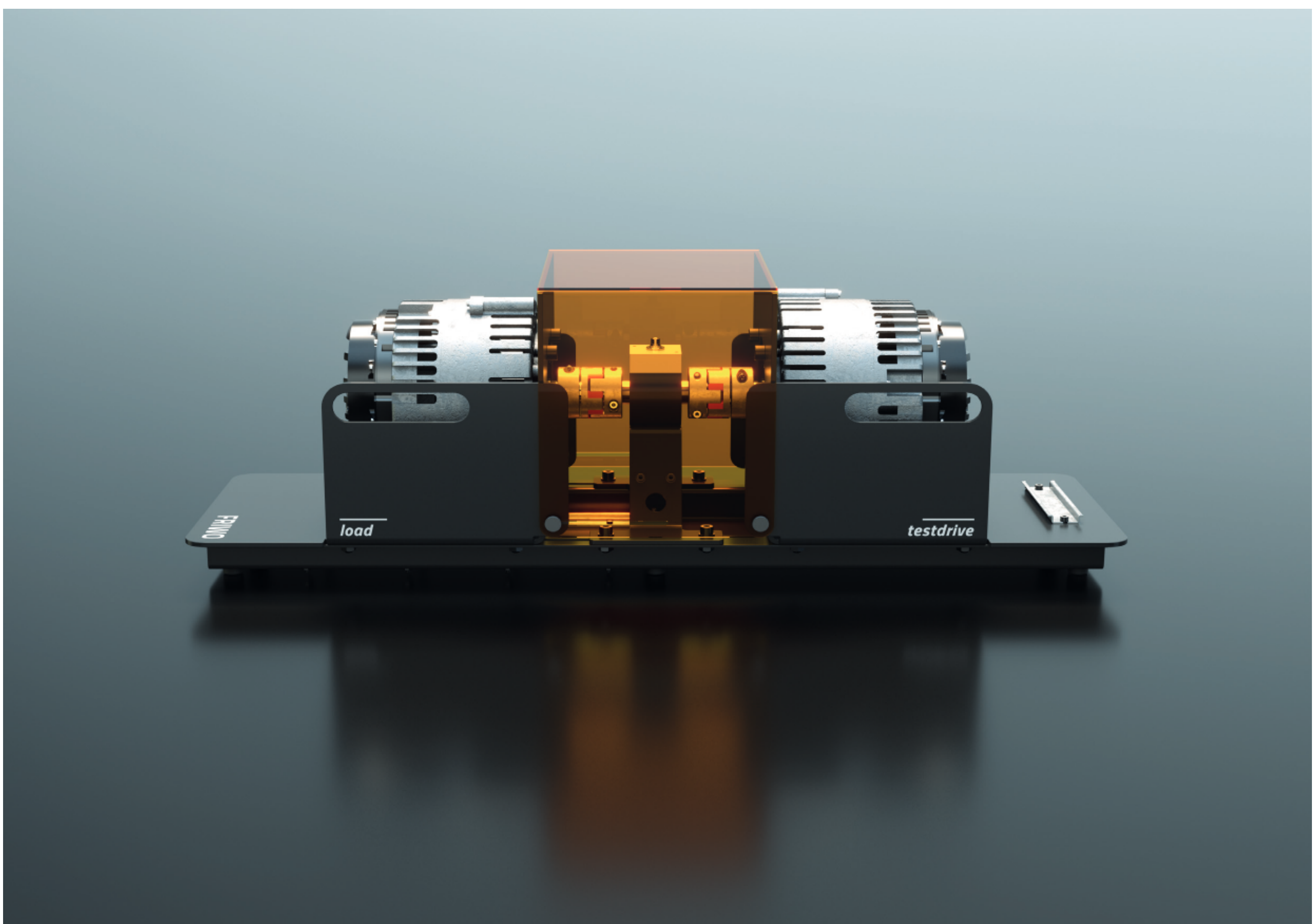
BACK-TO-BACK

FRIWO Motor Test Bench

MANUAL

Version 1.0



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3 LIST OF ABBREVIATIONS

Abbreviation	Description
PMSM	Permanent Magnet Synchronous Motor
CAN	Controler Area Network
USB	Universal Serial Bus
BUS	System for data transmission

4 AREAS OF APPLICATION OF THE TEST BENCH

The basic configuration of the test bench does not include a torque measuring shaft or a FRIWO battery pack. These components can be purchased by the user if required.

This system enables the user to test individual drive components and adjust them to each other. With the help of CAN software or the FRIWO Enable Tool the user can simulate and evaluate driving cycles and load curves. If the system limits listed in chapter 7 are adhered to, it is possible to replace the motor installed on the test side. In this case, the motor control must be adapted and configured to the motor, see chapter 12.

It is not intended to replace the motor on the load side. If a replacement is nevertheless carried out, the information and system limits in chapters 8 and 7 in the disclaimer must be observed. The same applies to the replacement of other components of the system.

5 SECURITY NOTICE

For the adaptation of the measuring shaft, holes in the substructure are provided for fastening the bracket.

The test bench may only be operated with the cover included in the scope of delivery.

The user of the system must be aware of the dangers of electrical current and trained in the handling of electrical systems.

During operation, the motor shaft must be covered by the enclosed cover so that rotating parts are not directly accessible.

All components under the cover must be properly mounted and fixed. Before commissioning, remove all stickers and protective foils from the components.

The clamping surfaces between the motor shaft and the coupling must be degreased and the screws on the couplings must be tightened to a maximum of 10 Nm.

For the load side to provide a braking torque against the test side, the parameter „TRQ_LIM_C_Rotor_Speed_Limit_Allow_Regenerative_Braking" must be set to the value „1" on the load side.

The baud rate of the motor control is 500 kBaud/s. If this value is changed, the connection to the FRIWO Enable Tool is interrupted and the CAN interface must be initialised with the desired baud rate.

It is not intended to replace the motor on the load side. Should a replacement nevertheless take place, the information and system limits in chapters 8 and 7 must be observed.

Before using the FRIWO test stand for the first time, all steps of the Quick-Start-Guide must be followed.

If the motor is replaced, the data of the MO register must be updated before commissioning and a rotor offset calibration must be performed. The procedure is described in detail in chapter 11.

When changing the system speed, both the speed limit of the forward and reverse gear must be adjusted. So compliance with the limits can be ensured regardless of direction.

The values of the ERR parameters that have already been stored may only be changed if the user is aware of the physical relationships.

The torque constant of the motor to be tested shall be specified to as many decimal places as possible.

The current values of the test side must always be lower than the regenerative current values of the load side. A maximum of 85% of the released peak power of the load side is recommended.

The maximum possible torque is determined by the system boundaries in the APP register and is also dependent on environmental variables, such as temperature.

⚠ The charging current of the battery pack via an external laboratory power supply must be limited to a maximum of 12 A and a maximum charging voltage to 58.8 V.

⚠ No more than 20 parameters should be stored in the live view, as there may be delays in updating the parameters outside the live view. (Querying the parameters in the live view is preferred)

⚠ The maximum possible torque is determined by the system boundaries in the APP register and depends on environmental variables such as temperature.

⚠ There is no reverse polarity protection on the motor controller. Only phases L1, L2, L3 can be swapped if a rotor offset calibration is subsequently performed.

⚠ The screw terminals of the motor control may be tightened with a maximum of 2 Nm.

⚠ No reverse polarity protection. The logic part of the controller is powered by an internal DCDC converter with 12V. This means that an additional power supply via the signal plug is not required.

⚠ An assembly of the motor must be carried out with the participation of two persons, one person fixes the motor, the other person tightens the screws from the opposite side.

⚠ To adapt another permanent-magnet synchronous motor, the system limits defined in chapter 7 must be adhered to.

⚠ In the attachment there is a drawing for an adapter plate, which already has the appropriate threaded hole dimensions for mounting on the test bench.

⚠ To mount a new motor, the adapter plates must be extended with threaded holes. The dimensions must be found in the data sheet of the motor.

⚠ The threads in the adapter plate must be fixed with screw locking varnish and tightened with the torque specified by the manufacturer.

⚠ Before performing the rotor offset calibration, it must be checked whether the motor shaft can rotate freely. The sensors and supply voltage on the motor must also be connected. (Set phase current to ~20 amps)

6 MECHANICAL DESIGN OF THE TEST BENCH

The test bench is available in two versions, with and without external torque measuring shaft. For adaptation between the motors, as well as the adaptation of the measuring shaft, jaw couplings are used.

6.1 MECHANICAL DESIGN OF THE TEST BENCH WITHOUT MEASURING SHAFT

⚠ Clamping surfaces between motor shaft and clutch must be degreased and the screw on the couplings tightened with 10 Nm.

⚠ It is not intended that the motor installed on the load side is replaced by another. If this exchange nevertheless takes place, attention must be paid to the information in the disclaimer and to the system boundaries.

⚠ A detailed description of the procedure for replacing the test motor can be found in chapter 11.

⚠ For the adaptation of the measuring shaft, holes in the substructure are provided for fastening the bracket.

⚠ The test bench may only be operated with the cover included in the scope of delivery.

When operating the test bench without an external torque measuring shaft, the torque of the motor is estimated by the motor control. The following simplifications apply to this assessment:

- neglection of magnetic losses due to hysteresis and saturation
- neglect of magnetic and mechanical losses due to friction
- neglect of electrical losses due to ohmic resistance, as well as electrical losses due to inverter circuits

The estimate also assumes an ideal permanent magnet synchronous machine with surface mounted magnets (PMSM) without reluctance torque, i.e. $L_d = L_q$. Consequently, the mechanical torque is calculated based on the actual i_q current value.

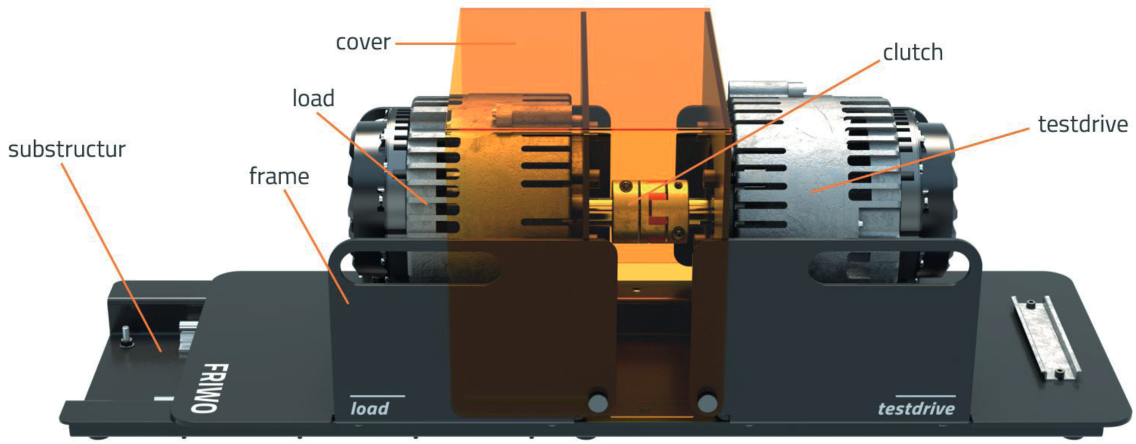


Figure 1: FRIWO test bench without torque measuring shaft

In the basic configuration, the test bench consists of the five assemblies shown in Figure 1, which are explained in Table 1 below.

Table 1: Mechanical design of the FRIWO test bench without torque measuring shaft

Assembly	Description
frame	All assemblies of the test bench are held in position via the frame. The load side is axially movable via the lower guide rails, allowing both parts to be separated from each other.
cover	To protect against rotating parts, there is a cover consisting of plexiglas over the space between the test side and the load side. This is attached to the frame via four knurled screws. **Note:** The test bench may only be operated with cover.
clutch	Under the cover is the claw clutch, which connects the two motor shafts. This is connected to the respective motor shafts via a clamp connection. **Note:** Clamping surfaces between motor shaft and clutch must be degreased and the screw on the couplings tightened with 10 Nm.
load	The load side, consisting of the motor control and the motor, is firmly connected to the frame via four screws and applies the counter-torque to the motor of the test side. **Note:** It is not intended that the load of the test bench will be replaced by another motor. Should this exchange nevertheless take place, attention must be paid to the information and system boundaries stored in the disclaimer in chapters 5 and 6.
testdrive	The test side consists of the same components as the load side and is also firmly connected to the frame via four screws. By loosening these four screws, the load can be detached from the test side and moved backwards on rails. **Note:** A detailed description of the procedure for replacing the test motor can be found in chapter 11.
substructure	The substructure connects the respective brackets of the test and load side with each other. **Note:** For the adaptation of the measuring shaft, holes are provided for attaching the bracket.

6.2 MECHANICAL DESIGN OF THE TEST BENCH WITH MEASURING SHAFT

⚠ Clamping surfaces between motor shaft and clutch must be degreased and the screw on the couplings tightened with 10 Nm.

⚠ It is not intended that the motor installed on the load side is replaced by another one. If this exchange nevertheless takes place, attention must be paid to the information in the disclaimer and system boundaries.

⚠ A detailed description of the procedure for replacing thetest motor can be found in chapter 11.

⚠ For the adaptation of the measuring shaft, holes in the substructure are provided for fastening the bracket.

⚠ The test bench may only be operated with cover.

If the test bench is operated using a measuring shaft as shown in Figure 2, the torque can be determined with high precision between the load side and the test side.

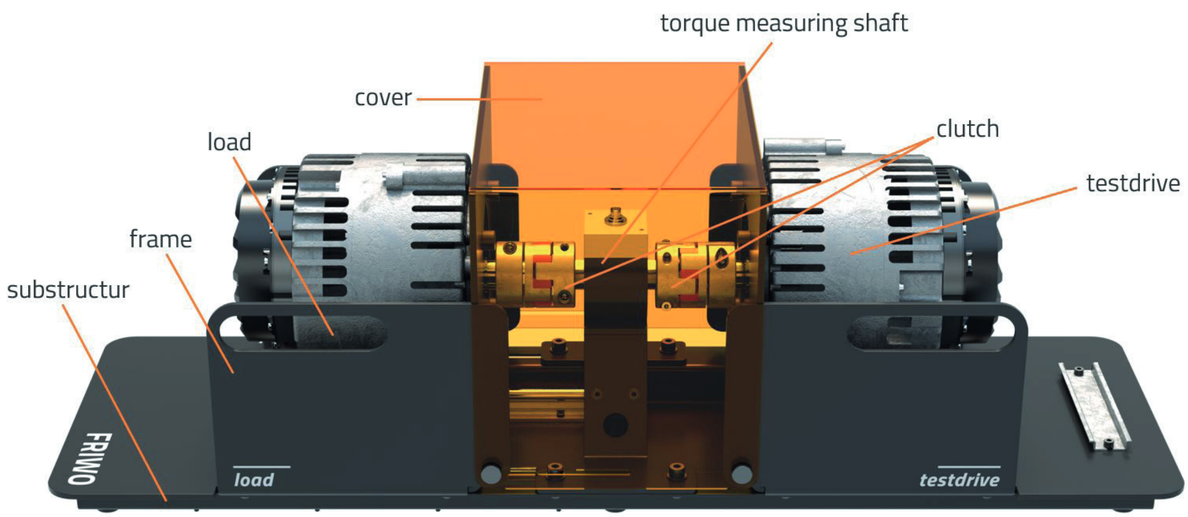


Figure 2: FRIWO test bench with torque measuring shaft

In this version, the test bench consists of six assemblies, which are explained in Table 2 below.

Table 2: Mechanical design of the FRIWO test bench with torque measuring shaft

Assembly	Description
frame	All assemblies of the test bench are held in position via the frame. The load side is axially movable via the lower guide rails, allowing both parts to be separated from each other.
cover	To protect against rotating parts, there is a cover consisting of plexiglas over the space between the test side and the load side. This is attached to the frame via four knurled screws. **Note:** The test bench may only be operated with cover.
torque measuring shaft	The measuring shaft is attached to the frame of the test bench with the help of a superstructure and four screws. The scope of delivery also includes two jaw couplings to adapt the measuring shaft to the two motor shafts. **Note:** The clamping surfaces between the measuring shaft and the coupling must be degreased and the screw on the couplings tightened with 10 Nm.
clutch	Under the cover is the claw clutch, which connects the two motor shafts. This is connected to the respective motor shafts via a clamp connection. **Note:** The clutch surfaces between the motor shaft and the clutch must be degreased and the screw on the couplings tightened with 10 Nm.
load	The load side, consisting of the motor control and the motor, is firmly connected to the frame via four screws and applies the counter-torque to the motor of the test side. **Note:** It is not intended that the load of the test bench will be replaced by another motor. Should this exchange nevertheless take place, attention must be paid to the information and system boundaries stored in the disclaimer in chapters 5 and 6.
testdrive	The test side consists of the same components as the load side and is also firmly connected to the frame via four screws. By loosening these four screws, the load can be detached from the test side and moved backwards on rails. **Note:** A detailed description of the procedure for replacing the test motor can be found in chapter 11.
substructure	The substructure connects the respective brackets of the measuring shaft, as well as the test side and the load side with each other. **Note:** For the adaptation of the measuring shaft, holes are provided for attaching the bracket.

7 GENERAL RULES AND SYSTEM BOUNDARIES

The system boundaries listed in this chapter are defined according to the load-side installed components, consisting of electric motor ME1117 and motor control MC6000. FRIWO Gerätebau GmbH therefore expressly points out to the user that an exchange of the components installed on the load side is not intended. Should the components nevertheless be replaced, FRIWO Gerätebau GmbH shall not be liable for any personal injury and/or damage to the system (see chapter 8 Disclaimer).

The following limit values generally apply to the complete system delivered by FRIWO Gerätebau GmbH (derived from the regenerative operation of the load side):

Maximum DC connection voltage	60 V
Maximum mechanical motor speed	5000 1/min
Maximum mechanical torque	38 Nm
Maximum mechanical peak performance	8.1 kW @ UDC = 48 V
Maximum regenerative DC peak power	6 kW @ UDC = 48 V
Maximum motorized DC peak power	10.8 kW @ 48 V
DC/AC cable cross section	10 mm²

If the drive system of the test side is replaced by other components at the customer's request and supplied by a separate constant voltage source, the following mechanical limits must be complied with for the test side:

Maximum mechanical motor speed	5000 1/min
Maximum mechanical torque	38 Nm
Maximum mechanical peak performance	6.8 kW

In principle, the mechanical peak power of the test side should be limited to a maximum of 85% of the released peak power of the load side in regenerative operation. This ensures that the load side can always adjust the default speed without reducing power output due to overtemperature. When the power reduction (derating) on the load side takes place, it could lead to overspeed or an instability of the system. A software-based speed limitation of the test side is recommended in order to avoid system damage in the event of a fault.

8 DISCLAIMER

The FRIWO Gerätebau GmbH assumes no liability in particular for the improper use of the motor test bench or non-observance of the safety instructions in points 5 and 7 of this manual, the replacement or modification of the load side to a third-party load unit, the replacement or modification of the MCU (Motor Control Unit) to a third-party MCU. FRIWO Gerätebau GmbH is liable exclusively according to the Product Liability Act, in case of intent, gross negligence of owners, legal representatives or executives, in case of malice, in case of non-compliance with an assumed guarantee, due to culpable injury to life/limb or health or due to culpable violation of essential contractual obligations. However, the claim for damages for the breach of essential contractual obligations is limited to the contractually typical, foreseeable damage, unless another of the aforementioned cases exists.

9 PREREQUISITES FOR COMMISSIONING

The availability of an external voltage source is a fundamental prerequisite for the operation of the test bench. This can be ensured in the form of a battery or a bidirectional constant voltage source. Both possible connection types are discussed in more detail in chapter 9.1.

The control and parameterization of the motor controls of the test bench is mainly carried out via the desktop application FRIWO Enable Tool Application. The application must already be installed and licensed on the user's PC, see Figure 3. The link to purchase a FRIWO Enable Tool Application license and to download the installation file can be found in chapter 12 Cross-references.

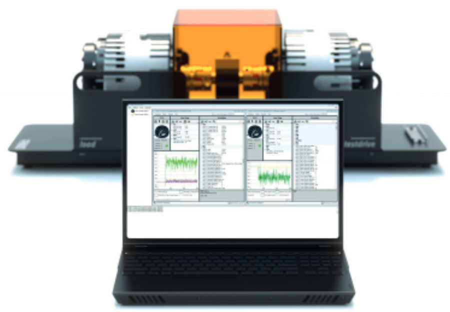


Figure 3: FRIWO Enable Tool in conjunction with the FRIWO motor test bench

To configure the test bench, a basic knowledge in handling of the FRIWO Enable Tool desktop application is recommended. For a detailed description of the functionality of this tool, please refer to the operating manual of the FRIWO Enable Tool Application. The link to this can also be found in chapter 12 Cross-references.

The basic functionality of the FRIWO Enable Tool Application is briefly described in subchapter 9.2 below.

9.1 POWER SUPPLY OF THE TEST BENCH

⚠ Care must be taken to ensure that the regenerative energy of the load side is fed back in the form of an electronic load or a bidirectional power supply.

⚠ The charging current of the battery pack via an external laboratory power supply must be limited to a maximum of 12 A and a maximum charging voltage to 58.8 V.

For the operation of the test bench, two topologies for power supply are recommended as standard. This includes both the supply by a bidirectional constant voltage source and the supply by a 48 V FRIWO battery pack.

The procedure for setting up the respective topologies is described in more detail in the following subchapters.

9.1.1 POWER SUPPLY VIA BIDIRECTIONAL CONSTANT VOLTAGE SOURCE

To connect the bidirectional constant voltage source to the test bench, the positive and negative terminals must be connected to the motor test bench via a 6AWG Anderson connector (item number: 6331G5) (see Figure 4). The cross-section of the supply lines used should be 10 mm² each.

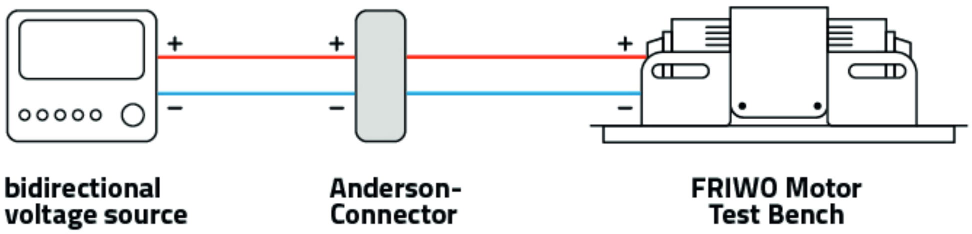


Figure 4: Principle of the test bench connected via an Anderson two-pin connector to a bidirectional power supply

The power supply is then set to a desired constant voltage between 48 V- 58 V. Care must be taken to ensure that the corresponding performance limits and operating instructions of the bidirectional power supply unit used are complied with.

Alternatively, it is possible to integrate a unidirectional voltage source and an electronic load in constant voltage mode. The electronic connection is also made via 6AWG power connector, with a maximum cross-section of 10mm² (article number: 6331G5).

It must be considered that the voltage limit of the sink is set about 0.5 - 1 V higher than the selected constant voltage value of the source. The circuit diagram shown in Figure 5 is for orientation.

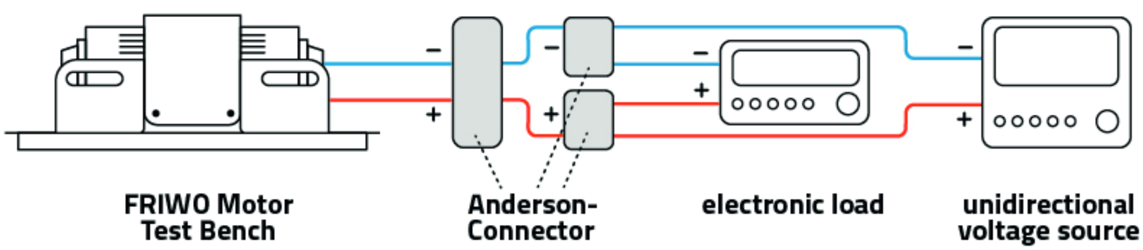


Figure 5: Principle of the test bench connected via Anderson two-pin connectors to an unidirectional voltage source with a separate electronic load

⚠ Care must be taken to ensure that the regenerative energy of the load side is fed back in the form of an electronic load or a bidirectional power supply.

9.1.2 POWER SUPPLY VIA FRIWO BATTERY-PACK

⚠ The charging current of the battery pack via an external laboratory power supply must be limited to a maximum of 12 A and a maximum charging voltage to 58.8 V.

If the supply of the test bench is selected by means of a FRIWO battery pack, the behavior of the complete electric drive system can be analyzed for a target application.

Before commissioning, the operating instructions of the FRIWO Battery Pack should be reviewed .

Brief overview of the most important electrical limits of the FRIWO Battery-Pack:

rated voltage: 50.4V	rated capacity: 40.2 Ah
rated energy: 2026 Wh	max. charging current: 20 A
recommended charging current: 12A	min. charging current: 1 A
charging voltage: 58.8 V	end of discharge voltage: 42 V

Note: To adapt the pack with the test bench, the user has the possibility to buy an adaption lead, which already has the appropriate plugs for connection to the test bench.

Activation of the FRIWO Battery-Pack:

In the first step, the Battery-Pack is connected to the test bench via the supplied cable. It has two toggle switches for the signals „BatEnable“ and „ChargeSense“. To activate the power section of the pack, the „ChargeSense“ switch must be turned on, see Figure 6.

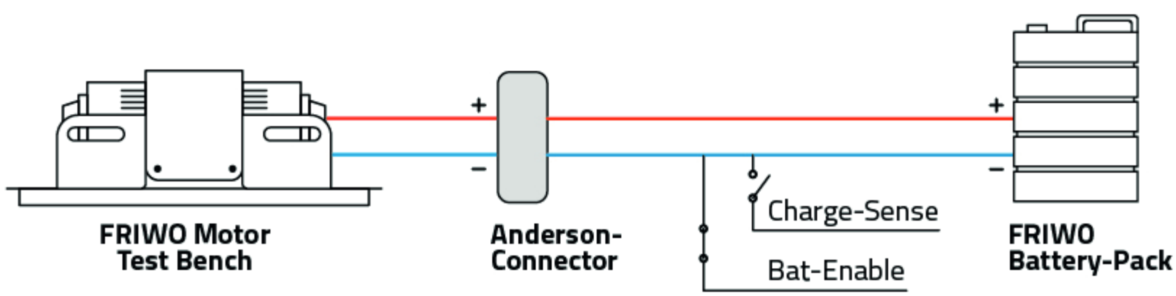


Figure 6: Schematic of the FRIWO Battery-Pack with the FRIWO test bench

Charging the FRIWO Battery-Pack:

An operation of the test bench at rated power is possible with a fully charged Battery-Pack for approx five hours. For optimal charging of the battery pack, the use of the LEV 500 charger is recommended.

Alternatively, it is possible to charge the battery pack with the help of the enclosed cable via a laboratory power supply. To do this, turn off the "BatEnable" signal switch and turn on the "ChargeSense" switch, as shown in Figure 7.

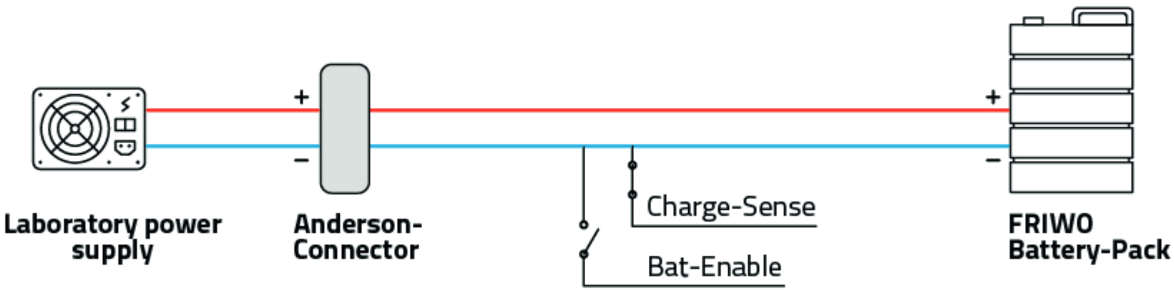


Figure 7: Charging the FRIWO battery pack via a unidirectional voltage source

The charging current of the battery pack via an external laboratory power supply must be limited to a maximum of 12 A and a maximum charging voltage to 58.8 V.

9.2 BRIEF DESCRIPTION OF THE FRIWO ENABLE TOOL

Figure 8 shows the home screen of the FRIWO Enable Tool, which explains the main functions of the program in numbers.

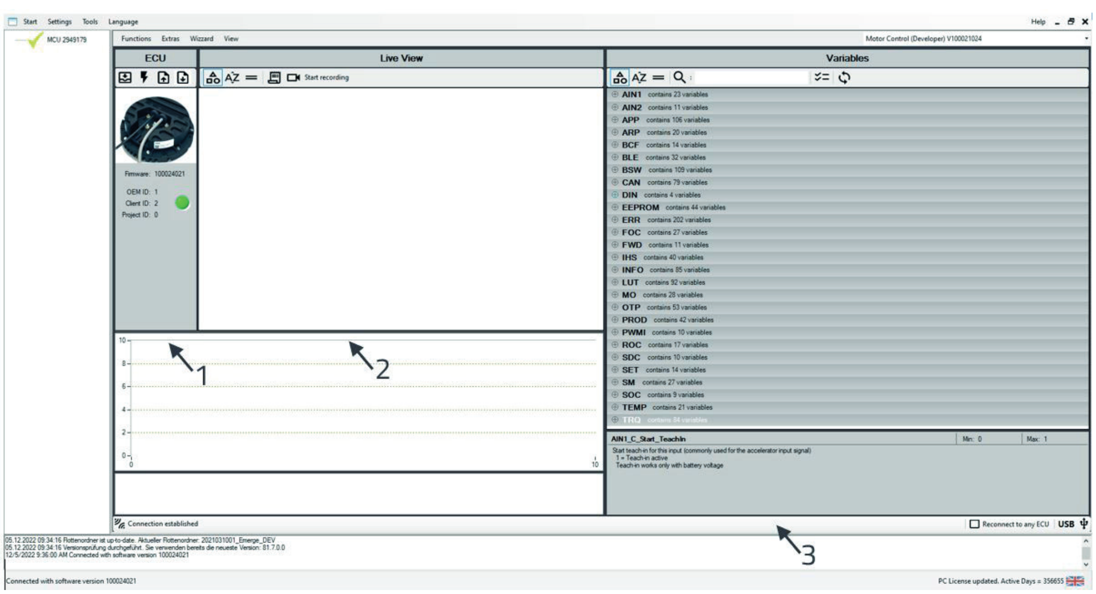


Figure 8: Start page of the FRIWO Enable Tool

1. ECU: This section contains a standard image of the connected ECU as well as information about the firmware version and licensing.

2. Live View: Individual variables can be dragged into the Live View area by double-clicking in the Variables area to query them in real time. The time values of the variables in the live view are also displayed in a scope.

3. Variables: This area lists all variables available for parameterizing the ECU firmware. The variables are arranged according to registers, which map the software modules of the firmware and provide a better overview.

The functions of the buttons and the light of the ECU area are described in more detail in the detailed view in Figure 9.

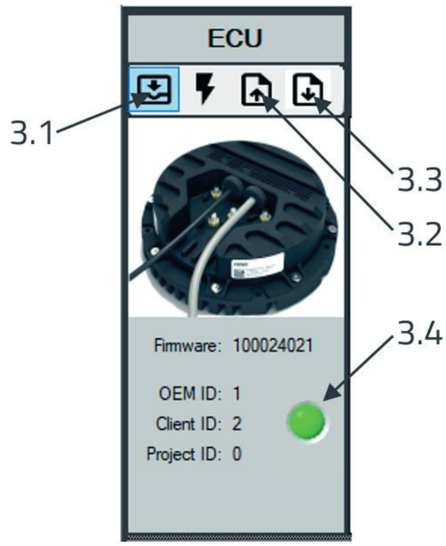


Figure 9: Detail view ECU window

3.1 Save-on-ECU: The Save-on-ECU button loads the settings made on the laptop to thecontrol unit. By pressing this button, the parameter settings made in the Enable Tool are permanently stored on the ECU. If this is not done, the unsaved changes to calibration parameters are reset during a system reboot.

3.2 Create-a-Snapshot: To create a backup of the data record active in the ECU, press the Create-a-Snapshot button. All settings of calibration parameters are saved as a *.p file at a storage location to be selected. This file is an image of the active ECU record and is called a snapshot.

3.3 Write-Snapshot-to-ECU: The „Write-Snapshot-to-ECU" button is pressed to select the button described in sub-item 3.2 snapshot and load it into the non-volatile memory of the ECU. The snapshot is permanently stored as a record on the ECU and is also available during a system restart with disconnection of the supply voltage.

3.4 Signal lamp: The signal lamp shows the current connection status to the connected ECU. If no ECU is connected or cannot be connected to the ECU, the signal color is gray. When connected to the ECU, the lamp lights up green.

9.3 ESTABLISHING CONNECTION BETWEEN TEST BENCH AND FRIWO ENABLE TOOL

The baud rate of the motor control is 500 kbaud/s. If this value is changed, the connection to the FRIWO Enable Tool Application is terminated and the CAN interface must be initialized with the desired baud rate.

Make sure that all necessary device drivers are installed on the user's PC.

By default, the USB interface is always preconfigured for the FRIWO Enable Tool Application and does not have to be initialized separately.

In order to enable control and parameterization of the test bench via the FRIWO Enable Tool, an active connection via USB or from the user PC to the motor control is necessary.

For communication via the USB interface, a USB 2.0 cable (male/male) must be used.

The connection can be made either individually, i.e. with one of the controls on the load or test side, or simultaneously with both motor controllers. No external power supply to the motor controller is required for communication via USB.

Establishing a connection via USB:

1. Connect the motor controller to the user's PC via the USB cable.
2. Then search for the motor controller by clicking the scan button or using the Short-cut: CTRL+S, see Figure 10.

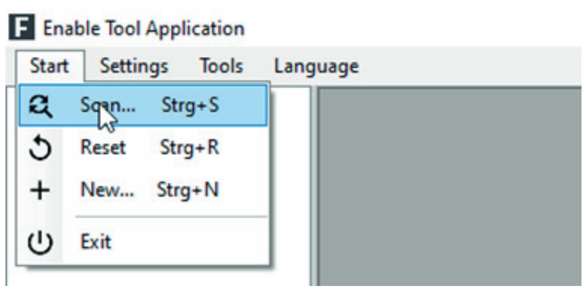


Figure 10: Diagram Connection setup to motor control via USB

3. The parameterization window of the connected motor control system opens which can be found in chapter 9.2 is explained.

Note: The USB interface is always preconfigured by default for the FRIWO Enable Tool and does not have to be initialized separately.

Establishing a connection via CAN:

Optionally, communication between FRIWO Enable Tool and the Motor-Control-Unit is also possible via a USB-to-CAN converter.

For error-free communication via CAN, the following prerequisites apply:

- Use of one of the supported USB-to-CAN converters: PEAK PCAN-USB Adapter or Vector VN1610
- Using a 120 Ω terminating resistor
- External power supply of the motor control of > 12 V

Note: Make sure that all necessary device drivers are installed on the user's PC.

1. Connect a motor controller via one of the above USB-to-CAN converter to the user's PC. An overview of the pin assignment of the motor control (i.e. CAN-High/-Low) can be found in chapter 12 in the corresponding delivery instruction.
2. Subsequently, the correct connection parameters must be set in the FRIWO Enable Tool. To do this, navigate to Settings > Connection Settings on the ribbon of the FRIWO Enable Tool Start window.
   An additional window opens as shown in Figure 11 with an area CAN connection/ PEAK adapter.

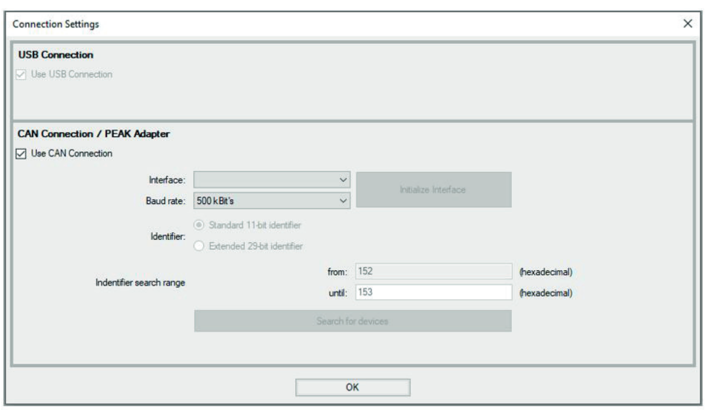


Figure 11: Connection Settings CAN Connection/ PEAK Adapter Window

3. Check „Connect via CAN" and select the connected USB-to-CAN device under „Interface".
4. Then select the baud rate of the communication and „baud rate" (i.e. 500 kbaud/s), as shown in Figure 6. The other setting parameters remain unchanged.

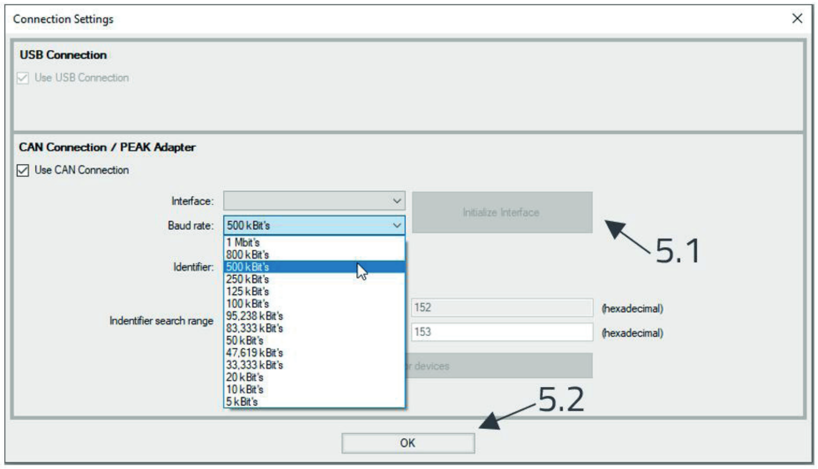


Figure 12: Select the baud rate diagram in the FRIWO Enable Tool

5. Then click on the button „Initialize interface“ (5.1) and „OK“ (5.2) marked in Figure 12. The interface to the USB-to-CAN converter is initialized and a connection to the connected motor controller can be established.
6. In the ribbon of the FRIWO Enable Tool, select Start > Scan... (short-cut: CTRL+S; see Figure 13) to establish a connection with a connected motor controller.

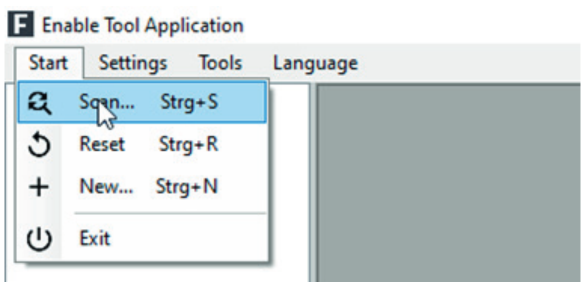


Figure 13: Diagram Establishing a connection with the connected ECU

7. The parameterization window of the connected motor controller opens which is explained in chapter 9.2.

⚠ The baud rate of the motor control is 500 kbaud/s. If this value is changed, the connection to the Enable Tool is terminated and the CAN interface must be initialized with the desired baud rate.

10 COMMISSIONING OF THE FRIWO TEST BENCH

All the requirements of chapter 9 should be fulfilled before the system is put into operation. In addition, check all mechanical components for a tight fit and the fixation of the cover. At best, the test bench should already have been commissioned for the first time using the Quick Start Guide.

10.1 LOAD SIDE

In principle, the load side of the test bench should be configured first, as this acts as speed control and thus ensures the stability of the overall system. The motor and the motor controller of the load side are in regenerative operation.

The following chapters explain the procedure for connecting via USB and CAN.

10.1.1 CALIBRATION VIA USB AND FRIWO ENABLE TOOL

⚠ No more than 20 parameters should be stored in the live view, as there may be delays in updating the parameters outside the live view. (Querying the parameters in the live view is preferred)

⚠ When changing the system speed, both the speed limit of the forward and reverse gear must be adjusted. In this way, compliance with the limits can be ensured regardless of the direction of rotation.

⚠ There is no provision for replacing the motor on the load side. If an exchange takes place, attention must be paid to the information and system boundaries stored in the disclaimer in chapters 8 and 7.

⚠ The values of the ERR parameters that have already been stored may only be changed if the user is aware of the physical relationships.

⚠ In order for the load side to set a braking torque against the test side,the parameter „TRQ_LIM_C_Rotor_Speed_Limit_Allow_Regenerative_Braking" on the load side must be set to the value „1".

⚠ The current values of the test side must always be lower than the regenerative current values of the load side. A maximum of 85% of the released peak power of the load side is recommended.

In the first step, a USB connection to the motor controller must be established in order to set the corresponding parameters. In default mode, the motor control always starts in ride mode 2 (ride mode 2). The initial calibration for commissioning is initially carried out only for this driving mode. For calibration of the other driving modes, please refer to the Enable Tool Application Manual.

Establishing a connection via USB:

1. Connect the motor controller to the user's PC via the USB cable.
2. Search for the motor controller by clicking the scan button or using short-cut: CTRL+S, see Figure 14.

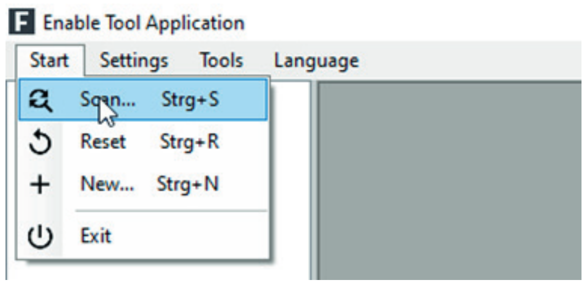


Figure 14: Diagram Connection setup to motor control via USB

3. The parameterization window of the connected motor controller opens which is explained in chapter 8.1.

At the beginning of the test, it is recommended to drag the most important parameters into an online view and save them as a *.ovp file.

Create an online view:

1. Drag the desired variables into the live view by double-clicking with the left mouse button, as shown in Figure 15.

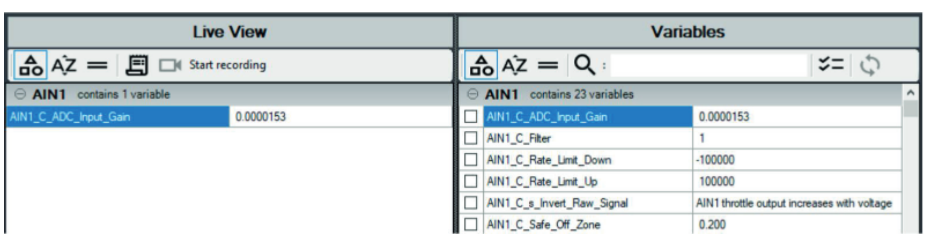


Figure 15: Diagram for dragging the parameters into the live view

2. The parameters stored in the Live View window can be saved as a *.ovp file. To do this, go to the View tab > „Save view settings". By clicking on the „Load View Settings" button shown in Figure 16, you can load the *.ovp file you created into the FRIWO Enable Tool.

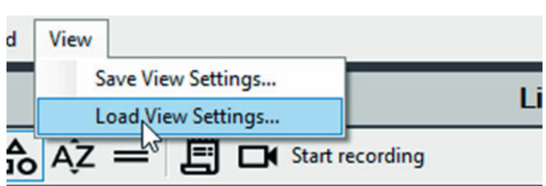


Figure 16: Load/Save View Settings Diagram

⚠ No more than 20 parameters should be stored in the live view, as there may be delays in updating the parameters outside the live view. (Querying the parameters in the live view is preferred)

For this reason, it is advisable to mark the desired parameters for a better overview and to display them in a reduced view.

Marking important parameters:

1. Select the desired parameter and check the box to the left of the parameter, see Figure 17.

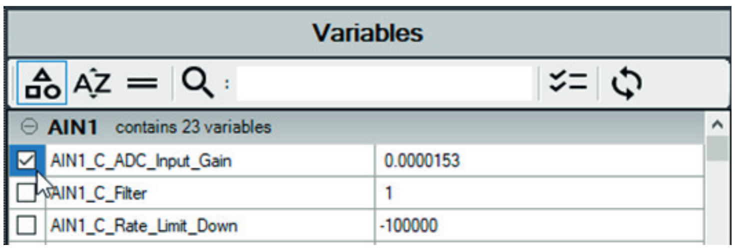


Figure 17: Figure marking important parameters

2. The selected parameters can be shown by clicking on the symbol shown in Figure 18.

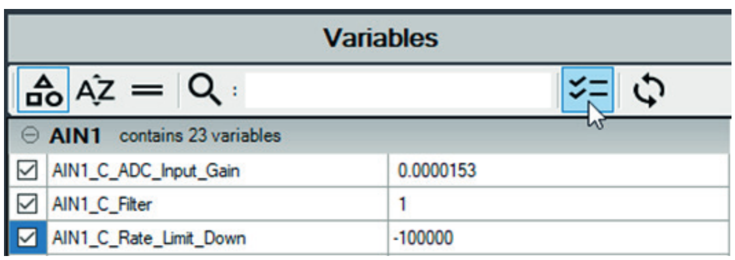


Figure 18: Diagram showing marked parameters

APP-Register:

The system boundaries are defined in the application register. It is important because the parameters correspond to the maximum values of the motor and voltage source data sheets. Since the load side works in regenerative mode, it is important to pay specific attention to the regenerative values and to the fact that some of the values must be entered negatively. For a more detailed list of APP parameters, please refer to the FRIWO Enable Tool Application Manual.

Table 3: List of parameters for defining the system boundaries on the load side

Parameters for defining system boundaries		
Parameter Name	**Function**	**Range**
APP_C_Ride_Mode_2_Max_Regenerativ_DC_Current	Maximum battery current when accelerating the motor (direct current) **Note:** The current values of the test side must always be lower than the regenerative current values of the load side. This is the only way to ensure speed control on the load side.	0...500 Ampere [A (DC)]
APP_C_Ride_Mode_2_Max_Regenerativ_Motor_Current	Maximum motor current when accelerating the motor (alternating current) **Note:** The current values of the test side must always be lower than the regenerative current values of the load side. This is the only way to ensure speed control on the load side.	0... 500 amps [A (AC)]
APP_C_Ride_Mode_2_Speed_Limit_Reverse	Maximum speed of the motor shaft in reverse. **Note:** The system is regulated to this speed when turning backwards.	0..2400 [1/s]
APP_C_Ride_Mode_2_Speed_Limit	Maximum speed of the motor shaft. **Note:** The system is controlled at this speed.	0..2400 [1/s]

⚠ When changing the system speed, both the speed limit of the forward and reverse gear must be adjusted. In this way, compliance with the limits can be ensured regardless of the direction of rotation.

⚠ The current values of the test side must always be lower than the regenerative current values of the load side. A maximum of 85% of the released peak power of the load side is recommended.

Table 4.: Continuation of the parameters for defining the system boundaries on the load side

Parameters for defining system boundaries		
Parameter Name	**Function**	**Range**
APP_C_Ride_Mode_2_Brake_Signal_Channel	Selection of the input signal to be used as the input for the torque. For control via CAN software, the value must be set to 4. For control via USB, the value must be set to 6.	0...7 [-]
APP_C_Ride_Mode_2_Reverse_Gear_Signal_Channel	Selection of the input signal to be used as the input for the torque. 0 = nothing selected; 1 = AIN1; 2 = AIN2; 3 = PWM@DIN2; 4 = CAN bus; 5 = USB	0...5 [-]

MO-Register:

The electromechanical parameters of the motor and the motor sensors are entered in the Motor-(MO)-Register. Correct calibration is a prerequisite for error-free operation of the drive system. It should be noted thatfor a fine calibration of the control behavior, the electrical motor parameters are necessary. The procedure for this is described in the FRIWO Enable Tool Application Manual.

Note: The data of the motor installed on the load side are already stored in the delivery of the FRIWO test bench.

⚠ There is no provision for replacing the motor on the load side. If an exchange takes place, attention must be paid to the information and system boundaries stored in the disclaimer in chapters 8 and 7.

Table 5: List of motor parameters on the load side

Motor parameters of the test side		
Parameter Name	**Function**	**Range**
MO_C_Polepairs	Number of pole pairs in the motor	1..127 [-]
MO_C_Temperature_Sensor_Type	Selection of position sensors in the motor 0= Hall sensors 1= Resolver	0..1 [-]
MO_C_Nm_per_Ampere	Motor-torque constant **Note:** Make sure that you store as many decimal places of the torque constant as possible. Based on this, the mechanical torque is calculated in the software.	0,001...100 [nm/a]
MO_C_Rotor_Position_Sensor_Type	Selection of motor temperature sensor types 0 = no sensor type selected 1 = KTY84/130 2 = B57550G0104 3 = AT130 4 = PT1000 5 = PT100	0..5 [-]

INFO-Register:

In the Information-(INFO)-Register, the relevant electrical quantities can be found as filtered signals. These are pure measured values that are determined by the software.

Note: These values in the INFO-Register can be used to perform a target/actual comparison with the values of the APP-Register. The calculated mechanical torque is based on simplifications, which are explained in chapter 6.1. The exact mechanical torque can only be determined with the optional torque measuring shaft. Based on the values in the INFO-Register, a target/actual comparison can be carried out with the values of the APP Register.

Table 6: List of information parameters on the load side

Parameters of the information register		
Parameter Name	**Function**	**Range**
INFO_DC_Current	Adjacent battery current	-1000... 1000 Ampere [A (DC)]
INFO_Motor_Current	Motor current (vectorial quantity of Iq and Id)	-1000... 1000 Ampere [A (AC)]
INFO_Motor_Current_Id	Motor current on the field weakening axis / field weakening current **Note:** Is provided when the motor is operated above the rated speed	-1000...1000 Ampere [A (AC)]
INFO_Motor_Current_Iq	Motor current on the torque axis/ active current **Note:** Is provided the main influencing variable for the torque of the rotor	-1000...1000 Ampere [A (AC)]
INFO_Power_El	Electrical energy of the system	-32.000... 32,000 [W]
INFO_Rotor_Speed	Mechanical rotor speed	-2400... 2400 [1/s]
INFO_Torque_Mech	Mechanical motor torque based on motor current Iq and torque constant	-1000... 1000 [nm]

ERR-Register:

The absolute system boundaries are defined in the error (ERR) register. If one of these limits is exceeded, the motor controller switches to the active short circuit within a few milliseconds to avoid destruction of the system. An active error is displayed as Error-Code, whereby the error history can also be read. The power section of the motor control can only be started again when the fault has been eliminated. A detailed explanation of the error messages can be found in the Application Manual of the FRIWO Enable Tool.

⚠ The values of the ERR parameters that have already been stored may be changed if the user is aware of the physical relationships.

Table 7: List of error parameters on the load side

Error register parameters		
Parameter Name	**Function**	**Range**
ERR_Errorcode	Message of the Enable Tool about the errors in the system, which are di-splayed via an error code. **Note:** Will be displayed as continuous text in Live View	1..4294967295 [-]
ERR_C_Rotor_Speed_Limit	Maximum mechanical motor speed **Note:** If this speed is exceeded, the system will be stopped	0... 2400 [1/s]
ERR_C_Temp_Motor_Max	Maximum motor temperature **Note:** If this temperature is exceeded, the system will be stopped.	-50... 500 [°C]
ERR_MEM_Trace_X_Errorcode	These parameters can be used to query the last nine error codes of the MCU. In this way, an error can be verified without it still being on the MCU. **Note:** The „X" can have the value 0 to 8 and represents a numeric list of the last nine error codes.	0... 4000000000 [-]
ERR_MEM_Trace_X_ODO	This parameter shows the respective mileage for the last nine error codes. **Note:** The „X" can have the value 0 to 8 and represents a numeric list of the last nine error codes.	0... 4000000000 [-]

TRQ Register:

Via the Torque-(TRQ)-Register, the initial calibration of the target torque as well as the direction of rotation is specified via internal software parameters. The processing of the specified target torque including the direction of rotation takes place within the motor control software in the sequence

- coordination of the target torque (TRQ_DES),
- limitation of the target torque (TRQ_LIM),
- conversion of the desired torque into current setpoints (TRQ_STR).

Note: The maximum possible torque is determined by the system boundaries in the APP register and is also dependent on environmental variables such as temperature.

In order for the load side to set a braking torque against the test side, the parameter „TRQ_LIM_C_Rotor_Speed_Limit_Allow_Regenerative_Braking“ on the load side must be set to the value „1“.

Table 8: List of torque parameters on the load side

Torque register parameters		
Parameter Name	**Function**	**Range**
TRQ_DES_C_Test_Reverse_Gear	Manual reverse gear selection via USB 0 = forward gear; 1= reverse gear **Note:** The channel for the reverse gear signal in the APP-Register must be set to USB.	0... 1 [-]
TRQ_DES_C_Test_Torque_Request	The percentage torque of the test side is set above the optimum specification of the target torque. If this value is set to 100%, the motor control system tries to set a constant 100% of the maximum possible torque. **Note:** The channel for the torque signal in the APP-Register must be set to USB.	0... 100 [%]
TRQ_STR_Id_Setpoint	Field weakest from setpoint for the current controller **Note:** Used to match the Id current in the INFO-Register.	-1000... 1000 [A(AC)]
TRQ_STR_Iq_Setpoint	Active current setpoint for the current controller. **Note:** Used to balance the Iq current in the INFO-Register.	-1000... 1000 [A(AC)]
TRQ_LIM_C_Rotor_Speed_Limit_ Allow_Regenerative_Braking	This parameter sets the rotor speed controller to be controlled by regenerative braking against the speed of the test side. **Note:** To run the load side against the test side, this parameter must be set to „1“. 0= not allow counterbraking 1= allow counterbraking	0... 1 [-]

10.1.2 CALIBRATION VIA CAN THIRD-PARTY SOFTWARE

In order to realize cyclic tests and load curves on the test bench, it must be controlled via CAN software. In this case, a connection to the motor controller using FRIWO Enable Tool via CAN (default baud-rate: 500 kbaud/s) should be established first, in order to configure the CAN interface properly. Many parameters of the test side are also relevant for those of the load side, but the formulation is adapted to the respective side.

Note: For a description of the connection setup of the motor control via CAN, please read chapter 9.3.

Table 9: Control via CAN (load side)

Control via CAN		
Parameter Name	**Function**	**Range**
APP_C_Activation_Mode	The parameter must be set to „1". The appropriate signal for the "CAN_EXT_State_Request" is then sent in the DBC file via the software. 1 = Activation of torque control via "CAN_EXT_State_Request"	0... 5 [-]
CAN_C_Baudrate_Select	In this parameter, the baud rate must be set so that the CAN software and the motor controller communicate at the same baud rate. You can choose from: 1= 125kb/s, 2= 500kb/s, 3= 1000kb/s	1... 3 [-]

After completing these adjustments, go to the menu of your CAN software and implement the DBC file of the test bench.

The most important tab in the DBC messages is that of the EXT_Torque_Control_01 (0x111), with Table 10 presenting the most important messages of the test side. All other parameters and their function are described in the comments of the DBC file.

Table 10: The most important DBC messages of the load side

EXT_Torque_Control_01(0x111)		
Parameter Name	**Function**	**Range**
MC_Torque_Request	This message is used to send the relative torque provided by the motor controller. (Simulates the gas tap)	0... 100 [%]
MC_Ridemode	This parameter can be used to change the driving mode. This should be in the driving mode in which you have adjusted the corresponding parameters. Interms of standards, this is „2".	0... 3 [-]
MC_State_Request	This parameter sets the "CAN_EXT_State_Request" from „0" to „1". This activa-tes the control via CAN on the test bench.	0... 1 [-]

Depending on the application software for CAN communication (e.g. Vector CanAlyzer etc.), additional signal generators can be implemented, which cyclically send new values for the speed or torque requirement to the motor controller.

10.2 TEST SIDE

Only after completion of the parameterization of the load side, the test side should be parameterized. The test side operates in motorized mode and is operated as a torque-controlled system, with the simplifications specified in chapter 6.1 applying. The required target torque can be communicated to the motor control via different input channels.

In the following subchapters, the procedure for the connection via USB and CAN is explained. All parameters of the test side are also relevant for those of the load side, the formulation is adapted to the respective side.

Note: The motor connected on the test side can be replaced by any permanent-magnet synchronous machine. (the proceeding is described in chapter 12 described in detail, pay attention to the system boundaries stored in chapter 7)

10.2.1 CALIBRATION VIA USB AND FRIWO ENABLE TOOL

⚠ Not more than 20 parameters should be stored in the live view, as there may be delays in updating the parameters outside the live view. (Querying the parameters in the live view is preferred)

⚠ The current values of the test side must always be lower than the regenerative current values of the load side. A maximum of 85% of the released peak power of the load side is recommended.

⚠ The values of the ERR parameters that have already been stored may be changed if the user is aware of the physical relationships.

⚠ The torque constant of the motor must be specified to as many decimal places as possible.

⚠ If the motor is replaced, the data of the MO-Register must be updated before commissioning and a rotor offset calibration must be performed. The procedure is described in detail in chapter 11.

⚠ The maximum possible torque is determined by the system boundaries in the APP-Register and also depends on environmental variables such as temperature.

In the first step, a USB connection to the motor controller must be established in order to set the corresponding parameters. In Default mode, the motor control always starts in ride mode 2. The initial calibration for commissioning is therefore initially carried out only for this driving mode. For calibration of the other driving modes, please refer to the FRIWO Enable Tool Application manual.

Establishing a connection via USB:

1. Connect the motor controller to the user's PC via the USB cable.
2. Search for the motor controller by clicking the scan button or using short-cut: CTRL+S, see Figure 19.

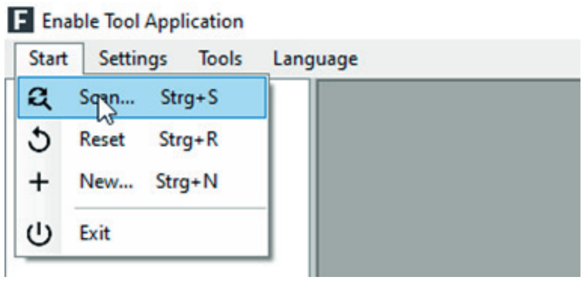


Figure 19: Diagram Connection setup to motor control via USB

3. The parameterization window of the connected motor controller opens which is explained in chapter 8.1.

At the beginning of the test, it is recommended to drag the most important parameters into a live view and call it *.ovp file.

Create an online view:

1. Drag the desired variables into the live view by double-clicking with the left mouse button as shown in Figure 20.

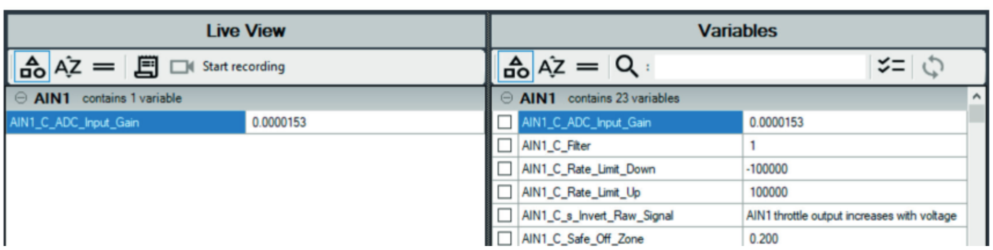


Figure 20: Diagram for dragging the parameters into the live view

2. The parameters stored in the Live View window can be defined as *.ovp file. To do this, go to the View tab > „Save view settings". By clicking on the „Load View Settings" button shown in Figure 21, you can select the *. Load the *.ovp file into the FRIWO Enable Tool.

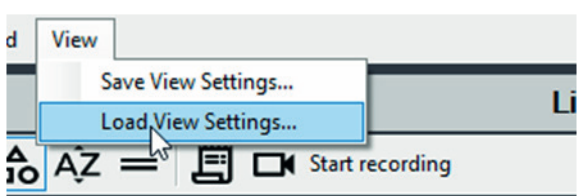


Figure 21: Load/Save View Settings Diagram

No more than 20 parameters should be stored in the live view, as there may be delays in updating the parameters outside the live view. (Querying the parameters in the live view is preferred)

For a better overview, it is recommended to mark the desired parameters and display them in a reduced view.

Marking important parameters:

1. Select the desired parameter and check the box to the left of the parameter, see Figure 22.

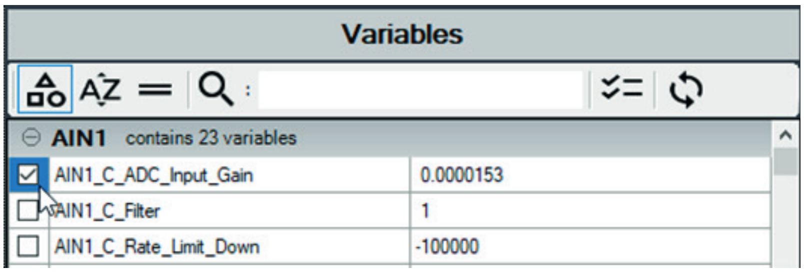


Figure 22: Graph marking important parameters

2. The selected parameters can be shown by clicking on the symbol shown in Figure 23.

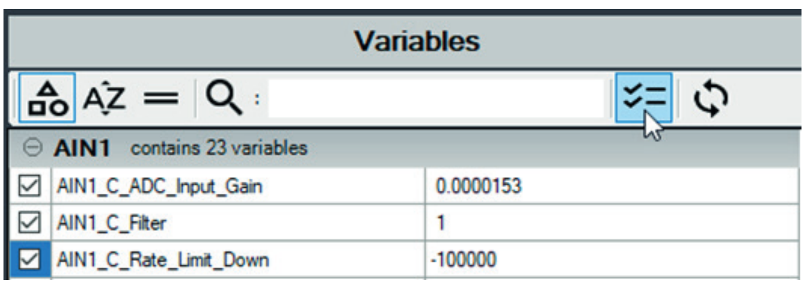


Figure 23: Diagram showing marked parameters

APP-Register:

The system boundaries are defined in the Application-(APP)-Register. It is important because the parameters correspond to the maximum values of the motor and voltage source data sheets. For a more detailed list of the APP parameters, we refer to the application manual of the Enable Tool.

When changing the system speed, both the speed limit of the forward and reverse gear must be adjusted. In this way, compliance with the limits can be ensured regardless of the direction of rotation.

The current values of the test side must always be lower than the regenerative current values of the load side. In this way, speed control on the load side is ensured.

Table 11: List of parameters used to define system boundaries on the test side

Parameters for defining system boundaries		
Parameter Name	**Function**	**Range**
APP_C_Activation_Mode	This command determines which parameter activates torque control. To control via the Enable Tool, the value must be set to 0. 0 = Manual activation of torque control via SET_C_PE_Mode_Request For control via CAN software, the value must be set to 1. 1 = Activation of torque control via CAN_EXT_State_Reqest	0... 5 [-]
APP_C_Ride_Mode_2_Max_DC_Current	Maximum battery current when accelerating the motor (direct current) **Note:** The current values of the test side must always be lower than the regenerative current values of the load side. This is the only way to ensure speed control on the load side.	0... 500 Ampere [A (DC)]
APP_C_Ride_Mode_2_Max_Motor_Current	Maximum motor current when accelerating the motor (alternating current) **Note:** The current values of the test side must always be lower than the regenerative current values of the load side. This is the only way to ensure speed control on the load side.	0... 500 Ampere [A (AC)]

Table 12: Continuation of parameters for defining system boundaries on the test side

Parameters for defining system boundaries		
Parameter Name	**Function**	**Range**
APP_C_Ride_Mode_2_Speed_Limit_Reverse	Maximum speed of the motor shaft in reverse **Note:** If the motor rotates backwards without load, the test side turns to the speed stored here.	0..2400 [1/s]
APP_C_Ride_Mode_2_Speed_Limit	Maximum speed of the motor shaft **Note:** If the motor rotates without load, the test side turns to the speed stored here	0..2400 [1/s]
APP_C_Ride_Mode_2_Throttle_Signal_Channel	Selection of the input signal to be used as the input for the torque. For control via USB, the value should be set to 5. 0 = nothing selected; 1 = AIN1; 2 = AIN2; 3 = PWM@DIN2; 4 = CAN bus; 5 = USB	0... 5 [-]
APP_C_Ride_Mode_2_Reverse_Gear_Signal_Channel	Selection of the input signal that is used as the input for the reverse gear. For control via USB, the value should be set to 5. 0 = nothing selected; 1 = AIN1; 2 = AIN2; 3 = PWM@DIN2; 4 = CAN bus; 5 = USB	0... 5 [-]
APP_C_Ride_Mode_2_Max_Power_El	Maximum electrical inputline on the test side	0..100.000 [W]
APP_C_Ride_Mode_2_Max_Regenerative_DC_Current	Maximum regenerative battery current, which is fed back from the test side into the DC link (recuperation)	-500...0 A [A (DC)]
APP_C_Ride_Mode_2_Max_Regenerative_Motor_Current	Maximum egenerative motor current, which is fed back from the test side into the DC link (recuperation)	-500...0 A [A (AC)]

MO-Register:

The electromechanical parameters of the motor and the motor sensors are entered in the Motor-(MO)-Register. Correct calibration is a prerequisite for error-free operation of the drive system. It should be noted thatfor a fine calibration of the control behavior, the electrical motor parameters are necessary. The procedure is described in the FRIWO Enable Tool Application Manual.

The torque constant of the motor must be specified to as many decimal places as possible.

If the motor is replaced, the data of the MO-Register must be updated before commissioning and a rotor offset calibration must be performed. Procedure is described in detail in chapter 11.

Table 13: List of motor parameters on the test side

Motor parameters of the test side		
Parameter Name	**Function**	**Range**
MO_C_Polepairs	Number of pole pairs in the motor	1... 127 [-]
MO_C_Temperature_Sensor_Type	Selection of position sensors in the motor 0= Hall sensors 1= Resolver	0... 1 [-]
MO_C_Nm_per_Ampere	Motor torque constant	0,001...100 [nm/a]
MO_C_Rotor_Position_Sensor_Type	Selection of motor temperature sensor types 0 = no sensor type selected 1 = KTY84/130 2 = B57550G0104 3 = AT130 4 = PT1000 5 = PT100	0...5 [-]

INFO-Register:

In the Information-(INFO)-Register , the relevant electrical quantities can be found as filtered signals. These are pure measured values that are determined by the software.

Note: These values in the INFO-Register can be used to perform a target/actual comparison with the values of the APP-Register. Make sure that the calculated mechanical torque is based on simplifications, which are explained in chapter 6.1. The exact mechanical torque can only be determined with the optional torque measuring shaft. These values in the INFO-Register can be used to perform a target/actual comparison with the values of the APP register.

Table 14: List of information parameters on the test side

Parameters of the Information-Register		
Parameter Name	**Function**	**Range**
INFO_DC_Current	Adjacent battery current	-1000... 1000 Ampere [A (DC)]
INFO_Motor_Current	Motor current (vectorial quantity of Iq and Id)	-1000... 1000 Ampere [A (AC)]
INFO_Motor_Current_Id	Motor current on the field weakening axis / field weakening current **Note:** Will set when the motor is operated above the rated speed.	-1000...1000 Ampere [A (AC)]
INFO_Motor_Current_Iq	Motor current on the torque axis/ active current **Note:** The main influencing factor for the torque of the rotor.	-1000...1000 Ampere [A (AC)]
INFO_Power_El	Electrical energy of the system	-32.000... 32,000 [W]
INFO_Rotor_Speed	Mechanical rotor speed	-2400... 2400 [1/s]
INFO_Torque_Mech	Mechanical motor torque based on motor current Iq and torque constant	-1000... 1000 [nm]

ERR-Register:

The absolute system boundaries are defined in the Error-(ERR)-Register. If one of these limits is exceeded, the motor controller switches to the active short circuit within a few milliseconds to avoid destruction of the system. An active error is displayed as an error code, whereby the error history can also be read. The power section of the motor control can only be started again when the fault has been eliminated.

⚠ The values of the ERR parameters that have already been stored may be changed if the user is aware of the physical relationships.

Table 15: List of error parameters on the test side

Parameters of the Information-Register		
Parameter Name	**Function**	**Range**
ERR_Errorcode	Message of the Enable Tool about the errors in the system, which are displayed via an error code. **Note:** Will be displayed as continuous text in Live View.	1..4294967295 [-]
ERR_C_Rotor_Speed_Limit	Maximum mechanical motor speed **Note:** If this speed is exceeded, the system will be stopped.	0... 2400 [1/s]
ERR_C_Temp_Motor_Max	Maximum motor temperature **Note:** If this temperature is exceeded, the system will be stopped.	-50... 500 [°C]
ERR_MEM_Trace_X_Errorcode	These parameters can be used to query the last nine error-codes of the MCU. In this way, an error can be verified without it still being on the MCU. **Note:** The „X" can have the value 0 to 8 and represents a numeric list of the last nine error-codes.	0... 4000000000 [-]
ERR_MEM_Trace_X_ODO	This parameter shows the respective mileage for the last nine error-codes. **Note:** The „X" can have the value 0 to 8 and represents a numeric list of the last nine error-codes.	0... 4000000000 [-]

TRQ-Register:

The Torque-(TRQ)-Register, the initial calibration of the target torque and the direction of rotation are specified via internal software parameters. A detailed explanation can be found in the Application Manual of the FRIWO Enable Tool in chapter 11.3.

The processing of the specified target torque including the direction of rotation takes place within the motor control software in the sequence

- coordination of the target torque (TRQ_DES),
- limitation of the target torque (TRQ_LIM),
- conversion of the desired torque into current setpoints (TRQ_STR).

⚠ The maximum possible torque is determined by the system boundaries in the APP register and depends on environmental variables such as temperature.

Table 16: List of motor parameters

Parameters for defining system boundaries		
Parameter Name	**Function**	**Range**
TRQ_DES_C_Test_Reverse_Gear	Manual reverse gear selection via USB 0 = forward gear; 1= reverse gear **Note:** The channel for the reverse gear signal in the APP-Register must be set to USB.	0... 1 [-]
TRQ_DES_C_Test_Torque_Request	The percentage torque of the test side is set above the optimum specification of the target torque. If this value is set to 100%, the motor control system tries to set a constant 100% of the maximum possible torque. **Note:** The channel for the torque signal in the APP-Register must be set to USB.	0... 100 [%]
TRQ_STR_Id_Setpoint	Field weakest rom setpoint for the current controller **Note:** Used to match the Id current in the INFO-Register.	-1000... 1000 [A(AC)]
TRQ_STR_Iq_Setpoint	Active current setpoint for the current controller **Note:** Used to balance the Iq current in the INFO-Register.	-1000... 1000 [A(AC)]

10.2.2 CALIBRATION VIA CAN THIRD-PARTY SOFTWARE

As explained in chapter 7.2.2, before commissioning via CAN software, a connection via USB to the motor controller must be established in order to adjust the parameters listed in Table 17.

Table 17: Control via CAN (testside)

Parameters of the Information-Register		
Parameter Name	**Function**	**Range**
APP_C_Activation_Mode	The parameter must be set to „1". The appropriate signal for the CAN_EXT_State_Request is then sent in the DBC file via the software. 1 = Activation of torque control via CAN_EXT_State_Request	0... 5 [-]
APP_C_Ride_Mode_2_Throttle_Signal_Channel	This parameter must be set to „4" so that the CAN software can take control. Selection of the input signal to be used as input for torque 0 = nothing selected; 1 = AIN1; 2 = AIN2; 3 = PWM@DIN2 4 = CAN bus; 5 = USB	0... 5 [-]
CAN_C_Baudrate_Select	In this parameter, the baud rate must be set so that the CAN software and the motor controller communicate at the same baud rate. You can choose from: 1= 125kb/s, 2= 500kb/s, 3= 1000kb/s	1... 3 [-]

After completing these adjustments, go to the menu of your CAN software and implement the DBC file of the test bench.

The most important tab in the DBC messages is that of the EXT_Torque_Control_01 (0x111), with Table 15 presenting the most important messages of the test side. All other parameters and their function are described in the comments of the DBC file.

Table 18: The most important DBC messages of the test side

EXT_Torque_Control_01(0x111)		
Parameter Name	**Function**	**Range**
MC_Torque_Request	This message is used to send the relative torque provided by the motor controller. (Simulates the gas pedal)	0... 100 [%]
MC_Ridemode	This parameter can be used to change the driving mode. This should be in the driving mode in which you have adjusted the corresponding parameters. By default, this is „2".	0... 3 [-]
MC_State_Request	This parameter sets the CAN_EXT_State_Request from „0" to „1". This activates the control via CAN on the test bench.	0... 1 [-]

11 REPLACEMENT OF COMPONENTS ON THE TEST SIDE

There is no reverse polarity protection on the motor controller. Only phases L1, L2, L3 can be swapped if a rotor offset calibration is subsequently performed.

The screw terminals of the motor control may only be tightened with a maximum of 2 Nm.

No reverse polarity protection. The logic part of the controller is powered by an internal DCDC converter with 12V. This means that an additional power supply via the signal plug is not required.

An assembly of the motor must be carried out with the participation of two persons, one person holds the motor, the other person tightens the screws from the opposite side.

To adapt another permanent-magnet synchronous motor, the system limits defined in chapter 7 must be adhered to.

In the attachment there is a drawing for an adapter plate, which already has the appropriate threaded hole dimensions for mounting on the test bench.

The cover over the motor shafts must not be removed until all rotating parts are stationary, and the system has been de-energized.

To mount a new motor, the adapter plates must be extended with threaded holes. The dimensions must be found in the data sheet of the motor.

The threads in the adapter plate must be fixed with screw locking varnish and tightened with the torque specified by the manufacturer.

Before performing the rotor offset calibration, it must be checked whether the motor shaft rotates freely and whether the sensors and supply voltage are connected to the motor. (Set phase current to ~20 amps)

This chapter describes the procedure for replacing the components of the test side. Replacing the components on the load side is not recommended.

FRIWO Gerätebau GmbH expressly points out to the user that an exchange of the components installed on the load side is not intended. Should the components nevertheless be replaced, FRIWO Gerätebau GmbH shall not be liable for any personal injury and/or damage to the system (see chapter 8 Disclaimer).

11.1 REPLACING THE MOTOR USING THE MC6000

The motor connected on the test side should have the following technical requirements:

- it is a three-phase permanent-magnet synchronous machine with or without reluctance behavior
- inside the motor, a suitable Hall sensor system is installed in a symmetrical arrangement offset by 120° via the stator
- the motor has a nominal line below 6 kW
- the motor has a maximum diameter of 300 mm and a length of 200 mm
- to evaluate the motor temperature, the motor has one of the following sensors: KTY84-130, B5755, AT103, PT1000, PT100
- the motor weighs no more than 20 kg
- the mechanical peak power of the motor to be tested, should be limited to a maximum of 85 % of the released peak power of the load side in regenerative operation

After complying with these conditions, the motor installed on the load side can be replaced.

Mechanical disassembly of the test motor

⚠ The cover over the motor shafts must not be removed until the system has been demonstrably de-energized and secured before restarting.

1. Unscrew the knurled screws highlighted in Figure 24 and remove the red-bordered cover.

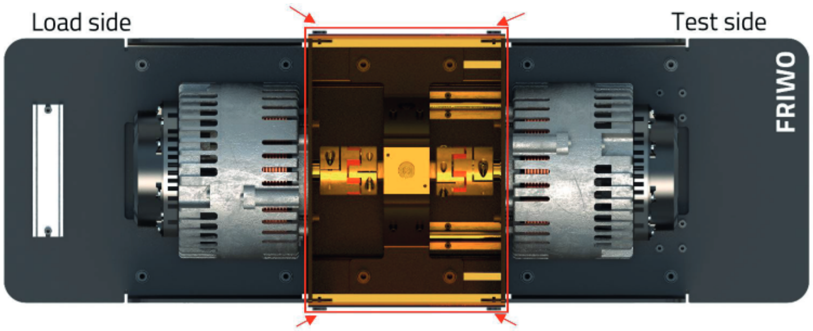


Figure 24: Diagram dismantling the cover on the FRIWO test bench

2. Then loosen the load side screws marked in Figure 25. Do not unscrew the screws completely, loosening them is not necessary.

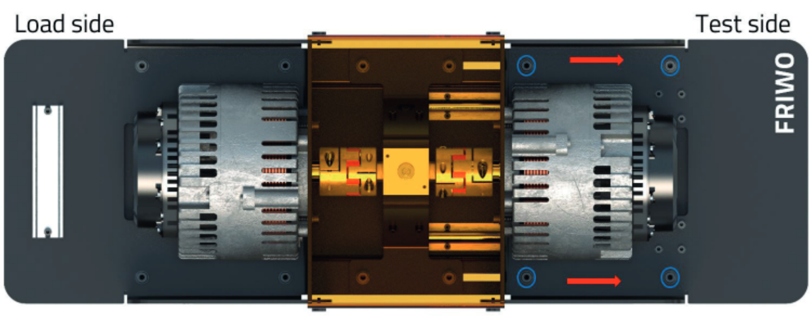


Figure 25: Diagram loosening the fittings on the load side

3. Next, slide the rail-guided load side backwards and remove the screws on the measuring shaft marked in Figure 26.

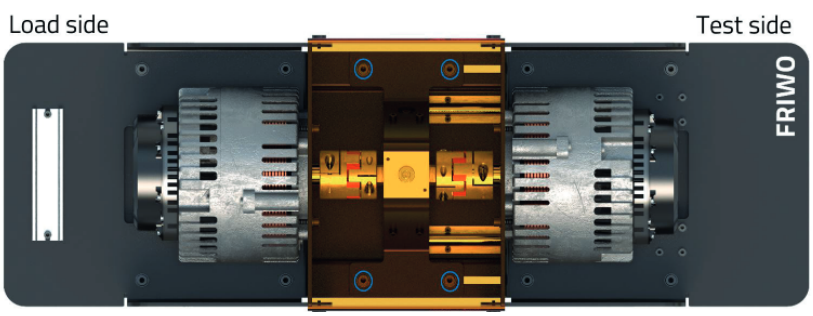


Figure 26: Diagram loosening the screw connections on the measuring shaft

4. Carefully remove the measuring shaft to have free access to the front-mounted screws of the test motor that connect the test motor to the frame.

5. Loosen the four screws and lift out the test motor

   Note: Work in pairs so that someone can hold the weight of the motor.

   Note: The screw connections installed for the adaptation of the standardized motor have an inch thread dimension 3/8 „. These can be loosened with an 8 mm inner hexagonal closure.

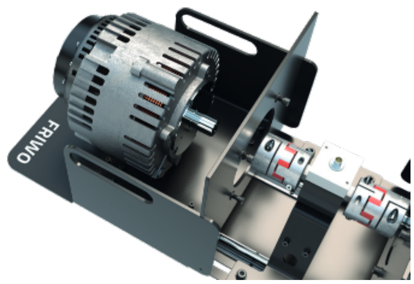


Figure 27: Frontal view of the frame for motor adaptation

11.2 PROCEDURE FOR ASSEMBLING A NEW TEST MOTOR

⚠ An assembly of the motor must be carried out with the participation of two persons, one person holds the motor, the other person tightens the screws from the opposite side.

⚠ To mount a new motor, the adapter plates must be extended with threaded holes. The measurements must be found in the data sheet of the model.

⚠ The threads in the adapter plate must be fixed with screw locking varnish and tightened with the torque specified by the manufacturer.

To adapt a new motor, it is recommended to make an adapter plate that is mounted between the motor and the bracket of the load side. A template drawing can be found in the appendix, the additional dimensions can be found in the data sheet of the desired motor.

1. Mount the new motor on the adapter plate and make sure that the specified M8 threaded holes are impregnated with screw locking varnish. These are required to attach the adapter plate to the motor test bench.

2. Attach the new motor and adapter plate to the outside of the test side bracket.

3. Now insert four M8x12mm threaded screws through the holes in the rack, see Figure 28.

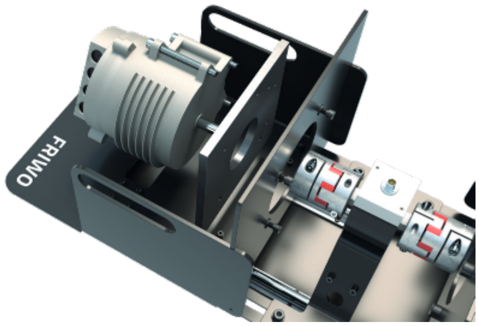
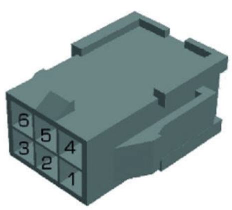


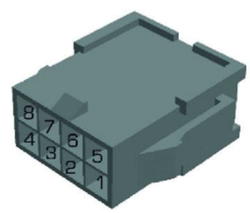
Figure 28: Adaptation of the new motor

4. Tighten the racks from the opposite side of the bracket with a maximum torque of 20 Nm.

11.2.1 CONNECTION DIAGRAM OF THE MC 6000

In order to connect the control signals of the motor with those of the motor control, standardized MPC4 connectors from Würth are used. The signals should be in accordance with the stored in the delivery instructions. Connection diagram can be connected. A section of the two main control lines is shown in Figure 29 .





1 / Grün / Green	Hall L3	Hall-Sensor Phase L3
2 / Grau-Pink	Temp IN	Temperatursensor Motor / Temperature sensor motor
3 / Rot / Red	5V	Sensor Versorgung 5V / Sensor supply 5V
4 / Blau / Blue	Hall L2	Hall-Sensor Phase L2
5 / Gelb / Yellow	Hall L1	Hall-Sensor Phase L1
6 / Schwarz / Black	GND	Sensor GND (nicht isoliert) / Sensor GND (not isolated)

1 / Gelb-Braun / Yellow-brown	DIN2	Digital Input 2 / active low
2 / Weiss-Grün / White-Green	SP1	Digital Input 1 / active low
3 / Rot-Blau / Red-Blue	5V	Sensor Versorgung 5V / Sensor supply 5V
4 / Grau / Grey	CAN-Low	125,250,500,1000kb/s
5	NC	Nicht belegt / Not used
6 / Weiss-Gelb / White-Yellow	AIN2	Analog Input 2, 0V bis 12V (z.B. Bremse) / Analog Input 2, 0V to 12V (e.g. brake)
7 / Braun-Grün / Brown-Green	GND	Sensor GND (nicht isoliert) / Sensor GND (not isolated)
8 / Weiss / White	CAN-High	125,250,500,1000kb/s

Figure 29: Connection diagram of signal lines with MPC4 connectors

⚠ No reverse polarity protection. The logic part of the controller is powered by an internal DCDC converter with 12V. This means that an additional power supply via the signal plug is not required.

The next step is to connect the motor phases L1, L2, L3 and the power supply of the MCU to the motor controller according to the diagram shown in Figure 30.

There is no reverse polarity protection. Only phases L1, L2, L3 can be swapped if a rotor offset calibration is subsequently performed.

The screw terminals of the motor control may only be tightened with a maximum of 2 Nm.

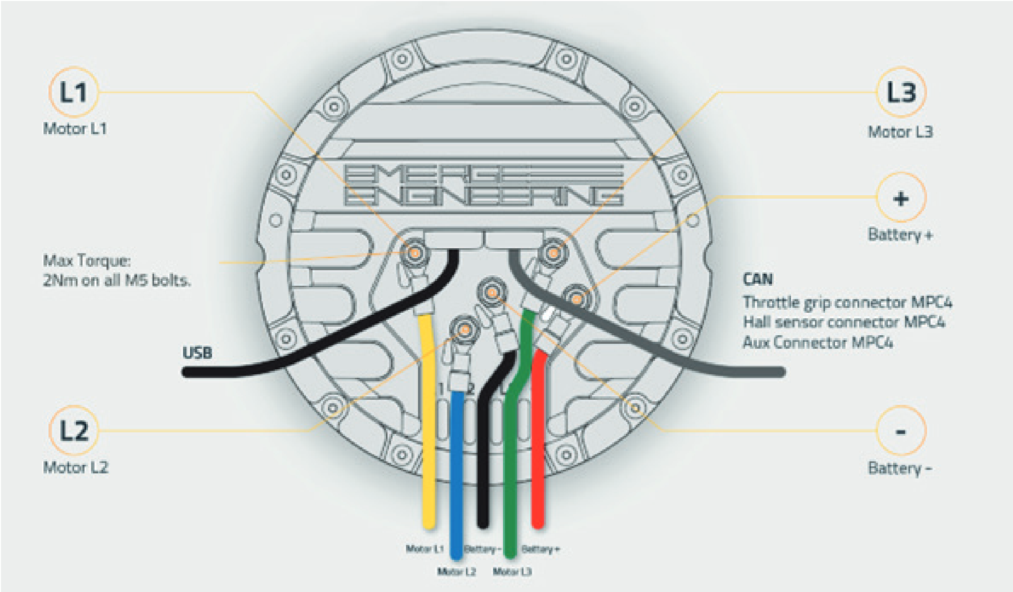


Figure 30: Connection diagram MC 6000 for connecting the phases

11.2.2 TEACH-IN OF A NEW TEST MOTOR

Before performing the rotor offset calibration, it must be checked whether the motor shaft rotates freely. Sensors and supply voltage am motor must also be connected. (Set phase current to ~20 amps)

If the motor is replaced, it must be taught in by the motor management system on the software side before commissioning. To do this, the user must establish a connection to the motor controller via USB and start the program FRIWO Enable Tool.

A detailed description of how to establish a connection with the motor controller can be found in chapter 9.2.

1. Go over the tab Wizzard on the button „Teach-in motor...", see Figure 31.

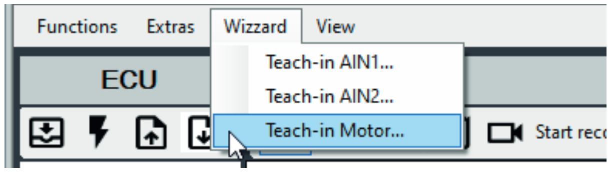


Figure 31: Diagram for opening the „Teach-in motor" window

2. Clicking on this button opens the window shown in Figure 32, which you can now use to enter the pool pairs of the motor. (Please refer to the motor data sheet)

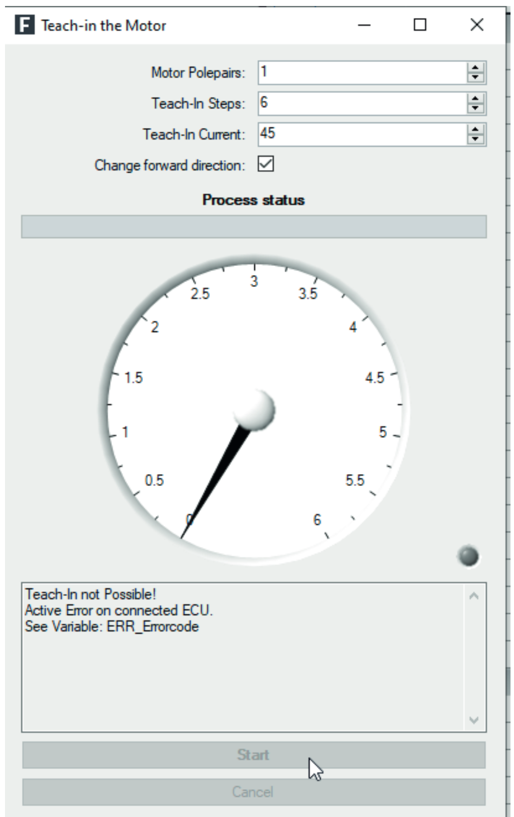


Figure 32: Diagram „Teach-in the motor" window

3. The rotor offset calibration can then be carried out by clicking on the „Start" button.

4. The motor shaft now rotates a few times and after successful calibration a signal sound.

Note: A comprehensive description of how to perform a rotor offset calibration can be found in chapter 10 of the FRIWO Enable Tool Application Manual.

12 REFERENCES

- Shop-Link FRIWO Enable Tool https://friwo.link/software
- Shop-Link FRIWO Battery-Pack https://friwo.link/battery-pack
- Shop-Link torque measuring shaft https://friwo.link/torque-shaft
- Shop-Link Lead https://friwo.link/battery-lead
- Enable Tool Download https://friwo.link/et-download
- Manual Enable Tool Application https://friwo.link/et-manual
- Quickstart Guide https://friwo.link/b2b-quickstart
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- Manual Battery-Pack https://friwo.link/batterypack-manual
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- Motor data sheet https://friwo.link/motor-datasheet

Feedback

We are working very hard to improve our products and therefore **feedback** is indispensable! Please send us your valuable feedback as contact form or via Mail to feedback@friwo.com

13 APPENDIX

- Drawing of the adapter plate