MACCON
MOTION UNDER CONTROL

Control-Box

Preliminary Data Sheet Rev.3

Control-Box

- Flexible FPGA-based Controller-Concept
- Multiple Communication Interfaces
- Up to 8 Half-Bridges addressable
- Two Position-Sensor Interface-Slots
- Two Universal I/O Interface-Slots
- LED-Display for Error-Codes
- Speed-Potentiometer

Description:

The MACCON Control-Box is a highly flexible controller-platform for drive-applications. Combined with other MACCON standard modules for converters, it offers a plug and play hardware concept for unusual topologies or difficult mounting space requirements. This concept allows designing customized converters with minimum engineering-effort in short delivery times.

Application software can be easily generated with the HDL-coder from a proven Matlab/Simulink simulation without deeper knowledge of internal hardware details or VHDL programming skills.

- **Large FPGA core** combined with 64MByte parallel flash and 32MByte SDRAM offers a powerful and flexible solution, sufficient for independent dual-motor-drive applications.
- **Multiple communication interfaces** for Ethernet/EtherCAT, CAN, RS232, RS422/RS485 cover most requirements for industrial and automotive applications.
- **Eight half-bridge connectors** can be used for complex single-motor applications or for medium complex dual motor applications. These connectors are compatible with the MACCON gate driver for EconoDUAL IGBT-modules and the MACCON air cooled half-bridge power block. Each connector supports signals for driver supply, half-bridge gate drive, gate failure, temperature signal, phase current signal and fan supply on a small 10-pole ribbon-cable connector. The fan supply for all eight connectors comes from the same source, which can be regulated depending on the IGBT-module with the actual highest baseplate temperature. This feature reduces the noise and the current consumption of the fans to a minimum.

- **Two internal half-seize expansion card slots with one 15-pin DSUB-connector each at the front side: Available is a universal I/O-interface card** with 2 digital inputs, 2 digital outputs, 2 differential analog inputs, 1 analog +/-10V output and 2 PT100 temperature sensor inputs. Maximum of two cards can be factory-configured per box.
  Custom expansion cards can be developed on request.

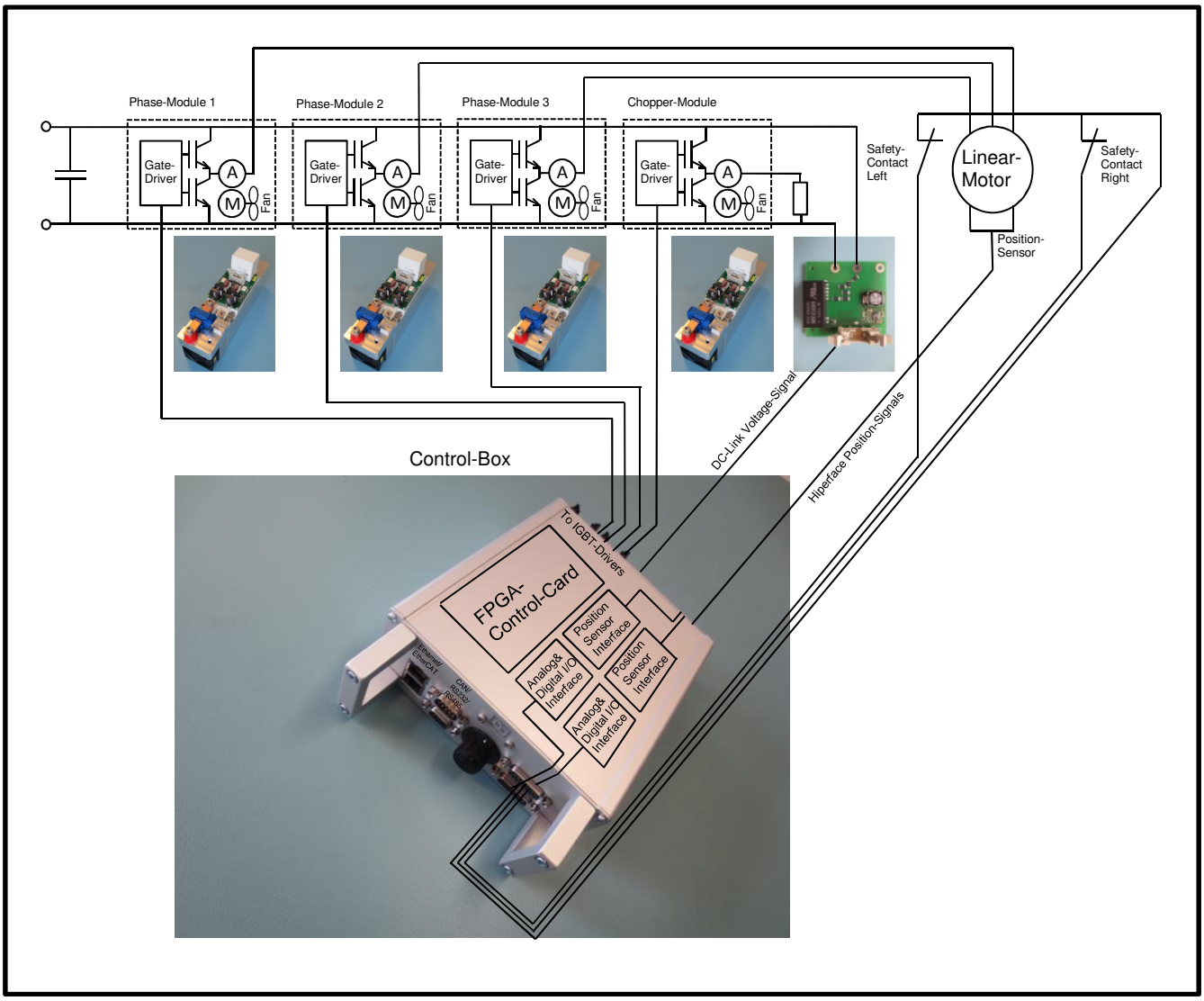
- **Two internal full-seize expansion card slots with one 25-pin DSUB-connector each at the back side: Available is a universal position sensor interface card**. Each card supports resolvers, encoders and Hiperface sensors, two PT100 temperature sensors and one PTC thermal-switch. For a dual motor application with two cards, different position sensors can be supported.
  Custom expansion cards can be developed on request.
  All sensor signals need to be double or reinforced isolated from high voltage parts inside or around the motor!

- **Signal connector for DC-Link voltage and current** is compatible with the MACCON isolated voltage sensor module to measure the DC-link voltage and offers also the possibility to connect an external 5V current sensor to measure the DC-link current.

- **Strong isolated 24V supply** can prevent ground loops or significant voltage drop on signal ground when the negative supply input gets a separate cable to the source. The large input voltage range fulfills 60Vpk railway requirements and is reverse polarity protected. The box provides sufficient power to drive eight half-bridges with 4W/Gate drivers plus the fans from eight MACCON half-bridge blocks. For air-cooled systems, there is nearly no limitation from the supply or gate driver side to reach 10kHz or higher PWM frequency, because the switching losses inside the IGBTs for these frequencies drive the air-cooling system into the limit. The controller has enough power to drive a liquid cooled power stage at higher PWM frequencies.

- **Speed-potentiometer and LED-displa**y for initial bring-up or manual debug. During these design phases, manual control and one-digit error code display might be very helpful.

Application-Example:



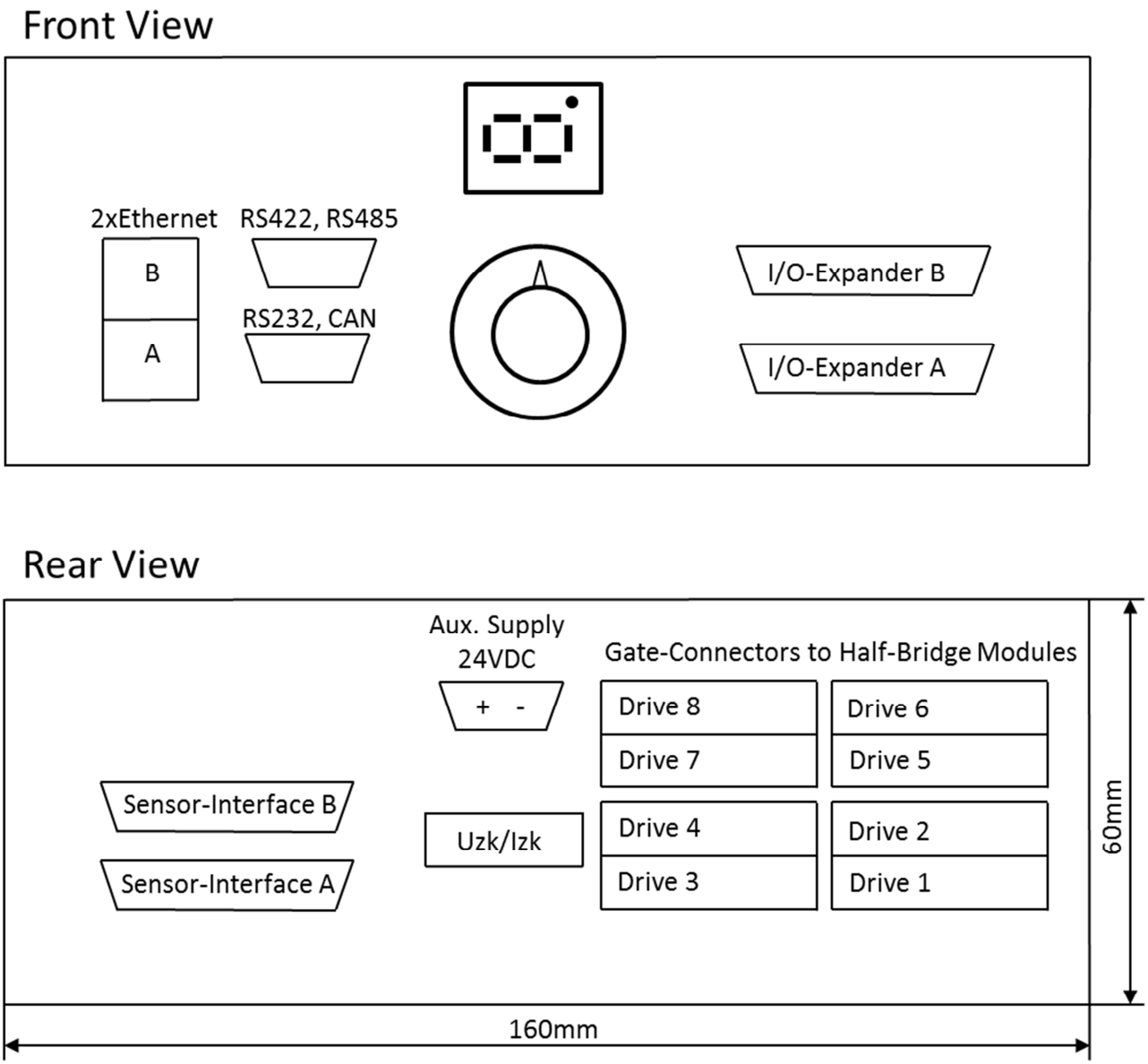
Application-Example of a Three-Phase Linear Motor Drive-System with Hiperface Position-Senso

Electrical Characteristics:

Parameter	min	typ	max	Unit
DC Supply Voltage	18	24	60	V
Quiescent Current: No Load, 24VDC, 1xResolver Card, 2x I/O-Expander Cards		320		mA
Internal input fuse		10		A
FPGA Logic Elements		75408		
Parallel Flash		64		MByte
SDRAM		32		MByte
Dimension Width		160		mm
Dimension Height		60		mm
Dimension Depth		245		mm
Ambient Temperature at Free Air Convection Full Load 8 Half-Bridges (2x4W)	-40		+60	℃
Storage Temperature and Powered No-Load Temperature	-40		+80	℃

Parameter Table

Connector Definition:



Potentiometer and 7-Segment Display

The potentiometer has a detent in middle position. It can be used for speed control in both directions, for example.

The 7-Segment LED-Display can be used for error-codes, for example.

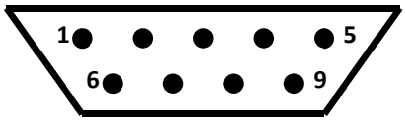
Both, potentiometer and 7-Segment LED-Display are NOT covered by the default software. They can be included in customer specific software.

Communication Interface RS232/CAN

This interface combines RS232 and CAN on a common connector to save mounting space on the front panel to keep the dimensions of the control-box small.
CAN can be plugged directly from the pinout.

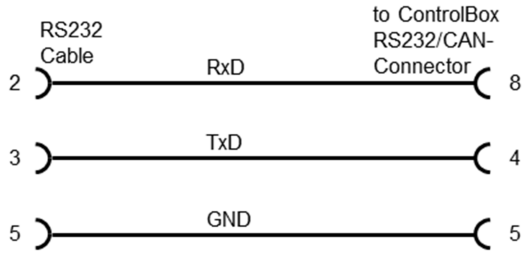
Please do NOT plug the RS232 directly! Direct plugging of RS232 without adapter might damage the interface! Each control-box will be delivered with one RS232-Adapter. Please check the direction of the adapter before use: The "Box" side needs to be plugged into the control-box, the "Cable" side connects the cable to the RS232 host.

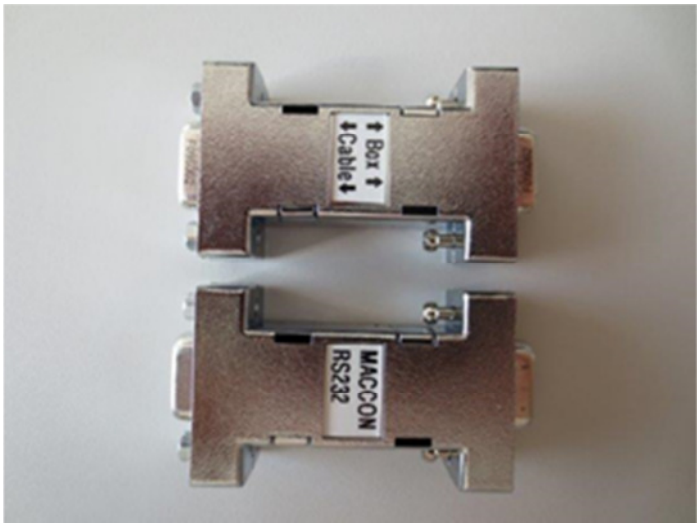
CAN and RS232 use a common GND, but this common GND is galvanically isolated from the internal controller GND to reduce common mode noise problems. This isolation is just a functional isolation, suitable for low voltage applications only!



Connector Pin	Signal	Description
1	n.c.	
2	CAN_L	
3	GND_ISO	
4	RS232 TxD	
5	GND	
6	n.c.	
7	CAN_H	
8	RS232 RxD	
9	n.c.	

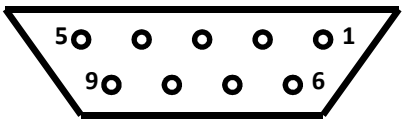
For RS232-applications, the following D-SUB cable adapter 9-pin female to 9-pin female must be used:





Communication Interface RS422/RS485

This interface combines RS422 and RS485 on a common connector.



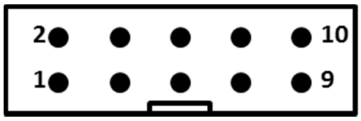
Connector Pin	Signal	Description
1	RxD-	
2	RxD+	
3	TxD+	
4	TxD-	
5	GND	
6	CTS-	
7	CTS+	
8	RTS+	
9	RTS-	

RJ45 Connectors for Ethernet/EtherCAT

Currently, Ethernet and EtherCAT are NOT covered by the default software.
EtherCAT is intellectual property of Beckhoff. If the customer requests a MACinverter with one fix software custom-programmed from MACCON for a specific application, a licence for EtherCAT might not be required. In most cases, the customer needs to use the open software platform flexibility to create own software solutions. If EtherCAT is required in combination with full software flexibility, please contact MACCON to find the optimized license model for EtherCAT.

Half-Bridge Gate Interface Connector for Modular Power Stage

This interface contacts the modular half-bridge power modules. Up to 8 modules are addressable including their auxiliary signals like phase current, temperature and fan supply. The fans are regulated to the highest module temperature independent on the slot location of the module with the highest temperature.
SGND and PGND are connected together inside the control-box. GND-Separation in the ribbon-cable is mandatory.



Connector Pin	Signal	Description
1	Vcc 15V	Supply Voltage
2	Failure	Open Collector pulls Signal always to GND at Normal Operation (Fail Safe)
3	PGND	Power-GND for Vcc and FAN
4	Current	Current Signal Input for Connection of External Current Sensors
5	PGND	Power-GND for Vcc and FAN
6	Drive	Drive = High, HS-IGBT is conducting, Drive = Low, the LS-IGBT is conducting
7	SGND	Signal-GND for Enable, Drive, Failure, Current, Temperature
8	Enable	When Enable is Low, both IGBTs are blocking
9	Temperature Signal	Analog Voltage Input for the Isolated Baseplate Temperature Signal
10	FAN	Fan Supply 12V/300mA max, can be regulated with the Measured Temperature

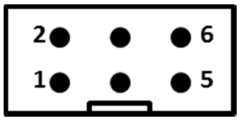
Signal Table for 10-Pole Gate-Drive Ribbon Cable Connector

Uzk/Izk Interface

This interface allows connection of:

- an external isolation amplifier to measure the DC-link voltage (e.g. the Isolated Voltage Sensor from MACCON)
- an external current sensor to measure the DC-link current

Voltage and current sensor use the same Vcc and GND from the inside view of the Control-Box.



Connector Pin	Signal	Description
1	Vcc 5V	Supply Voltage Output for Current Sensor
2	Current	Signal Input for Connection of External Current Sensor: 2,5V +/-2,5V
3	GND	GND for Current Sensor
4	Vcc 5V	Supply Voltage Output for Voltage Sensor
5	Voltage	Signal Input for Connection of External Voltage Sensor: 0V…5V
6	GND	GND for Voltage Sensor

Signal Table for 6-Pole DC-Link Voltage and Current Ribbon Cable Connector

Optional Universal I/O Interface

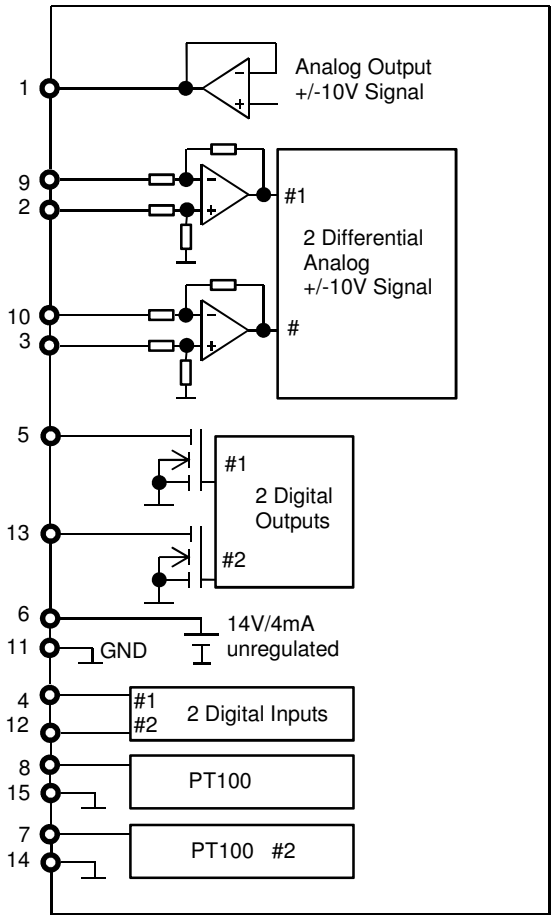
The control-box has two expansion slots for small expansion-cards. Each slot is connected with one 15-pole connector at the communication-side (front-side) of the box.

Up to two universal I/O interfaces per box can be factory-mounted inside the control-box.

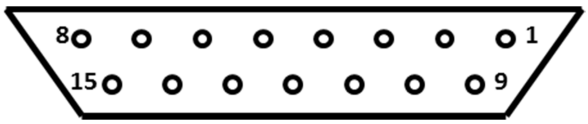
One universal I/O interface can be used to integrate the box into a pure analog regulation control system or additional functionality around the drive can be realized without a separate programmable logic controller (PLC). This can be, for example, reading external command-switches, temperature sensors, driving a precharge-relay for the DC-link or driving an external speed-gauge.

The interface card provides the following resources:

- 2 Digital Inputs
- 2 Digital Open Drain Outputs
- 2 Analog Inputs (+/-10V)
- 1 Analog Output (+/-10V)
- 2 PT100 Inputs
- 1 unregulated 14V/4mA Voltage Source



Block-Diagram of the Universal I/O-Interface



Connector Pin	Signal	Description
1	Analog OUT	+/-10V Analog Output
2	Analog_IN_1+	Positive Input Terminal of Differential +/-10V Analog Input Number 1
3	Analog_IN_2+	Positive Input Terminal of Differential +/-10V Analog Input Number 2
4	Digital_IN_1	Digital Input Number 1
5	Digital_OUT_1	Open Drain Digital Output Number 1
6	14V/4mA	Unregulated Short Circuit Protected 14V/4mA Auxiliary Supply
7	PT100_2	PT100_2 Signal
8	PT100_1	PT100_1 Signal
9	Analog_IN_1-	Negative Input Terminal of Differential +/-10V Analog Input Number 1
10	Analog_IN_2-	Negative Input Terminal of Differential +/-10V Analog Input Number 2
11	GND	GND
12	Digital_IN_2	Digital Input Number 2
13	Digital_OUT_2	Open Drain Digital Output Number 2
14	PT100_2_RTN	Return Path for PT100_2
15	PT100_1_RTN	Return Path for PT100_1

Signal Table for 15-Pole SUB-D Connector for Universal I/O-Interface

Warning:

External signals like temperature signals from temperature sensors inside a motor need to be double or reinforced isolated from dangerous voltages according to DIN EN 61800-5-1. The type of isolation needs to be explicit expressed in the specification of the motor or confirmed in written form from the manufacturer together with test voltage, working voltage and DIN EN 61800-5-1 confirmation! DIN EN 61800-5-1 defines minimum isolation thickness, creepage- and clearance distances and other important basics for electric drive systems with variable speed control. Just a defined test voltage, without the information of the isolation classification (basic, double or reinforced) and the DIN EN 61800-5-1 confirmation, is not sufficient for a safe system, even when the test voltage would be high enough for the application!

Optional Resolver-Encoder Interface

The control-box has two expansion slots for big expansion-cards. Each slot is connected with one 25-pole connector at the motor-side (back-side) of the box.

Up to two resolver-encoder interfaces per box can be factory-mounted inside the control-box.

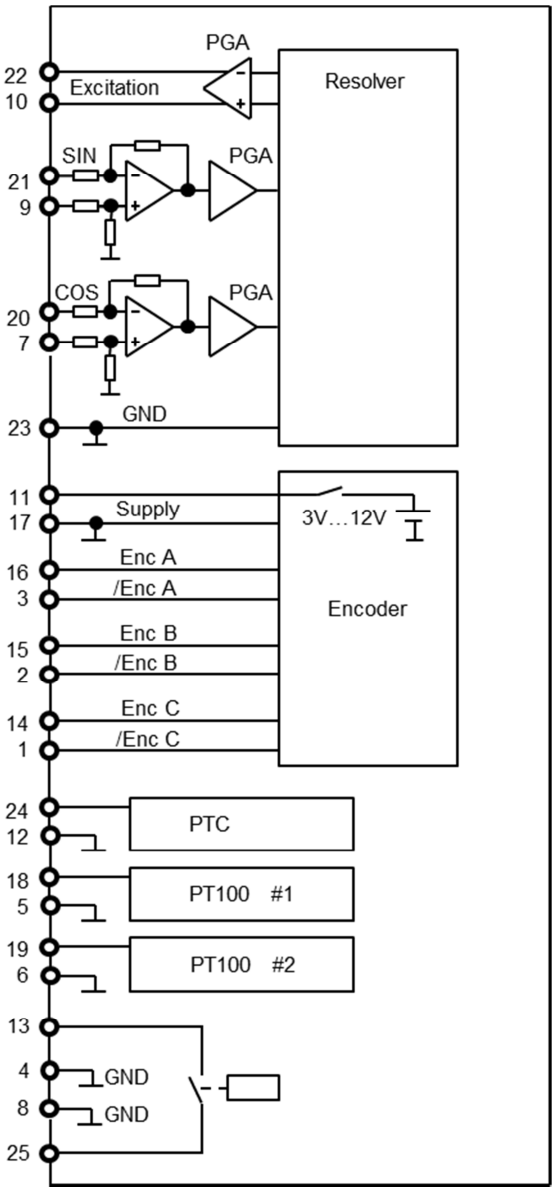
The analog and digital resources of one resolver-encoder interface can be used to connect a resolver, an encoder, both, or in mixed signal mode for Hiperface.

Wide range signal analog frontends allow the use and calibration of multiple sensors from different manufacturers.

Two PT100 and one PTC input provide broad temperature supervision possibilities of the motor.

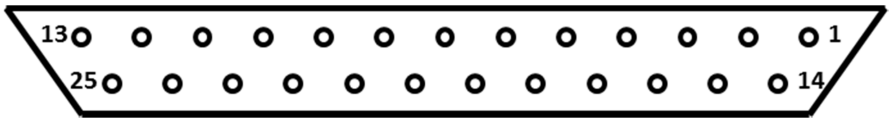
A 24V/1A relay output can be used to control an electromechanical brake, for example.

All sensor signals need to be double or reinforced isolated according to DIN EN 61800-5-1 from high voltage parts like motor windings!



Block-Diagram of the Universal I/O-Interface (PGA = Programmable Gain Amplifier)

Optional Resolver-Encoder Interface: Connector: Signal to pin assignment



Connector Pin	Signal	Description
1	/ENC C	Inverting Encoder C Signal
2	/ENC B	Inverting Encoder B Signal
3	/ENC A	Inverting Encoder A Signal
4	GND	GND
5	PT100_1_RTN	Return Path for PT100_1
6	PT100_2_RTN	Return Path for PT100_2
7	COS	From Positive Terminal of Resolver Cosinus Signal Coil
8	GND	GND
9	SIN	From Positive Terminal of Resolver Sinus Signal Coil
10	EXC	To Positive Terminal of Resolver Excitation Coil
11	Supply	Programmable DC-Supply for Digital Sensors (3VDC…12VDC)
12	PTC_RTN	Return Path for the PTC Sensor
13	Brake1	24V/1A Relay Contact for External Electromechanical Brake
14	ENC C	Encoder C Signal
15	ENC B	Encoder B Signal
16	ENC A	Encoder A Signal
17	GND	GND
18	PT100_1	PT100_1 Signal
19	PT100_2	PT100_2 Signal
20	/COS	From Negative Terminal of Resolver Cosinus Signal Coil
21	/SIN	From Negative Terminal of Resolver Sinus Signal Coil
22	/EXC	To Negative Terminal of Resolver Excitation Coil
23	GND	GND
24	PTC	PTC Signal from Thermal Motor PTC Resistor
25	Brake2	24V/1A Relay Contact for External Electromechanical Brake

Signal Table for 25-Pole SUB-D Connector for Resolver-Encoder Interface

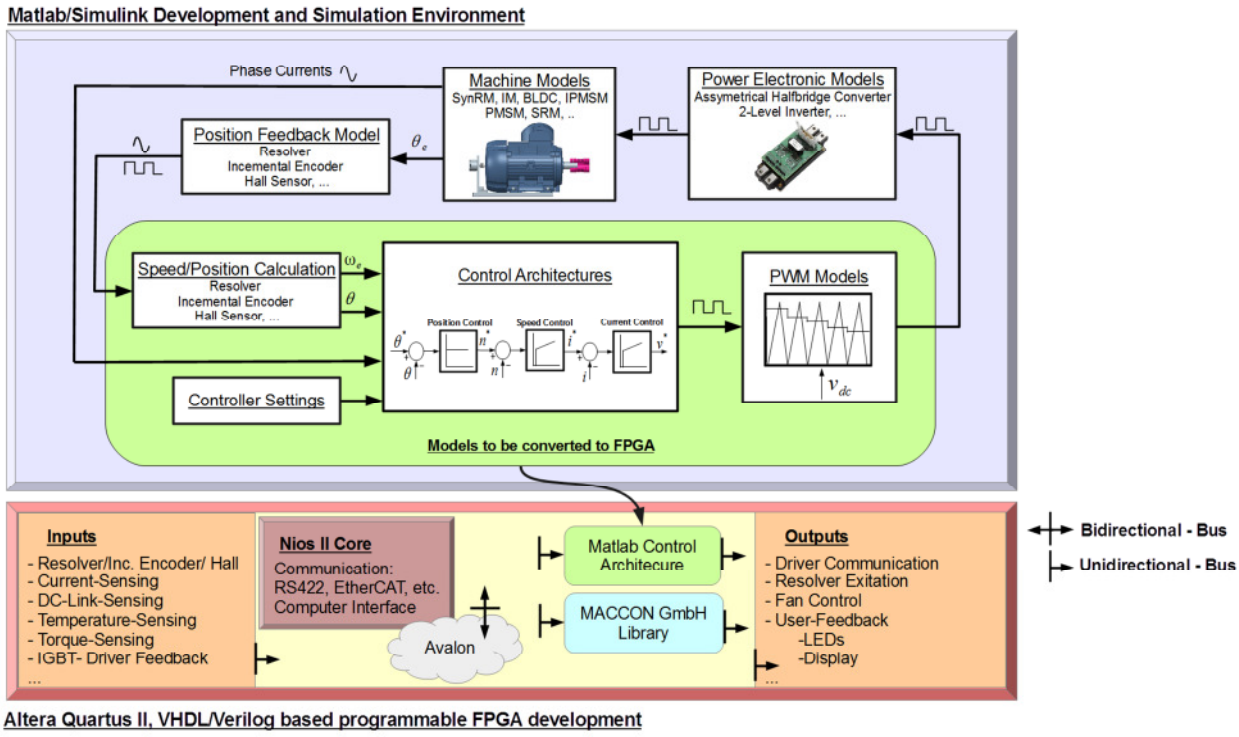
Rapid Prototyping Software Platform

For the software concept, the platform requirements for rapid prototyping designs are also valid. Hardware and software need to merge to a uniform platform. The software development can also be done without detailed basic knowledge of all hardware details. Software development can be done in three steps:

- Simulation in Matlab/Simulink: Like in hardware, also for the simulation model proven blocks can be configured like type of motor, power-stage, position feedback-sensor, PWM-model and other. This ensures easy development of the control-model combined with the high confidence of simulated functionality in an early stage of the project.

- Transformation of the proven simulation model into VHDL-code with an automatic tool called HDL-Coder ensures efficient code transformation with minimum effort and a minimum failure rate. Based on the architecture of the proven simulation model, executable control software is generated.

- Tests on a real hardware system to ensure reliable functionality under all circumstances. This task takes a lot of effort to deliver a high quality system and must not be underestimated. Combined with the preparation of the two previous development steps, the total software development effort is very low.



Rapid Prototyping Architecture of Control-Algorithm using Matlab/Simulink

The grey area shows the whole Matlab/Simulink simulation area without any real hardware. The embedded green area will be transformed into VHDL-code and programmed into the FPGA on the real hardware platform.

The NIOS II Core is an embedded microcontroller, which is available as standard core for FPGAs.