

MovingCap flatTRACK EtherCAT – Application Note

Version 1.3

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References

[1]: MovingCap Ethernet drives - Quick guide

<https://movingcap.com/webmanuals/eth/index.html>

[1]: Introduction to CANopen, CoE (CANopen over EtherCAT) and the CiA 402 device specification

https://movingcap.com/CANopen_CoE_EtherCAT_introduction_en/

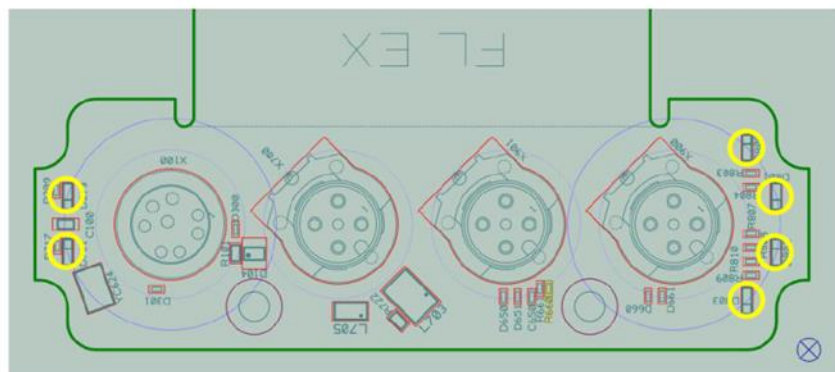
1 Version history

| Version | Date | Description | Amendment |
|---------|------------|--|---------------|
| 1.3 | 26.05.2025 | Formatting; DE+EN | OH |
| 1.2 | 29.04.2025 | Formatting, object numbers, references | OH |
| 1.1 | 08.04.2025 | Additions OH added | Daniel Wetzel |
| 1.0 | 19.02.2025 | Document created | Daniel Wetzel |

Table1 : Version history

2 LEDs and connection assignment

2.1 LEDs



uC-STATUS
TCP Service ACT

EtherCAT Link/Act PortA
EtherCAT Link/Act PortB
EtherCAT RUN
EtherCAT ERROR

Figure1 : LEDs

2.1.1 EtherCAT LEDs

The LEDs are located on the right-hand side.

● EtherCAT Link/Act PortB

- **Off (Off):** No physical connection (no cable connected or defective)
- **On (On):** Physical connection available, but no communication
- **Flashing:** Data traffic on the EtherCAT port (frames are being received/transmitted)

● EtherCAT Link/Act PortA

- **Off (Off):** No physical connection (no cable connected or defective)
- **On (On):** Physical connection available, but no communication
- **Flashing:** Data traffic on the EtherCAT port (frames are being received/transmitted)

● EtherCAT RUN

This LED indicates the status of the EtherCAT communication or the slave status:

- **Off (Off):** Device is not integrated in the EtherCAT network
- **Flashing pattern (1 Hz):** Device is in the **Init** or Pre-Operational **state**
- **Permanently On:** Device is in **safe-operational** or operational **mode**

EtherCAT ERROR

This LED indicates the status of the EtherCAT communication or the slave status:

On (On): Device has an error or communication fault

2.1.2 Ethernet LED, firmware status

The LEDs are located on the left-hand side

TCP Service ACT

- **Off (Off):**
No Ethernet cable connected, or no physical connection
- **On (On):**
Ethernet cable is connected, physical connection is established.
- **Flashing:**
Network activity is taking place (data is being sent/received)

µC status

This LED indicates the status of the µC firmware

- **Off (Off):** Bootloader active
- **Flashing pattern (1 Hz):** Drive firmware active. Among other things, the flashing pattern sends the current TCP/IP address of the Ethernet service interface. See: <https://movingcap.de/webmanuals/eth/index.html?anzeigen.html>

2.2 Connections

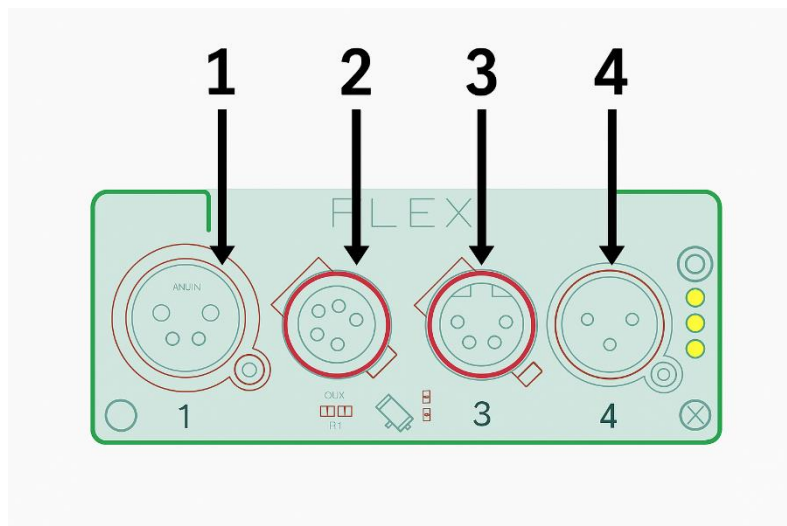


Figure2 : Connections 1 - 4

- 1. Power /I-O
- 2. Ethernet, service interface
- 3. EtherCAT PortA
- 4. EtherCAT PortB

2.2.1 Power / I-O

| MCFLAT ETH (MovingCap flatTRACK Ethernet) MCSHORT ETH (MovingCap shortTRACK Ethernet) POWER + I/O M12 hybrid socket, 8-pin, coding: Y | | | |
|--|-------------------|-----------------------------|--------------|
| Pin | Designation | Description | Color *1) |
| 1 | IN10 (opt. HW_EN) | Digital input 24 Vdc | white/orange |
| 2 | IO1 | Digital input/output 24 Vdc | orange |
| 3 | IN8 | Digital input 24 Vdc | white/green |
| 4 | IO2 | Digital input/output 24 Vdc | green |
| 5 | U_PWR | Power supply 24-48 Vdc | blue |

| | | | |
|---|---------|----------------------|-------|
| 6 | GND | GND Logic + Power | white |
| 7 | U_LOGIK | Logic supply 24 Vdc | brown |
| 8 | IN7 | Digital input 24 Vdc | black |

*1) Colors of the individual wires for Phoenix Contact NBC-M12MSY hybrid cable M12 8-pin, Y-coding

Table2 : Pin assignment

3 CoE / CANopen over EtherCAT

CoE (CANopen over EtherCAT) is used to manage EtherCAT devices according to CiA 402 device specification / defined according to IEC 61800-7-201:2015.

CiA 402 defines standardized access parameters and parameter numbers that you need for operation, diagnostics or commissioning. CiA 402 defines device behavior and standard operating modes such as positioning mode or speed mode.

3.1 State machine / Control Word 0x6040 according to CiA 402 (DS 402)

The **state machine according to CiA 402 / DS402** (PDS FSA, Power Drive System - Finite State Automat) is a standardized state model for electric drives in automation technology. It describes how a drive reacts to control commands and changes through various operating states.

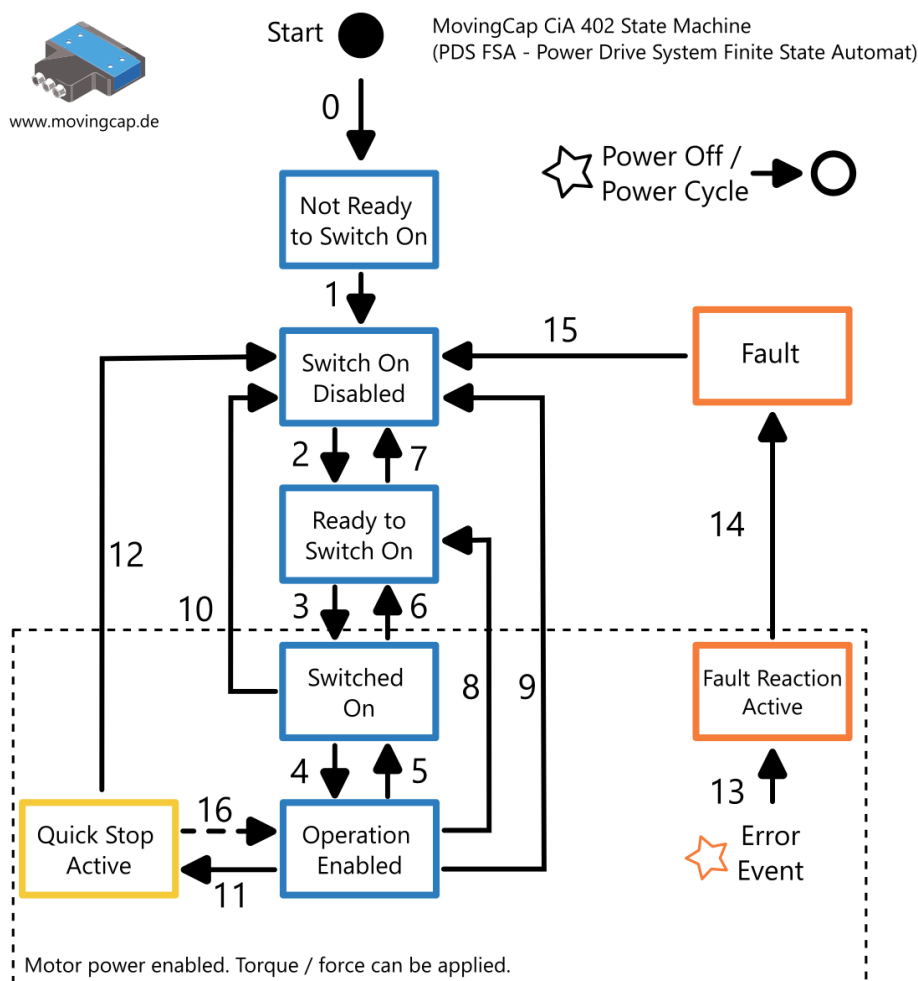


Figure3 : CoE Statemachine

The state transitions are controlled via the **control word (Controlword, index 0x6040)**. The current status is reported back in the **status word (status word, index 0x6041)**.

3.1.1 Overview of the states

| Condition | Description | Status word (0x6041) |
|------------------------|---|----------------------|
| Not Ready to Switch On | Drive is not ready for operation, initialization is running | 0x0000 |
| Switch On Disabled | Drive locked, cannot be switched on | 0x0040 |
| Ready to Switch On | Drive can be switched on | 0x0021 |
| Switched On | Drive switched on, but not ready for operation | 0x0023 |
| Operation Enabled | Drive is ready for operation and controllable | 0x0027 |
| Quick Stop Active | Emergency stop active, but power supply still on | 0x0007 |
| Fault Reaction Active | Error response active, depending on error behavior | 0x000F |
| Fault | Error status, drive disabled | 0x0008 |

Table3 : States

3.1.2 Overview of state transitions

| Initial state | Event/command | Target state | Control word (0x6040) |
|------------------------|----------------------------|-----------------------|-----------------------|
| Not Ready to Switch On | Automatic initialization | Switch On Disabled | - |
| Switch On Disabled | Shutdown | Ready to Switch On | 0x06 |
| Ready to Switch On | Switch On | Switched On | 0x07 |
| Switched On | Enable Operation | Operation Enabled | 0x0F |
| Operation Enabled | Quick Stop | Quick Stop Active | 0x02 |
| Quick Stop Active | Set Enable Operation again | Operation Enabled | 0x0F |
| Each state | Error occurred | Fault | - |
| Fault | Automatic transition | Fault Reaction Active | - |
| Fault | Fault reset | Switch On Disabled | 0x80 |

Table4 : State transitions

3.2 Operating modes / Operation Mode 0x6060

| Mode | Description | Application | Mode |
|-----------------------------|--|--------------------------|-----------------------------|
| PPM (Profile Position Mode) | Send a position command once, the drive executes it automatically. | Point-to-point movements | PPM (Profile Position Mode) |

| | | | |
|--|--|------------------------------------|--|
| CSP (Cyclic Position Mode) Synchronous | Continuous position specification by the master with high-precision synchronization. | Highly dynamic movements, robotics | CSP (Cyclic Synchronous Position Mode) |
|--|--|------------------------------------|--|

Table5 : Operating modes

The operating mode is selected via object 0x6060:

PPM Mode 1

CSP Mode 8

The value for object 0x6060 is transferred to **object 0x6061 (Modes of Operation Display)** as soon as the mode is active.

3.3 PDO mapping according to CiA 301

PDOs are communication objects that are used for the fast exchange of process data between EtherCAT master and slave devices. They transfer data in real time and enable cyclical communication.

There are two main types of PDOs:

TPDO (Transmit PDO): Used to transmit data from the slave to the master.

RPDO (Receive PDO): Used to transfer data from the master to the slave.

3.3.1 Modules

3.3.1.1 Mapping 1: csp, current, i/o

| Index | Size | Offs | Name | Type | TwinCat NC mapping |
|-----------|------|------|----------------------------|-------|---|
| 0x6041:00 | 2.0 | 0.0 | Status Word | UINT | <0-7> nState1 . In . Inputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF <8-15> nState2 . In . Inputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x6064:00 | 4.0 | 2.0 | Actual Position | DINT | <0-15> nDataIn1[0] . nDataIn1 . In . Inputs . Enc . Axis 1 . Axis 1 . Axes . NC task 1 SAF <16-31> nDataIn1[1] . nDataIn1 . In . Inputs . Enc . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x606C:00 | 4.0 | 6.0 | Actual velocity | DINT | <0-15> nDataIn7[0] . nDataIn7 . In . Inputs . Enc . Axis 1 . Axis 1 . Axes . NC task 1 SAF <16-31> nDataIn7[1] . nDataIn7 . In . Inputs . Enc . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x6061:00 | 1.0 | 10.0 | Modes of Operation Display | USINT | nState5 . In . Inputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |

| | | | | | |
|-----------|-----|------|-----------------|------|---|
| 0x6078:00 | 2.0 | 11.0 | Actual Current | INT | nDataIn3[0] . nDataIn3 . In . Inputs . Enc . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x60FE | 4.0 | 13.0 | Digital Outputs | DINT | |

Table6 : TPDO (Inputs) Mapping csp, current, i/o

| Index | Size | Offs | Name | Type | TwinCat NC mapping |
|-----------|------|------|--------------------|-------|---|
| 0x6040:00 | 2.0 | 0.0 | Control Word | UINT | <0-7> nCtrl1 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF <8-15> nCtrl2 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x607A:00 | 4.0 | 2.0 | Target position | DINT | <0-15> nDataOut1[0] . nDataOut1 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF <16-31> nDataOut1[1] . nDataOut1 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x60FF:00 | 4.0 | 6.0 | Target Velocity | DINT | <0-15> nDataOut2[0] . nDataOut2 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF <16-31> nDataOut2[1] . nDataOut2 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x6060:00 | 1.0 | 10.0 | Modes of Operation | USINT | nCtrl5 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x6073:00 | 2.0 | 11.0 | Max Current | INT | |
| 0x60FD | 4.0 | 13.0 | Digital Inputs | DINT | |

Table7 : RPDO (Outputs) Mapping csp, current, i/o

3.3.1.2 Mapping 2: csp

| Index | Size | Offs | Name | Type | TwinCat NC mapping |
|-----------|------|------|-----------------|------|---|
| 0x6041:00 | 2.0 | 0.0 | Status Word | UINT | <0-7> nState1 . In . Inputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF <8-15> nState2 . In . Inputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x6064:00 | 4.0 | 2.0 | Actual Position | DINT | <0-15> nDataIn1[0] . nDataIn1 . In . Inputs . Enc . Axis 1 . Axis 1 . Axes . NC task 1 SAF |

| | | | | | |
|-----------|-----|------|----------------------------|-------|---|
| | | | | | <16-31> nDataIn1[1] . nDataIn1 . In . Inputs . Enc . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x606C:00 | 4.0 | 6.0 | Actual velocity | DINT | <0-15> nDataIn7[0] . nDataIn7 . In . Inputs . Enc . Axis 1 . Axis 1 . Axes . NC task 1 SAF <16-31> nDataIn7[1] . nDataIn7 . In . Inputs . Enc . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x6061:00 | 1.0 | 10.0 | Modes of Operation Display | USINT | nState5 . In . Inputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |

Table8 : TPDO (Inputs) Mapping csp

| Index | Size | Offs | Name | Type | TwinCat NC mapping |
|-----------|------|------|--------------------|-------|---|
| 0x6040:00 | 2.0 | 0.0 | Control Word | UINT | <0-7> nCtrl1 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF <8-15> nCtrl2 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x607A:00 | 4.0 | 2.0 | Target position | DINT | <0-15> nDataOut1[0] . nDataOut1 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF <16-31> nDataOut1[1] . nDataOut1 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x60FF:00 | 4.0 | 6.0 | Target Velocity | DINT | <0-15> nDataOut2[0] . nDataOut2 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF <16-31> nDataOut2[1] . nDataOut2 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |
| 0x6060:00 | 1.0 | 10.0 | Modes of Operation | USINT | nCtrl5 . Out . Outputs . Drive . Axis 1 . Axis 1 . Axes . NC task 1 SAF |

Table9 : RPDO (Outputs) Mapping csp

4 TwinCAT3

4.1 Hardware

Fullmo FlatTrack HW Revision xxx with integrated EtherCAT slave controller.

Firmware version yy

4.2 Software

TwinCAT System Manager v3.1 (Build 4364)

TwinCAT version v3.1.402.62

4.3 ESI file

- Close TwinCAT.
- Copy the "fullmoFlatTrackDS402.xml" file to **C:\TwinCAT\3.1\Config\Io\EtherCAT**
- Start TwinCAT.

4.4 Modules

Selection of the PDO mapping via the corresponding slot. See 3.3.1

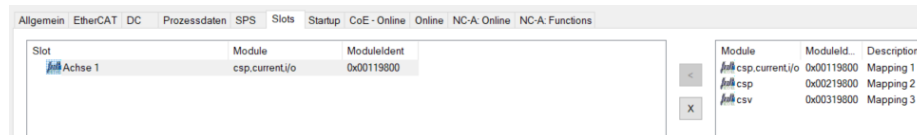


Figure4 :TwinCAT3 PDO mapping, slots

4.5 Connect NC axis

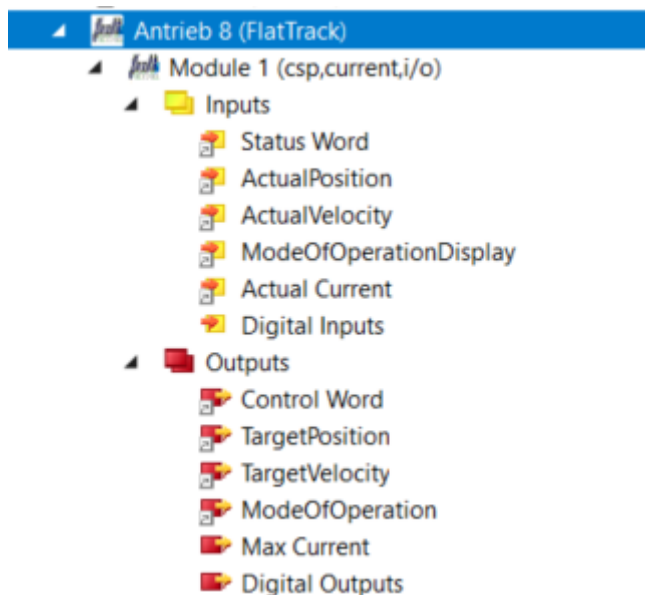


Figure5 : FlatTrack inputs / outputs

4.5.1 Inputs

Status Word

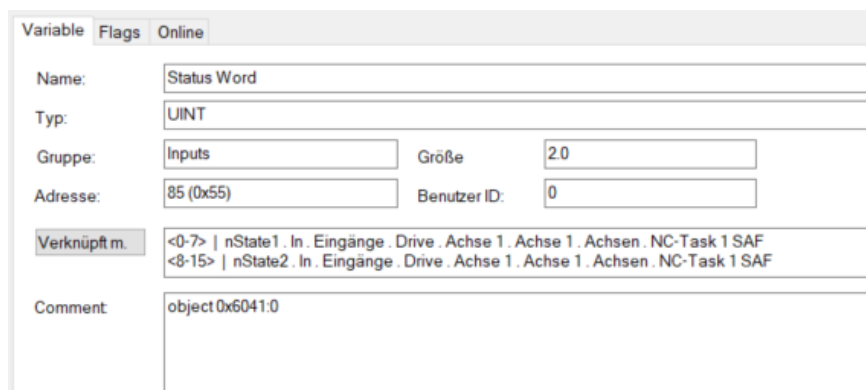


Figure6 : NC link status Word

Actual Position

The screenshot shows the 'ScopeWizard' window for a variable named 'ActualPosition'. The interface includes tabs for 'Variable', 'Flags', and 'Online'. The variable details are as follows:

- Name: ActualPosition
- Typ: DINT
- Gruppe: Inputs
- Größe: 4.0
- Adresse: 87 (0x57)
- Benutzer ID: 0
- Verknüpft m.: nDataIn1 . In . Eingänge . Enc . Achse 1 . Achse 1 . Achsen . NC-Task 1 SAF
- Comment: object 0x6064:0

Figure7 : NC link Actual Position

Actual velocity

The screenshot shows the 'ScopeWizard' window for a variable named 'ActualVelocity'. The interface includes tabs for 'Variable', 'Flags', and 'Online'. The variable details are as follows:

- Name: ActualVelocity
- Typ: DINT
- Gruppe: Inputs
- Größe: 4.0
- Adresse: 91 (0x5B)
- Benutzer ID: 0
- Verknüpft m.: nDataIn7 . In . Eingänge . Enc . Achse 1 . Achse 1 . Achsen . NC-Task 1 SAF
- Comment: object 0x606C:0
- ADS Info: Port: 11, IGrp: 0x3040010, IOffs: 0x8000005B, Len: 4
- Full Name: TIID^Device 1 (EtherCAT)^Box 7 (FlatTrack)^Module 1 (csv.csp - axis)^Inputs^ActualVelocity

Figure8 : NC link Actual Velocity

ModeOfOperationDisplay

| atTrack CX5130 | | ScopeWizard | |
|----------------|--|--------------|--------|
| Variable | | Flags | Online |
| Name: | ModeOfOperationDisplay | | |
| Typ: | USINT | | |
| Gruppe: | Inputs | Größe: | 1.0 |
| Adresse: | 95 (0x5F) | Benutzer ID: | 0 |
| Verknüpfung: | nState5 . In . Eingänge . Drive . Achse 1 . Achse 1 . Achsen . NC-Task 1 SAF | | |
| Comment: | object 0x6061:0 | | |
| ADS Info: | Port: 11, IGrp: 0x3040010, IOfs: 0x8000005F, Len: 1 | | |

Figure9 : NC link ModeOfOperationDisplay

4.5.2 Outputs

ControlWord

| atTrack CX5130 | | ScopeWizard | |
|----------------|---|--------------|--------|
| Variable | | Flags | Online |
| Name: | Control Word | | |
| Typ: | UINT | | |
| Gruppe: | Outputs | Größe: | 2.0 |
| Adresse: | 85 (0x55) | Benutzer ID: | 0 |
| Verknüpfung: | <0-7> nCtrl1 . Out . Ausgänge . Drive . Achse 1 . Achse 1 . Achsen . NC-Task 1 SAF <8-15> nCtrl2 . Out . Ausgänge . Drive . Achse 1 . Achse 1 . Achsen . NC-Task 1 SAF | | |
| Comment: | object 0x6040:0 | | |
| ADS Info: | Port: 11, IGrp: 0x3040010, IOfs: 0x81000055, Len: 2 | | |

Figure10 : NC link ControlWord

TargetPosition

| Variable | Flags | Online |
|--------------|--|----------------|
| Name: | TargetPosition | |
| Typ: | DINT | |
| Gruppe: | Outputs | Größe: 4.0 |
| Adresse: | 87 (0x57) | Benutzer ID: 0 |
| Verknüpft m. | nDataOut1 . Out. Ausgänge . Drive . Achse 1 . Achse 1 . Achsen . NC-Task 1 SAF | |
| Comment: | object 0x607A.0 | |
| ADS Info: | Port: 11, IGrp: 0x3040010, IOfs: 0x81000057, Len: 4 | |

Figure11 : NC link TargetPosition

TargetVelocity

| Variable | Flags | Online |
|--------------|--|----------------|
| Name: | TargetVelocity | |
| Typ: | DINT | |
| Gruppe: | Outputs | Größe: 4.0 |
| Adresse: | 91 (0x5B) | Benutzer ID: 0 |
| Verknüpft m. | nDataOut2 . Out. Ausgänge . Drive . Achse 1 . Achse 1 . Achsen . NC-Task 1 SAF | |
| Comment: | object 0x60FF.0 | |
| ADS Info: | Port: 11, IGrp: 0x3040010, IOfs: 0x8100005B, Len: 4 | |
| Full Name: | TID~Device 1 (EtherCAT)~Box 7 (FlatTrack)~Module 1 (csv.csp - axis)~Outputs~TargetVelocity | |

Figure12 : NC link TargetVelocity

ModeOfOperation

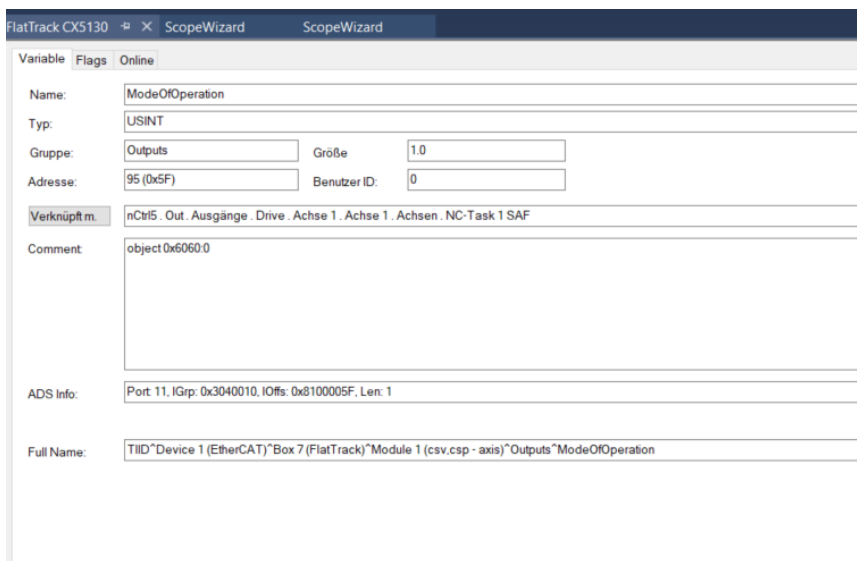


Figure13 : NC link ModeOfOperation

4.5.3 NC axis parameters

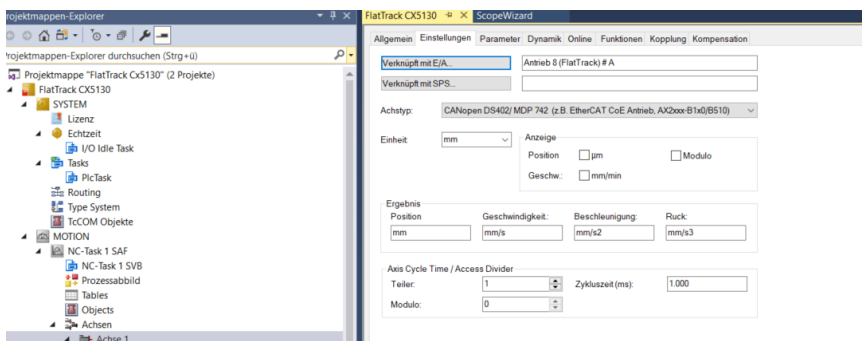


Figure14 : Axle parameters Unit mm

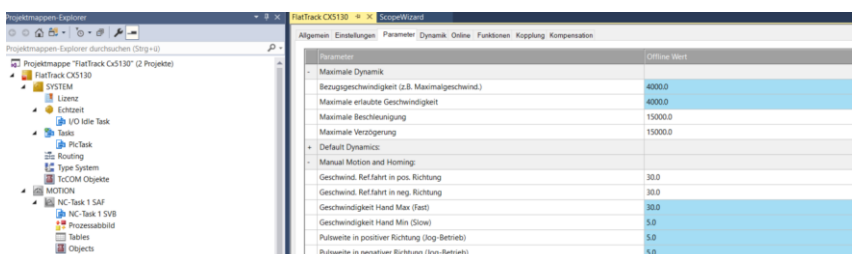


Figure15 : Maximum values

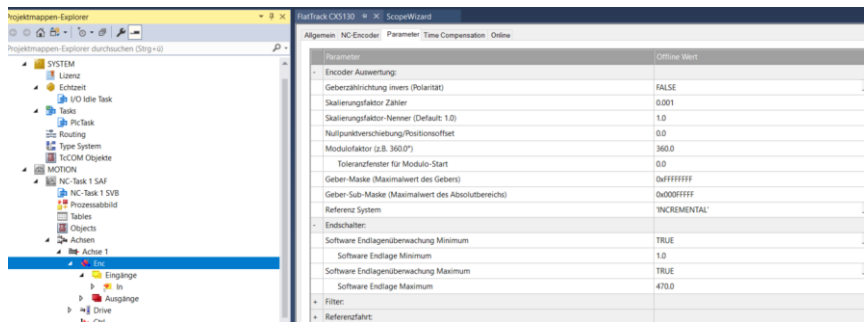


Figure16 : Scaling measuring system 1µm/inc

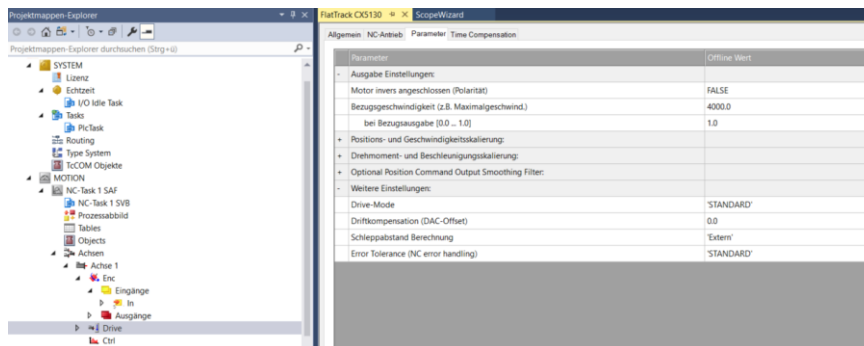


Figure17 : Tracking error monitoring "external"

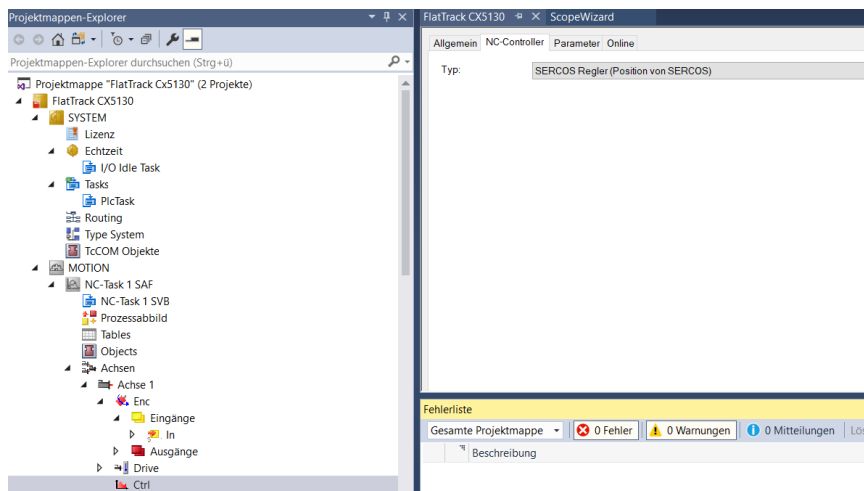


Figure18 : Controller type

4.5.4 NC-Online

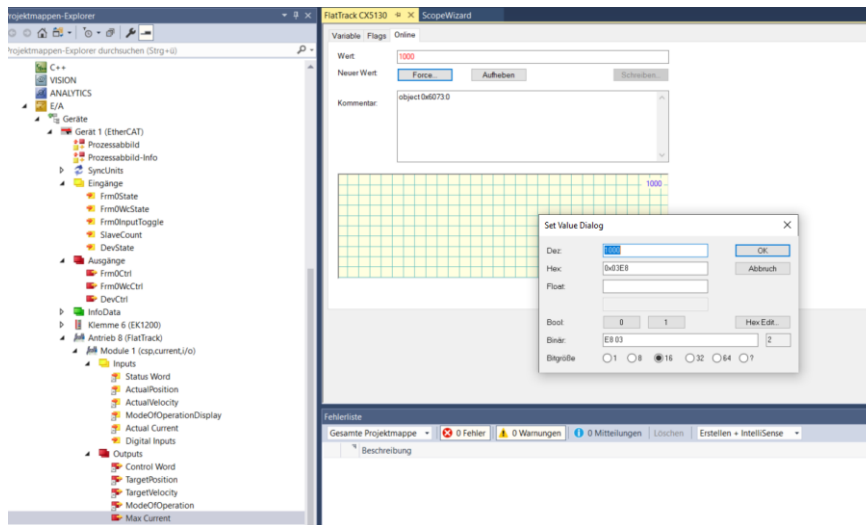


Figure19 : Set max current

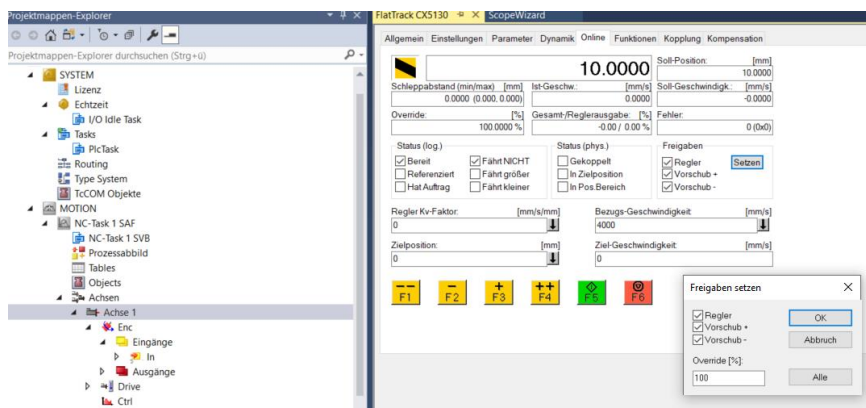


Figure20 : Controller enable