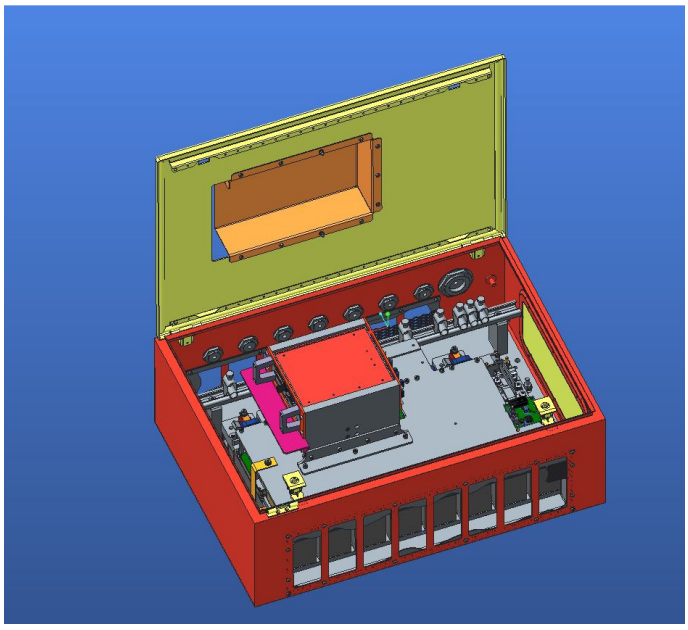
MACCON
MOTION UNDER CONTROL

MACinverter

Preliminary Data Sheet Rev.2



- Flexible FPGA-based Controller-Concept
- Simulation Models transformable into executable HDL-Code
- Multiple Communication Interfaces
- Up to 8 Half-Bridges addressable
- Three-Phase Rectifier Block available
- Two Position-Sensor Interface-Slots allow independent Control of two Motors
- Two Universal I/O Interface-Slots
- Regulated Fans for reduced Noise

MACinverter, Full-Configuration: Rectifier plus 7 Half-Bridges

Description:

The MACinverter is a highly flexible controller-platform for motor drive-applications. 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. A large choice of proven single hardware and software functional blocks can be combined individually to build a custom motor drive system, or are available as independent elements to solve a partial problem in a Non-MACCON Converter.

Examples for the functional hardware blocks are the control-box, the IGBT gate-driver, the modular fan-cooled IGBT half-bridge power-stage and the isolated DC-link voltage sensor. Individual detailed datasheets for each block can be found at the MACCON website:

https://www.maccon.de/antriebselektronik/maccon/macinverter.html

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. This offers a highly efficient, easy to use software concept. A large software library provides proven solutions for many applications.

Compared with complex hardware in the loop systems, the MACinverter acts directly as target system without the need of large external high performance computers.

The MACinverter platform has been developed based on more of 30 years' experience in the field of custom specific drives combined with the latest technology in control hardware, sensor and communication interface technology to address most specific drive solutions in automotive, defense or industrial applications or also in motor test benches.

Features:

- **Eight power-slots** for IGBT half-bridges or a three phase rectifier offer the flexibility to build the suitable power-stage topology for nearly all motor drive applications. For reluctance motors, two half-bridge blocks can be easily combined to a motor string driver. Even two independent three-phase motor drives on the same DC-bus are possible with the choice of two motor feedback cards in the controller.

- **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. All of these interfaces are direct parts of the control-box. There is no need to choose an option card.

- **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 universal I/O-interface slots:** Available are plug-in cards with 2 digital inputs, 2 digital outputs, 2 differential analog inputs, 1 analog +/-10V output and 2 PT100 inputs combined on one card. Maximum of two cards can be factory-configured.

- **Two position sensor interface slots** are designed as independent plug-in modules. For a dual motor application, different position sensors can be internally factory-mounted, if required. The first available universal sensor interface card can read resolvers, encoders and Hiperface sensors. Also two PT100 and one PTC thermal-switch can be connected. 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.

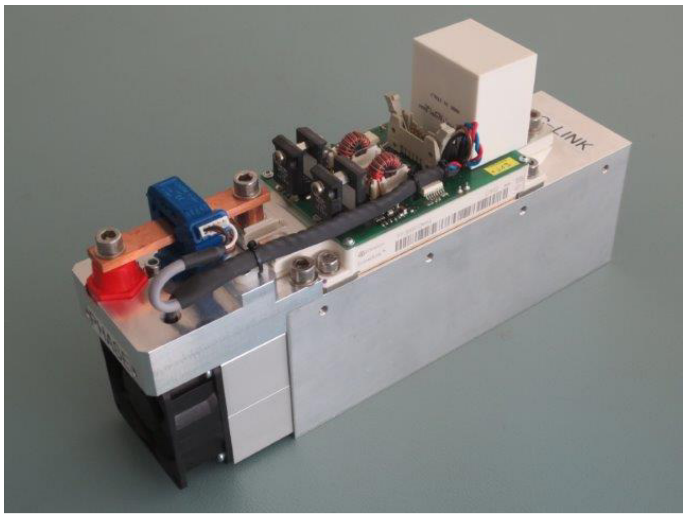
- **Strong isolated 24V supply** can prevent ground loops or significant voltage drop on signal ground when the negative supply input gets a separate cable to the source. The large input voltage range fulfills 60Vpk railway requirements and is reverse polarity protected. The box provides sufficient power 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. In these phases, manual control and one-digit error code display can be very helpful.

Hardware-Modules:

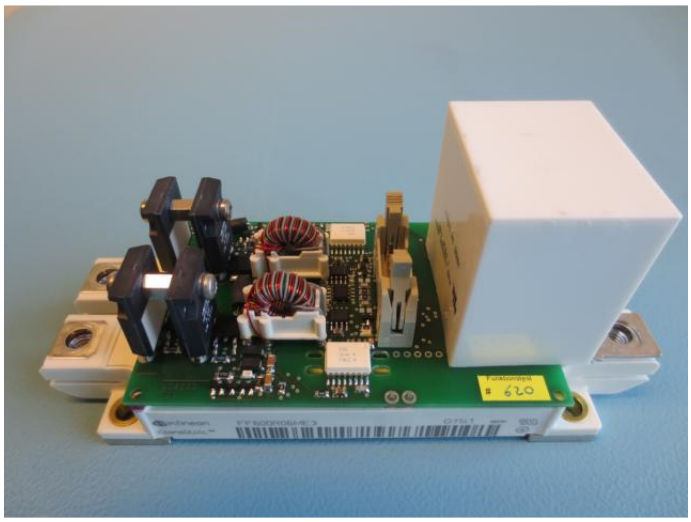
Control-Box

- 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



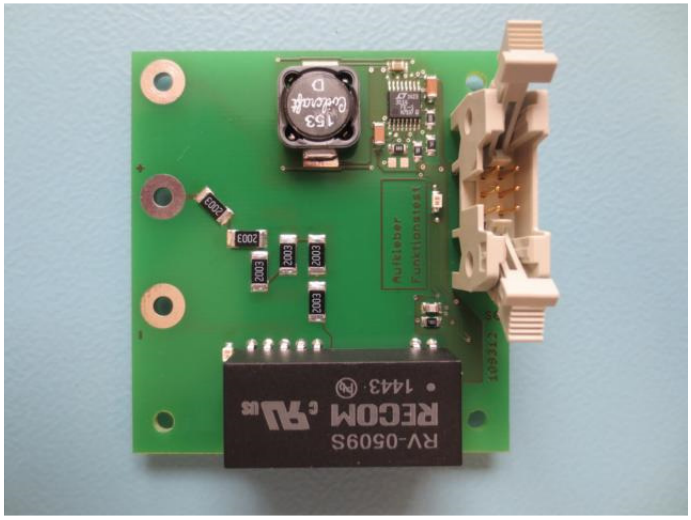
Modular IGBT Half-Bridge Power-Stage

- Plug and Play IGBT Half-Bridge Solution
- 10-Pole Standard Ribbon Cable Connector for all Signals including Fan-Power
- Strong Gate-Driver (2x4W)
- Current Sensor
- Isolated Module NTC Temperature Sensing
- Up to 1200V Peak DC-Link Voltage*



- Fast and Safe Switching of Large Gates: Dual 4W/15A Ready-To-Use Gate-Driver
- DESAT Protection with Soft Switch-Off
- Isolated Module NTC Temperature Sensing
- Temperature Range -40°C to 100°C, (Full Load up to 50°C)
- Small 10-Pole Ribbon Cable Controller-Interface contains Reserved Signal Lines for Future Connection of External Current Sensor and Fan

IGBT Gate-Driver (Example with IGBT-Module and Snubber Capacitor)



- Up to 1200V DC Primary Voltage Range
- Galvanic Isolation up to 1200V DC
- High Primary Input Resistance: 1.2 MOhm
- Wide DC Auxiliary Supply Range 3V to 16V
- Integrated Y-capacitor can be enabled
- -40°C to 85°C at Free Convection
- 8mm Creepage Distance

Isolated Voltage Sensor

Detailed datasheets for each hardware module are available at the MACCON homepage.

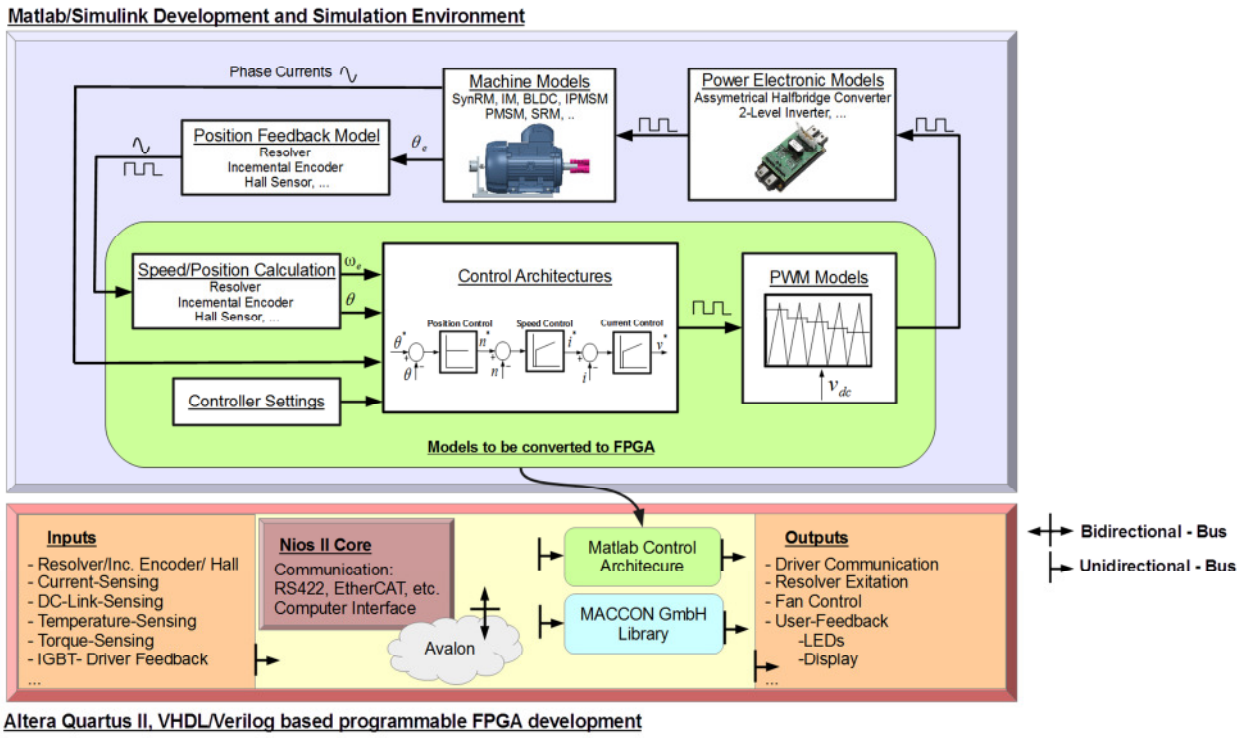
Rapid Prototyping Software Platform:

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.

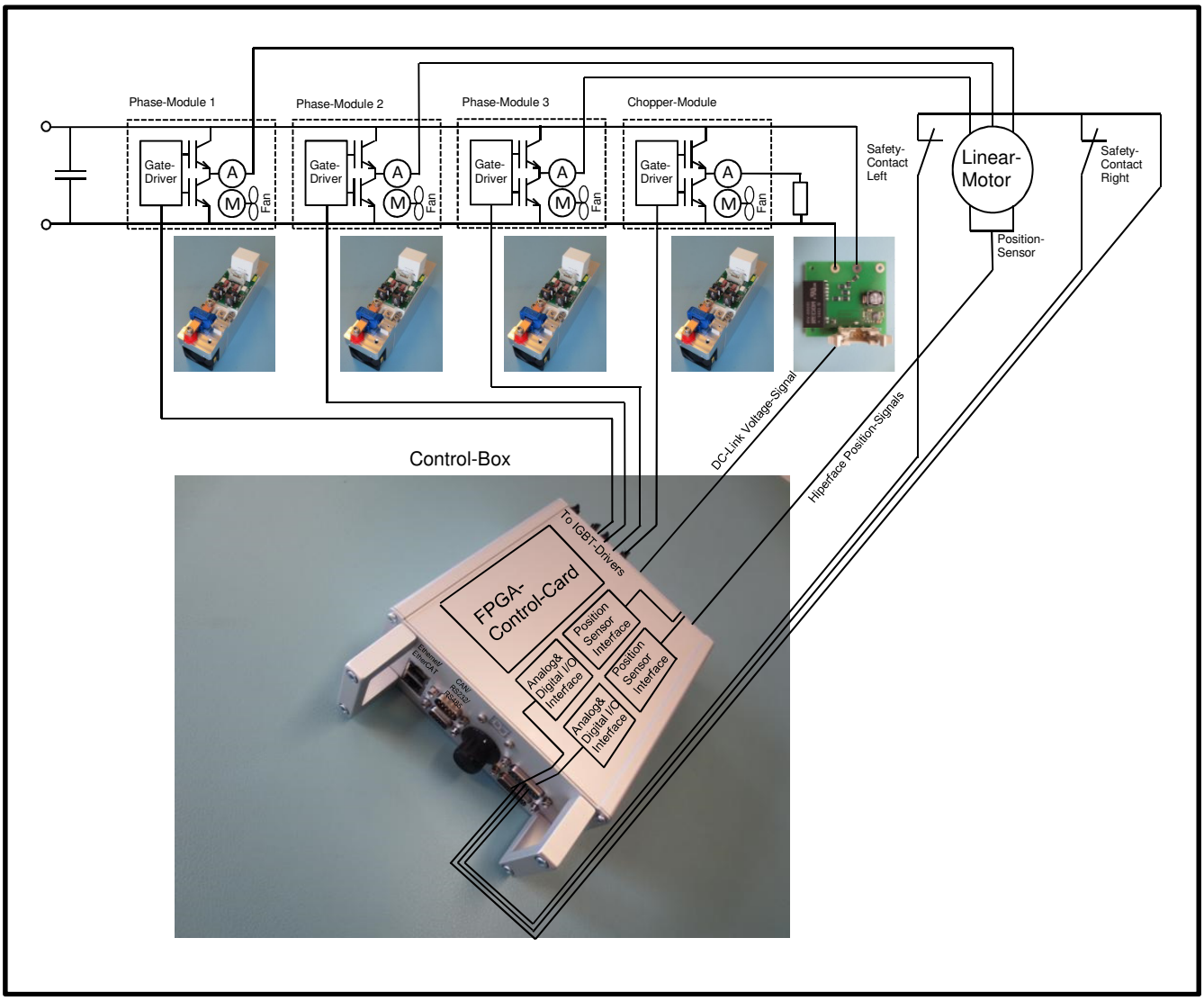


Rapid Prototyping Architecture of Control-Algorithm using Matlab/Simulink

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.

Application Example:



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

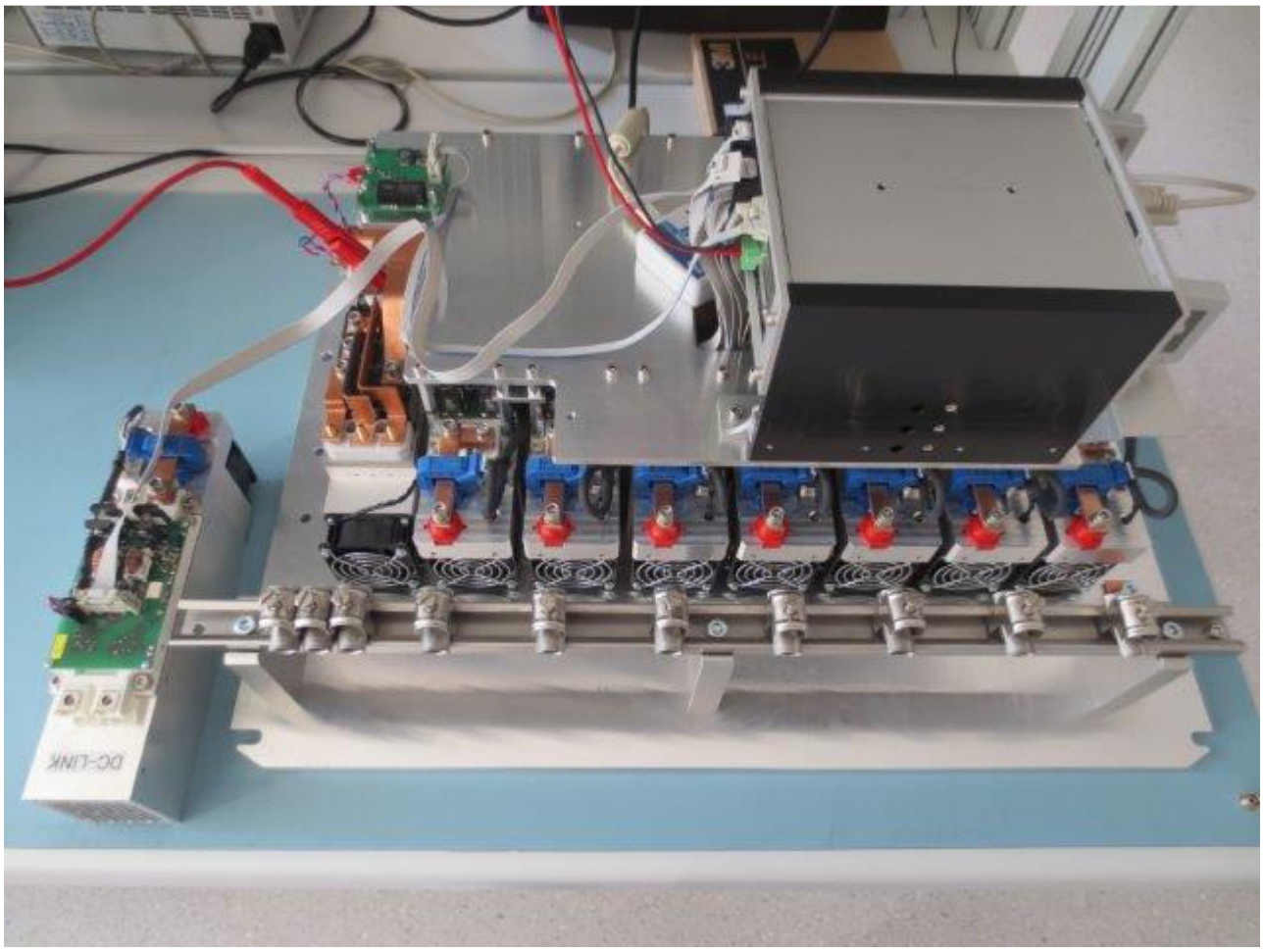
This application example represents a typical three phase motor application with brake chopper. The control-box with optional motor feedback interface for position sensing combined with four IGBT half-bridge power blocks and the isolated DC-link voltage sensor offers a complete motor controller solution for innovative control algorithm development.

The whole system can be ordered in a housing including DC-link and control cable connections.

Customers are complete free to choose more or less prepared integration.

Integration Example:

If the customer demands higher integration, MACCON integrates the required functional blocks into a standard or a custom specific housing including all connections, tests, documentation and even specific qualification of the whole system. Also complete drive solutions including controller, motor, feedback sensor and software can be offered.



MACinverter maximum configuration: Rectifier plus 7 IGBT half-bridges as open frame example.
An additional external half-bridge is connected for test purposes at the left side of the converter.

Electrical Characteristics:

A high percentage of the specification parameters depend on the configuration (e.g. auxiliary current consumption) and the working point of the specific application (e.g. PWM frequency). The following table represents configuration independent specifications or specifications of typical configurations.

Parameter	min	typ	max	Unit
DC-Link Voltage (for 600V IGBTs)			400	V
DC-Link Voltage (for 1200V IGBTs)			800	V
Phase Current (DC-Link 622V, T_air 40°C, PWM 8 kHz)			50	A rms
Quiescent Power per IGBT-Driver (Half-Bridge)		2		W
Dynamic Gate-Power per IGBT (Driver 50°C maximum)			4	W
Dynamic Half-Bridge Driver Power Referred to Auxilary Supply Input			10	W
DC Auxiliary Supply Voltage	18	24	60	V
FPGA Logic Elements		75408		
Parallel Flash		64		MByte
SDRAM		32		MByte
Noise: Single Fan, Full Load		41		dB(A)
Dimension Width		700		mm
Dimension Height		335		mm
Dimension Depth		500		mm
Ambient Temperature at Free Air Convection Full Load	-40		+40	°C
Storage Temperature and Powered No-Load Temperature	-40		+80	°C

Parameter Table

MACinverter (MI) Feature-Code:

MI/SB-BL3-700-050-1-IO-IO-RE-RE-A-1-0-0-0-1-XXXX

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 Rev.

	Parameter	Short	Explanation
1	**Block-Configuration**	**SB**	Single-Block: 8 Power-Slots
		DB	Double-Block: 16 Power-Slots
2	**Type of Motor**	**BL**	Brushless DC
		SR	Switched Reluctance
3	**Number of Motor-Phases**	**n**	[ ]
4	**Maximum DC-Link Voltage**	**400**	VDC
		700	VDC
5	**Phase Current**	**50**	A rms under conditions: 600VDC, 8kHz PWM, Sinewave
6	**Control-Box Power-Supply**	**0**	Standard
		1	Extended (Recommended)
7	**Half-Seize Expansion-Card A**	**00**	Slot empty
		IO	Universal I/O Expansion-Card
8	**Half-Seize Expansion-Card B**	**00**	Slot empty
		IO	Universal I/O Expansion-Card
9	**Full-Seize Expansion-Card A**	**00**	Slot empty
		RE	Resolver-Encoder Feedback Card
10	**Full-Seize Expansion-Card B**	**00**	Slot empty
		RE	Resolver-Encoder Feedback Card
11	**Type of Cooling**	**A**	Air-Cooling
12	**Chopper-Switch**	**0**	No
		1	Yes
13	**Rectifier (AC-Supply)**	**0**	No
		1	Yes
14	**Internal Chopper Resistor Slot**	**0**	No
		n	[ ]
15	**Extra DC-Link Capacitor Slot**	**0**	No
		n	[ ]
16	**Voltage-Measurement (VM-) Unit**	**0**	No
		1	Yes

The MACinverter is a very flexible platform for extreme innovative applications.
If the table does not provide the required combination of features, please contact MACCON.