Moving Towards Higher Powers – Electronic Control Units for the 48V Battery Network

Electrical loads (actuators, pumps, ...) with power demands higher than some hundred Watts needs them connected to the 48 V battery. MELECS has designed an Electronic Control Unit for evaluation purposes.

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How to Start?

When starting a project in the field of higher electric power there are a lot of questions to be answered: What is the mechanical power I need? Which motor fits these demands? What are the space needs? What is the power loss and how can I dissipate the respective heat?

To answer these questions tests in real environments are necessary. It is not possible to define realistic design requirements before the questions above are answered. To cope with these challenges MELECS has designed a "48 V Evaluation ECU" (Electronic Control Unit), which can be used in various motor and generator setups.

Design Goals

The ECU is able to drive brushless 3-phase motors up to 3 kVA electrical power – the three motor connections can deliver up to 100 Arms each. For best flexibility this Evaluation ECU is designed to be used with any 3 phase motor in the targeted power range and therefore developed as standalone device.

The complete voltage range for the 48 V battery, as defined in the VDA 320, is supported: Full power to the motor is delivered in the range of 36 V to 52 V, from 52 V to 60 V a power derating due to thermal reasons is carried out. The micro controller (CPU) works down to 24 V.

The ECU is controlled through a 500 kbit/s CAN interface, referred to the 12 V battery. One additional input switches the ECU on (drives it out of the "closed-circuit" state, typically connected to KL15), another one can be used to only stop the motor (e.g. in emergency cases).

Electronics

Figure 1 shows a block diagram of the ECU. Due to different PCB layer stacks the design is split onto two optimized PCBs. The Power PCB contains all high current parts and is optimized to distribute high currents horizontally and the dissipated power (mainly of the bridge FETs) vertically down to the heat sink. Besides the 3phase bridge and the necessary buffer capacitors the Power PCB carries an input filter and an inrush current limiter. Current sensing is done through low side shunt resistors.

The heart of the Controller PCB is a CPU with lock step architecture, which together with the system basis chip is able to support even

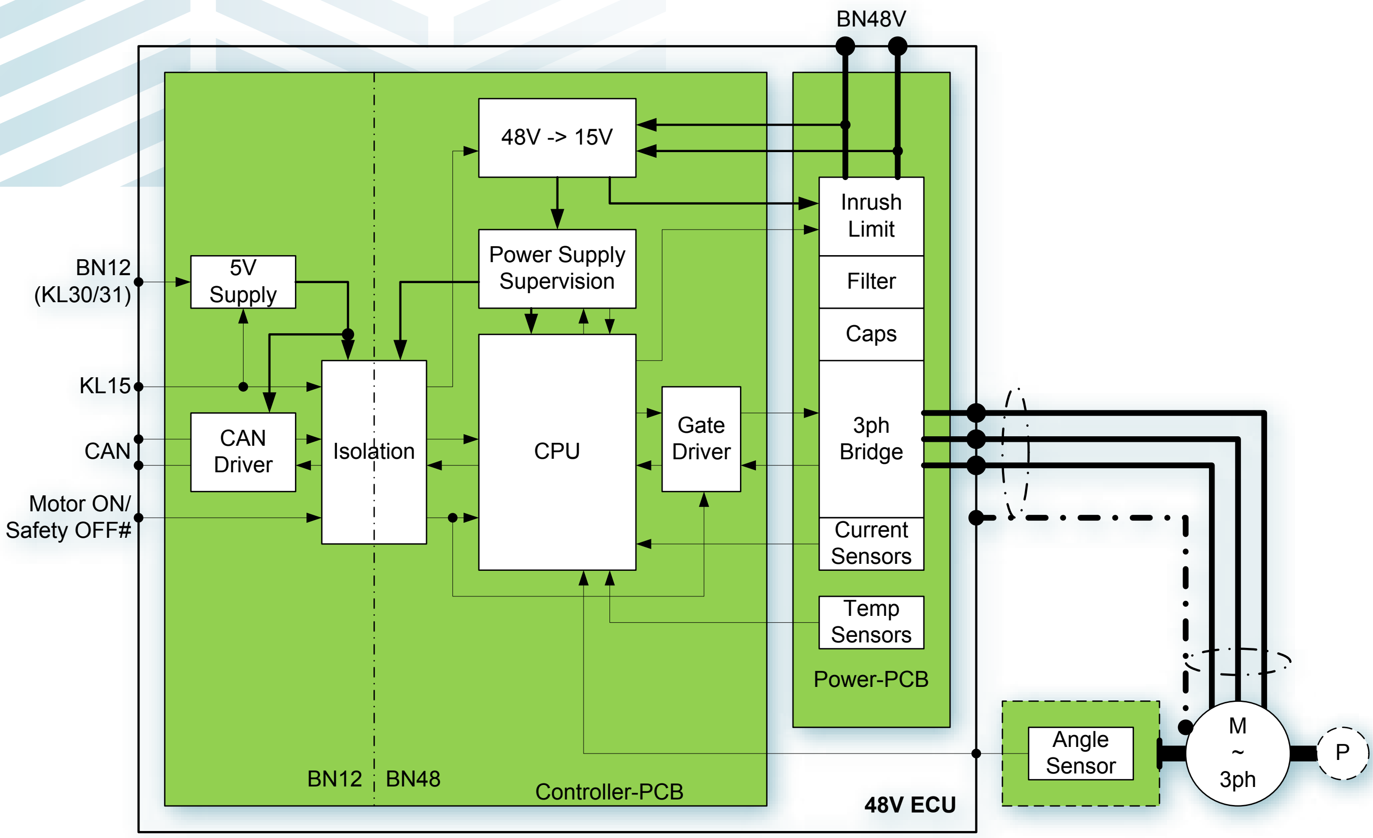

Figure 1 Block Diagram

safety relevant applications. The gate driver supports a number of supervising task, among them a V_{DS} supervision of the bridge FETs. The ECU has connections to both batteries and especially two different ground connections as required in the VDA 320. Internal data transfer between the CPU – related to the 48 V battery – and the communication and control interfaces – related to the 12 V battery – is done via an isolation barrier, to avoid disadvantageous effects when losing one of the grounds.

An angle sensor, which is necessary for controlling the motor at low speeds, has to be attached at the motor and is connected to the ECU through a separate connector.

Mechanics

The ECU is packed into a housing with a square base of 150 x 150 mm² and a height of 67 mm (without connectors). The base plate is made out of aluminum and can be mounted to any flat surface, which is able to dissipate the losses and keeps the temperature at an appropriate value to deliver the demanded power. The upper shell is made of plastic. Both the housing and the connectors are basically designed to be

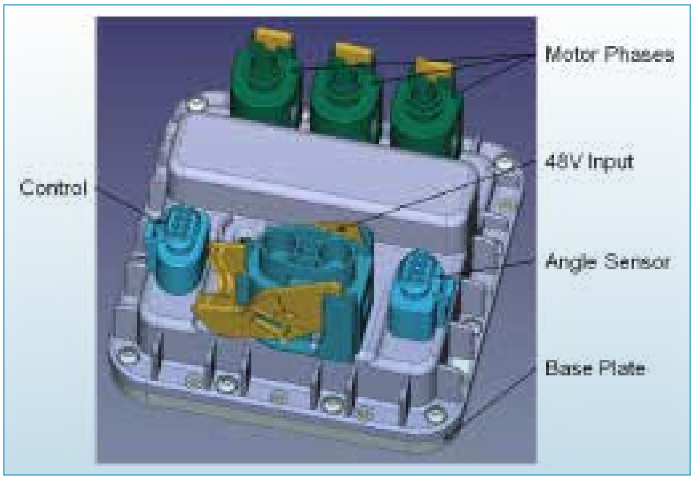

Figure 2 Mechanical Design

water proof and withstand vibrations as defined in profile D of the LV 124.

All interfaces are implemented as pluggable connectors (refer to Figure 2): The control interface (CAN) and the angle sensor interface use FEP connectors with 2 × 4 pins 1.5 × 0.64 mm²; the 48 V battery input uses a high power Delphi Ducon connector (to avoid reversed polarity of the BN48 system) with 9.5 × 1.2 mm² pins, and the motor is connected through three Kostal LSK8 connectors with 8 × 0.8 mm² pins.

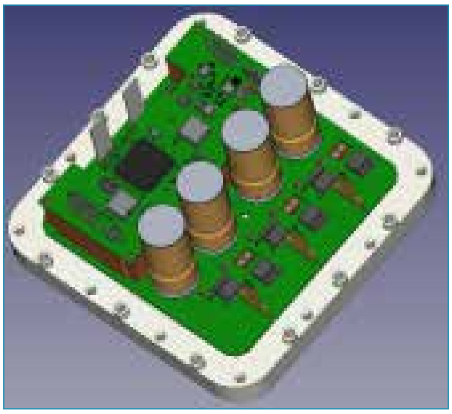

Figure 3 PCB Concept

Figure 4 Housing Prototype

Figure 5 Real PCBs

A Look Inside

As mentioned before the design contains two PCBs (refer to Figure 3). The Power PCB is tightly connected to the aluminum base plate to efficiently lead off the losses. The Controller PCB is in the "second floor" and distanced from the Power PCB by a plastic spacer. All parts are pressed towards the base plate by elastic elements in the shell: Especially the FETs – to ensure best thermal conditions by reducing the distance between PCB and base plate to a minimum – and the buffer capacitors – to fix them mechanically to avoid damage due to vibrations.

Controlling the ECU

Via the CANopen protocol the ECU can be configured, the output parameters set and the status read back. Basic output parameters are the motor speed (revolutions per minute) or the motor torque (given by a certain motor current) – depending on the configuration. Other configuration parameters are for example limits for current, speed, voltage and temperature. Status messages deliver the actual values of speed, current, DC voltage, output voltage, temperatures, errors, etc.

Further Features

Besides the main functions, the ECU is designed to fulfill most of the other requirements in the LV 124 and the VDA 320/LV 148. Among them are the idle current requirements, when the device is turned off, and the safe behavior, when one of the grounds is lost. Basically also mechanisms for safety functions are implemented (diagnosis, supervision, redundant turn off paths).

Usage

The ECU can be positioned on or near a motor or in a certain distance of it (using shielded wires). It just needs connections to the 48 V battery, to the motor (including an angle sensor), to a CAN bus and to a surface able to lead off the dissipated power.

Optimized Designs for our Customers

After tests with this ECU under real conditions, the findings can be used to define the requirements for a motor including the feature to be driven (e.g. a pump) on the one side and the ECU on the other side. These requirements are the basis for a customized ECU design to exactly fit the electrical and mechanical demands – to get an optimum design for our customers.