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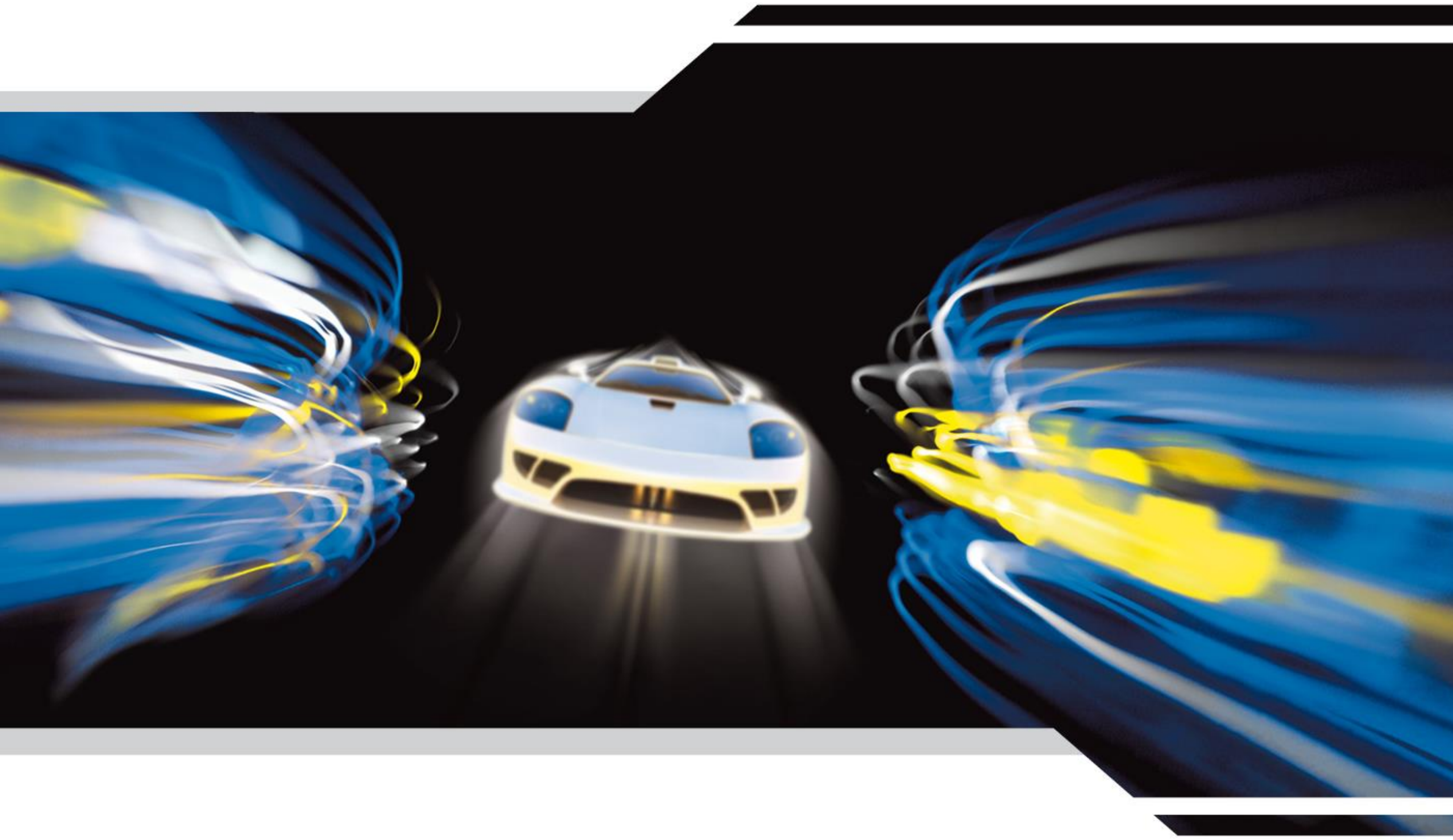

EPS-in-the-Loop Test Bench

Test Bench User Manual

KT 101409
Date: May 1, 2016
IPG Automotive GmbH

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Table of Contents

1 Introduction

This documentation gives information about the EPS test bench and the integrated HIL system. Different figures show the wiring and communication concept of the entire test bench. All installed components and their most important specifications are listed and described. The manual describes the general mechanical installation for an EPS ECU and a detailed description for each component used on the test bench. The new EPS test bench software is also described in this documentation.

Some devices such as the actuator-motor inverter used in this EPS test bench is powered by a 3 phases 400V AC power supply which provides up to 560V DC. Because of these high voltages, the user must be aware and read carefully this document to avoid any damage and injury.

A detailed wiring plan of the HIL-Rack and all cables can be found in a separate document.

2 Safety Regulations

The following basic safety notes **must be read carefully** to prevent **injury or death** to persons and damage to property. The operator must ensure that the basic safety notes are read and adhered to. Make sure that responsible person for the plant and its operation, as well as persons who work independently on the unit, have read through the operating instructions carefully and understood them.

If you have questions regarding the information in this document or if further information is required, please contact IPG Automotive GmbH.

2.1 Exclusion of liability

You must comply with the information contained in these operating instructions to ensure safe operation of the EPS Test Bench and to achieve the specified product characteristics and performance requirements. IPG Automotive GmbH assumes no liability for injury or death to persons or damage to equipment or property resulting from non-observance of these operating instructions. In such cases, any liability for defects is excluded.

2.2 General information

Never install damaged products or put them into operation. Submit a complaint to the shipping company immediately in the event of damage.

Removing covers without authorization, improper use as well as incorrect installation or operation may result in severe injuries to persons or damage to property.

2.3 Target group

Only qualified personnel are authorized to install, start up or service the test bench.

Qualified personnel in the context of these basic safety notes are all persons familiar with installation, assembly, startup and operation of the product who possess the necessary qualifications.

Any activities regarding transportation, storage, operation, and disposal must be carried out by persons who have been instructed appropriately.

2.4 Designated use

The EPS test bench is designed for function testing of motor driven steering systems in simulation environments, but the test bench is not designed for operations that have the function to destroy the steering system, e.g. static load tests.

The test bench is designed for nominal operation temperatures between 5°C and 40°C and installation altitudes ≤ 1000m above sea level.

2.5 Installation

The units must be installed and connected according to the regulations and specifications in the corresponding documentation. Contingent changes of the test bench installation can cause damage to the test bench system as well as severe injuries for people working in the test bench area.

Make sure that cable arrangement is performed avoiding damage to the cables by moving test bench parts. All cables must be fixed on the test bench to minimize the risk of fall for persons working on the test bench.

2.6 Electrical connection

Risk of injury due to electric shock.

Wire every component according to its regulations.

Perform electrical installation according to the pertinent regulations, e.g. cable cross sections, fusing, and protective conductor connection. For any additional information, refer to the applicable documentation.

All work may only be carried out by qualified personnel.

Cables may only be connected and switches may only be operated in a de-energized state. The test bench must be safeguarded against accidental restart during work.

2.7 Operation

Do not touch live components or power connections immediately after disconnecting the component from the supply voltage because there may still be some charged capacitors. Note the respective labels on the multi-axis actuator inverter.

Keep all covers and doors closed during operation.

Mechanical blocking or internal safety functions of the unit can cause a test bench standstill. Eliminating the cause of the problem or performing a reset may result in the drive restarting automatically. If this is not permitted for the driven machine for safety reasons, disconnect the unit from the supply system before correcting the fault.

- **Ensure that the test bench cannot start inadvertently, for example, by removing the power cable at the HiL-Rack.**
- **Additional safety precautions must be taken depending on the application to avoid injury to people and damage to machinery.**

During use, the test bench must always be controlled and supervised by a qualified person. Do not leave the test bench alone in running state.

2.8 Modification of the test bench configuration

Before starting modification work on the EPS test bench, please make sure that the main switch and main circuit breaker are off.

Heavy parts may fall down after screws are opened and can cause damage to parts and injuries. Please act carefully respecting the corresponding manual.

Crushing hazard at all moving parts.

Always wear gloves while assembling and disassembling mechanical parts.

All maintenance work and changing of parts is only allowed by a person from IPG Automotive GmbH.

Please refer to the corresponding safety regulations for test bench modifications. It is not recommended to change parts of the test bench but the tested EPS and its required electrical connectors.

In case of damaged parts, please contact IPG Automotive GmbH concerning spare parts. Do not run the test bench again.

2.9 Covers

Multiple figures in this or other manuals referring to the steering test bench may show units without the supplied cover. These covers are only removed for terms of demonstration and description.

Uncovered power connections can cause severe or fatal injuries from electric shock.

Never start the test bench if the covers are not installed.

Install the covers according to the regulations.

2.10 Safety functions

The safety concept of the steering test bench contains multiple safety components, which can be divided into two main classes. There are mechanical solutions for the protection of persons and components, as well functional protections to avoid damages in critical conditions.

1) Mechanical Safety Precautions
    a. Actuator motor
        i. Coverage of moving parts
    b. Miscellaneous
        i. Cover Safety-Switch
2) Functional Safety Precautions
    a. Actuator Motor
        i. Torque limitation
    b. Miscellaneous
        i. Emergency Stop

3 System Overview / Safety Concept

3.1 Overview

Figure 3-1: View on the complete system

The EPS test bench system consists of the HIL Rack and the EPS test bench chassis.

The HIL Rack includes the power distributor (main switch), the power supply (vehicle power), the real-time system, the FailSafeTester, a Break-out Box, as well as the connectors to EPS test bench chassis.

The EPS Test bench contains the test objects (EPS ECU + Assist Motor), actuator motor with its power supply and controlling modules, torque sensor, fault insert units for high current and RPS signals, as well as some ambient sensors and controlling devices.

The EPS test bench chassis is connected with two connectors to the HIL Rack (see Figure 3-1). The smaller connector provides the three phase 380V AC power supply for the actuator motor inverter (power supply module). The larger connector includes the vehicle power supply, IO for ECU, actuator motor inverter control (axis module), fault insert units control as well as the emergency circuit.

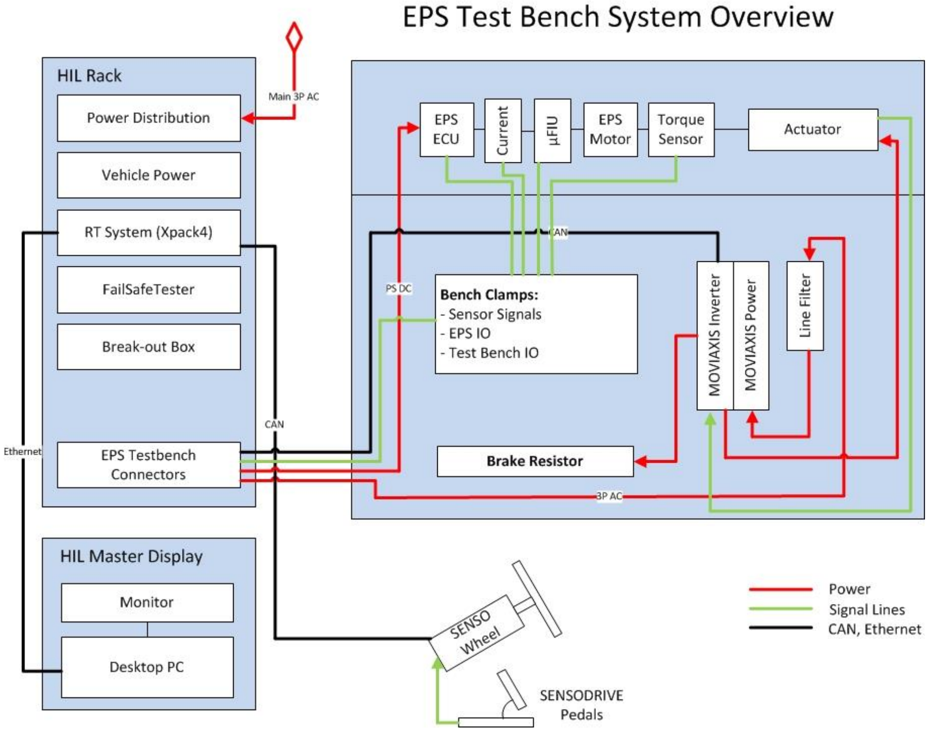


Figure 3-2: EPS test bench system overview

3.2 Safety concept

The primary safety concept (see Figure 3-5) includes an emergency button at the HIL-Rack and the EPS test bench chassis (see Figure 3-3)Figure 3-3. If one of the emergency buttons is pressed, the main fuse will be triggered and the complete power supply of the HIL-Rack and the EPS test bench will be shut off. The red LED, next to the HIL-Rack emergency button, indicates that one of the buttons has been pushed. For a safe reset of the power supply, first put the main switch to off position. Then the pushed emergency button has to be unlocked and the main fuse reactivated. By turning and pulling the button in the direction indicated by the arrow, it is unlocked.

The secondary safety concept contains an emergency stop or standstill of the actuator motor if the hood of the test bench gets opened, but not a shutdown of the whole power supply. A safety hinge switch (see Figure 3-4) breaks the enable signal to the actuator controller, if the hood is opened a few degrees. Without the enable signal the actuator controller actives the magnetic break and stay in idle mode. Additional a temperature switch of the brake resistor can cut off the enable signal if the temperature of the brake resistor exceeds the temperature limit.

To ensure that there is no voltage at the power supply connector (HAN02) while the male connector is not plugged in, a safety loop is integrated in the cable. Contactors are opened as long as the safety loop is not closed (see Figure 3-5).

Figure 3-3 : Emergency switch at the HIL-Rack and EPS test bench chassis


Figure 3-4: Safety hinge switch at chassis hood

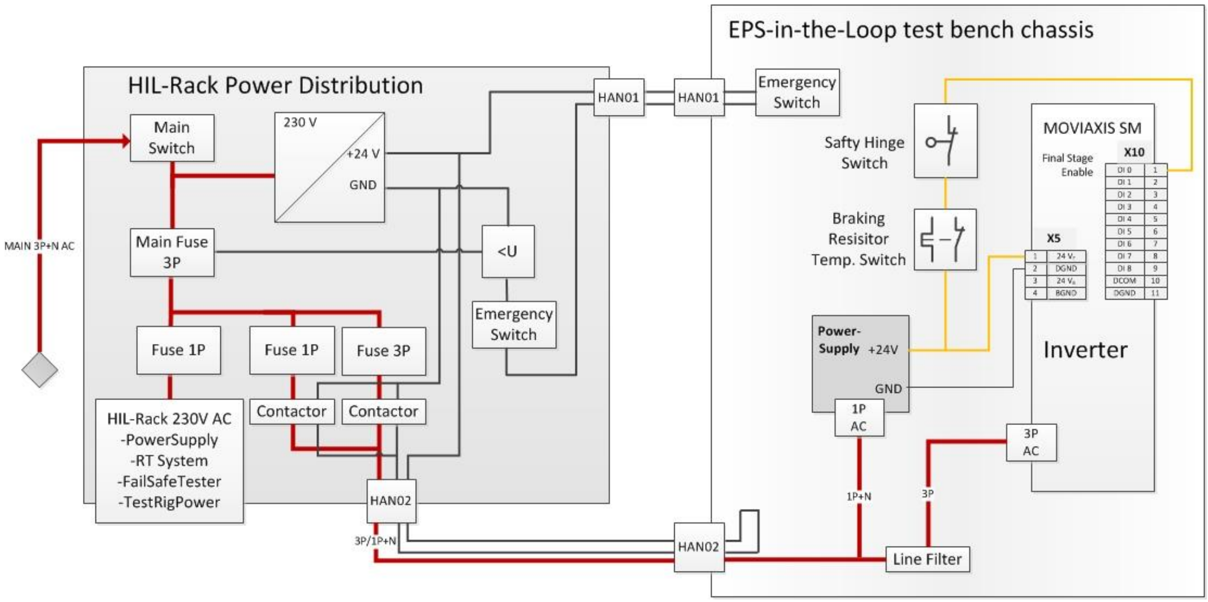


Figure 3-5: EPS Test Bench safety concept

4 Hardware Component Description

The following chapter contains the description of the hardware components of the delivery, supported by illustrations and charts.

4.1 HIL-Rack

The HIL-Rack includes the power distributor (main switch), the power supply (vehicle power), the real-time system, the FailSafeTester, Break-out Box, as well as the connectors to EPS test bench. The HIL-Rack is the main unit connecting the real time system with the tested ECUs.

Input: - CEE 380V AC, 3 phase (maximal power no less than 6.2kW)

Output: - HAN01 connector (EPS ECU I/O signals, TestRig I/O signals, vehicle power)

- HAN02 connector (3 phase 380V AC for actuator power supply, 1 single phase L1 from the 3 phase AC)

- CAN connector for SENSO-Wheel

- Ethernet connector to Host-PC

4.1.1 Main Power Supply Connector

The HIL rack and EPS test bench need a power supply of 380V AC, 3-phase with maximal power no less than 6.2kW.

For this power supply the main connector is the type CEE 16A 5-pin 6H. Accordingly a socket type of 3P+N+E 380V 16A as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** is required in the lab. The cable length from the HIL rack to the main connector is approximately 3m.

CEE 16 A 5-pin 6H connector and socket:

- 3 pins for 3-phase
- 1 pin for Neutral
- 1 pin for Earth

Figure 4-1: CEE 16A 5-pin 6H connector (left) and socket (right)

The electrical system design of the EPS in the loop test bench is prepared to be fused with a Residual Current Circuit Breaker (RCCB). A recommended type of RCCB which should be used in the fuse box is indicated as the Figure 4-2: Siemens 3+N Pole Type B Residual Current Circuit Breaker, 40A 5SM3, 30mA.

Figure 4-2: Siemens 3+N Pole Type B Residual Current Circuit Breaker, 40A 5SM3, 30mA

4.1.2 Rack Cabinet

Figure 4-3: HIL-Rack cabinet 19”/38U (Left: front, Right: rear)

19"/38U cabinet: H: 1910mm (including wheels), W: 600 mm, D: 1000 mm, color IPG blue, with mobile plinth. The weight of HIL rack including the whole built-in components is about 200kg. The rack cabinet includes main switch- and patch-panel and provides space for target real-time computer, FailSafeTester and power supply. It is also ready for integration of the components, such as ECU TestBoxes. It also includes customized mechanical build-up and cabling preparation.

1. TestRig Power: **TRACOPOWER TXL 060-0533TI METALL 60W 15V/3A**

Table 4-1: TestRig power characteristics

Characteristic	Value	Unit
Input Voltage AC range	85-264	V
Number of Outputs	3	-
Output 1 Voltage/Current	5/7	V/A
Output 2 Voltage/Current	15/3	V/A

Output 3 Voltage/Current	-15/1	V/A
Output Power Max.	60	W

Provides the power supply in various voltage level for different test rig components, e.g. sensors, interface circuits. The switch state of TestRig Power is indicated by the LED "TestRig Power" on the front panel.

4.1.3 Power Distribution Module

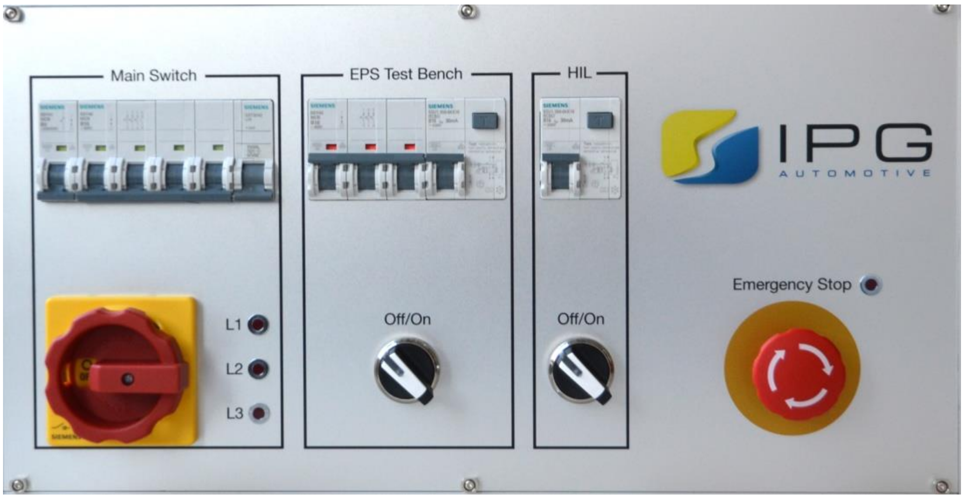


Figure 4-4: Power distribution module (front)

Power Distribution Module:

Front panel:

- Main switch and main fuse for complete system
  - LEDs for L1/L2/L3: indicates that the 3 phase lines are switched on
  - Main Circuit Breaker (MCB)
  - 16A/C main fuse (MCB)
- Main switch and main fuse for EPS test bench
  - 3 Phase 16A/C fuse (MCB) for SEW power
  - 16A/C RCBO (Residual current operated Circuit-Breaker with Overcurrent protection) for power supplies of EPS test bench
- Main switch and main fuse for HIL rack
  - 16A/C RCBO for HIL rack components
- Emergency stop with LED

Rear panel:

Figure 4-5: Power distribution module (rear)

(f. r. t. l.)

- Main plug (Input): CEE 380V AC, 3 phase (L1, L2, L3, N, PE) maximal power no less than 6.2kW
- EPS: 3 phase, 1 single phase (L1). Power supply for SEW components.
- UBat: L1, N, PE. Power supply for the ECU power supply from DELTA ELEKTRONIKA.
- HIL Power Outlet: L3, N, PE for RTU, FST, multiple sockets on front panel
- Remote Trip (Note: not to manipulate this power outlet!)
- TestRig Power 36V
- TestRig Power 12V
- TestRig Power +5V/+15V/-15V

4.1.4 Real-time System

Figure 4-6: Real-time system

Subrack: **19" Subrack cPCI, Height 3U**

- 5 Slots for 6U carrier boards and SBC's with 6U front, mains-operated (110-240 V AC)

- Usable for up to 16 M-Modules

- Internal Power Supply included

CPU: **MEN F22P** (Intel® Core i7 Single Board Computer, Intel 2.3 GHz Quad Core (Turbo max. 3.3 GHz), 4096 MB RAM, 2xGigEthernet, USB)

For connection of Host-PC and real-time system please use the GigEthernet port on the right on the CPU board.

Table 4-2: IO Module List

Slot No.	M-Module Type	Channels	Description
Carrier board 0	D203-08	-	
RT.0	M51	4	CAN interface
RT.1	M51	4	CAN interface
RT.2	M27	16	Binary outputs
RT.3	M27	16	Binary outputs
Carrier board 1	D203-08	-	
RT.4	M36N00	16	Analog voltage inputs
RT.5	M62N	16	Analog outputs
RT.6	M32	16	Digital Inputs
RT.7	M43	8	Relay output
Carrier board 2	D203-08	-	
RT.8	M408	20	Universal Binary/ PWM Input

RT.9	M409	-	Power Supply Control, MPIO-Module
RT.10	M441	16	Universal Digital / PWM Output

For more information about the M-Modules please refer to chapter 10 “MIO – M-Module Input/Output” in the Programmer’s Guide, or to the M-Module manuals (Xpack4 hardware). For wiring plan of the I/O channels please refer to IO.pdf document.

Those for user available I/O channels are placed on the 7U front panel with several sockets for easy access.

4.1.5 Power Supply (vehicle power)

Figure 4-7: Power supply

Type: DELTA ELEKTRONIKA SM 66-AR-110

Table 4-3: Power supply characteristics

Characteristic	Value	Unit
Input	180-528	V
Output Voltage	0..66	V
Output Current	0-110	A
Power	0…3300	W

4.1.6 FailSafeTester

Figure 4-8: FailSafeTester

Configuration:

Table 4-4: FailSafeTester Configuration

Slot	Quantity	Card	Description
0-5	6	SRC	Standard Relay Card (8 Ch), 3A max./Ch
18	1	PRC	Resistor Card
20	1	CC	Controller Card, CAN Input

For more information about the FailSafeTester, please refer to chapter 17 “FailSafeTester” in the Programmer’s Guide, to Appendix A of CarMaker User’s Guide or directly to the FailSafeTester manual. For wiring plan of the signals through FailSafeTester please refer to IO.pdf document.

The banana jacks S1..S3 of CC card and the banana jacks S1 and S2 of PRC card are wired to the customized 7U front panel for easier access.

Please note that in this HIL-Rack configuration the banana jacks S1 and S2 of CC card are connected respectively through a fuse with vehicle power supply (UBat) and GND, in order to realize the short to UBat and short to GND functions for the signals through FailSafeTester. Please DO NOT manipulate and use the S1 and S2 banana jacks of CC card in the customized 7U front panel.

4.1.7 Customized 7U Front Panel

Figure 4-9: Customized 7U front panel

The customized front panel includes Break-out Box, connectors for user accessible I/O signals, power supply (vehicle power) connectors and the sockets for FailSafeTester PRC and CC cards.

The Break-out Box (BOB) connecting the HIL equipment and the EPS controller is mounted into the front panel of rack cabinet. The signals through the Break-out Box are cut and each end will be connected to the sockets mounted in the front panel.

The upper sockets are connected to real-time unit (RT I/O) and the lower sockets are wired through the Sub-D 9 connectors below the BOB and finally to the ECU.

The signals can be disconnected by plugging the bridges out manually. It is also possible to plug external signal measurement tool to the hole in the bridges for signal acquisition.

There are 50 channels from RTU wired through BOB:

- 8x Analog In
- 8x Analog Out
- 4x Digital In
- 4x Digital Out (One channel is realized by relay out module for ignition signal)
- 8x PWM In
- 8x PWM Out
- 2x SENT
- 4x CAN (8 channels)

After BOB all the above mentioned I/O channels are wired through the various Sub-D 9 sockets for direct user access. The users are able to directly read the signals from RTU or send external signals to RTU. These channels are wired finally to the connector HAN01 to EPS test bench.

For wiring plans for BOB and the Sub-D 9 sockets please refer to IO.pdf document.

Please note that in this HIL-Rack configuration the banana jacks S1 and S2 of CC card are connected respectively through a fuse with vehicle power supply (UBat) and GND, in order to realize the short to UBat and short to GND functions for the signals through FailSafeTester. Please DO NOT manipulate and use the S1 and S2 banana jacks of CC card in the customized 7U front panel.

4.2 EPS Test Bench Chassis

The EPS test bench chassis (see Figure 4-10) contains the test objects (EPS ECU + Assist Motor), actuator motor with power supply and inverter module, torque sensor, fault insert units for high current and RPS signals, as well as some ambient sensors and controlling devices.

The chassis hood can be opened and serves as a protection from moving parts.

The total weight of the EPS test bench is about 160kg.

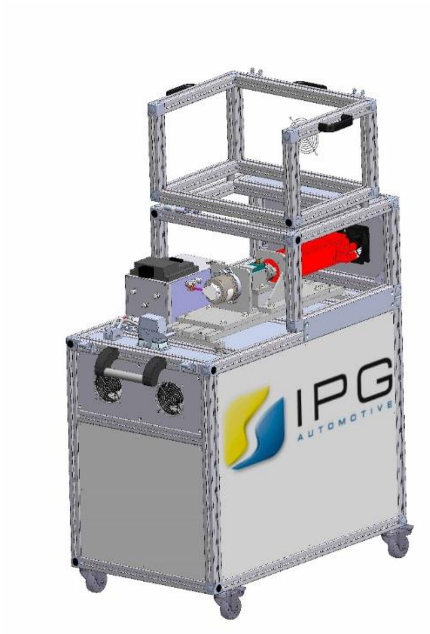
The dimension of the test bench (see Figure 4-11) is:

H: 1249mm, W: 700mm, L: 1160mm.

The cable connecting the HIL rack and EPS test bench will be approximately 2m long and is wired through a cable channel.

Main connectors:

- HAN01 connector (EPS I/O signals, TestRig I/O signals, vehicle power)
- HAN02 connector (3 phase 380 V AC, one single phase L1+N 230V AC)



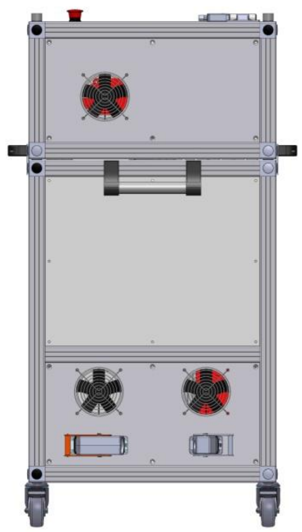


Figure 4-10: EPS test bench chassis

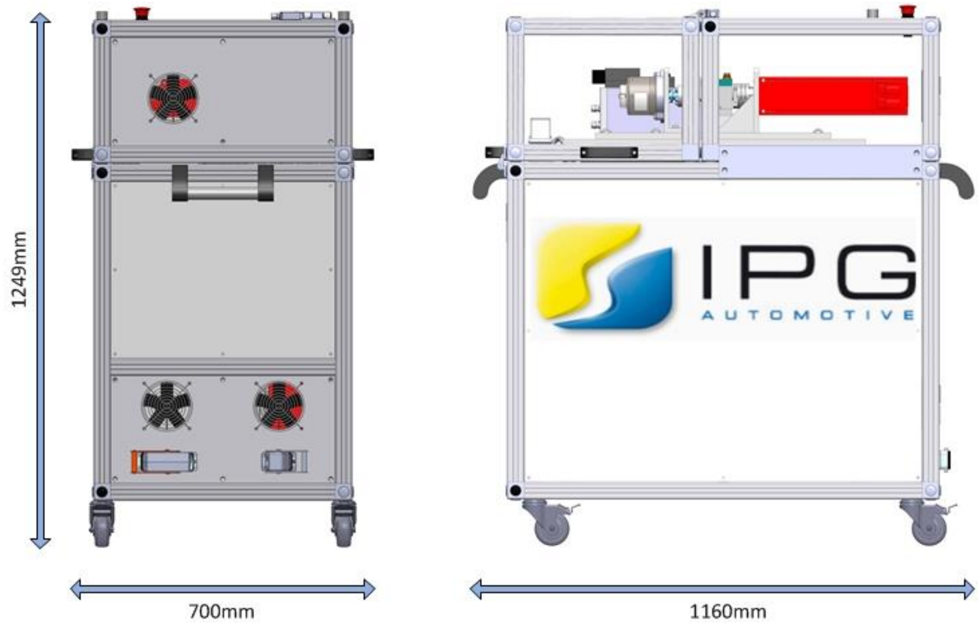


Figure 4-11: EPS test bench dimension overview

4.2.1 SEW Actuator Unit

The SEW actuator unit consist of the power and frequency inverter module. The power module is powered with three phase 380V AC and outputs up to 560V DC. To bring down the electric emission to the power supply a line filter is installed. The communication with the frequency inverter is via CAN-Bus. For further information concerning the SEW power and frequency inverter model please refer to their specific manual. The module description and technical data can be found in the following tables.

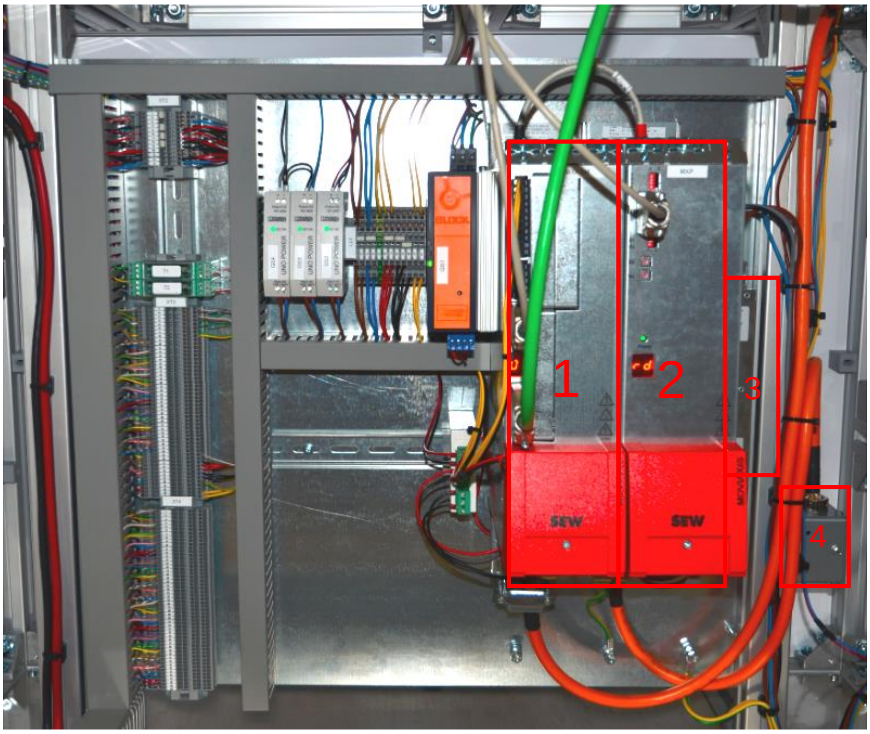


Figure 4-12: Power unit for actuator motor

1. Electronic Frequency Inverter for actuator motor: **SEW MXA81A-012-503-00**

Table 4-5: Characteristic of MOVIAXIS frequency inverter

Characteristic	Nameplate	Value	Unit
INPUT			
Nominal DC link voltage	U	560	V
Nominal DC link current	I	12	A
OUTPUT			
Output voltage	U	0 – max. U_{line}	V
Continuous output current AC I_N PWM = 4kHz	I	12	A
Continuous output current AC I_N PWM = 8kHz	I	12	A
Max. unit output current	I_{max}	30	A

Apparent output power S_{Nout}	S	8.5	kVA

2. Power Supply Module for MOVIAXIS Inverter: **SEW MXP80A-010-503-00**

Table 4-6: Characteristic of MOVIAXIS power supply module

Characteristic	Nameplate	Value	Unit
INPUT			
Supply voltage AC V_Line	U	3x380V-3x500V±10	V
Nominal line current AC I_Line	I	15	A
Nominal power P_N	P	10	kW
Line frequency f_line	F	50 - 60Hz±5%	Hz
OUTPUT (DC link)			
Nominal DC link voltage	U	560	V
Nominal DC link current I_NZK	I	18	A
Max. DC link current I_NZK,max	I_{max}	45	A

3. Line Filter: **SEW NF018-503**

To bring down the electric emission to the power supply of the frequency inverter

Table 4-7: Characteristic of line filter

Characteristic	Nameplate	Value	Unit
Rated line voltage	V_{line}	3x380V-500V±10, 50/60Hz	V
Nominal current	I_N	AC18	A
Power loss at I_N	P_V	12	W
Earth-leakage current	-	<25	mA
Ambient temperature	-	-25 - +40	°C
Degree of protection	IP	20 (EN60529)	-

4. Brake Resistor: **SEW BW247-T**

The brake resistor, which is connected to the MOVIAXIS Power Module, serves as an electric load while the actuator motor operates as generator. Under full load the brake resistor can reach a high temperature. To prevent any heat damage, the brake resistor is equipped with a temperature switch, which stops the actuator as soon as the switch is triggered. An additional temperature sensor is installed on the brake resistor and its value is read into the HIL rack together with the temperature value of mounting flange for EPS assist motor.

Table 4-8: Characteristic of brake resistor

Characteristic	Nameplate	Value	Unit
Power class of power supply module		10, 25, 50, 75	kW
Resistor value	R_BW	47 +/- 10%	Ω
Trip current (of F16)	I_F	6.5	A_RMS

Type		Wire resistor	
Acceptable energy amount		64	kWs
Degree of protection	IP	20	-
Environment temperature		-20 – 45	°C
Cooling		Self-cooling	

4.2.2 EPS Test Bench DC Power Supply (TestRig Power)

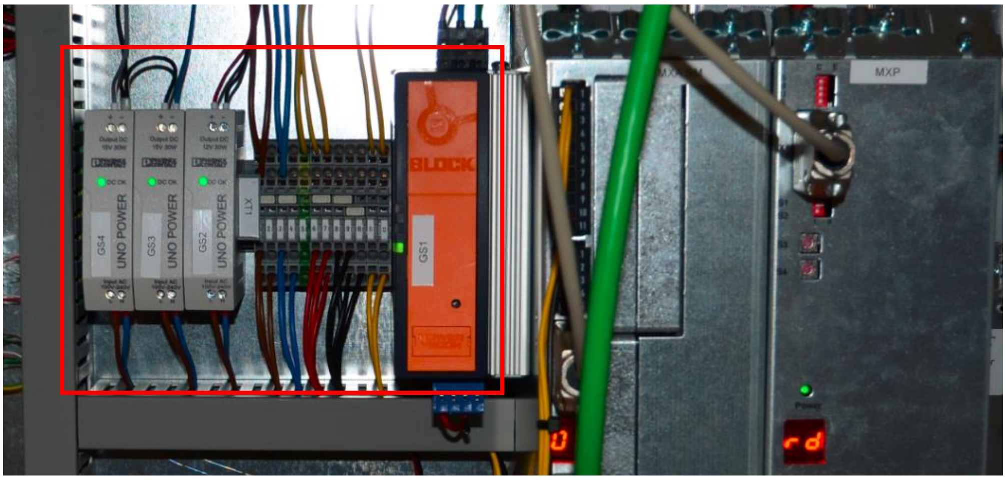


Figure 4-13: TestRig power

The test bench contains four DC power supplies:

GS1: +24V DC   Control voltage for actuator motor power and inverter unit, emergency circuit voltage for safety hinge switch and brake resistor temperature switch

GS2: +15V DC   Power supply for torque sensor, temperature sensors and current sensors

GS3: -15V DC   Power supply for current sensors (current sensor needs +/- 15V as power supply)

GS4: +12V DC   Power supply for relays in Fault Insert Unit Box

4.2.3 EPS Motor Unit

The EPS motor unit contains the EPS ECU, EPS assist motor, the required sensors for assist motor control and the actuator motor. The EPS ECU is supplied with the Vehicle Power in the HIL Rack. The load is simulated by the actuator motor which is applied on the output shaft of the assist motor via torque sensor, which is connected by axle couplings. The phase current of EPS assist motor is measured by the three touchless current sensors over each line.

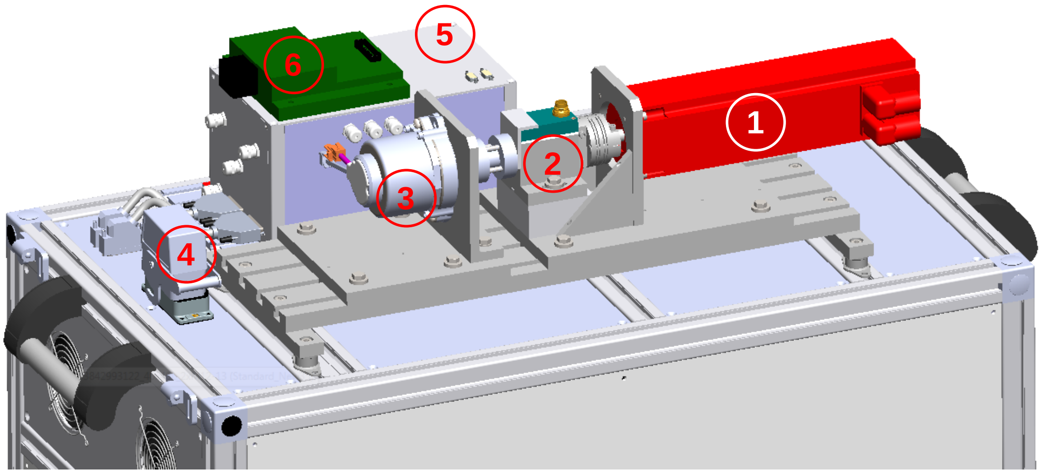


Figure 4-14: EPS motor unit (CAD)

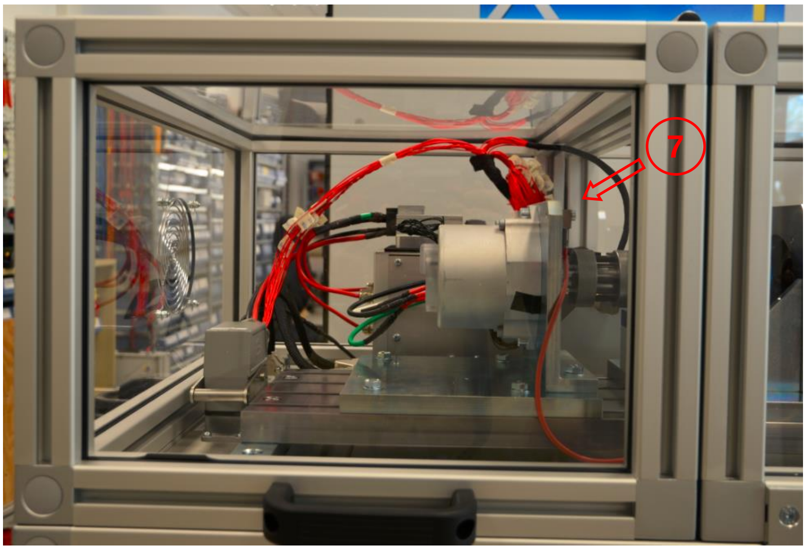


Figure 4-15: EPS motor unit (assist motor side)

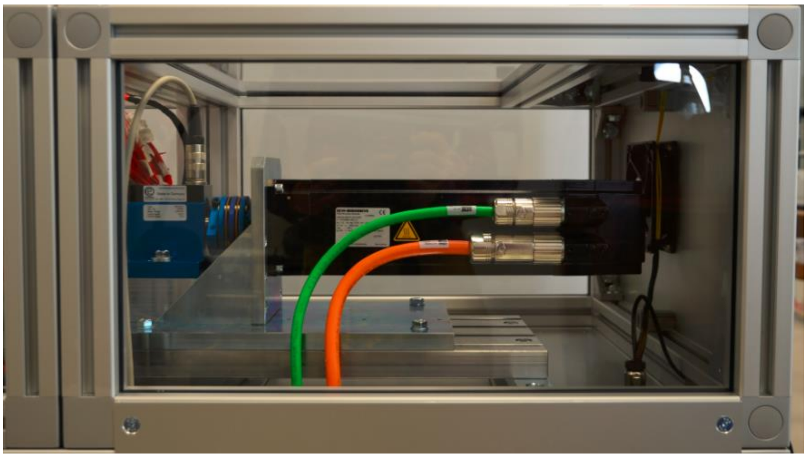


Figure 4-16: EPS motor unit (actuator motor side)

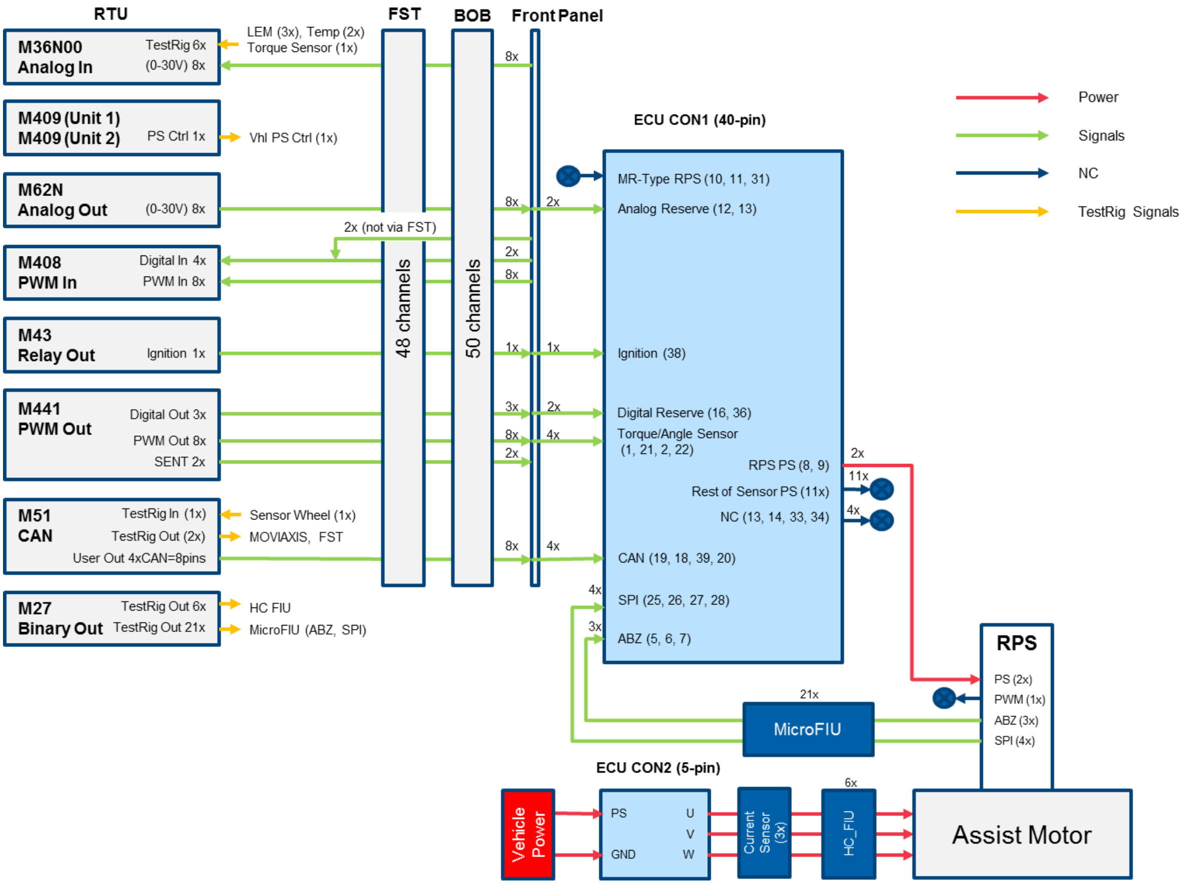


Figure 4-17: EPS ECU switch plan (from real-time unit to assist motor)

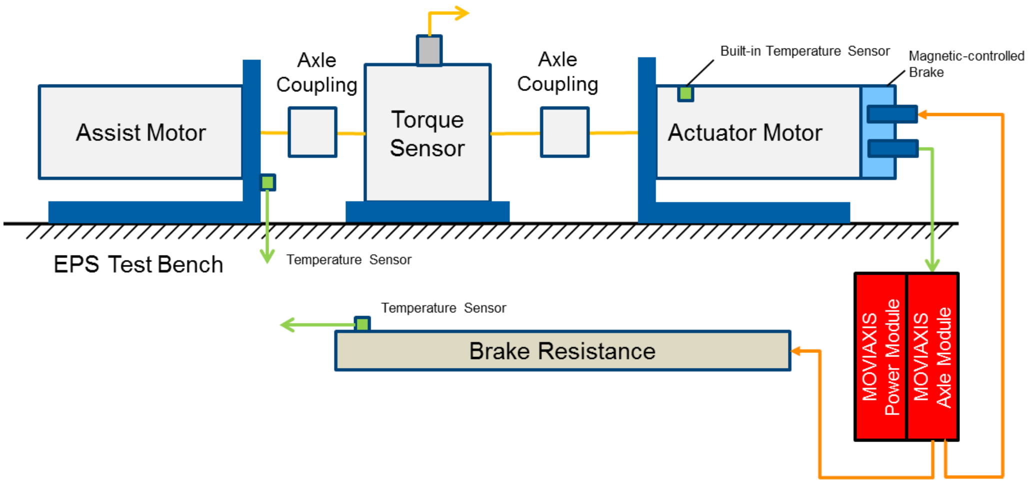


Figure 4-18: Mechanical connection from assist motor to actuator motor (schematic)

Table 4-9: Key components of EPS motor unit

Part	Function
Actuator Motor	Apply steering wheel angle
Fault Insert Unit Box	Apply fault insertion to high current lines between ECU and assist motor (HCFIU) and faults to signals between ECU and RPS (MicroFIU).
Current Sensor	Measurement of phase current between ECU and assist motor. Built in Fault Insert Unit Box above.
Torque Sensor	Measurement of actual assist torque from assist motor.

1. Synchronous Actuator Motor: **SEW CMP63L/BK/KY/AK1H/SB1**

Table 4-10: Characteristics of actuator motor

Characteristic	Nameplate	Value	Unit
System Voltage	-	400	V
Rated Speed	n_N	4500	rpm
Standstill torque	M_0	7.10	Nm
Standstill current	I_0	6.9	A
Dynamic limit torque	M_{pk}	30.4	Nm
Maximum permitted motor current	I_{max}	41.4	A
Standstill torque with forced cooling fan	M_{0VR}	10.3	Nm
Standstill current with forced cooling fan	I_{0VR}	10	A
Mass	m	7.5	Kg
Mass moment of inertia of the motor	J_{mot}	$2.7 \cdot 10^{-4}$	kgm^2
Degree of protection	-	IP F/65	-

In this servo motor the magnetic brake (BK brake) is integrated. The BK brake is a DC operated permanent magnet brake that is released electrically and is applied using the magnetic force of the permanent magnet. When the BK brake is not powered, the pressure plate is forced against the magnet body by the force of permanent magnets, in which case the motor is braked. The BK brake can be remote controlled from software on host PC via CAN.
In this case the BK07 is used and its characteristics can be found in Table 4-11: Characteristics of BK07. To note is that the BK brake can only be used for zero-position control or in other words for position holding, not for slipping brake, otherwise it will cause wearing in the BK brake. It has to be ensured that the BK brake force is applied after the actuator motor stops.

Table 4-11: Characteristics of BK07

Characteristic	Nameplate	Value	Unit
Minimum static braking torque (holding torque) at 100 °C	M4, 100°C	7.1	Nm
Minimum averaged dynamic braking torque in case of emergency switching off at 100 °C	M1m, 100°C	3.9	Nm
Maximum dynamic braking torque in case of emergency switching off	M1max	12.8	Nm
Permitted braking work per braking operation	W_1	0.740	kJ
Permitted braking work per hour	W_2	14.8	kJ
Permitted total braking work (braking work until maintenance)	W_{insp}	1.48	10^3kJ
Power consumption of the coil	P	15.0	W
Brake response time	t_1	70	Ms
Brake application time	t_2	30	ms
Mass moment of inertia of the motor	J_{mot}	$2.7*10^{-4}$	kgm²
Degree of protection	-	IP F/65	-

2. Torque Sensor: **Lorenz Messtechnik DR-2212**

Table 4-12: Characteristics of torque sensor

Characteristic	Nameplate	Value	Unit
Range		±20	Nm
Inertia drive side		1.2e-5	kgm²
Inertia test side		9.9e-6	kgm²
Accuracy class		0,1	% f. s.
Repeatability (DIN 1319)		±0,02	%
Output signal		0..10	V
Sample rate		10	kSample/s
Reference temperature		23	°C
Service temperature range		0..60	°C

Limit torque (static)		40	Nm
Level of protection (DIN EN 60529)		IP50	

The torsionally stiff coupling from **mayr GmbH 951.321** is provided together with the torque sensor.

3. EPS assist motor

   The assist motor is provided by FAW with type number **FM01-YQ-1**.

4. HAN03 connector

   HAN03 connector: EPS ECU I/O signals, vehicle power (UBat)

5. Fault Insert Unit Box

   The Fault Insert Unit Box is located beside the assist motor on the upper side of the test bench. This box contains three current sensors, one HCFIU, one MicroFIU, two fuses (F1/F2, on top of FIU Box) and relevant connectors.

5.1 3x Current Sensor: **LEM HTA 100-S**

The three current sensors are used to measure the phase current between ECU and assist motor. The current values of these current sensors can be read in HIL rack through the connector HCFIU.

Table 4-13: Characteristics of current sensor

Characteristic	Nameplate	Value	Unit
Primary current measuring range	I_PM	-300…300	A
Primary nominal rms current	I_PN	100	A
Supply voltage	V_C	± 15	V
Output voltage @ ± I_PN	V_Out	± 4	V
Load Resistance	R_L	> 1 (T_A = 0 .. + 70°C)_ >3 (T_A = - 25 .. + 85°C)	kΩ
Ambient operating temperature	T_A	-25 … 85	°C
Frequency bandwidth	BW	DC .. 50	kHz
Accuracy @ I_PN, T_A = 25°C, @ ± 15 V		± 1	%

5.2 HCFIU (High Current Fault Insert Unit)

In order to do fault inserting tests for the three phase lines (U, V, W phase) between EPS ECU and assist motor, a high current relay box is constructed and installed directly below the EPS ECU. With this box it is possible to make circuit open tests with the 3 phases as well as short to GND or short to UBat tests. The relay box is controlled by M27 via 7 digital channels through the HCFIU connector.

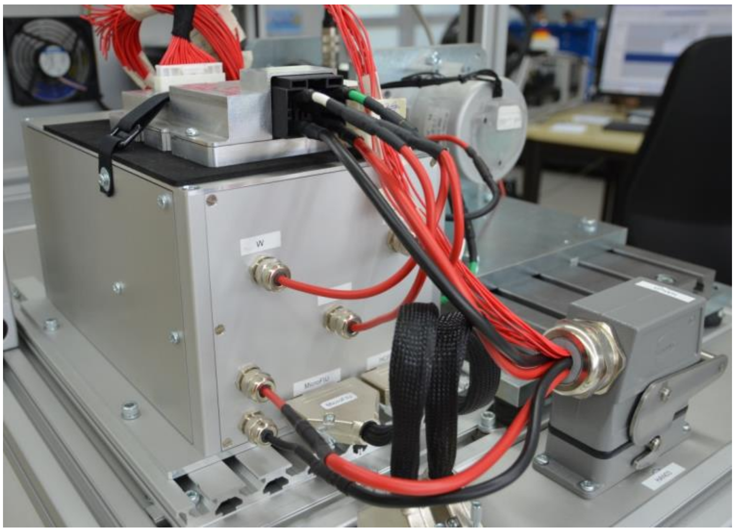


Figure 4-19: High Current FIU Box

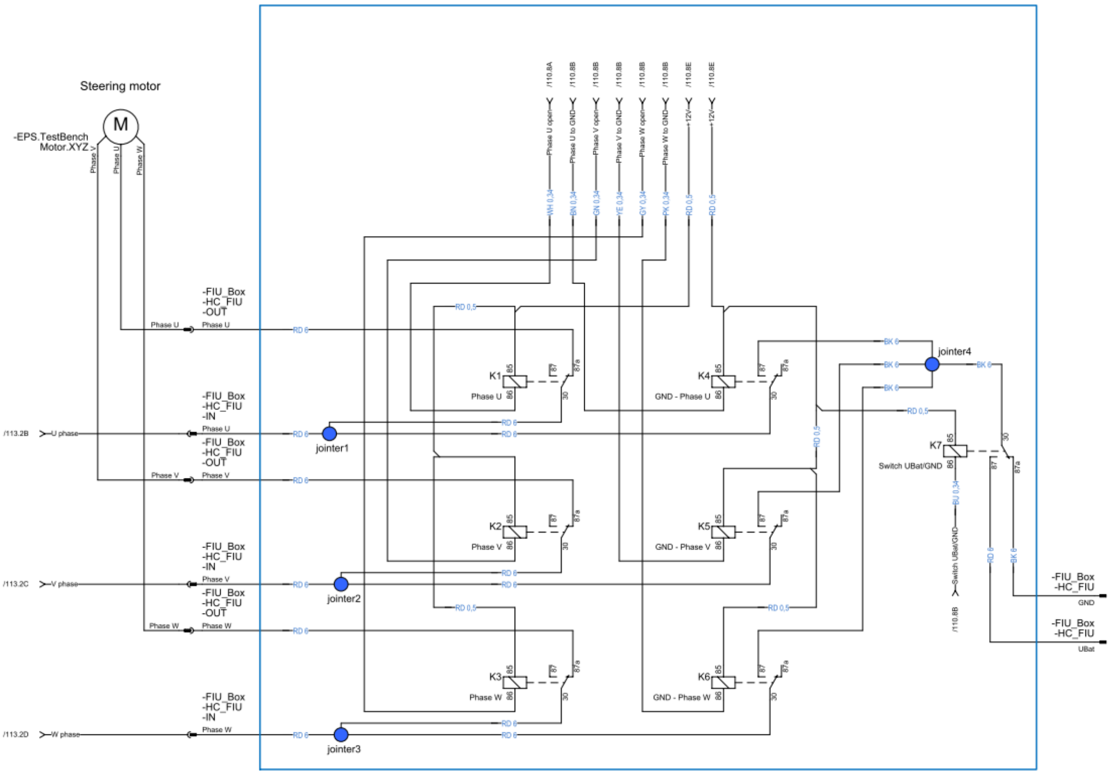


Figure 4-20: High Current FIU Box (schematic)

5.3 MicroFIU (Micro Fault Insert Unit)

The Rotor Position Sensor (RPS) is installed on the assist motor, in order to measure the rotor position of the assist motor and transfers this position information to the EPS ECU. The interface of the Motor Rotor Position Sensor includes: 4x SPI, 3x ABZ, 2x Power Supply, 1x PWM. According to the requirements from FAW, the SPI and ABZ signals shall be tested by inserting electrical faults.

Due to the high frequency characteristics of SPI and ABZ signals, their fault insertion tests are not realized via FailSafeTester in HIL rack but via a specific MicroFIU, in order to the keep the cable as short as possible.

The MicroFIU can perform following fault insert tests: circuit break, short to power supply (Ubat), short to ground. The MicroFIU is controlled via 21 channels from M27 Module through the MicroFIU connector.

The signals under test are wired into the MicroFIU box through connector XP3 and then through connector XS3 into the EPS ECU.

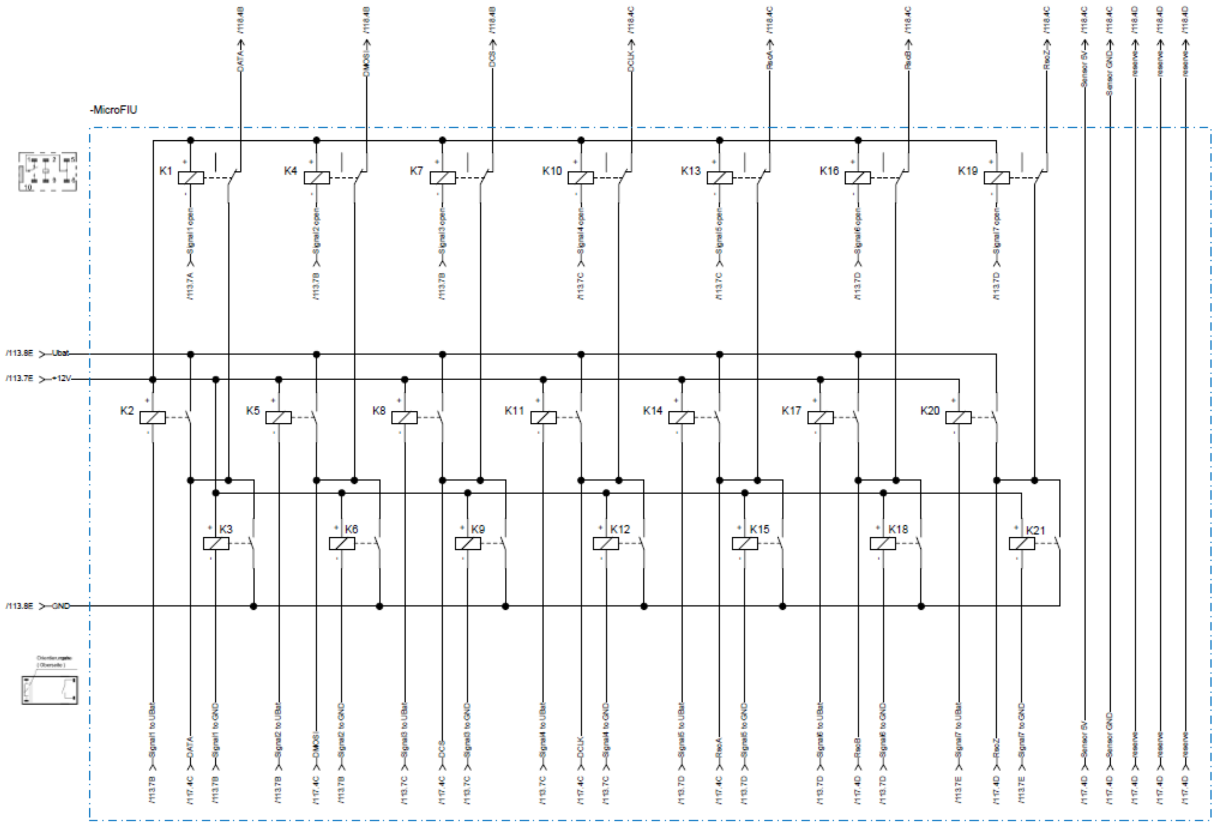


Figure 4-21: MicroFIU (schematic)

6. EPS ECU

   The EPS ECU is provided by FAW with type number **FAW-361205EPS-A101**.

7. Temperature Sensor and Transducer: **PT-100**

In order to make sure that the test bench working in an appropriate temperature range, we use several temperature sensors detecting the temperature of key devices and key areas.

There is already built-in temperature sensor in the SEW actuator motor. Its signal will be read.

The external temperature sensors are mounted at:

- Flange for assist motor (flange serves also as cooling body for assist motor)
- Brake resistor

Table 4-14: Characteristics of temperature sensor transducer

Characteristic	Nameplate	Value	Unit
Needed temperature sensor		PT100	
Power Supply		12…35V/DC	V
Output signal		0-10V or 4-20mA	
Accuracy		0.1	%
Measuring Range		0 – 150	°C
Operating temperature		0 - 50	°C
Level of protection		IP54	

Table 4-15: Characteristics of temperature sensor: PT100

Characteristic	Nameplate	Value	Unit
Switch type		2-conductor	
Measuring current		About 1	mA
Connection cable		Silicon cable	
Max. operating temperature		-50 – 200	°C
Level of protection		IP54	

4.3 SENSO-Wheel Package

4.3.1 SENSO-Wheel Package Hardware

The SENSO-Wheel package enables realistic simulation of physical effects and end stops. It provides full range force feedback for advanced steering applications.

The SENSO-Wheel package consists of:

- SENSO-Wheel SD-LC with steering wheel and tabletop rack (see Figure 4-22)
- SENSO-Wheel pedals (gas and brake pedals, see Figure 4-23)

Figure 4-22: SENSO-Wheel SD-LC with steering wheel and tabletop rack

Figure 4-23: SENSO-Wheel pedals (gas and brake pedals)

Table 4-16: Characteristics of SENSO-Wheel SD-LC

Characteristic	Nameplate	Value	Unit
Rated torque		7.50	Nm
Maximum torque		16.58	Nm
Torque resolution		0.03	VNm
Cogging torque		Very low	
Angle resolution		0.009° incr. + index	°
Gear ratio		Direct drive	-
Backlash		None	-
Maximum speed		>200	Rpm
Supply voltage		230VAC, 4A	-
Interface		1M (CAN)	baud
Cycle time		Normal mode 1 ms, basic mode 0.3 ms	ms
Weight (drive)		9.0	Kg
Motor dimensions		115x215	mm

The SENSO-Wheel SD-LC communicates with the HIL-Rack via CAN interface. It should be connected to the socket “SensoWheel” on the bottom front panel of HIL-Rack.

The pedals are robust and completely adjustable. Braking pedals are equipped with load cell technology, which enables the measurement of the pressure on the pedal rather than its position and, thus, conveys a realistic driving experience. The pedals are connected to the SENSO-Wheel controller in the SENSO-Wheel SD-LC and can be read out by CAN-Bus in the accustomed way.

4.3.2 Using SENSO-Wheel in Conjunction with EPS Test Bench

The Cockpit Package Pro, namely the CarMaker integration package for SENSO-Wheel Driver-in-the-Loop software for use with SENSO-Wheel input devices for steering as input for simulation, is delivered together with the CarMaker/HIL software.

If the SENSO-Wheel is used together with EPS test bench, then the internal friction and damping parameter of the SENSO-Wheel actuator controller should be used. This guarantees that the SENSO-Wheel works much more stable, even with the turn slip tires model.

4.4 Host PC

IPG Automotive provides a configured Host PC with Intel Core i5 and high performance graphic card. The operating system of Windows 7 Professional is installed. The CarMaker HIL/pro 5.0.3 for XENO is installed with a dongled license.

1 Monitor: LG 24”EB23, DVI 1920x1200

1 set of keyboard and mouse is also included.

5 Operating Instructions

5.1 Safety instructions

Before starting modification work on the EPS test bench, please make sure that the main switch and main circuit breaker are off

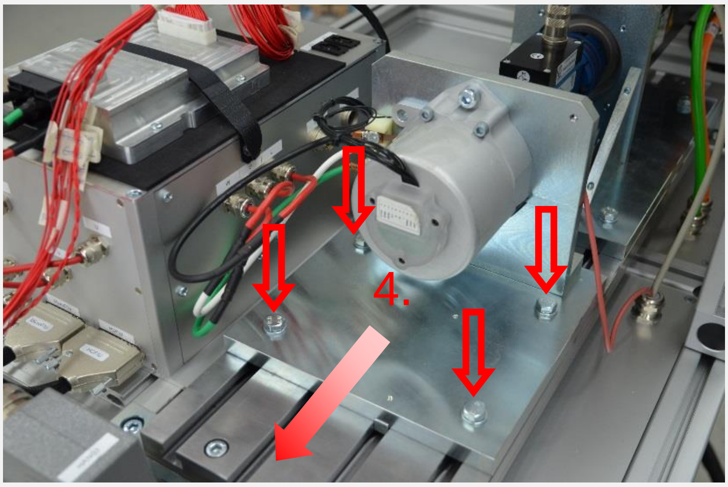
Only qualified personnel are authorized to install, startup or service the test bench.

Heavy parts may fall down after screws are opened and can cause damage to parts and injuries. Please act carefully respecting the corresponding manual.

Crushing hazard at all moving parts.

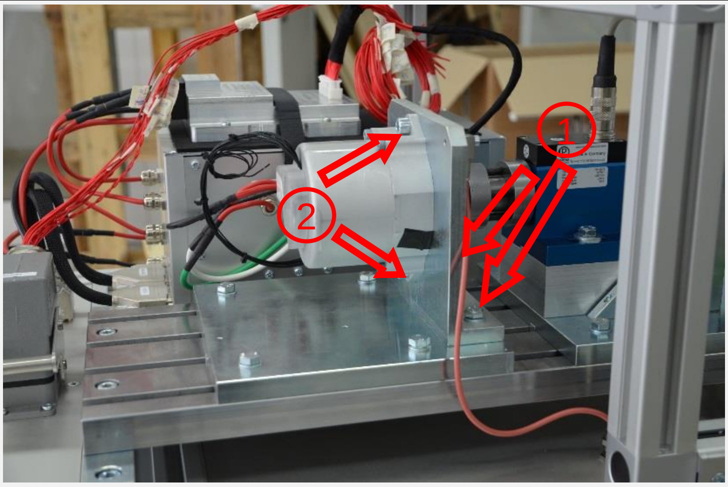
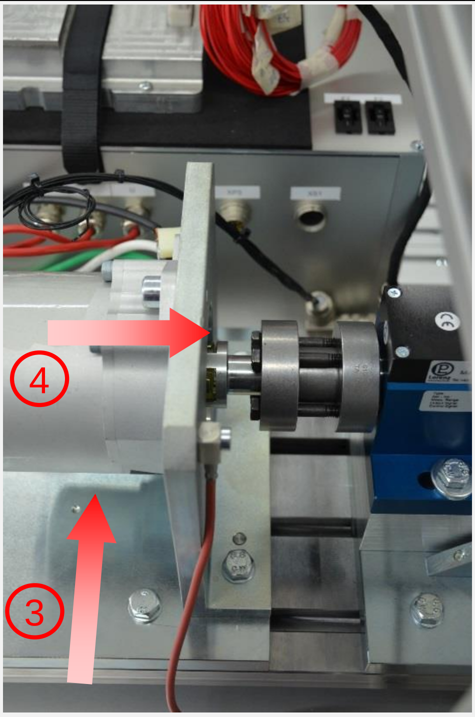
Always wear gloves while assembling and disassembling mechanical parts.

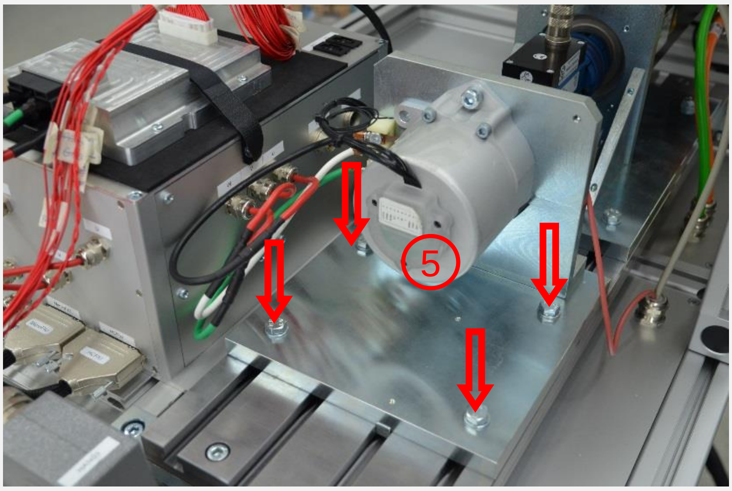
5.2 Removing the EPS assist motor



1. Switch off main switch at the HIL-Rack
2. Open the cover of EPS test bench
3. Disconnect the three EPS assist motor phase cables and the RPS connector at the micro FIU
4. Loosen the four screws and push the EPS mounting plate in the shown direction till the EPS motor coupling is detached
5. Loosen the EPS assist motor mounting screws and remove it

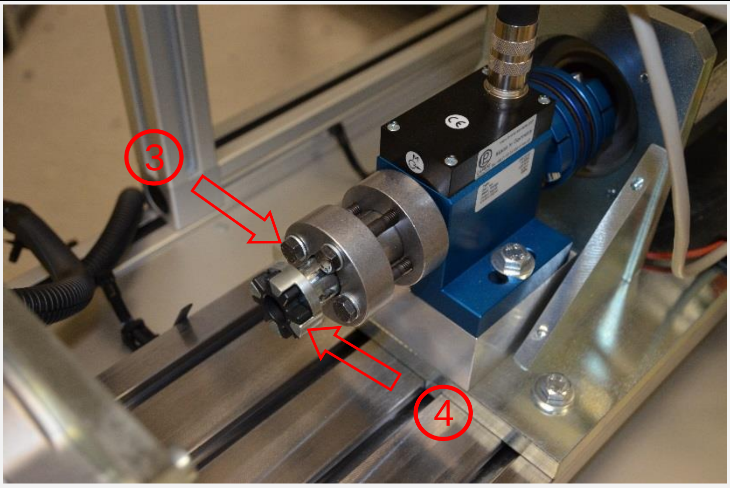
5.3 Install the EPS assist motor

	1. If required change the EPS mounting flange and tighten the two screws Torque: 25Nm 2. Install the EPS ECU and tighten the screws Torque: 25Nm
	3. Push the EPS mounting plate in the shown direction to align it with the servomotor / torque sensor unit 4. Push the EPS mounting plate till the EPS assist motor coupling is closed



5. Tighten the four screws of the EPS assist motor plate
   Torque: 25Nm
6. Connect the three EPS assist motor phase cables and the RPS connector at the micro FIU
7. Close the cover of EPS test bench

5.4 Change of the EPS Coupling

	1. Switch off main power from HIL-Rack 2. Detach the EPS assist motor (see chapter 5.2 step 4) 3. By holding the coupling adapter with one hand, loosen the four screws 4. Remove EPS coupling 5. Install the new EPS coupling **Hint: Push the EPS coupling and adapter up to the stop** 6. Tighten the screws while holding the coupling adapter with one hand to avoid damage to the torque sensor **Hint: Tighten the screws crossed-wise in several steps** Torque: 10-15Nm

5.5 Moving EPS Test Bench

The transportation of the EPS Test Bench requires a specific attention and must not be lifted using front or back handles. The front and back handles are only for pulling or pushing the EPS Test Bench on its wheels.

In case of lifting, please use a specific platform or lift to ensure the weight is on its four wheels or fit the whole body in once. The sides are made of plexiglass, so it is fragile and must not be pressed.

6 Software Documentation

6.1 Starting the Test Bench

Running up the test bench should only be conducted if all cables of EPS test bench and HIL-Rack are connected.

After an emergency shut off or a normal switch off, you have to wait one minute until the EPS test bench can be switched on. This avoids damage to the SEW inverter.

Starting up the Test Bench:

1) Make sure that <u>no</u> emergency stop button (1) is pressed. (Emergency stop LED off)

2) Turn the main switch to position ON. All three phase indicator LEDs should be on

3) Turn on the two emergency circuit switches. The main fuse can only be activated if the emergency switches are in position ON.

4) Put all fuses in ON position

5) Turn on the EPS test bench and HIL power

6) Make sure, RTU is switched on. If the real time system is not running, make sure that their switch on the back side is turned on. Therefore, open the door on the back.

7) Turn on the Host-PC and check if Ethernet network cable is connected to HIL-Rack

8) Start CarMaker-HIL on the Host-PC.

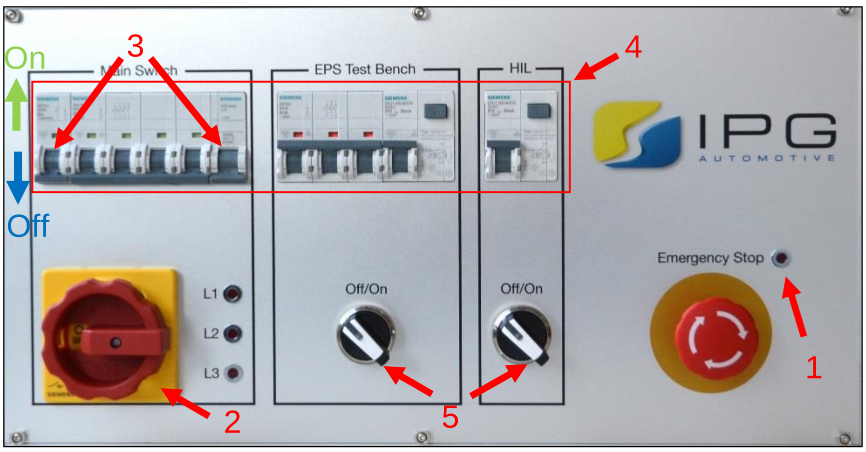


Figure 6-1: Starting the Power-Rack and HIL-Rack

9) Start the "*EPS Motor Control*" GUI by clicking "*File*" in the CarMaker main GUI and then "*EPS Motor Control*".

10) Activate the actuator motor by clicking on "*EPS Motor Activated*" in the upper part of the GUI. The button will be illuminated green, whereas the button "*EPS Motor Deactivated*" will be off. When an error occurs than click at the Reset button.

11) Load a TestRun and start the simulation using the main GUI.

Starting the simulation will automatically activate the actuator and deactivate the brake and their status light in the GUI will turn green, instead of red.

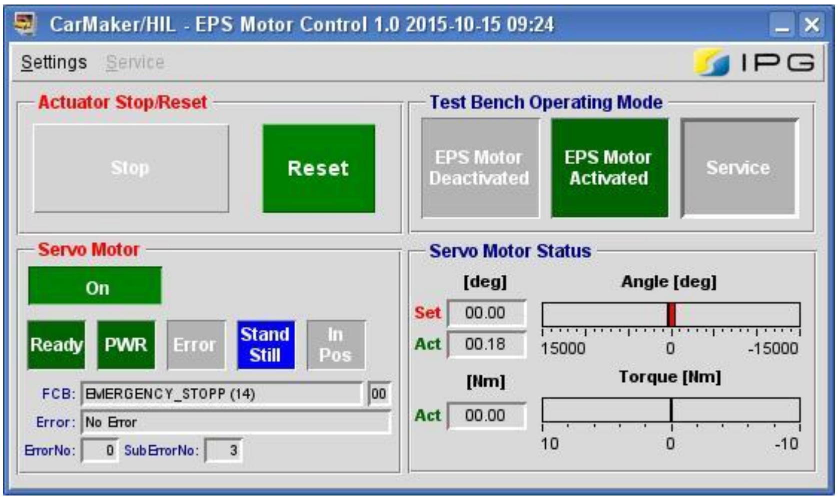


Figure 6-2: EPS Motor Control GUI

6.2 GUI Description

6.2.1 EPS Motor Control GUI

The "*EPS Motor Control*" GUI (see Figure 6-3) allows the user to control and monitor the EPS test bench. It is divided in in four fields which have the following functions:

The "**Actuator Stop/Reset**" field provides two buttons. One of the most important buttons is the "*Stop*" button. Pressing the big red button will immediately stop the actuator motor.

The function of this software button stopping the actuators is not identical to the function of the emergency stop buttons!

Clicking on the stop button will only stop the actuator, but every part will still be supplied electrically. Do not use this button before starting maintenance on the test bench.

With the "Reset" button the actuator inverter controller can be reset if an error occurred.

The "**Servo Motor**" field of the GUI shows the device status, functional and error status of the actuator inverter controller.

"On/Off" button:	Enables/disables the actuator inverter control
"Ready" light on:	Inverter control is ready for operation, No Error/Warning
"PWR" light on:	DC link voltage V_Z >= 100V
"Error" light on:	Inverter control is in an error state
"Stand Still" light on:	Actuator is in standstill
"In Pos" light on:	Shows that the actual actuator position value is in a predefined range to the set value.

FCB (Functional Control Block) is the SEW naming for the operation mode of the actuator motor. Depending on the settings and processes, the FCB can be for example "Position Control", "Speed Control" or "Emergency Stop". For more information about the FCB and errors please refer to the SEW control manuals.

If the inverter controller is in error state, the error fields shows the error with the corresponding error number and sub error number.

The light "*Stand Still*" shows if the corresponding actuator is not moving anymore and the light "*In Pos*" shows that the actual value is in a predefined range to the set value.

The "**Test Bench Operating Mode**" field contains three buttons. If the "EPS Motor Activated" button is active the actuator inverter controller goes to the "Position Control" mode when a TestRun is started, otherwise with "EPS Motor Deactivated" the controller stays in inhibit state.

By clicking the Service button it is possible to enter the service menu which is described in chapter 6.2.1.2.

The “**Servo Motor Status**” field gives more detailed information about the position and measured torque of the actuator motor. Actual and set position value as well as the measured torque are shown in separate fields. Additional a bar diagrams indicates the actuator motor position and measured torque.

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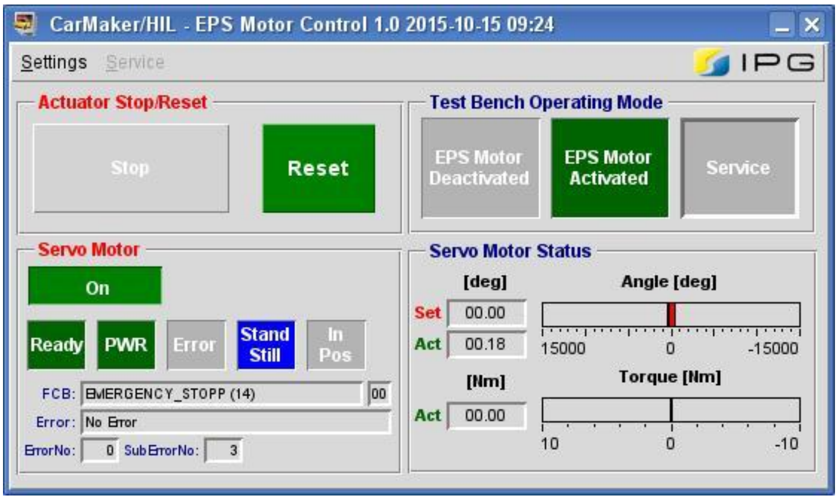

Figure 6-3: Steer TB Control GUI

6.2.1.1 Settings Actuator Motor

Clicking on the button “*Settings*” in the menu bar opens the “Actuator Motor *Settings*” GUI, which allows changing the actuator motor offsets and limits (see Figure 6-4).

Please notice that changes will have effect after the next start of a TestRun.

Figure 6-4: Settings EPS Actuators GUI

6.2.1.2 Service

Clicking the “*Service*” button activates the menu bar option “*Service*”. If the button is not activated, the menu bar button “*Service*” cannot be clicked and will be shown in grey.

Clicking the activated menu bar button shows the option:

Manual Control

Opening the “*Manual Control*” GUI (see Figure 6-5) allows turning the actuator motor by manual angle input or by using a roll bar.

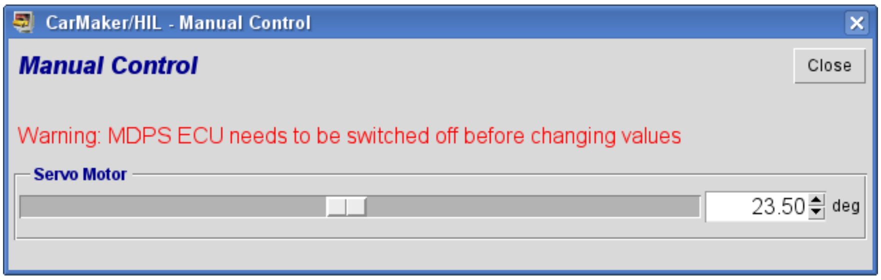

Figure 6-5: Manual Control GUI

Reference run servomotor

The reference run function saves the actual position of the servo motor as the zero position. This function should be used at the first start-up of the test bench or a change of the position sensor, servomotor.

6.2.2 Power Supply Control GUI

The Power Supply Control GUI (see Figure 6-6) allows the user to remote control the vehicle power supply. By clicking the PWR button the constant voltage mode is activated and the power supply outputs the predefined voltage. The output voltage and the current limit can be set by writing the value at the corresponding field and clicking the set button. Additional the actual output voltage and current are shown in the displays above. The CC/CV light shows if the power supply is in CV “Constant Voltage” or CC “Constant Current” mode.

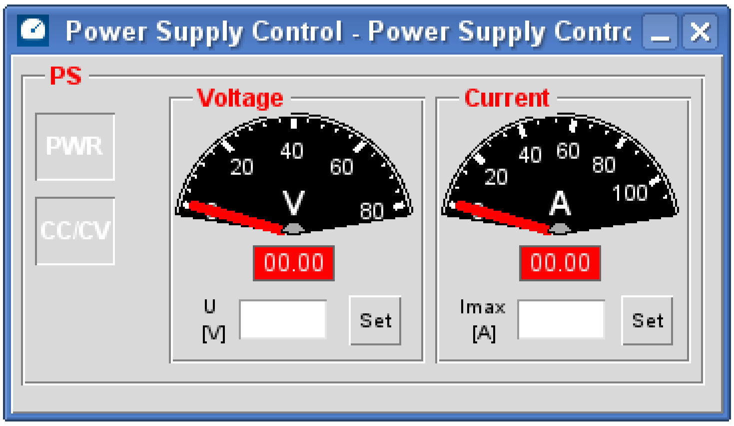

Figure 6-6: Power Supply Control GUI

6.2.3 FailSafeTester Extension / Fault Insert Unit GUI

With the FailSafeTester Extension GUI (see Figure 6-7) the active fault insert can be monitored or directly activated in the GUI. The upper part of the GUI shows the state of the relays at the HighCurrent FIU (HCFIU). By clicking the relays icons, the state of the relays can be changed.

The lower part of the GUI allows the user to monitor and control the MicroFIU (RPS Sensor). By clicking the buttons OPEN, 2UBat (short to UBat), 2GND (short to GND) the fault insert can be activated and the colour of the buttons turns to red. To avoid a short between UBat and GND the buttons or values 2UBat and 2GND are locked against each other.

With the “Reset all” buttons the activated fault inserts can be set to the default value.

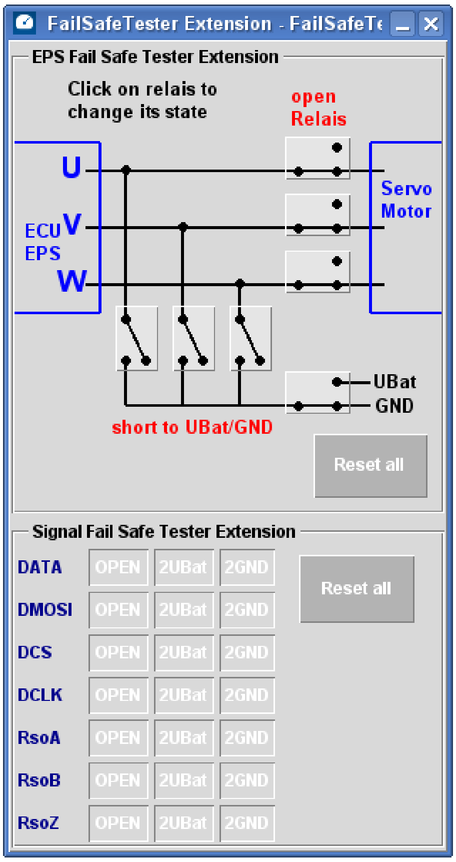

Figure 6-7: FailSafeTester Extension / Fault Insert Unit GUI

6.3 Turning off the Test Bench

Make sure, that no simulation is running and all data is saved correctly before switching off the test bench.

1) If a simulation is still running: stop the simulation by clicking the "Stop" button in the CarMaker GUI or wait until the end of the simulation.

   At the end of each simulation, the post-processing will ramp down the actuator positions back to zero.

2) Deactivate the test bench by clicking "*EPS Motor Deactivated*"

3) Switch off the Main Switch at HIL Rack

4) Close the CarMaker GUI and shut down the Host-PC

6.4 Error Handling

In case of an error occurring during the simulation, please check the error number and the error text in the "*EPS Motor Control*" GUI. Additional information might be given in the CarMaker log window. Solve the error and restart the actuator motor and restart the test bench.

If an error occurs frequently, please contact IPG Automotive GmbH.

6.5 User Accessible Quantities

6.5.1 EPS.Motor

Name UAQ	Name C-Code	Unit	Info
EPSMotor.EPSMotor.Acc	EPSMotor.EPSMotor.Acc	rad/s^2	EPS Motor rotational acceleration
EPSMotor.EPSMotor.Vel	EPSMotor.EPSMotor.Vel	rad/s	EPS Motor rotational speed
EPSMotor.EPSMotor.Ang	EPSMotor.EPSMotor.Ang	rad	EPS Motor angle
EPSMotor.EPSMotor.Trq	EPSMotor.EPSMotor.Trq	Nm	Measured EPS Motor torque by torque sensor
EPSMotor.FromEPS.Acc	EPSMotor.FromEPS.Acc	rad/s^2	Steering wheel rotational acceleration from ECU (not used)
EPSMotor.FromEPS.Vel	EPSMotor.FromEPS.Vel	rad/s	Steering wheel rotational speed from ECU (not used)
EPSMotor.FromEPS.Ang	EPSMotor.FromEPS.Ang	rad	Steering wheel angle from ECU (not used)
EPSMotor.FromEPS.Trq	EPSMotor.FromEPS.Trq	Nm	Steering wheel torque from ECU (not used)

EPSMotor.FromEPS.x are unified quantities (names) received from the EPS ECU CAN messages

6.5.2 IO.EPS

Name UAQ	Name C-Code	Unit	Info
IO.EPS.StWhlAngOutRaw	IO.EPS.StWhlAngOutRaw	rad	Steering wheel angle + 740° Offset for calculation of the TAS steering angle signals
IO.EPS.StWhlAngOut	IO.EPS.StWhlAngOut	rad	Steering wheel angle
IO.EPS.DiffAng	IO.EPS.DiffAng	rad	Difference angle between input and output shaft of the torsion bar
IO.EPS.TAS.PWM_T1	IO.EPS.TAS.PWM_T1	%	Simulated TAS sensor PWM signal T1: Duty Cycle
IO.EPS.TAS.PWM_T2	IO.EPS.TAS.PWM_T2	%	Simulated TAS sensor PWM signal T2: Duty Cycle
IO.EPS.TAS.Frq_T1	IO.EPS.TAS.Frq_T1	Hz	Simulated TAS sensor PWM signal T1: Frequency
IO.EPS.TAS.Frq_T2	IO.EPS.TAS.Frq_T2	Hz	Simulated TAS sensor PWM signal T2: Frequency
IO.EPS.PWM_P	IO.EPS.PWM_P	%	Simulated TAS sensor PWM signal P: Duty Cycle
IO.EPS.PWM_S	IO.EPS.PWM_S	%	Simulated TAS sensor PWM signal S: Duty Cycle

IO.EPS.Frq_P	IO.EPS.Frq_P	Hz	Simulated TAS sensor PWM signal P: Frequency
IO.EPS.Frq_S	IO.EPS.Frq_S	Hz	Simulated TAS sensor PWM signal S: Frequency
IO.EPS.SPA1	IO.EPS.SPA1	V	Analog input reserve 1 for EPS ECU
IO.EPS.SPA2	IO.EPS.SPA2	V	Analog input reserve 2 for EPS ECU
IO.EPS.SPA3	IO.EPS.SPA3	bool	Digital input reserve 1 for EPS ECU
IO.EPS.SPA4	IO.EPS.SPA4	bool	Digital input reserve 2 for EPS ECU
IO.EPS. TB_Manip.DiffAng.Activate	IO.EPS. TB_Manip.DiffAng.Activate	bool	Activates the torsion bar difference angle manipulation for open loop tests
IO. EPS. TB_Manip.DiffAng.Set	IO. EPS. TB_Manip.DiffAng.Set	rad	Manipulated torsion bar difference angle
IO. EPS. TB_Manip.Torque.Activate	IO. EPS. TB_Manip.Torque.Activate	bool	Activates the torsion bar torque manipulation for open loop tests
IO. EPS. TB_Manip. Torque.Set	IO. EPS. TB_Manip. Torque.Set	Nm	Manipulated torsion bar torque

6.5.3 IO.TB_Sensor

Name UAQ	Name C-Code	Unit	Info
IO.TB_Sensors.EPS_temp	IO.TB_Sensor.Temp_EPS	°C	Temperature at EPS mounting flange
IO.TB_Sensors.Brake_resistor_temp	IO.TB_Sensor.Temp_BR	°C	Temperature at EPS test bench braking resistor
IO.TB_Sensor.I_U	IO. TB_Sensor.I_U	A	Measured EPS assist motor U phase current
IO. TB_Sensor.I_V	IO. TB_Sensor.I_V	A	Measured EPS assist motor U phase current
IO. TB_Sensor.I_W	IO. TB_Sensor.I_W	A	Measured EPS assist motor U phase current

6.5.4 IO.PWR

Name UAQ	Name C-Code	Unit	Info
IO.PWR.IGN	IO.PWR.IGN	bool	Set ignition
IO.PWR.PS.PWR	IO.PWR.PS.PWR	bool	Set remote shut down (RSD) on/off
IO.PWR.PS.Uout	IO.PWR.PS.Vsel	V	Actual voltage
IO.PWR.PS.Iout	IO.PWR.PS.Csel	A	Actual current
IO.PWR.PS.Umon	IO.PWR.PS.Vmon	V	Remote set voltage
IO.PWR.PS.Imon	IO.PWR.PS.Cmon	A	Remote set current
IO.PWR.PS.OVP	IO.PWR.PS.OVP	bool	Over Voltage protection
IO.PWR.PS.CC_CV	IO.PWR.PS.CC_CV	bool	Over current protection

6.5.5 Fault Insert Unit

Name UAQ	Name C-Code	Unit	Info
IO.HC_FIU.SW_UBAT_GND	IO.Dout1.Ch[11]	bool	Switch between short 2GND(0) or 2UBAT(1)
IO.HC_FIU.Ph_U_CO	IO.Dout0. Ch[0]	bool	Set U phase line short to open
IO.HC_FIU.Ph_U2GND	IO.Dout0. Ch[1]	bool	Set U phase line short to GND

IO.HC_FIU.Ph_V_CO	IO.Dout0. Ch[2]	bool	Set V phase line short to open
IO.HC_FIU.Ph_V2GND	IO.Dout0. Ch[3]	bool	Set V phase line short to GND
IO.HC_FIU.Ph_W_CO	IO.Dout0. Ch[4]	bool	Set W phase line short to open
IO.HC_FIU.Ph_W2GND	IO.Dout0. Ch[5]	bool	Set W phase line short to GND
IO.uFIU.DATA_CO	IO.Dout0.Ch[6]	bool	Set DATA in RPS short to open
IO.uFIU.DATA_2UBat	IO.Dout0.Ch[7]	bool	Set DATA in RPS short to UBat
IO.uFIU.DATA_2GND	IO.Dout0.Ch[8]	bool	Set DATA in RPS short to GND
IO.uFIU.DMOSI_CO	IO.Dout0.Ch[9]	bool	Set MOSI in RPS short to open
IO.uFIU.DMOSI 2UBat	IO.Dout0.Ch[10]	bool	Set MOSI in RPS short to UBat
IO.uFIU.DMOSI2GND	IO.Dout0.Ch[11]	bool	Set MOSI in RPS short to GND
IO.uFIU.DSC_CO	IO.Dout0.Ch[12]	bool	Set CS in RPS short to open
IO.uFIU.DSC2UBat	IO.Dout0.Ch[13]	bool	Set CS in RPS short to UBat
IO.uFIU. DSC2GND	IO.Dout0.Ch[14]	bool	Set CS in RPS short to GND
IO.uFIU.DCLK_CO	IO.Dout0.Ch[15]	bool	Set CLK in RPS short to open
IO.uFIU.DCLK2UBat	IO.Dout1.Ch[0]	bool	Set CLK in RPS short to UBat
IO.uFIU.DCLK2GND	IO.Dout1.Ch[1]	bool	Set CLK in RPS short to GND
IO.uFIU.RsoA_CO	IO.Dout1.Ch[2]	bool	Set RsoA in RPS short to open
IO.uFIU.RsoA2UBat	IO.Dout1.Ch[3]	bool	Set RsoA in RPS short to UBat
IO.uFIU.RsoA _2GND	IO.Dout1.Ch[4]	bool	Set RsoA in RPS short to GND
IO.uFIU.RsoB_CO	IO.Dout1.Ch[5]	bool	Set RsoB in RPS short to open
IO.uFIU.RsoB2UBat	IO.Dout1.Ch[6]	bool	Set RsoB in RPS short to UBat
IO.uFIU.RsoB2GND	IO.Dout1.Ch[7]	bool	Set RsoB in RPS short to GND
IO.uFIU.RsoZ_CO	IO.Dout1.Ch[8]	bool	Set RsoZ in RPS short to open
IO.uFIU.RsoZ2UBat	IO.Dout1.Ch[9]	bool	Set RsoZ in RPS short to UBat
IO.uFIU.RsoZ2GND	IO.Dout1.Ch[10]	bool	Set RsoZ in RPS short to GND

6.5.6 IO.Analog In/Out

Name UAQ	Name C-Code	Unit	Info
IO.AnalogIn.In6 ... IO.AnalogIn.In7	IO.AD.Ch[6] ... IO.AD.Ch[7]	V	Analog In: 0 - 10V
IO.AnalogIn.In8 … IO.AnalogIn.In15	IO.AD.Ch[6] ... IO.AD.Ch[7]	V	Analog In: 0 - 30V
IO.AnalogOut_10V.out0 … IO.AnalogOut_10V.out 7	IO.DA.Ch[8] … IO.DA.Ch[15]	V	Analog Out: 0 – 10V
IO.AnalogOut_30V.out2 … IO.AnalogOut_30V.out7	IO.DA.Ch[2] … IO.DA.Ch[7]	V	Analog Out: 0 – 30V

6.5.7 IO.DigitalIn

Name UAQ	Name C-Code	Unit	Info
IO.DigitalIn.in0 ... IO.DigitalIn.in15	IO.Din.Ch[0] ... IO.Din.Ch[15]	bool	Digital In Channels

6.5.8 IO.RelayOut

Name UAQ	Name C-Code	Unit	Info
IO.RelayOut.out1 ... IO.RelayOut.out7	IO.Rel.Ch[1] ... IO.Rel.Ch[7]	bool	Set Relay

6.5.9 IO.PWMin

Name UAQ	Name C-Code	Unit	Info
IO.PWMin.Din0 ... IO.PWMin.Din3	IO.PWMin.b0 ... IO.PWMin.b3	bool	Digital In with M441 Modul
IO.PWMin.d2 … IO.PWMin.d9	IO.PWMin.Ch[2] ... IO.PWMin.Ch[9]	%	PWM Input duty cycle
IO.PWMin.d12 … IO.PWMin.d19	IO.PWMin.Ch[12] ... IO.PWMin.Ch[19]	%	PWM Input duty cycle
IO.PWMin.f2 … IO.PWMin.f9	IO.PWMin.Ch[2] ... IO.PWMin.Ch[9]	Hz	PWM Input frequency
IO.PWMin.f12 … IO.PWMin.f19	IO.PWMin.Ch[12] ... IO.PWMin.Ch[19]	Hz	PWM Input frequency

6.5.10 IO.PWMout

Name UAQ	Name C-Code	Unit	Info
IO.PWMout.Dout4	IO.PWMout.b2	bool	Digital Out with M441 Module
IO. PWMout.d9 … IO. PWMout.d15	IO.PWMout.d9 ... IO.PWMout.d15	%	PWM Output duty cycle
IO.PWMout.f9 … IO.PWMout.f15	IO.PWMout.f9 ... IO.PWMout.f15	Hz	PWM Output frequency

6.6 ECU Parameters

6.6.1 Steering Test Bench

Parameter Name	Unit	Info
EPSMotor.ParamsFName	-	Name of the EPS Test Bench parameter file (encrypted). Internal control parameters not user changeable.
EPSMotor.ShowDebugQuants	-	If set to 1, additional quantities for debugging of test bench functions are available in the IPG Control. Default: 0
EPSMotor.SaveServiceERGFile	-	

6.7 Fail Safe Tester Configuration

Card	Channel	Name	Description
0	0	RT1_CAN0_L	
0	1	RT1_CAN0_H	
0	2	RT1_CAN1_L	
0	3	RT1_CAN1_H	
0	4	RT1_CAN2_L	
0	5	RT1_CAN2_H	
0	6	RT1_CAN3_L	
0	7	RT1_CAN3_H	
1	0	RT4AnalogIn30V_0	
1	1	RT4AnalogIn30V_1	
1	2	RT4AnalogIn30V_2	
1	3	RT4AnalogIn30V_3	
1	4	RT4AnalogIn30V_4	
1	5	RT4AnalogIn30V_5	
1	6	RT4AnalogIn30V_6	
1	7	RT4AnalogIn30V_7	
2	0	RT4AnalogOut30V_0	
2	1	RT4AnalogOut30V_1	
2	2	RT4AnalogOut30V_2	
2	3	RT4AnalogOut30V_3	
2	4	RT4AnalogOut30V_4	

2	5	RT4AnalogOut30V_5	
2	6	RT4AnalogOut30V_6	
2	7	RT4AnalogOut30V_7	
3	0	RT8_PWMDig_In0	
3	1	RT8_PWMDig_In1	
3	2	RT8_PWM_In2	
3	3	RT8_PWM_In3	
3	4	RT8_PWM_In4	
3	5	RT8_PWM_In5	
3	6	RT8_PWM_In6	
3	7	RT8_PWM_In7	
4	0	RT8_PWM_In8	
4	1	RT8_PWM_In9	
4	2	RT7Relay_OutIgnition	
4	3	RT10PWMDig_Out0	
4	4	RT10PWMDig_Out1	
4	5	RT10PWMDig_Out2	
4	6	RT10PWM_out3	
4	7	RT10PWM_out4	
5	0	RT10PWM_out5	
5	1	RT10PWM_out6	
5	2	RT10PWM_out7	
5	3	RT10PWM_out8	
5	4	RT10PWM_out9	
5	5	RT10PWM_out10	
5	6	RT10PWMSENT_out11	
5	7	RT10PWMSENT_out12	

7 Wiring diagram/ IO Documentation

For IO documentation please refer to **IO.pdf** document.

For information about the connectors (housing, pins, pressing tools, etc.) used in the EPS-in-the-Loop test bench in case of purchasing spare parts or manufacturing customer adapters, please refer to **Material_List.pdf** document.

For the information to adapter cable for ECU (FAW-361205EPS-A101) and motor (FM01-YQ-1) please refer to **IO_Adapter1.pdf** document.