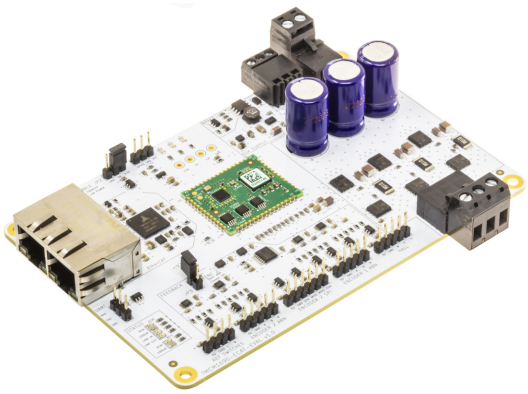
# TMCM-1690-COE-EVAL Evaluation Board

Hardware Version V1.00 | 319-101074, Rev 0: 07/24

**The TMCM-1690-COE-EVAL evaluates the TMCM-1690-COE as a standalone board. It uses the standard schematic and offers several options to test different modes of operation. The TMCM-1690-COE is a module for three-phase brushless DC motors and single-phase DC motors up to 10$A_{RMS}$ (14$A_{PEAK}$). It can be configured through EtherCAT/UART interface option.**

**⚠ WARNING** **DO NOT CONNECT/DISCONNECT MOTOR WHILE POWER IS CONNECTED.**



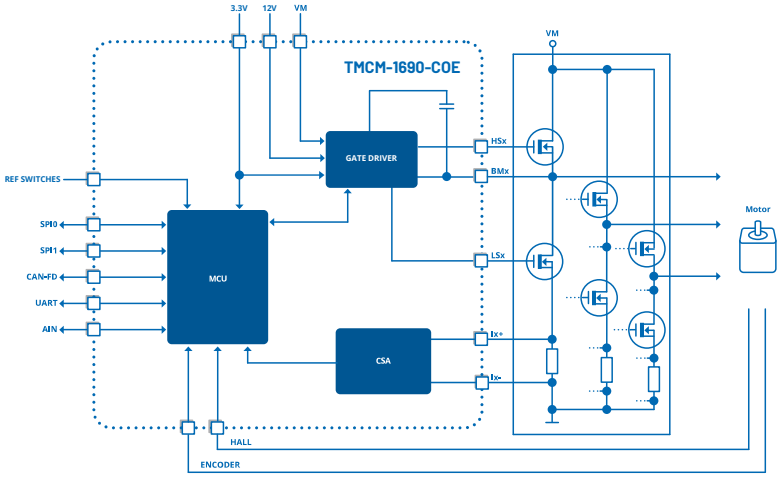
## Features

- **3-phase** BLDC motor and **1-phase** DC motor up to 10$A_{RMS}$ coil current (14$A_{PEAK}$)
- **Supply voltage:** 16V to 50V DC
- FOC servo controller gate driver module (up to 120kHz PWM frequency)
- Supports UART (RS232/RS485-ready) and EtherCAT™ interface
- CANOpen over EtherCAT protocol stack
- Supports incremental encoders (ABN), digital HALL sensors, absolute SPI encoders
- Reference switch inputs

## Applications

- Robotics
- Factory Automation
- Motorized Tables and Chairs
- Manufacturing
- Servo Drives
- Industrial BLDC and DC Motor Drives

## Simplified Block Diagram






ANALOG DEVICES
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# Contents

# 1 Order Codes

| Order Code | Description | Size |
|---|---|---|
| TMCM-1690-COE-EVAL | Evaluation board for TMCM-1690-COE with EtherCAT and UART interface, 3-phase 48V/10A power stage for BLDC/PMSM | 130mm x 85mm |

*Table 1: TMCM-1690-COE-EVAL Order Codes*

# 2 Getting Started

## Required Equipment

- TMCM-1690-COE-EVAL evaluation board
- Brushless DC (BLDC) motor (example, QMot line)
- Ethernet cable CAT5
- UART FTDI 3.3V cable (optional)
- Power supply
- Cables for interface, motors, and power

## Precautions

- Do not mix connections or short-circuit pins.
- Avoid bundling I/O wires with motor wires.
- Do not exceed the maximum rated supply voltage!
- Do not connect or disconnect the motor while powered!
- START WITH POWER SUPPLY OFF!

## 2.1 First Start-Up with TMCL-IDE

The UART connection is recommended for the monitoring and basic configuration of the TMCM-1690-COE-EVAL.

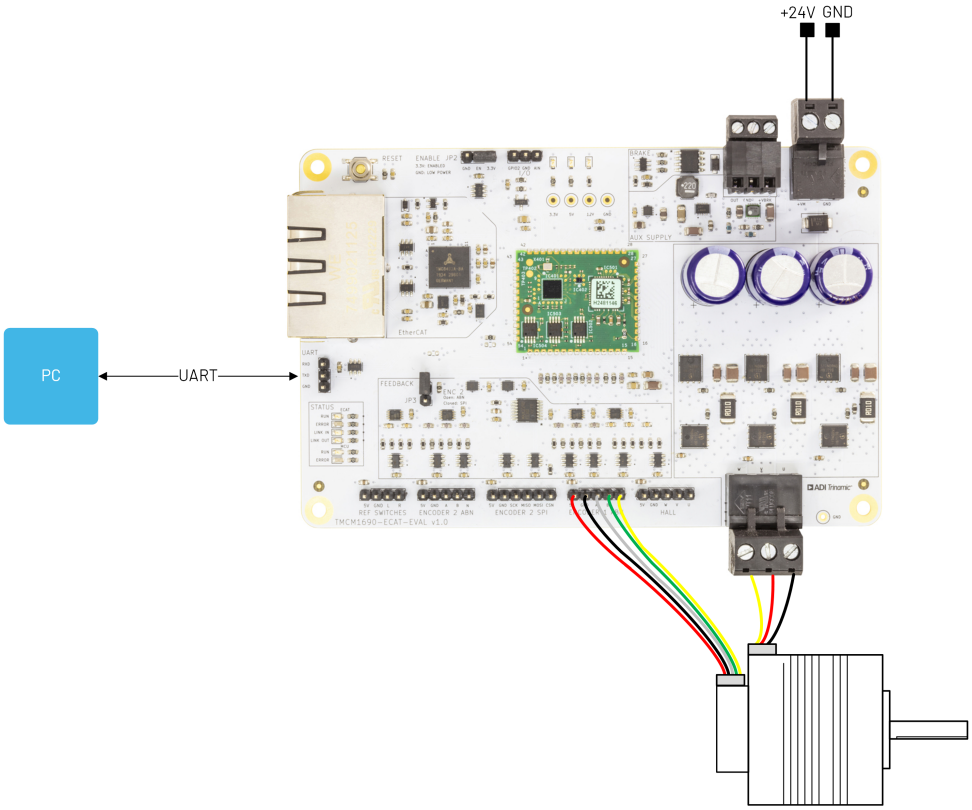



*Figure 1: Getting Started Example*

1. Make sure that the latest version of the TMCL-IDE is installed. The TMCM-1690-COE-EVAL is supported for TMCL-IDE V4.3.3 or newer version. Download the TMCL-IDE from www.analog.com TMCL-IDE.
2. Connect the motor phases to the TMCM-1690-COE-EVAL motor connector.
3. Connect the motor sensor feedback (example, incremental encoder, absolute encoder, or hall) to the TMCM-1690-COE-EVAL .
4. Connect TMCM-1690-COE-EVAL UART to the PC using a Future Technology Devices International (FTDI) cable.
5. Power the module through the power supply connector.
6. Open the TMCL-IDE and connect with the TMCM-1690-COE-EVAL. For Microsoft Windows® 8 and higher, no driver is needed. For Microsoft Windows 7, TMCL-IDE installs the driver automatically.
7. Verify that the TMCM-1690-COE-EVAL is using the latest firmware version. The device tree shows the firmware version. Download the newest firmware from https://www.analog.com/en/lp/001/trinamic-support.html.

Windows is a registered trademark of Microsoft, Corp.

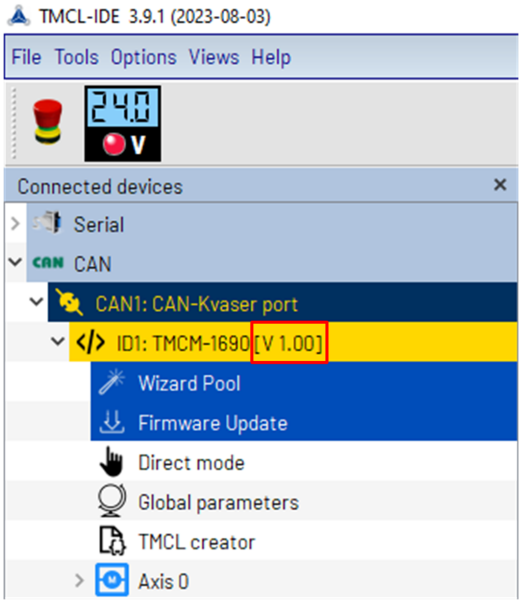



*Figure 2: Firmware Version*

8. The TMCL-IDE needs space to display all important information and provide a good overview. Using the full-screen mode is recommended.
9. Enable the motor by setting the jumper JP2 to 3.3V.
10. Configure the motor using the Motor Settings Tool.
11. Configure the motor driver using the Control Loop Settings Tool.
12. Use an EtherCAT MainDevice (example, TwinCAT) to create application specific motor control programs.

## 2.2 First Start-Up with EtherCAT Motor Settings Tool

This section shows first steps with a TMCM-1690-COE-EVAL. An EtherCAT MainDevice is required to control the TMCM-1690-COE-EVAL.

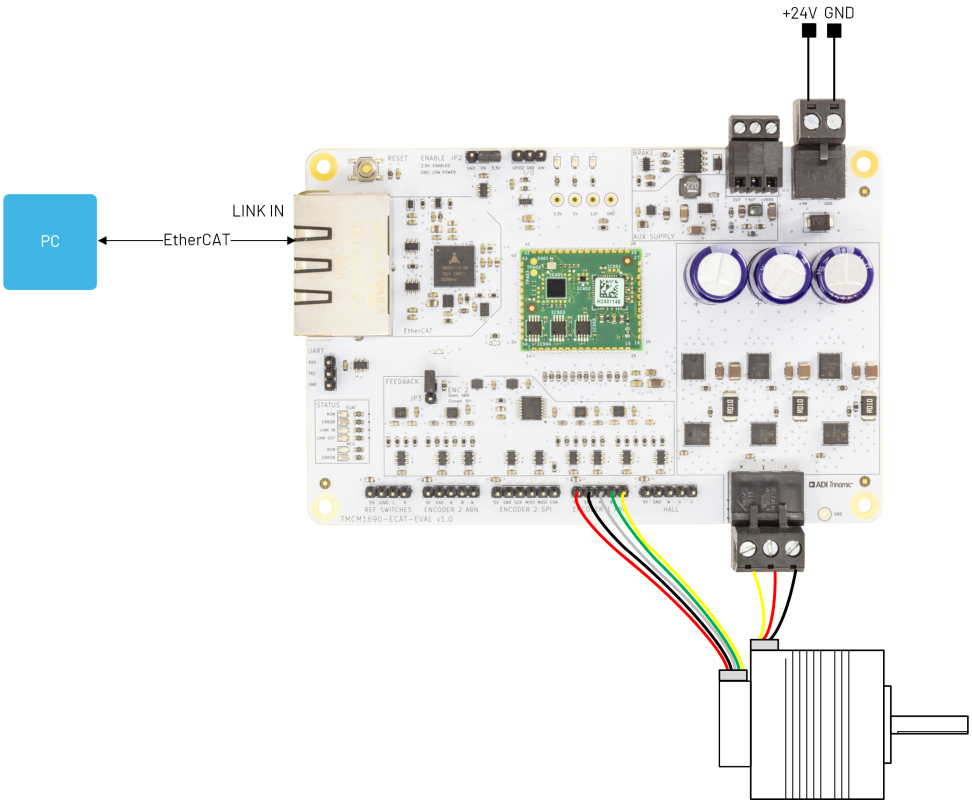



*Figure 3: Getting Started Example*

1. Connect the motor phases to the TMCM-1690-COE-EVAL motor connector.
2. Connect the motor sensor feedback (example, incremental encoder, absolute encoder, or hall) to the TMCM-1690-COE-EVAL .
3. Connect TMCM-1690-COE-EVAL through the EtherCat connector to the PC using a standard CAT cable suitable for 100Mbit/s Ethernet (example, CAT5/5e etc.).

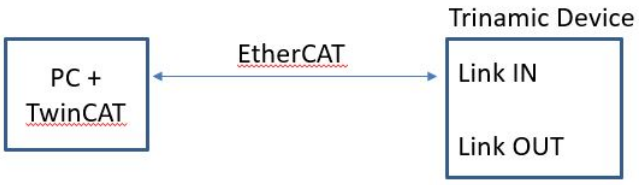



*Figure 4: Connecting EtherCAT MainDevice and SubDevice*

4. Power the module through the power supply connector.
5. Open the Motor Settings Tool and connect with the TMCM-1690-COE-EVAL.
6. Verify that the TMCM-1690-COE-EVAL is using the latest firmware version. Download the newest firmware from www.analog.com.
7. Enable the motor by setting the jumper JP2 to 3.3V.
8. Configure the motor using the EtherCAT Motor Settings Tool.

## 2.3 First Start-Up with TwinCAT MainDevice

For the following steps, TwinCAT3 Engineering version is used. A free evaluation version of TwinCAT can be obtained from Beckhoff. Other EtherCAT MainDevices can also be used (example, Acontis, OMRON, or SOEM).

### 2.3.1 Include the ESI File

Include the ESI file of the TMCM-1690-COE-EVAL in TwinCAT. The ESI file can be found on the TMCM-1690-COE page. Put the **TMCM-1690-CoE_Hw1.00_Fw1.03.xml** into the following TwinCAT folder: **..\TwinCAT\3.1 \Config\Io\EtherCAT**

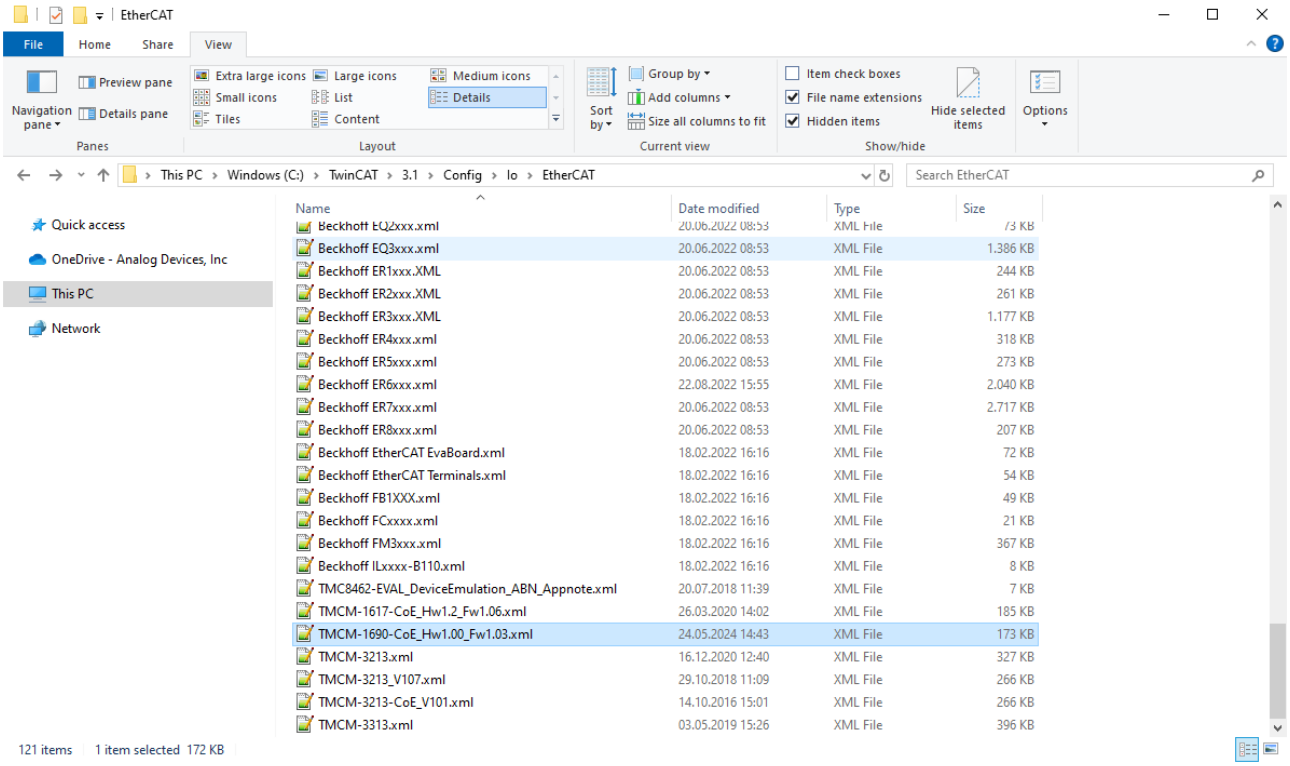



*Figure 5: Copy the .xml to TwinCAT folder*

### 2.3.2 Connect to TwinCAT

1. Connect the TMCM-1690-COE-EVAL with the PC with an Ethernet cable (CAT5 is sufficient).
2. Open TwinCAT XAE (VS2013).
3. Create *TwinCAT XAE Project (XML Format)*.
4. I/O → Devices → Scan

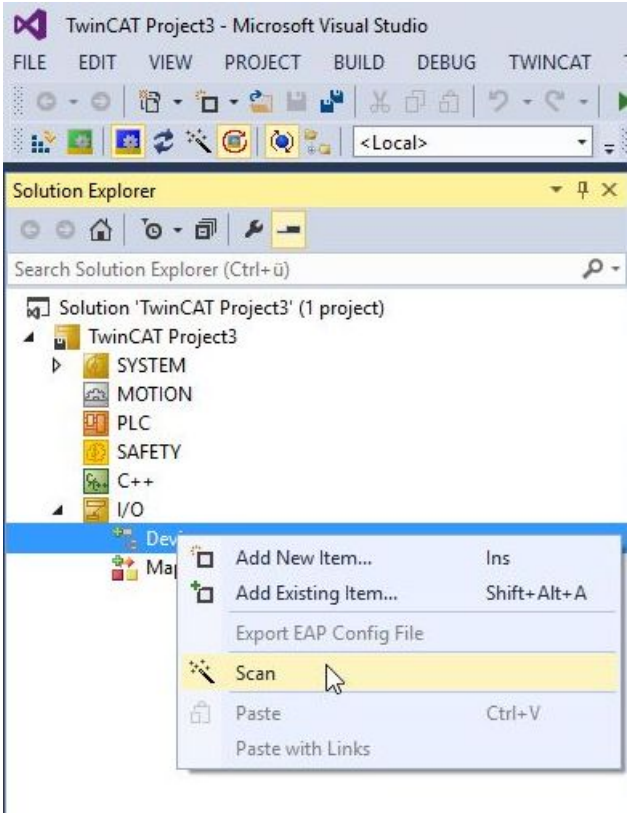



*Figure 6: Scan for the TMCM-1690-COE-EVAL*

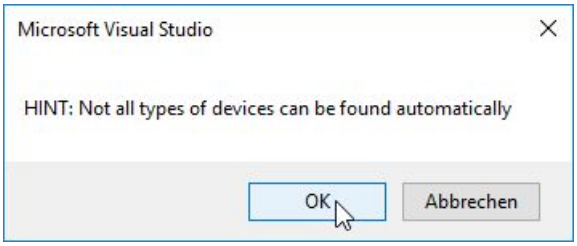



*Figure 7: Confirm*

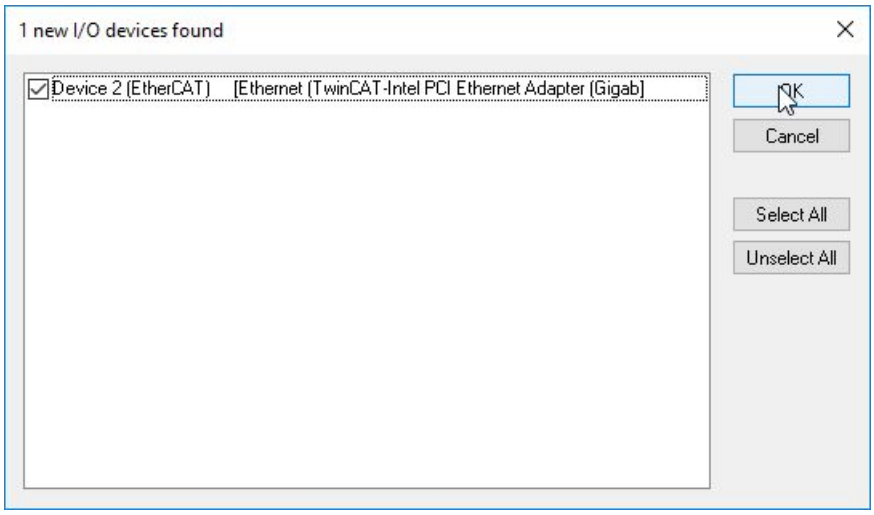



*Figure 8: Found EtherCAT devices are Displayed*

5. Scan for boxes → *yes*
(Modul is a box)

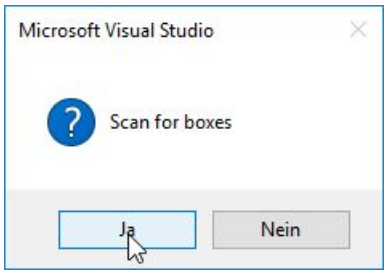



*Figure 9: Scan for Boxes*

6. NC configuration → *OK*

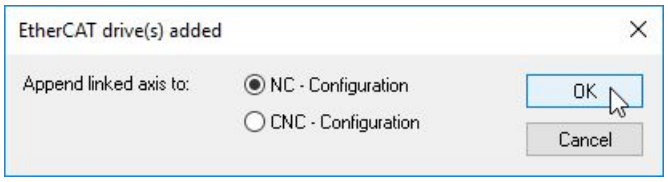



*Figure 10: NC-Configuration*

7. Activate Free run → *yes*
(activate PDOs)

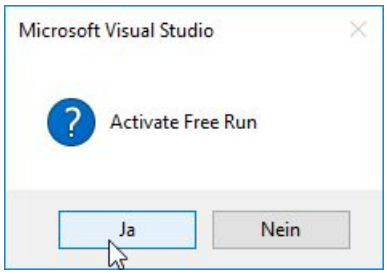



*Figure 11: Activate Free Run*

The TMCM-1690-COE-EVAL is displayed as *Drive 1 (TMCM-1690)*, as depicted in 12.

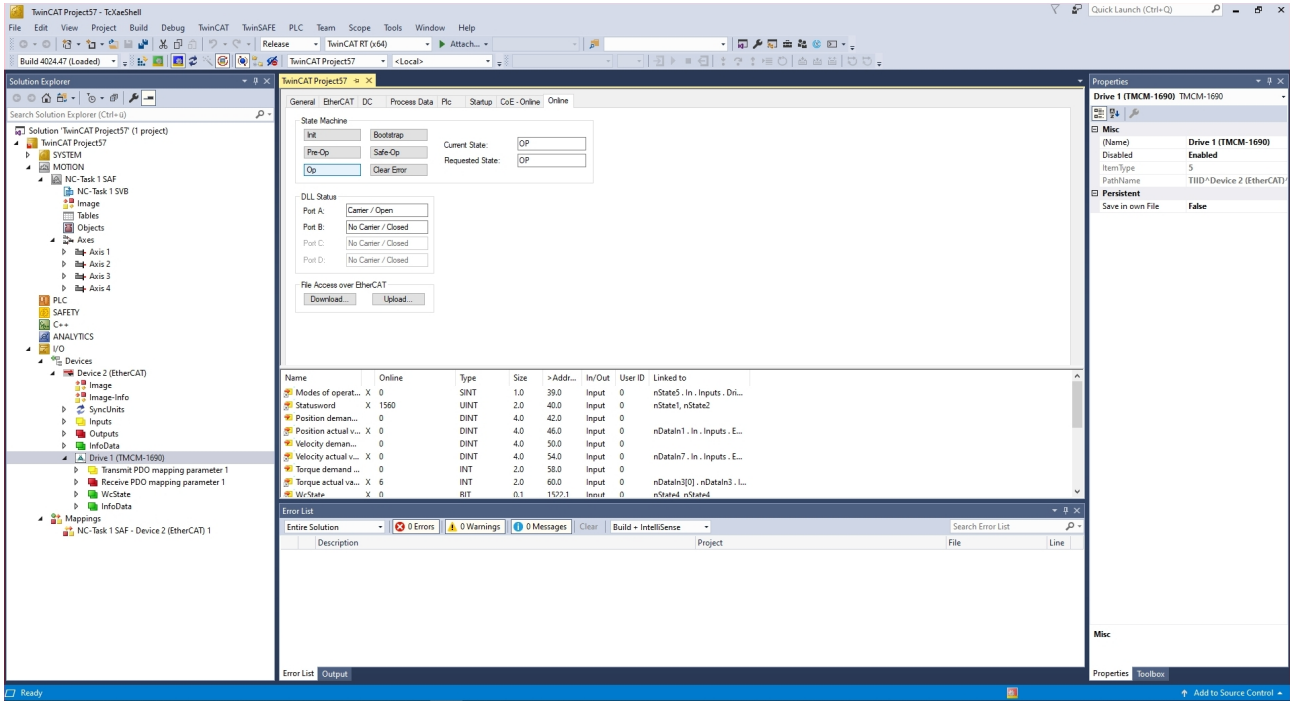


*Figure 12: TMCM-1690 in TwinCAT*

### 2.3.3 Control Motor in Profile Position Mode with TwinCAT

1. Write SDO Commutation mode (0x2003, subindex 3) to the required sensor feedback.
2. Write 1 to the PDO Object Modes of Operation (0x6060) to choose the Profile Position Mode.

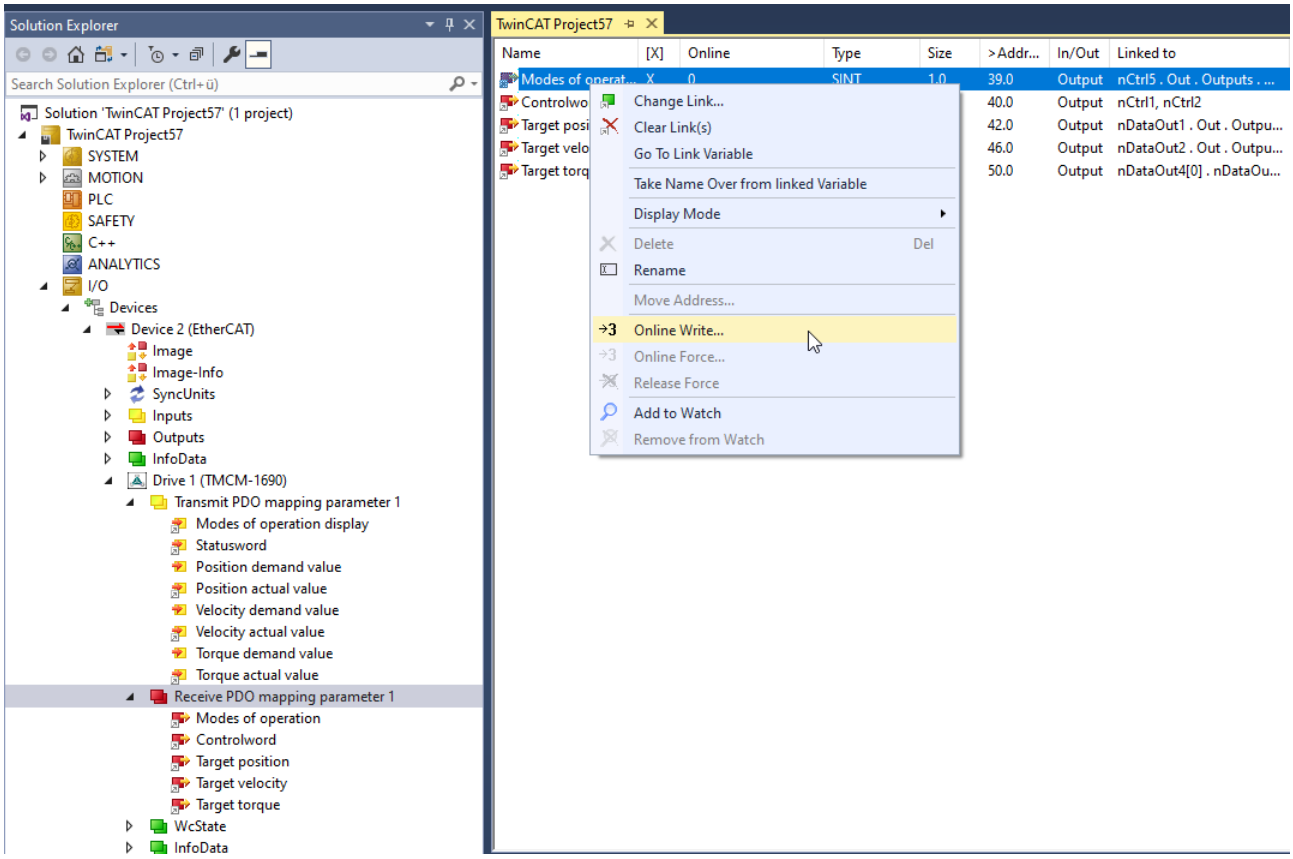
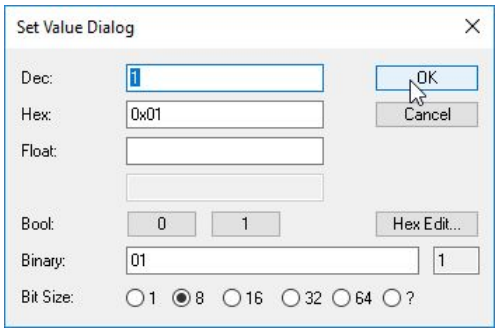



*Figure 13: Write a Value to PDO*




3. Verify by reading the TxPDO sent from the Evalboard.

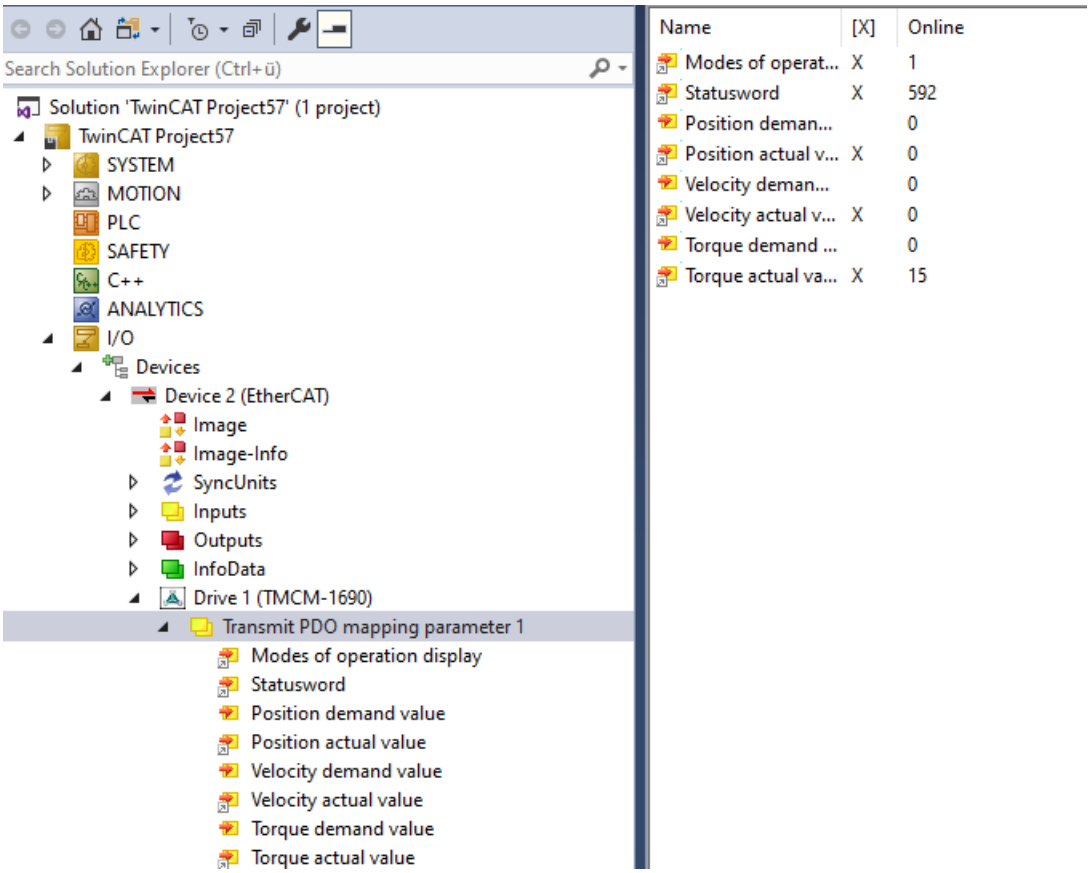



*Figure 14: TxPDO of the TMCM-1690*

4. Write 6 to the Controlword object (0x6040) to switch to READY_TO_SWITCH_ ON state.
5. Write 7 to Controlword object (0x6040) to switch to SWITCHED_ON state.
6. Write 15 to Controlword object 6040h to switch to OPERATION_ENABLED state.
7. Write the desired target position (example, 500000) to object 607Ah.
8. The TMCM-1690 can be monitored by the TMCL-IDE (through UART). Specific parameters can be configured (such as current).

Use an EtherCAT MainDevice (example, TwinCAT) to create application specific motor control programs.

# 3 Hardware Information

All design files for ADI TRINAMIC evaluation boards are available for free. The original ECAD files, Gerber data, the BOM, and PDF copies are available. Typically, the ECAD files are in KiCAD format.
Check the schematics for jumper settings and input/output connector descriptions.

Download the files from the TRINAMIC evaluation boards home page.

| NOTE | To locate files or raise concerns, contact Customer Service. |
|---|---|

## 3.1 Connectors

The TMCM-1690-COE-EVAL has 11 onboard connectors. The following table contains information on the connector type and mating connectors.
The connector pinning and signal names can be derived from the board design and schematic files available here: TRINAMIC TMCM-1690-COE-EVAL homepage

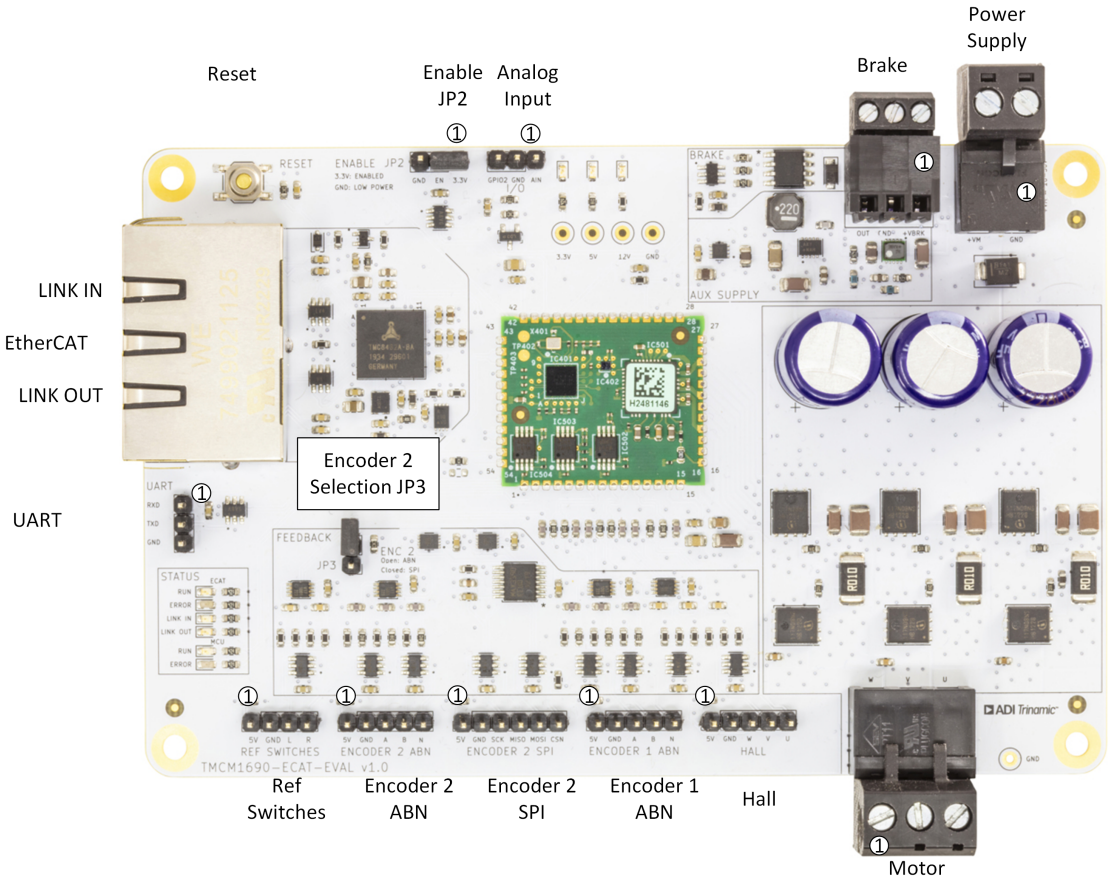



*Figure 15: TMCM-1690-COE-EVAL Connectors*

| # | Connects to... | Connector Type | Description |
|---|---|---|---|
| 1 | Power Supply | METZ CONNECT 31330102 | Power supply to the evaluation board. Mating connector METZ CONNECT 31349102. |
| 2 | Motor | METZ CONNECT 31330103 | Connects the motor to the TMCM-1690-COE output. Mating connector METZ CONNECT 31349103. |
| 3 | 2x Encoder ABN | Standard 5x 2.54mm header | Connects ABN encoder to evalboard. |
| 4 | Encoder SPI | Standard 6x 2.54mm header | Connects SPI encoder to evalboard. |
| 5 | Hall | Standard 5x 2.54mm header | Connects motor hall sensor to evalboard. |
| 6 | Ref Switches | Standard 4x 2.54mm header | Connects reference switches to evalboard. |
| 7 | EtherCAT | RJ45 plug connector | Example, standard CAT 5/CAT 5e cables, suitable for 100Mbit/s Ethernet |
| 8 | UART | Standard 3x 2.54mm header | UART connector |
| 9 | Brake | METZ CONNECT 31182103 | Use to connect a brake resistor or a motor brake to the TMCM-1690. Mating connector METZ CONNECT 31169103. |
| 10 | AIN | Standard 2x 2.54mm header | Analog Input |

*Table 3: TMCM-1690-COE-EVAL Connectors*

### 3.1.1 Power Supply Connector

The power supply connector to power the TMCM-1690-COE-EVAL. Required for operation and communication.

| Pin | Label | Description |
|---|---|---|
| 1 | +VM | Motor supply voltage (16V to 50V). |
| 2 | GND | Signal and supply ground. |

*Table 4: Power Supply Pin Assignment*

### 3.1.2 Motor Connector

| Pin | Label | Description |
|---|---|---|
| 1 | W | Motor coil phase W |
| 2 | V | Motor coil phase V |
| 3 | U | Motor coil phase U |

*Table 5: Motor Pin Assignment*

### 3.1.3 Encoder 1 ABN Connector

| Pin | Label | Description |
|---|---|---|
| 1 | +5V | +5V output for encoder sensor supply |
| 2 | GND | Encoder sensor supply and signal ground |
| 3 | A | Encoder channel A |
| 4 | B | Encoder channel B |
| 5 | N | Encoder index/null channel |

*Table 6: Encoder 1 Pin Assignment*

### 3.1.4 Encoder 2 ABN connector

To use Encoder2 as ABN encoder, jumper JP3 must be left open.

| Pin | Label | Description |
|---|---|---|
| 1 | +5V | +5V output for encoder sensor supply |
| 2 | GND | Encoder sensor supply and signal ground |
| 3 | A | Encoder channel A |
| 4 | B | Encoder channel B |
| 5 | N | Encoder index/null channel |

*Table 7: Encoder 2 ABN Pin Assignment*

### 3.1.5 Encoder 2 SPI Connector

To use Encoder 2 as SPI encoder, jumper JP3 must be closed.

| Pin | Label | Description |
|---|---|---|
| 1 | +5V | +5V output for SPI encoder sensor supply |
| 2 | GND | SPI Encoder sensor supply and signal ground |
| 3 | SCK | SPI Encoder, clock signal, +5V level |
| 4 | MISO | SPI Encoder, MISO signal, +5V level |
| 5 | MOSI | SPI Encoder, MOSI signal, +5V level |
| 6 | CSN | SPI Encoder, chip select signal, +5V level |

*Table 8: Encoder 2 SPI Pin Assignment*

### 3.1.6 Hall Connector

| Pin | Label | Description |
|---|---|---|
| 1 | +5V | +5V output for hall sensor supply |
| 2 | GND | Hall sensor supply and signal ground |
| 3 | W | Hall sensor signal 3 |
| 4 | V | Hall sensor signal 2 |
| 5 | U | Hall sensor signal 1 |

*Table 9: Hall Pin Assignment*

### 3.1.7 Reference Switches Connector

| Pin | Label | Description |
|---|---|---|
| 1 | +5V | +5V output for SPI encoder sensor supply |
| 2 | GND | SPI Encoder sensor supply and signal ground |
| 3 | L | Left reference switch input, +5V level |
| 4 | R | Right reference switch input, +5V level |

*Table 10: Reference Switches Pin Assignment*

### 3.1.8 EtherCAT Connector

There are two EtherCAT connectors on the board. One for LINK IN (towards/coming from the EtherCAT MainDevice) and one for LINK OUT (for connecting further SubDevices). The EtherCAT connector is the main communication interface for the TMCM-1690-COE-EVAL.

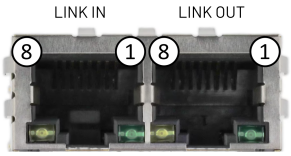



*Figure 16: EtherCAT Connector*

| Pin | Label | Description |
|---|---|---|
| 1 | TX+ | Transmit data output, differential, non-inverting |
| 2 | TX- | Transmit data output, differential, inverting |
| 3 | RX+ | Receive data input, differential, non-inverting |
| 4 | | |
| 5 | | |
| 6 | RX- | Receive data input, differential, inverting |
| 7 | | |
| 8 | | |

*Table 11: EtherCAT Pin Assignment*

### 3.1.9 UART

The Universal Asynchronous Receiver Transmitter (UART) interface connects to the TMCM-1690-COE for debugging and firmware updates.

| Pin | Label | Description |
|---|---|---|
| 1 | RXD | UART RxD, receive data in (+3.3V level) |
| 2 | TXD | UART TxD, transmit data out (+3.3V level) |
| 3 | GND | Supply and signal ground |

*Table 12: UART Pin Assignment*

### 3.1.10 Brake Connector

The brake connector can be used in two ways. Either a brake resistor can be connected to dissipate energy from a voltage overshoot or the brake connector can be used to control an active motor brake. For configuration of the BRAKE pin function, see 4.2.8 and 4.2.9 and the TMCM-1690-COE firmware data sheet.

| Pin | Label | Description |
|---|---|---|
| 1 | VBRAKE | Power supply output |
| 2 | GND | Signal and supply ground |
| 3 | BRAKE_OUT | Open collector brake output |

| Pin | Label | Description |
|---|---|---|

*Table 13: Brake Pin Assignment*

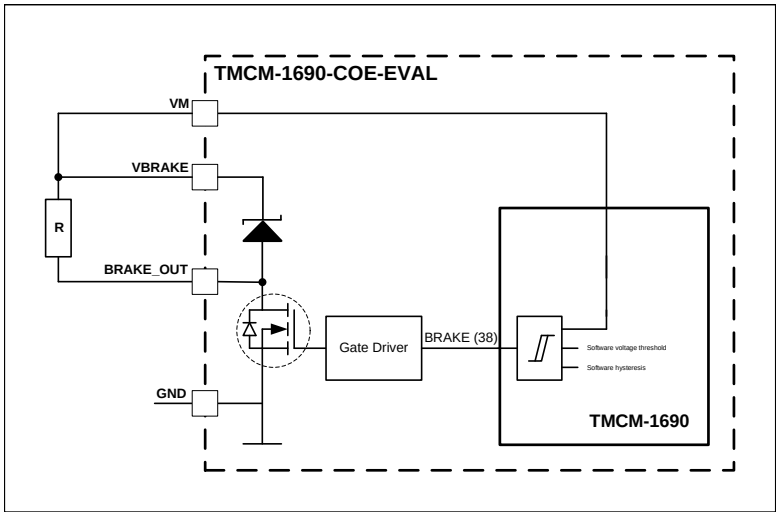



*Figure 17: Example Brake: Shunt Resistor*

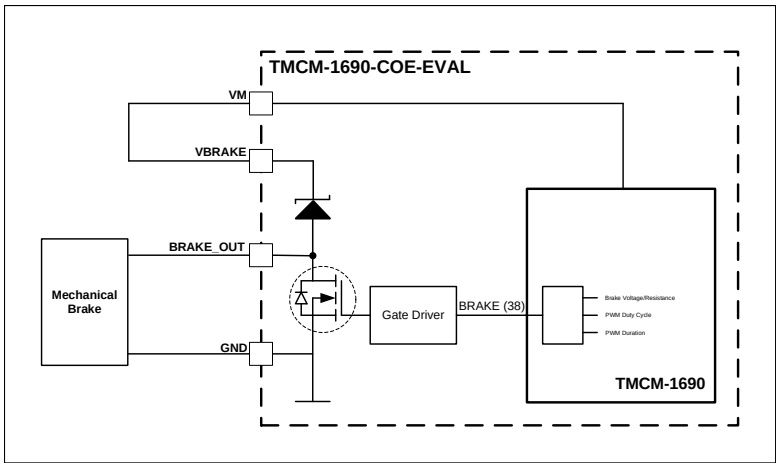



*Figure 18: Example Brake: Mechanical Brake*

### 3.1.11 AIN Connector

| Pin | Label | Description |
|---|---|---|
| 1 | AIN | Analog input (0V to 10V), may be used as velocity control input in standalone mode (depending on firmware) |
| 2 | GND | Supply and signal ground |

*Table 14: AIN Pin Assignment*

## 3.2 Jumper and Button

### 3.2.1 JP2: Motor Driver Enable

The TMCM1690 includes an enable pin that is set by jumper JP2. When the *Enable* pin is low, the TMCM-1690 is in low power mode. When it is high, the motor driver is enabled.

| Pin | Description |
|---|---|
| Open | Pin ENABLE = 3.3V, motor driver is enabled |
| Closed | Pin ENABLE = GND, motor driver is disabled |

*Table 15: JP2: Motor Driver Enable*

### 3.2.2 JP3: Encoder 2 Selection

The TMCM-1690-COE-EVAL offers two feedback options for the second encoder. Either SPI encoder can be selected or a second ABN encoder can be used.

| Pin | Description |
|---|---|
| Open | ABN encoder, use connector ENCODER 2 ABN |
| Closed | SPI encoder, use connector ENCODER 2 SPI |

*Table 16: JP3: Encoder 2 Selection*

### 3.2.3 Reset Button

The reset button pulls the TMCM-1690 nRST pin low when pressed, which resets the TMCM-1690.

| Pin | Description |
|---|---|
| Open | pin nRST = 3.3V, normal operation |
| Pressed | pin nRST = GND, TMCM-1690 reset |

*Table 17: Reset Button*

# 4 TMCL-IDE Evaluation Features

This section gives tips on using the TMCL-IDE. For example, how to use the velocity mode or some feature-based tools.
For further information on the TMCL-IDE usage, refer to the TMCL IDE user manual.

**NOTE**

To achieve optimal settings, refer to the descriptions and flow charts in the TMCM-1690-COE data sheet. The *Direct Mode* tool of the TMCL-IDE provides helpful information about any axis parameter. Beyond that, the data sheet explains concepts and ideas essential for understanding how the axis parameters are linked together and which settings are suitable for the application. At first, to get more familiar with the evaluation board, drive the motor using open loop mode first.

## 4.1 Board Information

The TMCM-1690-COE-EVAL board information tool is available from the tree view, when clicking on the board. It provides information on the analog inputs and digitial inputs status of the board. The digital output states can be changed using the checkboxes.

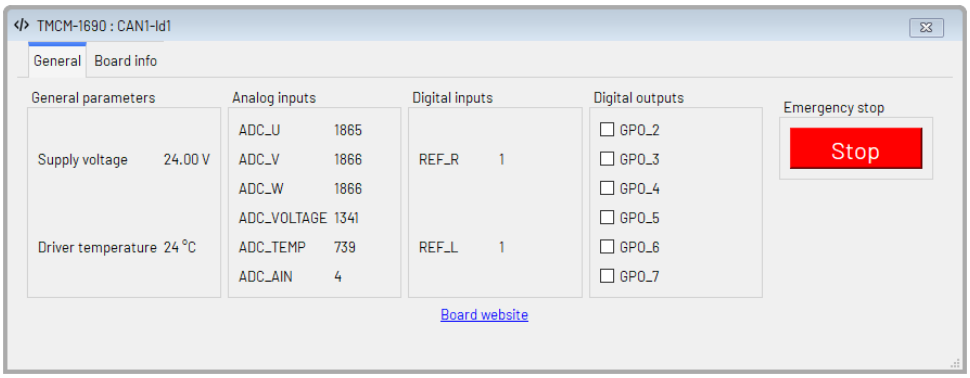



*Figure 19: Board Information Tool*

The *Emergency Stop* stops the motor by sending the following commands to the module:

- Stop the application/stop TMCL program execution (128).
- Stop the motor (MST).

## 4.2 Motor Settings

To configure the motor settings for the TMCM-1690-COE-EVAL, open the TMCM-1690-COE *Motor Settings* tool by clicking the appropriate entry in the tool tree. The motor is then run in open loop to determine the configuration of the ADCs, feedback sensors (example, ABN, hall), gears, and brake.

It is ideal to use this tool first to bring up and go through each tab step by step.

The bottom of the *Motor Settings* tool has different parameter functions:

- Refresh: Update all parameters in the *Motor Settings* tool.
- Store: Store all parameters from the *Motor Settings* tool to EEPROM.
- Restore: Load all parameters from EEPROM to the *Motor Settings* tool.
- Copy to TMCLCreator: Copy all parameters from the *Motor Settings* tool to the *TMCLCreator*.

### 4.2.1 Motor Setup

In the *Motor setup* tab, choose the motor family (rotary or linear) and type (3-phase or 1-phase). In addition, select the building blocks specific to the application.

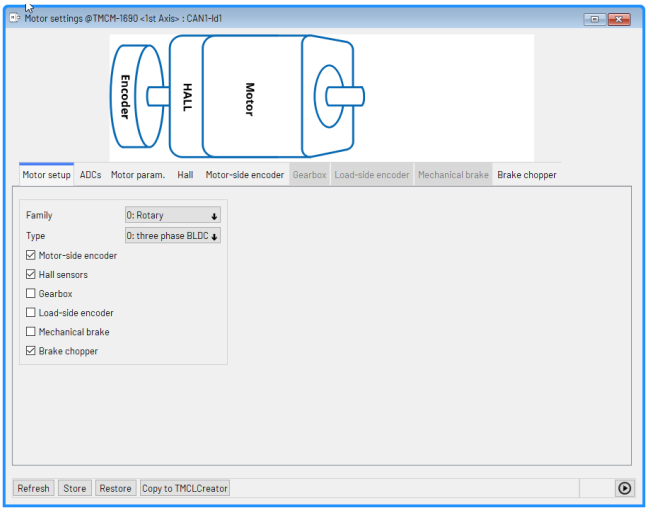



*Figure 20: Motor Setup*

### 4.2.2 ADCs

In the *ADCs* tab, the motor current ADC offset is compensated. The *Update* buttons determine the offset automatically for each motor phase. With *Update all*, the compensation is calculated for all motor phases. With the respective *Store* button, the parameters are saved to EEPROM and loaded automatically upon power up.


*Figure 21: Configuring the Motor Current ADCs*

### 4.2.3 Motor param.

In the *Motor param.* tab, the motor parameters are configured as follows:

- Pole pairs: Number of pole pairs of the motor.
- Max current: Maximum rated motor current of the motor.
- Open loop current (RMS): The applied motor current during open loop.
- PWM frequency: PWM frequency of the current loop. Can be increased, example, for lower inductance motor.

After above configuration, the motor is driven in open loop with *Start motor* using *Open loop current*. For position constricted mechanics, the motor can reverse repeatedly using *Swap direction*. The direction change time is defined by *Swap Time[ms]*.

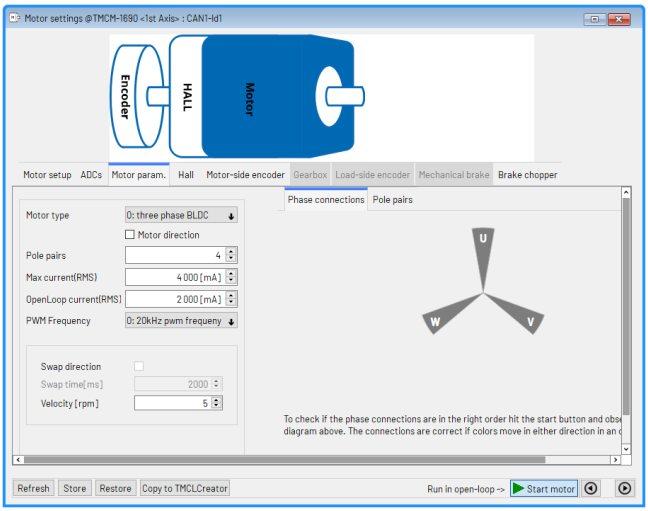



*Figure 22: Configuring the Motor Parameter*

### 4.2.4 Hall

In the *Hall* tab, the hall sensor feedback of the motor is configured as follows:

1. With *Start motor*, the motor is run in open loop.
2. Hall configuration:
   (a) With *Identify config*, the hall configuration is automatically determined.
   (b) Alternatively, the hall configuration can be set manually by sector and direction.
3. Optional: *Digital hall interpolation* can be enabled to activate interpolation of the hall signals for smoother run in closed loop.

After sucessfull hall configuration, the open loop angle should start in the same sector as the hall angle.

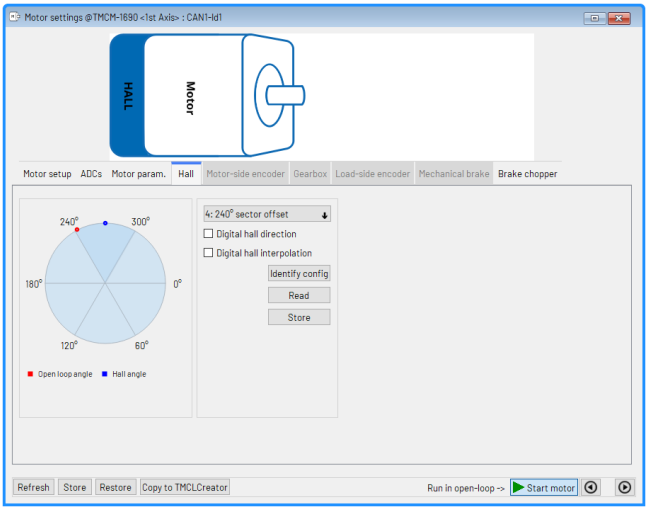



*Figure 23: Completed Configuration Hall Sensor Feedback*

### 4.2.5 Motor-Side Encoder

The TMCM-1690-COE-EVAL supports different encoder sensors that can be used for commutation. Incremental encoder (ABN) and absolute encoder (ABS) are supported.

Configuration of the *ABN encoder*:

1. Enable the respective encoder using the *Enabled* checkbox.
2. With *Start motor*, the motor is run in open loop.
3. Steps: This is the encoder resolution with the the encoder pulse per revolution.
4. Estimated Steps: This is the encoder resolution estimated by the tool. The longer the motor runs, the more accurate is the estimation.
5. Init mode: Different encoder initalization routines are supported. Refer to the TMCM-1690-COE data sheet for further description.

Configuration of the *ABS encoder*:

1. Enable the respective encoder using the *Enabled* checkbox.
2. With *Start motor*, the motor is run in open loop.
3. Select the encoder *type*.
4. Set the *Absolute encoder direction*.
5. Init mode: Different encoder initalization routines are supported.

**NOTE** If an absolute encoder is missing, contact Customer Service.

After succesfull encoder configuration, the *Open loop angle* turns with the same frequency of the *ABN Angle*.

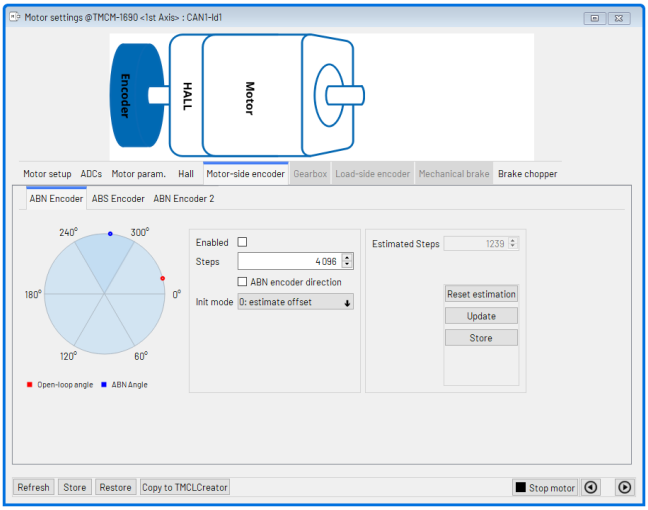



*Figure 24: Configuration Encoder Sensor*

### 4.2.6 Gearbox

The TMCM-1690-COE-EVAL supports gearing with either *Rotary to rotary* or *Rotary to linear* transmission.

1. Motor displacement of: Gear input/motor shaft revolution.
2. Results on load to: Resulting gear output revolution.
3. Gearbox invert direction: Invert the direction of the gearbox transmission.

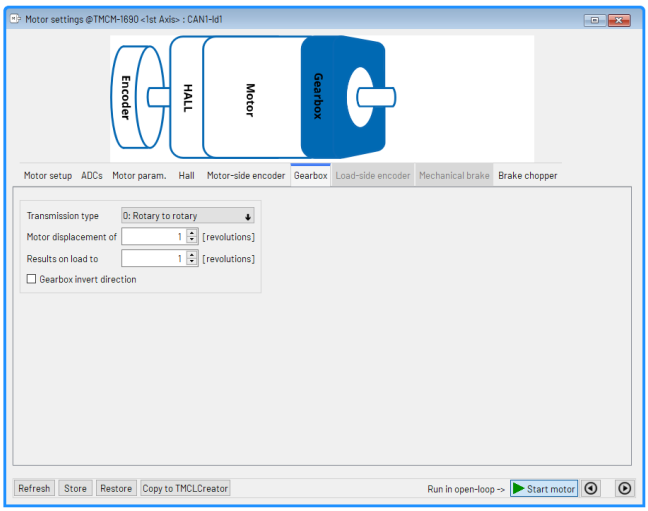



*Figure 25: Configuration Gearbox*

### 4.2.7 Load-Side Encoder

The TMCM-1690-COE-EVAL supports the direct control of an end effector point using a second encoder behind the gear.
Either an absolute encoder or an ABN encoder can be selected as load-side encoder. The configuration is analog to the motor-side encoder in section 4.2.5.

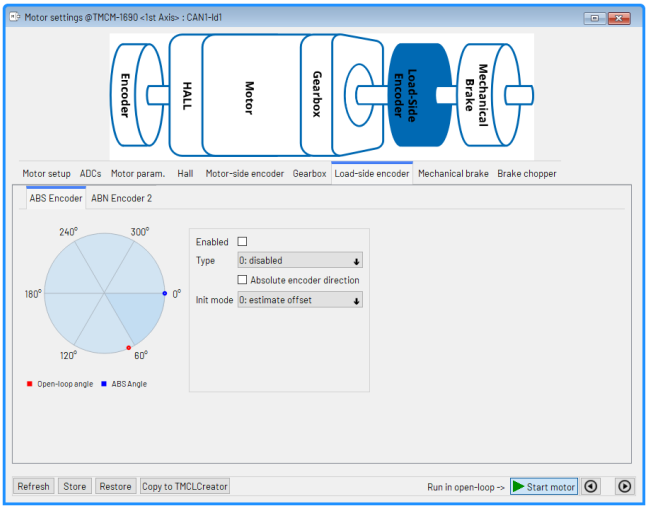



*Figure 26: Configuration Load-Side Encoder*

### 4.2.8 Mechanical Brake

The TMCM-1690-COE-EVAL supports the control of an active mechanical brake using the respective connector. The *Supply Voltage* and *Resistance* of the brake must be defined before enabling the brake.

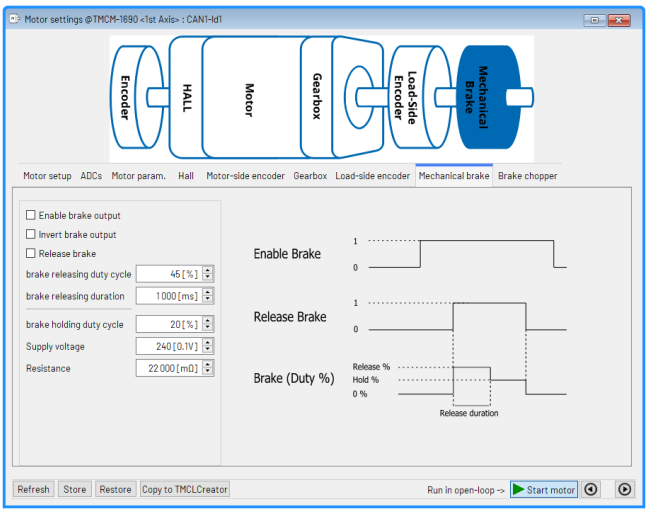



*Figure 27: Configuration Mechanical Brake*

### 4.2.9 Brake Chopper

The TMCM-1690-COE-EVAL supports a brake chopper that is active during overvoltage situations. Two schemes are supported:

- PWM braking: Shorting of the motor coils.
- Shunt braking: Discharge the excess energy through a shunt resistor. Connect a shunt resistor to the respective connector.

The brake chopper is active when the measured supply voltage crosses the threshold defined by *Voltage limits* and the *Hysteresis*.
Configure the *Supply Voltage* and *Resistance* of the brake resistor before enabling the shunt brake.

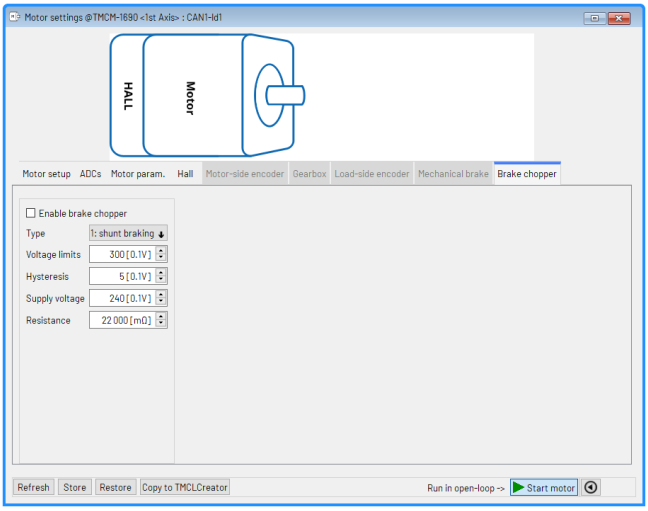



*Figure 28: Configuration Brake Chopper*

## 4.3 Control Loop Settings

To configure the driver settings for the TMCM-1690-COE-EVAL, open the TMCM-1690-COE *Control Loop Settings* tool by clicking the appropriate entry in the tool tree. The configuration includes the parameter of the different loops (current, velocity, position) as well as filters. It is recommended to use this tool after setting up the motor in chapter 4.2.

The bottom of the *Control Loop Settings* tool has different parameter functions:

- Export: Export filter settings to .ini file.
- Import: Import filter settings from .ini file.
- Apply: Apply imported filter settings.
- Refresh: Update all parameters in the *Motor Settings* tool.
- Store: Store all parameters from the *Motor Settings* tool to EEPROM.
- Restore: Load all parameters from EEPROM to the *Motor Settings* tool.
- Copy to TMCLCreator: Copy all parameters from the *Motor Settings* tool to the *TMCLCreator*.

### 4.3.1 Overview

The *Overview* tab shows the control loop structure of the driver. The sensors for each control loop are set.

Example:

1. *Torque Mode* Tool: Stop the motor.
2. Current Control Loop Sensor: Change from Open Loop to ABN encoder.

Result:
→ The encoder initialization is performed immediately and the driver operates in closed loop torque mode.

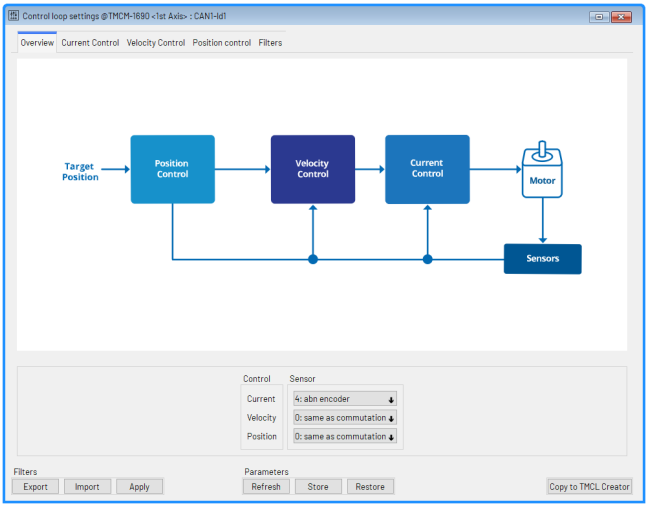



*Figure 29: Control Loop Settings - Overview*

**NOTE** Click the block diagram to directly open the detail loop configuration.

### 4.3.2 Current Control

The drivers current control loop is configured in the *Current Control* tab:

- PI values: The current controller PI values can be set manually or by using the *Auto tuning* tool (recommended).
- Current offset: A current constant offset can be defined for the current controller. This is helpful to compensate mechanics with constant load (example, by gravity).
- Limits: The limits should be derived by the motor data sheet. To monitor the heatup of the motor, the driver supports IIT limits and shutdown, if these are crossed.

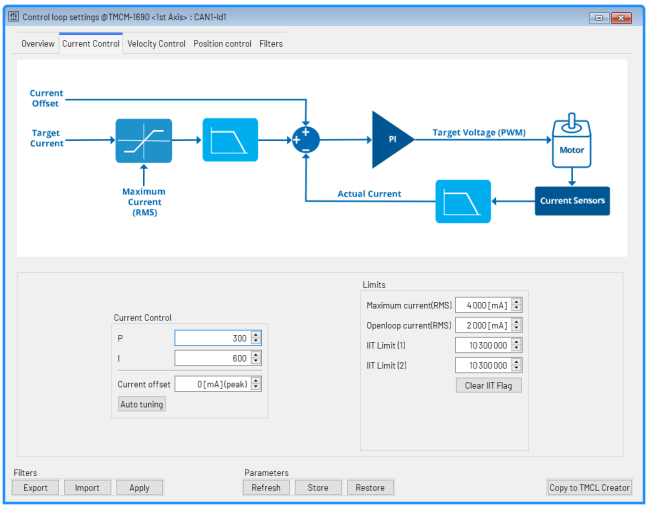



*Figure 30: Control Loop Settings - Current Controller*

**NOTE** For further description of the PI Tuning tool, refer to the documentation of the TMCL-IDE.

### 4.3.3 Velocity Control

The drivers velocity control loop is configured in the *Velocity Control* tab.

- PI values: The velocity controller PI values can be set manually or using the *Auto tuning* tool (recommended).
- Velocity Ramp: The motion controller velocity ramp (example, linear, trapezoidal, s-ramp) and maximum velocity can be set.
- Velocity Window: The *Velocity Window* defines a maximum limit between the actual and target velocity before the driver is stopped. The respective flag can be cleared, if triggered.

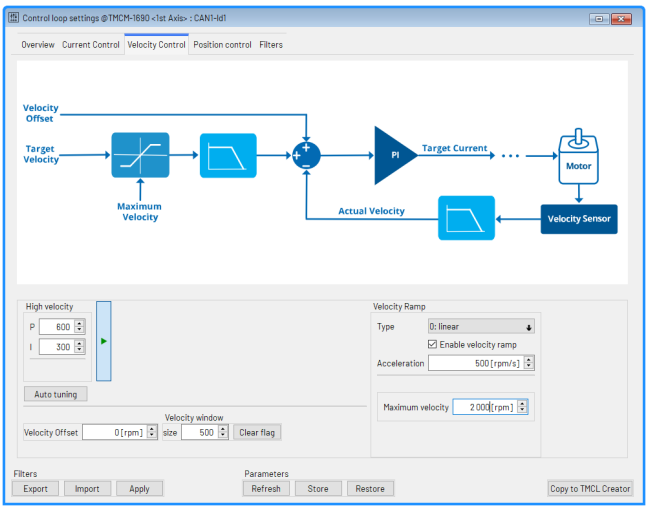



*Figure 31: Control Loop Settings - Velocity Controller*

### 4.3.4 Position Control

The drivers position control loop is configured in the *Position Control* tab.

- P value: The position controller P value can be set manually or by using the *Auto tuning* tool (recommended).
- Position Ramp: The motion controller position ramp and maximum velocity can be configured.
- Position Window The *Position Window* defines a maximum limit between the actual and target position before the driver is stopped. The respective flag can be cleared, if triggered.

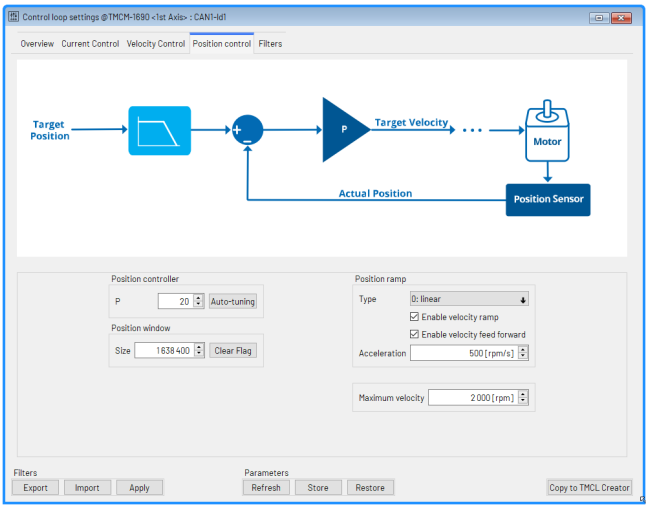



*Figure 32: Control Loop Settings - Position Controller*

### 4.3.5 Filters

The TMCM-1690-COE supports various filters. These can be configured and enabled on the *Filters* tabs. For further information on the filters, refer to the firmware data sheet.

## 4.4 Torque Mode

To control the motor in torque mode, open the torque mode tool from the tool tree. In the torque mode tool, enter the desired current and then apply to the motor using the arrow buttons. Stop the motor at any time by clicking the stop button. Open the torque graph tool to get a graphical view of the actual velocity.

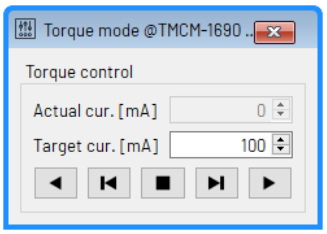



*Figure 33: Torque Mode Tool*

## 4.5 Velocity Mode

To move the motor in velocity mode, the *Velocity mode* tool is available in the tool tree. Here, enter a target velocity and apply to the motor using the arrow buttons. Stop the motor at any time by clicking the stop button.
Additional ramp settings are unfolded with the arrow button on the right side. Besides the maximum velocity, the ramp can be enabled with a defined acceleration.
Open the *Velocity graph* tool to get a graphical view of the actual velocity.

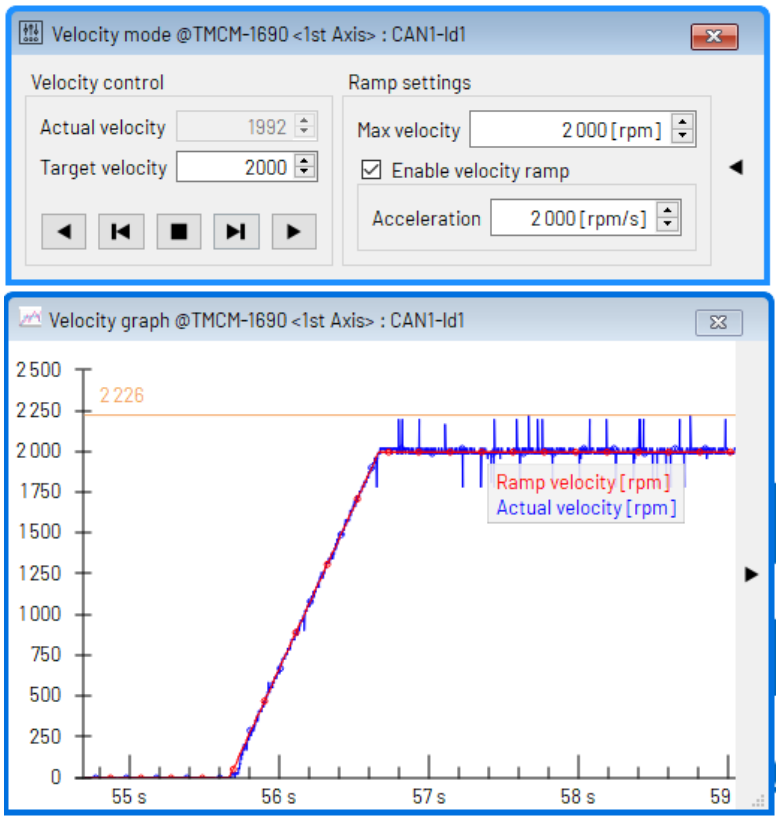



*Figure 34: Driving the Motor in Velocity Mode*

## 4.6 Position Mode

To move the motor in position mode, open the *Position mode* tool by clicking the appropriate entry in the tool tree. Here, enter a target position. The movement is started by the absolute or relative move button. Additional ramp settings can be unfolded with the arrow button on the right side. Besides the maximum velocity, the ramp can be enabled with a defined acceleration.
Open the *Position graph* tool to get a graphical view of the actual position.

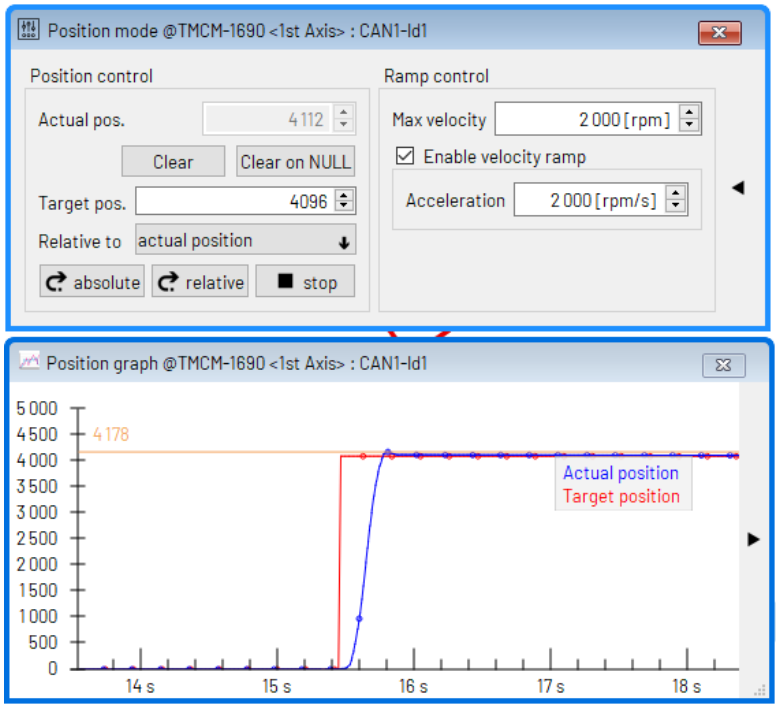



*Figure 35: Driving the Motor in Position Mode*

# 5 EtherCAT Evaluation Features

## 5.1 Motor Settings EtherCAT Tool

Use this tool first to bring up and go through each tab step by step. The motor is run in open loop to determine the configuration of the ADCs, feedback sensors (example, ABN, hall), gears, and brake.

To configure the motor settings for the TMCM-1690-COE-EVAL using the EtherCAT interface, connect the TMCM-1690-COE-EVAL through the Ethernet cable with the PC. Then, open the TMCM-1690-COE *Motor Settings* tool and connect to the EtherCAT adapter.

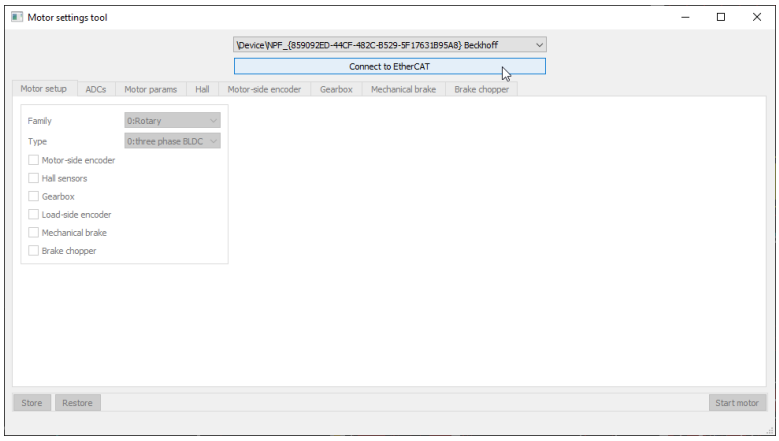



*Figure 36: Connect to Motor Settings Tool*

The bottom of the *Motor Settings* tool shows different parameter options:

- Store: Store all parameters from the *Motor Settings* tool to EEPROM.
- Restore: Load all parameters from EEPROM to the *Motor Settings* tool.

### 5.1.1 Motor Setup

In the *Motor setup* tab, choose the motor family (rotary or linear) and type (3-phase or 1-phase). In addition, select the building blocks specific to the application.

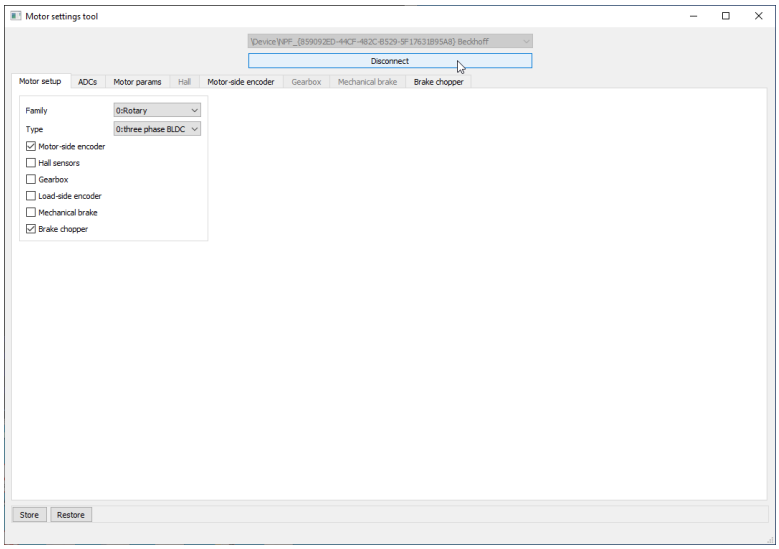



*Figure 37: Motor Setup*

### 5.1.2 ADCs

In the *ADCs* tab, the motor current ADC offset is compensated. The *Update* buttons determine the offset automatically for each motor phase. With *Update all*, the compensation is calculated for all motor phases. With the respective *Store all* button, the parameters are saved to EEPROM and are loaded automatically upon power up.

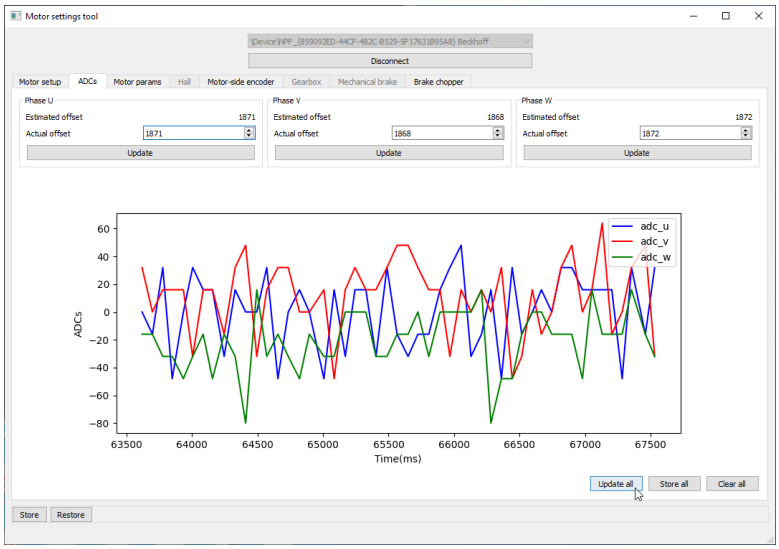



*Figure 38: Configuring the Motor Current ADCs*

### 5.1.3 Motor param.

In the *Motor param.* tab, the motor parameters are configured as follows:

- Pole pairs: Number of pole pairs of the motor.

- Max current: Maximum rated motor current of the motor [mA rms].
- Open loop current (RMS): The applied motor current during open loop [mA rms].
- PWM frequency: PWM frequency of the current loop. Can be increased, example, for lower inductance motor.

After above configuration, the motor is driven in open loop with *Start motor* using *Open loop current*. For position constricted mechanics, the motor can reverse repeatedly using *Swap direction*. The direction change time is defined by *Swap Time[ms]*.

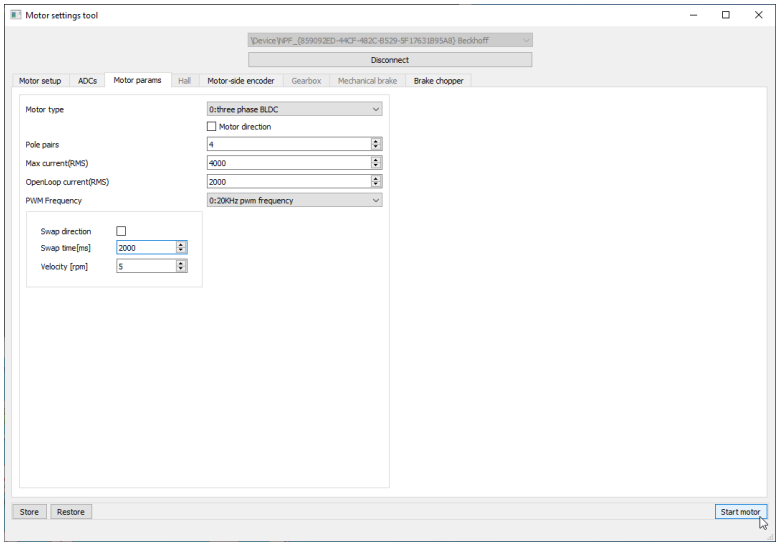



*Figure 39: Configuring the Motor Parameter*

### 5.1.4 Hall

In the *Hall* tab, the hall sensor feedback of the motor is configured as follows:

1. With *Start motor*, the motor is run in open loop.
2. Hall configuration: Configure the hall sensor by setting the sector and direction.
3. Optional: *Digital hall interpolation* can be enabled to activate interpolation of the hall signals for smoother run in closed loop.

After sucessfull hall configuration, the open loop angle should start in the same sector as the hall angle.

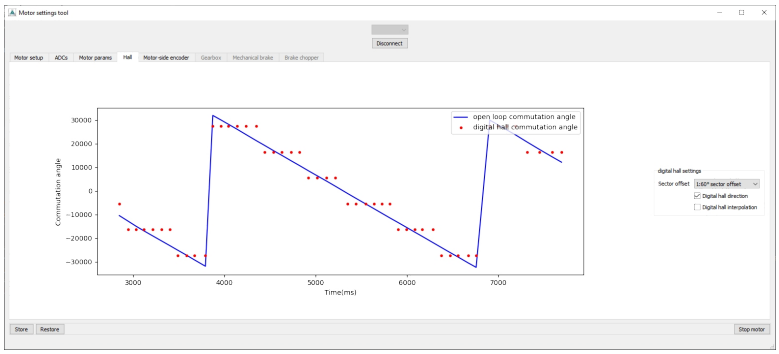



*Figure 40: Completed Configuration Hall Sensor Feedback*

### 5.1.5 Motor-Side Encoder

The TMCM-1690-COE-EVAL supports different encoder sensors that can be used for commutation. Incremental encoder (ABN) and absolute encoder (ABS) are supported.

Configuration of the *ABN encoder*:

1. Enable the respective encoder using the *Enabled* checkbox.
2. With *Start motor*, the motor is run in open loop.
3. Steps: This is the encoder resolution with the the enocoder pulse per revolution.
4. Estimated Steps: This is the encoder resolution estimated by the tool. The longer the motor runs, the more accurate is the estimation.
5. Init mode: Different encoder initalization routines are supported. Refer to the TMCM-1690-COE data sheet for further description.

Configuration of the *ABS encoder*:

1. Enable the respective encoder using the *Enabled* checkbox.
2. With *Start motor*, the motor is run in open loop.
3. Select the encoder *type*.
4. Set the *Absolute encoder direction*.
5. Init mode: Different encoder initalization routines are supported.

**NOTE** If an absolute encoder is missing, contact Customer Service.

After succesfull encoder configuration, the *Open loop angle* turns with the same frequency of the *ABN Angle*.

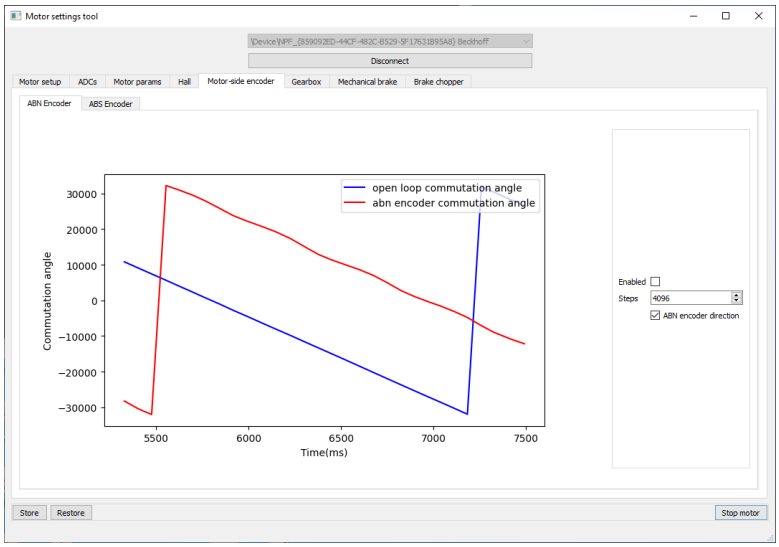



*Figure 41: Configuration Encoder Sensor*

### 5.1.6 Gearbox

The TMCM-1690-COE-EVAL supports gearing with either *Rotary to rotary* or *Rotary to linear* transmission.

1. *Motor displacement of*: Gear input/motor shaft revolution.
2. *Results on load to*: Resulting gear output revolution.
3. *Gearbox invert direction*: Invert the direction of the gearbox transmission.

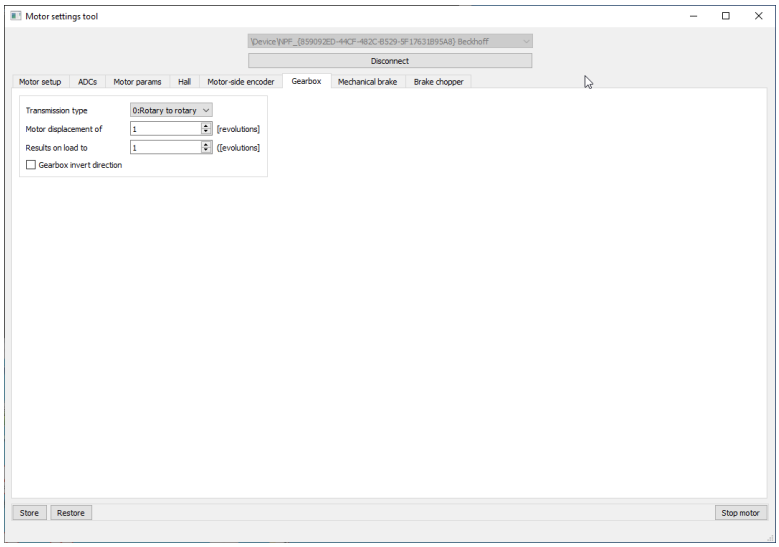



*Figure 42: Configuration Gearbox*

### 5.1.7 Mechanical Brake

The TMCM-1690-COE-EVAL supports the control of an active mechanical brake using the respective connector. The *Supply Voltage* and *Resistance* of the brake must be defined before enabling the brake.

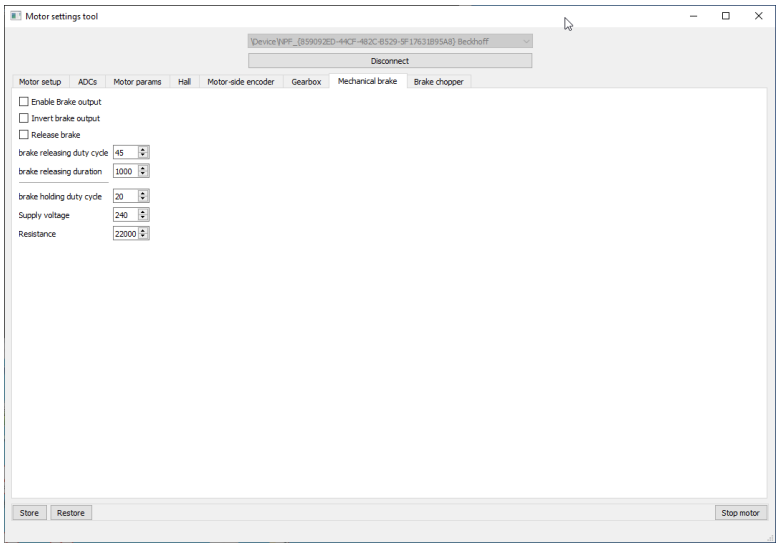



*Figure 43: Configuration Mechanical brake*

### 5.1.8 Brake Chopper

The TMCM-1690-COE-EVAL supports a brake chopper that is active during overvoltage situations. Two schemes are supported:

- PWM braking: Shorting of the motor coils.
- Shunt braking: Discharge the excess energy through a shunt resistor. Connect a shunt resistor to the respective connector.

The brake chopper is active when the measured supply voltage crosses the threshold defined by *Voltage limits* and the *Hysteresis*.
Configure the *Supply Voltage* and *Resistance* of the brake resistor before enabling the shunt brake.

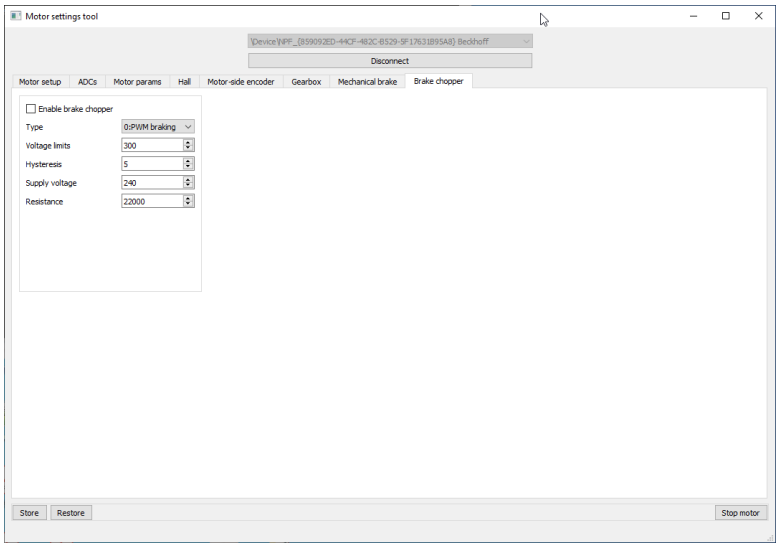



*Figure 44: Configuration Brake Chopper*

## 5.2 How to update the firmware

This section describes how to update the firmware of the TMCM-1690-COE using TwinCAT.

1. Double click *Drive 1(TMCM-1690)* → *Online*

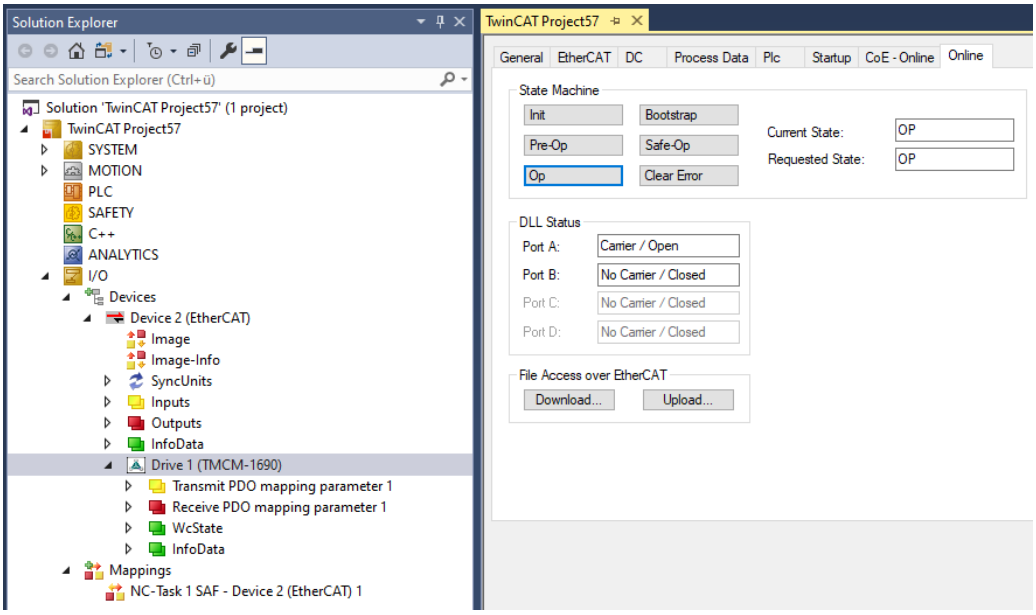



*Figure 45: TMCM-1690 Firmware Update*

2. Set state machine to *PREOP*.

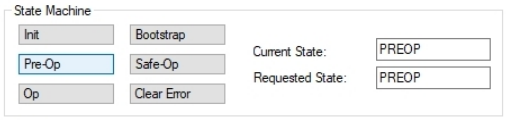



*Figure 46: Set the State Machine to PREOP*

3. Set state machine to *Bootstrap*.

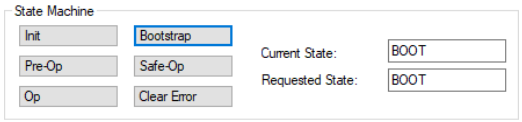



*Figure 47: Set the State Machine to Bootstrap*

4. Click *Download...*
5. Choose the firmware in .bin format.

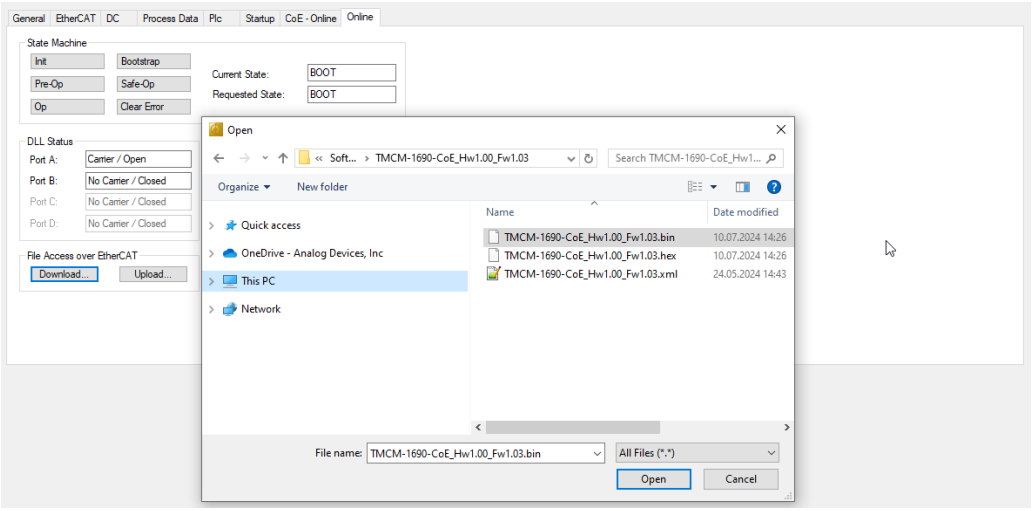



*Figure 48: Firmware Selection*

6. Choose *OK* to update the firmware.

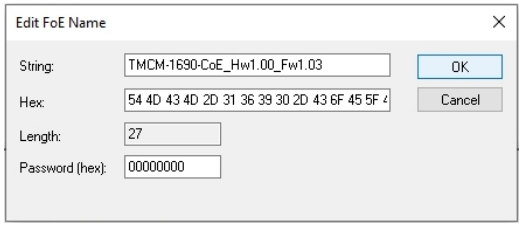



*Figure 49: Firmware update*

7. After the firmware update, power cycle the TMCM-1690-COE-EVAL.

## 5.3 How to Update the EEPROM

This section describes how to update the EEPROM of the TMCM-1690-COE using TwinCAT.

1. Double click *Device X(TMCM-1690)* → Online → Right click *EEPROM Update*

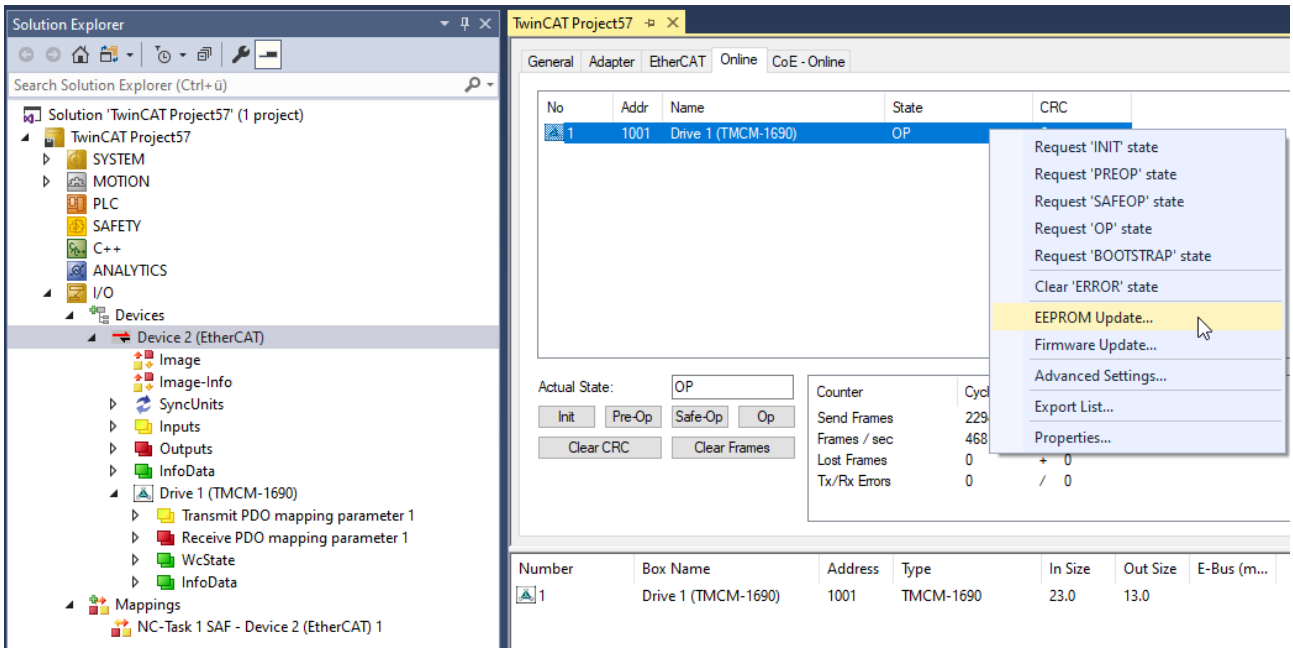



*Figure 50: Update EEPROM of the TMCM-1690*

2. Select the TMCM-1690-COE device description.
   Note: In case the drive does not show up, the .xml is yet to be put into the the TwinCAT I/O folder.

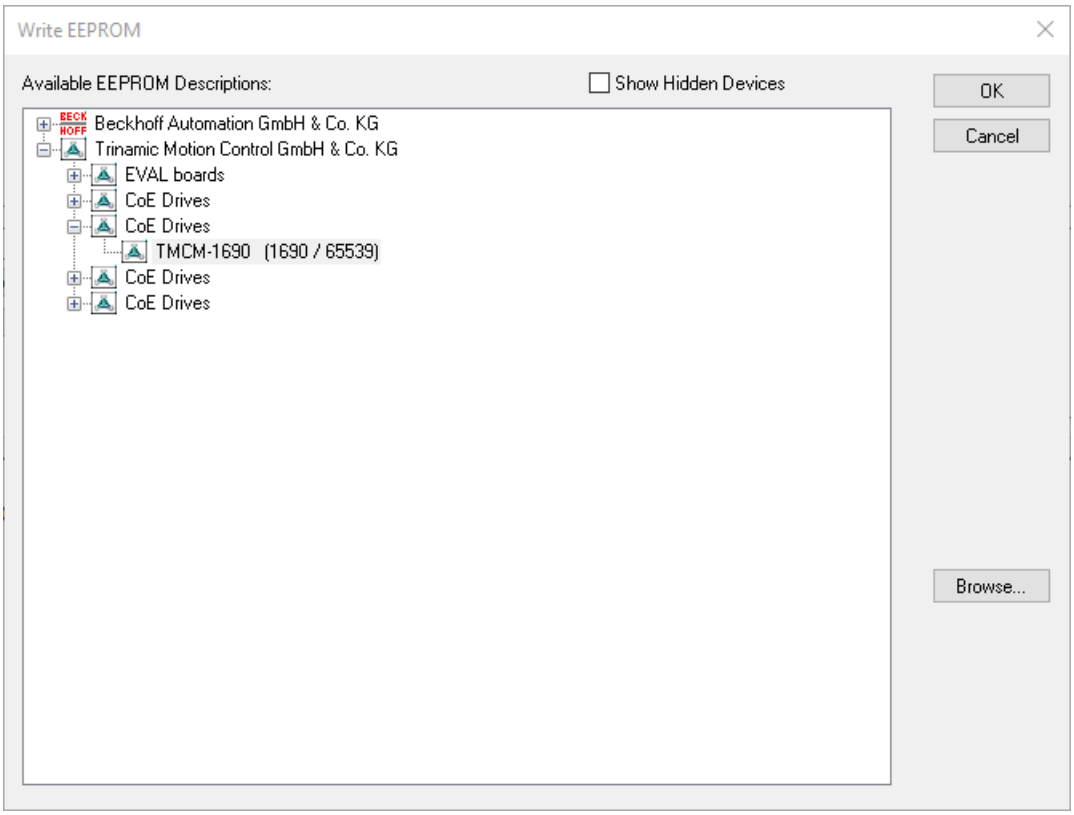



*Figure 51: Selection of the TMCM-1690-COEDevice Description*

3. After update is completed, power cycle, remove, and reconnect the device. Alternatively, create a new TwinCAT project.

### 5.3.1 Check the Connectivity with TwinCAT

From the tab *CoE-Online*, the communication of TwinCAT with the evaluation board can be checked by reading the SDOs such as the *Vendor Id* (Object x1018:01) or the *Driver Temperature* (Object 0x200F).

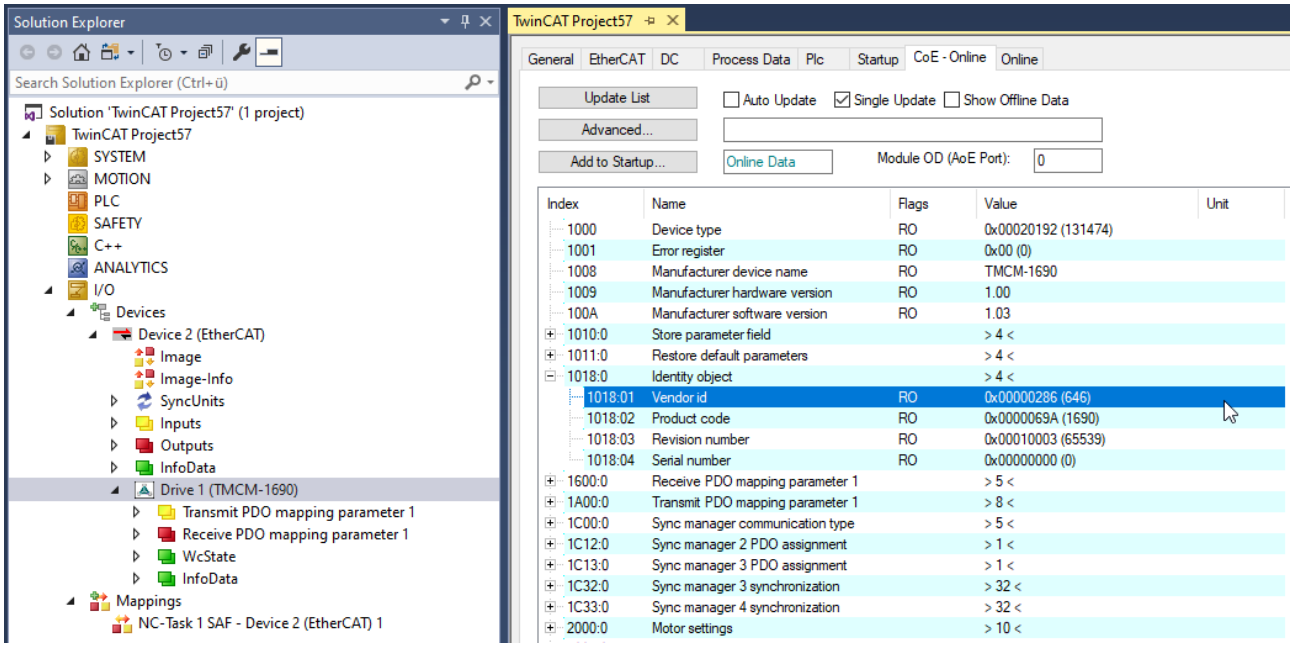



*Figure 52: EtherCAT SDO Object: 0x1018:01 - Vendor ID*

# 6 Revision History

## 6.1 Hardware Revision

| Version | Date | Description |
|---|---|---|
| V1.0 | 2024-JUN-20 | Initial release |

*Table 18: Hardware Revision*

## 6.2 Document Revision

| Version | Date | Description |
|---|---|---|
| Rev 0 | 07/24 | Initial release |

*Table 19: Document Revision*