x000682)

Velocity = 6.00 IU (0x000600)

Time = 250 IU (0xFA)

IC = 4 (0x04)

Set X1=00000682h; X2=08FA0006h;

20. Send the 5th PVT point.

Position = 1240 IU (0x0004D8)

Velocity = 3.00 IU (0x000300)

Time = 250 IU (0xFA)

IC = 5 (0x05)

Set X1=000004D8h; X2=0AFA0003h;

21. Send the last PVT point.

Position = 410 IU (0x00019A)

Velocity = 0.00 IU (0x000000)

Time = 250 IU (0xFA)

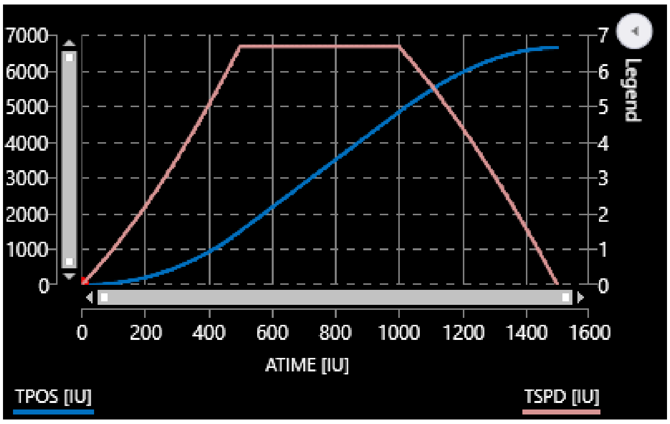
IC = 6 (0x06)

Set X1=0000019A h; X2=0CFA0000h;

22. Start a relative PVT motion.

Set in **Control Word** mapped in RPDO1 the value 5Fh.

The PVT motion should be like the one below.



If the initial position before the motion was 0, the final position should be 6630 IU (3.315 rotation for a 500line encoder). All points should be executed in 1.5s, considering the default time base is 1ms.

10 Velocity Profile Mode

10.1 Overview

In the Velocity Profile Mode the drive performs speed control. The built-in reference generator computes a speed profile with a trapezoidal shape, due to a limited acceleration. The **Target Velocity** object (index 60FF$_h$) specifies the jog speed (speed sign specifies the direction) and the **Profile Acceleration** object (index 6083$_h$) the acceleration/deceleration rate. While the mode is active, any change of the Target Velocity object by the EtherCAT® master will update the drive's demand velocity enabling you to change on the fly the slew speed and/or the acceleration/deceleration rate. The motion will continue until the **Halt** bit from the Controlword is set. An alternate way to stop the motion is to set the jog speed to zero.

While the mode is active (profile velocity mode is selected in *modes of operation*), every time a write access is performed inside the object *target velocity*, the demand velocity of the drive is updated.

Remark1: This mode works only if the speed loop is active in Drive setup/ Advanced button.

Remark2: If the velocity is already set when entering velocity mode, the motion will not start until a value (even if it is the same) will be set again in Target Velocity 60FF$_h$.

10.1.1 Controlword in Profile Velocity mode

MSB **LSB**

See 6040$_h$	Halt	See 6040$_h$	reserved	See 6040$_h$
15 9	8	7	6 4	3 0

Table 10.1.1 *– Controlword bits for Profile Velocity mode*

Name	Value	Description
Halt	0	Execute the motion
	1	Stop drive with *profile acceleration*

10.1.2 Statusword in Profile Velocity mode

MSB **LSB**

See 6041$_h$	Max slippage error	Speed	See 6041$_h$	Target reached	See 6041$_h$
15 14	13	12	11	10	9 0

Table 10.1.2 *– Statusword bits for Profile Velocity mode*

Name	Value	Description

Target reached	0	Halt = 0: *Target velocity* not (yet) reached
		Halt = 1: Drive decelerates

	1	Halt = 0: *Target velocity* reached Halt = 1: Velocity of drive is 0
Speed	0	Speed is not equal to 0
	1	Speed is equal to 0
Max slippage error	0	Maximum slippage not reached
	1	Maximum slippage reached

Remark*: In order to set / reset bit 12 (speed), the object 606F$_h$, velocity threshold is used. If the actual velocity of the drive / motor is below the velocity threshold, then bit 12 will be set, else it will be reset.*

10.2 Velocity Mode Objects

10.2.1 Object 6069$_h$: Velocity sensor actual value

This object describes the value read from the velocity encoder in increments.

The velocity units are user defined speed units. The value can be converted into internal units using the *velocity factor*

If no factor is applied, then the value 65536 = 1 encoder increment / sample.

Object description:

Index	6069$_h$
Name	Velocity sensor actual value
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Possible
Value range	INTEGER32
Default value	-

10.2.2 Object 606B$_h$: Velocity demand value

This object provides the output of the trajectory generator and is provided as an input for the velocity controller. It is given in user-defined velocity units.

If no factor is applied, then the value 65536 = 1 encoder increment / sample.

Object description:

Index	606B$_h$
Name	Velocity demand value
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Possible
Value range	INTEGER32
Default value	-

10.2.3 Object 606C$_h$: Velocity actual value

The *velocity actual value* is given in user-defined velocity units and is read from the velocity sensor.

If no factor is applied, then the value 65536 = 1 encoder increment / sample.

Object description:

Index	606C$_h$
Name	Velocity actual value
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Yes
Value range	INTEGER32
Default value	-

10.2.4 Object 606D$_h$: Velocity window[1]

When the difference between the target velocity (60FF$_h$) and the velocity actual value (606C$_h$) is in the velocity window for longer than the velocity window time (606E$_h$), the *Target reached bit* (Statusword) is set. The value is given in user-defined velocity units which means it can be modified by Factor group objects.

Object description:

Index	606D$_h$
Name	Velocity window
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Yes
Value range	UNSIGNED16
Default value	-

10.2.5 Object 606E$_h$: Velocity window time[2]

When the difference between the target velocity (60FF$_h$) and the velocity actual value (606C$_h$) is in the velocity window (606D$_h$) for longer than the velocity window time, the *Target reached bit* (Statusword) is set. The value is given in milliseconds.

Object description:

[1] Available starting with F515K / FA00x firmware version

[2] Available starting with F515K / FA00x firmware version

Index	606E$_h$
Name	Velocity window time
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Yes
Value range	UNSIGNED16
Default value	-

10.2.6 Object 606F$_h$: Velocity threshold

The *velocity threshold* is given in user-defined velocity units and it represents the threshold for velocity at which it is regarded as zero velocity. Based on its value, bit 12 of *Statusword* (speed) will be set or reset.

If no factor is applied, then the value 65536 = 1 encoder increment / sample.

Object description:

Index	606F$_h$
Name	Velocity threshold
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Possible
Value range	UNSIGNED16
Default value	-

10.2.7 Object 60FF$_h$: Target velocity

This object is used for the velocity command only when 6060$_h$ Modes of Operation is 3 (Speed Mode).

The *target velocity* is the input for the trajectory generator and the value is given in user-defined velocity units.

If no factor is applied, then the value 65536 = 1 encoder increment / sample.

Object description:

Index	60FF$_h$
Name	Target velocity
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RW
PDO mapping	possible
Value range	INTEGER32
Default value	-

10.2.8 Object 60F8$_h$: Max slippage

The *max slippage* monitors whether the maximum speed error has been reached. The value is given in user-defined velocity units. When the *max slippage* has been reached, the corresponding bit 13 *max slippage error* in the *Statusword* is set and the drive will fault by signalizing a control error (MER register/object 2000$_h$ bit3=1).

The Speed control error is active only if the speed loop is active in setup. By default it is disabled. The speed control error is set when the actual speed error is greater than what is defined in object 60F8$_h$ for a time defined in object 2005$_h$.

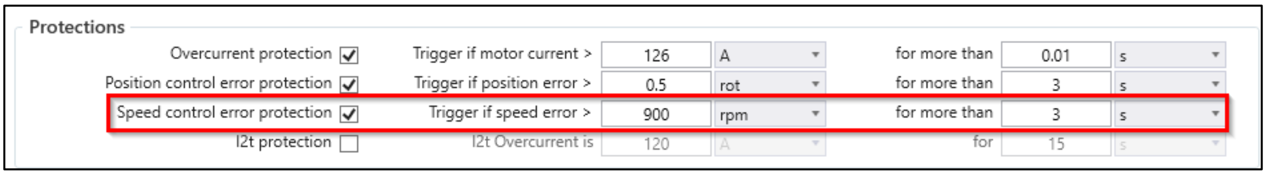
Object description:

Index	60F8$_h$
Name	Max slippage
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RW
PDO mapping	possible
Value range	INTEGER32
Default value	-

This object is automatically set in the Setup part by modifying the Speed control error under the Protections and limits section.



Protections

Overcurrent protection	☑	Trigger if motor current >	126	A	for more than	0.01	s
Position control error protection	☑	Trigger if position error >	0.5	rot	for more than	3	s
Speed control error protection	☑	Trigger if speed error >	900	rpm	for more than	3	s
I2t protection	☐	I2t Overcurrent is	120	A	for	15	s

The value for this object can be changed by editing the parameter “SERRMAX” found in parameters.xml of the project file.

If no factor is applied, then the value 65536 = 1 encoder increment / sample.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

10.2.9 Object 2005$_h$: Max slippage time out

Time interval for *max slippage*. The value is given in slow loop (control loop) time which is by default set to 1ms. This object is coupled with *Object 60F8h: Max slippage*.

Object description:

Index	2005$_h$
Name	Max slippage time out
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Value range	UNSIGNED16
Default value	-

The value for this object can be changed by editing the parameter “TSERRMAX” found in parameters.cfg of the project file.

Activating *Object 2076h: Save current configuration*, will set its current values as the a new default.

10.2.10 Object 2087$_h$[1]: Actual internal velocity from sensor on motor

This object describes the velocity value read from the encoder on the motor in increments, in case a dual loop control method is used. The value is given in increments per sampling loop. The default sampling loop is 1ms.

If no factor is applied, then the value 65536 = 1 encoder increment / sample.

Object description:

Index	2087$_h$
Name	Actual internal velocity sensor on motor
Object code	VAR
Data type	INTEGER32

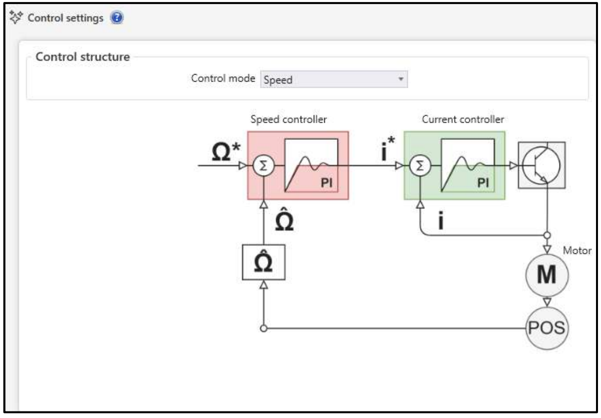
Entry description:

Access	RO
PDO mapping	Possible
Value range	INTEGER32
Default value	-

[1] Object 2087$_h$ applies only to drives which have a secondary feedback

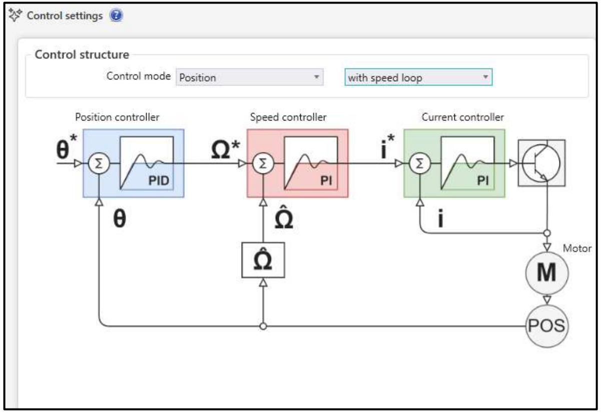
10.3 Speed profile example

Remark: any speed profile mode can be run only if the speed loop is active in setup.
To enable the Current + Speed loop, in the setup part, under Control settings section select:



Control mode: Speed

After the speed is selected, the tuning for the speed loop must be done.
To enable the Current + Speed + Position loop, select:



Control mode: Position, with speed loop

After all three loops are selected, the tuning for the speed and position must be done again.

Execute a speed control with 600 rpm target speed.

1. **Start remote node**.

   Enter **Pre-Operational** state.

   Enter **Safe-Operational** state.

   Enter **Operational** state.
2. **Modes of operation.** Select speed mode.

   Set in **Modes of Operation** mapped in RPDO1 the value 03$_h$.
3. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06$_h$.
4. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07$_h$.
5. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

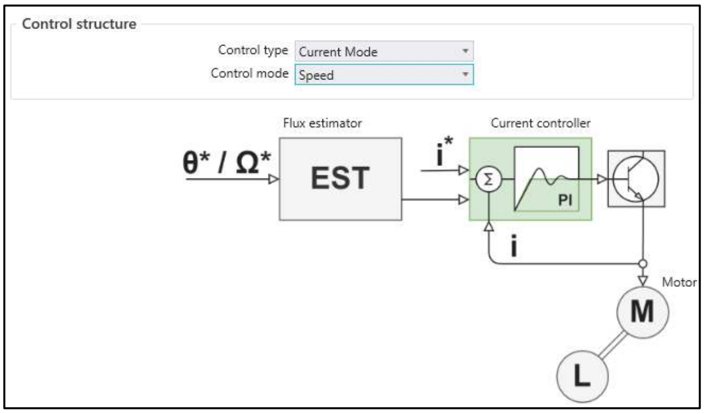
   Set in **Control Word** mapped in RPDO1 the value 0F$_h$.
6. **Target velocity.** Set the target velocity to 600 rpm. By using a 500 lines incremental encoder and 1ms sample rate for position/speed control the corresponding value of object 60FF$_h$ expressed in encoder counts per sample is 140000$_h$ (20.0 IU).

   Send the following message: SDO access to object 60FF$_h$ 32-bit value 00140000$_h$.
7. **Check the motor actual speed.** It should rotate with 600 rpm.

Read by SDO protocol the value of object 606C$_h$.

10.4 Speed profile example for stepper open loop

Remark: In the case of stepper open-loop control, speed control is possible irrespective of the chosen control mode, whether it is speed or position. However, for proper operation, the current controller needs to be tuned.



Control structure

Control type: Current Mode

Control mode: Speed

Execute a speed control with 300 rpm target speed.

1. **Start remote node**.

   Enter **Pre-Operational** state.

   Enter **Safe-Operational** state.

   Enter **Operational** state.
2. **Modes of operation.** Select speed mode.

   Set in **Modes of Operation** mapped in RPDO1 the value 03h.
3. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06h.
4. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07h.
5. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

   Set in **Control Word** mapped in RPDO1 the value 0Fh.
6. **Target velocity.** Set the target velocity to 300 rpm. By using a stepper open-loop control with 200 steps and µstepping set to 512, along with a 1 ms sample rate for position and speed control (slow loop), the 300 rpm expressed in internal units (IU) is 512. This calculation takes into account that 1 rotation is equal to the product of steps number and µstep number, and 1 IU is equivalent to 1 µstep per slow loop. The value to be configured in object 60FFh is 512*65536 = 33554432 = 2000000h

   Send the following message: SDO access to object 60FFh 32-bit value 00140000h.

11 Electronic Gearing Position (EGEAR) Mode

11.1 Overview

In Electronic Gearing Position Mode the drive follows the position of an electronic gearing master with a programmable gear ratio.

The electronic gearing slave can get the position information from the electronic camming master in three ways:

1. Via EtherCAT® master, which writes the master position in object **Master position** (index 201E$_h$).
2. Via an external digital reference[1] of type pulse & direction or quadrature encoder. Both options have dedicated inputs. The pulse & direction signals are usually provided by an indexer and must be connected to the pulse & direction inputs of the drive. The quadrature encoder signals are usually provided by an encoder on the master and must be connected to the 2nd encoder inputs.
3. From one of the analogue inputs of the drive.

The reference type, i.e. the selection between the online reference received via communication channel and the digital reference read from dedicated inputs is done with object **External Reference Type** (index 201D$_h$). The source of the digital reference (pulse & direction or second encoder inputs) is set during drive commissioning.

The drive set as slave in electronic gearing mode performs a position control. At each slow loop sampling period, the slave computes the master position increment and multiplies it with its programmed gear ratio. The result is the slave position reference increment, which added to the previous slave position reference gives the new slave position reference.

Remark: *The slave executes a relative move, which starts from its actual position*

The gear ratio is specified via **EGEAR multiplication factor** object (index 2013$_h$). EGEAR ratio numerator (sub-index 1) is a signed integer, while EGEAR ratio denominator (sub-index 2) is an unsigned integer. The EGEAR ratio numerator sign indicates the direction of movement: positive – same as the master, negative – reversed to the master. The result of the division between EGEAR ratio numerator and EGEAR ratio denominator is used to compute the slave reference increment.

The **Master Resolution** object (index 2012$_h$) provides the master resolution, which is needed to compute correctly the master position and speed (i.e. the position increment). If master position is not cyclic (i.e. the resolution is equal with the whole 32-bit range of position), set master resolution to 0x80000001.

You can smooth the slave coupling with the master, by limiting the maximum acceleration of the slave drive. This is particularly useful when the slave has to couple with a master running at high speed, in order to minimize the shocks in the slave. The feature is activated by setting Controlword.5=1 and the maximum acceleration value in

Object 6083h: Profile acceleration.

11.1.1 Controlword in electronic gearing position mode (slave axis)

MSB **LSB**

See 6040$_h$	Halt	See 6040$_h$	Reserved	Activate Acceleration Limitation	Enable Electronic Gearing Mode	See 6040$_h$
15 9	8	7	6	5	4	3 0

Table 11.1.1 *– Controlword bits for Electronic Gearing Position Mode*

Name	Value	Description
Enable Electronic Gearing Mode	0	Do not start operation
	0 -> 1	Start electronic gearing procedure
	1 -> 0	Does nothing (does not stop current procedure)
Activate Acceleration Limitation	0	Do not limit acceleration when entering electronic gear mode
	1	Limit acceleration when entering electronic gear mode to the value set in *profile acceleration* (object 6083$_h$)
Halt	0	Execute the instruction of bit 4
	1	Stop drive with *profile acceleration*

11.1.2 Statusword in electronic gearing position mode

MSB **LSB**

See 6041$_h$	Following error	Reserved	See 6041$_h$	Target reached	See 6041$_h$

[1] Not all drives have a secondary encoder input.

15	14	13	12	11	10	9	0

Table 11.1.2 *– Statusword bits for Electronic Gearing Position Mode*

Name	Value	Description

Target reached	0	Halt = 0: Always 0
		Halt = 1: Drive decelerates

	1	Halt = 0: Always 0 Halt = 1: Velocity of drive is 0
Following error	0	No following error
	1	Following error occurred

11.2 Gearing Position Mode Objects

11.2.1 Object 201E$_h$: Master position

This object is used in order to receive the position from the master, which is used for Electronic Gearing or Camming calculations. The position units are in increments.

Example: if it takes 4000 increments for the motor to do one revolution, these same increments apply for this object.

Object description:

Index	201E$_h$
Name	Master position
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RW
PDO mapping	Possible
Units	Increments
Value range	0 … 2^{31}-1
Default value	-

11.2.2 Object 2012$_h$: Master resolution

This object is used in order to set the master resolution in increments per revolution. This object is valid for the slave axis.

Object description:

Index	2012$_h$
Name	Master resolution
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Possible
Units	Increments
Value range	0 … 2^{31}-1
Default value	80000001$_h$ (full range)

11.2.3 Object 2013$_h$: EGEAR multiplication factor

In digital external mode, this object sets the gear ratio, or gear multiplication factor for the slaves. The sign indicates the direction of movement: positive – same as the master, negative – reversed to the master. The slave demand position is computed as the master position increment multiplied by the gear multiplication factor.

Example: if the gear ratio is Slave/Master = 1/3, the following values must be set: 1 in EGEAR ratio numerator (sub-index 1) and 3 in EGEAR ratio denominator (sub-index 2) .

Remark: the gear ratio is computed after sub-index 2 is written. So sub-index1 must be written first and then sub-index 2. Even if sub-index 2 has the same value as before, it must be written again for the gear ratio to be computed correctly.

Object description:

Index	2013$_h$
Name	EGEAR multiplication factor
Object code	RECORD
Number of elements	2

Entry description:

Sub-index	1
Description	EGEAR ratio numerator (slave)
Object code	VAR
Data type	INTEGER16
Access	RW
PDO mapping	Possible
Value range	-32768 … 32767
Default value	1

Sub-index	2
Description	EGEAR ratio denominator (master)
Object code	VAR
Data type	UNSIGNED16
Access	RW
PDO mapping	Possible
Value range	0 … 65535
Default value	1

11.2.4 Object 2017$_h$: Master actual position

The actual position of the master can be monitored through this object, regardless of the way the master actual position is delivered to the drive (on-line through a communication channel in object 201E$_h$ or from the digital inputs of the drive). The units are increments.

Object description:

Index	2017$_h$
Name	Master actual position
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	Possible
Value range	-2^{31} … $2^{31}-1$
Default value	0

11.2.5 Object 2018$_h$: Master actual speed

This object is used to inform the user of the actual value of the speed of the master, regardless of the way the master actual position is delivered to the drive (on-line through a communication channel or from the digital inputs of the drive). The units are increments / sampling. 1 IU = 1 encoder increment / sample.

Object description:

Index	2018$_h$
Name	Master actual speed
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RO
PDO mapping	Possible
Value range	-32768 … 32767
Default value	0

11.2.6 Object 201D$_h$: External Reference Type

This object is used to set the type of external reference for use with electronic gearing position, electronic camming position, position external, speed external and torque external modes.

Object description:

Index	201D$_h$
Name	External Reference Type
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Value range	UNSIGNED16

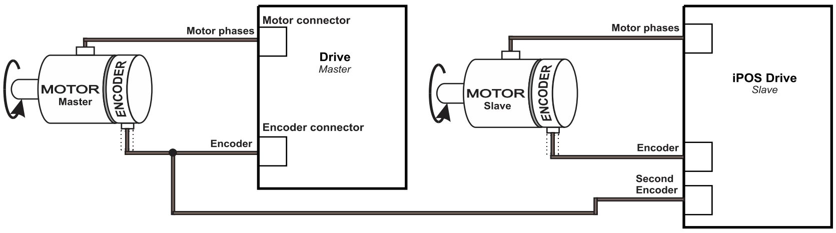
Default value	-

***Table 11.2.1** – External Reference Type bit description*

Value	Description
0	Reserved
1	On-line. Received via object 201E$_h$.
2	Analogue. In case of External Reference Position / Speed / Torque Modes, select this option in order to read the reference from the dedicated analogue input.
3	Digital[1]. In case of External Reference Position Modes, select this option in order to read the reference from the dedicated digital inputs as set in the setup made using EasyMotion Studio II (either 2nd encoder or pulse & direction) In case of Electronic Gearing and Camming Position Modes, select this option in order to read master position from the dedicated digital inputs as set in the setup made using EasyMotion Studio II (either 2nd encoder or pulse & direction)
4 … 65535	Reserved

11.3 Electronic gearing through second encoder input example

The encoder from the master drive can also be connected in parallel to the second encoder input of an iPOS drive (that has one).



After connecting the master encoder to the second encoder input, the Electronic Gearing Slave can be started.

1. **Start remote node**.

   Enter **Pre-Operational** state.

   Enter **Safe-Operational** state.

   Enter **Operational** state.

2. **Modes of operation.** Select Electronic Gearing mode (-1).

   Set in **Modes of Operation** mapped in RPDO1 the value FF$_h$.

3. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06$_h$.

4. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07$_h$.

5. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

   Set in **Control Word** mapped in RPDO1 the value 0F$_h$.

6. **External reference type.** Slave receives reference through 2nd encoder input.

   Send the following message: SDO access to object 201D$_h$ 16-bit value 0003$_h$.

7. **Master resolution.** Set the master resolution 2000, assuming a 500 line encoder is used.

   Send the following message: SDO access to object 2012$_h$ 32-bit value 000007D0$_h$.

8. **Electronic gearing multiplication factor.**

   Set EG numerator to 1.

[1] Not all drives and configurations have secondary encoder inputs.

Send the following message: SDO access to object 2013h, sub-index 1, 16-bit value 0001h.

Set EG denominator to 1.

Send the following message SDO access to object 2013h,sub-index 2, 16-bit value 0001h.

9. Set the initial Master position into the associated RPDO where 201Eh is mapped.

10. **Enable/Start EG slave** in control word associated RPDO.

 Set in **Control Word** mapped in RPDO1 the value 1Fh.

11. Start moving the master encoder and the slave will follow.

11.4 Electronic gearing through online communication example

Start an Electronic Gearing Slave.

1. Map in a RPDO the object 201Eh Master position to be able to send the drive the position reference every communication cycle. See *2.4 PDOs mapping general example* or paragraph *0* for a TwinCAT PDO mapping example.

The PDOs must be sent every slow loop period which is by default 1ms. It is recommended to set the SYNC 0 time equal to the communication cycle and slow loop.

2. **Start remote node**.

 Enter **Pre-Operational** state.

 Enter **Safe-Operational** state.

 Enter **Operational** state.

3. **Modes of operation.** Select Electronic Gearing mode (-1).

 Set in **Modes of Operation** mapped in RPDO1 the value FFh.

4. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

 Set in **Control Word** mapped in RPDO1 the value 06h.

5. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

 Set in **Control Word** mapped in RPDO1 the value 07h.

6. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

 Set in **Control Word** mapped in RPDO1 the value 0Fh.

7. **External reference type.** Slave receives reference through online communication.

 Send the following message: SDO access to object 201Dh 16-bit value 0001h.

8. **Master resolution.** Set the master resolution 2000, assuming a 500 line encoder is used.

 Send the following message: SDO access to object 2012h 32-bit value 000007D0h.

9. **Electronic gearing multiplication factor.**

 Set EG numerator to 1.

 Send the following message: SDO access to object 2013h, sub-index 1, 16-bit value 0001h.

 Set EG denominator to 1.

 Send the following message SDO access to object 2013h,sub-index 2, 16-bit value 0001h.

10. Set the initial Master position into the associated RPDO where 201Eh is mapped.

11. **Enable EG slave** in control word associated RPDO.

 Set in **Control Word** mapped in RPDO1 the value 1Fh.

12. Start changing the Master position in the RPDO where 201Eh is mapped every communication cycle.

The slave motor should start rotating with the same speed as the difference between the master position values received every slow loop.

12 Electronic Camming Position (ECAM) Mode

12.1 Overview

In Electronic Camming Position the drive executes a cam profile function of the position of an electronic camming master. The cam profile is defined by a cam table – a set of (X, Y) points, where X is cam table input i.e. the position of the electronic camming master and Y is the cam table output i.e. the corresponding slave position. Between the points the drive performs a linear interpolation.

The electronic camming slave can get the position information from the electronic camming master in three ways:

1. Via EtherCAT® master, who writes the master position in object **Master position** (index 201E$_h$).
2. Via an external digital reference of type pulse & direction or quadrature encoder. Both options have dedicated inputs. The pulse & direction signals are usually provided by an indexer and must be connected to the pulse & direction inputs of the drive. The quadrature encoder signals are usually provided by an encoder on the master and must be connected to the 2nd encoder inputs.
3. From one of the analogue inputs of the drive.

The reference type, i.e. the selection between the online reference received via communication channel and the digital reference read from dedicated inputs is done with object **External Reference Type** (index 201D$_h$). The source of the digital reference (pulse & direction or second encoder inputs) is set during drive commissioning.

The electronic camming position mode can be: **relative** (if ControlWord.6 = 0) or **absolute** (if ControlWord.6 = 1).

In the relative mode, the output of the cam table is added to the slave actual position. At each slow loop sampling period the slave computes a position increment **dY = Y – Yold**. This is the difference between the actual cam table output Y and the previous one Yold. The position increment dY is added to the old demand position to get a new demand position. The slave detects when the master position rolls over, from 360 degrees to 0 or vice-versa and automatically compensates in dY the difference between **Ymax** and **Ymin**. Therefore, in relative mode, you can continuously run the master in one direction and the slaves will execute the cam profile once at each 360 degrees with a glitch-free transition when the cam profile is restarted.

When electronic camming is activated in relative mode, the slave initializes **Yold** with the first cam output computed: **Yold = Y = f(X)**. The slave will keep its position until the master starts to move and then it will execute the remaining part of the cam. For example if the master moves from X to Xmax, the slave moves with Ymax – Y.

In the absolute mode, the output of the cam table Y is the demand position to reach.

Remark: *The absolute mode must be used with great care because it may generate abrupt variations on the slave demand position if:*

Slave position is different from Y at entry in the camming mode
Master rolls over and Ymax < Ymin

In the absolute mode, you can introduce a maximum speed limit to protect against accidental sudden changes of the positions to reach. The feature is activated by setting ControlWord.5=1 and the maximum speed value in object **Profile Velocity** (index 6081$_h$).

Typically, the cam tables are first downloaded into the EEPROM memory of the drive by the EtherCAT® master or with EasyMotion Studio II. Then using the object **CAM table load address** (index 2019$_h$) they are copied in the RAM address set in object **CAM table run address** (index 201A$_h$). It is possible to copy more than one cam table in the drive/motor RAM memory. When the ECAM mode is activated it uses the CAM table found at the RAM address contained in **CAM table run address**.

A CAM table can be shifted, stretched or compressed.

12.1.1 Controlword in electronic camming position mode

MSB **LSB**

See 6040$_h$	Halt	See 6040$_h$	Abs / Rel	Activate Speed Limitation	Enable Electronic Camming Mode	See 6040$_h$
15 9	8	7	6	5	4	3 0

***Table 12.1.1** – Controlword bits for electronic camming position mode*

Name	Value	Description
Enable Electronic Camming Mode	0	Do not start operation
	0 -> 1	Start electronic camming procedure
	1 -> 0	Do nothing (does not stop current procedure)
Activate Speed Limitation	0	Do not limit speed when entering absolute electronic camming mode
	1	Limit speed when entering absolute electronic camming mode at the value set in *profile velocity* (ONLY for absolute mode)
Abs / Rel	0	Perform relative camming mode – when entering the camming mode, the slave will compute the cam table relative to the starting moment.
	1	Perform absolute camming mode – when entering the camming mode, the slave will go to the absolute position on the cam table
Halt	0	Execute the instruction of bit 4
	1	Stop drive with *profile acceleration*

12.1.2 Statusword in electronic camming position mode

MSB **LSB**

See 6041$_h$		Following error	Reserved	See 6041$_h$	Target reached	See 6041$_h$	
15	4	13	12	11	10	9	0

***Table 12.1.2** – Statusword bits for electronic camming position mode*

Name	**Value**	**Description**

Target reached	0	Halt = 0: Always 0
		Halt = 1: Drive decelerates

	1	Halt = 0: Always 0 Halt = 1: Velocity of drive is 0
Following error	0	No following error
	1	Following error occurred

12.2 Electronic Camming Position Mode Objects

12.2.1 Object 2019$_h$: CAM table load address

This is the **load address** of the CAM table. The CAM table is stored in EEPROM memory of the drive starting from the load address. The initialization of the electronic camming mode requires the CAM table to be copied from the EEPROM memory to the RAM memory of the drive, starting from the **run address**, set in object 201A$_h$, for faster processing. The copy is made every time object 2019$_h$ is written by SDO access.

***Remark:** The **CAM table run address** object must be set before writing the object **CAM table load address** to assure a proper copy operation from EEPROM to RAM memory.*

Object description:

Index	2019$_h$
Name	CAM table load address
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Units	-
Value range	UNSIGNED16
Default value	Variable depending on motor + feedback configuration

12.2.2 Object 201A$_h$: CAM table run address

This is the run address of the CAM table e.g. the RAM address starting from which the CAM table is copied into the RAM during initialization of the electronic camming mode. (See also 2019$_h$).

Object description:

Index	201A$_h$
Name	CAM table run address
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	No
Units	-
Value range	UNSIGNED16
Default value	9E00$_h$

12.2.3 Object 201B$_h$: CAM offset

This object may be used to shift the master position in electronic camming mode. The position actually used as X input in the cam table is not the master actual position (2017$_h$) but (master actual position – CAM offset) computed as modulo of master resolution (2012$_h$) The CAM offset must be set before enabling the electronic camming mode. The *CAM offset* is expressed in increments.

Object description:

Index	201B$_h$
Name	CAM offset
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	No
Value range	0 … 2^{32}-1
Default value	0

12.2.4 Object 206B$_h$: CAM: input scaling factor

You can use this scaling factor in order to achieve a scaling of the input values of a CAM table. Its default value of 00010000$_h$ corresponds to a scaling factor of 1.0.

Object description:

Index	206B$_h$
Name	CAM input scaling factor
Object code	VAR
Data type	FIXED32

Entry description:

Access	RW
PDO mapping	Possible
Units	-
Value range	FIXED32
Default value	00010000$_h$

12.2.5 Object 206C$_h$: CAM: output scaling factor

You can use this scaling factor in order to achieve a scaling of the output values of a CAM table. Its default value of 00010000$_h$ corresponds to a scaling factor of 1.0.

Object description:

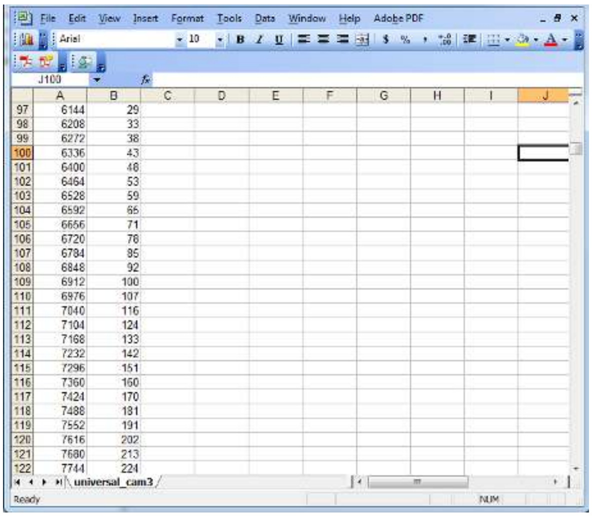
Index	206C$_h$
Name	CAM output scaling factor
Object code	VAR
Data type	FIXED32

Entry description:

Access	RW
PDO mapping	Possible
Units	-
Value range	FIXED32
Default value	00010000$_h$

12.2.6 Building a CAM profile and saving it as an .sw file example

You can create a CAM profile using any program of your choice. In this example, Microsoft Excel is used to construct a CAM table in an organized and effective manner.



	A	B	C	D	E	F	G	H	I	J
97	6144	29								
98	6208	33								
99	6272	38								
100	6336	43								
101	6400	48								
102	6464	53								
103	6528	59								
104	6592	66								
105	6656	71								
106	6720	78								
107	6784	85								
108	6848	92								
109	6912	100								
110	6976	107								
111	7040	116								
112	7104	124								
113	7168	133								
114	7232	142								
115	7296	151								
116	7360	160								
117	7424	170								
118	7488	181								
119	7552	191								
120	7616	202								
121	7680	213								
122	7744	224								

Figure 12.2.1. *MS Excel interface*

CAM tables are structured as arrays of points, where each point consists of two values: X and Y. These values represent the following:

- X: The input value, corresponding to the master position.
- Y: The output value, corresponding to the slave position.

The X points are expressed in the master's internal position units, while the Y points are expressed in the slave's internal position units. Both X and Y values must be stored as 32-bit integers. To ensure proper functionality, the CAM table must respect to the following requirements:

1. The X points must be positive values, including zero.
2. The X points must be equally spaced with an interpolation step that is a power of 2 (e.g., 1, 2, 4, 8, 16, 32, 64, or 128).
3. The maximum number of points for a single CAM table is 8192.

Since the X points are evenly spaced, they can be fully defined using only two parameters:

1. The starting value of the master position, which corresponds to the first X point.
2. The interpolation step, which determines the spacing between consecutive X points.

Using Microsoft Excel, you can input these X and Y points into two separate columns to create the CAM table. Excel provides a straightforward way to visualize and manage the points:

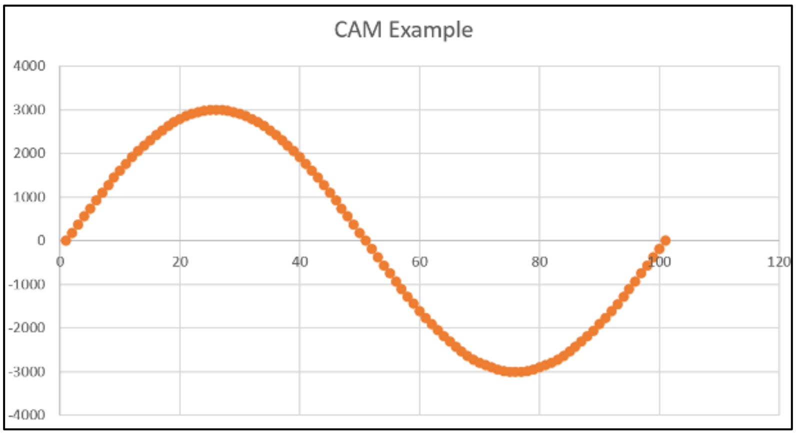
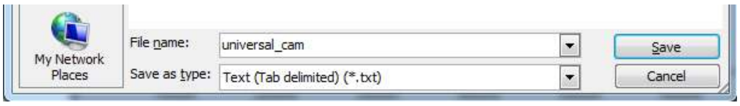


Figure 12.2.2. *Cam example*

After the cam is ready, save it as Text (Tab delimited) (*.txt) file.



File name: universal_cam

Save as type: Text (Tab delimited) (*.txt)

Figure 12.2.3. *Save As example.*

Once you have your cam file saved, start EasyMotion Studio II, either LITE or FULL version.

Press New button and set the appropriate communication settings, then Scan for drives.

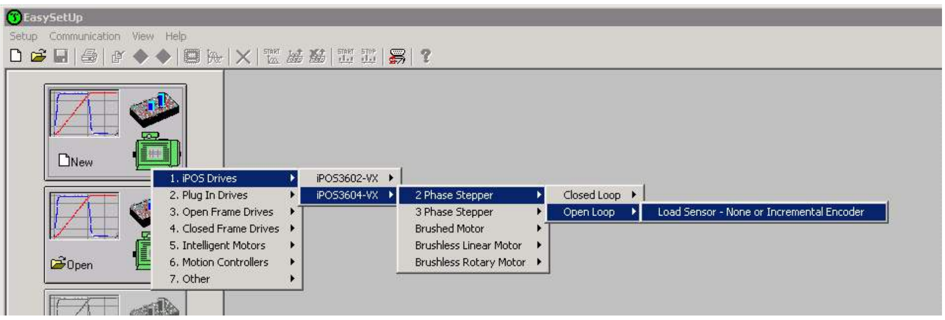
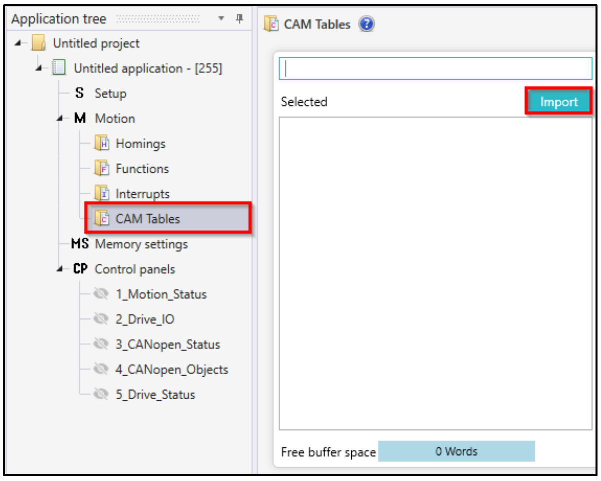


Figure 12.2.4. *Choose drive configuration.*

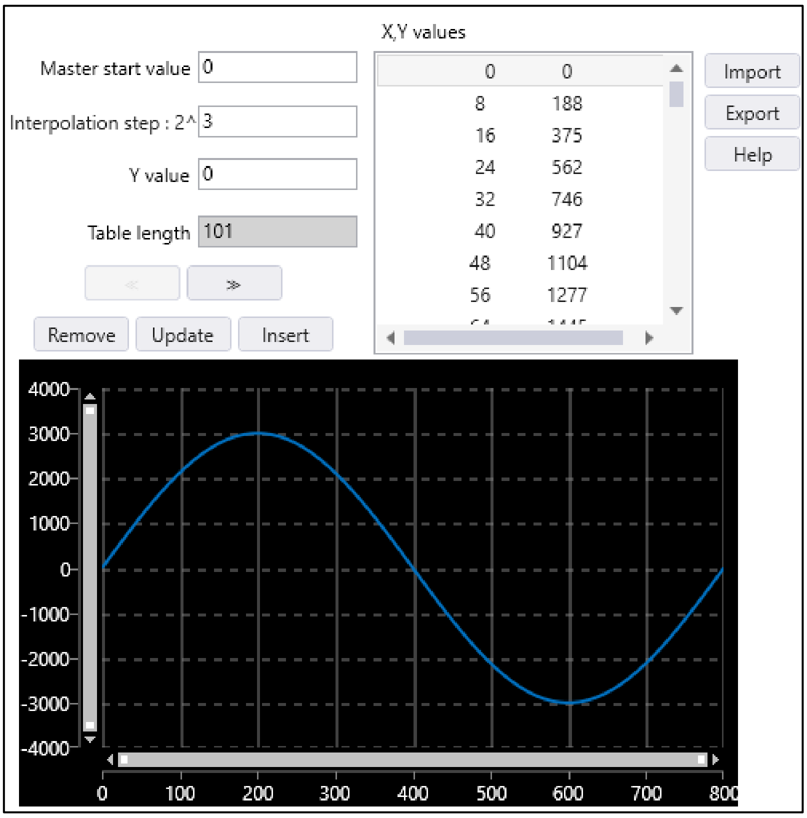
After locating the drive, select the motor technology and open a new configuration. Navigate to the CAM Tables tab in the Application tree (typically located on the left side of the screen by default). Click the Import button and select your recently saved CAM file (refer to **Figure 12.2.5**).



Free buffer space 0 Words

Figure 12.2.5. *CAM tab.*

If the CAM file loaded, it should look like this:



Master start value 0

Interpolation step : 2^ 3

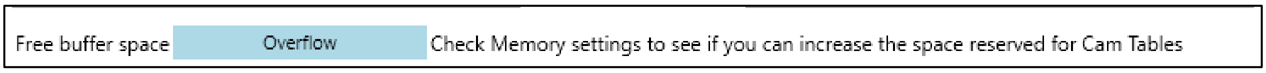
Y value 0

Table length 101

0	0
8	188
16	375
24	562
32	746
40	927
48	1104
56	1277

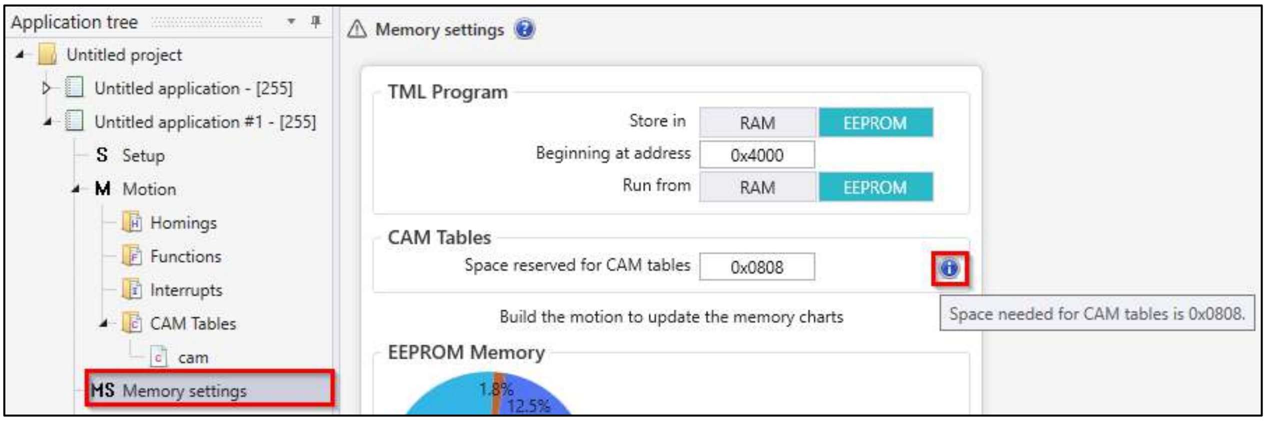
Figure 12.2.6. *CAM file loaded.*

After loading the CAM file, in the CAM tables section, EasyMotion Studio II will display the free buffer space reserved for CAM Tables.



Free buffer space Overflow Check Memory settings to see if you can increase the space reserved for Cam Tables

In the Memory Settings tab, located under the Application tree, EasyMotion Studio II automatically calculates and displays the space required for the uploaded CAM file. Additionally, this tab allows you to adjust the memory allocation reserved for CAM tables as needed.



TML Program

Store in: RAM | EEPROM

Beginning at address: 0x4000

Run from: RAM | EEPROM

CAM Tables

Space reserved for CAM tables: 0x0808

Space needed for CAM tables is 0x0808.

Build the motion to update the memory charts

__Figure 12.2.7.__ Memory settings - CAM tables

In the Memory Settings window, you will find charts for both EEPROM and RAM memory.

- In the EEPROM memory chart, locate the first address listed. This is the CAM Table Load Address, which must be entered later in object Object 2019$_h$: CAM table load address.
- In the RAM memory chart, identify the first address listed. This is the CAM Table Run Address, which must be entered later in object Object 201A$_h$: CAM table run address.

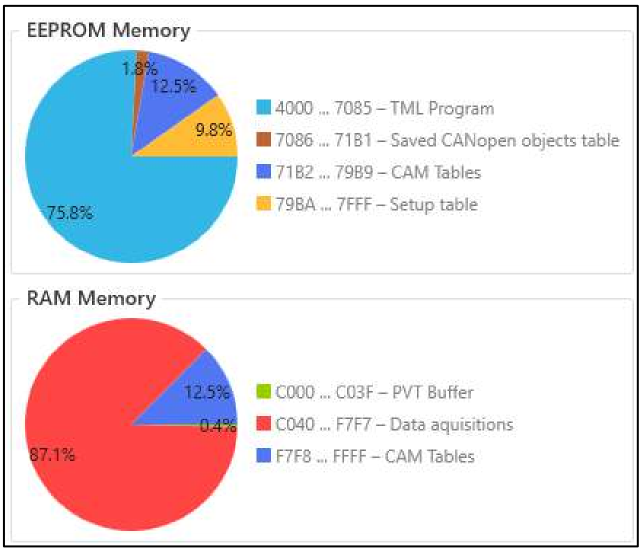


__Figure 12.2.8.__ Cam table load and run addresses.

After loading the CAM file successfully, click over the Application tab and download your saved cam file.

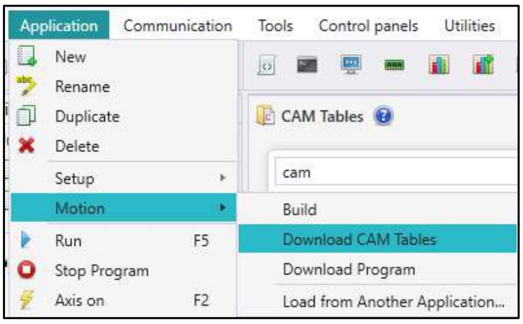
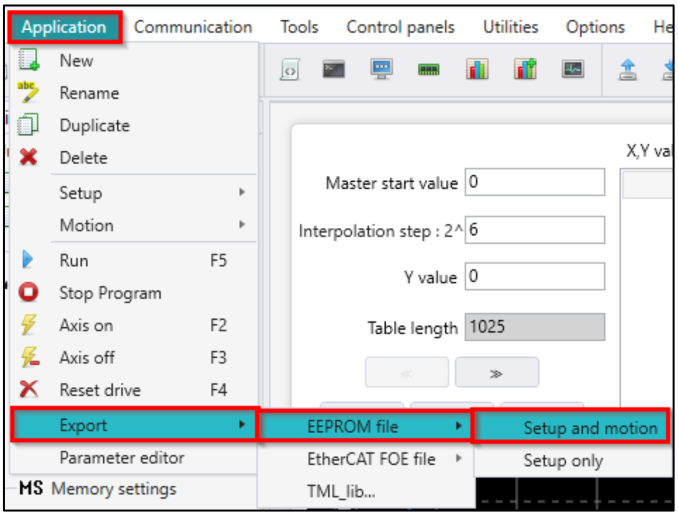


__Figure 12.2.9.__ Download CAM Tables.

To generate a SW file that includes the CAM file, save the project and navigate to Application -> EEPROM file -> Motion and Setup... as shown in the figure below. Save the resulting EEPROM file, which contains your setup and motion data (including the CAM data), to your PC.

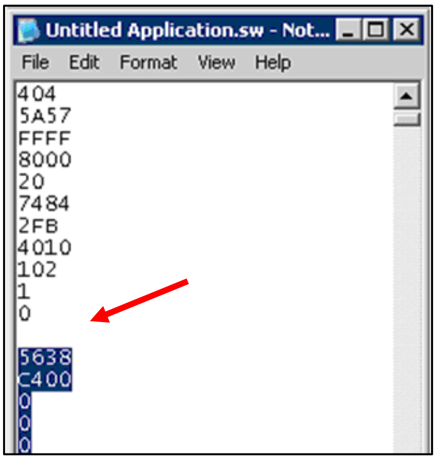


Master start value 0
Interpolation step : 2^ 6
Y value 0
Table length 1025

Figure 12.2.10. *Create .sw file.*

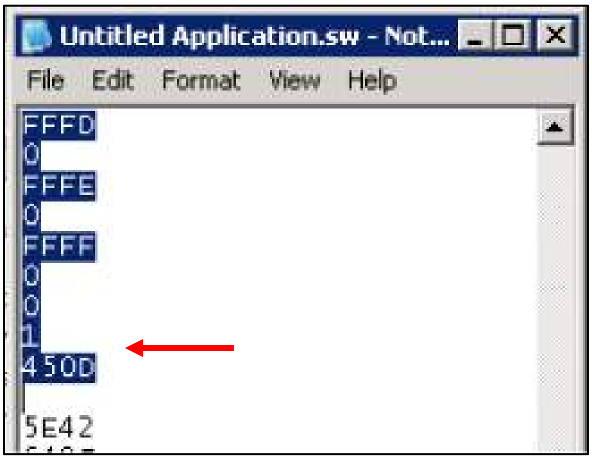
12.2.6.1 Extracting the cam data from the motion and setup .sw file

Open the recently saved .sw file using any text editor. Locate the number corresponding to the CAM Table load address by searching within the file. This number will be preceded by an empty line (as shown in **Figure 12.2.11**) with the preceding numbers representing the setup data. Select all the numbers that correspond to the CAM file, continuing until you encounter another empty line (as illustrated in **Figure 12.2.12**).



```
404
5A57
FFFF
8000
20
7484
2FB
4010
102
1
0

5638
C400
0
0
0
```

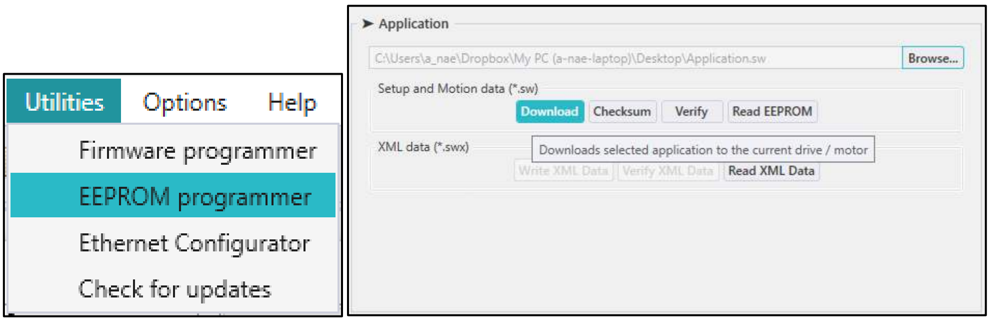
Figure 12.2.11. *.sw file structure example*



```
FFFD
0
FFFE
0
FFFF
0
0
1
450D

5E42
```

Figure 12.2.12. *.sw file empty line*

Copy all the selected numbers and save them as a new text file, changing the extension from .txt to .sw. You now have a file that can be loaded onto the drive using the EEPROM Programmer tool (included with EasyMotion Studio II software) or by utilizing the 2064h and 2065h objects, as explained in the following subchapter.



C:\Users\a_nae\Dropbox\My PC (a-nae-laptop)\Desktop\Application.sw

Downloads selected application to the current drive / motor

Figure 12.2.13. *THS EEPROM Programmer.*

Note: The THS EEPROM programmer allows you to write the entire setup and motion .sw file, not just the CAM .sw file created in this example.

12.2.6.2 Downloading a CAM .sw file with objects 2064$_h$ and 2065$_h$ example

- Send the following message: SDO access to object 2064$_h$ 32-bit value xxxx0008$_h$.

Where xxxx is the first 16 bit number found in the CAM .sw file and represents the CAM table load address. The 08 activates writing/reading 16 bit data in EEPROM memory in object 2064$_h$ (see more in the object description).

All the next numbers until the end of the file must be written with the following type of command.

- Send the following message: SDO access to object 2065$_h$ 32-bit value 0000xxxx$_h$.

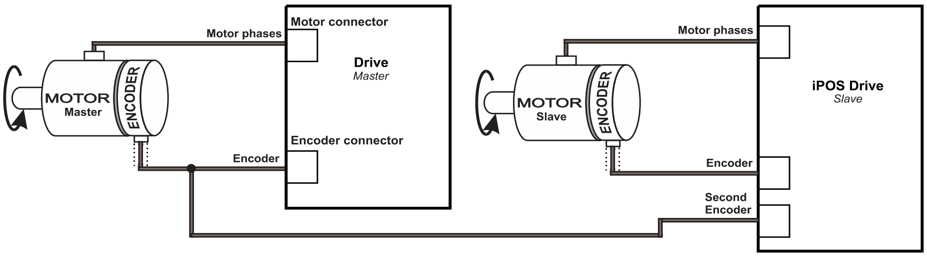
Where xxxx is the 16 bit number taken from the .sw file (the data to write) after the first one (which is the address at which to first write the data and increment it).

Warning! When object 2064$_h$ bit 7=0 (auto-incrementing is ON), do not read the object list in parallel with a read/write operation using a script. By reading object 2066h in parallel with another application, the target memory address will be incremented and will lead to incorrect data writing or reading.

12.3 Electronic camming through second encoder input example

Start an Electronic Gearing Slave.

The encoder from the master drive can also be connected in parallel to the second encoder input of a drive (if the drive is equipped with one).



After connecting the master encoder to the second encoder input, the Electronic Gearing Slave can be started.

1. **Start remote node**.

   Enter **Pre-Operational** state.

   Enter **Safe-Operational** state.

   Enter **Operational** state.

2. **Modes of operation.** Select Electronic Camming mode (-2).

   Set in **Modes of Operation** mapped in RPDO1 the 8 bit value 0xFE.

3. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06$_h$.

4. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07$_h$.

5. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

   Set in **Control Word** mapped in RPDO1 the value 0F$_h$.

6. **External reference type.** Slave receives reference through 2nd encoder input.

   Send the following message: SDO access to object 201D$_h$ 16-bit value 0003$_h$.

7. **Cam table load address.** Set cam table load address as **5638**$_h$.

   The cam table load address can be discovered as explained in paragraph *12.2.6* .

   Send the following message: SDO access to object 2019$_h$ 16-bit value 5638$_h$.

8. **Cam table run address.** Set cam table load address as **97F6**$_h$.

   The cam table load address can be discovered as explained in paragraph *12.2.6* .

   Send the following message: SDO access to object 201A$_h$ 16-bit value 97F6$_h$.

9. **Master resolution.** Set the master resolution 2000, assuming a 500 line encoder is used.

   Send the following message: SDO access to object 2012$_h$ 32-bit value 000007D0$_h$.

10. **Cam offset.** Set cam offset to 6000 counts (0x1770).

    If the master resolution is 2000 counts/revolution, the slave shall start applying the cam when the master is at position 6000 + CamX value.

    Send the following message: SDO access to object 201B$_h$ 32-bit value 00001770$_h$.

11. **Cam input scaling factor.** Set it to 1.

    Send the following message: SDO access to object 206B$_h$ 32-bit value 00000001$_h$.

12. **Cam output scaling factor.** Set it to 1.

    Send the following message: SDO access to object 206C$_h$ 32-bit value 00000001$_h$.
13. Set the initial Master position into the associated RPDO where 201E$_h$ is mapped.
14. **Enable EG slave** in control word associated RPDO.

    Set in **Control Word** mapped in RPDO1 the value 3F$_h$ to start electronic gearing and activate speed limitation.
15. Start changing the Master position.

The slave motor should start rotating. After the master position of 6000 IU (cam offset), the slave motor will rotate depending on the set cam values.

12.4 Electronic camming through online communication example

Start an Electronic Gearing Slave.

1. Map in a RPDO the object 201E$_h$ Master position to be able to send the drive the position reference every communication cycle. See *2.4 PDOs mapping general example* or paragraph *0* for a TwinCAT PDO mapping example.

   The PDOs must be sent every slow loop period which is by default 1ms. It is recommended to set the SYNC 0 time equal to the communication cycle and slow loop.
2. **Start remote node**.

Enter **Pre-Operational** state.

Enter **Safe-Operational** state.

Enter **Operational** state.

3. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

Set in **Control Word** mapped in RPDO1 the value 06$_h$.

4. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

Set in **Control Word** mapped in RPDO1 the value 07$_h$.

5. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

Set in **Control Word** mapped in RPDO1 the value 0F$_h$.

6. **External reference type.** Slave receives reference through online communication.

   Send the following message: SDO access to object 201D$_h$ 16-bit value 0001$_h$.
7. **Cam table load address.** Set cam table load address as **5638**$_h$.

   The cam table load address can be discovered as explained in paragraph *12.2.6*.

   Send the following message: SDO access to object 2019$_h$ 16-bit value 5638$_h$.
8. **Cam table run address.** Set cam table load address as **97F6**$_h$.

   The cam table load address can be discovered as explained in paragraph *12.2.6*.

   Send the following message: SDO access to object 201A$_h$ 16-bit value 97F6$_h$.
9. **Modes of operation.** Select Electronic Gamming mode (-2).

   Set in **Modes of Operation** mapped in RPDO1 the 8 bit value 0xFE.
10. **Master resolution.** Set the master resolution 2000, assuming a 500 line encoder is used.

    Send the following message: SDO access to object 2012$_h$ 32-bit value 000007D0$_h$.
11. **Cam offset.** Set cam offset to 6000 counts (0x1770).

    If the master resolution is 2000 counts/revolution, the slave shall start applying the cam when the master is at position 6000 + CamX value.

    Send the following message: SDO access to object 201B$_h$ 32-bit value 00001770$_h$.
12. **Cam input scaling factor.** Set it to 1.

    Send the following message: SDO access to object 206B$_h$ 32-bit value 00000001$_h$.
13. **Cam output scaling factor.** Set it to 1.

    Send the following message: SDO access to object 206C$_h$ 32-bit value 00000001$_h$.
14. Set the initial Master position into the associated RPDO where 201E$_h$ is mapped.
15. **Enable EG slave** in control word associated RPDO.

    Set in **Control Word** mapped in RPDO1 the value 3F$_h$ to start electronic gearing and activate speed limitation.
16. Start changing the Master position in the RPDO where 201E$_h$ is mapped every communication cycle.

The slave motor should start rotating. After the master reports the position 6000 IU (cam offset), the slave motor shall rotate depending on the set cam values.

13 Cyclic Synchronous Position mode (CSP)

13.1 Overview

The overall structure for this mode is shown in **Figure 13.1.1**. With this 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 performs position control, velocity control and torque control. Measured by sensors, the drive provides actual values for position, velocity and torque to the control device.

The cyclic synchronous position motion can be also limited to a maximum velocity by setting a number in object 6081$_h$ Profile velocity when object 2086$_h$ is set to 1. By default the object 2086$_h$ has the value 0.

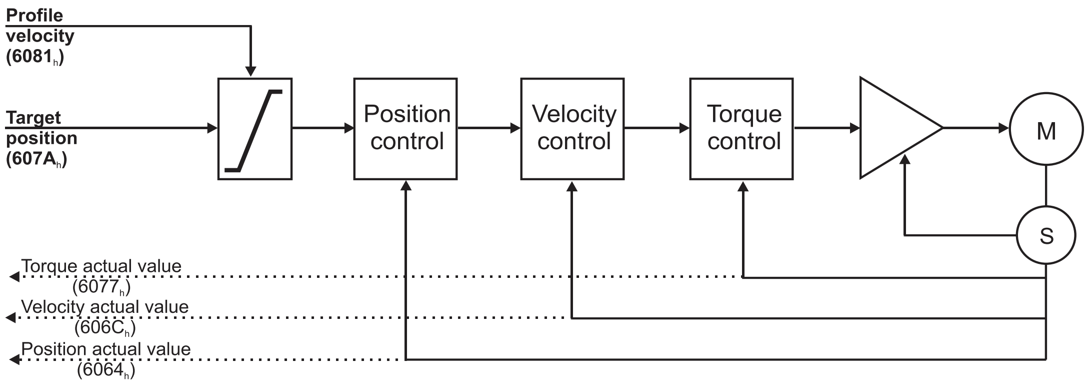

Profile velocity (6081$_h$)
Target position (607A$_h$)
Position control
Velocity control
Torque control
M
S
Torque actual value (6077$_h$)
Velocity actual value (606C$_h$)
Position actual value (6064$_h$)

Figure 13.1.1. *Cyclic synchronous position mode overview*

13.1.1 Controlword in Cyclic Synchronous Position mode (CSP)

MSB **LSB**

See 6040$_h$	Halt	See 6040$_h$	Abs / rel	Reserved	Reserved	See 6040$_h$
15 9	8	7	6	5	4	3 0

Table 13.1.1 *– Controlword bits description for Cyclic Synchronous Position Mode*

Name	Value	Description
Abs / rel	0	Absolute position mode
	1	Relative position mode

In absolute position mode, the drive will always travel to the absolute position given to object 607A$_h$. This is the standard mode.

In Relative position mode, the drive will add to its current position the value received in object 607A$_h$. By sending this value periodically and setting the correct interpolation period time in object 60C2$_h$, it will be like working in Cyclic Synchronous Velocity mode (CSV).

13.1.2 Statusword in Cyclic Synchronous Position mode (CSP)

MSB **LSB**

See 6041$_h$	Following error	Target position ignored	See 6041$_h$	Reserved	See 6041$_h$
15 14	13	12	11	10	9 0

Table 13.1.2 *– Statusword bit description for Cyclic Synchronous Position mode*

Name	Value	Description
Bit 10	0	Reserved
	1	Reserved
Target position ignored	0	Target position ignored
	1	Target position shall be used as input to position control loop
Following error	0	No following error
	1	Following error occurred

13.2 Cyclic Synchronous Position Mode Objects

13.2.1 Object 60C2$_h$: Interpolation time period

The **Interpolation time period** indicates the configured interpolation cycle time. Its value must be set with the time value of the EtherCAT master communication cycle time and sync time in order for the Cyclic Synchronous Position mode to work properly. The interpolation time period (sub-index 01$_h$) value is given in $10^{(\text{interpolation time index})}$ s(second). The interpolation time index (sub-index 02$_h$) is dimensionless.

Example: to set a communication cycle time of 4ms, 60C2$_h$ sub-index 01$_h$ = 4 and 60C2$_h$ sub-index 02$_h$ = -3. The result is 4ms = $4*10^{-3}$.

Because the drive default control loop is 1ms, it means that every new command (in CSP, CSV or CST) will be divided by 4. In other words, in each 1ms, 1/4 of the command will be executed.

Object description:

Index	60C2$_h$
Name	Interpolation time period
Object code	ARRAY
Number of elements	2
Data Type	Interpolation time period record

Entry description:

Sub-index	00$_h$
Description	Number of sub-indexes
Access	RO
PDO mapping	No
Default value	2

Sub-index	01$_h$
Description	Interpolation time period value
Access	RW
PDO mapping	Possible
Value range	Unsigned8
Default value	1

Sub-index	02$_h$
Description	Interpolation time index
Access	RW
PDO mapping	Possible
Value range	INTEGER8, (-128 to +63)
Default value	-3

13.2.2 Object 2086$_h$: Limit speed/acceleration for CSP/CSV[1]

This object is used to set a maximum velocity during CSP mode of operation.

Object description:

Index	2086$_h$
Name	Limit speed/acceleration for CSP
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Yes
Value range	UNSIGNED16
Default value	0000$_h$

If 2086 $_h$ = 1, the limit is active. During CSP mode, the maximum velocity will be the one defined in object 6081$_h$. During CSV mode, the maximum acceleration will be the one defined in object 6083$_h$.

Remark: If 6081$_h$ = 0 and 2086$_h$ =1, during CSP mode, the motor will not move when it receives new position commands because its maximum velocity is limited to 0. The same scenario applies to the CSV mode.

[1] Available only with F515x firmware.

13.3 Cyclic Synchronous Position Mode basic example

1. **Start remote node**.

   Enter **Pre-Operational** state.

   Enter **Safe-Operational** state.

   Enter **Operational** state.

2. **Set the interpolation time object to the value of the communication cycle.**

   By default a new project in TwinCAT runs at 4ms.

   Set Object 60C2$_h$ sub-index 1 to 4.

   Set object 60C2$_h$ sub-index 2 to (-3).

   This means a value of $4^{(-3)}$ which means 4ms.

   Because the drive default control loop is 1ms, it means that when every new position command is received in object 607A$_h$, it will be divided by 4. In other words, over the course of 4ms, the position command will be reached in a linear manner.

3. **Modes of operation.** Select cyclic synchronous position mode.

   Set in **Modes of Operation** mapped in RPDO1 the value 08$_h$.

4. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06$_h$.

5. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07$_h$.

6. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

   Set in **Control Word** mapped in RPDO1 the value 0F$_h$.

7. **Send position points.** The drive will execute a new motion with every new value it receives in RxPDO2 variable Target position which is object 607A$_h$.

Set in **Target position** mapped in RPDO2, the 32bit value xxxxxxxx$_h$. The motor will travel to the new position value within 4ms (as set in 60C2$_h$). If actual position =0 and the new target position is 40, then the motor will move 10 increments in 1 ms and translates to a speed of 10IU/ms.

13.4 Cyclic Synchronous Position Mode TwinCAT3 example

In TwinCAT, the NC-PTP interface actually uses by default the CSP mode. Read chapter *1.5.4* to run the TwinCAT 3 example.

14 Cyclic synchronous Velocity mode (CSV)

14.1 Overview

The overall structure for this mode is shown in *Figure 14.1.1*. With this 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 performs velocity control and torque control. Measured by sensors, the drive device provides actual values for position, velocity and torque to the control device.

The cyclic synchronous velocity motion is limited to a maximum acceleration by setting a number in object 6083$_h$ Profile acceleration.

The cyclic synchronous velocity mode covers the following sub-functions:

Demand value input

Velocity capture using position sensor or velocity sensor

Velocity control function with appropriate input and output signals

Limitation of torque demand

Remark: the speed control loop must be active for this mode to function.

Various sensors may be used for velocity capture. In particular, the aim is that costs are reduced and the drive power system is simplified by evaluating position and velocity using a common sensor, such as is optional using a resolver or an encoder.

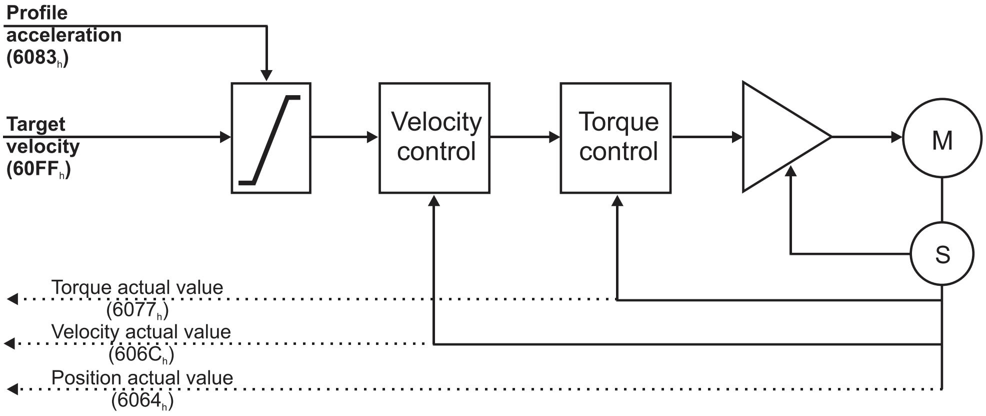

Profile acceleration (6083$_h$)
Target velocity (60FF$_h$)
Velocity control
Torque control
M
S
Torque actual value (6077$_h$)
Velocity actual value (606C$_h$)
Position actual value (6064$_h$)

Figure 14.1.1. *Cyclic synchronous velocity mode overview*

14.1.1 Controlword in cyclic synchronous velocity mode

The cyclic synchronous velocity mode uses no mode specific bits of the Controlword. See *Object* 6040h: Controlword.

14.1.2 Statusword in cyclic synchronous velocity mode

MSB **LSB**

See 6041$_h$	Reserved	Target velocity ignored	See 6041$_h$	Reserved	See 6041$_h$
15 14	13	12	11	10	9 0

Table 14.1.1 *– Statusword bit description for cyclic synchronous velocity mode*

Name	Value	Description
Bit10	0	Reserved
	1	Reserved
Target velocity ignored	0	Target velocity ignored. When 6040$_h$.8 Halt is set to 1.
	1	Target velocity shall be used as input to velocity loop control
Bit13	0	Reserved
	1	Reserved

14.2 Cyclic Synchronous Velocity Mode basic example

1. **Start remote node**.

   Enter **Pre-Operational** state.

2. **Disable the Sync Manager 1C12h by setting Subindex 0 to 0.**

   Send the following message: SDO access to object 1C12h 8-bit value 00h.

3. **Disable the PRDO4 1603h by setting Subindex 0 to 0.**

   Send the following message: SDO access to object 1603h, sub-index 0 the 8-bit value 00h.

4. **Map to PRDO4 1603h the object 60FFh Target velocity.**

   Send the following message: SDO access to object 1603h, sub-index 1 the 32-bit value 60FF0020h.

5. **Enable the PRDO4 1603h by setting Subindex 0 to 1.**

   Send the following message: SDO access to object 1603h, sub-index 0 the 8-bit value 01h.

6. **Map RPDO4 to Sync Manager 1C12h Subindex 3.** The RPDO4 has now mapped the object 60FFh Target velocity.

   Send the following message: SDO access to object 1C12h, Subindex 3, 16-bit value 1603h.

7. **Enable the Sync Manager 1C12h by setting Subindex 0 to 3.**

   Send the following message: SDO access to object 1C12h 8-bit value 03h.

8. **Enter Operational state.**

9. **Set the interpolation time object to the value of the communication cycle.**

   By default a new project in TwinCAT runs at 4ms.

   Set Object 60C2h sub-index 1 to 4.

   Set object 60C2h sub-index 2 to (-3).

   This means a value of $4^{(-3)}$ which means 4ms.

   Because the drive default control loop is 1ms, it means that when every new position command is received in object 607Ah, it will be divided by 4. In other words, over the course of 4ms, the position command will be reached in a linear manner.

10. **Modes of operation.** Select cyclic synchronous velocity mode.

    Set in **Modes of Operation** mapped in RPDO1 the value 09h.

11. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

    Set in **Control Word** mapped in RPDO1 the value 06h.

12. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

    Set in **Control Word** mapped in RPDO1 the value 07h.

13. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

    Set in **Control Word** mapped in RPDO1 the value 0Fh.

14. **Send velocity points.** The drive will change its velocity with every new value it receives in RxPDO4 variable Target velocity which is object 60FFh.

    Set in **Target velocity** mapped in RPDO4, the 32bit value xxxxxxxxh.

Remark: By default, without the Factor Group set, the Target velocity structure is 16.16. Meaning the integer part of the speed in IU is set in the MSB and the fractional is set in the LSB.

15 Cyclic synchronous Torque mode (CST)

15.1 Overview

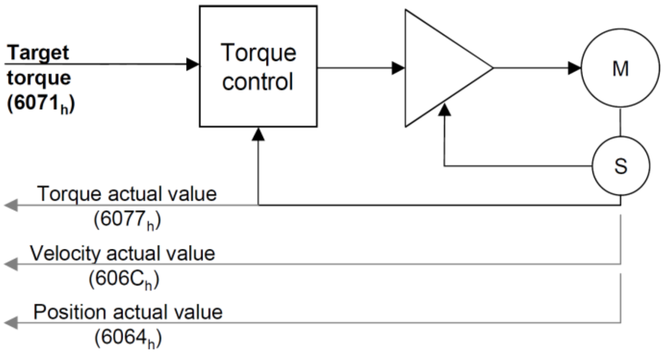
The overall structure for this mode is shown in Figure 14.1. With this mode, the trajectory generator is located in the control device, not in the drive device. In cyclic synchronous manner, it provides a target torque to the drive device, which performs torque control.

Measured by sensors, the drive device provides actual values for position, velocity and torque to the control device.

The cyclic synchronous torque mode covers the following sub-functions:

- demand value input;
- torque capture;
- torque control function with appropriate input and output signals;

limitation of torque demand.



Target torque (6071$_h$)
Torque control
M
S
Torque actual value (6077$_h$)
Velocity actual value (606C$_h$)
Position actual value (6064$_h$)

Figure 15.1.1. *Cyclic synchronous torque mode overview*

15.1.1 Controlword in cyclic synchronous torque mode

The cyclic synchronous torque mode uses no mode specific bits of the Controlword. See *Object 6040h: Controlword*.

15.1.2 Statusword in cyclic synchronous torque mode

MSB LSB

See 6041$_h$		Reserved	Target torque ignored	See 6041$_h$	Reserved	See 6041$_h$	
15	14	13	12	11	10	9	0

Table 15.1.1 *– Statusword bit description for Cyclic Synchronous Torque Mode*

Name	Value	Description
Bit10	0	Reserved
	1	Reserved
Target torque ignored	0	Target torque ignored
	1	Target torque shall be used as input to torque control loop
Bit13	0	Reserved
	1	Reserved

15.2 Cyclic synchronous torque mode objects

15.2.1 Object 6071$_h$: Target torque

This parameter specifies the input value configured for the torque controller when operating in Torque Profile mode. The unit for this object is given in IU, except for FA00x and FA02x firmware versions, where Object 2115$_h$: ASR4 bit 0 controls the unit in which the object is given:

- If ASR4.0 = 0, the unit for this object is given in IU
- If ASR4.0 = 1, the unit is in thousandths (‰) of the motor's rated current specified in object 6075$_h$. Example:

- If the target torque is set to 500, it represents 50.0% (500 ‰) of the motor's rated current.
- If the target torque is set to 255, it represents 25.5% (255 ‰) of the motor's rated current.

Remarks:
1. When object 2115_h is set to 1, the target torque can exceed 100% (equivalent to 1000 ‰) of the motor's rated current, as defined by object 6075_h.
2. The current limit is set through Object $207F_h$: Current limit. This value acts as a safety threshold and will restrict the maximum current, regardless of the value specified in object 6071_h.

Object description:

Index	6071_h
Name	Target torque
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Yes
Value range	INTEGER16
Default value	0000_h

The computation formula for the current [IU] in [A] is:

$$current[IU] = \frac{65520 \cdot current[A]}{2 \cdot Ipeak}$$

where I_{peak} is the peak current supported by the drive and *current[IU]* is the command value for object 6071_h.

15.2.2 Object 6077_h: Torque actual value

This parameter provides the actual value of the torque, reflecting the instantaneous torque in the motor. The unit for this value is in Internal Units (IU), except for FA00x and FA02x firmware versions. In those versions, the unit is determined by the bit 0 of object 2115_h: ASR4:

- If ASR4.0 = 0, the unit is displayed in IU.
- If ASR4.0 = 1, the unit is displayed in thousandths (‰) of the motor's rated current specified in object 6075_h. Example:

  - If the actual torque value is 500, it represents 50.0% (500 ‰) of the motor's rated current.

  - If the actual torque value is 255, it represents 25.5% (255 ‰) of the motor's rated current.

Object description:

Index	6077_h
Name	Torque actual value
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RO
PDO mapping	Yes
Value range	INTEGER16
Default value	No

The computation formula for the current [IU] in [A] is:

$$current[A] = \frac{2 \cdot Ipeak}{65520} \cdot current[IU]$$

where I_{peak} is the peak current supported by the drive and *current[IU]* is the read value from object 6077_h.

15.2.3 Object 6080_h: Max motor speed[1]

This object indicate the configured maximal allowed speed of the motor, taken from the motor specifications, when the mode of operation is CST or External Torque value. The value is given is given in user-defined velocity units. User-defined means it can be modified by Factor group objects. The speed limitation is activated when setting a value different from zero (default).

Object description:

Index	6080_h
Name	Max motor speed
Object code	VAR
Data type	UNSIGNED32

[1] Available starting with firmware version FA00x / FA02x / F515K.

Entry description:

Access	RW
PDO mapping	Possible
Value range	UNSIGNED32
Default value	0

15.2.4 Object 2115$_h$: ASR4[1]

This object is responsible for setting up the ASR4 register, with Bit 0 of ASR4 determining the formatting and representation of values in Object 6071$_h$: Target torque and 6077$_h$: Torque actual value. The remaining bits in ASR4 are reserved.

Object description:

Index	2115$_h$
Name	ASR4
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	no
Value range	UNSIGNED32
Default value	0

15.3 Cyclic synchronous torque (CST) example

1. **Start remote node**.

   Enter **Pre-Operational** state.

2. **Disable the Sync Manager** 1C12$_h$ **Subindex 0 to 0.**

   Send the following message: SDO access to object 1C12$_h$ 8-bit value 00$_h$.

3. **Map RPDO3 to Sync Manager** 1C12$_h$ **Subindex 3.** The RPDO3 has mapped by default, the object 6071$_h$ Target torque.

   Send the following message: SDO access to object 1C12$_h$, Subindex 3, 16-bit value 1602$_h$.

4. **Enable the Sync Manager** 1C12$_h$ **by setting Subindex 0 to 3.**

   Send the following message: SDO access to object 1C12$_h$ 8-bit value 03$_h$.

5. **Enter Operational state.**

   Enter **Safe-Operational** state.

   Enter **Operational** state.

6. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.

   Set in **Control Word** mapped in RPDO1 the value 06$_h$.

7. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.

   Set in **Control Word** mapped in RPDO1 the value 07$_h$.

8. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.

   Set in **Control Word** mapped in RPDO1 the value 0F$_h$.

9. **Modes of operation.** Select cyclic synchronous torque mode.

   Set in **Modes of Operation** mapped in RPDO1 the value 0A$_h$.

10. **Send target torque points.** The drive will apply a new current value with every new command it receives in RxPDO3 variable Target torque which is object 6071$_h$.

Set in **Target torque** mapped in RPDO3, the 16bit value xxxx$_h$.

[1] Available starting with firmware version FA00G / FA02G or newer

16 Touch probe functionality

16.1 Overview

The Touch probe functionality offers the possibility to capture the motor current position when a configurable digital input trigger event happens.

Remark: do not use the touch probe functionality objects during a homing procedure. It may lead to incorrect results.

16.2 Touch probe objects

16.2.1 Object 60B8$_h$: Touch probe function

This object indicates the configuration function of the touch probe.

Object description:

Index	60B8$_h$
Name	Touch probe function
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RW
PDO mapping	Yes
Value range	0 … 65535
Default value	0

Table 16.2.1 *– Bit Assignment of the Touch probe function*

Bit	Value	Description
14,15	-	Reserved
13	0	Switch off sampling at negative edge of touch probe 2
	1	Enable sampling at negative edge of touch probe 2*
12	0	Switch off sampling at positive edge of touch probe 2
	1	Enable sampling at positive edge of touch probe 2*
11,10	00$_b$	Trigger with touch probe 2 input (LSN input)
	01$_b$	Trigger with zero impulse signal
	10$_b$	Reserved
	11$_b$	Reserved
9	0	Trigger first event
	1	Reserved
8	0	Switch off touch probe 2
	1	Enable touch probe 2
7	-	Reserved
6	0	Enable limit switch functionality. The motor will stop, using quickstop deceleration, when a limit switch is active.
	1	Disable limit switch functionality. The motor will not stop when a limit switch is active.
5	0	Switch off sampling at negative edge of touch probe 1
	1	Enable sampling at negative edge of touch probe 1*
4	0	Switch off sampling at positive edge of touch probe 1
	1	Enable sampling at positive edge of touch probe 1*
3,2	00$_b$	Trigger with touch probe 1 input (LSP input)
	01$_b$	Trigger with zero impulse signal
	10$_b$	Reserved
	11$_b$	Reserved
1	0	Trigger first event
	1	Reserved
0	0	Switch off touch probe 1
	1	Enable touch probe 1

***Remarks**:

The position cannot be captured on both positive and negative edges simultaneously using the zero impulse signal as a trigger.

The position cannot be captured when touch probe 1 and 2 are active and the trigger is set on the zero impulse signal.

The following bit settings are reserved:

-Bit 3 and Bit2 = 1;

-Bit 13 and Bit12 = 1;

-Bit11 and Bit2 = 1;

The homing procedures also utilize the capture function. Using this object during a homing procedure may lead to unforeseen results.

16.2.2 Object 60B9h: Touch probe status

This object provides the status of the touch probe.

Object description:

Index	60B9h
Name	Touch probe status
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	Yes
Value range	0 … 65535
Default value	0

***Table 16.2.2** – Bit Assignment of the Touch probe status*

Bit	Value	Description
11 to 15	-	Reserved
10	0	Touch probe 2 no negative edge value stored
	1	Touch probe 2 negative edge position stored in object 60BDh
9	0	Touch probe 2 no positive edge value stored
	1	Touch probe 2 positive edge position stored in object 60BCh
8	0	Touch probe 2 is switched off
	1	Touch probe 2 is enabled
7	-	Reserved
6	0	Limit switch functionality enabled.
	1	Limit switch functionality disabled.
3 to 5	-	Reserved
2	0	Touch probe 1 no negative edge value stored
	1	Touch probe 1 negative edge position stored in object 60BBh
1	0	Touch probe 1 no positive edge value stored
	1	Touch probe 1 positive edge position stored in object 60BAh
0	0	Touch probe 1 is switched off
	1	Touch probe 1 is enabled

Note: Bit 1 and bit 2 are set to 0 when touch probe 1 is switched off (object 60B8h bit 0 is 0). Bit 9 and 10 are set to 0 when touch probe 2 is switched off (object 60B8h bit 8 is 0). Bits 1,2,9 and 10 are set to 0 when object 60B8h bits 4,5,12 and 13 are set to 0.

16.2.3 Object 60BAh: Touch probe 1 positive edge

This object provides the position value of the touch probe 1 at positive edge.

Object description:

Index	60BAh
Name	Touch probe 1 positive edge
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	YES
Value range	$-2^{31}…2^{31}-1$
Default value	-

16.2.4 Object 60BB$_h$: Touch probe 1 negative edge

This object provides the position value of the touch probe 1 at negative edge.

Object description:

Index	60BB$_h$
Name	Touch probe 1 negative edge
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	YES
Value range	$-2^{31}…2^{31}-1$
Default value	-

16.2.5 Object 60BC$_h$: Touch probe 2 positive edge

This object provides the position value of the touch probe 2 at positive edge.

Object description:

Index	60BC$_h$
Name	Touch probe 2 positive edge
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	YES
Value range	$-2^{31}…2^{31}-1$
Default value	-

16.2.6 Object 60BD$_h$: Touch probe 2 negative edge

This object provides the position value of the touch probe 2 at negative edge.

Object description:

Index	60BD$_h$
Name	Touch probe 2 negative edge
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	YES
Value range	$-2^{31}…2^{31}-1$
Default value	-

16.2.7 Object 2104$_h$[1]: Auxiliary encoder function

This object configures the auxiliary feedback position capture on the zero impulse signal.

Object description:

Index	2104$_h$
Name	Auxiliary encoder function
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RW
PDO mapping	Yes
Value range	0 … 255
Default value	0

[1] Object 2104$_h$ applies only to drives which have a secondary feedback input with an index signal

***Table 16.2.3** – Bit Assignment of the Auxiliary encoder function*

Bit	Value	Description
8..6	-	Reserved
5	0	Switch off sampling at negative edge of touch probe
	1*	Enable sampling at negative edge of touch probe
4	0	Switch off sampling at positive edge of touch probe
	1*	Enable sampling at positive edge of touch probe
3	-	Reserved
2	0	Reserved
	1	Trigger with zero impulse signal
1	-	Reserved
0	0	Switch off touch probe
	1	Enable touch probe

***Remark**

The position cannot be captured on both positive and negative edges simultaneously using the zero impulse signal as a trigger.

16.2.8 Object 2105h[1]: Auxiliary encoder status

This object provides the status of the auxiliary feedback touch probe.

Object description:

Index	2105h
Name	Auxiliary encoder status
Object code	VAR
Data type	UNSIGNED8

Entry description:

Access	RO
PDO mapping	Yes
Value range	0 … 255
Default value	0

***Table 16.2.4** – Bit Assignment of the Auxiliary encoder status*

Bit	Value	Description
8 to 3	-	Reserved
2	0	Auxiliary feedback touch probe no negative edge value stored
	1	Auxiliary feedback touch probe negative edge position stored in object 2107h
1	0	Auxiliary feedback touch probe no positive edge value stored
	1	Auxiliary feedback touch probe positive edge position stored in object 2106h
0	0	Auxiliary feedback touch probe is switched off
	1	Auxiliary feedback touch probe is enabled

Note: Bit 1 and bit 2 are set to 0 when auxiliary feedback touch probe is switched off (object 2104h bit 0 is 0). Bits 1 and 2 are set to 0 when object 2104h bits 4 and 5 are set to 0.

16.2.9 Object 2106h[2]: Auxiliary encoder captured position positive edge

This object provides the position value of the auxiliary feedback captured at positive edge.

Object description:

Index	2106h
Name	Auxiliary encoder captured positive edge
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	YES
Value range	$-2^{31}…2^{31}-1$
Default value	-

[1] Object 2105h applies only to drives which have a secondary feedback input with an index signal

[2] Object 2106h applies only to drives which have a secondary feedback input with an index signal

16.2.10 Object 2107h[1]: Auxiliary encoder captured position negative edge

This object provides the position value of the auxiliary feedback captured at negative edge.

Object description:

Index	2107h
Name	Auxiliary encoder captured position negative edge
Object code	VAR
Data type	INTEGER32

Entry description:

Access	RO
PDO mapping	YES
Value range	$-2^{31}…2^{31}-1$
Default value	-

16.3 Touch probe example

In this example, the touch probe 1 will be enabled to capture the position when the positive limit switch LSP is triggered on the positive edge while moving the motor in trapezoidal mode.

1. **Start remote node**.
   Enter **Pre-Operational** state.

   Enter **Safe-Operational** state.

   Enter **Operational** state.
2. **Modes of operation.** Select position mode.
   Set in **Modes of Operation** mapped in RPDO1 the value 01h.
3. **Ready to switch on.** Change the node state from *Switch on disabled* to *Ready to switch on* by sending the shutdown command.
   Set in **Control Word** mapped in RPDO1 the value 06h.
4. **Switch on.** Change the node state from *Ready to switch on* to *Switch on* by sending the switch on command.
   Set in **Control Word** mapped in RPDO1 the value 07h.
5. **Enable operation.** Change the node state from *Switch on* to *Operation enable* by sending the enable operation command.
   Set in **Control Word** mapped in RPDO1 the value 0Fh.
6. **Target position.** Set the target position to 4 rotations. By using a 500 lines incremental encoder the corresponding value of object 607Ah expressed in encoder counts is 1F40h.
   Set in **Target position** mapped in RPDO2 the value 00001F40h.
7. **Target speed.** Set the target speed normally attained at the end of acceleration ramp to 2IU/ms (low speed).
   Send the following message: SDO access to object 6081h, 32-bit value 00020000h.
8. **Set touch probe function to 0x11.** Set touch probe function to enable touch probe 1, touch probe 1 to be the positive limit switch LSP, capture the position on the positive edge of the signal (when LSP goes low to high).
   Send the following message: SDO access to object 60B8h, 16-bit value 0011h.
9. **Read touch probe status.** Read touch probe status.
   Send the following message: SDO read access to object 60B9h.

   If the read value is 0x0001 it means that touch probe 1 is active (bit0=1) and a capture was detected on the positive edge (bit1=1).
10. **While the motor is moving, trigger the LSP input. The motor should stop.**
11. **Read touch probe status.** Read touch probe status.
    Send the following message: SDO read access to object 60B9h.

    If the read value is 0x0003 it means that touch probe 1 is active (bit0=1) and no capture was detected on the positive edge (bit1=0).
12. **Read the touch probe 1 positive edge captured value.**
    Send the following message: SDO read access to object 60BAh.

    If the read value should be close to the value of motor actual position (6064h). When the capture was detected, the motor was moving. The limit switch caused the motor to decelerate and stop after the even occurred.

[1] Object 2107h applies only to drives which have a secondary feedback input with an index signal

17 Data Exchange between EtherCAT® master and drives

17.1 Checking Setup Data Consistency

During the configuration phase, an EtherCAT® master can quickly verify using the checksum objects and a reference .sw file whether the non-volatile EEPROM memory of the drive contains the right information. If the checksum reported by the drive does not match the one computed from the .sw file, the EtherCAT® master can download the entire .sw file into the drive EEPROM using the communication objects for writing data into the drive EEPROM.

In order to be able to inspect or to program any memory location of the drive, as well as for downloading of a new TML program (application software), three manufacturer specific objects were defined: Object 2064$_h$ – Read/Write Configuration Register, 2065$_h$ – Write Data at address specified in 2064$_h$, 2066$_h$ – Read Data from address specified in 2064$_h$, 2067$_h$ – Write data at specified address.

17.2 Data Exchange Objects

17.2.1 Object 2064$_h$: Read/Write Configuration Register

Object Read/Write Configuration Register 2064$_h$ is used to control the read from drive memory and write to drive memory functions. This object contains the current memory address that will be used for a read/write operation. It can also be specified through this object the type of memory used (EEPROM, data or program) and the data type the next read/write operation refers to. Additionally, it can be specified whether an increment of the memory address should be performed or not after the read or write operation. The auto-increment of the memory address is particularly important in saving valuable time in case of a program download to the drive as well when a large data block should be read from the device.

Object description:

Index	2064$_h$
Name	Read/Write configuration register
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	Possible
Units	-
Value range	0 … 2^{32}-1
Default value	0x84

Table 17.2.1 *– Read/Write Configuration Register bit description*

Bit	Value	Description
31…16	x	16-bit memory address for the next read/write operation
15…8	0	Reserved (always 0)
7	0	Auto-increment the address after the read/write operation
	1	Do not auto-increment the address after the read/write operation
6…4	0	Reserved (always 0)
3,2	00	Memory type is program memory
	01	Memory type is data memory
	10	Memory type is EEPROM memory
	11	Reserved
1	0	Reserved (always 0)
0	0	Next read/write operation is with a 16-bit data
	1	Next read/write operation is with a 32-bit data

Warning! When object 2064$_h$ bit 7=0 (auto-incrementing is ON), do not read the object list in parallel with a read/write operation using a script. By reading object 2066$_h$ in parallel with another application, the target memory address will be incremented and will lead to incorrect data writing or reading.

17.2.2 Object 2065$_h$: Write 16/32 bits data at address set in Read/Write Configuration Register

The object is used to write 16 or 32-bit values using the parameters specified in object 2064$_h$ – Read/Write Configuration Register. After the successful write operation, the memory address in object 2064$_h$, bits 31…16 will be auto-incremented or not, as defined in the same register. The auto-incrementing of the address is particularly useful in downloading a program (software application) in the drives memory.

Object description:

Index	2065h
Name	Write data at address set in 2064h (16/32 bits)
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	WO
PDO mapping	Possible
Units	-
Value range	0 … 2^{32}-1
Default value	No

The structure of the parameter is the following:

Bit	Value	Description
31…16	0	Reserved if bit 0 of object 2064h is 0 (operation on 16 bit variables)
	X	16-bit MSB of data if bit 0 of object 2064h is 1 (operation on 32 bit variables)
15…0	X	16 bit LSB of data

17.2.3 Object 2066h: Read 16/32 bits data from address set in Read/Write Configuration Register

This object is used to read 16 or 32-bit values with parameters that are specified in object 2064h – Read/Write Configuration Register. After the successful read operation, the memory address in object 2064h, bits 31…16, will be auto-incremented or not, as defined in the same register.

Object description:

Index	2066h
Name	Read data from address set in 2064h (16/32 bits)
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RO
PDO mapping	No
Units	-
Value range	UNSIGNED32
Default value	No

The structure of the parameter is the following:

Bit	Value	Description
31…16	0	Reserved if bit 0 of object 2064h is 0 (operation on 16 bit variables)
	X	16-bit MSB of data if bit 0 of object 2064h is 1 (operation on 32 bit variables)
15…0	X	16 bit LSB of data

17.2.4 Object 2067h: Write 16bit data at specified address

This object is used to write a single 16-bit value at a specified address in the memory type defined in object 2064h – Read/Write Configuration Register. The rest of the bits in object 2064h do not count in this case, e.g. the memory address stored in the Read/Write Control Register is disregarded and also the control bits 0 and 7. The object may be used to write only 16-bit data. Once the type of memory in the Read/Write Control Register is set, the object can be used independently. If mapped on a PDO, it offers quick access to any drive internal variable.

Object description:

Index	2067h
Name	Write data at specified address
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	WO
PDO mapping	Possible
Units	-
Value range	UNSIGNED32
Default value	No

Bit	Value	Description
31…16	x	16-bit memory address
15…0	X	16 bit data value to be written

17.2.4.1 Writing 16 bit data to a specific address using object 2067h example

Considering the following variable found in variables.xml in the /Firmwares/F515I folder:

UINT POSOKLIM @0x036A. It means that it is found at address 0x036A.

Write the data **0x1234** to address **0x036A** using SDO access to object 2067h:

SDO access to object 2067h 32-bit value **036A1234**h.

17.2.5 Object 2069h: Checksum configuration register

This object is used to specify a start address and an end address for the drive to execute a checksum of the E2ROM memory contents. The 16 LSB of this object are used for the start address of the checksum, and the 16 MSB for the end address of the checksum.

Note: The end address of the checksum must be computed as the start address to which you add the length of the section to be checked. The drive will actually compute the checksum for the memory locations between start address and end address.

The checksum is computed as a 16 bit unsigned addition of the values in the memory locations to be checked. When the object is written through SDO access, the checksum will be computed and stored in the read-only object 206Ah.

Object description:

Index	2069h
Name	Checksum configuration register
Object code	VAR
Data type	UNSIGNED32

Entry description:

Access	RW
PDO mapping	No
Units	-
Value range	UNSIGNED32
Default value	No

The structure of the parameter is the following:

Bit	Value	Description
31…16	X	16-bit end address of the checksum
15…0	X	16 bit start address of the checksum

17.2.6 Object 206Ah: Checksum read register

This object stores the latest computed checksum.

Object description:

Index	206Ah
Name	Checksum read register
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	RO
PDO mapping	No
Units	-
Value range	UNSIGNED16
Default value	No

17.2.7 Object 210Ch: enable SW file download

This object allows writing a SW file using FoE protocol while in BOOTSTRAP state.

TwinCAT3 has the function “fbDownload” which can be used for FoE transfer protocol. When this function is called, the drive is reset into BOOTSTRAP state.

This object must be set to 0 to use the function to download a firmware file using FoE protocol.

This object must be set to 1 to use the function to download a SW setup file using FoE protocol.

Object description:

Index	210Ch
Name	Enable SW file download
Object code	VAR
Data type	INTEGER16

Entry description:

Access	RW
PDO mapping	Yes
Units	-
Value range	INTEGER16
Default value	No

17.3 Image Files Format and Creation

An image file with the .sw extension is essentially a text file that can be opened and read using any text editor. It consists of blocks of data, each separated by an empty line. Every block begins with a block start address, followed by data values that are written sequentially to ascending memory addresses. Specifically:

- The first data value is written to the block start address.
- The second data value is written to the start address + 1, and so on.

All data values are represented as 16-bit hexadecimal numbers (up to 4 hexadecimal digits). Each line contains a single data value, and any value with fewer than 4 digits must be right-aligned. For instance, the value 42 corresponds to 0x0042.

A software file can contain up to 4 sections:

1. TML program
2. setup table
3. product and application ID
4. setup table start address

The .sw files can be created using EasyMotion Studio II (both full and lite versions) by navigating to: Application | Export | EEPROM Programmer File | Motion and Setup or Setup Only.

- The Motion and Setup option generates a .sw file containing comprehensive data, including setup configurations, TML programs, cam tables (if applicable), and drive/motor configuration IDs.
- The Setup Only option creates a .sw file with just the setup data and configuration IDs.

The .sw file can be programmed into a drive using the following methods:

1. From an EtherCAT® master, utilizing communication objects to write data into the drive's EEPROM.
2. Using the EEPROM Programmer tool, included with EasyMotion Studio II, which is designed for quick, repetitive programming of .sw files into Technosoft drives during production.

17.4 Downloading an image file (.sw) to the drive using CoE objects example

The structure of an image file (.sw) is described in paragraph **17.3** and shown in **Figure 17.4.1**.

In order to download the data block pointed by the red arrow, first the block start address i.e. 5638$_h$ must be set using an SDO access to object 2064$_h$.

- Send the following message: SDO access to object 2064$_h$, 32-bit value **5638**0008$_h$.

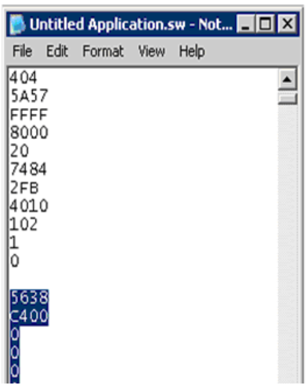
The above configuration command also indicates that next read or write operation shall be executed with drive's EEPROM memory using 16-bit data and auto increment of address. All the numbers from the lines after 5638$_h$ until the following blank line represents data to write in the EEPROM memory at consecutive addresses starting with 5638$_h$. The data writes are done using an SDO access to object 2065$_h$. First data word C400$_h$ is written using:

- Send the following message: SDO access to object 2065$_h$, 32-bit value 0000**C400$_h$**.

From the whole 32bit number, only **C400$_h$** will be written and 0000$_h$ will be ignored because the write operation was configured for 16bits in object 2065 $_h$.

Next data word 0000$_h$ is written with:

Send the following message: SDO access to object 2065$_h$, 32-bit value 0000**0000$_h$**.



```
404
5A57
FFFF
8000
20
7484
2FB
4010
102
1
0

5638
C400
0
0
0
```

Figure 17.4.1. *.sw file structure example*

Continue sending the 16 bit data, until the next blank line from the .sw file. Because the next data after a blank line is again an address, and the above process repeats. Finally to verify the integrity of the information stored in the drive EEPROM, checksum objects 2069$_h$ and 206A$_h$ can be used to compare the checksum computed by the drive with that computed on the master.

Warning! When object 2064$_h$ bit 7=0 (auto-incrementing is ON), do not read the object list in parallel with a read/write operation using a script. By reading object 2066$_h$ in parallel with another application, the target memory address will be incremented and will lead to incorrect data writing or reading.

17.4.1 Checking and loading the drive setup via .sw file and CoE commands example.

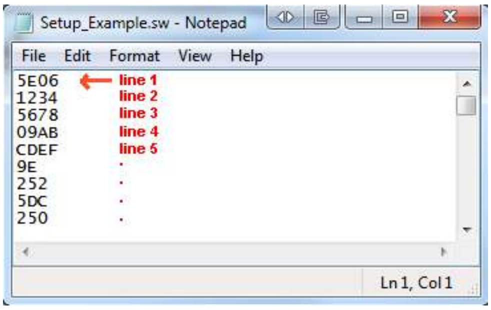
Check the integrity of the setup data on a drive and update it if needed.

Before reading this example, please read **paragraph 17.4.**

To create a .sw file containing only the setup data do the following:

- In EasyMotion Studio II navigate to Application | Export | EEPROM Programmer File | Setup Only. Choose where to save the .sw file.

Let's suppose that the setup data of a Technosoft drive is located at EEPROM addresses between 0x**5E06** and 0x**5EFF**. Here are the steps to be taken in order to check the setup data integrity and to re-program the drive if necessary:



```
5E06
1234
5678
09AB
CDEF
9E
252
5DC
250
```

1. **Compute the checksum in the .sw file**. Let's suppose that the computed checksum is 0x1234.
2. **Access object 2066$_h$ in order to compute the checksum of the setup table located on the drive.** Write the value 0x**5EFF5E06**

   Send the following message: SDO write to object 2066$_h$ sub-index 0, 32-bit value 5EFF5E06$_h$.

Following the reception of this message, the drive will compute the checksum of the EEPROM locations 0x**5E06** to 0x**5EFF**. The result is stored in the object 206A$_h$.

3. **Read the computed checksum from object 206A$_h$**.

   Read by SDO protocol the value of object 206A$_h$.

   Let us assume the drive returns the following message (Object 206A$_h$ = 0x2345):

As the returned checksum (0x2345) does not match the checksum computed from the .sw file, the setup table has to be configured from the .sw file.

4. **Prepare the Read/Write Configuration Register for EEPROM write**. Let us assume the address 0x**5E06** is the first 16 bit number found in the .sw file where setup data begins**.** Write the value 0x**5E06**0009 into the object 2064$_h$ (write 32-bit data at EEPROM address 0x**5E06** and auto-increment the address after the write operation).

   Send the following message: SDO write to object 2064$_h$ sub-index 0, 32-bit value 5E060009$_h$.

5. **Write the sw file data 32 bits at a time**. Supposing that the next 2 entries in the .sw file after the start address 0x**5E06** are 0x**1234** and 0x**5678**, you have to write the value 0x**56781234** into object 2065$_h$.

   Send the following message (SDO write to object 2065$_h$ sub-index 0, 32-bit value 56781234$_h$):

The number 0x**1234** will be written at address 0x**5E06** and 0x**5678** will be at 0x**5E07**.

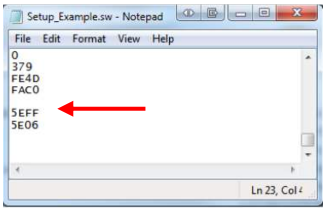
6. Assuming the next data after 0x**5678** will be 0x**09AB** and 0x**CDEF**, write the value 0x**CDEF09AB** into object 2065$_h$.

   Send the following message (SDO write to object 2065$_h$ sub-index 0, 32-bit value CDEF09AB$_h$):

The number 0x**09AB** will be written at address 0x**5E08** and 0x**CDEF** will be at 0x**5E09**.

7. **Repeat step 5 until a blank line is found in the .sw file.**

This means that all the setup data is written, even if there is more data after the blank line.



```
0
379
FE4D
FAC0

5EFF
5E06
```

8. **Re-check the checksum (repeat steps 2 and 3). If ok, go to step 9**

9. **Reset the drive in order to activate the new setup.**

Send with the Cob ID 0x0 the data 0x81 0x0A. Where 0x0A means Axis ID 10.

Warning!	When object 2064$_h$ bit 7=0 (auto-incrementing is ON), do not read the object list in parallel with a read/write operation using a script. By reading object 2066$_h$ in parallel with another application, the target memory address will be incremented and will lead to incorrect data writing or reading.

17.4.2 SW file Checksum calculation C# example code

The code presented below is written in C# language and its structure can be used as an example for other programming languages.

The program itself works as standalone. Just create a new console script in Visual Studio C# 2005 or newer and copy it directly.

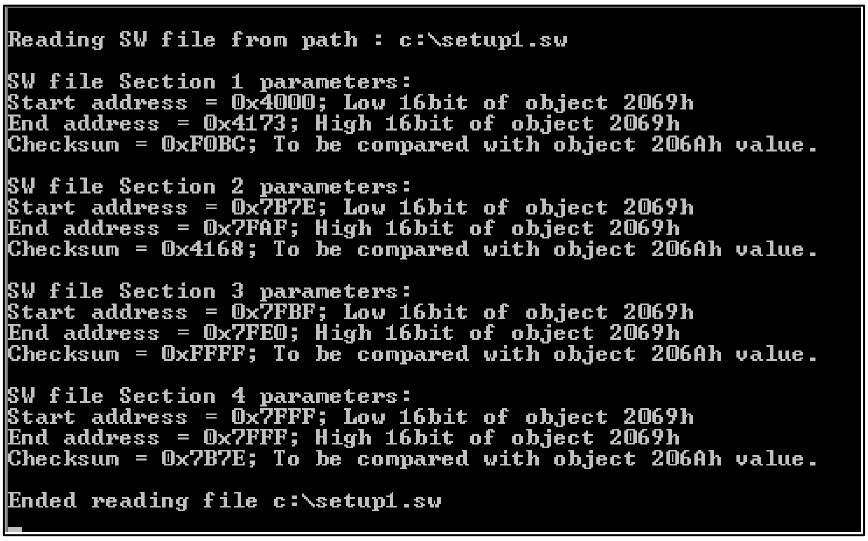
A script cam download a .sw file and at the same time calculate the checksum for each section in order to verify it later with object 2066$_h$ and 206A$_h$.

A SW file has up to 4 data sections. This script will Display the Start, End address and Checksum of each section. These three parameters can later be used with objects 2066$_h$ and 206A$_h$ to verify the checksum on the drive after the SW file is downloaded. Later, to verify the data integrity, at each drive start-up, the checksum can be verified to ensure the correct setup data is present on the drive.

17.4.2.1 SW file Checksum calculation C# example code

```
using System;
using System.Collections.Generic;
using System.Text;
using System.IO;
using System.Threading;
using System.Collections;
using System.Runtime;
using System.Diagnostics;

namespace THS_checksum_calculator
{
    static class Program
    {
        static void Main(string[] args)
        {
            String Path = "c:\\setup1.sw"; //define the SW file path
            CalculateSWfileChecksum(Path);
        }
        private static void CalculateSWfileChecksum(String Path)
        {
            System.Console.WriteLine("");
            System.Console.WriteLine ("Reading SW file from path : " + Path);
            System.Console.WriteLine ("");
            try
            {
                StreamReader sr = File.OpenText(Path);
                String strLine;
                bool setAddress = true; //because the first line in the SW is an
address, start with setAddress TRUE.
                UInt16 checksumSW = 0;
                UInt16 StartAddress = 0;
                UInt16 EndAddress = 0;
                Byte[] LineData;
                int swFileSection = 1;
                while (null != (strLine = sr.ReadLine()))
                {
                    if (strLine == "") //checks for blank spaces with no data
                    {
                        System.Console.WriteLine ("End address = 0x" +
EndAddress.ToString("X") + "; High 16bit of object 2066h"); //Display in HEX the
current section End address
                        System.Console.WriteLine ("Checksum = 0x" +
(checksumSW).ToString("X") + "; To be compared with object 206Ah value."); //Display in
HEX the current section Checksum value
                        System.Console.WriteLine ("");
                        checksumSW = 0;
                        setAddress = true;
                        continue;
                    }
                    if (setAddress)
                    {
                        LineData = BitConverter.GetBytes(Int16.Parse(strLine,
System.Globalization.NumberStyles.HexNumber, null));
                        StartAddress = BitConverter.ToUInt16(LineData, 0);
                        EndAddress = StartAddress;
                        EndAddress--;
                        System.Console.WriteLine ("SW file Section " + swFileSection +
" parameters:"); //Display the SW file section
                        System.Console.WriteLine ("Start address = 0x" +
StartAddress.ToString("X") + "; Low 16bit of object 2066h"); //Display in HEX the
current section Start address
                        swFileSection++; //increment the file section number
                        setAddress = false;
                        continue;
                    }
                    EndAddress++;
                    LineData = BitConverter.GetBytes(Int16.Parse(strLine,
System.Globalization.NumberStyles.HexNumber, null));
                    checksumSW += BitConverter.ToUInt16(LineData, 0) ;
                }
                System.Console.WriteLine ("Ended reading file " + Path );
                sr.Close();
                Thread.Sleep(5000); //Wait and display results in Debug window before
it closes
            }
            catch (FileNotFoundException e)
            {
                System.Console.WriteLine (e.Message);
            }
        }
    }
}
```

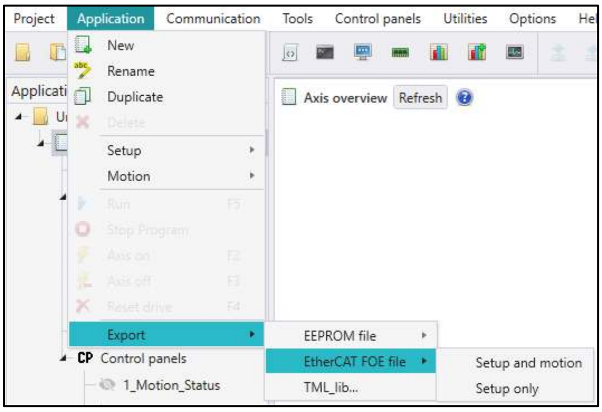
The output window of the program should look like this:



```
Reading SW file from path : c:\setup1.sw

SW file Section 1 parameters:
Start address = 0x4000; Low 16bit of object 2069h
End address = 0x4173; High 16bit of object 2069h
Checksum = 0xF0BC; To be compared with object 206Ah value.

SW file Section 2 parameters:
Start address = 0x7B7E; Low 16bit of object 2069h
End address = 0x7FAF; High 16bit of object 2069h
Checksum = 0x4168; To be compared with object 206Ah value.

SW file Section 3 parameters:
Start address = 0x7FBF; Low 16bit of object 2069h
End address = 0x7FE0; High 16bit of object 2069h
Checksum = 0xFFFF; To be compared with object 206Ah value.

SW file Section 4 parameters:
Start address = 0x7FFF; Low 16bit of object 2069h
End address = 0x7FFF; High 16bit of object 2069h
Checksum = 0x7B7E; To be compared with object 206Ah value.

Ended reading file c:\setup1.sw
```

17.4.3 FoE software files, creation and use

Only drives with firmware FA0x, FA02x, F515F or newer, support FoE (File over EtherCAT) protocol to transfer Setup data or Firmware update. The **FoE** software can be generated by EasyMotion Studio II by navigating to **Application | Export | EtherCAT FoE File**.



Two export options are available:

1. **Motion and Setup**: This generates a complete FoE file containing setup data, TML programs, custom functions, homing routines, and the drive/motor configuration ID.
2. **Setup Only**: This produces a .sw file that includes only the setup data and the configuration ID.

The resulting FoE file can be saved in either **.bin** or **.efw** format, providing flexibility for various applications.

17.4.3.1 FoE files rules and information

- The FoE file must start with "FOESW_".
- The entire FoE file name length must not exceed 14 characters. The extension is excluded.
- A Setup data file can be transferred via FoE protocol only in Op, Pre-OP and Safe-Op ECAT states. While in Bootstrap state, the file is rejected.
- The password to program a FoE setup data file is 0.

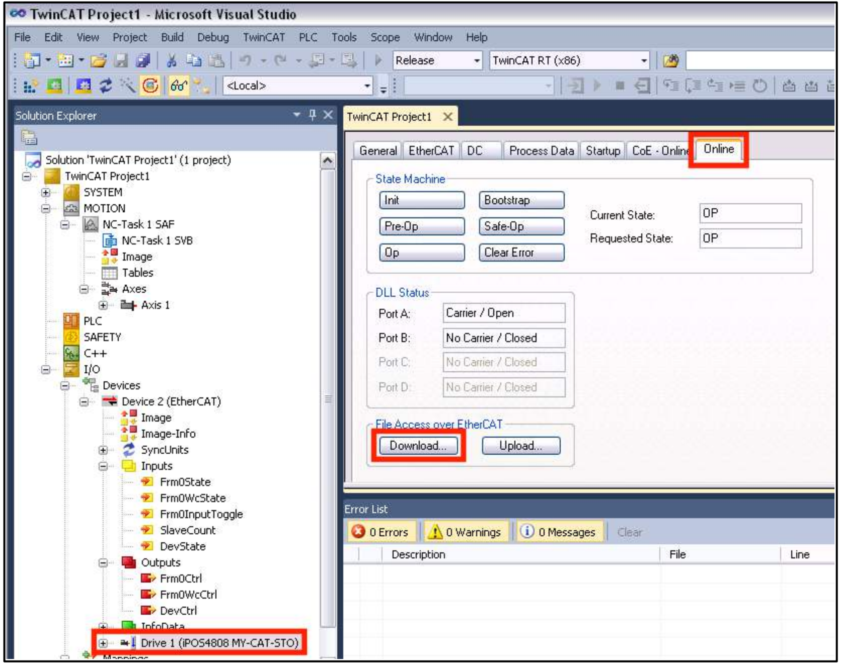
If any of the rules mentioned above is not fulfilled, the file will be rejected by the drive.

17.4.4 Writing a FoE (File over EtherCAT) Setup data file using TwinCAT 3 example

Only drives with firmware versions FA0x, FA02x, F515F, or newer support the FoE (File over EtherCAT) protocol for transferring setup data or performing firmware updates. Before proceeding, refer to. *17.3* for guidance on creating a FoE file.

To update the setup or firmware using TwinCAT 3:

- Open a TwinCAT 3 project connected to a Technosoft EtherCAT drive.
- Select the drive from the list and navigate to the Online tab.

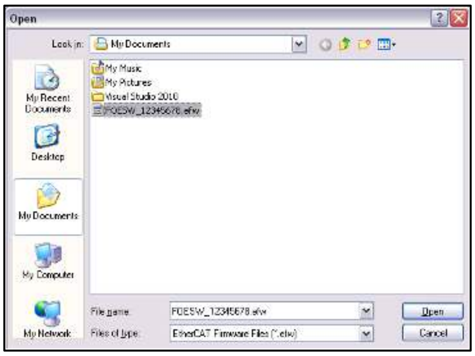


Current State: OP
Requested State: OP

Port A: Carrier / Open
Port B: No Carrier / Closed
Port C: No Carrier / Closed
Port D: No Carrier / Closed

In the **File Access over EtherCAT** section:

1. Click the **Download** button.
   - ○ **Note**: For drives with **F515x firmware**, the File Access over EtherCAT feature is only available if the drive is configured with the latest XML file. Ensure the XML revision is **892417350 (0x35313546 or 515F in ASCII)** or newer. For instructions, see **Par. 1.5.4.6 Checking and updating the XML file stored in the drive**.
2. Select the drive setup file and click **Open**.



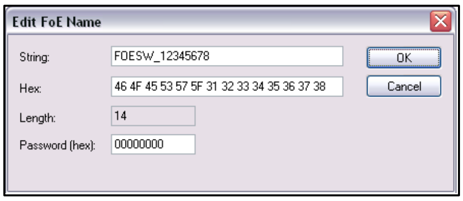
Look in: My Documents

My Music
My Pictures
Visual Studio 2010
FOESW_12345678.efw

File name: FOESW_12345678.efw

Files of type: EtherCAT Firmware Files (*.efw)

3. When prompted, enter **0** as the password and click **OK**.



String: FOESW_12345678

Hex: 46 4F 45 53 57 5F 31 32 33 34 35 36 37 38

Length: 14

Password (hex): 00000000

A progress bar will appear in the bottom-right corner, confirming the completion of the writing process.

Note: The TwinCAT function **FB_EcFoeLoad** does not directly support loading FoE setup data files because it automatically switches the drive state to Bootstrap. To transfer setup data using FoE in Bootstrap mode, first set **object 210Ch to 1**.

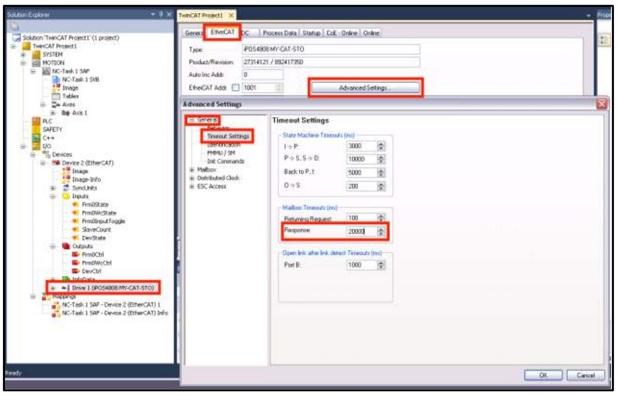
17.4.5 Writing a FoE (File over EtherCAT) Setup data file using TwinCAT 3 ST script example

Before proceeding, ensure you have reviewed *17.4.4* ven if you do not intend to use it.

Prerequisite: Only drives with firmware F515I or newer support the FoE (File over EtherCAT) protocol for transferring setup data while in the Bootstrap state when object 210Ch = 1. Refer to Par. *17.3* for instructions on creating a FoE file.

To update setup data using the TwinCAT FB_EcFoeLoad function:

- Ensure **object 210Ch is set to 1** before starting the transfer. The **FB_EcFoeLoad** function automatically switches the drive into Boot mode.
- Increase the **Mailbox receive timeout** to **20000 ms**:
  - ○ Select the drive in TwinCAT and navigate to the **EtherCAT** tab.
  - ○ Click the **Advanced Settings** button to open a new window.
  - ○ Under the **General** section, go to **Timeout Settings** and set the Mailbox timeout to **20000 ms**.



Type: iPOS4808 MY-CAT-STO

Product/Revision: 27314121 / 892417350

Auto Inc Addr: 0

EtherCAT Addr: □ 1001

Timeout Settings

State Machine Timeouts (ms)

I -> P: 3000

P -> S, S -> O: 10000

Back to P, I: 5000

O -> S: 200

Mailbox Timeouts (ms)

Returning Request: 100

Response: 20000

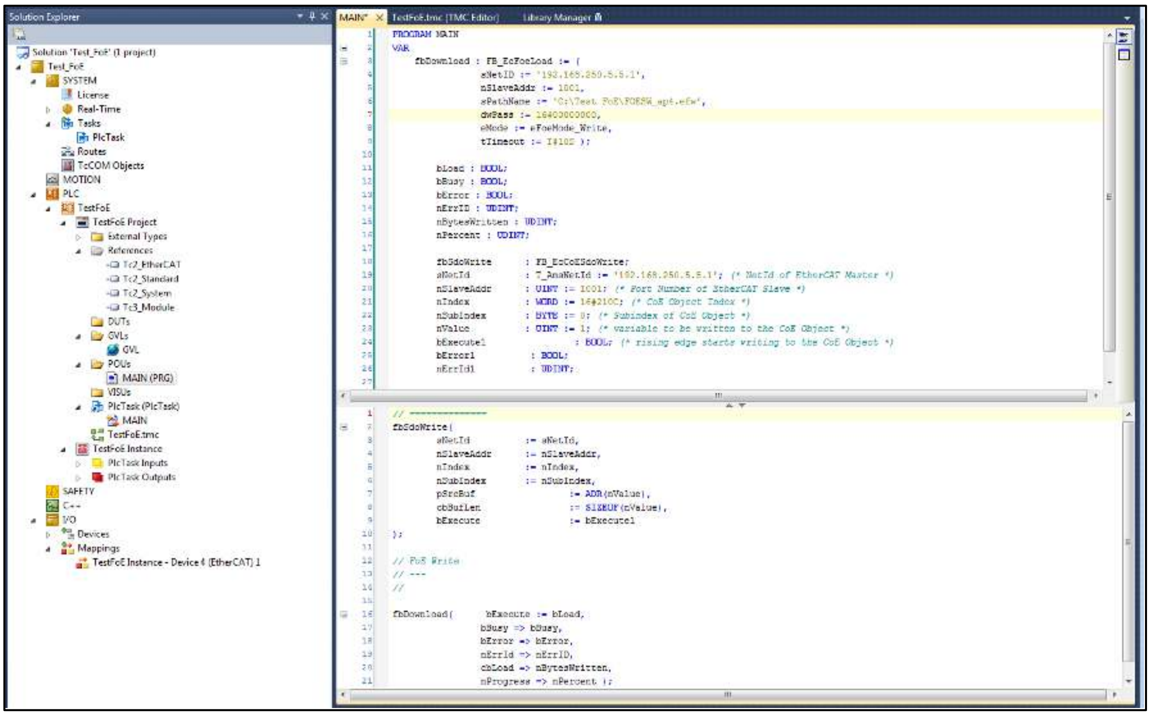
Open link after link detect Timeouts (ms)

Port B: 1000

  - ○ Click **OK** to save and close the window.

Creating the Script:

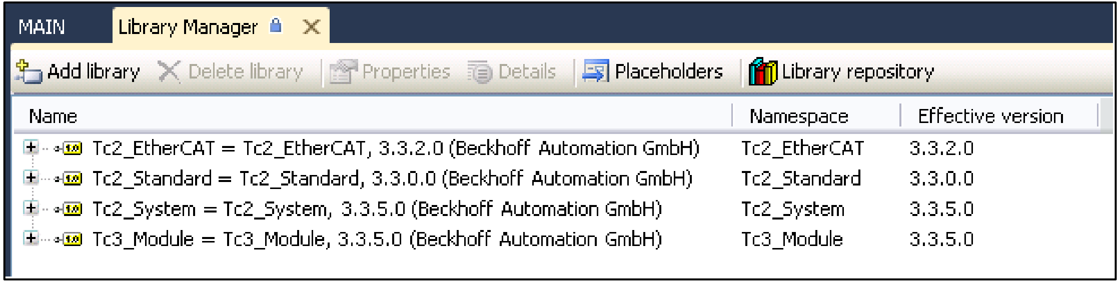
1. In the PLC area, create an ST (Structured Text) program and include the script lines shown in the image below.



```
PROGRAM MAIN
VAR
    fbDownload : FB_EcFoeLoad := (
                sNetID := '192.168.250.5.5.1',
                nSlaveAddr := 1001,
                sPathName := 'C:\Test FoE\FOEFW_ep4.efw',
                dwPass := 16#00000000,
                eMode := eFoeMode_Write,
                tTimeout := T#10S );

        bLoad : BOOL;
        bBusy : BOOL;
        bError : BOOL;
        nErrID : UDINT;
        nBytesWritten : UDINT;
        nPercent : UDINT;

        fbSdoWrite      : FB_EcCoESdoWrite;
        sNetId          : T_AmsNetId := '192.168.250.5.5.1'; (* NetId of EtherCAT Master *)
        nSlaveAddr      : UINT := 1001; (* Port Number of EtherCAT Slave *)
        nIndex          : WORD := 16#210C; (* CoE Object Index *)
        nSubIndex       : BYTE := 0; (* Subindex of CoE Object *)
        nValue          : UINT := 1; (* variable to be written to the CoE Object *)
        bExecute1                 : BOOL; (* rising edge starts writing to the CoE Object *)
        bError1          : BOOL;
        nErrId1          : UDINT;
```

```
// -------------
fbSdoWrite(
        sNetId          := sNetId,
        nSlaveAddr      := nSlaveAddr,
        nIndex          := nIndex,
        nSubIndex       := nSubIndex,
        pSrcBuf                 := ADR(nValue),
        cbBufLen                := SIZEOF(nValue),
        bExecute                := bExecute1
);

// FoE Write
// ---
//

fbDownload(      bExecute := bLoad,
                bBusy => bBusy,
                bError => bError,
                nErrId => nErrID,
                cbLoad => nBytesWritten,
                nProgress => nPercent );
```

2. Ensure the Library Manager includes the libraries displayed in the image provided.



Name	Namespace	Effective version
Tc2_EtherCAT = Tc2_EtherCAT, 3.3.2.0 (Beckhoff Automation GmbH)	Tc2_EtherCAT	3.3.2.0
Tc2_Standard = Tc2_Standard, 3.3.0.0 (Beckhoff Automation GmbH)	Tc2_Standard	3.3.0.0
Tc2_System = Tc2_System, 3.3.5.0 (Beckhoff Automation GmbH)	Tc2_System	3.3.5.0
Tc3_Module = Tc3_Module, 3.3.5.0 (Beckhoff Automation GmbH)	Tc3_Module	3.3.5.0

17.4.6 Updating the firmware via FoE (File over EtherCAT) TwinCAT 3 GUI example

Only drives with firmware FA0x, FA02x, F515F or newer, support FoE (File over EtherCAT) protocol to for Firmware update.

***Remark:** For F515x firmware versions, the file Access over EtherCAT area in the TwinCAT GUI becomes available only if the drive is programmed with the latest XML information. The XML revision must be 892417350 (0x35313546 or 515F in ASCII) or later. See Par 1.5.4.6 Checking and updating the XML file stored in the drive.*

The firmware file has the following name structure:

"FOEFW_XXXX". The file must start with and contain the name FOEFW_. XXXX is the firmware name.

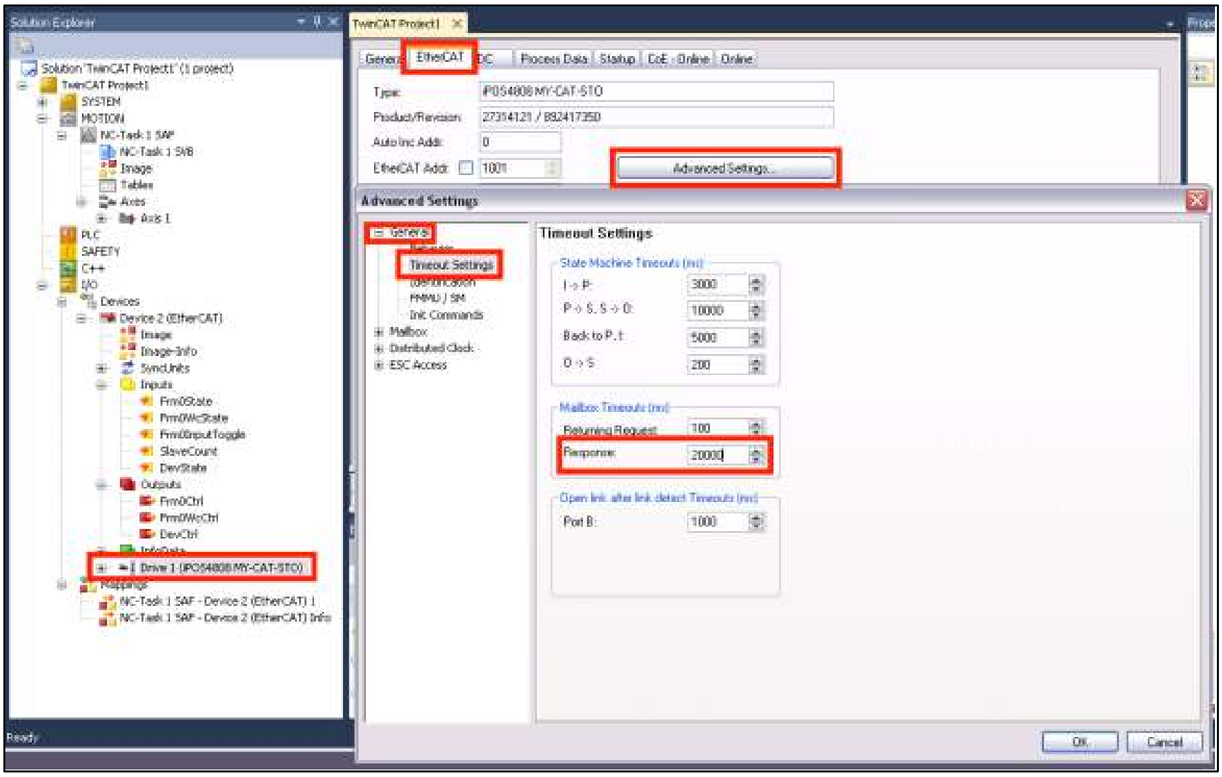
To update a firmware via FoE protocol, the password:

- 0x35313546 must be supplied for F515x firmware versions.
- 0x41303041 must be supplied for FA0xx firmware versions.

Remark: in case the firmware update procedure fails or is interrupted, power cycle the drive and start the procedure again. Starting with F515F, the drives have a non-erasable boot section.

Open a TwinCAT 3 project that is communicating with a Technosoft EtherCAT drive.

Click the drive name and select the EtherCAT tab. Click the Advanced settings button and a new window will open.



Type: iPOS4808 MY-CAT-STO

Product/Revision: 27314121 / 892417350

Auto Inc Addr: 0

EtherCAT Addr: ☐ 1001

Timeout Settings

State Machine Timeouts (ms)

I -> P: 3000

P -> S, S -> O: 10000

Back to P, I: 5000

O -> S: 200

Mailbox Timeouts (ms)

Returning Request: 100

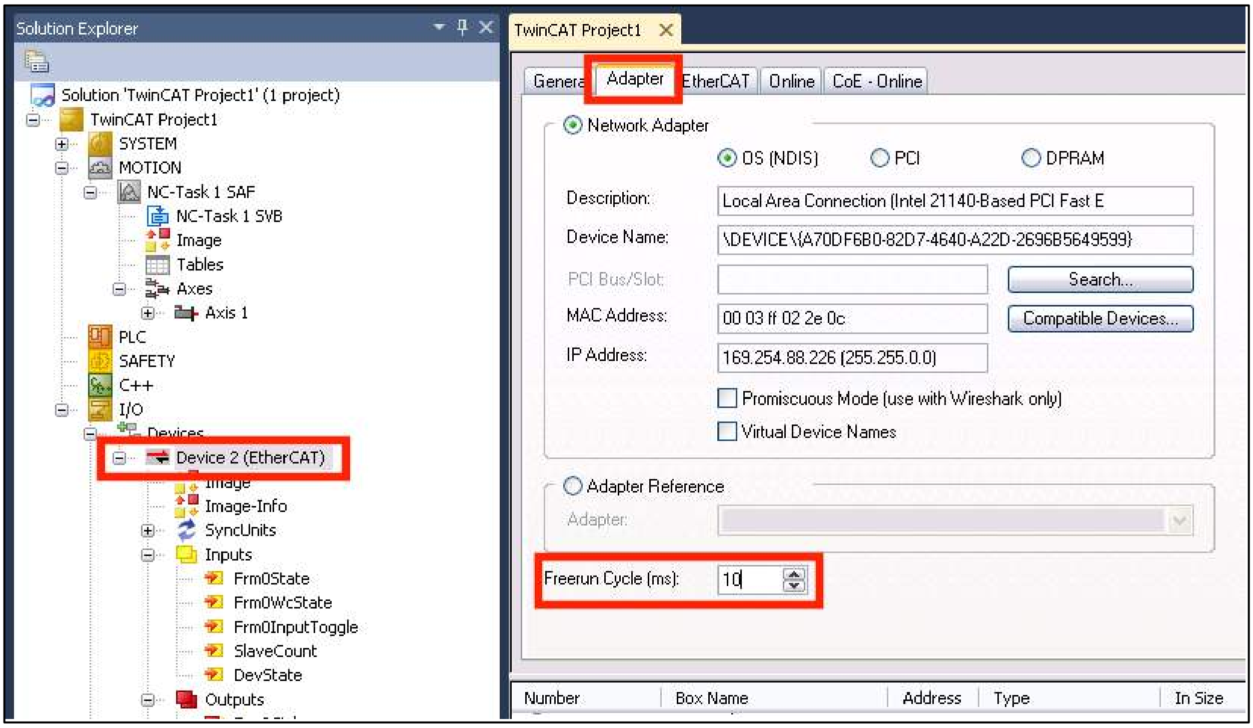
Response: 20000

Open link after link detect Timeouts (ms)

Port B: 1000

Under General, select the Timeout Settings and write a value of 20000 under response for the Mailbox timeout. Click OK to close the window.

Under Devices, click the EtherCAT device and then select the Adapter tab.



● Network Adapter

● OS (NDIS) ○ PCI ○ DPRAM

Description: Local Area Connection (Intel 21140-Based PCI Fast E

Device Name: \DEVICE\{A70DF6B0-82D7-4640-A22D-2696B5649599}

PCI Bus/Slot:

MAC Address: 00 03 ff 02 2e 0c

IP Address: 169.254.88.226 (255.255.0.0)

☐ Promiscuous Mode (use with Wireshark only)

☐ Virtual Device Names

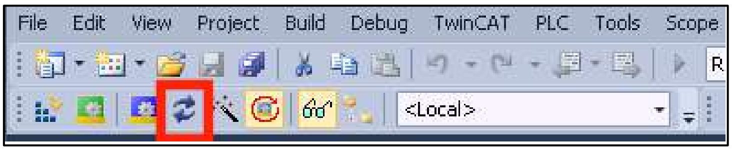
○ Adapter Reference

Adapter:

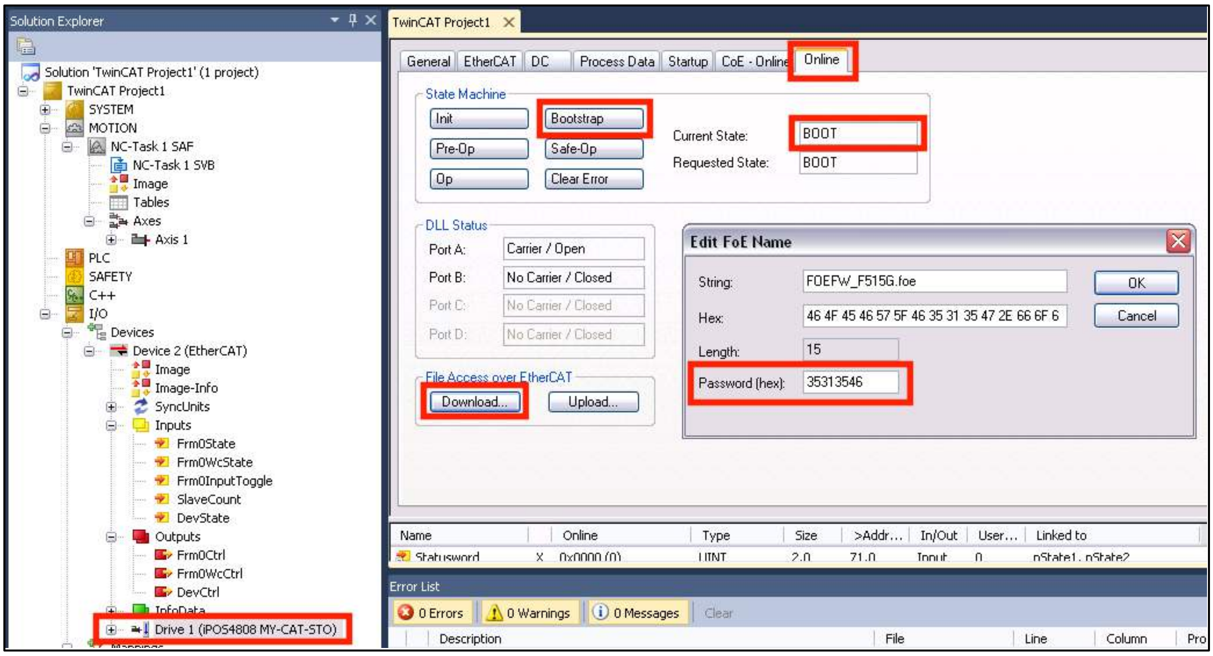
Freerun Cycle (ms): 10

Set for the Freerun cycle a 10ms value.

To apply these new settings, click the Reload Devices in the TwinCAT toolbar to re-start Freerun cycle mode.



Click the drive name again and select the Online tab.



Current State: BOOT

Requested State: BOOT

Port A: Carrier / Open

Port B: No Carrier / Closed

Port C: No Carrier / Closed

Port D: No Carrier / Closed

String: FOEFW_F515G.foe

Hex: 46 4F 45 46 57 5F 46 35 31 35 47 2E 66 6F 6

Length: 15

Password (hex): 35313546

Statusword X 0x0000 (0) UINT 2.0 71.0 Input 0 nState1 . nState2

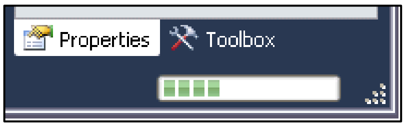
Under state machine, click the Bootstrap button and wait until the drive changes its current state into BOOT.

Under File Access over EtherCAT, click the download button and select the firmware file. In this example, the file name FOEFW_F515G.foe was selected.

Under Password(hex), write 35313546.

Click OK to continue.

A progress bar will be shown in the lower right corner of TwinCAT.



Wait until it finishes and then click the Op button in the state machine section.

The drive will reset internally and start with the new firmware.

Warning: while downloading the firmware, never power off. At first, the flash memory is erased and the drive might be permanently damaged. Only if an error occurs, the power can be cycled to re-establish communication and start the procedure again.

Remarks:

- If the firmware programing fails, most likely the firmware is partially erased. Until a correct firmware is written, the drive will not be fully functional.

In case the TwinCAT update procedure keeps failing, the firmware can still be updated using an RS232 connection and the Technosoft Firmware programmer tool that is included in the Easy Motion Studio II software package.

17.4.7 Updating the firmware via FoE with TwinCAT 3 ST script example

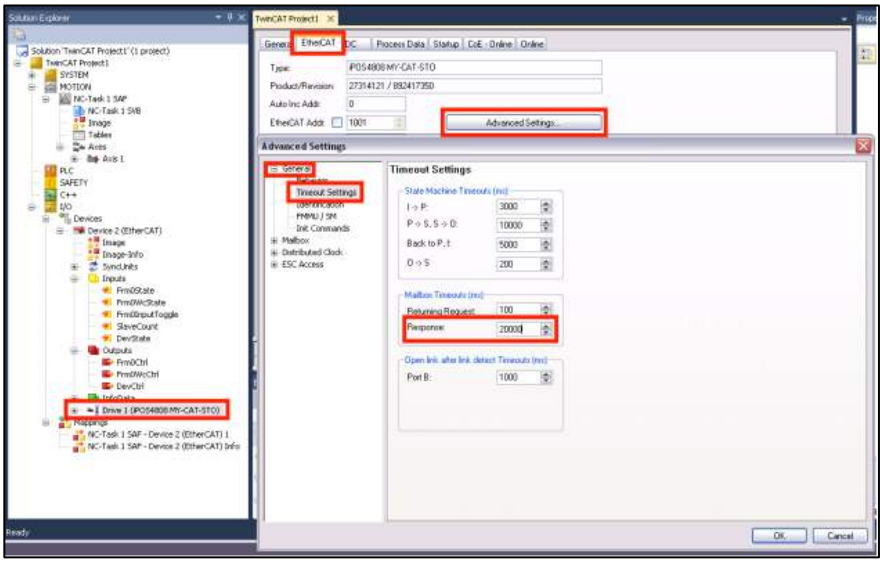
Note: Before proceeding, review Par *17.4.4*, even if you do not plan to use it.

The firmware can be updated using the TwinCAT FB_EcFoeLoad function. This function automatically places the drive into Boot mode during the update process.

Preparation Steps:

1. Increase the Mailbox Receive Timeout to 20000 ms:

- Select the drive in the TwinCAT interface and navigate to the EtherCAT tab.
- Click on the Advanced Settings button to open a new configuration window.
- Under the General section, select Timeout Settings.
- Set the Mailbox timeout response value to 20000 ms.
- Click OK to save changes and close the window.



Type: iPOS4808 MY-CAT-STO

Product/Revision: 27314121 / 892417350

Auto Inc Addr: 0

EtherCAT Addr: □ 1001

Timeout Settings

State Machine Timeouts (ms)

I -> P:	3000
P -> S, S -> O:	10000
Back to P, I:	5000
O -> S:	200

Mailbox Timeouts (ms)

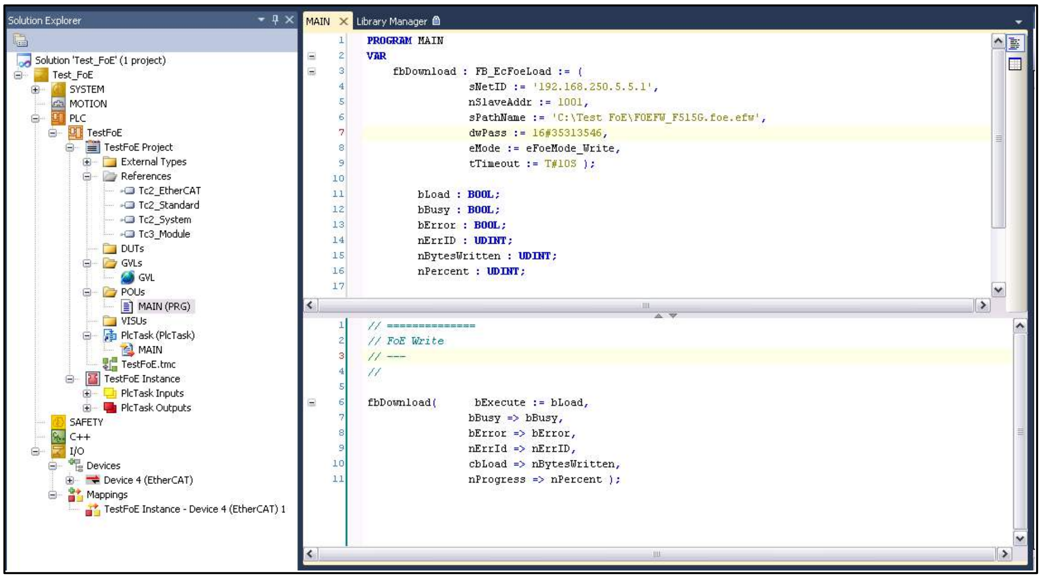
Returning Request:	100
Response:	20000

Open link after link detect Timeouts (ms)

Port B:	1000

2. Create a Structured Text (ST) Program:

- In the **PLC** area of TwinCAT, create a new ST program and include the code shown in the referenced image.

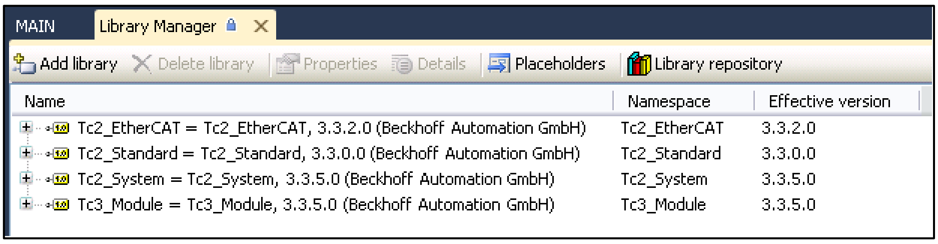


```
PROGRAM MAIN
VAR
    fbDownload : FB_EcFoeLoad := (
                sNetID := '192.168.250.5.5.1',
                nSlaveAddr := 1001,
                sPathName := 'C:\Test FoE\FOEFW_F515G.foe.efw',
                dwPass := 16#35313546,
                eMode := eFoeMode_Write,
                tTimeout := T#10S );

        bLoad : BOOL;
        bBusy : BOOL;
        bError : BOOL;
        nErrID : UDINT;
        nBytesWritten : UDINT;
        nPercent : UDINT;

```

```
// ==============
// FoE Write
// ---
//

fbDownload(      bExecute := bLoad,
                bBusy => bBusy,
                bError => bError,
                nErrId => nErrID,
                cbLoad => nBytesWritten,
                nProgress => nPercent );
```

3. Verify the Required Libraries:

- Ensure that the **Library Manager** has loaded the libraries listed in the image provided.



Name	Namespace	Effective version
Tc2_EtherCAT = Tc2_EtherCAT, 3.3.2.0 (Beckhoff Automation GmbH)	Tc2_EtherCAT	3.3.2.0
Tc2_Standard = Tc2_Standard, 3.3.0.0 (Beckhoff Automation GmbH)	Tc2_Standard	3.3.0.0
Tc2_System = Tc2_System, 3.3.5.0 (Beckhoff Automation GmbH)	Tc2_System	3.3.5.0
Tc3_Module = Tc3_Module, 3.3.5.0 (Beckhoff Automation GmbH)	Tc3_Module	3.3.5.0

Following these steps will prepare the environment for updating the firmware using the **FB_EcFoeLoad** function.

17.5 Ethernet over EtherCAT (EoE) communication[1]

17.5.1 Overview

The Ethernet over EtherCAT (EoE) communication allows the EasyMotion Studio II software to communicate with Technosoft EtherCAT slaves over an EtherCAT network without the need of a direct RS232 or USB connection.

Warning: Do not connect the EtherCAT slave directly to a Local Area Network.

The EtherCAT communication will flood the LAN with unsolicited messages. The EtherCAT slave must be connected to an EtherCAT master which can later be connected to the LAN through its dedicated Ethernet port. EoE communication can occur only if the EtherCAT master supports forwarding EoE messages.

For detailed step by step instructions on setting up EoE communication using TwinCAT, read chapter *17.5.3*. The connection diagram below is just an example that uses the settings you can find in chapter *17.5.3*

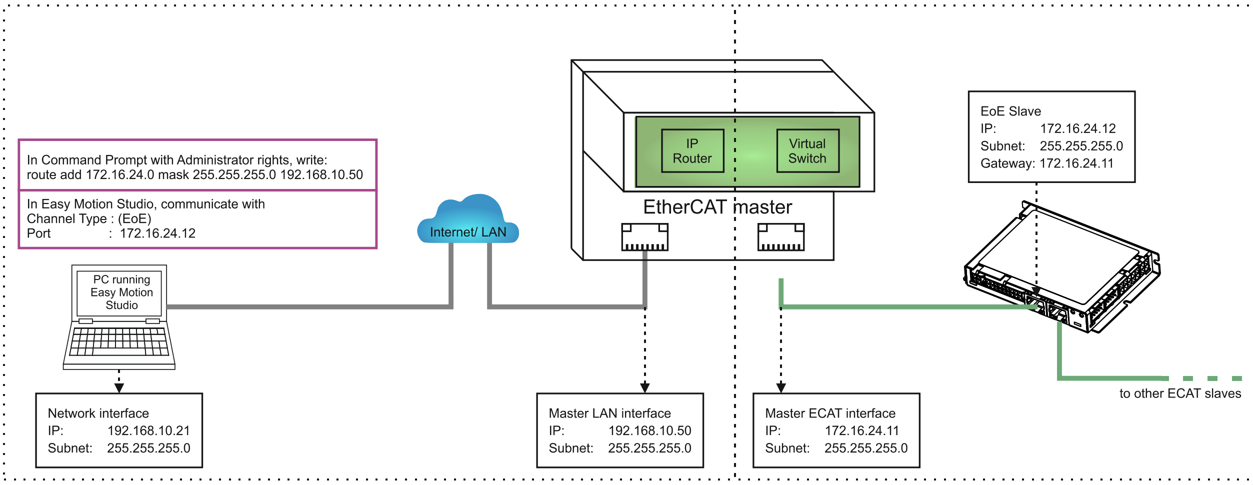


***Figure 17.5.1.** EoE example schema*

17.5.2 EoE communication objects

17.5.2.1 Object 210D$_h$: Virtual MAC address for EoE

This object reveals the virtual MAC address of the drive that has been configured by the EtherCAT master for EoE protocol.

The object is also writable and can be modified with a new value. Keep in mind that the EtherCAT master might overwrite its value every time it re-initializes.

Object description:

Index	210D$_h$
Name	Virtual MAC address for EoE
Object code	VAR
Data type	UNSIGNED48

Entry description:

Access	RW
PDO mapping	No
Units	-
Value range	UNSIGNED48
Default value	No

17.5.2.2 Object 210E$_h$: IP config for EoE

This object reveals the IP settings of the drive that has been configured by the EtherCAT master for EoE protocol.

The object is also writable and can be modified with new values. Keep in mind that the EtherCAT master might overwrite its values every time it re-initializes.

[1] EoE communication is available only with firmware version FA0x, FA02x, F515F or newer

Object description:

Index	$210E_h$
Name	IP config for EoE
Object code	Record
Data type	UNSIGNED32

Entry description:

Sub-index	0
Description	Number of entries
Access	RO
PDO mapping	No
Value range	3
Default value	3

Sub-index	1
Description	IP Address
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	-

Sub-index	2
Description	Subnet Mask
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	-

Sub-index	3
Description	Default Gateway
Access	RW
PDO mapping	No
Value range	UNSIGNED32
Default value	-

Sub-index description and data structure:

Sub-index 1 shows or can set the IP address of the drive. The IP address is written as bytes in little endian format.

Example:

IP address is 192.168.24.12

Converted to bytes in hex it is : **C0**.**A8**.**18**.**0C**

Sub-index 1 value is: 0x**0C18A8C0**

IP address selection:

- the IP address of the drive must be in the same sub-net as the IP address of the Ethernet port of the master that is used for the EtherCAT connection. The EtherCAT slave(s) must be connected to this port.

- the IP address range of the EtherCAT slaves must be on a different subnet than the IP addresses on the LAN.

Example:

Local LAN IP of EtherCAT master: 192.168.**23**.230 – (IP in LAN are between 192.168.23.1 to 255)

IP of the Ethernet port of the master that is connected to the EtherCAT network: 192.168.**24**.11

IP of one EtherCAT slave : 192.168.**24**.12

Sub-index 2 shows or can set the subnet mask of the drive. The data is written as bytes in little endian format.

Example:

Subnet mask is 255.255.255.0

Converted to bytes in hex it is : **FF**.**FF**.**FF**.**00**

Sub-index 1 value is: 0x**00FFFFFF**

Sub-index 3 shows or can set the Gateway address of the drive. The Gateway address is written as bytes in little endian format. The gateway address should be set the same as the IP address of the Ethernet port of the master that is used for the EtherCAT connection.

Example:

Gateway address is 192.168.24.11

Converted to bytes in hex it is : **C0.A8.18.0B**

Sub-index 1 value is: 0x**0B18A8C0**

17.5.3 Setting up EoE communication using EasyMotion Studio II and TwinCAT3 example

Prerequisites:

For EoE capability, the Technosoft drives must have:

- the firmware F515J or newer installed

- the newest XML file compatible with F515J or newer should be present in TwinCAT. See *1.5.1 Adding the XML file*.

- the drive XML data should have the revision 892417354 or greater programmed to the ECAT EEPROM. The revision number means 515J when converted to ASCII. See *1.5.4.6 Checking and updating the XML file stored in the drive* to update to the latest version if needed.

17.5.3.1 Step 1 Setting an IP to the EtherCAT network port of the master

On the EtherCAT master, the port that connects to the EtherCAT slaves usually has no fixed IP defined.
Edit Windows Network Adapter settings on the EtherCAT master and manually add an IP to this port and a subnet mask.
Make sure no other EtherCAT slave will use this IP.
Important: the IPs for the EtherCAT network must be in a different subnet than the IPs of your local network.

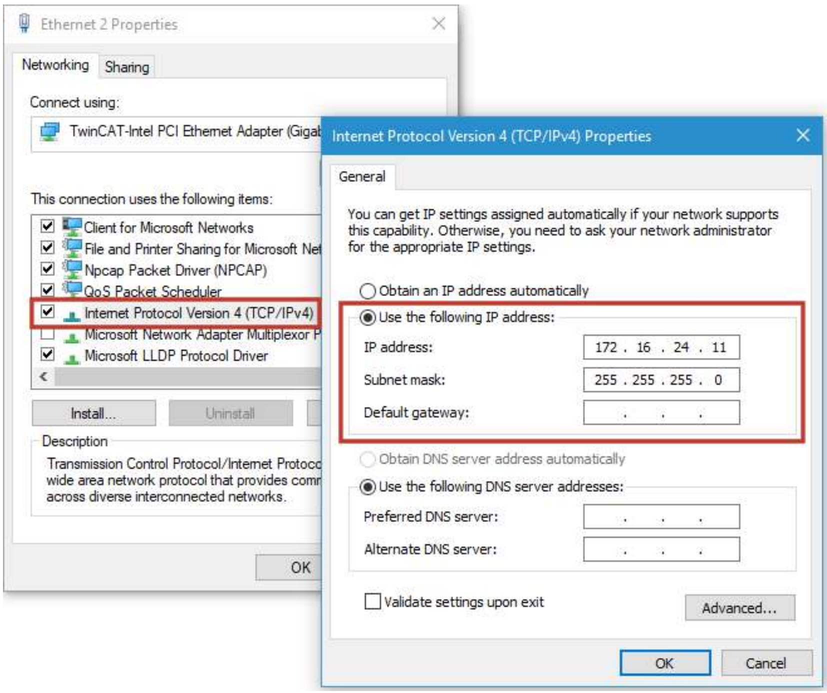
Example of a good configuration:

IPs of local network:	192.168.**23**.1.. to 254	Subnet: 255.255.255.0
IPs of EtherCAT network	192.168.**24**.1 .. to 254	Subnet: 255.255.255.0

Example of a wrong configuration:

IPs of local network:	192.168.**23**.1.. to 254	Subnet: 255.255.255.0
IPs of EtherCAT network	192.168.**23**.1 .. to 254	Subnet: 255.255.255.0

For this example, set the IP of the EtherCAT interface to 172.16.24.11 and subnet mask to 255.255.255.0. No gateway or DNS are needed.



Ethernet 2 Properties

Networking | Sharing

Connect using:

TwinCAT-Intel PCI Ethernet Adapter (Gigab

This connection uses the following items:

☑ Client for Microsoft Networks
☑ File and Printer Sharing for Microsoft Net
☑ Npcap Packet Driver (NPCAP)
☑ QoS Packet Scheduler
☑ Internet Protocol Version 4 (TCP/IPv4)
☐ Microsoft Network Adapter Multiplexor P
☑ Microsoft LLDP Protocol Driver

Description

Transmission Control Protocol/Internet Protoco wide area network protocol that provides comr across diverse interconnected networks.

Internet Protocol Version 4 (TCP/IPv4) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
● Use the following IP address:

IP address: 172 . 16 . 24 . 11
Subnet mask: 255 . 255 . 255 . 0
Default gateway: . . .

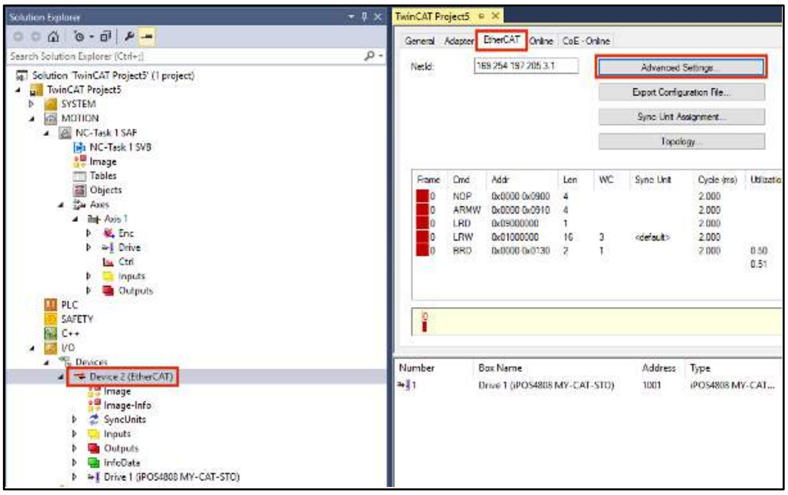
○ Obtain DNS server address automatically
● Use the following DNS server addresses:

Preferred DNS server: . . .
Alternate DNS server: . . .

☐ Validate settings upon exit

17.5.3.2 Step 2 Configure TwinCAT for EoE by enabling IP routing on the EtherCAT master

In the TwinCAT project, you must first detect all the EtherCAT slaves.
Enable IP Routing on the EtherCAT master to be able to forward EoE packets from the EtherCAT slaves to your LAN.
In TwinCAT, under I/O select the EtherCAT interface, choose the EtherCAT tab and click on the Advanced Settings button as in the image below.

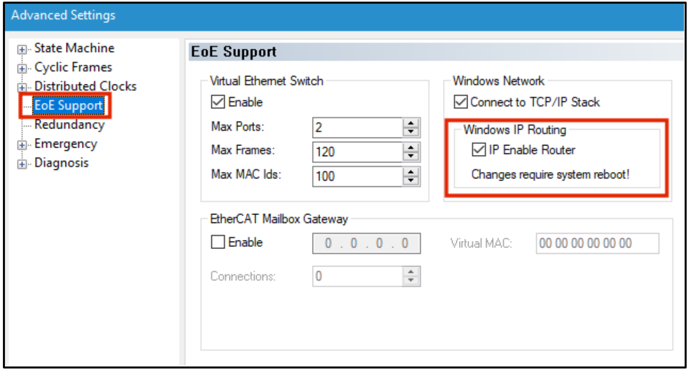


NetId: 169.254.197.205.3.1

Frame	Cmd	Addr	Len	WC	Sync Unit	Cycle (ms)	Utilizatio
0	NOP	0x0000 0x0900	4			2.000	
0	ARMW	0x0000 0x0910	4			2.000	
0	LRD	0x09000000	1			2.000	
0	LRW	0x01000000	16	3	<default>	2.000	
0	BRD	0x0000 0x0130	2	1		2.000	0.50
							0.51

Number	Box Name	Address	Type
1	Drive 1 (iPOS4808 MY-CAT-STO)	1001	iPOS4808 MY-CAT...

Under Advanced Settings, select the EoE Support and enable Windows IP Routing.



EoE Support

Virtual Ethernet Switch
☑ Enable
Max Ports: 2
Max Frames: 120
Max MAC Ids: 100

Windows Network
☑ Connect to TCP/IP Stack
Windows IP Routing
☑ IP Enable Router
Changes require system reboot!

EtherCAT Mailbox Gateway
☐ Enable 0 . 0 . 0 . 0
Virtual MAC: 00 00 00 00 00 00
Connections: 0

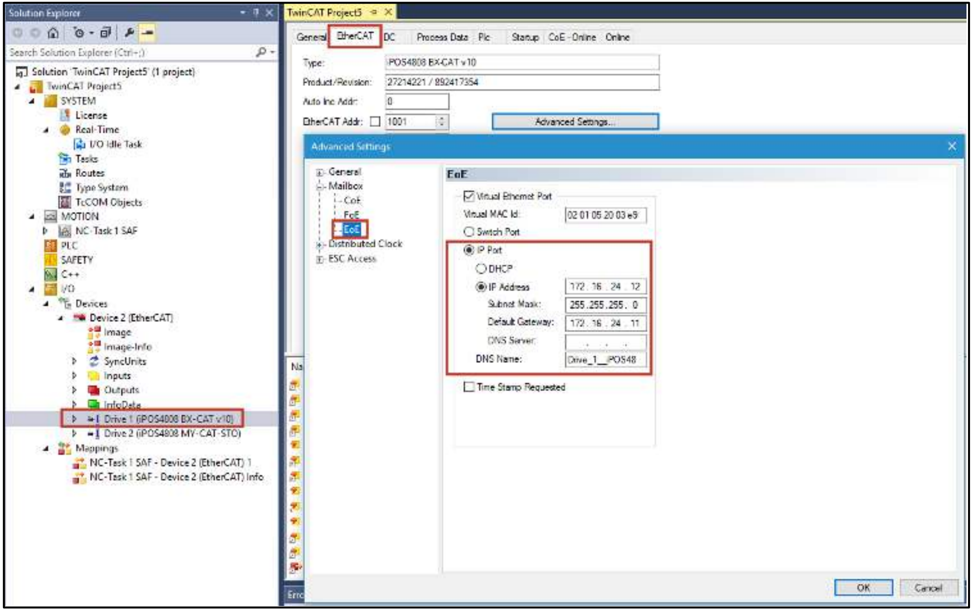
Next, rebuild and save your project, then reboot to apply the new settings.

In case the EtherCAT master has a Windows CE platform, open CX configuration tool and enable “IP Routing”.

17.5.3.3 Step 3 Configure TwinCAT to set an IP for the EterCAT slave

In TwinCAT, under I/O select a slave, select the EtherCAT tab and click the Advanced Settings button.
Under Mailbox / EoE, select a manual configuration for the IP Port:

IP Address	- set an IP in the same subnet as the one previously set for the EtherCAT interface
	- in this example, set 172.16.24.12
Subnet Mask	- in this example, set 255.255.255.0
Default Gateway	- set the IP that was set for the EtherCAT port of the master (set @ step 1)
	- in this example, set 172.16.24.11



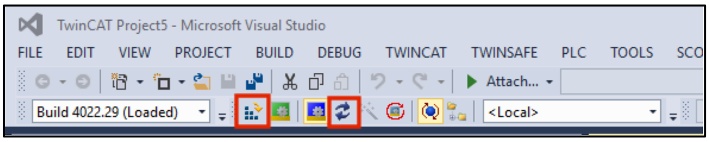
Type: iPOS4808 BX-CAT v10
Product/Revision: 27214221 / 892417354
Auto Inc Addr: 0
EtherCAT Addr: ☐ 1001

EoE
☑ Virtual Ethernet Port
Virtual MAC Id: 02 01 05 20 03 e9
○ Switch Port
● IP Port
○ DHCP
● IP Address 172 . 16 . 24 . 12
Subnet Mask: 255 . 255 . 255 . 0
Default Gateway: 172 . 16 . 24 . 11
DNS Server: . . .
DNS Name: Drive_1__iPOS48
☐ Time Stamp Requested

In case other slaves are present and EoE is needed for them too, set an individual IP to each one by repeating this step.

17.5.3.4 Step 4 Enable TwinCAT EoE settings.

Click the “Reload IO devices” button or the “Activate Configuration” button to apply the new settings.


TwinCAT Project5 - Microsoft Visual Studio
FILE EDIT VIEW PROJECT BUILD DEBUG TWINCAT TWINSAFE PLC TOOLS SCO
Attach...
Build 4022.29 (Loaded)
<Local>

17.5.3.5 Step 5 Configure the PC running EasyMotion Studio II to communicate with the EoE slaves.

In Windows, open the Command Prompt using Administrator rights.

Write

route add 172.16.24.0 mask 255.255.255.0 192.168.10.50

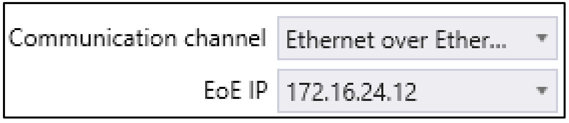
where 172.16.24.0 is the destination IP class of the EtherCAT slaves
255.255.255.0 is the subnet of the destination
192.168.10.50 is the local LAN IP of the EtherCAT master interface.

Remarks:

1. the route will be added only until next system reboot. If Windows is restarted, the same command should be given before using EasyMotion Studio with EoE.
2. If the EtherCAT master IP will not change and the route setting is wished to be permanent, write the following in Command Prompt
   route add -p 172.16.24.0 mask 255.255.255.0 192.168.10.50
   the -p option will set the route as persistent across system reboots

17.5.3.6 Step 6 Configure EasyMotion Studio II to communicate with the EoE slaves

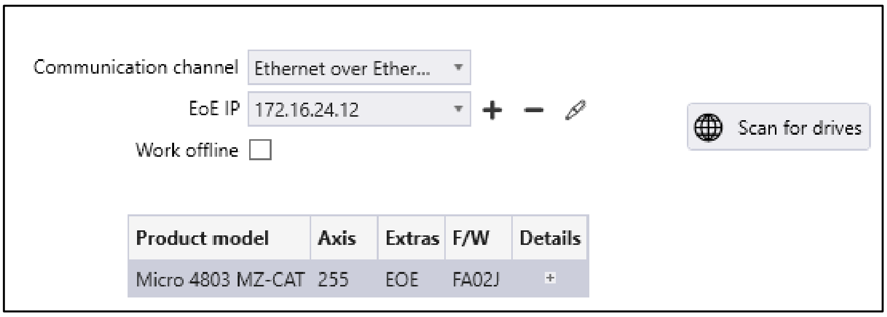
1. Launch **EasyMotion Studio II** and click the **New** button. This will open the **Drive Selection** menu.



Communication channel: Ethernet over Ether...
EoE IP: 172.16.24.12

2. For **Channel Type**, select **Ethernet over EtherCAT (EoE)** and choose an existing EoE IP address (e.g., **172.16.24.12**).
3. Click Scan for drives.

- If the EtherCAT master is running and the IP route has been added, the connected drive will appear, displaying their Axis ID, Product Code, and Firmware Version.



Communication channel: Ethernet over Ether...
EoE IP: 172.16.24.12
Work offline □

Product model	Axis	Extras	F/W	Details
Micro 4803 MZ-CAT	255	EOE	FA02J	+

17.5.4 Remarks about EoE limitations

- The response time is slower, and communication is noticeably less efficient compared to RS232 running at 115200 bps.
- To improve the performance of control panels, close any unnecessary panels and display only the essential data. Reducing the amount of displayed data results in faster updates.
- For optimal data refresh rates, configure the EtherCAT cycle time as close as possible to 1 ms.

17.5.5 Example: Starting a new project using EasyMotion Studio II with EoE communication

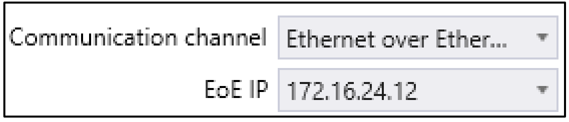
Prerequisites:

- two drives are already configured in TwinCAT for EoE communication using IPs 172.16.24.12 and 172.16.24.13. See *17.5.3.3*.

- a route was added in Windows to allow communication with the EtherCAT IPs. See *17.5.3.5*.

17.5.5.1 Step 1, establish communication

1. Launch **EasyMotion Studio II** and click the **New** button. This will open the **Drive Selection** menu.

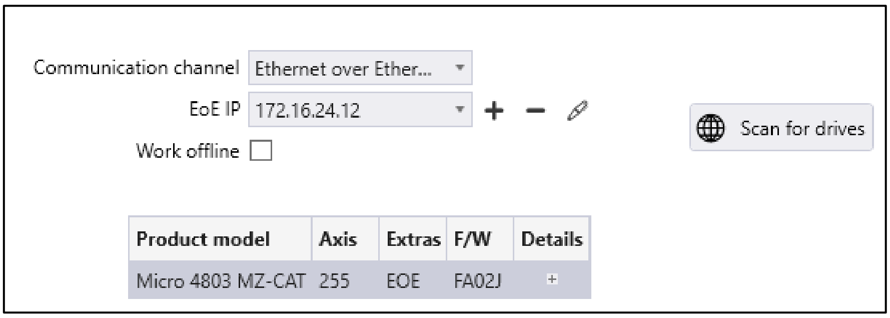


Communication channel: Ethernet over Ether...

EoE IP: 172.16.24.12

2. For **Channel Type**, select **Ethernet over EtherCAT (EoE)** and choose an existing EoE IP address (e.g., **172.16.24.12**).
3. Click Scan for drives.

- If the EtherCAT master is running and the IP route has been added, the connected drive will appear, displaying their Axis ID, Product Code, and Firmware Version.



Communication channel: Ethernet over Ether...

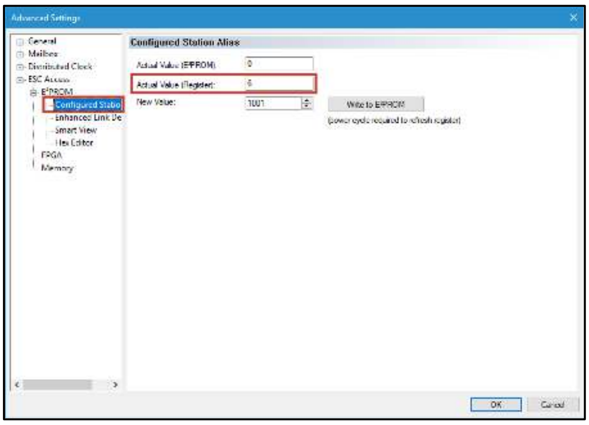
EoE IP: 172.16.24.12

Work offline □

Product model	Axis	Extras	F/W	Details
Micro 4803 MZ-CAT	255	EOE	FA02J	+

Note:

- The drive's hardware ID (HW ID) address will also be visible in TwinCAT under the **Configured Station Alias** field.



Configured Station Alias

Actual Value (E²PROM): 0

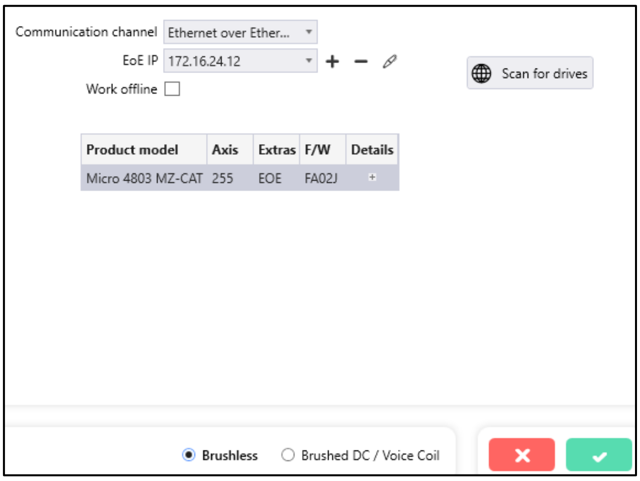
Actual Value (Register): 6

New Value: 1001

- Navigate to TwinCAT, open the EtherCAT tab for the drive, and click Advanced Settings to locate this value.

17.5.5.2 Step 2, create a new project

1. Once communication is established, select the appropriate motor technology and confirm by pressing the green checkmark.



Communication channel: Ethernet over Ether...

EoE IP: 172.16.24.12

Work offline □

Product model	Axis	Extras	F/W	Details
Micro 4803 MZ-CAT	255	EOE	FA02J	+

● Brushless ○ Brushed DC / Voice Coil

2. A new untitled application will be created, and the drive's IP address will be displayed in the Axis Overview page.
3. The IP address can be modified from this page if necessary.

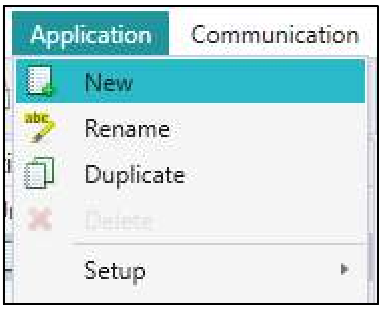
- **Setup and Motor Tuning:**
  - Configuration and tuning can be performed over EoE and later downloaded to the drive.

  Note: Due to the higher latency of EoE compared to RS232 communication, setup and test executions may take longer.

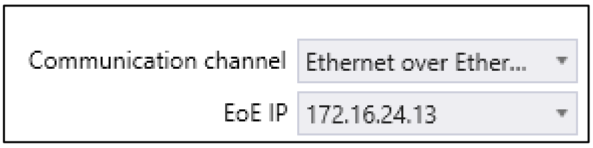
- **Working with Multiple Applications:**
  - EasyMotion Studio II allows multiple applications within a single project file.
  - Each application can correspond to a specific axis within the EtherCAT network. By assigning a unique IP to each application, you can switch between them and directly communicate with individual drives via EoE.

17.5.5.3 Step 3, create another application

1. Navigate to **Application | New**



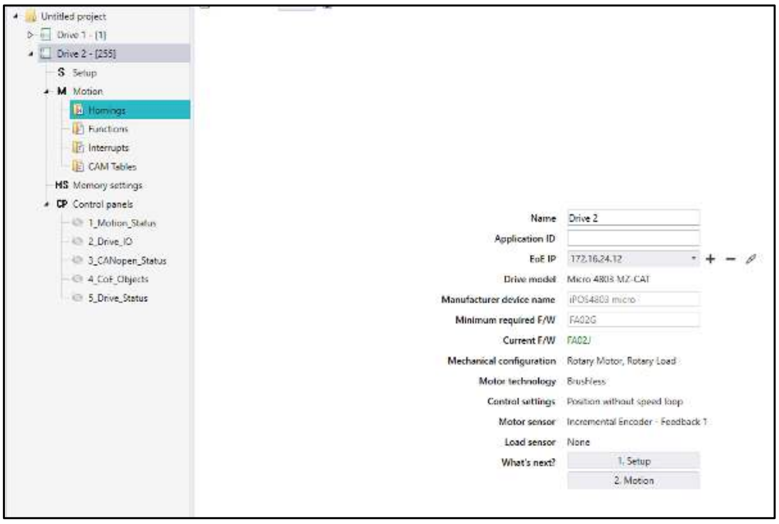
2. The Drive Selection menu will reappear, similar to the previous steps.
3. Assign the second EoE IP address (e.g., 172.16.24.13) and click Scan for Drives to establish communication and configure the drive and motor type.



Communication channel: Ethernet over Ether...

EoE IP: 172.16.24.13

4. Once the motor technology is selected, a new application will be created. The project file will now contain two applications.



Name: Drive 2

Application ID:

EoE IP: 172.16.24.12

Drive model: Micro 4803 MZ-CAT

Manufacturer device name: iPOS4803 micro

Minimum required F/W: FA02G

Current F/W: FA02J

Mechanical configuration: Rotary Motor, Rotary Load

Motor technology: Brushless

Control settings: Position without speed loop

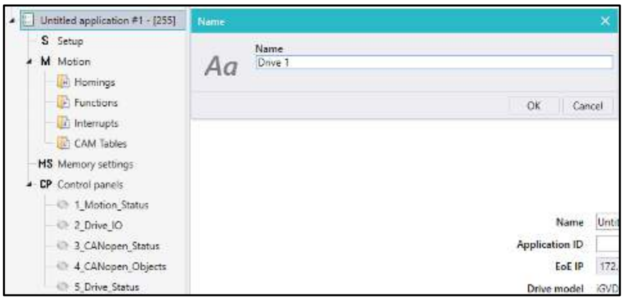
Motor sensor: Incremental Encoder - Feedback 1

Load sensor: None

What's next?

17.5.5.4 Step 4, renaming and switching between applications / drives

- In EasyMotion Studio II, double-click the application name to rename it.



Name

Name: Drive 1

Name: Unti
Application ID:
EoE IP: 172.
Drive model: iGVD

- To switch between drives, click on the desired application name.
- Control Panels associated with the selected application will display the drive status, allowing you to modify or retune the setup.

17.5.6 Example: Converting an existing EasyMotion Studio II project made for RS232 to work with EoE communication

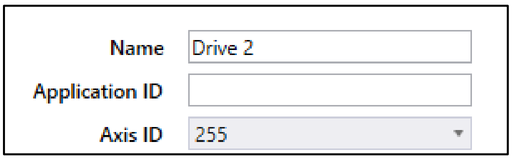
Prerequisites:

- Two drives are already configured in TwinCAT for EoE communication using IPs 172.16.24.12 and 172.16.24.13. See *17.5.3.3*.

- A route was added in Windows to allow communication with the EtherCAT IPs. See *17.5.3.5*.

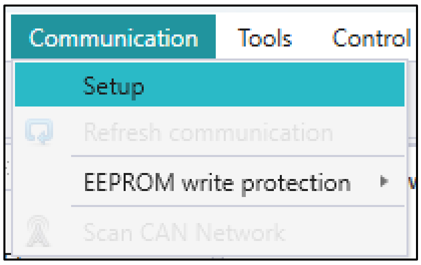
- A project file containing multiple applications that were made while using RS232 communication.

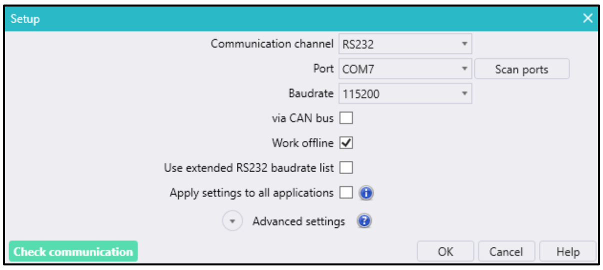
1. Open the EasyMotion Studio II project initially configured for RS232 communication.



Name: Drive 2
Application ID:
Axis ID: 255

2. If RS232 communication is still active, the assigned axis number will be visible on the Axis Overview page.
3. Navigate to **Communication | Setup**

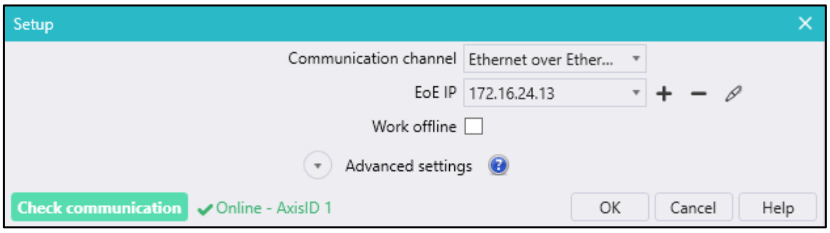




Setup

Communication channel: RS232
Port: COM7
Baudrate: 115200
via CAN bus ☐
Work offline ☑
Use extended RS232 baudrate list ☐
Apply settings to all applications ☐

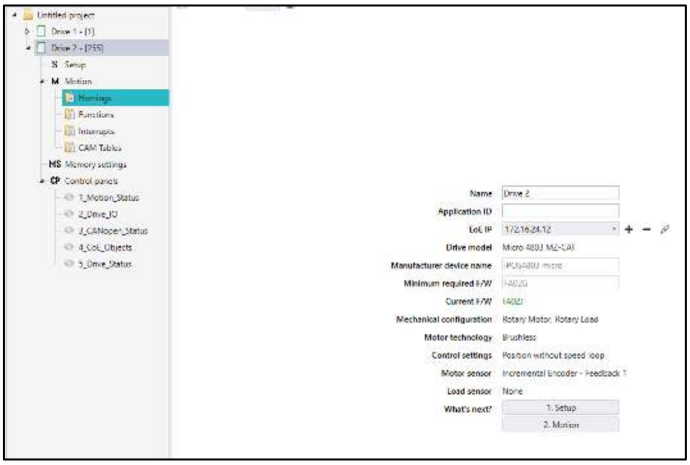
4. In the Communication Settings, select the EoE channel and enter the assigned IP address.
5. Press Check Communication. If the connection is successful, a checkmark will appear, followed by the Online status and the Axis ID text next to the button.



Setup

Communication channel: Ethernet over Ether...
EoE IP: 172.16.24.13
Work offline ☐
✓Online - AxisID 1

6. Exit the communication settings by clicking OK.
7. The Axis ID field (specific to RS232 communication) will disappear, and the EOE IP field will appear. By confirming with OK, you will now be online with the drive.



Name	Drive 2
Application ID	
LoE IP	172.16.24.12
Drive model	Micro 4803 MZ-CAT
Manufacturer device name	iPOS4803 micro
Minimum required F/W	F402G
Current F/W	F402J
Mechanical configuration	Rotary Motor, Rotary Load
Motor technology	Brushless
Control settings	Position without speed loop
Motor sensor	Incremental Encoder - Feedback 1
Load sensor	None
What's next?	1. Setup 2. Motion

8. Repeat this process for all applications within the project.

18 Advanced features

Due to its embedded motion controller, a Technosoft intelligent drive/motor offers many programming solutions that may simplify a lot the task of a EtherCAT® master. This paragraph overviews a set of advanced programming features which can be used when combining TML programming at drive level with EtherCAT® master control. All features presented below require usage of EasyMotion Studio II as TML programming tool.

Remark: *If you do not use the advanced features presented below you do not need EasyMotion Studio II FULL version.*

18.1 Using EasyMotion Studio II

18.1.1 Starting a new project

EasyMotion Studio II establishes communication with the drive using one of the following interfaces: RS-232 serial link, USB, or CAN. The appropriate interface depends on the specific drive model and its supported communication protocols. For detailed information about the supported protocols, refer to the Drive Technical Reference Manual.

To connect to a drive using EasyMotion Studio II, begin by creating a New project. During this process, you'll select the communication channel and configure the necessary parameters. Once your settings are in place, use the Scan Ports option to refresh the list of available ports and choose the correct one for your setup.

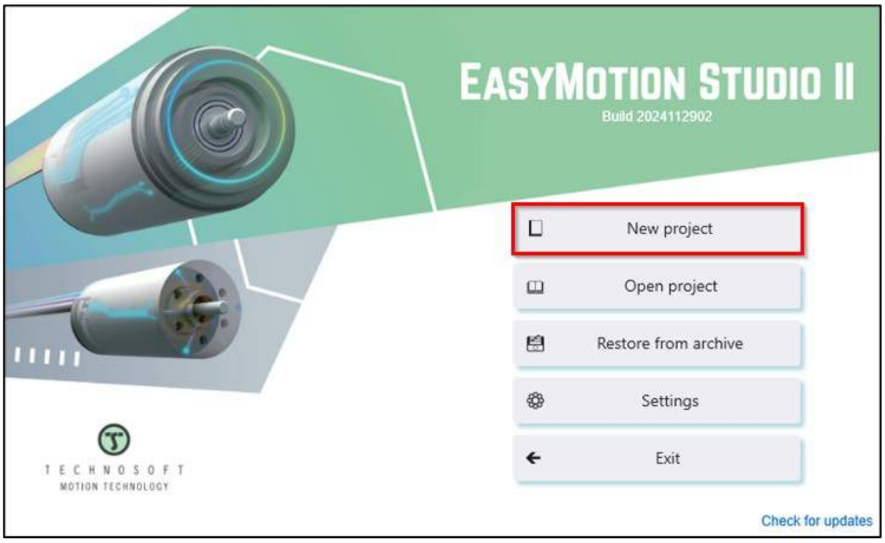
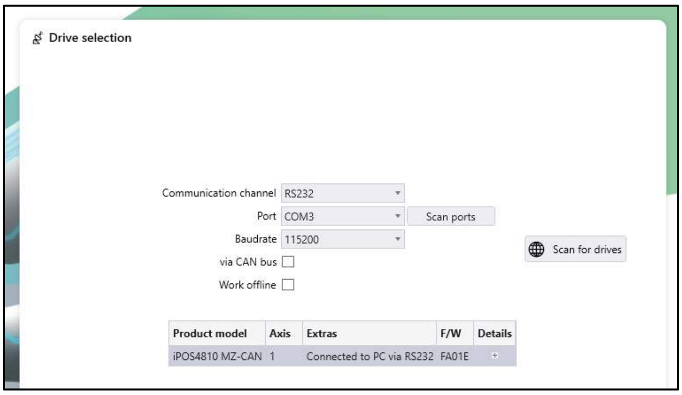


Figure 18.1.1. *EasyMotion Studio II - Opening window*

Once the physical connection is established, click **Scan for Drives** to initiate the detection process. EasyMotion Studio II will search for connected drives and display their details in a table, including the drive name, Axis ID, and firmware version. If no drives are detected, the software will display an error message, prompting you to double-check your connections and configuration settings before trying again.



Drive selection

Communication channel: RS232

Port: COM3

Baudrate: 115200

via CAN bus □

Work offline □

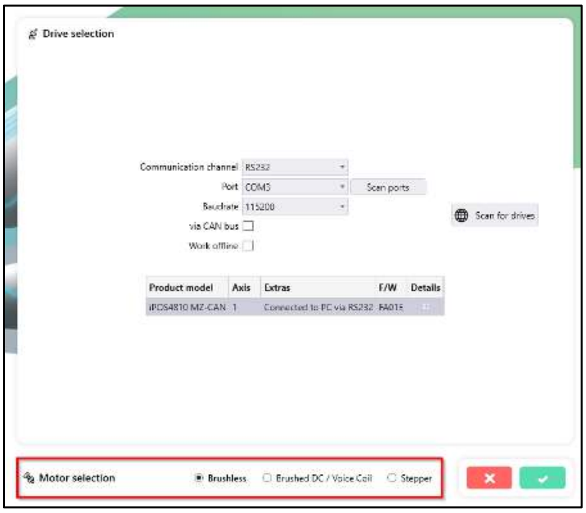
Product model	Axis	Extras	F/W	Details
iPOS4810 MZ-CAN	1	Connected to PC via RS232	FA01E	+

Figure 18.1.2. *EasyMotion Studio II – Scan results*

For drives connected within a CAN network, you can use the via CAN bus option to enable automatic detection of all connected drives. However, this feature requires certain conditions to be met: all drives in the network must use

18.1.2 Choosing the drive, motor and feedback configuration

Once the drive has been successfully identified, key information such as its name, AxisID, and firmware version will be displayed. At this point, you can select the desire motor technology. After finalizing the drive and motor technology selection, simply click the green tick button in the Motor Selection group box to proceed. This action concludes the selection wizard and transitions you to the project window, where you can continue with advanced configuration and programming tasks.



Drive selection

Communication channel: RS232

Port: COM3

Baudrate: 115200

via CAN bus □

Work offline □

Product model	Axis	Extras	F/W	Details
iPOS4810 MZ-CAN	1	Connected to PC via RS232	FA01E	+

Motor selection: ● Brushless ○ Brushed DC / Voice Coil ○ Stepper

Figure 18.1.3. *EasyMotion Studio II – Drive and Motor selection*

When you start a new project in EasyMotion Studio II, the software automatically creates an initial application as a starting point.

Each application is organized into three main branches:

- ❑ **Setup** – Dedicated to configuring the drive and motor settings.
- ❑ **Motion** – Reserved for application development, accessible only in the full version of EasyMotion Studio II.
- ❑ **Memory Settings** – Provides an overview of memory usage and tools for configuring memory-related parameters.

The **Setup** branch, essential for initializing the drive, motor and feedback, is presented in chapter **Commissioning the drive**.

18.1.3 Downloading setup data to drive/motor

The configured setup can be transferred to the drive using the Write Setup to Drive option, accessible from the Application menu or via the ribbon button highlighted with a red square in the image below.

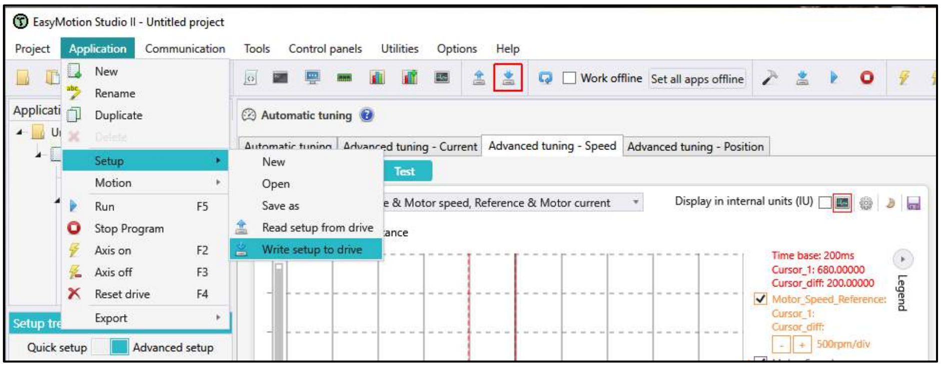


Figure 18.1.4. *EasyMotion Studio II - Write the setup parameters to the drive memory*

Once the setup is successfully written to the drive's non-volatile memory (EEPROM), a reset is required to activate it. The new settings will take effect at the next power-on, as the setup data is loaded into the active RAM memory used during runtime.

18.2 Using TML Functions to Split Motion between Master and Drives

With Technosoft intelligent drives you can really distribute the intelligence between a EtherCAT®master and the drives in complex multi-axis applications. Instead of trying to command each step of an axis movement, you can program the drives using TML to execute complex tasks and inform the master when these are done. Thus for each axis, the master task may be reduced at: calling TML functions (with possibility to abort their execution) stored in the drives EEPROM and waiting for a message, which confirms the finalization of the TML functions execution.

18.2.1 Build TML functions within EasyMotion Studio II

Steps to Create TML Functions with EasyMotion Studio II

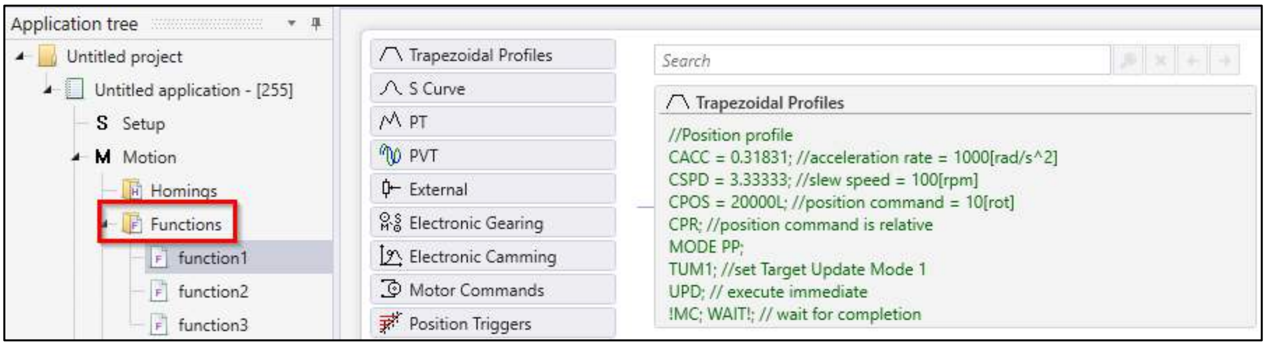
1. **Define the TML Functions**

   Start by opening your EasyMotion Studio II project. In the project tree, select the Functions entry. On the right-hand side of the project panel, you can add the TML functions that the drive will execute. Additionally, you can rename, remove, or rearrange the download order of these functions as needed. *Note: You can call up to 10 TML functions using the EtherCAT® objects.*

2. **Add the TML Code**

   Once the functions are added, they will appear under the Functions entry in the project tree. Select each function from the list and input the TML code that should be executed by it.

3. **Download the TML Functions to the Drive Memory**
   Use the following commands to complete the process:
   - Application | Motion | Build: Generates the executable code.
   - Application | Motion | Download Program: Uploads the TML code to the drive memory.



```
//Position profile
CACC = 0.31831; //acceleration rate = 1000[rad/s^2]
CSPD = 3.33333; //slew speed = 100[rpm]
CPOS = 20000L; //position command = 10[rot]
CPR; //position command is relative
MODE PP;
TUM1; //set Target Update Mode 1
UPD; // execute immediate
!MC; WAIT!; // wait for completion
```

Figure 18.2.1. *EasyMotion Studio II project window – functions edit view*

18.2.2 TML Function Objects

18.2.2.1 Object 2006h: Call TML Function

The object allows the execution of a previously downloaded TML function. When a write is performed to this object, the TML function with the index specified in the value provided is called. The TML function body is defined using EasyMotion Studio II and saved in the EEPROM memory of the drive. The function index represents an offset in a predefined table of TML callable functions.

It is not possible to call another TML function, while the previous one is still running. Bit 8 of Statusword (6041h) shows if a function is running. In case a function was called while another was still running, bits 7 (warning) from the Statusword (6041h) and 14 (command error) from Motion Error Register (2000h) are set, and the function call is ignored. The execution of any called TML function can be aborted by setting bit 13 in Controlword.

There are 10 TML functions that can be called through this mechanism (the first 10 TML functions defined using the EasyMotion Studio advanced programming environment). Any attempt to call another function (writing a number different from 1...10 in this object) will be signaled with an SDO abort code 0609 0030h (Value range of parameter exceeded). If a valid value is entered and no TML function is defined in that position, an SDO abort code will be issued: 0800 0020h (Data cannot be transferred or stored to the application).

The functions are initialized and available for calling, only after Controlword receives the Shutdown command (6040h = 06).

Object description:

Index	2006h
Name	Call TML function
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	WO
PDO mapping	No
Units	-
Value range	1...10
Default value	-

18.3 Executing TML programs

The distributed control concept can go on step further. You may prepare and download into a drive a complete TML program including functions, homing procedures, etc. The TML program execution can be started simply by writing a value in the dedicated object.

18.3.1 Object 2077h: Execute TML program

This object is used in order to execute the TML program from either EEPROM or RAM memory. The TML program is downloaded using the EasyMotion Studio II software or by the EtherCAT® master using the .sw file created in EasyMotion Studio II.

Writing any value in this object (through the SDO protocol) will trigger the execution of the TML program in the drive. If no TML program is found on the drive, an SDO abort code will be issued: 0800 0020h (Data cannot be transferred or stored to the application).

If the TML program is downloaded in the EEPROM memory, the beginning address needs to be 4000h (for F515x firmwares) or 2000h for (FA00x firmwares).

The TML program can be executed only after Controlword receives the Shutdown command (6040h = 06).

Object description:

Index	2077h
Name	Execute TML program
Object code	VAR
Data type	UNSIGNED16

Entry description:

Access	WO
PDO mapping	No
Value range	UNSIGNED16
Default value	-

18.4 Loading Automatically Cam Tables Defined in EasyMotion Studio II

In addition to the CiA402 standard operation modes, Technosoft drives offer advanced functionalities such as electronic gearing, electronic camming, and external modes with analog or digital references.
When using **electronic camming**, the cam tables (predefined motion profiles) can be loaded into the drive's active memory in one of the following ways:

1. Master Download to RAM - After each power-on, the master system downloads the cam points directly into the drive's active RAM memory.
2. Stored in EEPROM with Manual Copy to RAM - The cam points are stored in the drive's EEPROM. Upon command from the master, these points are copied into the active RAM memory.
3. Stored in EEPROM with Automatic Copy to RAM - The cam points are stored in the drive's EEPROM. During the drive initialization (when transitioning to the "Ready to Switch On" status), they are automatically copied from the EEPROM into the active RAM memory.

For the second and third methods, the cam tables are predefined in EasyMotion Studio II, where they are included in the data stored in the drive's EEPROM along with setup configurations, TML programs, and functions.

Note: The cam tables are also embedded in the .sw file generated by EasyMotion Studio II. This allows the master to verify the presence of cam tables in the drive's EEPROM using the same procedure used to check for setup data.

18.4.1 CAM table structure

Cam tables are arrays of (X, Y) points where:

- X represents the cam input (master position), expressed in the master's internal position units.
- Y represents the cam output (slave position), expressed in the slave's internal position units.

Both X and Y points are 32-bit integers. The X points must be non-negative (including 0) and evenly spaced, with an interpolation step of 2^n (where n ranges from 0 to 7). This results in steps of 1, 2, 4, 8, 16, 32, 64, or 128. A single cam table can contain up to 8192 points.

Since X points are evenly spaced, they can be fully defined using just two parameters:

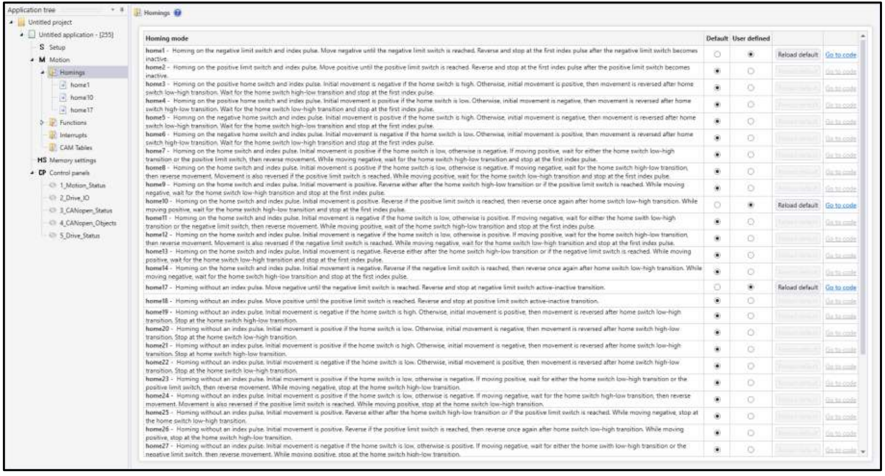
1. Master start value (the first X point).
2. Interpolation step (distance between consecutive X points).

This optimization reduces the cam table size, which is stored in the drive/motor using the following format:

1. 1st word (16 bits):
    - Bits 15–13: Power of 2 for the interpolation step. For example, if the binary value is 010 (2), the step is 2^2=4, resulting in X points like 0, 4, 8, 12, etc.
    - Bits 12–0: Length of the table minus 1 (length is the number of points, with each point occupying 2 words).
2. 2nd and 3rd words:
    - Master start value (32 bits), expressed in master position units.
    - The 2nd word stores the lower part, and the 3rd word stores the higher part.
3. 4th and 5th words: Reserved fields (must be set to 0).
4. Subsequent pairs of words:
    - Slave Y positions (32 bits), expressed in position units.
    - Each pair includes the lower part (1st word) and the higher part (2nd word).
5. Final word:
    - Cam table checksum (sum of all table data modulo 65536, excluding the checksum itself).

18.5 Customizing the Homing Procedures

The homing methods defined by the CiA402 are highly modifiable to accommodate your application. If needed, any of these homing modes can be customized. In order to do this you need to select the Homing Modes from your EasyMotion Studio II application and in the right side to set as "User defined" one of the Homing procedures. Following this operation the selected procedure will occur under Homing Modes in a sub tree, with the name *HomeX* where X is the number of the selected homing.



Homing mode	Default	User defined		
home1 - Homing on the negative limit switch and index pulse. Move negative until the negative limit switch is reached. Reverse and stop at the first index pulse after the negative limit switch becomes inactive.	○	●	Reload default	Go to code
home2 - Homing on the positive limit switch and index pulse. Move positive until the positive limit switch is reached. Reverse and stop at the first index pulse after the positive limit switch becomes inactive.	●	○	Reload default	Go to code
home3 - Homing on the positive home switch and index pulse. Initial movement is negative if the home switch is high. Otherwise, initial movement is positive, then movement is reversed after home switch low-high transition. Wait for the home switch high-low transition and stop at the first index pulse.	●	○	Reload default	Go to code
home4 - Homing on the positive home switch and index pulse. Initial movement is positive if the home switch is low. Otherwise, initial movement is negative, then movement is reversed after home switch high-low transition. Wait for the home switch low-high transition and stop at the first index pulse.	●	○	Reload default	Go to code
home5 - Homing on the negative home switch and index pulse. Initial movement is positive if the home switch is high. Otherwise, initial movement is negative, then movement is reversed after home switch low-high transition. Wait for the home switch high-low transition and stop at the first index pulse.	●	○	Reload default	Go to code
home6 - Homing on the negative home switch and index pulse. Initial movement is negative if the home switch is low. Otherwise, initial movement is positive, then movement is reversed after home switch high-low transition. Wait for the home switch low-high transition and stop at the first index pulse.	●	○	Reload default	Go to code
home7 - Homing on the home switch and index pulse. Initial movement is positive if the home switch is low, otherwise is negative. If moving positive, wait for either the home switch low-high transition or the positive limit switch, then reverse movement. While moving negative, wait for the home switch high-low transition and stop at the first index pulse.	●	○	Reload default	Go to code
home8 - Homing on the home switch and index pulse. Initial movement is positive if the home switch is low, otherwise is negative. If moving negative, wait for the home switch high-low transition, then reverse movement. Movement is also reversed if the positive limit switch is reached. While moving positive, wait for the home switch low-high transition and stop at the first index pulse.	●	○	Reload default	Go to code
home9 - Homing on the home switch and index pulse. Initial movement is positive. Reverse either after the home switch high-low transition or if the positive limit switch is reached. While moving negative, wait for the home switch low-high transition and stop at the first index pulse.	●	○	Reload default	Go to code
home10 - Homing on the home switch and index pulse. Initial movement is positive. Reverse if the positive limit switch is reached, then reverse once again after home switch low-high transition. While moving positive, wait for the home switch high-low transition and stop at the first index pulse.	○	●	Reload default	Go to code
home11 - Homing on the home switch and index pulse. Initial movement is negative if the home switch is low, otherwise is positive. If moving negative, wait for either the home swith low-high transition or the negative limit switch, then reverse movement. While moving positive, wait of the home switch high-low transition and stop at the first index pulse.	●	○	Reload default	Go to code
home12 - Homing on the home switch and index pulse. Initial movement is negative if the home switch is low, otherwise is positive. If moving positive, wait for the home switch high-low transition, then reverse movement. Movement is also reversed if the negative limit switch is reached. While moving negative, wait for the home switch low-high transition and stop at the first index pulse.	●	○	Reload default	Go to code
home13 - Homing on the home switch and index pulse. Initial movement is negative. Reverse either after the home switch high-low transition or if the negative limit switch is reached. While moving positive, wait for the home switch low-high transition and stop at the first index pulse.	●	○	Reload default	Go to code
home14 - Homing on the home switch and index pulse. Initial movement is negative. Reverse if the negative limit switch is reached, then reverse once again after home switch low-high transition. While moving negative, wait for the home switch high-low transition and stop at the first index pulse.	●	○	Reload default	Go to code
home17 - Homing without an index pulse. Move negative until the negative limit switch is reached. Reverse and stop at negative limit switch active-inactive transition.	○	●	Reload default	Go to code
home18 - Homing without an index pulse. Move positive until the positive limit switch is reached. Reverse and stop at positive limit switch active-inactive transition.	●	○	Reload default	Go to code
home19 - Homing without an index pulse. Initial movement is negative if the home switch is high. Otherwise, initial movement is positive, then movement is reversed after home switch low-high transition. Stop at the home switch high-low transition.	●	○	Reload default	Go to code
home20 - Homing without an index pulse. Initial movement is positive if the home switch is low. Otherwise, initial movement is negative, then movement is reversed after home switch high-low transition. Stop at the home switch low-high transition.	●	○	Reload default	Go to code
home21 - Homing without an index pulse. Initial movement is positive if the home switch is high. Otherwise, initial movement is negative, then movement is reversed after home switch low-high transition. Stop at home switch high-low transition.	●	○	Reload default	Go to code
home22 - Homing without an index pulse. Initial movement is negative if the home switch is low. Otherwise, initial movement is positive, then movement is reversed after home switch high-low transition. Stop at the home switch low-high transition.	●	○	Reload default	Go to code
home23 - Homing without an index pulse. Initial movement is positive if the home switch is low, otherwise is negative. If moving positive, wait for either the home switch low-high transition or the positive limit switch, then reverse movement. While moving negative, stop at the home switch high-low transition.	●	○	Reload default	Go to code
home24 - Homing without an index pulse. Initial movement is positive if the home switch is low, otherwise is negative. If moving negative, wait for the home switch high-low transition, then reverse movement. Movement is also reversed if the positive limit switch is reached. While moving positive, stop at the home switch low-high transition.	●	○	Reload default	Go to code
home25 - Homing without an index pulse. Initial movement is positive. Reverse either after the home switch high-low transition or if the positive limit switch is reached. While moving negative, stop at the home switch low-high transition.	●	○	Reload default	Go to code
home26 - Homing without an index pulse. Initial movement is positive. Reverse if the positive limit switch is reached, then reverse once again after home switch low-high transition. While moving positive, stop at the home switch high-low transition.	●	○	Reload default	Go to code
home27 - Homing without an index pulse. Initial movement is negative if the home switch is low, otherwise is positive. If moving negative, wait for either the home swith low-high transition or the negative limit switch, then reverse movement. While moving positive, stop at the home switch high-low transition.	●	○	Reload default	Go to code

If you click on the *HomeX* procedure, on the right side you'll see the TML function implementing it. The homing routine can be customized according to your application needs. Its calling name and method remain unchanged.

18.6 Customizing the Drive Reaction to Fault Conditions

Similarly to the homing modes, the default service routines for the TML interrupts can be customized according to your application needs. However, as most of these routines handle the drive reaction to fault conditions, it is mandatory to keep the existent functionality while adding your application needs, in order to preserve the correct protection level of the drive. The procedure for modifying the TML interrupts is similar with that for the homing modes.

Appendix A: Object Dictionary by Index

Index	Sub-index	Description
1000$_h$	00$_h$	Device type
1001$_h$	00$_h$	Error register
1008$_h$	00$_h$	Manufacturer device name
100A$_h$	00$_h$	Manufacturer software version
1018$_h$		Identity Object
	00$_h$	Number of entries
	01$_h$	Vendor ID
	02$_h$	Product Code
	03$_h$	Revision Number
	04$_h$	Serial Number
1600$_h$		RPDO1 mapping parameters
	00$_h$	Number of entries
	01$_h$	1st mapped object – 6040$_h$ – Controlword
	02$_h$	2nd mapped object – 607A$_h$ – target position
1601$_h$		RPDO2 mapping parameters
	00$_h$	Number of entries
	01$_h$	1st mapped object–60FE$_h$.01 – Digital outputs – Physical outputs
	02$_h$	2nd mapped object–60FE$_h$.02 – Digital outputs – Bit mask
1602$_h$		RPDO3 mapping parameters
	00$_h$	Number of entries
	01$_h$	1st mapped object – 6040$_h$ – Controlword
	02$_h$	2nd mapped object – 607A$_h$ – target position
1603$_h$		RPDO4 mapping parameters
	00$_h$	Number of entries
	01$_h$	1st mapped object – 6081$_h$ – profile velocity
	02$_h$	2nd mapped object – 6083$_h$ – profile acceleration
1A00$_h$		TPDO1 mapping parameters
	00$_h$	Number of entries
	01$_h$	1st mapped object – 6041$_h$ – Statusword
	02$_h$	2nd mapped object – 6064$_h$ – position actual value
	03$_h$	3rd mapped object – 6077$_h$ – Torque (current) actual value
1A01$_h$		TPDO2 mapping parameters
	00$_h$	Number of entries
	01$_h$	1st mapped object – 60F4$_h$ – Following error actual value
	02$_h$	2nd mapped object – 60FD$_h$ – Digital inputs
1A02$_h$		TPDO3 mapping parameters
	00$_h$	Number of entries
	01$_h$	1st mapped object – 606C$_h$ – Velocity actual value
1A03$_h$		TPDO4 mapping parameters
	00$_h$	Number of entries
	01$_h$	1st mapped object – 6061$_h$ – Modes of operation display
1C00$_h$		Sync Manager Communication type
	00$_h$	Number of entries
	01$_h$	Communication Type Sync Manager 0
	02$_h$	Communication Type Sync Manager 1
	03$_h$	Communication Type Sync Manager 2
	04$_h$	Communication Type Sync Manager 3
1C12$_h$		Sync Manager Channel 2 (Process Data Output)
	00$_h$	Number of entries
	01$_h$	PDO Mapping object index of assigned RxPDO : 1st mapped object (1600$_h$)
1C13$_h$		Sync Manager Channel 3 (Process Data Input)
	00$_h$	Number of entries
	01$_h$	PDO Mapping object index of assigned TxPDO : 1st mapped object (1A00$_h$)

	02$_h$	PDO Mapping object index of assigned TxPDO : 2nd mapped object (1A01$_h$)
1C32$_h$		Output Sync Manager Parameter
	00$_h$	Number of entries
	01$_h$	Synchronization Type
	02$_h$	Cycle Time
	04$_h$	Synchronization Types supported
	05$_h$	Minimum Cycle Time
	06$_h$	Calc and Copy Time
	09$_h$	Delay Time
	0B$_h$	SM-Event Missed Counter
	0C$_h$	Cycle Time Too Small Counter
	20$_h$	Sync Error
1C33$_h$		Input Sync Manager Parameter
	00$_h$	Number of entries
	01$_h$	Synchronization Type
	02$_h$	Cycle Time
	04$_h$	Synchronization Types supported
	05$_h$	Minimum Cycle Time
	06$_h$	Calc and Copy Time
	09$_h$	Delay Time
	0B$_h$	SM-Event Missed Counter
	0C$_h$	Cycle Time Too Small Counter
	20$_h$	Sync Error
2000$_h$	00$_h$	Motion Error Register
2001$_h$	00$_h$	Motion Error Register mask
2002$_h$	00$_h$	Detailed Error Register
2005$_h$	00$_h$	Max slippage time out
2006$_h$	00$_h$	Call TML function
2009$_h$	00$_h$	Detailed Error Register 2
2012$_h$	00$_h$	Master resolution
2013$_h$		EGEAR multiplication factor
	00$_h$	Number of entries
	01$_h$	EGEAR ratio numerator (slave)
	02$_h$	EGEAR ratio denominator (master)
2017$_h$	00$_h$	Master actual position
2018$_h$	00$_h$	Master actual speed
2019$_h$	00$_h$	CAM table load address
201A$_h$	00$_h$	CAM table run address
201B$_h$	00$_h$	CAM offset
201D$_h$	00$_h$	External reference type
201E$_h$	00$_h$	Master position
2022$_h$	00$_h$	Control effort
2023$_h$	00$_h$	Jerk time
2025$_h$	00$_h$	Stepper current in open loop operation
2026$_h$	00$_h$	Stand-by current for stepper in open loop operation
2027$_h$	00$_h$	Timeout for stepper stand-by current
2045$_h$	00$_h$	Digital outputs status
2046$_h$	00$_h$	Analogue input: Reference
2047$_h$	00$_h$	Analogue input: Feedback
2050$_h$	00$_h$	Over current protection level
2051$_h$	00$_h$	Over current time out
2052$_h$	00$_h$	Motor nominal current
2053$_h$	00$_h$	I2t protection integrator limit
2054$_h$	00$_h$	I2t protection scaling factor
2055$_h$	00$_h$	DC-link voltage
2058$_h$	00$_h$	Drive temperature
2060$_h$	00$_h$	Software version of the TML application
2064$_h$	00$_h$	Read/Write configuration register
2065$_h$	00$_h$	Write data at address set in object 2064$_h$ (16/32 bits)
2066$_h$	00$_h$	Read data from address set in object 2064$_h$ (16/32 bits)
2067$_h$	00$_h$	Write data at specified address
2066$_h$	00$_h$	Checksum configuration register
206A$_h$	00$_h$	Checksum read register
206B$_h$	00$_h$	CAM input scaling factor
206C$_h$	00$_h$	CAM output scaling factor
206F$_h$	00$_h$	Time notation index
2070$_h$	00$_h$	Time dimension index

2071$_h$		Time factor
	00$_h$	Number of entries
	01$_h$	Numerator
	02$_h$	Divisor
2072$_h$	00$_h$	Interpolated position mode status
2073$_h$	00$_h$	Interpolated position buffer length
2074$_h$	00$_h$	Interpolated position buffer configuration
2075$_h$		Position triggers
	00$_h$	Number of entries
	01$_h$	Position trigger 1
	02$_h$	Position trigger 2
	03$_h$	Position trigger 3
	04$_h$	Position trigger 4
2076$_h$	00$_h$	Save current configuration
2077$_h$	00$_h$	Execute TML program
2079$_h$	00$_h$	Interpolated position initial position
207A$_h$	00$_h$	Interpolated position 1st order time
207B$_h$	00$_h$	Homing current threshold
207C$_h$	00$_h$	Homing current threshold time
207D$_h$	00$_h$	Dummy
207F$_h$	00$_h$	Current limit
2080$_h$	00$_h$	Reset drive
2081$_h$	00$_h$	Set/Change the actual motor position value
2082$_h$	00$_h$	Sync on fast loop
2083$_h$	00$_h$	Encoder resolution for step loss protection
2084$_h$	00$_h$	Stepper resolution for step loss protection
2085$_h$	00$_h$	Position triggered outputs
2086$_h$	00$_h$	Limit speed for CSP
2087$_h$	00$_h$	Actual internal velocity from sensor on motor
2088$_h$	00$_h$	Actual internal position from sensor on motor
2089$_h$	00$_h$	Synchronization test config
208A$_h$	00$_h$	Save setup status
208B$_h$	00$_h$	Sin AD signal from Sin/Cos encoder
208C$_h$	00$_h$	Cos AD signal from Sin/Cos encoder
208D$_h$	00$_h$	Auxiliary encoder position
208E$_h$	00$_h$	Auxiliary Settings Register
208F$_h$		Digital inputs 8bit
	00$_h$	Number of entries
	01$_h$	Device profile defined inputs
	02$_h$	Manufacturer specific inputs
2090$_h$		Digital outputs 8bit
	00$_h$	Number of entries
	01$_h$	Physical outputs 8bit
	02$_h$	Bit mask 8bit
2091$_h$	00$_h$	Lock EEPROM
2092$_h$		User Variables
	00$_h$	Number of entries
	01$_h$	UserVar1
	02$_h$	UserVar2
	03$_h$	UserVar3
	04$_h$	UserVar4
20A0$_h$		Load Position and Speed monitoring
	00$_h$	Number of entries
	01$_h$	Reserved
	02$_h$	Load Position Monitor
	03$_h$	Load Speed Monitor
2100$_h$	00$_h$	Number of steps per revolution
2101$_h$	00$_h$	Number of microsteps per step
2102$_h$	00$_h$	Brake status
2103$_h$	00$_h$	Number of encoder counts per revolution
2104$_h$	00$_h$	Auxiliary encoder function
2105$_h$	00$_h$	Auxiliary encoder status
2106$_h$	00$_h$	Auxiliary encoder captured position positive edge
2107$_h$	00$_h$	Auxiliary encoder captured position negative edge
2108$_h$		Filter variable 16bit
	00$_h$	Number of entries
	01$_h$	16 bit variable address
	02$_h$	Filter strength

	03$_h$	Filtered variable 16bit
2109$_h$	00$_h$	Sync offset
210A$_h$	00$_h$	Sync rate
210B$_h$	00$_h$	Auxiliary Settings Register 2
210C$_h$	00$_h$	Enable SW file download
210D$_h$	00$_h$	Virtual MAC address for EOE
210E$_h$		IP config for EoE
	00$_h$	Number of entries
	01$_h$	IP address
	02$_h$	Subnet mask
	03$_h$	Default gateway
210F$_h$		Acceleration encoder factor
	00$_h$	Number of entries
	01$_h$	Acceleration internal units (IU)
	02$_h$	Acceleration units (AU)
2110$_h$		Jerk encoder factor
	00$_h$	Number of entries
	01$_h$	Jerk internal units (IU)
	02$_h$	Jerk units (JU)
2113$_h$		Detailed Option Code
	00$_h$	Number of entries
	01$_h$	Short-Circuit option code
	02$_h$	Reserved
	03$_h$	Control error option code
	04$_h$	Communication error option code
	05$_h$	Reserved
	06$_h$	Reserved
	07$_h$	Reserved
	08$_h$	Over current option code
	09$_h$	Reserved
	10$_h$	Over temperature – Motor option code
	11$_h$	Over temperature – Drive option code
	12$_h$	Over voltage option code
	13$_h$	Under voltage option code
	14$_h$	Reserved
	15$_h$	Enable / STO inactive option code
2114$_h$	00$_h$	Fault Override Option Code
2115$_h$	00$_h$	ASR4
6007$_h$	00$_h$	Abort connection option code
603F$_h$	00$_h$	Error code
6040$_h$	00$_h$	Controlword
6041$_h$	00$_h$	Statusword
605A$_h$	00$_h$	Quick stop option code
605B$_h$	00$_h$	Shutdown option code
605C$_h$	00$_h$	Shutdown option code
605D$_h$	00$_h$	Disable operation option code
605E$_h$	00$_h$	Fault reaction option code
6060$_h$	00$_h$	Modes of operation
6061$_h$	00$_h$	Modes of operation display
6062$_h$	00$_h$	Position demand value
6063$_h$	00$_h$	Position actual internal value
6064$_h$	00$_h$	Position actual value
6065$_h$	00$_h$	Following error window
6066$_h$	00$_h$	Following error time out
6067$_h$	00$_h$	Position window
6068$_h$	00$_h$	Position window time
6069$_h$	00$_h$	Velocity sensor actual value
606B$_h$	00$_h$	Velocity demand value
606D$_h$	00$_h$	Velocity window
606E$_h$	00$_h$	Velocity window time
606C$_h$	00$_h$	Velocity actual value
606F$_h$	00$_h$	Velocity threshold
6071$_h$	00$_h$	Target torque
6075$_h$	00$_h$	Motor rate current
6077$_h$	00$_h$	Torque actual value
607A$_h$	00$_h$	Target position
607B$_h$		Position range limit
	00$_h$	Number of entries

	01$_h$	Min position range limit	
	02$_h$	Max position range limit	
607C$_h$	00$_h$	Home offset	
607D$_h$		Software position limit	
	00$_h$	Number of entries	
	01$_h$	Minimal position limit	
	02$_h$	Maximal position limit	
607E$_h$	00$_h$	Polarity	
6080$_h$	00$_h$	Max motor speed	
6081$_h$	00$_h$	Profile velocity	
6083$_h$	00$_h$	Profile acceleration	
6085$_h$	00$_h$	Quick stop deceleration	
6086$_h$	00$_h$	Motion profile type	
6087$_h$	00$_h$	Torque slope	
6089$_h$	00$_h$	Position notation index	
608A$_h$	00$_h$	Position dimension index	
608B$_h$	00$_h$	Velocity notation index	
608C$_h$	00$_h$	Velocity dimension index	
608D$_h$	00$_h$	Acceleration notation index	
608E$_h$	00$_h$	Acceleration dimension index	
6091$_h$		Gear Ratio	
	00$_h$	Number of entries	
	01$_h$	Motor rotation	
	02$_h$	Load rotation	
6092$_h$		Feed constant	
	00$_h$	Number of entries	
	01$_h$	Feed	
	02$_h$	Shaft rotation	
6093$_h$		Position factor	
	00$_h$	Number of entries	
		Factor group – CiA 402	Factor group – CiA 402-2
	01$_h$	Numerator	Position internal units (IU)
	02$_h$	Divisor	Position units (PU)
6094$_h$		Velocity encoder factor	
	00$_h$	Number of entries	
		Factor group – CiA 402	Factor group – CiA 402-2
	01$_h$	Numerator	Velocity internal units (IU)
	02$_h$	Divisor	Velocity units (VU)
6096$_h$		Velocity factor	
	00$_h$	Number of entries	
	01$_h$	Velocity units (VU)	
	02$_h$	Position units (PU)	
6097$_h$		Acceleration factor	
	00$_h$	Number of entries	
		Factor group – CiA 402	Factor group – CiA 402-2
	01$_h$	Numerator	Acceleration units (AU)
	02$_h$	Divisor	Velocity units (VU)
6098$_h$	00$_h$	Homing method	
6099$_h$		Homing speeds	
	00$_h$	Number of entries	
	01$_h$	Speed during search for switch	
	02$_h$	Speed during search for zero	
609A$_h$	00$_h$	Homing acceleration	
60A2$_h$		Jerk factor	
	00$_h$	Number of entries	
	01$_h$	Jerk Units (JU)	
	02$_h$	Acceleration units (AU)	
60A8$_h$	00$_h$	SI unit position	
60A9$_h$	00$_h$	SI unit velocity	
60AA$_h$	00$_h$	SI unit acceleration	
60AB$_h$	00$_h$	SI unit jerk	
60B8$_h$	00$_h$	Touch probe function	
60B9$_h$	00$_h$	Touch probe status	
60BA$_h$	00$_h$	Touch probe 1 positive edge	
60BB$_h$	00$_h$	Touch probe 1 negative edge	
60BC$_h$	00$_h$	Touch probe 2 positive edge	
60BD$_h$	00$_h$	Touch probe 2 negative edge	
60C0$_h$	00$_h$	Interpolation sub mode select	

60C1$_h$		Interpolation Data Record
	00$_h$	Number of entries
	01$_h$	The first parameter
	02$_h$	The second parameter
60C2$_h$		Interpolation Time Period
	00$_h$	Number of entries
	01$_h$	Interpolation time period value
	02$_h$	Interpolation time index
60F2$_h$	00$_h$	Positioning Option Code
60F4$_h$	00$_h$	Following error actual value
60F8$_h$	00$_h$	Max slippage
60FC$_h$	00$_h$	Position demand internal value
60FD$_h$	00$_h$	Digital inputs
60FE$_h$		Digital outputs
	00$_h$	Number of entries
	01$_h$	Physical outputs
	02$_h$	Bit mask
60FF$_h$	00$_h$	Target velocity
6502$_h$	00$_h$	Supported drive modes

Appendix B: Definition of Dimension Indices

Dimension/Notation Index Table

physical dimension	dimension index	units exponent	unit type	notation index
non	0	units		0
length	1		metre	0
		milli	metre	-3
		kilo	metre	3
		micro	metre	-6
area	2	square	metre	0
		square milli	metre	-6
		square kilo	metre	6
volume	3	cubic	metre	0
time	4		second	0
			minute	70
			hour	74
			day	77
		milli	second	-3
		micro	second	-6
actual power	9		watt	0
		kilo	watt	3
		mega	watt	6
		milli	watt	-3
apparent power	10		voltampere	0
		kilo	voltampere	3
		mega	voltampere	6
no. of revolutions	11		per second	0
			per minute	73
			per hour	74
angle	12		radian	0
			second	75
			minute	76
			degree	77
			newdegree	78
velocity	13		metre p. second	0
		milli	metre p. second	-3
		milli	metre p. minute	79
			metre p. minute	80
		kilo	metre p. minute	81
		milli	metre p. hour	82
			metre p. hour	83
		kilo	metre p. hour	84
torque	16		newton metre	0
		kilo	newton metre	3
		mega	newton metre	6
temperature	17		kelvin	0
			centigrade	94
			Fahrenheit	95
voltage	21		Volt	0
		kilo	Volt	3
		milli	Volt	-3
		micro	Volt	-6
current	22		Ampere	0
		kilo	Ampere	3
		milli	Ampere	-3
		micro	Ampere	-6
ratio	24		percent	0
frequency	28		Hertz	0
		kilo	Hertz	3
		mega	Hertz	6
		giga	Hertz	9
steps	32		steps	0

encoder resolution	33	revolution steps per	0

Examples for Notation Indices

Examples for notation indices < 64:

For notation index <64 the value is used as an exponent. The unit is defined by the physical dimension and calculated by unit type and exponent, all declared in the dimension/notation index table above.

position unit dimension index = 1: length
notation index = -6: micro meter

position_units = $10^{notation\_index}$ x f(dimension_index) = 10^{-6} m

dimension index = 12: angle notation index
= 0: radian

position_units = $10^{notation\_index}$ x f(dimension_index) = radian

velocity unit

dimension index = 13: velocity notation index = -3: milli metre per second

velocity_units = $10^{notation\_index}$ x f(dimension_index) = 10^{-3} m/s

frequency units dimension index = 28:
frequency notation index = 3: kilo hertz

frequency_units = $10^{notation\_index}$ x f(dimension_index) = 10^{3} Hz

Examples for notation indices > 64:

The unit is defined by the physical dimension and unit type, both declared in the dimension/notation index table.

time units

dimension index = 4: time notation index = 77: day

time_units = f(dimension_index,notation_index) = day

position unit dimension index = 12:
angle notation index = 76:
minute

position_units = f(dimension_index,notation_index)

= minute

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