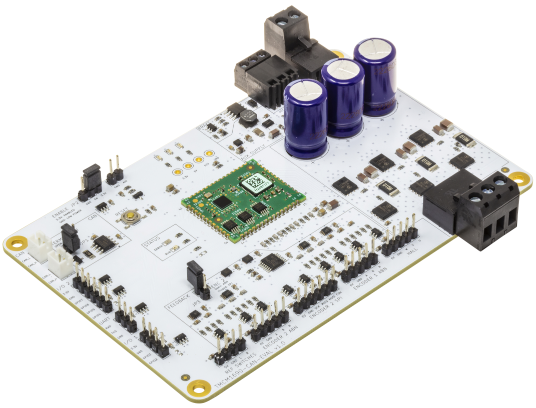
TMCM-1690-CAN-EVAL Evaluation Board

Hardware Version V1.00 | 319-101076, Rev 0: 01/24

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

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



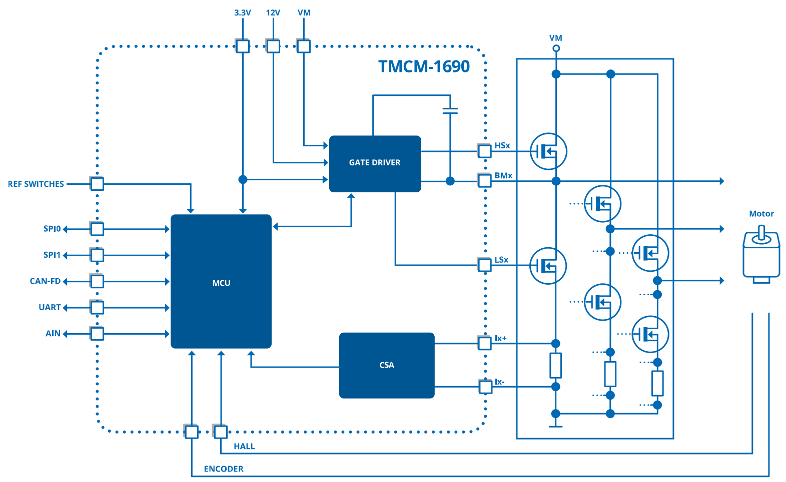
Features

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

Applications

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

Simplified Block Diagram



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Contents

1 Order Codes

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

Table 1: TMCM-1690-CAN-EVAL Order Codes

2 Getting Started

Required Equipment

- TMCM-1690-CAN-EVAL evaluation board
- Brushless DC (BLDC) motor (example, QMot line)
- CAN adapter (example, PCAN-USB, Kvaser Leaf Light, ESD, IXXAT)
- UART FTDI 3.3V cable (optional)
- Power supply
- TMCL-IDE (TMCL-IDE V3.9.0 or newer)
- Cables for interface, motors, and power

Precautions

- Do not mix up 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

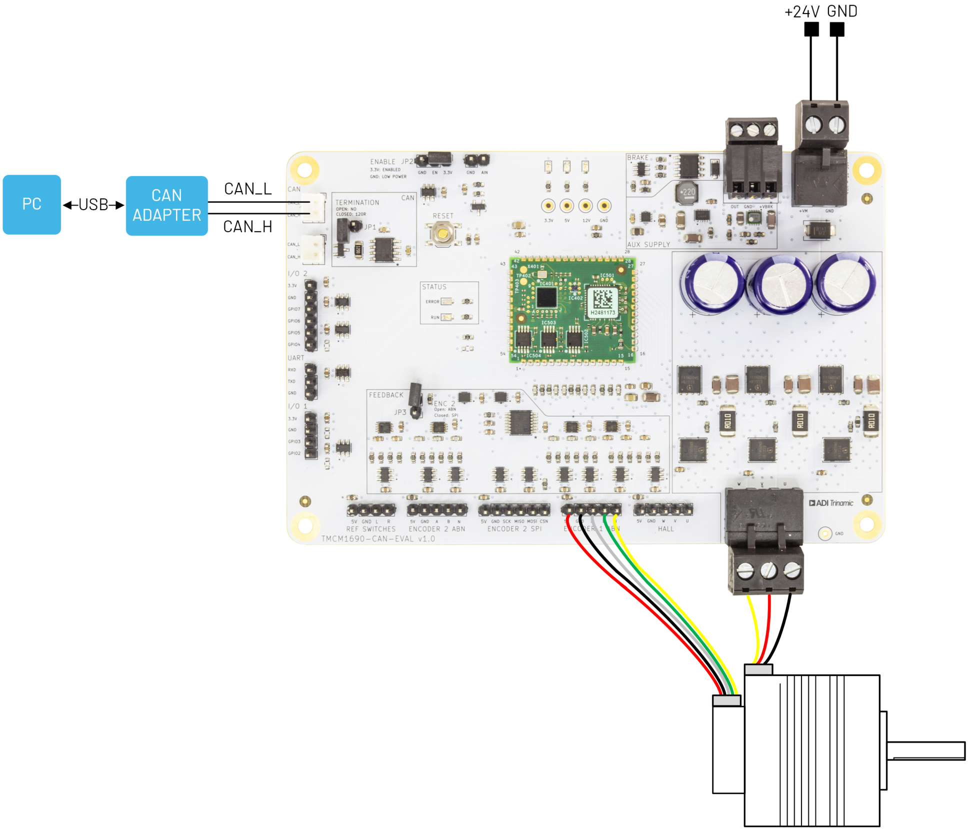

Figure 1: Getting Started Example

1. Make sure that the latest version of the TMCL-IDE is installed. The TMCM-1690-CAN-EVALis supported for TMCL-IDE V3.9.0 or newer. Download the TMCL-IDE from www.analog.com TMCL-IDE.
2. Connect the motor phases to the TMCM-1690-CAN-EVAL motor connector.
3. Connect the motor sensor feedback (example, incremental encoder, absolute encoder, or hall) to the TMCM-1690-CAN-EVAL .
4. Connect TMCM-1690-CAN-EVAL CAN to the PC using a CAN adapter.
5. Power the module through the power supply connector.
6. Open the TMCL-IDE and connect with the TMCM-1690-CAN-EVAL. For Windows® 8 and higher, no driver is needed. For Windows 7, TMCL-IDE installs the driver automatically.
7. Verify that the TMCM-1690-CAN-EVAL is using the latest firmware version. The device tree shows the firmware version. Download the newest firmware from www.analog.com.

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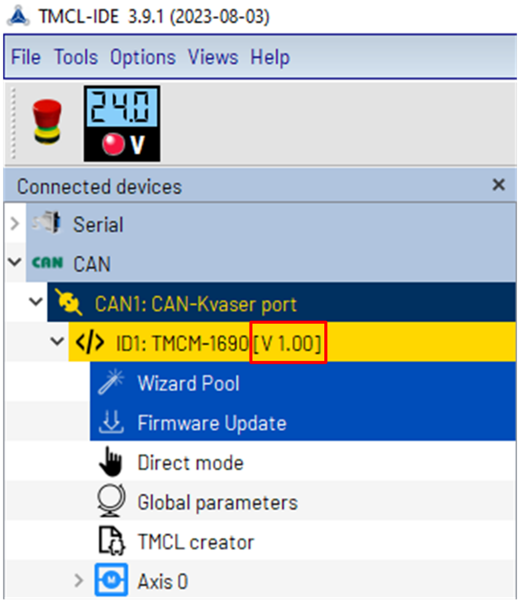

Figure 2: Firmware Version

8. The TMCL-IDE needs space to display all important information and to 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 the TMCL Creator tool to create application specific motor control programs.

3 Hardware Information

All design files for 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 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-CAN-EVAL has 14 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-CAN-EVAL homepage

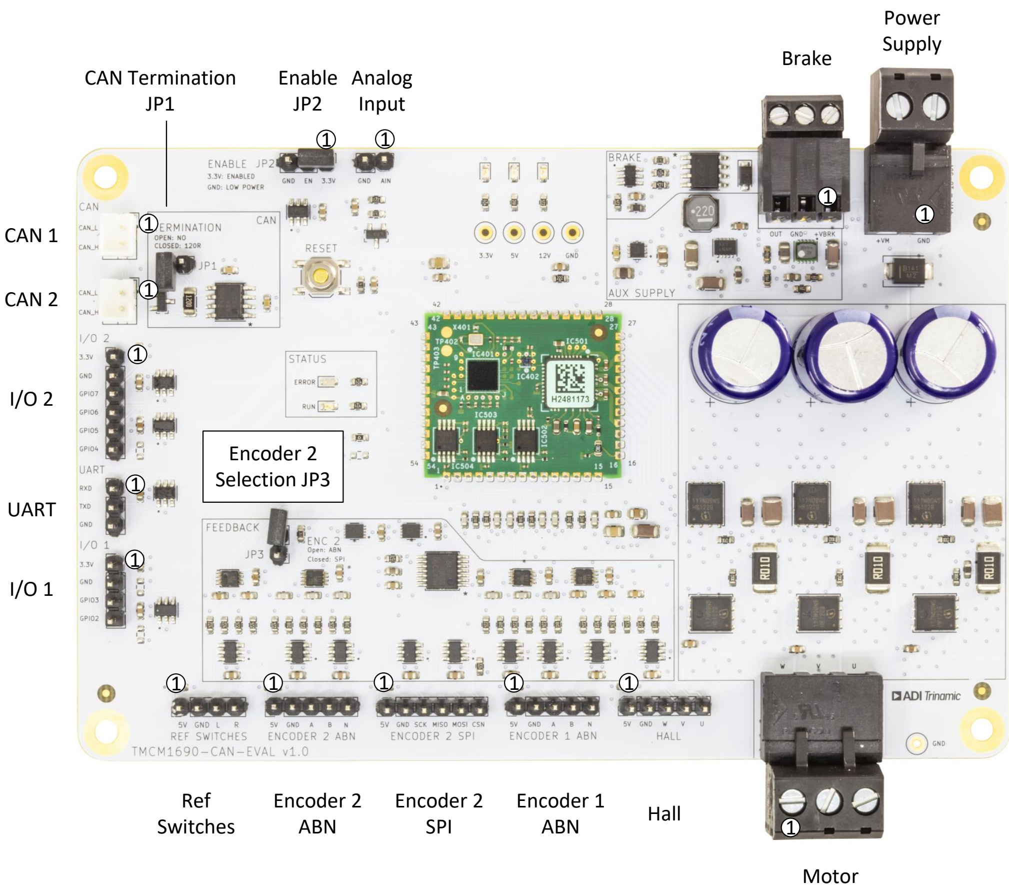

Figure 3: TMCM-1690-CAN-EVAL Connectors

#	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 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	Connect reference switches to evalboard.
7	I/O 1	Standard 4x 2.54mm header	I/O 1 connector.
8	I/O 2	Standard 6x 2.54mm header	I/O 2 connector.
9	UART	Standard 3x 2.54mm header	UART connector.
10	2x CAN	JST_PH_B2B-PH-K_1x02_P2.00mm_Vertical	CAN interface. Mating connector: Housing: JST PHR-2 Crimp contacts: BPH-002T-P0.5S (0.5-0.22mm).
11	Brake	METZ CONNECT 31182103	Use to connect a brake resistor or a motor brake to the TMCM-1690. Mating connector METZ CONNECT 31169103.
12	AIN	Standard 2x 2.54mm header	Analog Input.

Table 3: TMCM-1690-CAN-EVALConnectors

3.1.1 Power Supply Connector

The power supply connector to power the TMCM-1690-CAN-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 Brake Connector

The brake connector can be used in two ways. Either a brake resistor can be connected to dissipate energy from 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 firmware data sheet.

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

Table 5: Brake Pin Assignment

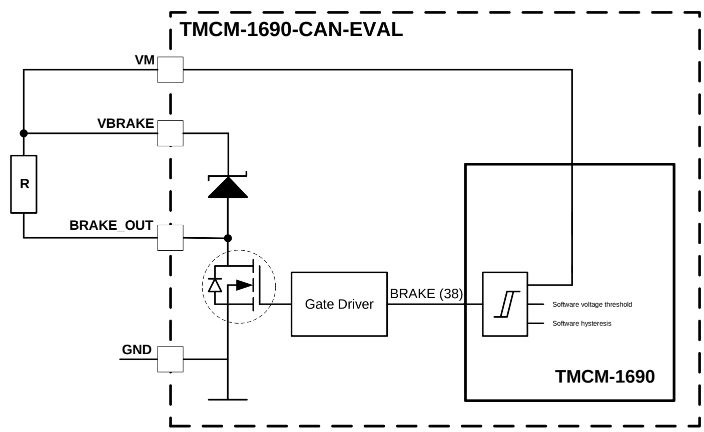

Figure 4: Example Brake: Shunt Resistor

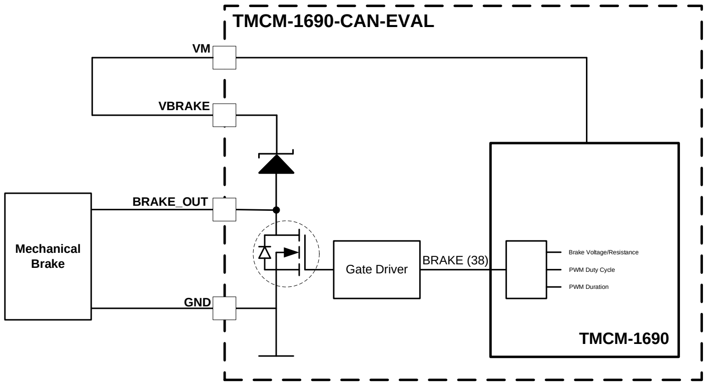

Figure 5: Example Brake: Mechanical Brake

3.1.3 CAN Connector

The CAN connector is the main interface for the TMCM1690-CAN-EVAL. The second CAN connector can be used to connect a second CAN node. CAN Bus transceiver is ISO 11898-2.

Pin	Label	Description
1	CAN-	CAN interface, diff.signal (inverting)
2	CAN+	CAN interface, diff.signal (non-inverting)

Table 6: CAN Pin Assignment

The CAN termination can be set by Jumper JP1.

3.1.4 Motor Connector

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

Table 7: Motor Pin Assignment

3.1.5 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

Pin	Label	Description
4	V	Hall sensor signal 2
5	U	Hall sensor signal 1

Table 8: Hall Pin Assignment

3.1.6 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 9: Encoder 1 Pin Assignment

3.1.7 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 10: Encoder 2 ABN Pin Assignment

3.1.8 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 11: Encoder 2 SPI Pin Assignment

3.1.9 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 12: Reference Switches Pin Assignment

3.1.10 I/O 1 Connector

Pin	Label	Description
1	+3.3V	+3.3V output rail
2	GND	Supply and signal ground
3	GPIO3	RS485 direction pin output, Alternative: General purpose input/output, +3.3V level
4	GPIO2	General purpose input/output, FW default: input, +3.3V level

Table 13: I/O 1 Pin Assignment

As an option, GPIO3 and GPIO2 can be used as I^2C interface (firmware update required).

3.1.11 I/O 2 Connector

Pin	Label	Description
1	+3.3V	+3.3V output rail
2	GND	Supply and signal ground
3	GPIO7	General purpose input/output, FW default: input, +3.3V level
4	GPIO6	General purpose input/output, FW default: input, +3.3V level
5	GPIO5	General purpose input/output, FW default: input, +3.3V level
6	GPIO4	General purpose input/output, FW default: input, +3.3V level

Table 14: I/O 2 Pin Assignment

3.1.12 UART

The UART interface connects to the TMCM-1690 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 15: UART Pin Assignment

3.1.13 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 16: AIN Pin Assignment

3.2 Jumper and Button

3.2.1 JP1: CAN Termination

The TMCM1690-CAN-EVAL supports optional 120 Ω termination of the CAN bus, which can be set with jumper JP1. Especially for longer buses and/or multiple nodes connected to the bus and/or high communication speeds, the bus should be properly terminated at both ends.

Pin	Description
Open	No termination
Closed	120 Ω termination between CAN_TX and CAN_RX

Table 17: JP1: CAN termination

3.2.2 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 18: JP2: Motor Driver Enable

3.2.3 JP3: Encoder 2 Selection

The TMCM1690-CAN-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 19: JP3: Encoder 2 Selection

3.2.4 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 20: Reset Button

4 TMCL-IDE Evaluation Features

This section gives tips on using 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 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-CAN-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.

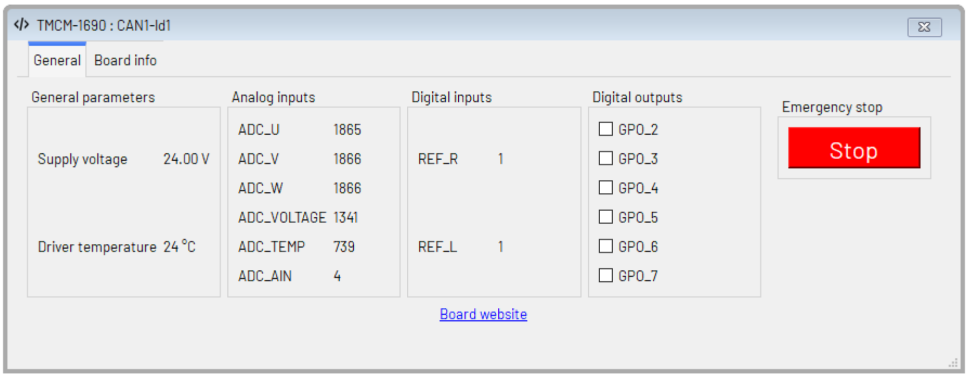

Figure 6: Board Information Tool

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-CAN-EVAL, open the TMCM-1690 *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.

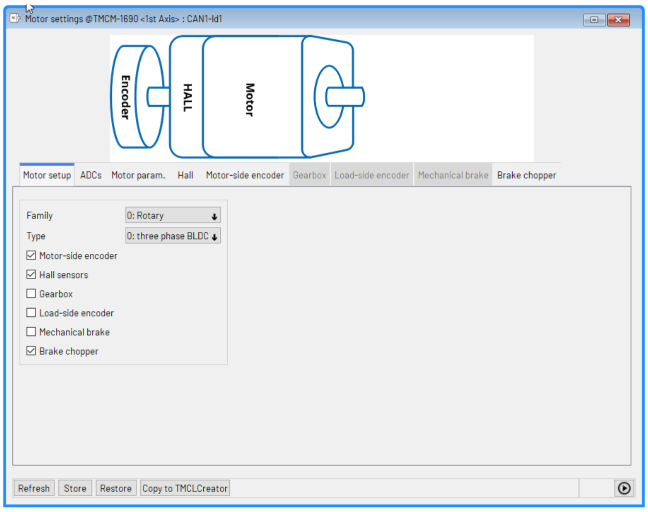

Figure 7: Motor Setup

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 8: 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]*.

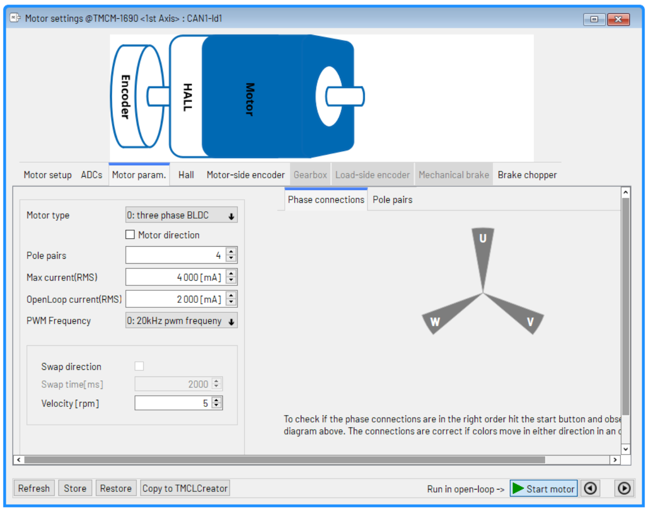

Figure 9: Configuring the Motor Parameter

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.

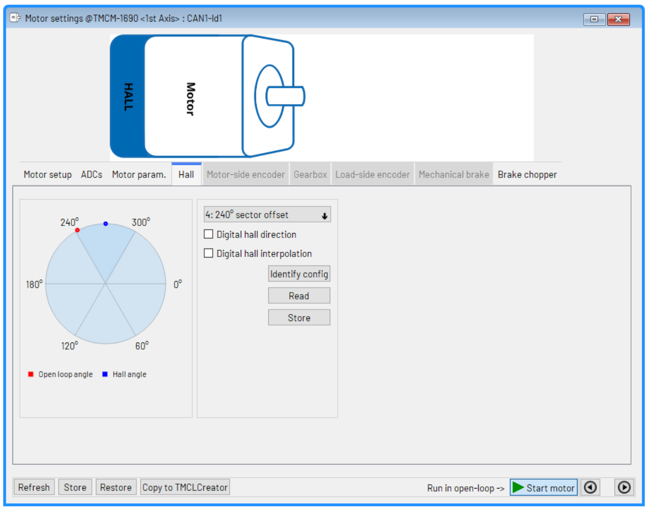

Figure 10: Completed Configuration Hall Sensor Feedback

4.2.5 Motor-Side Encoder

The TMCM-1690-CAN-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 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*.

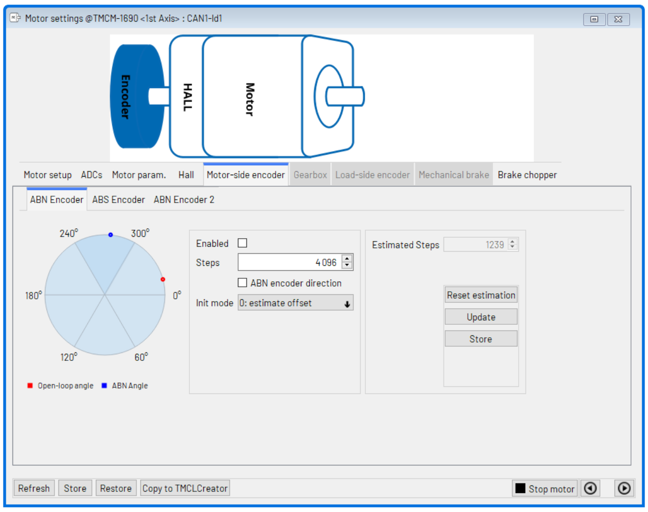

Figure 11: Configuration Encoder Sensor

4.2.6 Gearbox

The TMCM-1690-CAN-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.

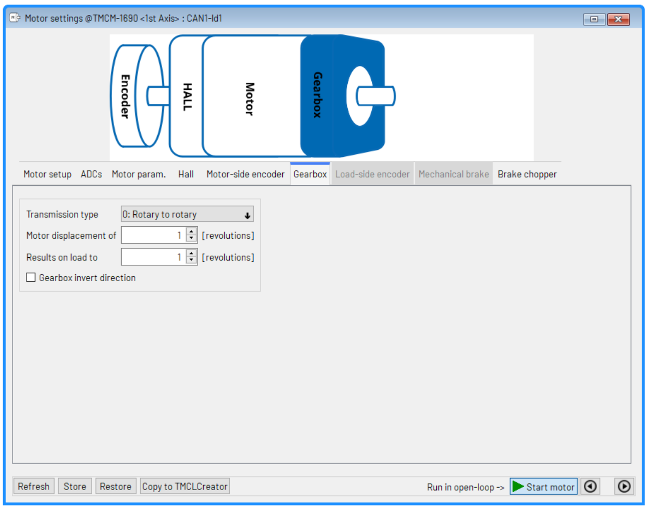

Figure 12: Configuration Gearbox

4.2.7 Load-Side Encoder

The TMCM-1690-CAN-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.

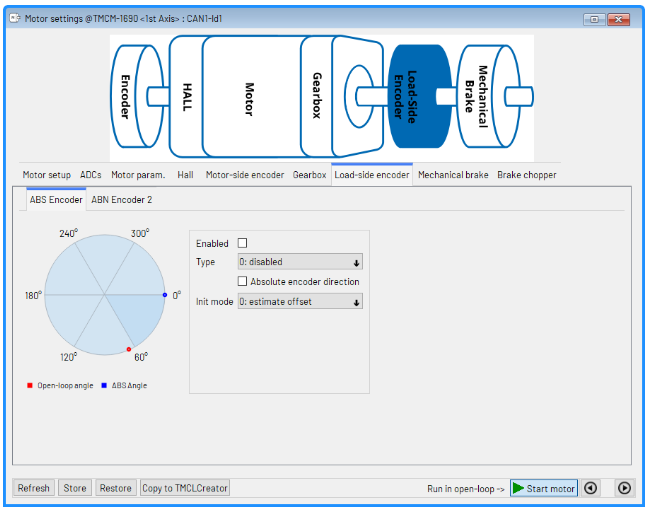

Figure 13: Configuration Load-Side Encoder

4.2.8 Mechanical Brake

The TMCM-1690-CAN-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.

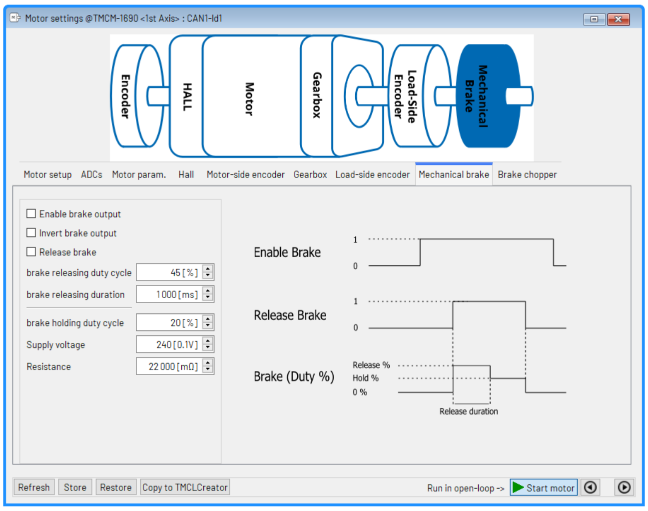

Figure 14: Configuration Mechanical Brake

4.2.9 Brake Chopper

The TMCM-1690-CAN-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.

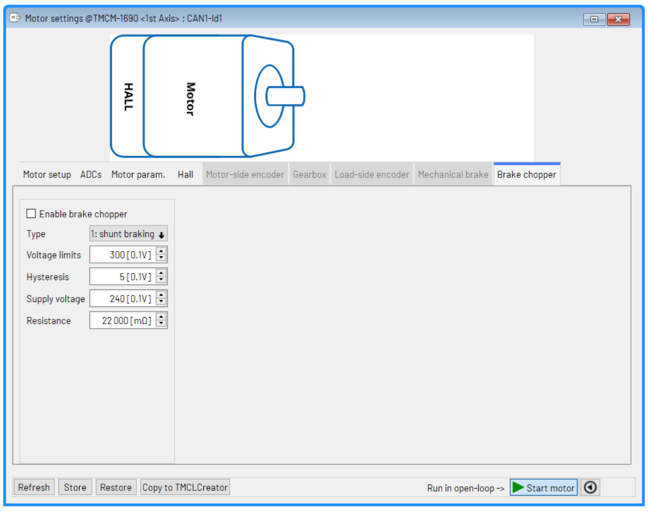

Figure 15: Configuration Brake Chopper

4.3 Control Loop Settings

To configure the driver settings for the TMCM-1690-CAN-EVAL, open the TMCM-1690 *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.

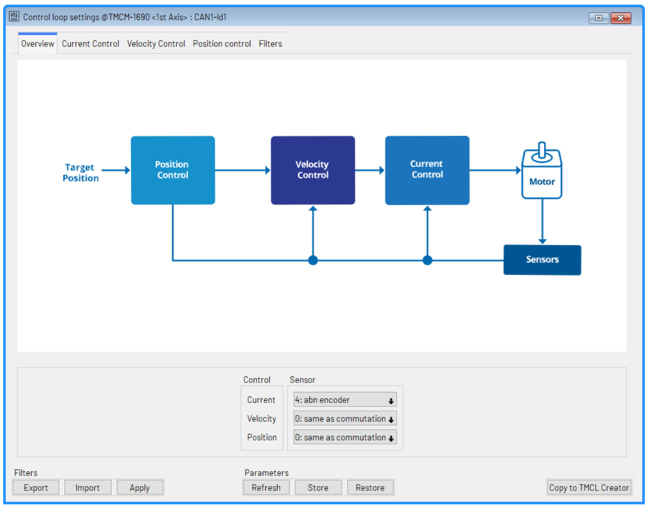

Figure 16: Control Loop Settings - Overview

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.

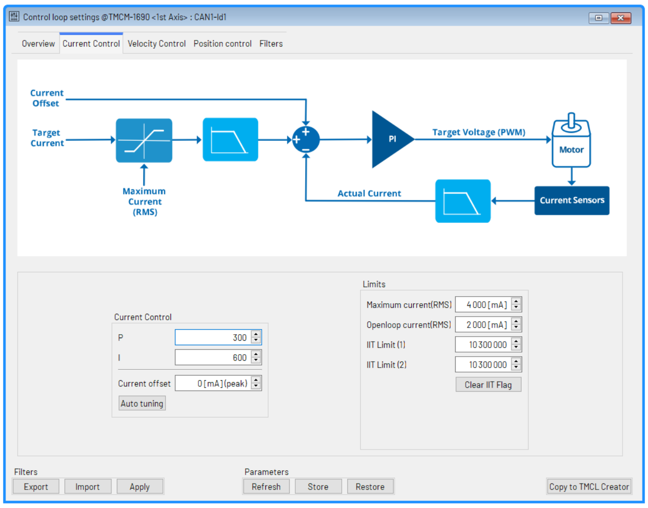

Figure 17: Control Loop Settings - Current Controller

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.

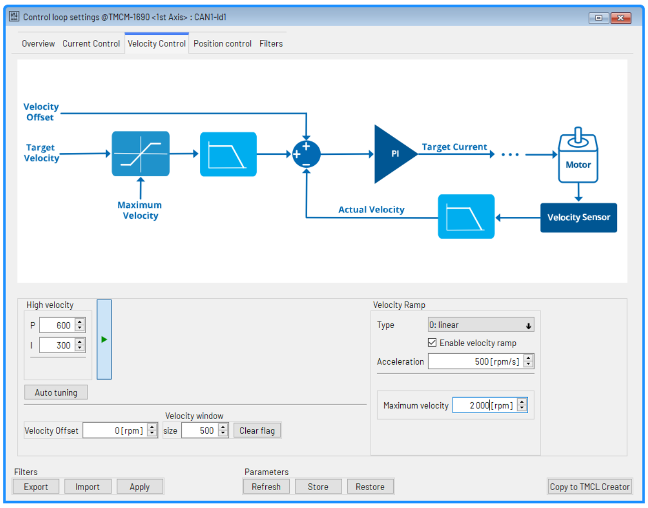

Figure 18: Control Loop Settings - Velocity Controller

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.

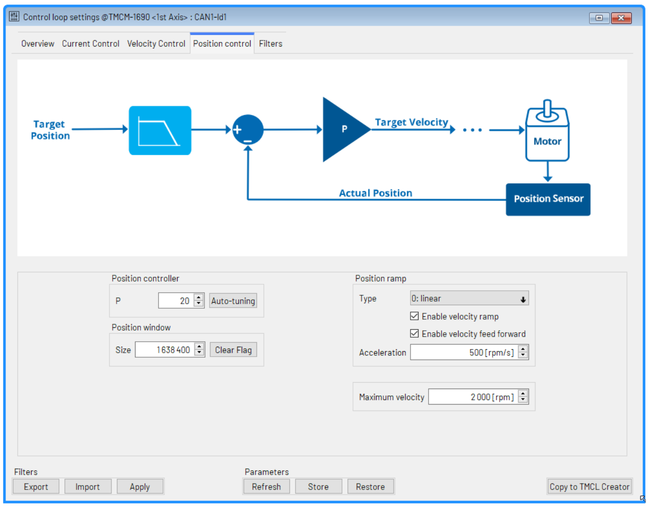

Figure 19: Control Loop Settings - Position Controller

4.3.5 Filters

The TMCM-1690 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.

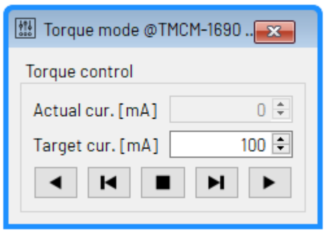

Figure 20: Torque Mode Tool

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.

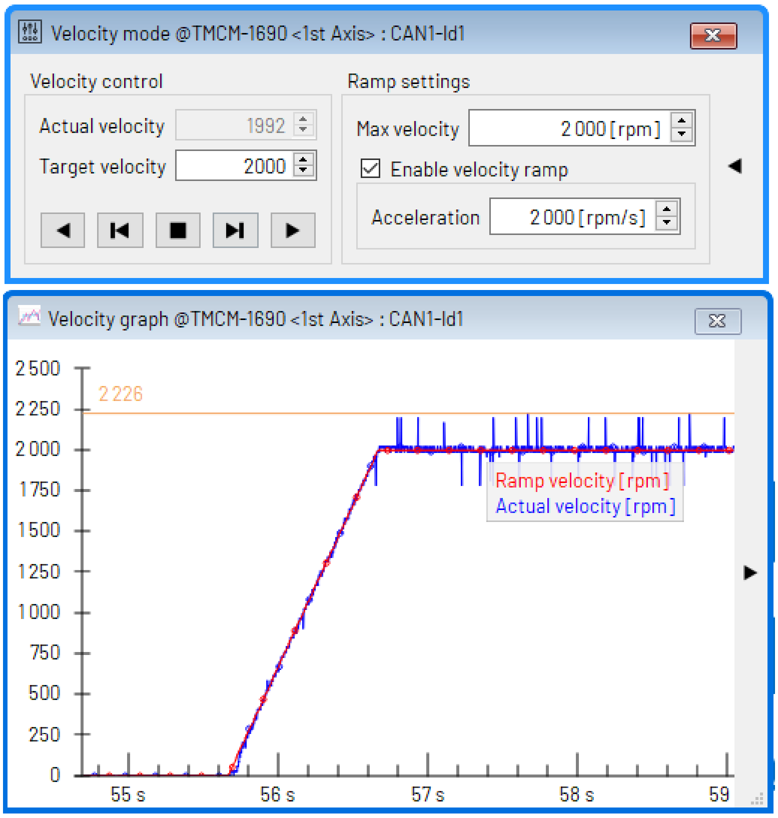

Figure 21: Driving the Motor in Velocity Mode

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.

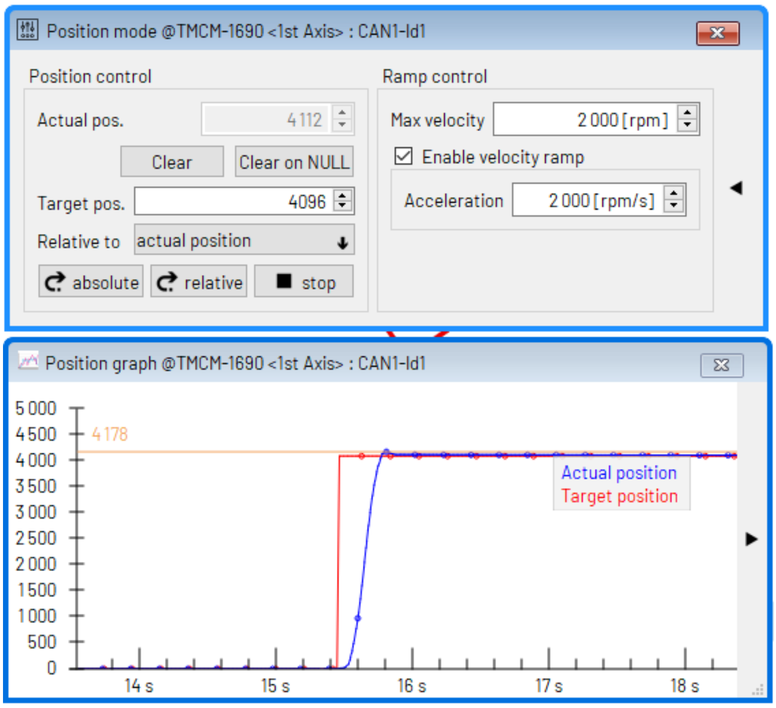

Figure 22: Driving the Motor in Position Mode

4.7 TMCL Creator

The *TMCL Creator* can be used to develop standalone TMCL programs on the TMCM-1690. These TMCL programs can be downloaded to the TMCM-1690 and then run standalone after power up. The central part of the TMCL Creator is its main window with its own menu bar and the TMCL program editor. The TMCL program editor mainly provides the functionality of a standard text editor with built-in syntax highlighting for TMCL. Here, TMCL programs can be entered and modified. After a program is entered, it can be assembled, downloaded to the module, and run on the module.

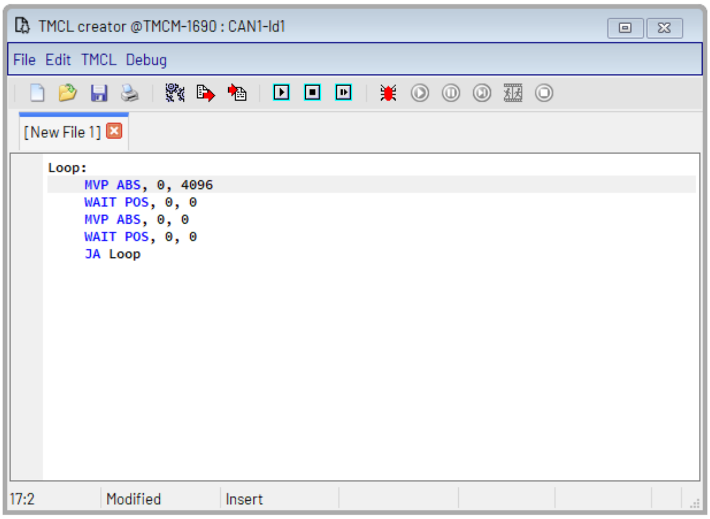

Figure 23: TMCL Creator Example

For further information on the syntax of the TMCL programming language and the *TMCL Creator* tool, refer to the TMCL-IDE user manual manual. Refer to the TMCM-1690 TMCL firmware manual to learn more about using TMCL as a programming language.

5 Revision History

5.1 Hardware Revision

Version	Date	Description
V1.0	2022-JUL-19	Initial release

Table 21: Hardware Revision

5.2 Document Revision

Version	Date	Description
Rev 0	01/24	Initial release

Table 22: Document Revision