

CoolSiC™ MOSFET motor drives evaluation board in T0247 packages

EVAL-M5-IMZ120R-SIC

About this document

Scope and purpose

This application note provides an overview of the evaluation board EVAL-M5-IMZ120R-SIC including its main features, key data, pin assignments, mechanical dimensions and corresponding control card.

The EVAL-M5-IMZ120R-SIC is a complete evaluation board including a six discrete CoolSiC™ MOSFETs realizing a B6 inverter for motor drive applications. In combination with control boards equipped with an M5 32-pin interface connector such as the XMC DriveCard 4400, the evaluation board features and demonstrates, Infineon's CoolSiC™ MOSFETs in motor drives.

The evaluation board EVAL-M5-IMZ120R-SIC was developed to support customers during their first steps designing applications with CoolSiC™. The MOSFET has a rated blocking voltage of 1200 V at a typical on-state resistance of 45 mΩ. It is optimized for motor drive applications with a high-frequency switching operation.

The evaluation board can be as well used for other technologies (etc. IGBTs) in different voltage range (etc. 650 V) in T0247 3 pin and 4 pin package.

Intended audience

This application note is intended for power electronic engineers evaluating the use of CoolSiC™ devices in drives applications.

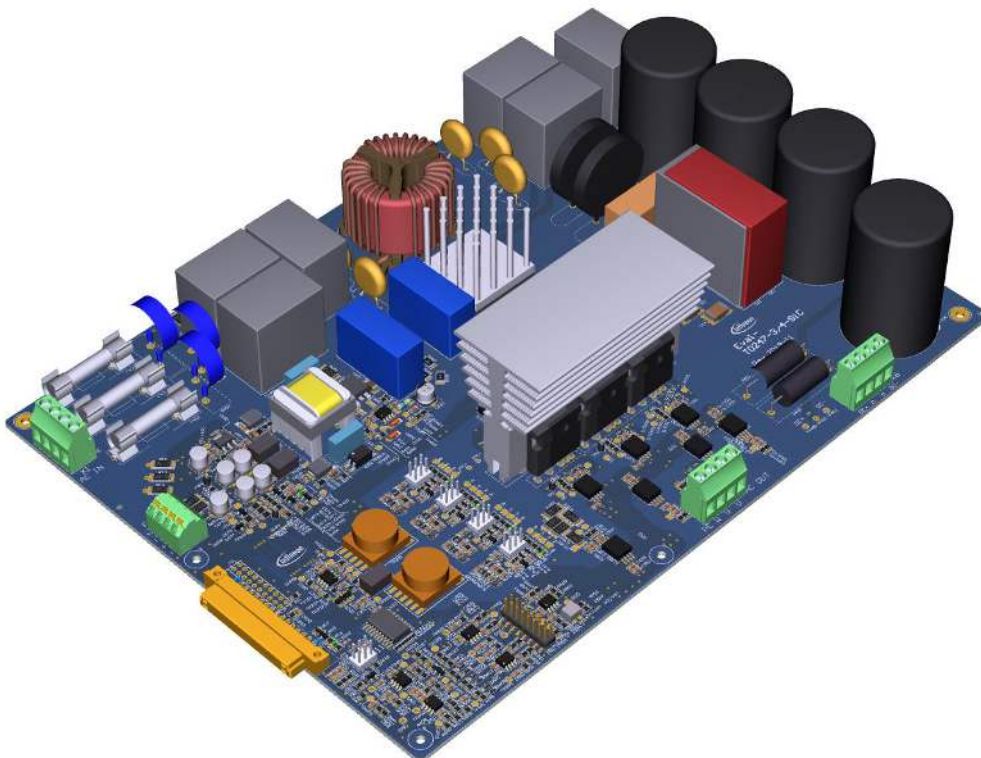


Table of contents









| | |
|---|-----------|
| About this document | 1 |
| Table of contents | 2 |
| 1 Safety precautions | 3 |
| 2 Introduction | 5 |
| 3 Main features | 7 |
| 3.1 Functional Groups..... | 8 |
| 3.2 Pin Assignments | 9 |
| 3.3 Analog measurement adjustment..... | 12 |
| 4 Demo control | 13 |
| 4.1 Installing DEMO Graphical User Interface (GUI) | 13 |
| 4.2 Using the DEMO Graphical User Interface for CoolSiC™ MOSFET MADK..... | 15 |
| 5 Schematics and Layout | 17 |
| 5.1 Overview | 17 |
| 5.2 Input Circuit..... | 17 |
| 5.2.1 EMI Filter | 18 |
| 5.3 Auxiliary Supply | 18 |
| 5.4 Power Stage..... | 20 |
| 5.5 Driver Circuit..... | 21 |
| 5.6 Thermistor Output | 24 |
| 5.7 Current Measurement | 25 |
| 5.8 Voltage Measurement | 26 |
| 5.9 Digital to Analogue Converter..... | 26 |
| 5.10 Overload and Overtemperature Protection..... | 27 |
| 5.11 Overcurrent / Short Circuit Protection | 28 |
| 5.12 PCB Layout | 29 |
| 6 Measurements | 30 |
| 6.1 Thermal measurements..... | 31 |
| 7 Bill of Material | 33 |
| Revision history | 41 |

Safety precautions

1 Safety precautions

In addition to the precautions listed in this manual, please read the following statements regarding hazards associated with development systems.

Table 1 Safety precautions

| | |
|---|--|
|  | <p>Attention: The DC-link potential of the EVAL-M5-IMZ120R-SIC system is connected to the grid input. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.</p> |
|  | <p>Attention: the EVAL-M5-IMZ120R-SIC system contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.</p> |
|  | <p>Attention: Only personnel familiar with the drive and associated machinery should plan or implement the installation, start-up and subsequent maintenance of the system. Failure to comply may result in personal injury and/or equipment damage.</p> |
|  | <p>Attention: The surfaces of the drive may become hot, which may cause injury.</p> |
|  | <p>Attention: the EVAL-M5-IMZ120R-SIC system contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to applicable ESD protection handbooks and guidelines.</p> |
|  | <p>Attention: A drive, incorrectly applied or installed, can cause component damage or reduction in product lifetime. Wiring or application errors such as under sizing the motor, supplying an incorrect or inadequate AC supply or excessive ambient temperatures may result in system malfunction.</p> |
|  | <p>Attention: Remove and lock out power from the drive before you disconnect or reconnect wires, or perform service work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.</p> |
|  | <p>Attention: the EVAL-M5-IMZ120R-SIC system is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.</p> |

Introduction

2 Introduction

The EVAL-M5-IMZ120R-SIC evaluation board is a part of the iMOTION™ Modular Application Design Kit for motor drives. These boards can easily be interfaced via the iMOTION™ MADK-M5 32-pin interface connector to control boards such as the XMC DriveCard 4400 or XMC DriveCard 1300. Infineon provides a demonstration program provided with a XMC Drive Card 4400 platform, controlling the main board, and demonstrates Infineon’s CoolSiC™ MOSFETs in motor drives.

This evaluation board is designed to be an easy-to-use power stage based on Infineon's discrete SiC power MOSFETs. The board is equipped with all assembly groups for sensorless field oriented control (FOC). It provides a three-phase AC-connector, EMI filter, rectifier and a 3-phase output for connecting the motor. The power stage also contains isolated current, voltage and temperature sensing circuits.

The features of this board are described in the design feature chapter of this document, whereas the remaining paragraphs provide information to enable the customers to copy, modify and qualify the design for production according to their own specific requirements.

Environmental conditions were considered in the design of the EVAL-M5-IMZ120R-SIC. The design was tested as described in this document but not qualified regarding safety requirements or manufacturing and operation over the whole operating temperature range or lifetime. The boards provided by Infineon are subject to functional testing only. Evaluation boards are not subject to the same procedures as regular products regarding returned material analysis (RMA), process change notification (PCN) and product discontinuation (PD). Evaluation boards are intended to be used under laboratory conditions and by trained specialists only.

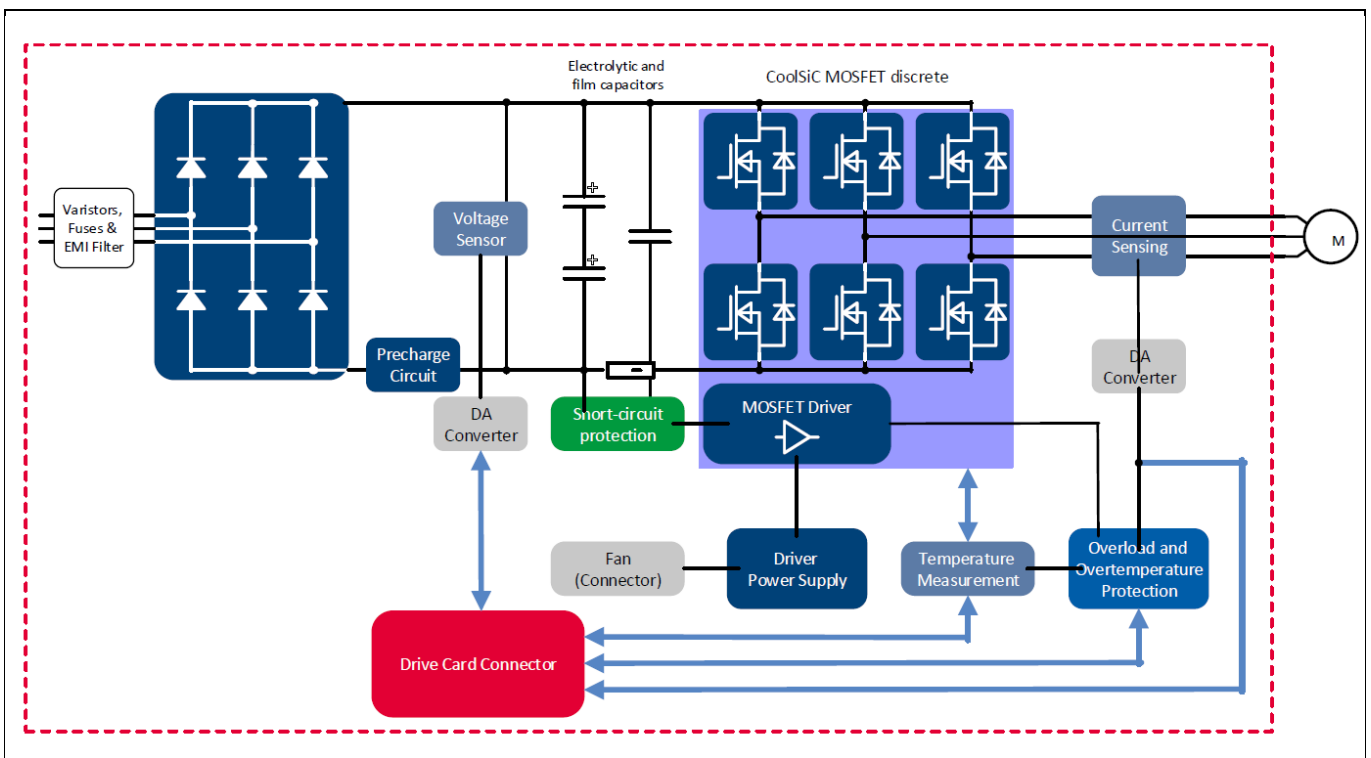


Figure 1 The block diagram of the EVAL-M5-IMZ120R-SIC

The block diagram of the EVAL-M5-IMZ120R-SIC is depicted in Figure 1. This evaluation board includes an EMI filter, a line rectifier with a soft power up circuit, an auxiliary power supply to provide 5 V, and the silicon

Introduction

carbide power MOSFETs IMW120R045M1 or IMZ120R045M1. All measuring and control signals are available on a 32-pin drive card interface connector. The hardware circuit for overtemperature and overcurrent protection is also included in this power board.

The signal part of this evaluation board is fully separated from the power part by a basic insulation. Whereas the power components are on grid potential, the signal part is earthed by the input connector. The design can be upgraded easily to a safe electrical insulation by replacing the present MOSFET drivers (X.U150, X.U151) and the auxiliary power supply transformer (T650) by parts with an appropriate safety approval.

Main features

3 Main features

The EVAL-M5-IMZ120R-SIC is an evaluation board for motor drive applications comprising the silicon carbide technology. Combined in a kit with one of the available MADK control board options, it demonstrates Infineon's silicon carbide power technology used in discrete CoolSiC™ MOSFETs.

The evaluation board characteristics are:

- Input voltage 340~480 V_{AC}
- Peak 11 kW motor power output
- On-board EMI filter
- Basic insulation between power and signal part
- Isolated current sensing with $\Delta\Sigma$ -ADC
- Isolated sensing of DC-link voltage by $\Delta\Sigma$ -ADC
- Thermistor output
- Overload and short-circuit hardware protection
- Overtemperature hardware protection
- All six switches turn off during protection
- Rugged gate driver technology with stability against transient and negative voltage
- Auxiliary power supply with 5 V
- Measurement test-points compatible with standard oscilloscope probes
- Dimension of PCB are 259 mm x 204 mm; PCB has four layers of 35 μ m copper each
- RoHS compliant

Table 2 depicts the key specifications of the evaluation board EVAL-M5-IMZ120R-SIC.

Table 2 EVAL-M5-IMZ120R-SIC board specifications

| Parameters | Values | Conditions / Comments |
|--|----------------------------|--|
| Input | | |
| Voltage | 340 – 480 V _{rms} | lower AC input, less motor power output |
| Current | 16 A _{rms} | Input 400 V _{AC} , T _a = 25 °C |
| Output | | |
| Power (3 phases) without forced cooling | 2,5 kW | input 400 V _{AC} , f _{PWM} = 10 kHz, T _a = 25 °C |
| Power (3 phases) with forced cooling | Up to 6 kW | input 400 V _{AC} , f _{PWM} = 10 kHz, T _a = 25 °C, forced convection cooling, limited by input current |
| Continuous current per leg at f _{nom} without forced cooling | 5 A _{rms} | input 400 V _{AC} , f _{PWM} = 10 kHz, T _a = 25 °C |
| Peak current per leg at f _{nom} | 25 A _{rms} | input 400 V _{AC} , f _{PWM} = 10 kHz, T _a = 25 °C |
| DC bus voltage | | |
| Typical DC bus voltage | 530 V – 670 V | |
| Brown-in Aux-supply | 480 V | |
| Brown-out Aux-supply | 300 V | |
| Maximum DC bus voltage | 720 V | |
| Switching frequency | | |
| Nominal switching frequency f _{nom} | 10 kHz | |

Main features

| | | |
|---------------------------------------|----------------------|--|
| Maximal switching frequency f_{max} | 100 kHz | |
| Current feedback | | |
| Analog output | 38,3 mV/A | |
| Digital output | 5 V | $\Delta\Sigma$ bitstream @ 20 MHz |
| DC link voltage feedback | | |
| Analog output | 5 mV/V | |
| Digital output | 5 V | $\Delta\Sigma$ bitstream @ 20 MHz |
| Protections | | |
| Output current trip level | 60 A _{peak} | Disables driver stage for 30 ms |
| Temperature trip level | 110 °C | Disables driver stage for 30 ms |
| On board power supply | | |
| +5 V | ± 2 % | Used for primary side of MOSFET drivers and for the controller board |
| +6 V | ± 10 % | Used for analogue circuits |
| -5 V | ± 10 % | Used for analogue circuits |
| -15 V | ± 5 % | Used for driver supply |
| System environment | | |
| Ambient temperature | From 0 to 50 °C | Non-condensing, maximum RH of 95 % |
| PCB characteristics | | |
| Material | FR4, 1.6mm thickness | 4 layers, 35 µm copper thickness |
| Dimensions | 259 mm x 204 mm | |

3.1 Functional groups

Figure 2 points out the functional groups of the evaluation board. Figure 3 gives a more detailed view of the power stage. The functional groups are explained in Table 3.

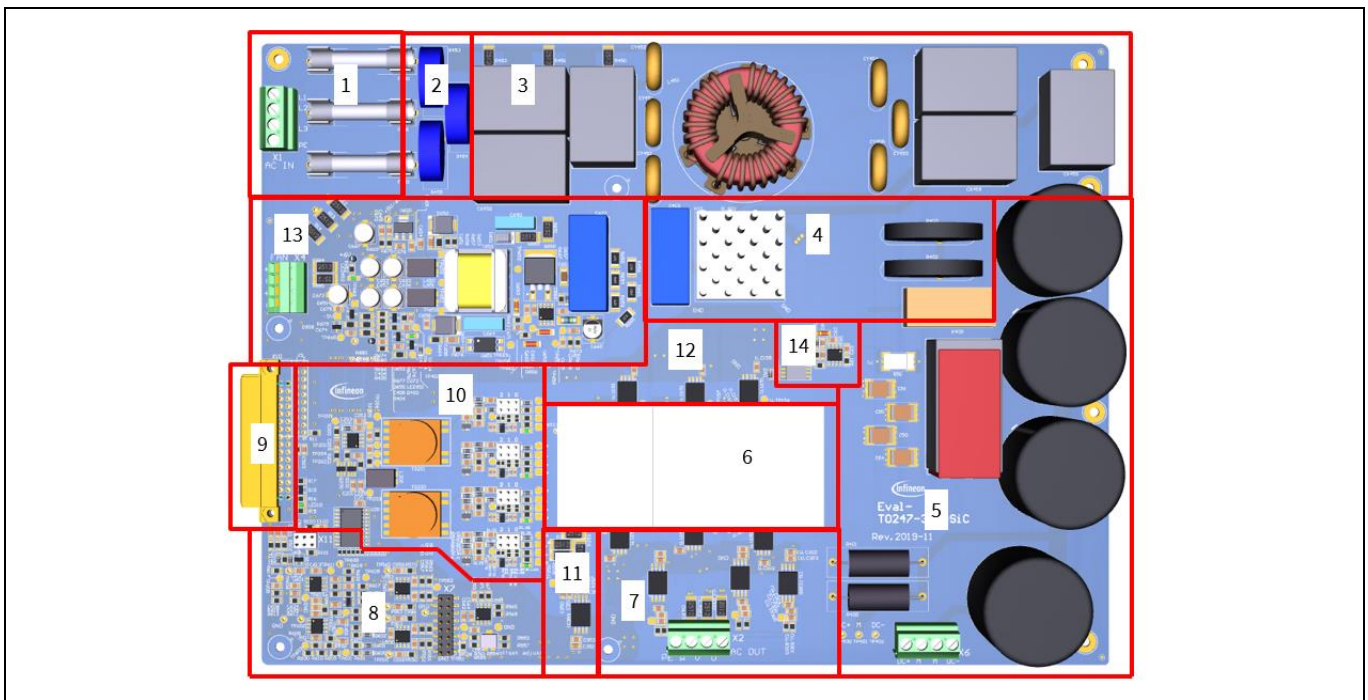


Figure 2 Top view of the EVAL-M5-IMZ120R-SIC

Main features

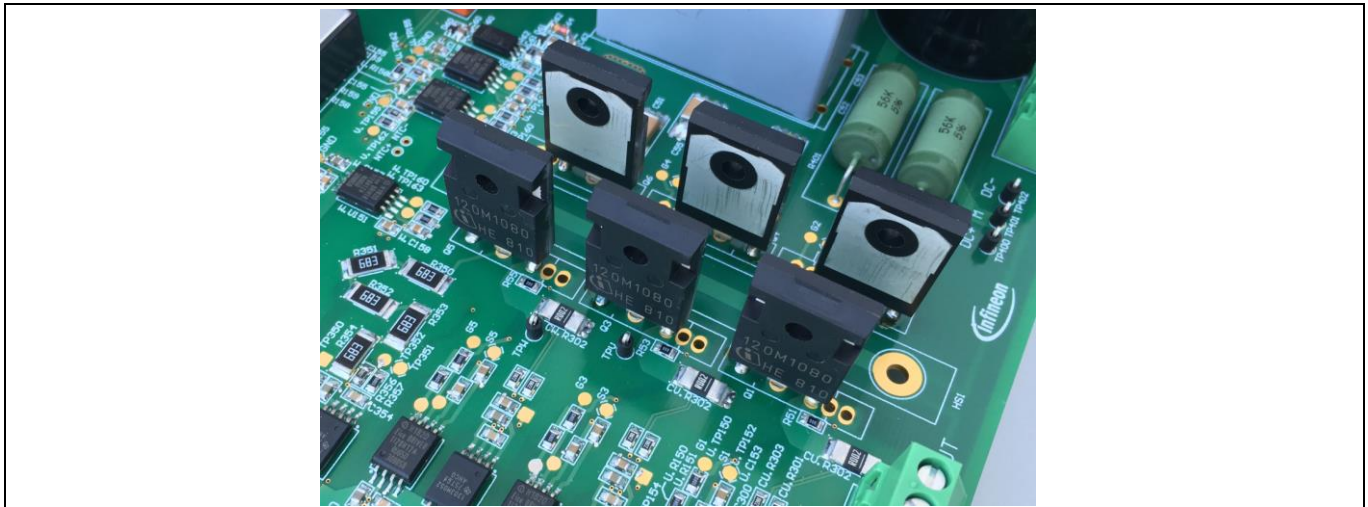


Figure 3 View of the power stage without heatsink

Table 3 Functional groups of EVAL-M5-IMZ120R-SIC

| Nr. | Functional groups |
|-----|--|
| 1 | AC input connector with fuses |
| 2 | Varistors for overvoltage protection |
| 3 | EMI filter |
| 4 | Rectifier with precharge relay and precharge NTC resistors |
| 5 | DC-bus capacitors, balancing resistors and DC-bus connector |
| 6 | Power stage: 6 MOSFETS TO-247 with heatsink and phase current shunts |
| 7 | High-side MOSFET drivers with $\Delta\Sigma$ -DACs for shunt sensors |
| 8 | Low-pass filter of $\Delta\Sigma$ -signals and overcurrent comparators |
| 9 | Connector for controller |
| 10 | Isolated power supply for MOSFET drivers |
| 11 | DC-bus voltage measurement with $\Delta\Sigma$ -DAC |
| 12 | Low-side MOSFET drivers |
| 13 | Flyback converter for auxiliary supply |
| 14 | Overcurrent detection and measuring shunt |

3.2 Pin assignments

General information about the connectors of the EVAL-M5-IMZ120R-SIC evaluation board is provided. Table 4 includes the details of the AC input connector X1.

Table 4 X1 – AC line connector

| S. No. | Pin | Details |
|--------|--------------|---------|
| 1 | Line phase 1 | |
| 2 | Line phase 2 | |
| 3 | Line phase 3 | |
| 4 | EARTH | |

Table 5 provides the details of the motor side connector X2.

Main features

Table 5 X2 – Motor side connector

| S. No. | Pin | Details |
|--------|-------|--------------------------|
| 1 | EARTH | Connected to X1/4 |
| 2 | U | Connect to motor phase W |
| 3 | V | Connect to motor phase V |
| 4 | W | Connect to motor phase U |

Table 6 provides the pin assignments of driver board connector X10. This connector is the interface to the controller board.

Table 6 X10 – Power board connector

| S. No. | Pin | Details |
|--------|----------|--|
| A1 | - | n. c. |
| A2 | - | n. c. |
| A3 | - | n. c. |
| A4 | - | n. c. |
| A5 | - | n. c. |
| A6 | - | n. c. |
| A7 | - | n. c. |
| A8 | - | n. c. |
| A9 | - | n. c. |
| A10 | I_W | Phase W current sense output, scale 76,56 mV/A, offset 2,5 V |
| A11 | I_V | Phase V current sense output, scale 76,56 mV/A, offset 2,5 V |
| A12 | I_U | Phase U current sense output, scale 76,56 mV/A, offset 2,5 V |
| A13 | - | n. c. |
| A14 | - | n. c. |
| A15 | - | n. c. |
| A16 | GND | Ground |
| B1 | /ENABLE | /ENABLE signal – if high drivers are disabled |
| B2 | /FAULT | /FAULT signal – active low when overcurrent or overtemperature is detected |
| B3 | PWMWH | 3.3 V compatible logic input for high side gate driver-Phase W |
| B4 | PWMWL | 3.3 V compatible logic input for low side gate driver-Phase W |
| B5 | PWMVH | 3.3 V compatible logic input for high side gate driver-Phase V |
| B6 | PWMVL | 3.3 V compatible logic input for low side gate driver-Phase V |
| B7 | PWMUH | 3.3 V compatible logic input for high side gate driver-Phase U |
| B8 | PWMUL | 3.3 V compatible logic input for low side gate driver-Phase U |
| B9 | - | n. c. |
| B10 | - | n. c. |
| B11 | - | n. c. |
| B12 | - | n. c. |
| B13 | DCBsense | DC bus voltage sense output, scale 5 mV/V (1/200) |
| B14 | VTH | Thermistor voltage output, 100°C = 0,448 V |
| B15 | - | n. c. |
| B16 | VCC | On board 5 V supply, max. 120 mA |

Main features

Table 7 denotes the details of the fan connector X4. The connector is provided for two fans with a nominal voltage of 12 V cooling the heatsinks. The maximum output current is limited to 180 mA. The connector is connected via two series resistors to a supply of 15 V. Consequently, it is possible to drive most fans with a nominal voltage of 12 V in the power range of 0.6 W to 1 W in their allowed voltage range.

Table 7 X4 – Fan connector

| S. No. | Pin | Details |
|--------|-------|---|
| 1 | Fan1- | Connected via 8.2 Ω resistor to -15 V, max. 180 mA |
| 2 | Fan1* | Connected via 8.2 Ω resistor to GND, max. 180 mA |
| 3 | Fan2- | Connected to Fan1- |
| 4 | Fan2+ | Connected to Fan1+ |

Table 8 includes the details of the dc bus connector X6.

Table 8 X6 – DC bus connector

| S. No. | Pin | Details |
|--------|-------|--|
| 1 | DC+ | Connected to positive side of DC-bus capacitor |
| 2 | DC M | Connected to midpoint of DC-bus capacitor |
| 3 | DC- M | Do not connect load at this point! |
| 4 | DC- | Connected to negative side of DC-bus capacitor |

The following table provide the details of the digital measurements connector X7.

Table 9 X7 – $\Delta\Sigma$ measurement connector

| S. No. | Pin | Details |
|--------|-----------|---|
| 1 | Clock_lu | 20 MHz clock output, signal level 5 V |
| 2 | GND | |
| 3 | DS_lu | $\Delta\Sigma$ modulated output of current measurement, phase U, signal level 5 V, 50% positive equals 0 A, 89.06% positive equals +50 A, 10.94 % positive equals -50 A |
| 4 | GND | |
| 5 | Clock_lv | 20 MHz clock output, signal level 5 V |
| 6 | GND | |
| 7 | DS_lv | $\Delta\Sigma$ modulated output of current measurement, phase V, signal level 5 V, 50% positive equals 0 A, 89.06% positive equals +50 A, 10.94 % positive equals -50 A |
| 8 | GND | |
| 9 | Clock_lw | 20 MHz clock output, signal level 5 V |
| 10 | GND | |
| 11 | DS_lw | $\Delta\Sigma$ modulated output of current measurement, phase W, signal level 5 V, 50% positive equals 0 A, 89.06 % positive equals +50 A, 10.94% positive equals -50 A |
| 12 | GND | |
| 13 | Clock_Vdc | 20 MHz clock output, signal level 5 V |
| 14 | GND | |

Main features

| | | |
|----|--------|---|
| 15 | DS_Vdc | $\Delta\Sigma$ modulated output of DC link voltage measurement, signal level 5 V, 50% positive equals 0 V, 89.06% positive equals 851 V |
| 16 | GND | |

3.3 Analog measurement adjustment

In order to achieve a precise measurement of the output currents and a symmetric overcurrent detection, the offset voltage of the analogue signals must be adjusted. All relevant parts for the adjustment of the offset voltage are shown in Figure 4.

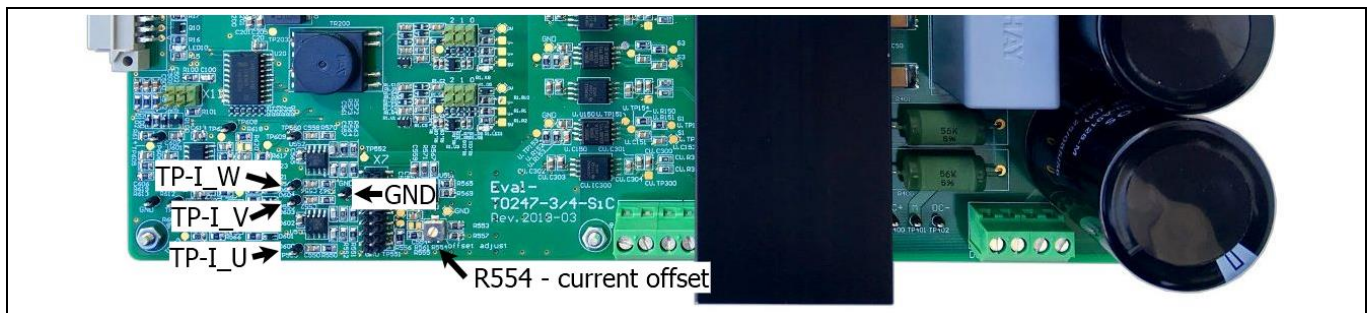


Figure 4 Relevant parts for offset adjustments

The DC-bus voltage measurement has only a small deviation, consequently, there is no offset compensation necessary. To adjust the current offset, simply vary R554 at no load until either the software readings of the currents are zero or the voltages at the currents' test points reach almost 2.5 V. Due to component tolerances, an exact adjustment of all three currents to zero at the same time will not be possible. Additional Information about the circuit itself can be found in the chapter "Digital-to-analogue converter".

4 Demo control

The CoolSiC™ MOSFET platform is intended for use with various power stages with different control boards. These boards can easily be interfaced via the iMOTION™ MADK-M5 32-pin interface connector to control boards such as the XMC DriveCard 4400 or XMC DriveCard 1300. Infineon provide a DEMO program with XMC Drive Card 4400 platform, for controlling the main board, and demonstrates Infineon's CoolSiC™ MOSFETs in motor drives. A detailed description of the XMC4400 drive card can be found online:

https://www.infineon.com/cms/en/product/evaluation-boards/kit_xmc4400_dc_v1/

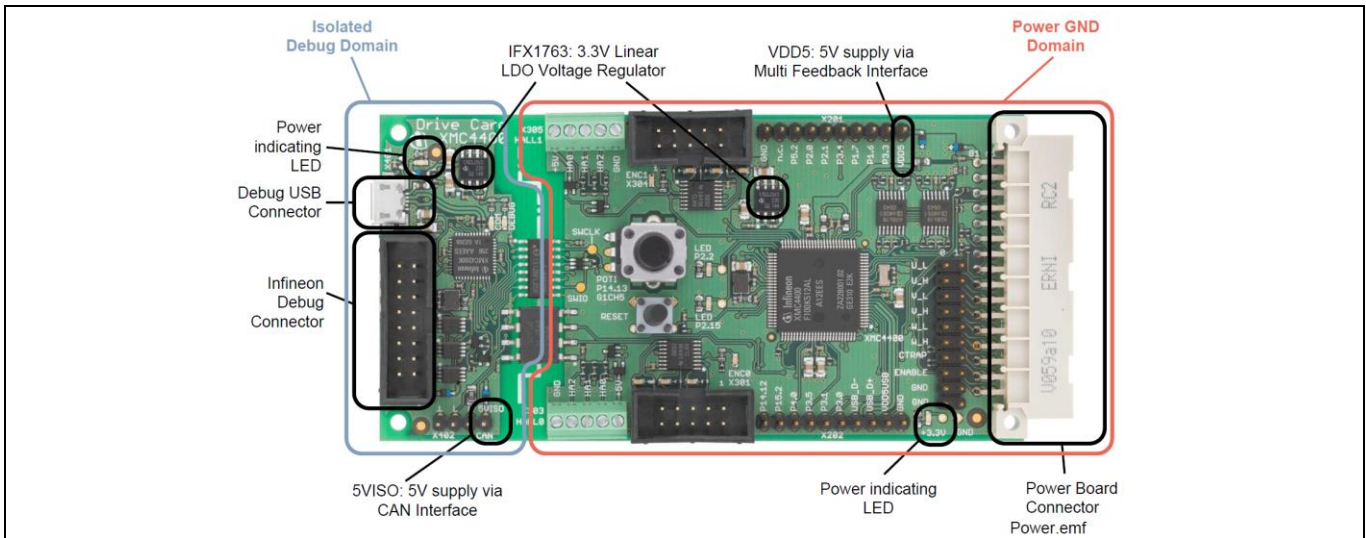


Figure 5 XMC drive card overview

4.1 Installing DEMO graphical user interface (GUI)

Infineon provides a basic control for this board for demonstration purpose only. Please note that such control is only for easiness to use the MAKD board, only limited functions and protections are included. Infineon cannot provide extra technical supports for code modification.

This section describes how to install the Infineon DEMO GUI and what are the pre-required softwares that need to be installed, before using the software.

Prerequisites for usage of DEMO GUI from Infineon (follow the instructions from provider to install):

- Windows 10 Enterprise
- User interface for programming target Flash memory, like the “J-Flash Lite” that is a part of the J-Link software pack, available here:
<https://www.segger.com/downloads/jlink/#JLinkSoftwareAndDocumentationPack>
- XMC™ Flasher tool for XMC™ MCU Flash programming:
<https://www.infineon.com/cms/en/product/microcontroller/32-bit-industrial-microcontroller-based-on-arm-cortex-m-#!tools>
- The latest version of Microsoft .NET Framework
- Infineon GUI software package provided with the setup (unzip to preferred location) or download from the website <https://www.infineon.com/cms/en/product/evaluation-boards/eval-m5-imz120r-sic/> under Boards/+ PCB Design Data/PCB Project Files

Demo control

- Micro USB cable Type-B
- XMC 4400 operate only when a 5 V is applied to the pins A1 and B1 (Evaluation board has included internal power supply)

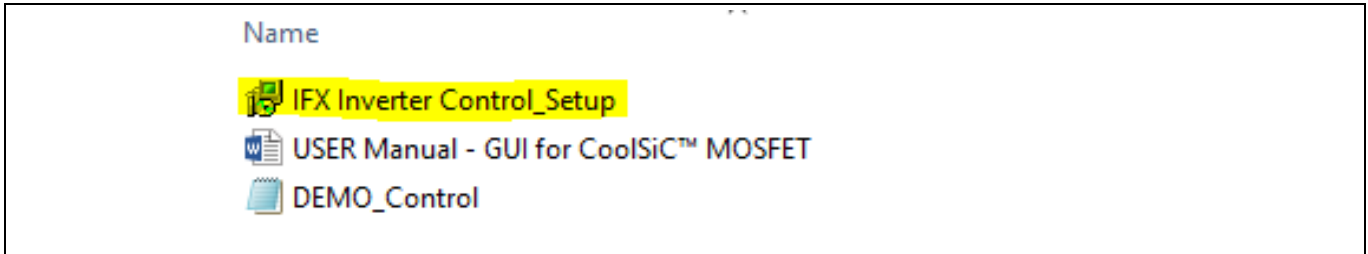
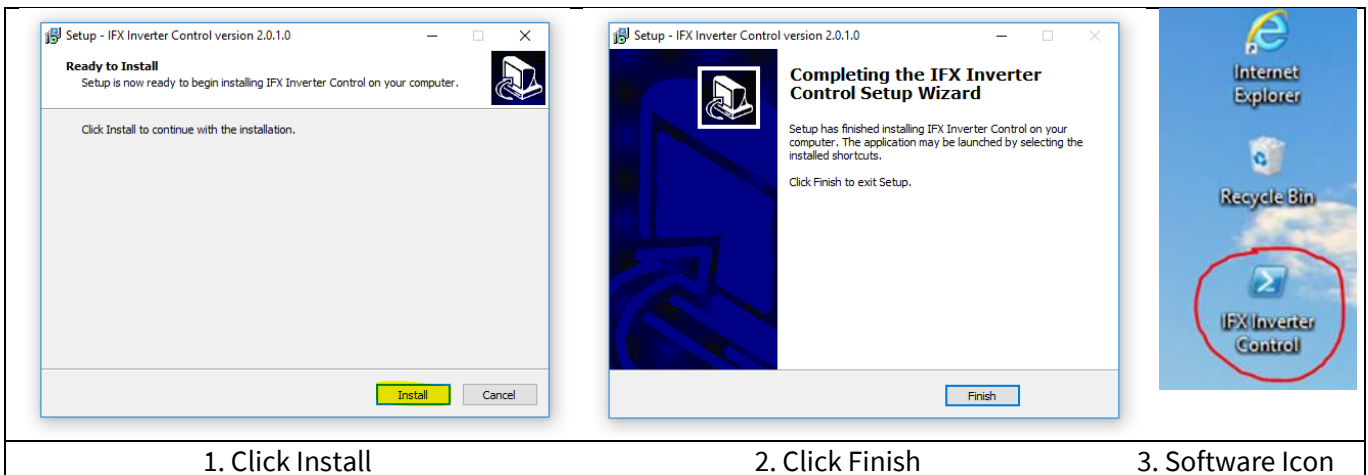


Figure 6 GUI execution files

When the provided package is unzipped, the user needs to install the software package called **IFX Inverter Control_Setup**. The user should be able to use the software in 8 easy steps as presented in the following:



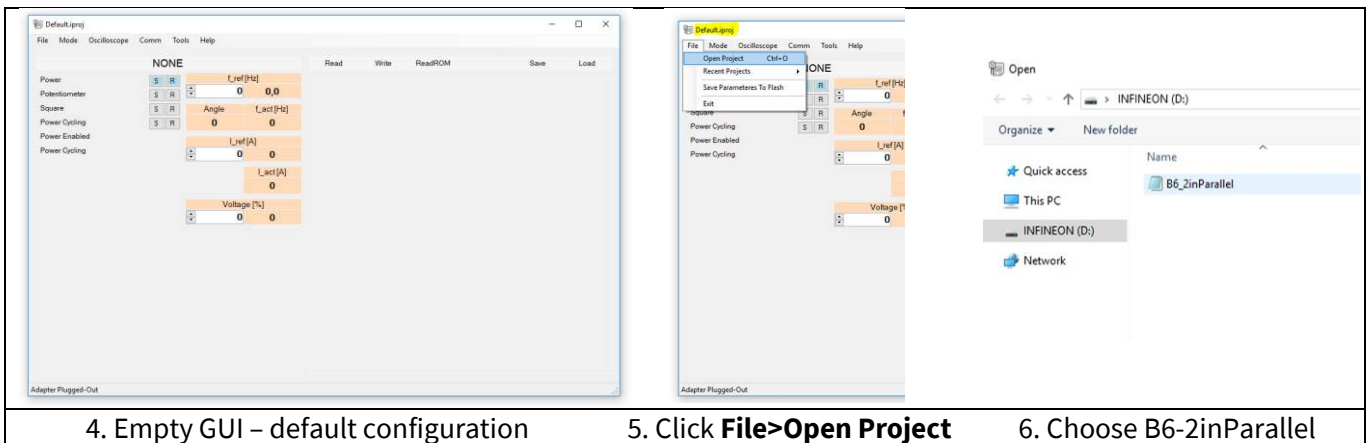
1. Click Install

2. Click Finish

3. Software Icon

Figure 7 Installation process of IFX Inverter Control Setup software

In the IFX Inverter Control Setup, an empty GUI without parameters has been installed by default. Therefore, it is necessary to open a provided GUI configuration like it is shown in Figure 8. The user is required to open a provided GUI configuration as shown in Figure 8.



4. Empty GUI – default configuration

5. Click **File>Open Project**

6. Choose B6-2inParallel

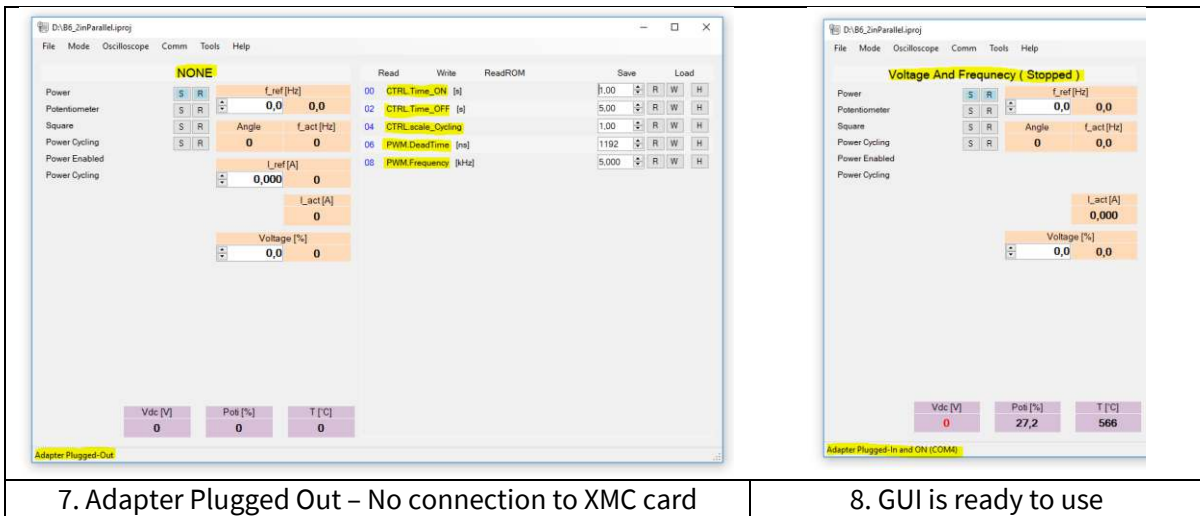
Figure 8 Configuration of Infineon DEMO Graphical User Interface

User Manual

EVAL-M5-IMZ120R-SIC

Demo control

The Infineon’s software gives the users a feedback about the current status, if any devices are connected to the GUI (computer) as shown in Figure 9 (if NONE appears, the board is connected). The same indication appears at the bottom of the software window as Adapter Plugged Out.



7. Adapter Plugged Out – No connection to XMC card

8. GUI is ready to use

Figure 9 Inactive software – No board connected to the computer

When the XMC driver card is connected with the computer, the software will automatically recognize the controller, and the software will show the status Adapter Plugged-in and ON (COMX). The software needs to be restarted in case of connecting the controller when the software was opened already.

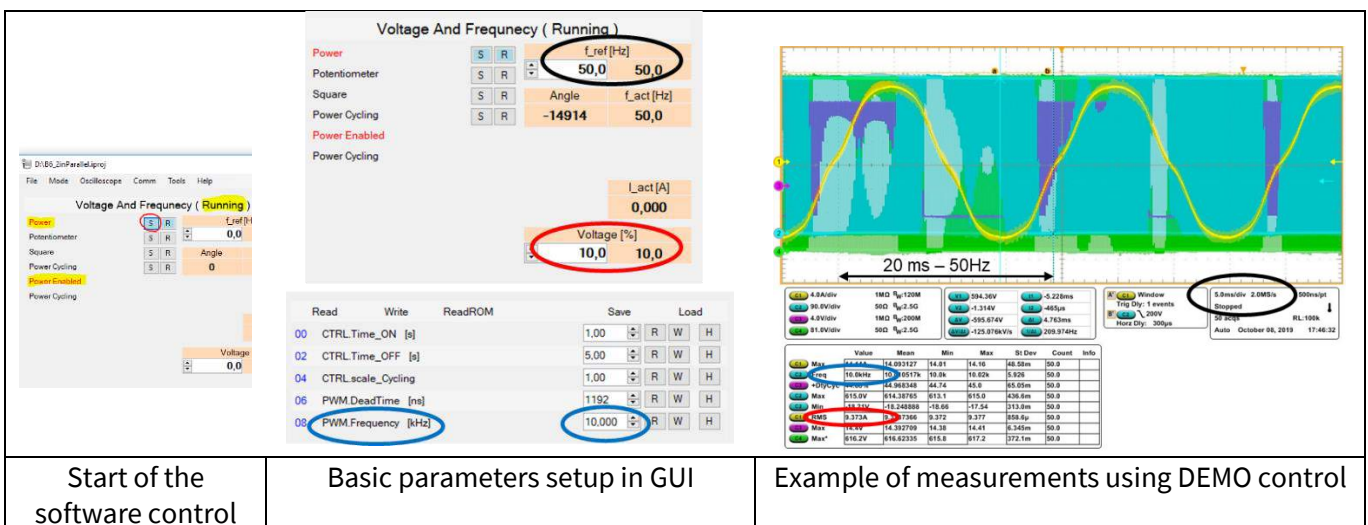
In case that the XMC driver card is empty and do not have any software preinstalled you can use the XMCTM Flasher and flash the board. All the the instructions can be found in user manual [4] at page 10.

4.2 Using the DEMO graphical user interface for CoolSiC™ MOSFET MADK

After following the instructions in the previous section, the user should be able to operate the CoolSiC™ MOSFET motor drives evaluation board with the provided demo software.

This section will show an example of how to use Infineon’s DEMO GUI for controlling the evaluation board, and testing the performance of SiC MOSFETs in motor-drive applications.

Figure 10 illustrates a step-by-step process of how to use the DEMO control in applications



Start of the software control

Basic parameters setup in GUI

Example of measurements using DEMO control

Figure 10 Example 1 – Changing a main parameters of the Infineon DEMO control

User Manual

EVAL-M5-IMZ120R-SIC

Demo control

The user has the possibility to change four basic parameters of the DEMO control:

- Phase fundamental/current frequency [Hz],
- Voltage duty cycle [%],
- Switching frequency [kHz],
- Deadt time [ns]

In addition, users can define a different testing load profile by changing two time periods and the scale factor of the duty cycle. Figure 11 shows an example of how to create a testing load profile. This enables the devices to be tested at different load profiles, like the $3 \times I_{nom}$, for a short time pulse.

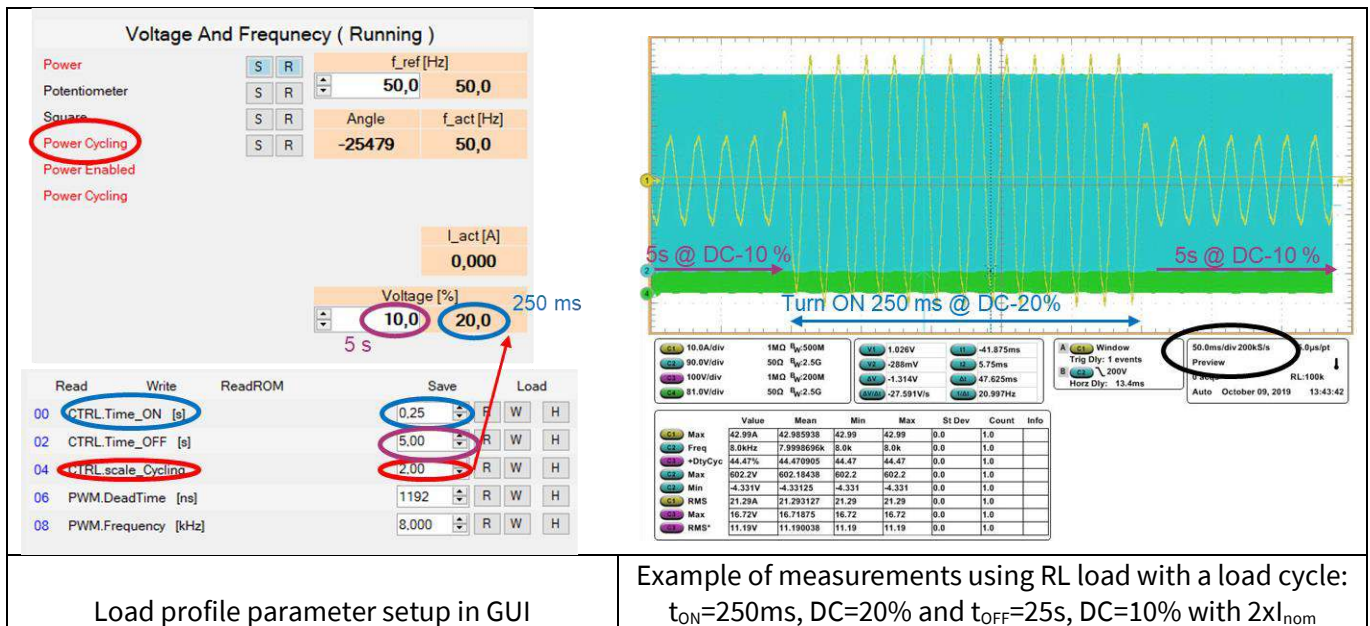


Figure 11 Example 2 – Defining a load profile with Infineon DEMO control

5 Schematics and layout

5.1 Overview

An overview of the board's schematics is given in Figure 12. Basically the schematic can be divided into four subcategories: the input circuit of the converter, the auxiliary supply, the power stage and the measurements. The external controller board has to be connected to the evaluation board by the X10 driver board connector. The logical ground is connected to earth by the resistors R12 to R14. Alternatively, the board can be equipped with an iMOTION™ MADK M1 20 pin interface connector in a different population variant.

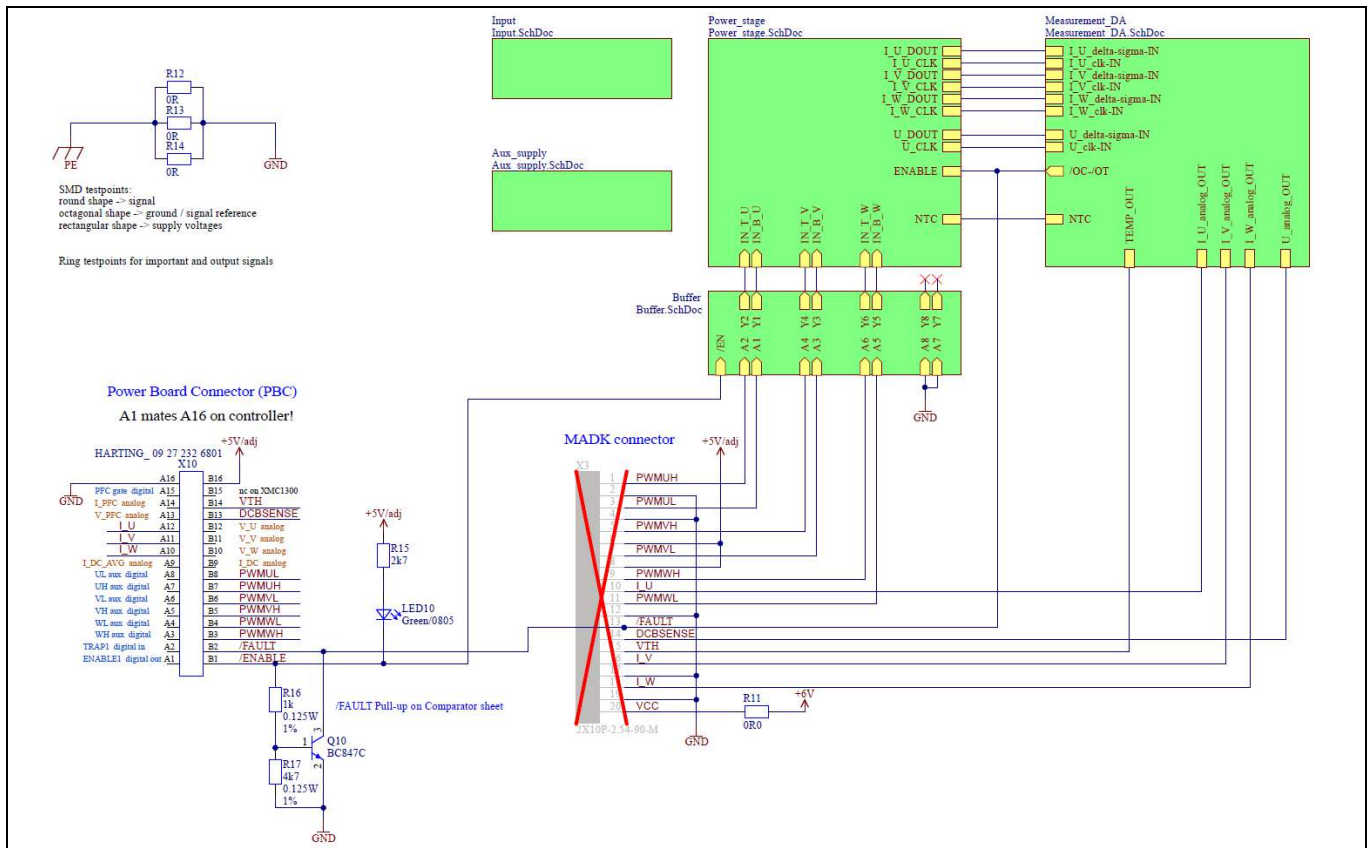


Figure 12 Overview and driver board connector

5.2 Input circuit

The input circuit is shown in Figure 13. It is equipped with two NTC resistors, which limit the inrush current. The resistors are bypassed after the start of the auxiliary supply and a constant delay time. The DC-bus consists of four electrolytic capacitors and one film capacitor as well as four ceramic capacitors for the high frequency ripple currents. The electrolytic capacitors are series connected and balanced with two resistors.

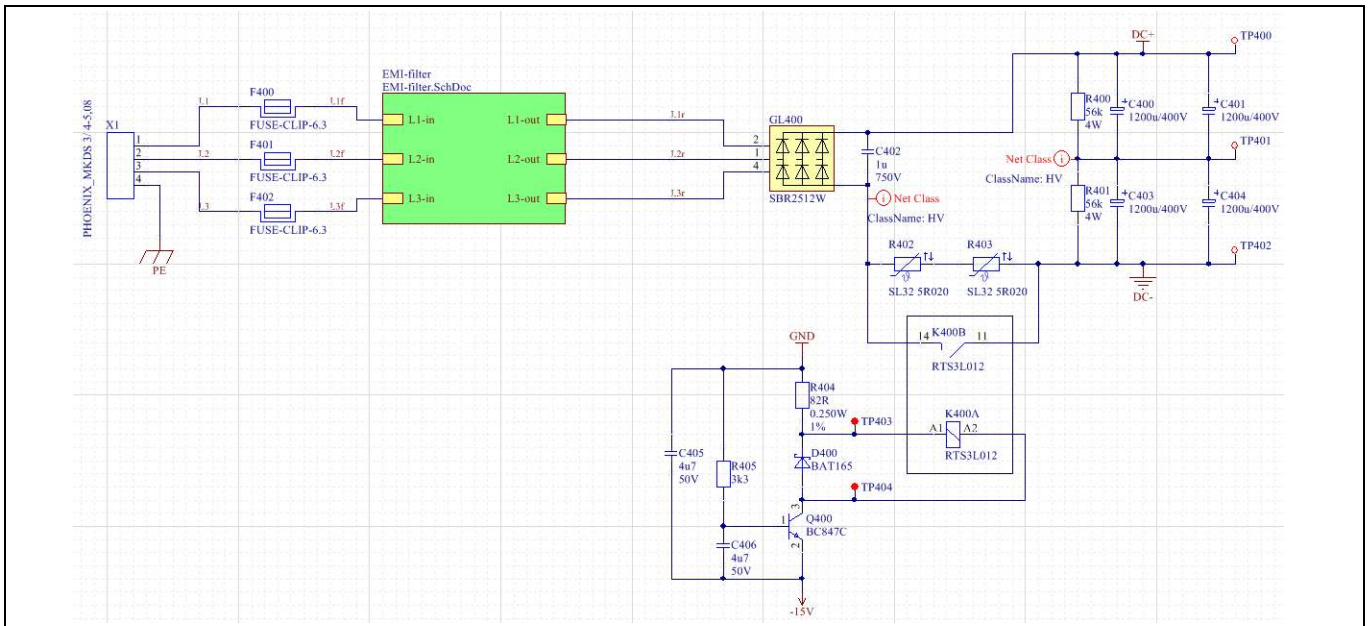


Figure 13 Mains input and precharge circuit

5.2.1 EMI filter

The EVAL-M5-IMZ120R-SIC is equipped with an EMI filter circuit. The circuit is depicted in Figure 14.

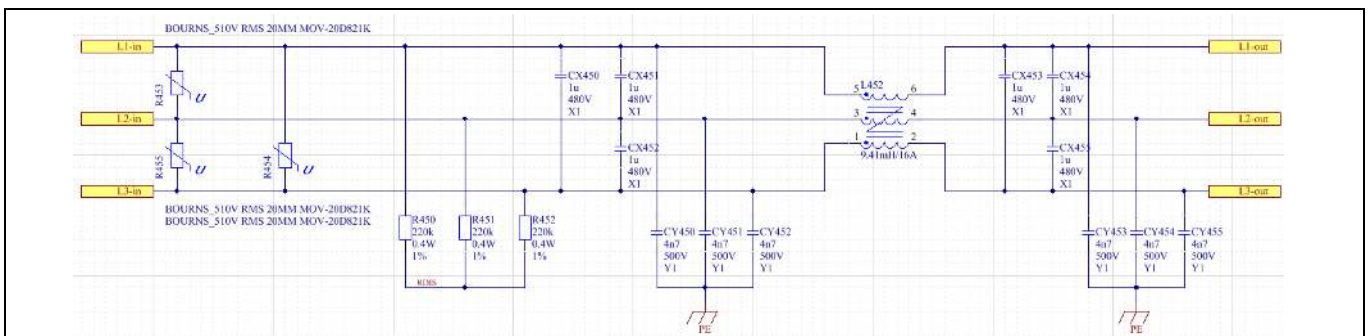


Figure 14 EMI filter

The EMI filter is designed to minimize high-frequency emissions to the connected grid. Lower harmonics of the grid current are not suppressed. Additional mains line choke must be used to fulfil harmonic standards. In addition a mains line choke also reduces the crest factor of the input current. Hence, an external choke allows higher rms input currents leading to a higher output power. Without an additional mains line choke, an output power of approx. 6 kW can be achieved at 400 V line voltage.

However, the conducted EMI emission strongly depends on several operating conditions, like the connected motor, switching frequency used, and so on. Consequently, the implemented filter does not necessarily fulfil the required standard. If necessary a Vacuumschmelze W 424-53 ring core, or similar, with three turns can be added to the supply lines as a common mode choke to further reduce the conducted EMI.

5.3 Auxiliary supply

All supply voltages are generated by a flyback converter, supplied from the DC bus. It starts operation at a bus voltage of 477 V_{dc}, which corresponds to approximately 340 V_{ac} input voltage. The supply circuit is implemented with an Infineon ICE5QSAG control IC. The supply voltages are isolated from the DC-bus potential by a basic insulation. The complete schematic diagram is shown in Figure 15.

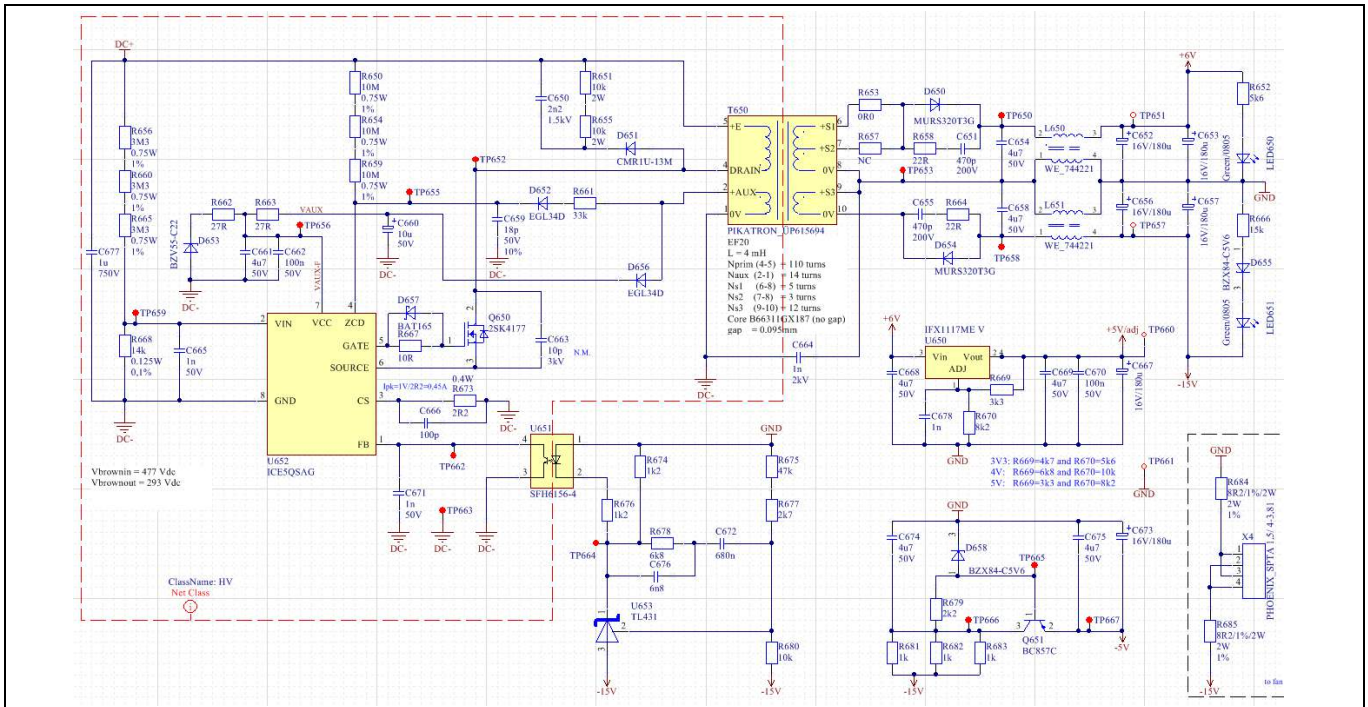


Figure 15 Auxiliary supply

The flyback converter generates three voltages. The auxiliary winding on the primary side of the transformer generates an unregulated 17.6 V supply for the control IC itself. On the transformer’s secondary side two output voltages are generated: a regulated -15 V and indirectly regulated +6 V. The -15 V supply voltage is mainly used for the MOSFET driver supply circuit. From this voltage, a -5 V supply voltage is derived by a linear regulator used for the negative supply for the analogue circuitry of the board. The positive analogue supply is directly connected to the +6 V supply. This voltage rail is also used to generate the +5 V for the controller and overcurrent threshold generations.

If the EVAL-M5-IMZ120R-SIC is to be used with low DC-bus voltages below the brown in threshold of the flyback converter it is possible to supply it with an external power supply. Therefore the test points TP651, TP656 and TP661 can be used. These test points are labelled with their corresponding voltage on the PCB. The points are depicted in Figure 16.

The AUX supply is by default designed in a way that at least 400 V of DC-link voltage need to be applied in order to trigger it’s operation. This mean if lower DC-link voltage is applied all components with low voltage will not be functional. In order to change the trigger level of AUX supply can be achieved by simply setting the resistor value of R668 accordingly. For example changing the resistor value of R668 from 14 kΩ (default value) to 39 kΩ will allow AUX supply to trigger at lower DC voltage of around 200V instead of 400 V.

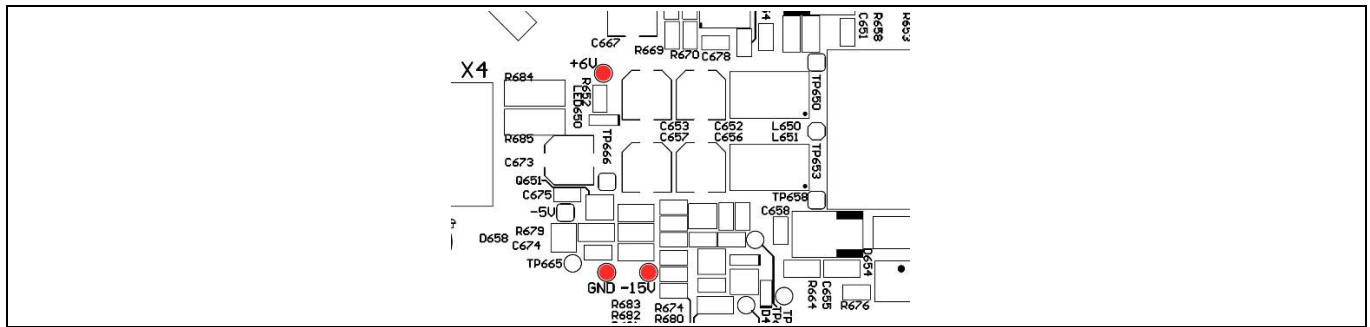


Figure 16 Major power supply test points

5.4 Power stage

The schematic diagram of the power stage is shown in Figure 17. The three-phase legs are connected to one film capacitor and four ceramic capacitors. Two of the ceramic capacitors are connected directly to the power module in front of the current measuring shunt. For the film capacitors, two alternate packages can be mounted. Both high-frequency capacitor types are placed as close as possible to the power module to minimize overvoltage at switching. Only two of the ceramic capacitors are connected prior the shunt to limit short-circuit energy. The DC bus is led through to the connector X6.

The current measuring shunt is used to detect output short-circuits. An overcurrent protection circuit is used to monitor the shunt voltage and to disable all switches in overcurrent condition.

At each phase, the output current is measured by a shunt resistor. The shunt voltages are measured by galvanically isolated $\Delta\Sigma$ -DACs. Their supply is derived from an additional voltage level of the top-side driver supply circuit. The voltage of the DC bus is measured by a voltage divider and the same isolated $\Delta\Sigma$ -DAC supplied from an additional driver voltage of the low-side driver supply. The functionalities of these blocks are explained below.

An NTC can be mounted on the heatsink for generating a temperature-related measuring voltage V_{th} .

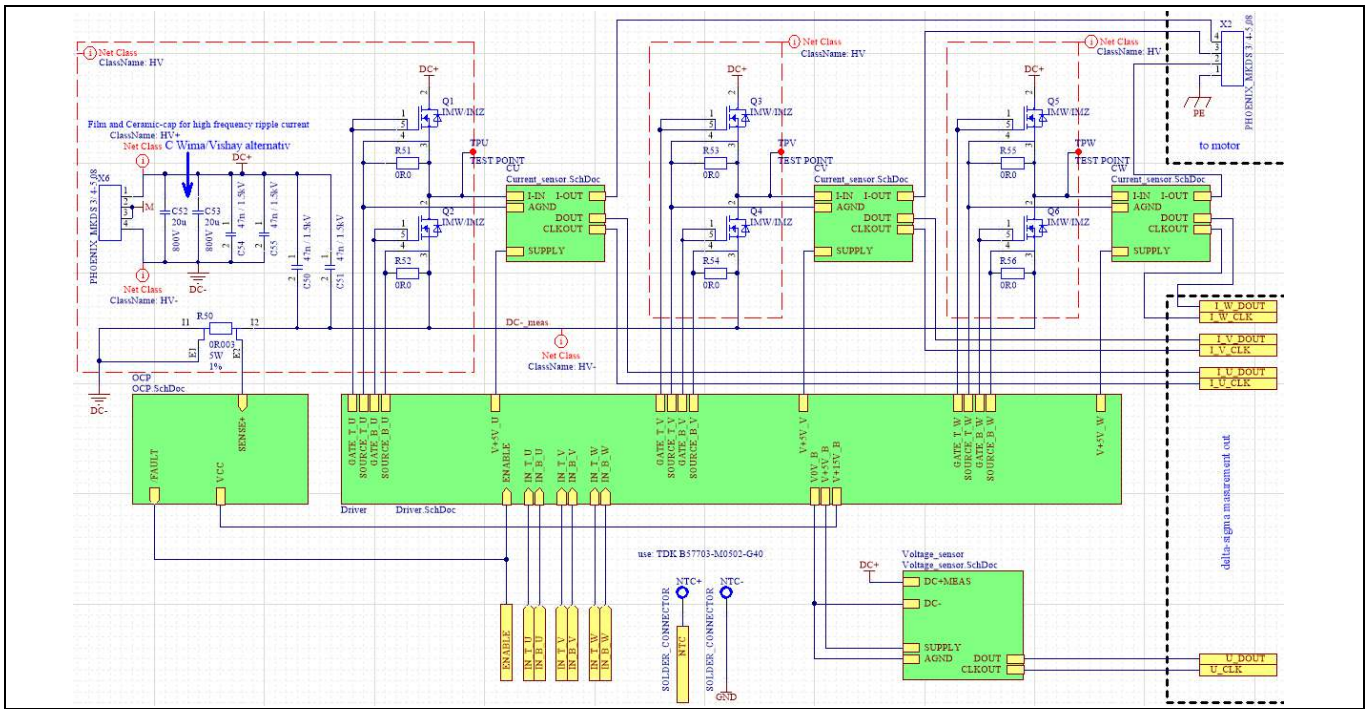


Figure 17 Power stage

5.5 Driver circuit

Each of the six MOSFETS is driven by Infineon’s MOSFET EiceDRIVER™ 1EDI20H12AH. The positive input is protected by an additional glitch filter and a pull down resistor. All negative inputs are connected together and are used for a global /ENABLE signal. The circuit, which is used for each phase leg, is shown in Figure 18.

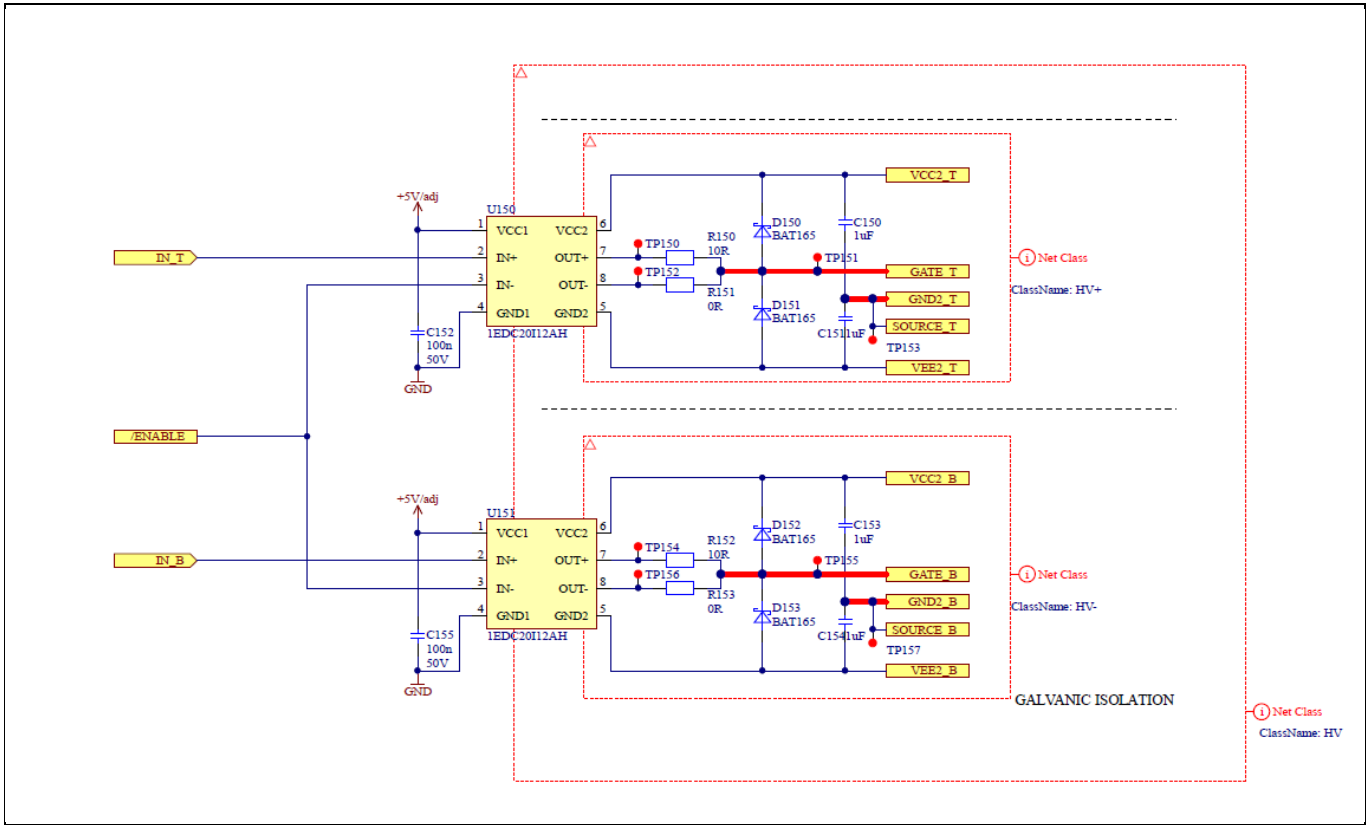


Figure 18 Driver circuit for one phase leg

The secondary sides of the EiceDRIVER™ are supplied by four galvanically isolated power supplies: one for each top-side driver including the current sensor supply and one for all low-side drivers together with the voltage sensor. The whole circuit is shown in Figure 19. The four output voltages are generated by two impulse transformers, which are supplied by a high-frequency oscillator. At each output a rectifier is located, which generates three different voltage levels.

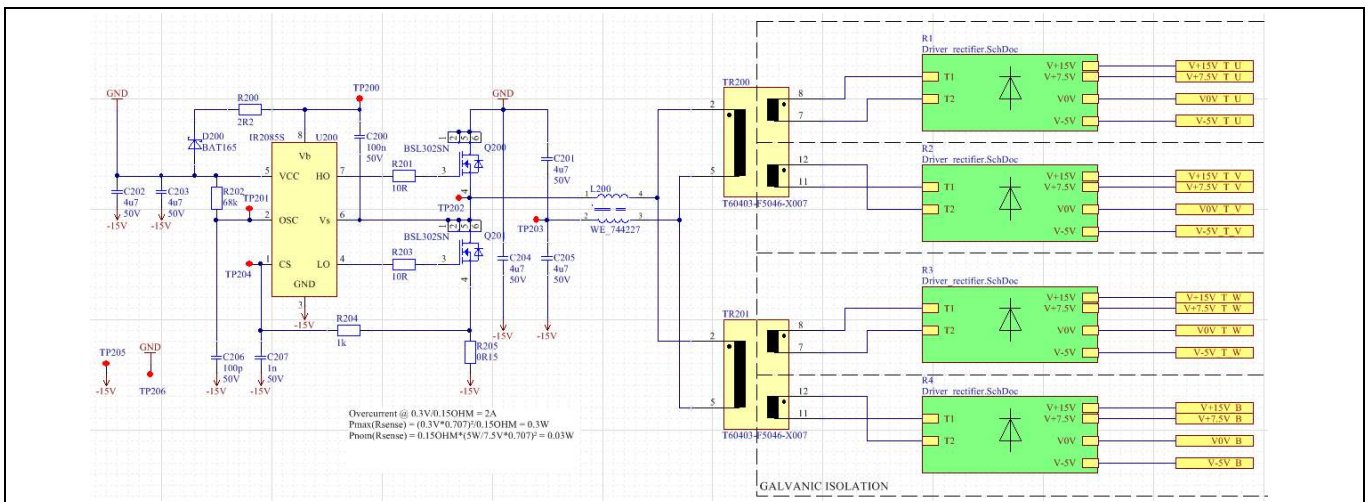


Figure 19 Driver power supply

Schematics and layout

The rectifier circuit generates three voltage levels for each driver: a regulated negative voltage for safe turning off the power MOSFET, +15 V for turning on the power MOSFET and additionally +5 V for the additional current and voltage measurement. The circuit is shown in Figure 20.

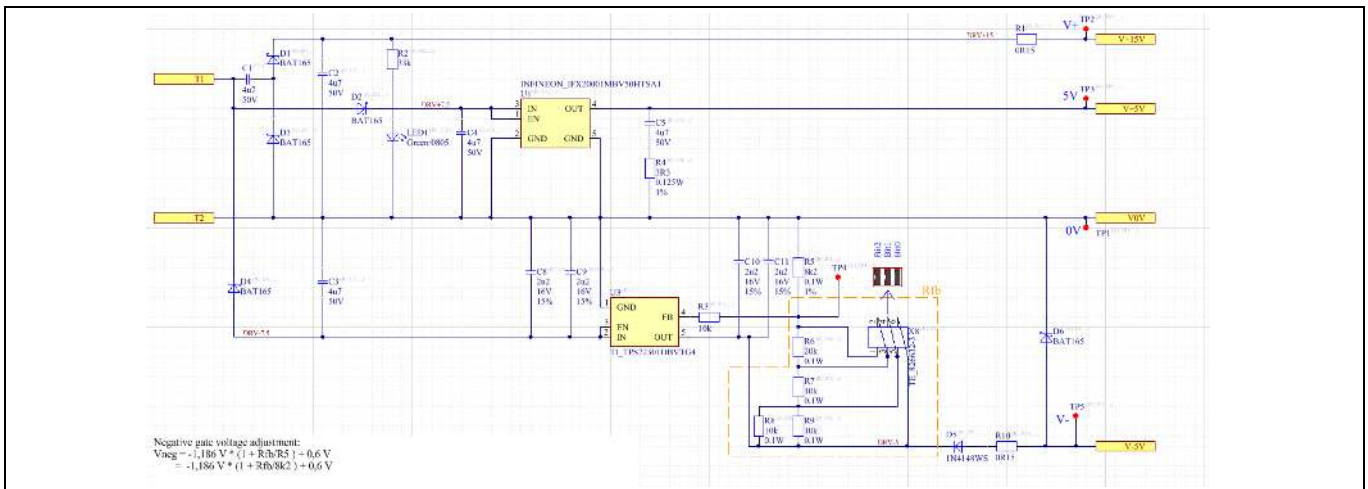










Figure 20 Rectifier circuit of driver power supply

The regulated negative voltage can be adjusted in 8 steps by placing jumpers on the pin header X8. This adjustment must be done for each rectifier circuit separately. By placing the jumpers in a certain way, the feedback resistor of the negative voltage regulator is changed. Consequently, its output voltage can be adjusted. The selectable voltages are shown in Table 10.

Additionally, it is possible to use real 0 V turn off voltage if R10 is removed and TP1 is connected to TP5. Be careful with adjusting the negative voltage! Load conditions might occur, which lead to undesired turn on of the power switches.

Table 10 X8 pin header negative gate voltage selection

| Jumper setting | Negative gate voltage |
|---|-----------------------|
|  | -5.6 V |
|  | -4.9 V |
|  | -4.2 V |
|  | -3.5 V |
|  | -2.8 V |
|  | -2.0 V |
|  | -1.3 V |
|  | -0.6 V |

5.6 Thermistor output

The temperature of the heatsink is measured with a TDK B57703-M0502-G40 NTC resistor. The NTC resistor is connected to 5 V via a series resistor of 10 kΩ. The resulting NTC voltage is fed to the control board via an amplifier with a gain of 2. If necessary the signal level can be changed by exchanging the resistors R617, R620, R621 and R623. The evaluation circuit is depicted in Figure 21.

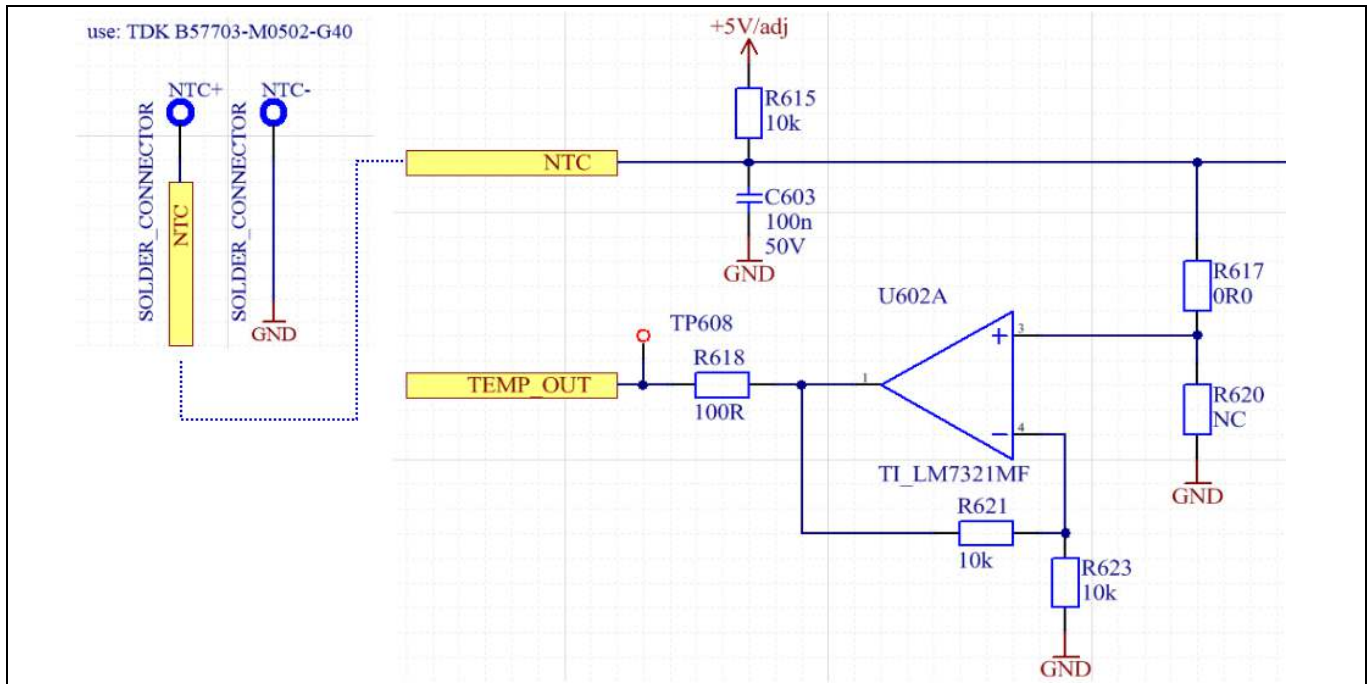


Figure 21 Evaluation circuit for NTC measurement

The dependency of the generated output voltage vs. the heatsink temperature when using a TDK B57703-M0502-G40 NTC resistor is shown in Figure 22.

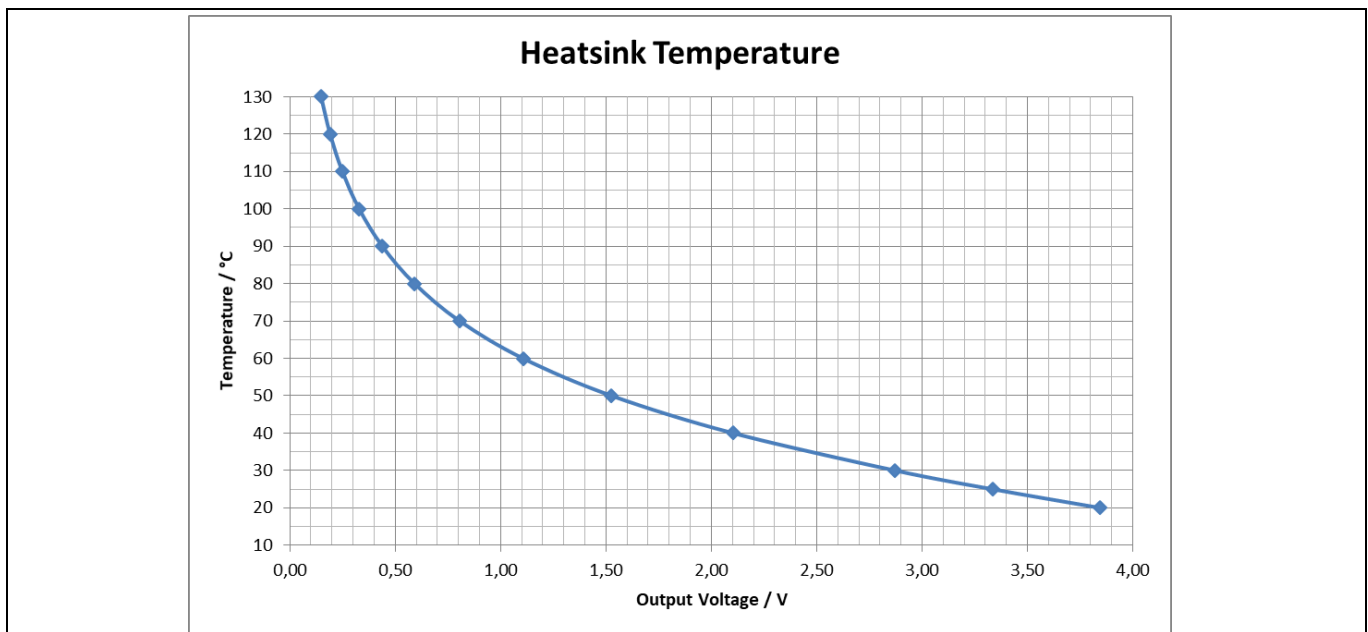


Figure 22 Heatsink temperature output

5.7 Current measurement

The three phase currents are measured by shunt resistors. Each shunt voltage is measured by a galvanically isolated $\Delta\Sigma$ -modulator. The modulator generates a $\Delta\Sigma$ -modulated bit stream output with a clock frequency of

20 MHz. The circuit can be seen in Figure 23. The modulator is supplied via the +5 V output from the rectifier circuit.

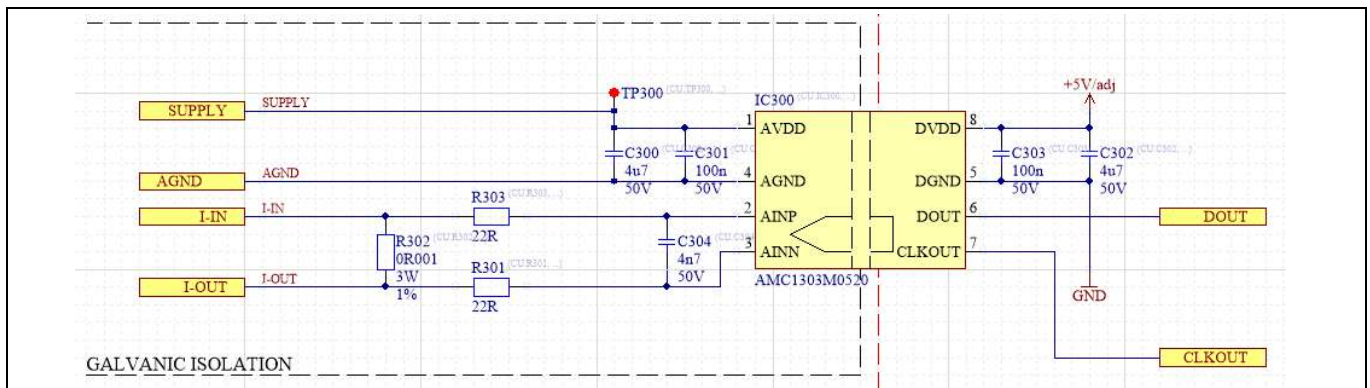


Figure 23 Phase current measurement

5.8 Voltage measurement

Similar to the current measurement, the DC-bus voltage is measured via a voltage divider and the galvanically isolated $\Delta\Sigma$ -modulator.

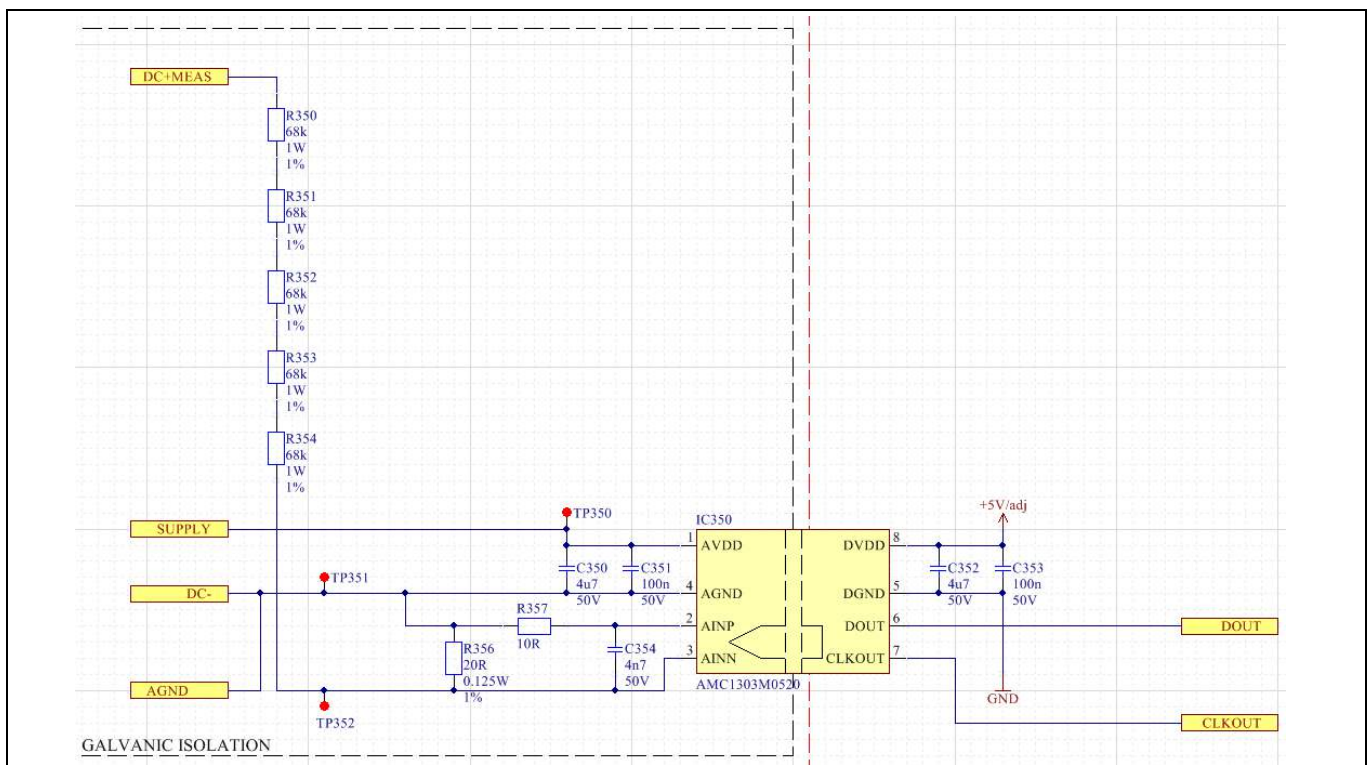


Figure 24 DC-bus voltage measurement

5.9 Digital-to-analogue converter

The evaluation board contains four discrete digital-to-analogue converters to generate analogue signals from the digital $\Delta\Sigma$ -modulated bit streams. The analogue signals are used for the on-board protection as well as for the external controller. The conversion is done by 2nd order low pass filters with approximately 6.5 kHz

bandwidth. At zero input, the $\Delta\Sigma$ -converter generates a bit stream with 50% duty cycle. For offset adjustment the reference voltage of the low pass filters can be adjusted via the potentiometer R5564 for all three currents. The four $\Delta\Sigma$ -modulated bit streams can be measured directly at the pin headers X7.

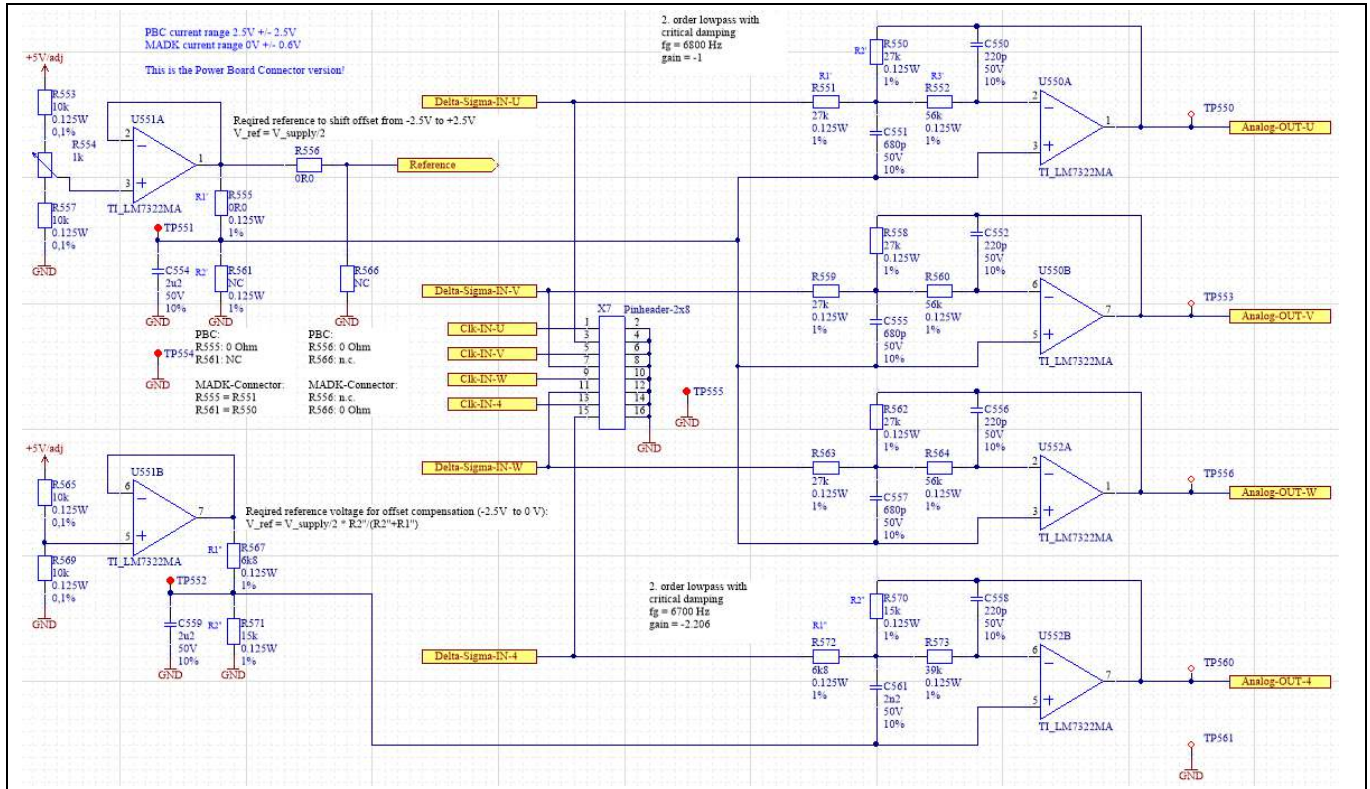


Figure 25 Measurement digital to analogue conversion

5.10 Overload and overtemperature protection

The EVAL-M5-IMZ120R-SIC evaluation board is equipped with an overcurrent and overtemperature protection. If an overcurrent or overtemperature event is detected, the /FAULT signal is pulled low and the MOSFET drivers are simultaneously disabled for around 30 ms.

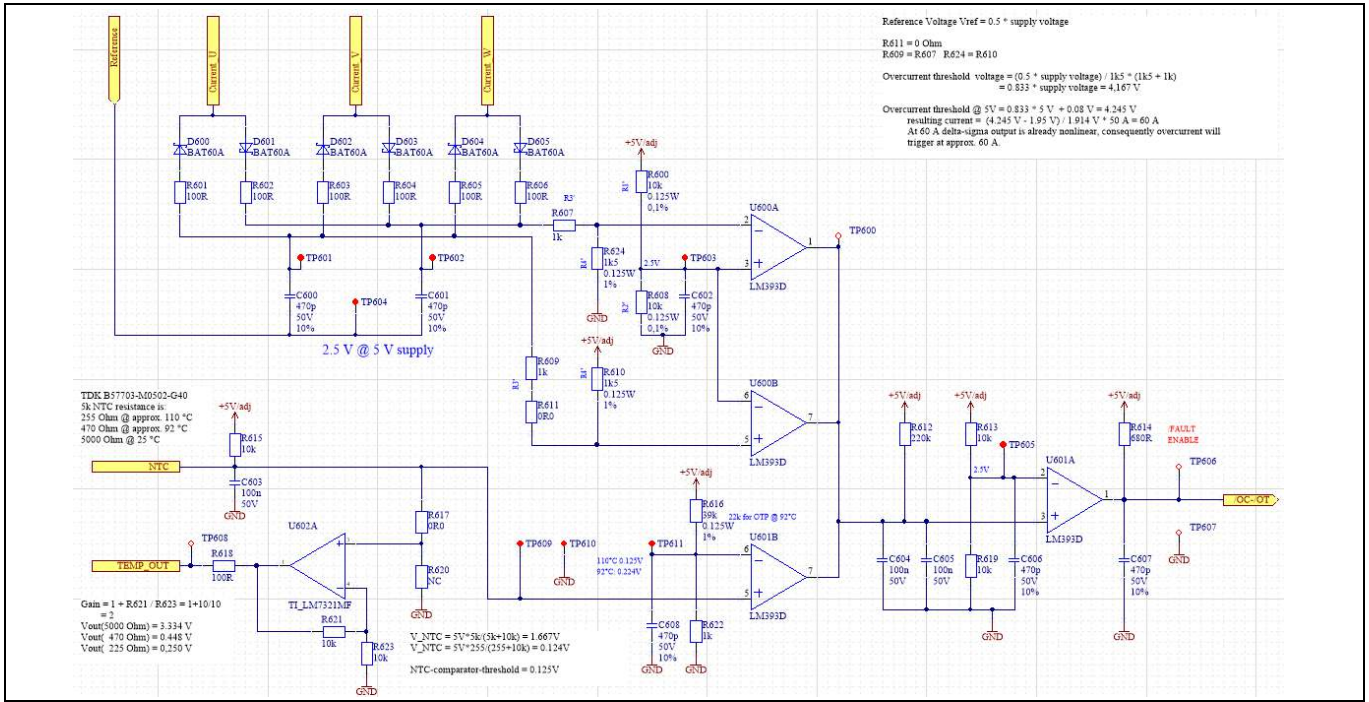


Figure 26 Protection circuit and temperature measurement

The overcurrent detection is implemented with six ultra-low forward voltage drop diodes (D600 ... D605) which rectify the peak current of each phase. The peak positive value and the peak negative value are compared with a threshold value. If one of the values is exceeded, the /FAULT signal is triggered.

The overtemperature detection monitors directly the NTC voltage. A voltage below 0.125 V triggers the /FAULT signal. This threshold corresponds to a measured heatsink temperature of 110°C.

5.11 Overcurrent / Short-circuit-protection

The circuit, which monitors the voltage across a 3 mΩ shunt placed in the DC- path of the power MOSFET, is shown in Figure 27. A low-side driver with overcurrent protection feature is used here. The driver stage itself is unused. The Infineon 1ED44176N01F has 0.5 V overcurrent trigger threshold. This leads to a nominal current threshold of 167 A.

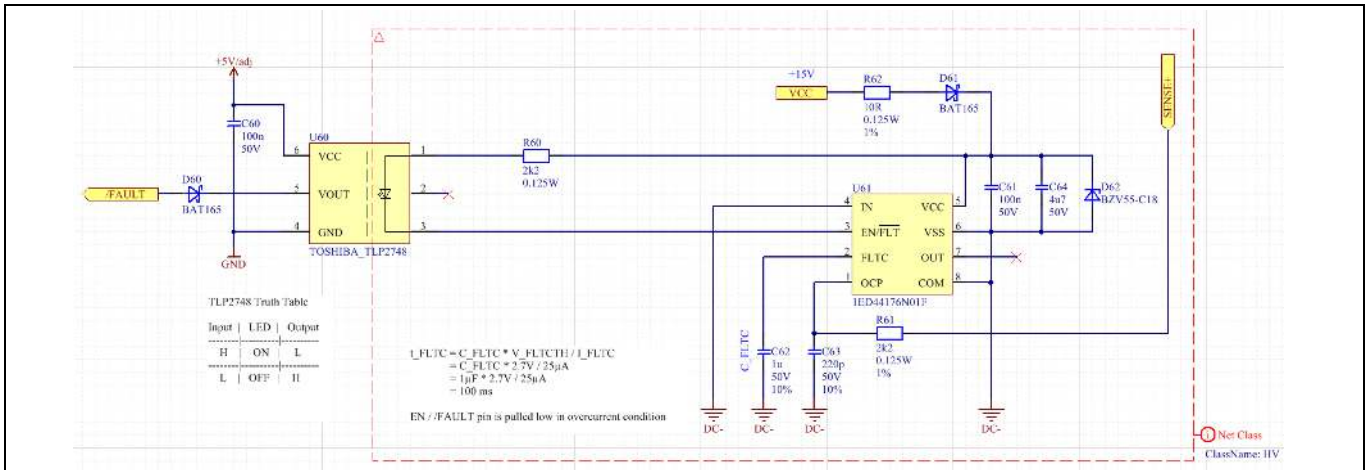


Figure 27 Short-circuit protection

A low pass filter (R61/C63) is placed at the OCP pin of the IC. Its time constant of 484 ns is required to block high voltage spikes at fast current rises due to the parasitic inductance of the measuring shunt and its connection. If an overcurrent is detected the EN/FAULT pin of the driver is pulled low and the LED of the connected optocouple turns on. Hence, the isolated side of the optocouple turns low and the /FAULT signal is pulled low. Consequently, all MOSFET drivers are turned off. The overall time delay from overcurrent to MOSFET gate low is approximately 1 μ s.

The circuit is supplied via the low-side gate driver supply. This supply is referenced to the source of the low-side MOSFETs which is in front of the shunt. Consequently, the supply of the OCP protection is decoupled with a diode (D61) and buffered with a capacitor (C64). This leads to a voltage drop of approximately 1 V in overcurrent condition, but this is still sufficient to supply the circuit.

It is important to mention that Infineon are not testing every board with SCWT (short circuit withstand time) robustness (due to lowering the production cost), but design was intended to be developed to show a reference design on how to protect a design against SCWT under 1 μ s!

5.12 PCB layout

The layout of this board is especially designed for evaluation purposes. Consequently, it has many test points and is not necessarily suited for continuous operation at full load. The PCB has four electrical layers with 35 μ m copper. Its dimensions are 204 mm x 259 mm. The PCB thickness is 1.6 mm. Contact our technical support team to get more detailed information on the layout design and the latest Gerber files.

Measurements

6 Measurements

The following chapter shows some typical measurements made with the EVAL-M5-IMZ120R-SIC evaluation board.

All thermal measurements were done with 60 mΩ MOSFETs in place of the designed 45 mΩ types. The board was supplied by a 400 V grid and it is connected at the output to a symmetrical RL – load illustrated in Figure 28.

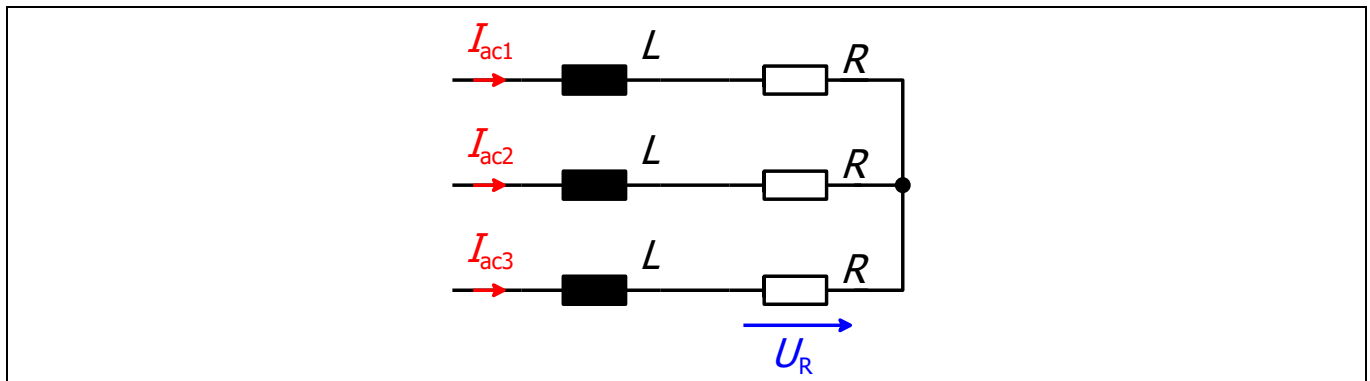


Figure 28 Test load

The value of the inductance is 1.5 mH and the value of the resistor is 30 Ω. With a nominal output current of 5 A_{RMS} the output power is about 2.3 kW. The switching frequency was set to 10 kHz and the dV/dt was reduced to max. 10 kV/μs with gate resistors of 33 Ω and an additional gate capacitance of 3.3 nF. The following screenshot shows the related measurement.

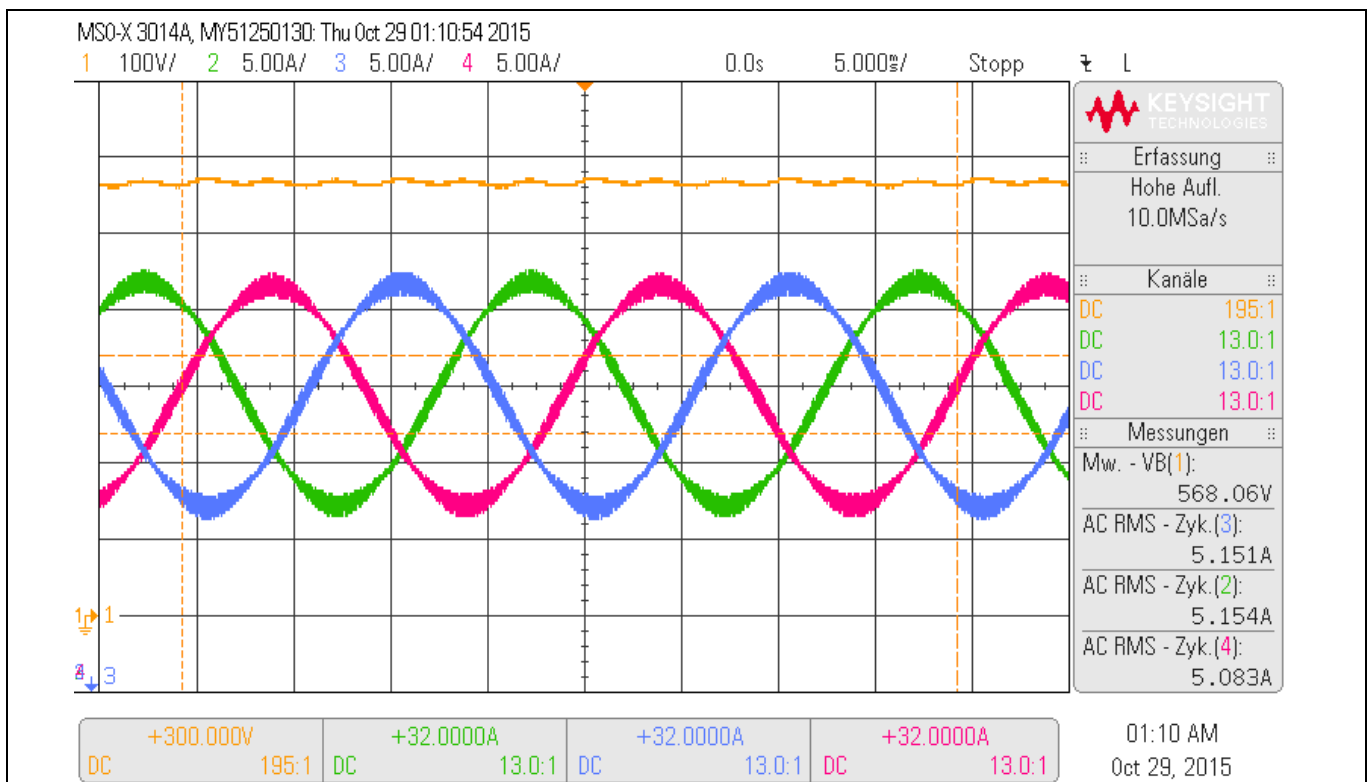


Figure 29 Measurement waveforms with test load (Ch1: DC-Bus voltage, Ch2 to Ch4: load currents)

Measurements

6.1 Thermal measurements

After the board was powered for 40 minutes at this load condition, the following thermal images were made. At the same time the heatsink – temperature was measured via the mounted NTC with $T_{HS} \approx 75\text{ }^{\circ}\text{C}$.



Figure 30 Thermal image the left power MOSFETs



Figure 31 Thermal image of right power MOSFETs (hotspot at the capacitor's balancing resistors)



Figure 32 Thermal image of the input rectifier

Measurements

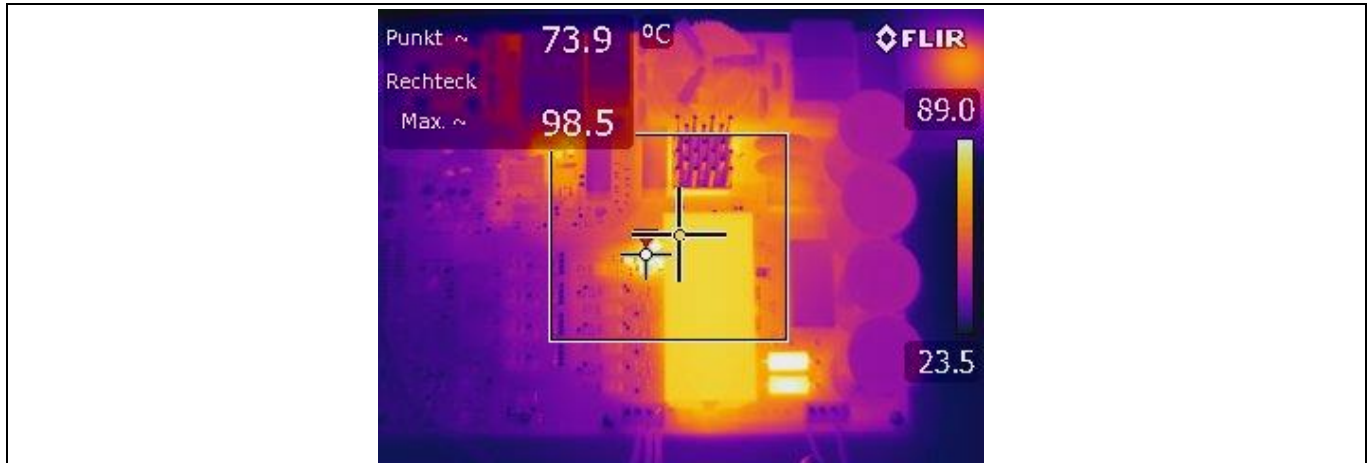


Figure 33 Top view thermal image (hotspot at voltage measurement resistors)

To evaluate the thermal behaviour of the EVAL-M5-IMZ120R-SIC evaluation board at forced convection and faster switching, the output current was increased to 10 A_{RMS} and a 40 mm x 40 mm fan was mounted on the heatsink. Gate resistors were changed to 10 Ω and the switching frequency was set to 18 kHz. Figure 34 shows the thermal image at this operating point. The measured heatsink temperature via the NTC circuit was $T_{HS} \approx 60\text{ °C}$.



Figure 34 Thermal image of evaluation board at 18 kHz switching frequency, 10 Ω gate resistance and forced convection

Bill of Material

7 Bill of Material

| No | Qty | Part description | Designator | Part number | Manufacturer |
|----|-----|---|--|------------------|-----------------------------|
| | 11 | SCREW M3: ZYK ISK / 8mm / ST8,8 vz bp | SCREW1, SCREW2, SCREW3 | | no special |
| 1 | 1 | NUT: M3 / ST 8 vz bp | NUT1, NUT2, NUT3, NUT4, NUT5, NUT6, NUT7, NUT8, NUT9 | | no special |
| 2 | 4 | WASHER: 3,2mm / ST vz bp | WASHER1, WASHER2 | | no special |
| 3 | 2 | SPACER BOLT: M3 / M3 / 12mm / STvz / SW 5,5mm / Freistich | SPACER1, SPACER2, SPACER3, SPACER4, SPACER5, SPACER6, SPACER7, SPACER8, SPACER9 | 05.13.121 | ETTINGER GmbH |
| 4 | 2 | DIODE ZENER: BZV55-C18 | D62 | BZV55-C18 | no special |
| 5 | 1 | DIODE ZENER: BZV55-B22 | D653 | BZV55-B22 | no special |
| 6 | 2 | DIODE ZENER: BZX84-C5V6 | D655, D658 | BZX84-C5V6 | no special |
| 7 | 1 | DIODE SCHOTTKY: BAT165 | D60, D61, D100, D101, D200, D400, D657, R1.D1, R1.D2, R1.D3, R1.D4, R1.D6, R2.D1, R2.D2, R2.D3, R2.D4, R2.D6, R3.D1, R3.D2, R3.D3, R3.D4, R3.D6, R4.D1, R4.D2, R4.D3, R4.D4, R4.D6 | BAT165 | Infineon |
| 8 | 11 | DIODE SCHOTTKY: BAT60A | D600, D601, D602, D603, D604, D605 | BAT60AE6327HTSA1 | Infineon |
| 9 | 4 | DIODE STANDARD: MURS320T3G | D650, D654 | MURS320T3G | ON Semiconductor |
| 10 | 1 | DIODE STANDARD: CMR1U-13M | D651 | CMR1U-13M | Central Semiconductor Corp. |
| 11 | 1 | DIODE STANDARD: EGL34D-E3 | D652, D656 | EGL34D-E3 | Vishay |
| 12 | 2 | DIODE STANDARD: 1N4148WS | R1.D5, R2.D5, R3.D5, R4.D5 | 1N4148WS | no special |
| 13 | 27 | RECT BRIDGE: SBR2512W | GL400 | SBR2512W | Multicomp |
| 14 | 6 | IC ADC: AMC1303M0520 | CU.IC300, CV.IC300, CW.IC300, IC350 | AMC1303M0520 | Texas Instruments |
| 15 | 4 | IC OPAMP: LM7322MA | U550, U551, U552 | LM7322MA | Texas Instruments |
| 16 | 2 | IC OPAMP: LM7321MF | U602 | LM7321MF | Texas Instruments |
| 17 | 1 | IC DRIVER: 1ED44176N01F | U61 | 1ED44176N01F | Infineon |
| 18 | 2 | IC DRIVER: IR2085 | U200 | IR2085S | Infineon |

Bill of Material

| | | | | | |
|----|---|-------------------------------------|--|--------------------------------|-------------------|
| 19 | 1 | IC DRIVER: 1EDI20H12AH | U.U150, U.U151, V.U150, V.U151, W.U150, W.U151 | 1EDI20H12AH | Infineon |
| 20 | 4 | IC VOLT REG: IFX20001MBV50HTSA1 | R1.U1, R2.U1, R3.U1, R4.U1 | IFX20001MBV50HTS A1 | Infineon |
| 21 | 3 | IC VOLT REG: TPS72301DBVTG4 | R1.U3, R2.U3, R3.U3, R4.U3 | TPS72301DBVTG4 | Texas Instruments |
| 22 | 1 | IC VOLT REG: IFX1117ME V | U650 | IFX1117ME V | Infineon |
| 23 | 1 | IC VOLT REG: ICE5QSAG | U652 | ICE5QSAG | Infineon |
| 24 | 6 | IC VOLT REG: TL431AFDT | U653 | TL431AFDT | NXP |
| 25 | 1 | IC COMP: LM393D | U600, U601 | LM393D | Texas Instruments |
| 26 | 1 | IC LOGIC: 74HCT7541D | U20 | 74HCT7541D | NXP |
| 27 | 1 | IC OPTOCOUPLE: TLP2748 | U60 | TLP2748 | Toshiba |
| 28 | 1 | IC OPTOCOUPLE: SFH6156-4T | U651 | SFH6156-4T | Vishay |
| 29 | 4 | LED: 0805 / green | LED10, LED650, LED651, R1.LED1, R2.LED1, R3.LED1, R4.LED1 | SMD-G0805-02 | Sloan AG |
| 30 | 4 | TRANS NPN: BC847C | Q10, Q100, Q400 | BC847C | Infineon |
| 31 | 2 | TRANS PNP: BC857C | Q651 | BC857C | Infineon |
| 32 | 1 | MOSFET: BSL302SN | Q200, Q201 | BSL302SN | Infineon |
| 33 | 1 | MOSFET: 2SK4177 | Q650 | 2SK4177 | ON Semiconductor |
| 34 | | POWER MOSFET: IMW / IMZ | Q1, Q2, Q3, Q4, Q5, Q6 | IMW120R045M1 / IMZ120R045M1 | Infineon |
| 35 | 1 | RES SMD 0805: 22R / 1% / 0,125W | CU.R301, CU.R303, CV.R301, CV.R303, CW.R301, CW.R303 | | no special |
| 36 | 7 | RES SMD 0805: 0R15 / 1% / 0,125W | R1.R1, R1.R10, R2.R1, R2.R10, R3.R1, R3.R10, R4.R1, R4.R10, R205 | | no special |
| 37 | 3 | RES SMD 0805: 33k / 1% / 0,125W | R1.R2, R2.R2, R3.R2, R4.R2, R661 | | no special |
| 38 | 1 | RES SMD 0805: 3R3 / 1% / 0,125W | R1.R4, R2.R4, R3.R4, R4.R4 | | no special |
| 39 | 2 | RES SMD 0805: 0R0 / 1% / 0,125W | R11, R51, R52, R53, R54, R55, R56, R555, R556, R611, R617, R653 | | no special |
| 40 | 1 | RES SMD 0805: 2k7 / 1% / 0,125W | R15, R677 | | no special |

Bill of Material

| | | | | | |
|----|----|-----------------------------------|--|--|------------|
| 41 | 1 | RES SMD 0805: 1k0 / 1% / 0,125W | R16, R100, R204, R607, R609, R622 | | no special |
| 42 | 6 | RES SMD 0805: 4k7 / 1% / 0,125W | R17 | | no special |
| 43 | 1 | RES SMD 0805: 2k2 / 1% / 0,125W | R60, R61 | | no special |
| 44 | 4 | RES SMD 0805: 10R / 1% / 0,125W | R62, R101, R201, R203, R357, R667, U.R152, U.R158, V.R152, V.R158, W.R152, W.R158 | | no special |
| 45 | 24 | RES SMD 0805: 10k / 1% / 0,125W | R102, R613, R615, R619, R621, R623, R680, U.R153, U.R159, V.R153, V.R159, W.R153, W.R159 | | no special |
| 46 | 1 | RES SMD 0805: 2R2 / 1% / 0,125W | R200 | | no special |
| 47 | 6 | RES SMD 0805: 68k / 1% / 0,125W | R202 | | no special |
| 48 | 2 | RES SMD 0805: 20R / 1% / 0,125W | R356 | | no special |
| 49 | 11 | RES SMD 0805: 3k3 / 1% / 0,125W | R405, R669 | | no special |
| 50 | 1 | RES SMD 0805: 100R / 1% / 0,125W | R500, R501, R502, R503, R601, R602, R603, R604, R605, R606, R618 | | no special |
| 51 | 6 | RES SMD 0805: 27k / 1% / 0,125W | R550, R551, R558, R559, R562, R563 | | no special |
| 52 | 2 | RES SMD 0805: 56k / 1% / 0,125W | R552, R560, R564 | | no special |
| 53 | 2 | RES SMD 0805: 10k / 0,1% / 0,125W | R553, R557, R565, R569, R600, R608 | | no special |
| 54 | 1 | RES SMD 0805: 6k8 / 1% / 0,125W | R567, R572, R678 | | no special |
| 55 | 2 | RES SMD 0805: 15k / 1% / 0,125W | R570, R571, R666 | | no special |
| 56 | 2 | RES SMD 0805: 39k / 1% / 0,125W | R573, R616 | | no special |
| 57 | 2 | RES SMD 0805: 1k5 / 1% / 0,125W | R610, R624 | | no special |
| 58 | 3 | RES SMD 0805: 220k / 1% / 0,125W | R612 | | no special |
| 59 | 1 | RES SMD 0805: 680R / 1% / 0,125W | R614 | | no special |
| 60 | 1 | RES SMD 0805: 5k6 / 1% / 0,125W | R652 | | no special |
| 61 | 13 | RES SMD 0805: 27R / 1% / 0,125W | R662, R663 | | no special |
| 62 | 2 | RES SMD 0805: 14k / 0,1% / 0,125W | R668 | | no special |
| 63 | 1 | RES SMD 0805: 8k2 / 1% / 0,125W | R670 | | no special |

Bill of Material

| | | | | | |
|----|---|-------------------------------------|--|--------------------|-----------------|
| 64 | 1 | RES SMD 0805: 1k2 / 1% / 0,125W | R674, R676 | | no special |
| 65 | 6 | RES SMD 0805: 47k / 1% / 0,125W | R675 | | no special |
| 66 | 5 | RES SMD 0805: 33R / 1% / 0,125W | U.R150, U.R151, U.R156, U.R157, V.R150, V.R151, V.R156, V.R157, W.R150, W.R151, W.R156, W.R157 | | no special |
| 67 | 1 | RES SMD 1206: 82R / 1% / 0,25W | R404 | | no special |
| 68 | 1 | RES SMD 1206: 22R / 1% / 0,25W | R658, R664 | | no special |
| 69 | 3 | RES SMD 1206: 2k2 / 1% / 0,25W | R679 | | no special |
| 70 | 1 | RES SMD 1206: 1k0 / 1% / 0,25W | R681, R682, R683 | | no special |
| 71 | 1 | RES SMD Melf: 2R2 / 1% / 0,4W | R673 | | no special |
| 72 | 6 | RES THT: PO591-0 5T 56K | R400, R401 | PO591-0 5T 56K | VITROHM |
| 73 | 1 | VARISTOR: 510V RMS 20MM MOV-20D821K | R453, R454, R455 | MOV-20D821K | Bourns |
| 74 | 9 | NTC: SL32 5R020 | R402, R403 | SL32 5R020 | Ametherm |
| 75 | 2 | NTC: B57703-M0502-G40 | THERMISTOR1 | B57703M0502G040 | TDK ehem. Epcos |
| 76 | 1 | RES VAR: 1k / 250mW / SMD | R554 | 23BR1KLFTR | BI Technologies |
| 77 | 3 | RES SMD 2512: 0R001 / 1% / 3W | CU.R302, CV.R302, CW.R302 | CRE2512-FZ-R001E-3 | Bourns |
| 78 | 1 | RES SMD 2512: 0R0 / 1W | R12, R13, R14 | | no special |
| 79 | 1 | RES SMD 2512: 68k / 1% / 1W | R350, R351, R352, R353, R354 | | no special |
| 80 | 2 | RES SMD 2512: 220k / 1% / 2W | R450, R451, R452 | | no special |
| 81 | 3 | RES SMD 2512: 10k / 1% / 1W | R651, R655 | | no special |
| 82 | 2 | RES SMD 2512: TE_8R2 / 1% / 3W | R684, R685 | 35228R2JT | TE Connectivity |
| 83 | 1 | RES SMD 0603: 10k / 1% / 0,1W | R1.R3, R1.R7, R1.R8, R1.R9, R2.R3, R2.R7, R2.R8, R2.R9, R3.R3, R3.R7, R3.R8, R3.R9, R4.R3, R4.R7, R4.R8, | | no special |

Bill of Material

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| | | | R4.R9, R20, R21, R22, R23, R24, R25 | | |
| 84 | 5 | RES SMD 0603: 8k2 / 1% / 0,1W | R1.R5, R2.R5, R3.R5, R4.R5 | | no special |
| 85 | 3 | RES SMD 0603: 20k / 1% / 0,1W | R1.R6, R2.R6, R3.R6, R4.R6 | | no special |
| 86 | 2 | RES SMD 2010: 10M / 1% / 0,75W | R650, R654, R659 | | no special |
| 87 | 2 | RES SMD 2010: 3M3 / 5% / 0,75W | R656, R660, R665 | | no special |
| 88 | 3 | RES SMD special: 0R003 / 1% / 5W | R50 | CSS2H-3920K-3L00F | no special |
| 89 | 3 | CAP CER 0805: 100n / 50V / X7R | C20, C60, C61, C200, C351, C353, C563, C564, C565, C603, C604, C605, C610, C611, C612, C613, C662, C670, CU.C301, CU.C303, CV.C301, CV.C303, CW.C301, CW.C303, U.C152, U.C157, V.C152, V.C157, W.C152, W.C157 | | no special |
| 90 | 4 | CAP CER 0805: 1u0 / 50V / X7R | C62 | | no special |
| 91 | 22 | CAP CER 0805: 220p / 50V / X7R | C63, C550, C552, C556, C558 | | no special |
| 92 | 4 | CAP CER 0805: 4u7 / 35V / X5R | C64, C201, C202, C203, C204, C205, C350, C352, C405, C406, C562, C609, C654, C658, C661, C668, C669, C674, C675, CU.C300, CU.C302, CV.C300, CV.C302, CW.C300, CW.C302, R1.C1, R1.C2, R1.C3, R1.C4, R1.C5, R2.C1, R2.C2, R2.C3, R2.C4, R2.C5, R3.C1, R3.C2, R3.C3, R3.C4, R3.C5, R4.C1, R4.C2, R4.C3, R4.C4, R4.C5, U.C151, U.C153, U.C156, U.C158, V.C151, V.C153, V.C156, V.C158, W.C151, W.C153, W.C156, W.C158 | | no special |
| 93 | 3 | CAP CER 0805: 47p / 50V / X7R | C100 | | no special |
| 94 | 3 | CAP CER 0805: 100p / 50V / X7R | C206, C666, U.C150, U.C155, V.C150, V.C155, W.C150, W.C155 | | no special |
| 95 | 1 | CAP CER 0805: 1n0 / 50V / X7R | C207, C665, C671, C678 | | no special |
| 96 | 1 | CAP CER 0805: 4n7 / 50V / X7R | C354, CU.C304, CV.C304, CW.C304 | | no special |
| 97 | 8 | CAP CER 0805: 10n / 50V / X7R | C500, C501, C502, C503 | | no special |

Bill of Material

| | | | | | |
|-----|----|--|--|--------------------|------------------|
| 98 | 5 | CAP CER 0805: 680p / 50V / X7R | C551, C555, C557 | | no special |
| 99 | 6 | CAP CER 0805: 2u2 / 50V / X7R | C554, C559 | | no special |
| 100 | 3 | CAP CER 0805: 2n2 / 50V / X7R | C561 | | no special |
| 101 | 4 | CAP CER 0805: 470p / 50V / X7R | C600, C601, C602, C606, C607, C608 | | no special |
| 102 | 1 | CAP CER 0805: 18p / 50V / X7R | C659 | | no special |
| 103 | 4 | CAP CER 0805: 680n / 50V / X7R | C672 | | no special |
| 104 | 1 | CAP CER 0805: 6n8 / 50V / X7R | C676 | | no special |
| 105 | 4 | CAP CER 0805: 3n3 / 50V / X7R | U.C154, U.C159, V.C154, V.C159, W.C154, W.C159 | | no special |
| 106 | 30 | CAP CER 1206: 470p / 200V / X7R | C651, C655 | | no special |
| 107 | 1 | CAP CER: 47n / 1,5kV / X7R | C50, C51, C54, C55 | 2220SC473KAT1A | AVX |
| 108 | 1 | CAP CER: VY1472M61Y5UC63V0 | CY450, CY451, CY452, CY453, CY454, CY455 | VY1472M61Y5UC63V0 | Vishay |
| 109 | 2 | CAP FILM: MKP 20u 800VDC DC-Link 4Pin | C52 | DCP4L052007GD4K*SD | WIMA |
| 110 | 57 | CAP FILM: B32674D1105K000 | C402, C677 | B32674D1105K000 | TDK ehem. Epcos |
| 111 | 1 | CAP FILM: B32021A3222M189 | C650 | B32021A3222M189 | TDK ehem. Epcos |
| 112 | 2 | CAP FILM: B32021A3102M | C664 | B32021A3102M289 | TDK ehem. Epcos |
| 113 | 6 | CAP FILM: 1u / 480V / X1 | CX450, CX451, CX452, CX453, CX454, CX455 | F339X151048KKI2B0 | Vishay |
| 114 | 4 | CAP ALUM: B43630A9128M000 | C400, C401, C403, C404 | B43630A9128M000 | TDK ehem. Epcos |
| 115 | 1 | CAP ALUM: 16SVPF180M | C652, C653, C656, C657, C667, C673 | 16SVPF180M | Panasonic |
| 116 | 1 | CAP ALUM: NACZ100M50V6,3X6,3 | C660 | NACZ100M50V6.3X6.3 | NIC Components |
| 117 | 6 | CAP CER 0603: 2u2 / 16V / X5R | R1.C8, R1.C9, R1.C10, R1.C11, R2.C8, R2.C9, R2.C10, R2.C11, R3.C8, R3.C9, R3.C10, R3.C11, R4.C8, R4.C9, R4.C10, R4.C11 | | no special |
| 118 | 1 | IND CM MODE: 744227 | L200 | 744227 | Würth Elektronik |
| 119 | 2 | IND CM MODE: T60405-S6123-X317 | L452 | T60405-S6123-X317 | VACUUMSCHMELZ E |
| 120 | 1 | IND CM MODE: 744221 | L650, L651 | 744221 | Würth Elektronik |
| 121 | 6 | TRANSFORMER: T60403-F5046-X007 Pulstrafo | TR200, TR201 | T60403-F5046-X007 | VACUUMSCHMELZ E |

Bill of Material

| | | | | | |
|-----|----|---|---|--------------------|---------------------------|
| 122 | 4 | FUSE: D6,3x32mm / 16A | F400, F401, F402 | | no special |
| 123 | 16 | FUSE CLIP: 8040.0001 | X401, X402, X403, X404, X405, X406 | 80.400.001 | Schurter |
| 124 | 1 | RELAY: RTS3L012 | K400 | 1-1415898-9 | TE Connectivity / Schrack |
| 125 | 2 | CON MULTIPOLE: 2x16 | X10 | 09 27 232 6801 | Harting |
| 126 | 1 | CON: pinheader 2x3 | R1.X8, R2.X8, R3.X8, R4.X8, X11 | 826632-3 | TE Connectivity |
| 127 | 2 | CON: pin header 2x8 | X7 | TSM-108-01-T-DV | Samtec |
| 128 | 3 | CON TERM BLOCK: MKDS 3/ 4-5,08 | X1, X2, X6 | 1712805 | PHOENIX CONTACT |
| 129 | 6 | CON TERM BLOCK: SPTA 1,5/ 4-3,81 | X4 | 1751493 | PHOENIX CONTACT |
| 130 | 1 | TRANSFORMER: Flyback | T650 | ÜP615694 | Pikatron GmbH |
| 131 | 1 | HEATSINK: ICK S 29 x 29 x 30 | HS2 | ICK S 29 x 29 x 30 | Fischer Elektronik |
| 132 | 5 | HEATSINK: SK 641/84 SA | HS1 | SK 641 84 SA | Fischer Elektronik |
| 133 | 1 | HEATSINK CLIP: THFU3 | TRANSISTOR_CLIP_1, TRANSISTOR_CLIP_2, TRANSISTOR_CLIP_3, TRANSISTOR_CLIP_4, TRANSISTOR_CLIP_5, TRANSISTOR_CLIP_6 | THFU 3 | Fischer Elektronik |
| 134 | 3 | HEATSINK ISO: Keramik / TO218/247/248 / ohne Loch | TRANSISTOR_ISO_1, TRANSISTOR_ISO_2, TRANSISTOR_ISO_3, TRANSISTOR_ISO_4, TRANSISTOR_ISO_5, TRANSISTOR_ISO_6 | AOS 247 | Fischer Elektronik |
| 135 | 11 | SCREW M3: ZYK ISK / 8mm / ST8,8 vz bp | SCREW1, SCREW2, SCREW3 | | no special |

8 References

- [1] Datasheet of compatible Infineon SiC MOSFETs
- [2] Datasheet of Infineon EiceDRIVER™ 1EDI20H12AH
- [3] Datasheet of Texas Instruments isolated $\Delta\Sigma$ -Modulator AMC1303M2520
- [4] Infineon Technologies AG “ User Manual 24 GHz radar tools and development environment user manual ”
https://www.infineon.com/dgdl/Infineon-24GHz_Radar_Tools_and_Development_Environment_User_Manual-ApplicationNotes-v01_00-EN.pdf?fileId=5546d4626c1f3dc3016c20b224db15a5
- [5] Infineon Technologies AG “AN2019-25 CoolSiC™ MOSFET motor drives evaluation board for 7.5 kW”
https://www.infineon.com/dgdl/Infineon-EVAL-M5-E1B1245N-SiC-ApplicationNotes-v01_00-EN.pdf?fileId=5546d4626cb27db2016d438785217e27

Revision history

Revision history

| Document version | Date of release | Description of changes |
|------------------|-----------------|--|
| Revision 1.0 | 21.2.2020 | first release |
| Revision 1.1 | 10.9.2020 | page 1 – Information that the eval board can be used for other technologies too, page 13 - Adding location of installation package data, page 15 - How to flash the XMC board, page 19 – How to set the trigger level of AUX supply, page 29 – comment on SCWT testing and General grammar correction through all the document |
| | | |

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