User guide for REF-DR3KIMBGSIC2MA

Reference design for servo motor and drive integration

UG 2024-16

About this document

Scope and purpose

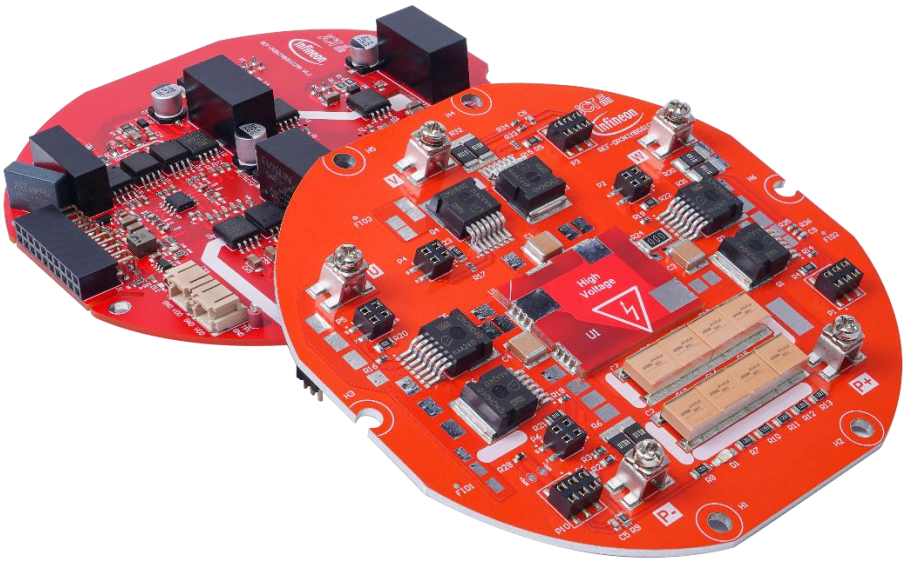
This user guide provides an overview of REF-DR3KIMBGSIC2MA including its main features, key data, pin assignments, and mechanical dimensions. REF-DR3KIMBGSIC2MA is a reference design that contains two PCBs (driver board and power board), a driver circuit, and a 3-phase inverter for motor-drive applications. The driver circuit is based on the EiceDRIVER™ compact single-channel isolated gate driver 1ED3122MC12H with Miller clamp function. The 2nd generation CoolSiC™ MOSFET, IMBG120R040M2H, is the main component in the 3-phase inverter. REF-DR3KIMBGSIC2MA has been developed to provide initial support to customers in designing servo motors with integrated inverters using EiceDRIVER™ IC and CoolSIC™ MOSFET. This reference design is the power component of an integrated servo motor solution, which is an Infineon joint development project with partner JingChuan and Maxsine.

https://www.infineon.com/ http://www.igbt.cn/ http://www.maxsine.com/

Note: Please note that this product is not qualified according to the AEC Q100 or AEC Q101 documents of the Automotive Electronics Council

Intended audience

This user guide is intended for all technical specialists working with REF-DR3KIMBGSIC2MA.



Reference board/kit

Infineon product(s) embedded on this PCB have functions and form factor close to a commercial design. PCB and auxiliary circuits are optimized for the final design.

Note: Boards do not necessarily meet safety, EMI, and quality standards (for example UL, CE) requirements.

Important notice

"Evaluation Boards and Reference Boards" shall mean products embedded on a printed circuit board (PCB) for demonstration and/or evaluation purposes, which include, without limitation, demonstration, reference and evaluation boards, kits and design (collectively referred to as "Reference Board").

Environmental conditions have been considered in the design of the Evaluation Boards and Reference Boards provided by Infineon Technologies. The design of the Evaluation Boards and Reference Boards has been tested by Infineon Technologies only as described in this document. The design is not qualified in terms of safety requirements, manufacturing, and operation over the entire operating temperature range or lifetime.

The Evaluation Boards and Reference Boards provided by Infineon Technologies are subject to functional testing only under typical load conditions. Evaluation Boards and Reference 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 and Reference Boards are not commercialized products, and are solely intended for evaluation and testing purposes. In particular, they shall not be used for reliability testing or production. The Evaluation Boards and Reference Boards may therefore not comply with CE or similar standards (including but not limited to the EMC Directive 2004/EC/108 and the EMC Act) and may not fulfill other requirements of the country in which they are operated by the customer. The customer shall ensure that all Evaluation Boards and Reference Boards will be handled in a way, which is compliant with the relevant requirements and standards of the country in which they are operated.

The Evaluation Boards and Reference Boards as well as the information provided in this document are addressed only to qualified and skilled technical staff, for laboratory usage, and shall be used and managed according to the terms and conditions set forth in this document and in other related documentation supplied with the respective Evaluation Board or Reference Board.

It is the responsibility of the customer's technical departments to evaluate the suitability of the Evaluation Boards and Reference Boards for the intended application, and to evaluate the completeness and correctness of the information provided in this document with respect to such application.

The customer is obliged to ensure that the use of the Evaluation Boards and Reference Boards does not cause any harm to persons or third-party property.
The Evaluation Boards and Reference Boards and any information in this document is provided "as is" and Infineon Technologies disclaims any warranties, express or implied, including but not limited to warranties of noninfringement of third-party rights and implied warranties of fitness for any purpose, or for merchantability.

Infineon Technologies shall not be responsible for any damages resulting from the use of the Evaluation

Boards and Reference Boards and/or from any information provided in this document. The customer is obliged to defend, indemnify, and hold Infineon Technologies harmless from and against any claims or damages arising out of or resulting from any use thereof.

Infineon Technologies reserves the right to modify this document and/or any information provided herein at any time without further notice.

Safety precautions

Please note the following warnings regarding the hazards associated with development systems.

Table 1 Safety precautions

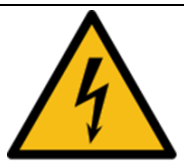
	**Warning:** *The DC link potential of this board is up to 1000 VDC. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death.*
	**Warning**: *The evaluation or reference board contains DC bus capacitors which 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.*
	**Warning:** *The evaluation or reference board is connected to the grid input during testing. Hence, high-voltage differential probes must be used when measuring voltage waveforms by oscilloscope. 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.*
	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance 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.*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board 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.*

Table of contents

1 The board at a glance

REF-DR3KIMBGSIC2MA is the inverter and gate driver board to demonstrate an integrated servo motor and drive. The driver circuit is based on the EiceDRIVER™ compact single-channel isolated gate driver, 1ED3122MC12H, with Miller clamp function [1]. Second generation CoolSiC™ MOSFET, IMBG120R040M2H, is the main component for the 3-phase inverter [2].

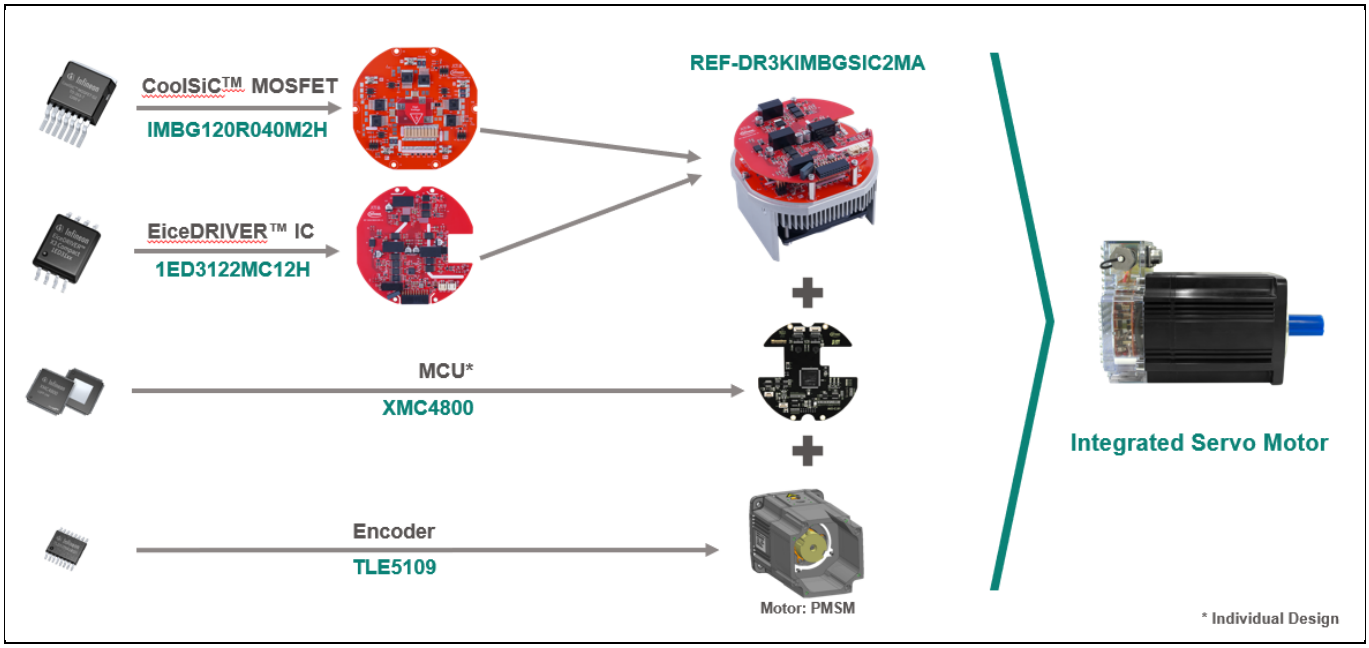


Figure 1 Integrated servo motor with drive

The full set consists of: an inverter board, a gate driver board, a controller board, and a servo motor, as shown in Figure 1. The control board and the motor are not part of the reference design. To evaluate the electrical performance of the system, iMOTION™ MADK EVAL-M1-101TF can be used to provide a simple control. A heatsink and a fan are included for easy evaluation, even though the system can work without a cooling fan. A fan cable is provided for connecting the 24 V supply on REF-DR3KIMBGSIC2MA to the fan.

1.1 Delivery contents

The reference design REF-DR3KIMBGSIC2MA is delivered together with complete documentation in an environment-friendly carton box.

As shown in Figure 2, the box contains:

- The reference board of size 12 cm x 12 cm x 10 cm (L x W x H) and weighing 800 grams assembled as a stack; including an inverter board, a gate driver board, a heatsink, and a cooling fan. The PCB diameter (without heatsink) is 11cm.
- A fan cable, for connecting the 24 V supply on REF-DR3KIMBGSIC2MA to the fan
- A user guide
- An introduction sheet

Figure 2 Delivery contents

1.3 Block diagram

The inverter has a standard 3-phase, 2-level topology, with a DC link capacitor and six CoolSiC™ MOSFETs in D^2PAK (IMBG120R040M2H) package. The components are soldered on to a single layer Insulated metallic substrate (IMS) board. All the CoolSiC™ MOSFETs are driven by an isolated gate driver EiceDRIVER™ IC - 1ED3122MC12H with Miller clamp function.

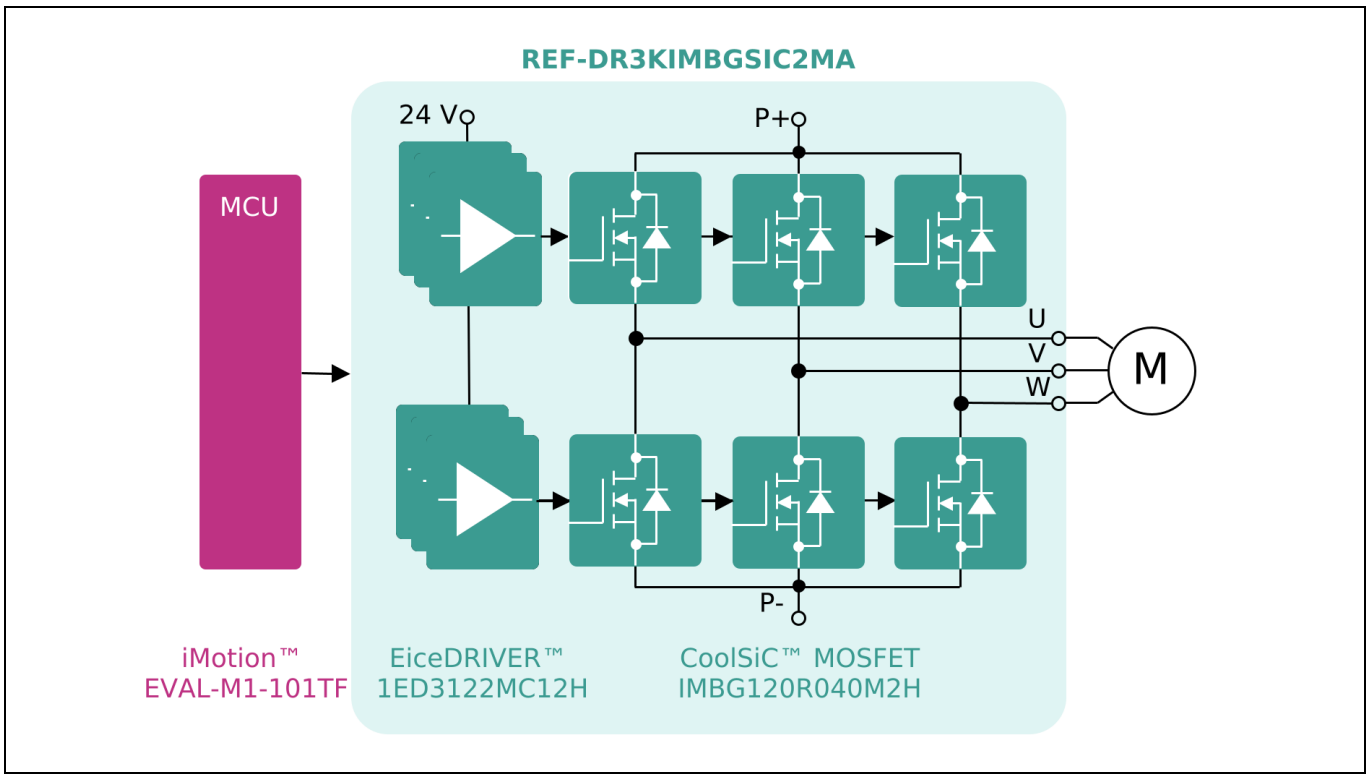


Figure 3 Block diagram

1.4 Main features

The main features of REF-DR3KIMBGSIC2MA are:

- 3-phase servo motor with integrated drive
- 1200 V/40mΩ CoolSiC™ MOSFET in SMD package (TO263-7), with .XT interconnection technology
- Compact design: PCB diameter 110 mm, 120 mm considering the heatsink
- Insulated metallic substrate (IMS) PCBs with high thermal conductivity
- Overcurrent detection
- Input voltage 350 – 800 VDC
- Output voltage: 220 V to ~480 V

1.5 Board parameters and technical data

Table 2 Key parameters

Parameter	Value	Condition
Input voltage (DC)	350 ~800 V	
Output voltage (AC, 3-phase)	220 ~480 V	
Output current (AC, 3-phase)	6.46 A	Input voltage = 600 V (DC)
Output max current (AC, 3-phase)	14.88 A	Input voltage = 600 V (DC)
Output power	4.2 kW	Input voltage = 600 V (DC)
Ambient temperature	0-40°C	

2 System and functional description

2.1 Commissioning

The REF-DR3KIMBGSIC2MA board is intended for evaluating a CoolSiC™ MOSFET solution in an integrated servo drive application. The control of the servo motor is not the intended focus. This section introduces the minimum connections required to start the evaluation.

Minimum connections for the gate driver board (see Figure 4):

- An auxiliary power supply connection CN1 (input): 0 ~ 24 V DC from an external power supply
- Gate driver signal connection: J1

Minimum connections for the power board (see Figure 5):

- A DC link connection (input): 350 ~ 800 V DC from an external power supply
- A 3-phase AC (output) connection to 3-phase motor or resistor- inductor (RL) load

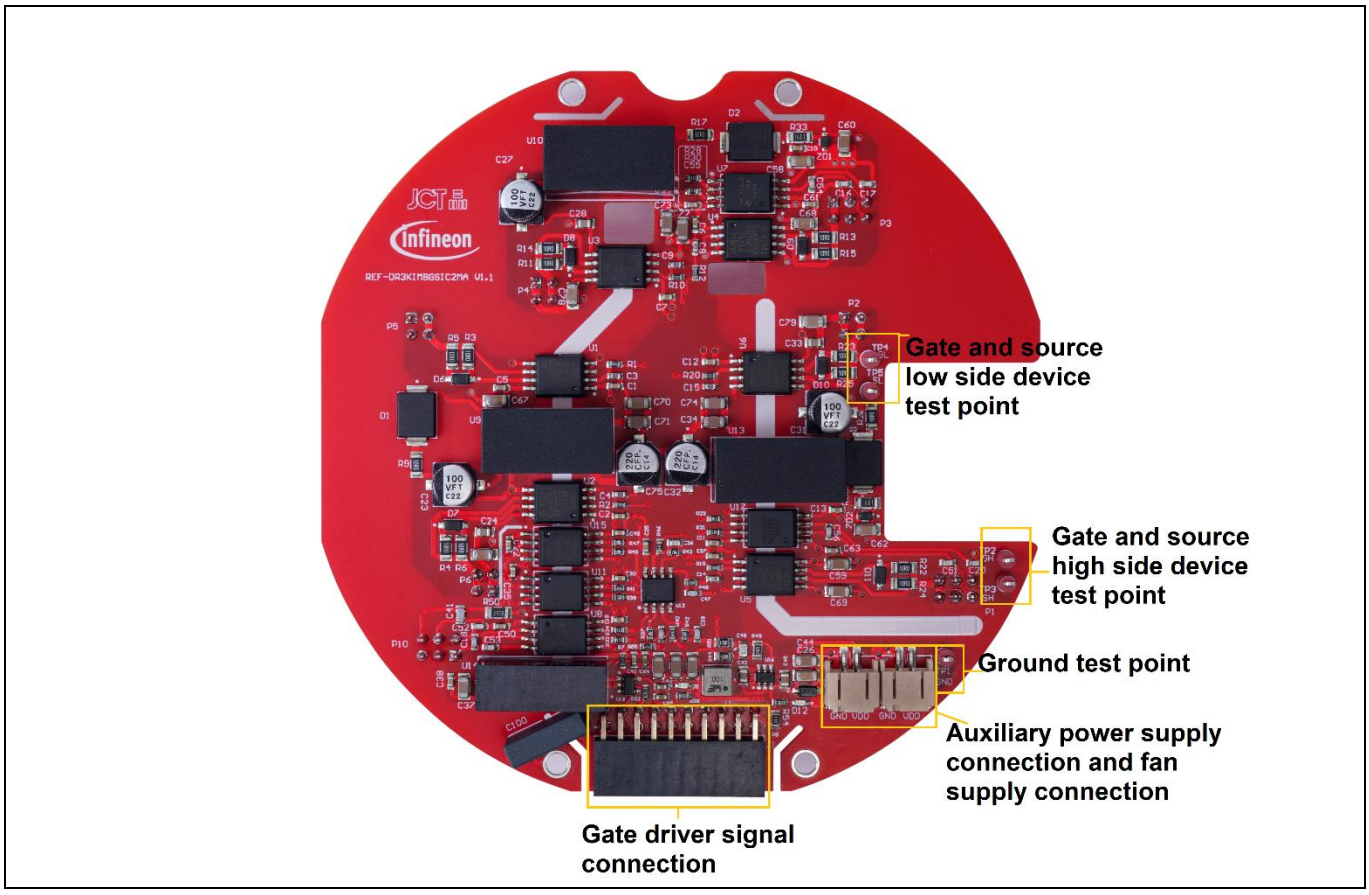


Figure 4 Driver board connections

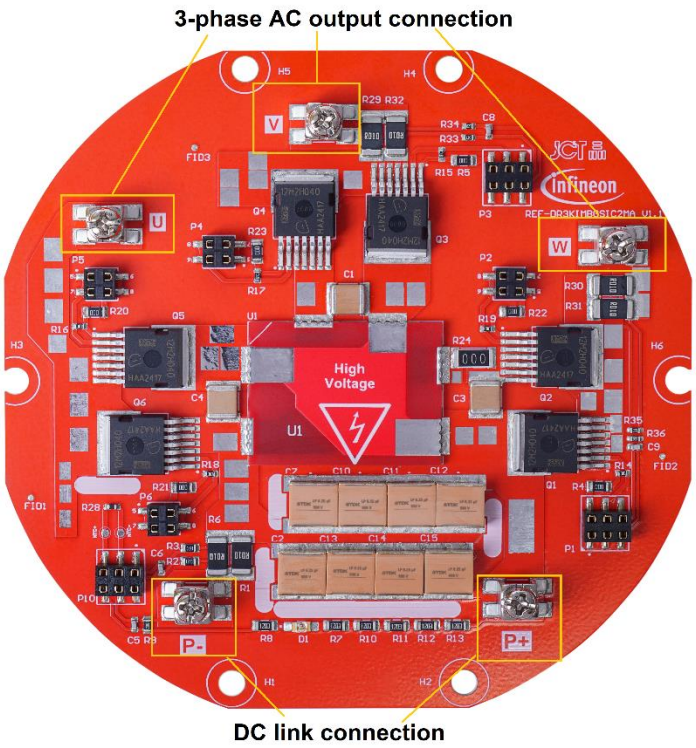


Figure 5 Power board connections

2.2 Basic operation using a controller

Table2 indicates electrical key parameters valid for basic operation (including maximum ratings). To evaluate the electrical performance of the system, the iMOTION™ MADK EVAL-M1-101TF control board can be used. Detailed information about the drive card can be found in [3].

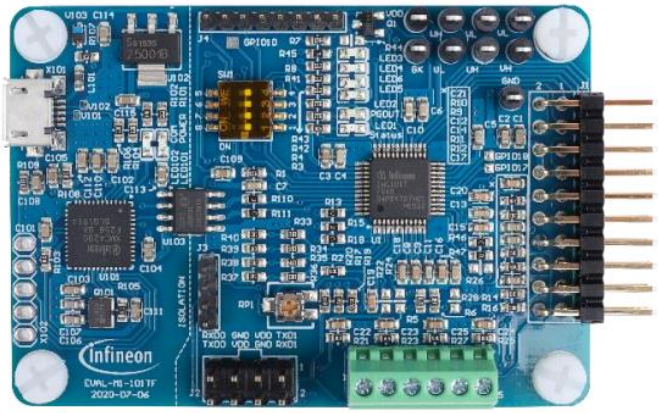


Figure 6 iMotion™ MADK EVAL-M1_101TF

The connection between REF-DR3KIMBGSIC2MA and EVAL-M1-101TF is pin-to-pin. The details are listed in Table 3 and in Table 8 (gate driver board, connector J1). An adaption cable, jumpers and extra wires are not required for the connection.

Table 3 CoolSiC™ MADK-M1 20-pin interface connector for the control board

Pin number	Pin	Details
1	PWMUH	3.3 V compatible logic output for high-side gate driver, phase U
2	GND	Ground
3	PWMUL	3.3 V compatible logic output for low-side gate driver, phase U
4	GND	Ground
5	PWMVH	3.3 V compatible logic output for high-side gate driver, phase V
6	+3.3 V	On board 3.3 V supply
7	PWMVL	3.3 V compatible logic output for low-side gate driver, phase V
8	+3.3 V	Onboard 3.3 V supply
9	PWMWH	3.3 V compatible logic output for high-side gate driver, phase W
10	IU+	Shunt voltage, phase U
11	PWMWL	3.3 V compatible logic output for low-side gate driver, phase W
12	IU-	Ground
13	GK	Gatekill signal – active low when overcurrent is detected
14	DCBSENSE	DC bus positive voltage, scaled in 0 - 3.3 V range by a voltage divider
15	VTH	Thermistor input
16	IV+	Shunt voltage, phase V
17	IV-	Ground
18	IW+	Shunt voltage, phase W
19	IW-	Ground
20	VCC	Defined for 15 V power supply (not used on this board)

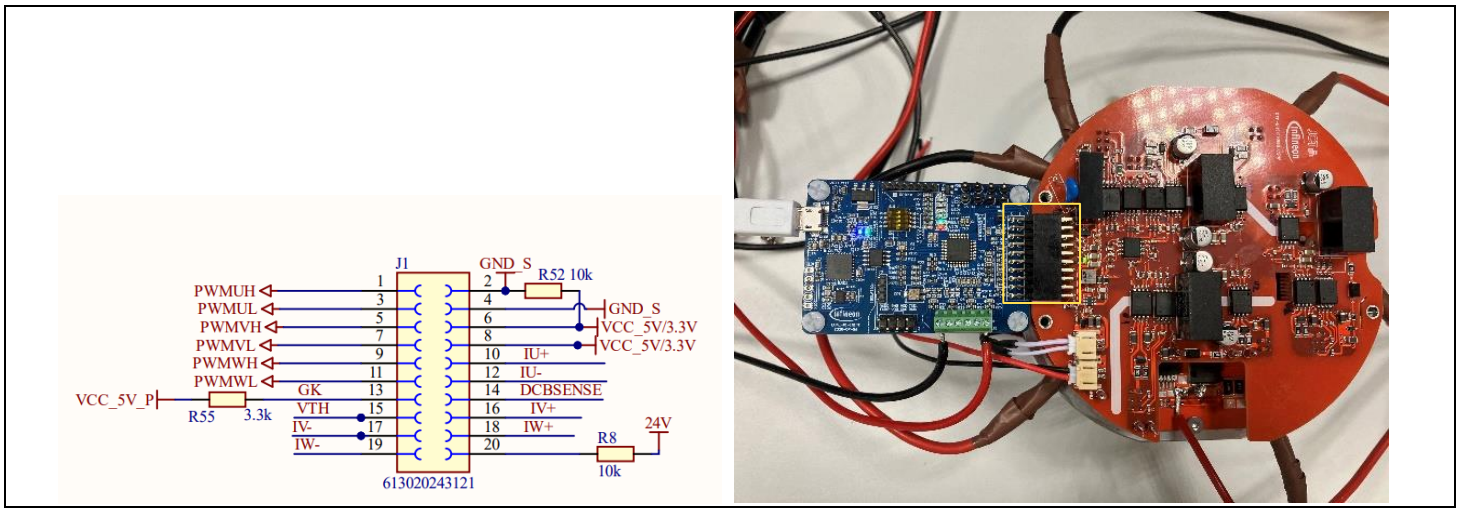


Figure 7 Connection between iMotion™ MADK EVAL-M1-101TF and REF-DR3KIMBGSIC2MA

3 System design

3.1 Schematics

The schematics of the power board is shown in Figure 8.

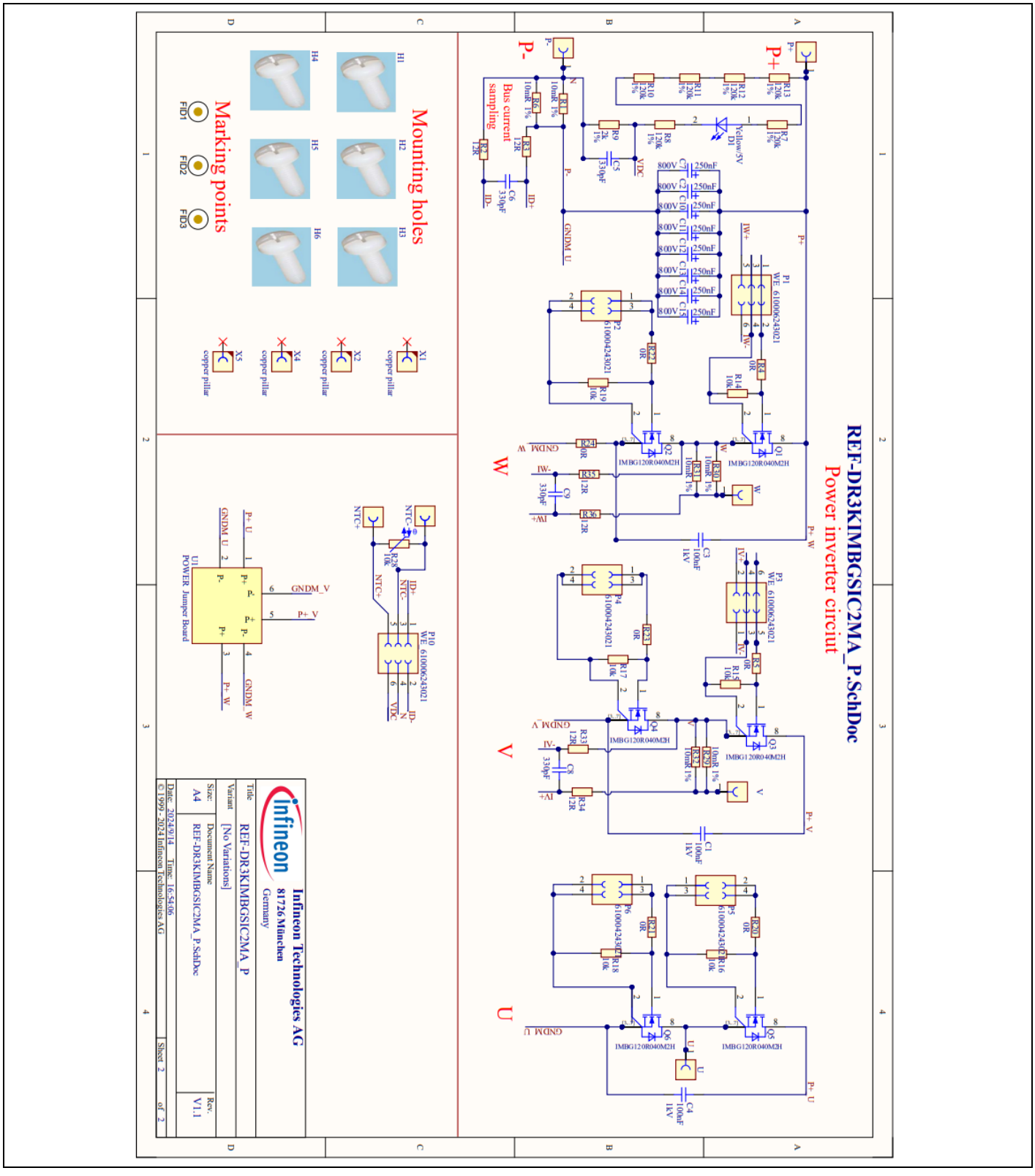


Figure 8 The schematics of the power board (REF-DR3KIMBGSIC2MA)

The schematics of the gate driver board is shown in Figure9 and Figure 10.

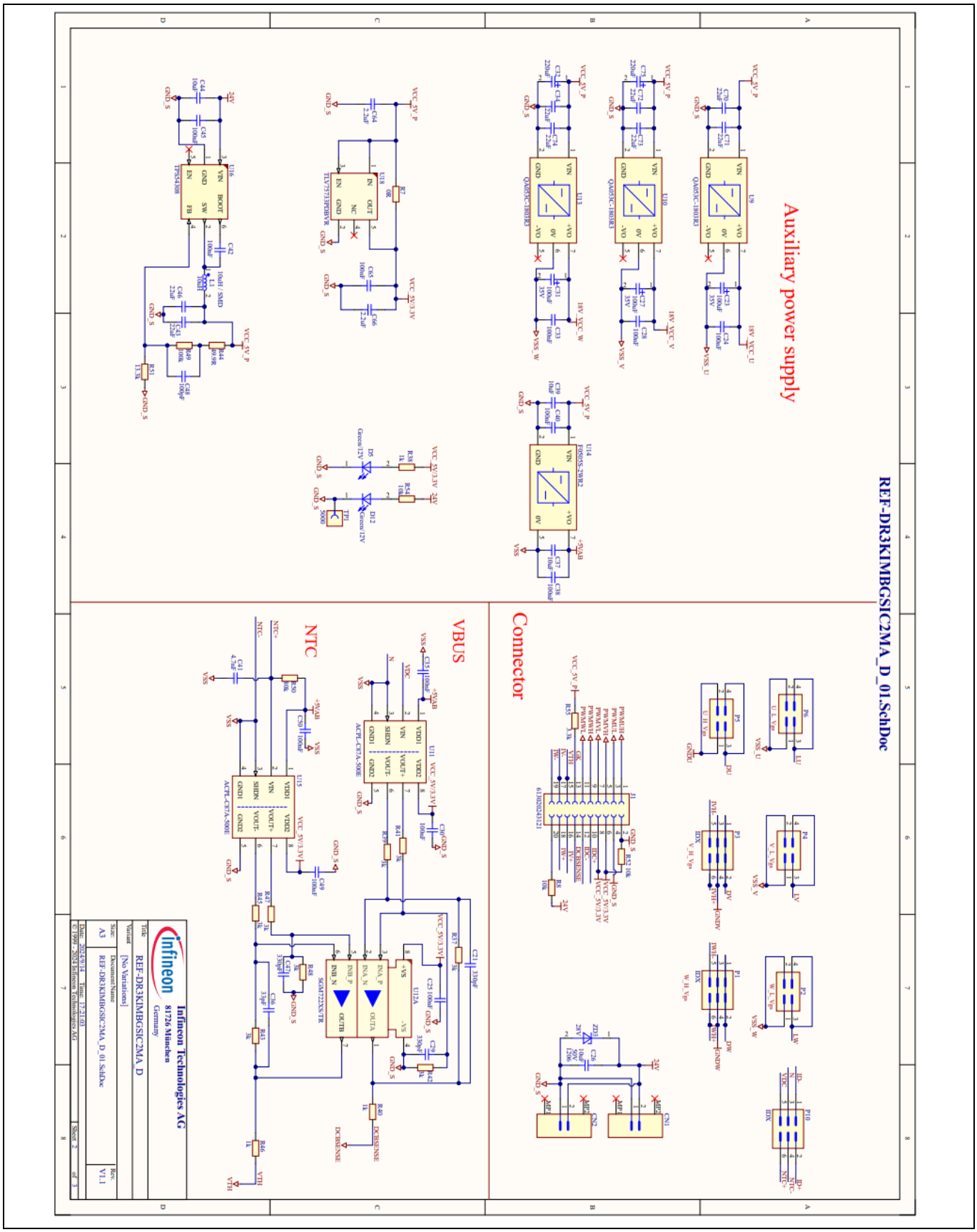


Figure 9 Auxiliary power supply of the driver board (REF-DR3KIMBGSIC2MA)

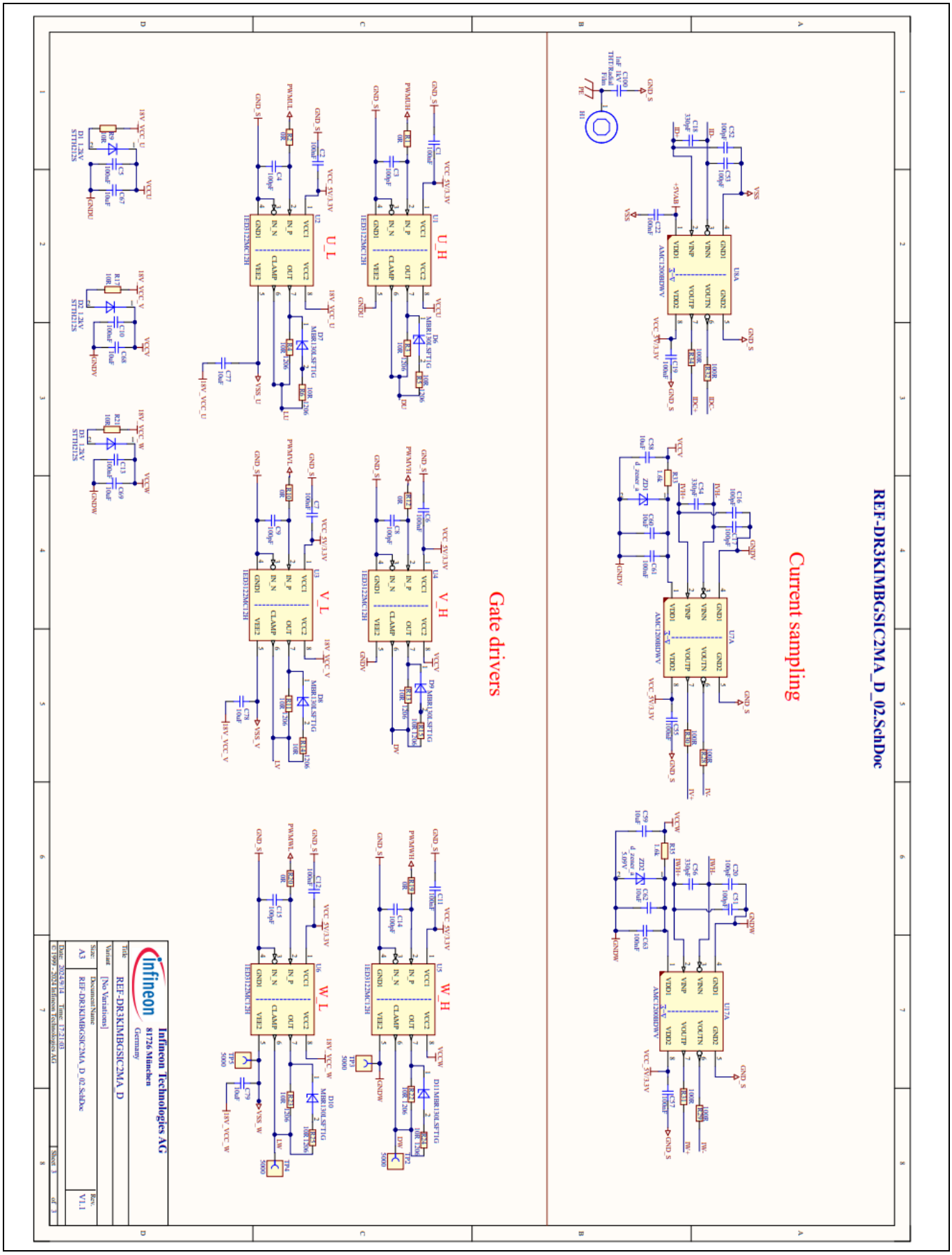


Figure 10 The schematics of the gate driver board (REF-DR3KIMBGSIC2MA)

3.2 Layout

The power board is a single-layer IMS board. The gate driver board is a 4-layer PCB board. The layouts of the boards are shown in Figure 11 and Figure 12 respectively.

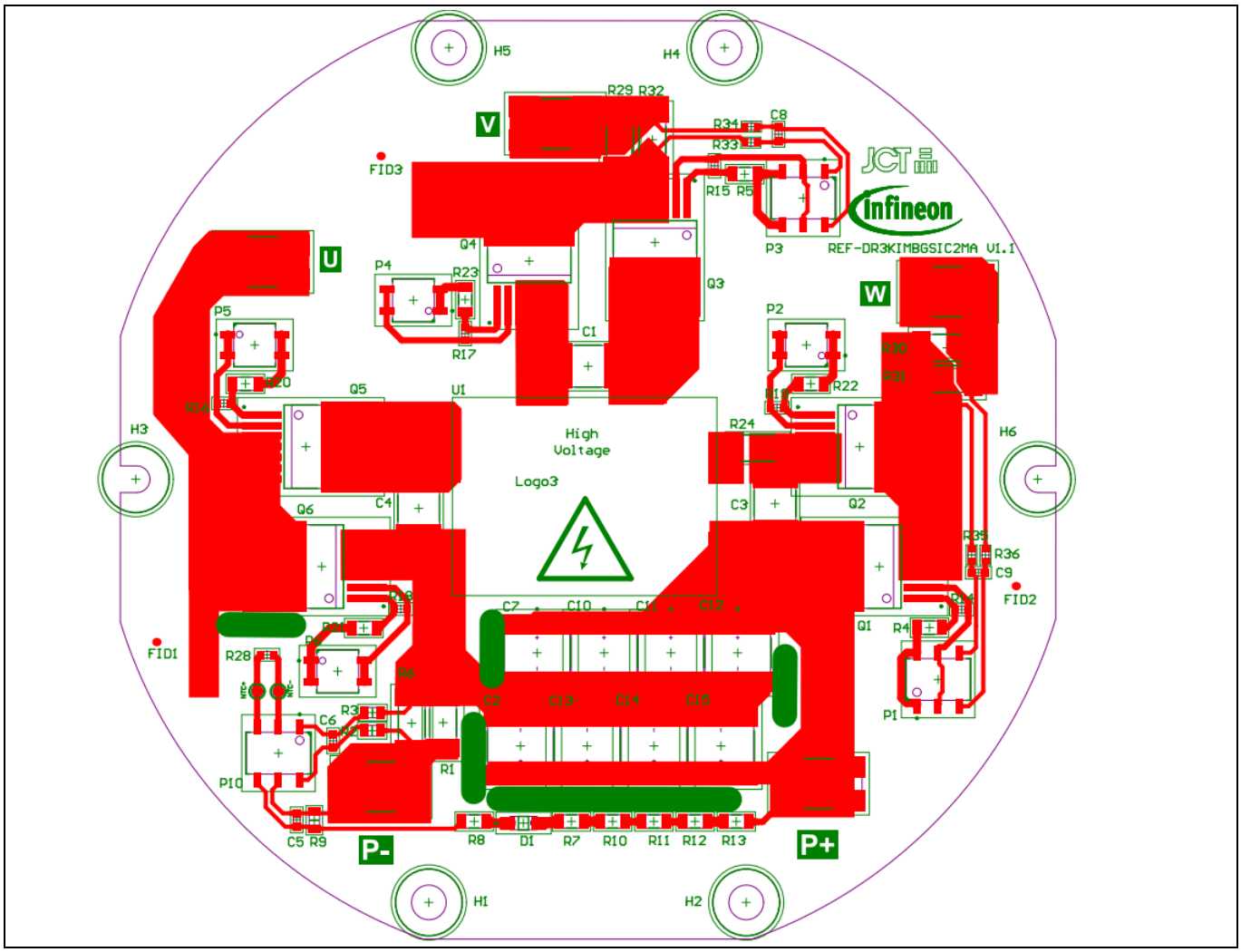


Figure 11 The layout of the power board (REF-DR3KIMBGSIC2MA)

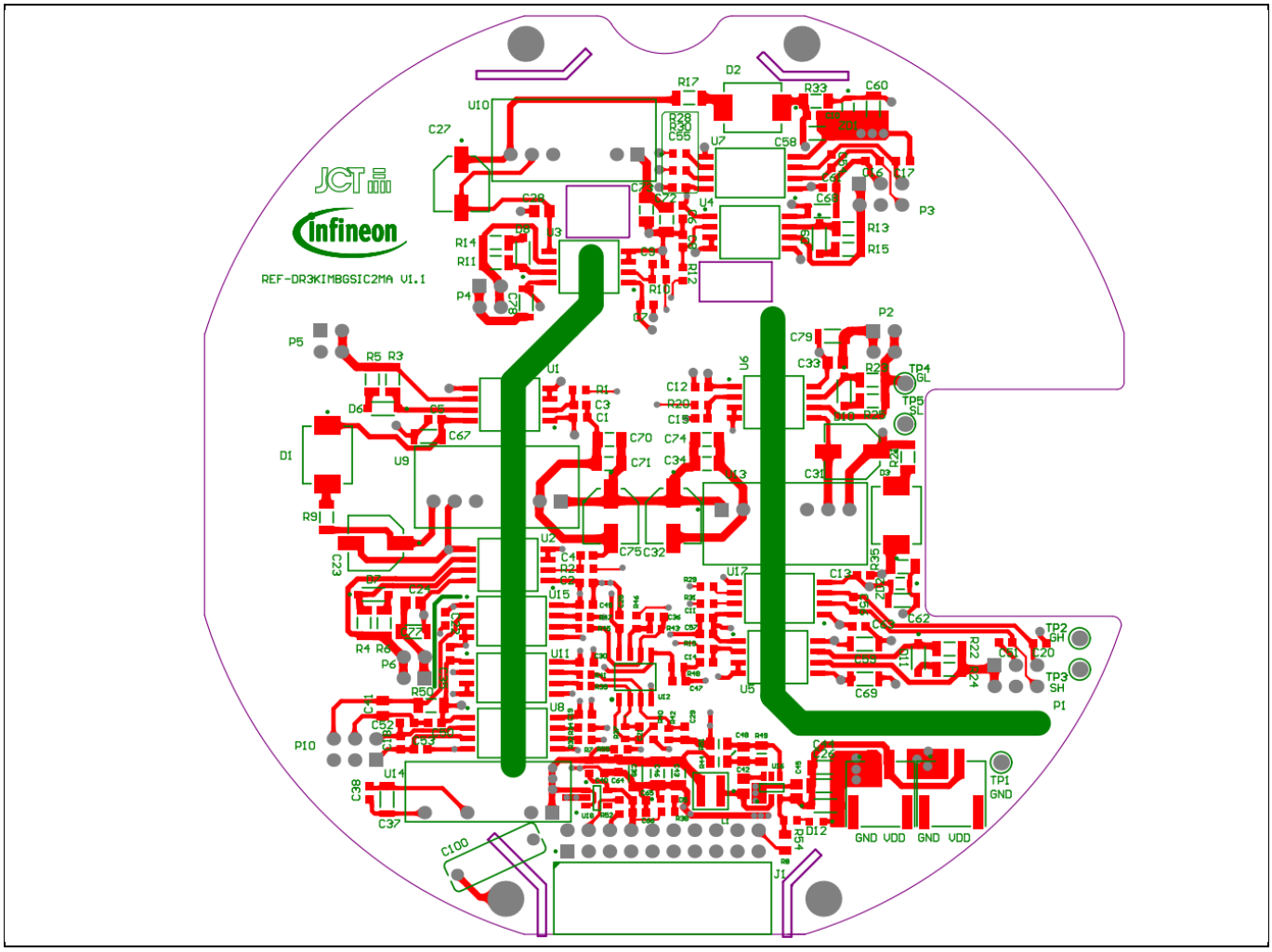


Figure 12 The layout of the driver board (REF-DR3KIMBGSIC2MA)

3.3 Bill of material

The complete bill of material is available in the Download section of Infineon's website.

Table 4 BOM of the power board

No.	Designator	Value	Description	Manufacturer	Manufacturer P/N
10	Q1, Q2, Q3, Q4, Q5, Q6	IMBG120R040 M2H	CoolSiC 1200V SiC Trench MOSFET Silicon Carbide MOSFET, Sense pin for optimized switching performance, Reduction of system complexity and cost, Qualified for industrial applications	Infineon Technologies	IMBG120R040M2H
21	X1, X2, X4, X5	copper pillar, connect Power Board to Driver Board	copper pillar from WURTH, manufacture order number 971190324	Wurth	971190324

Table 5 BOM of the gate driver board

No.	Designator	Value	Description	Manufacturer	Manufacturer P/N
2	C3, C4, C8, C9, C14, C15	100pF	CAP / CERA / 100pF / 25V / 10% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	Wurth Elektronik	885012206053
12	C48	100pF	CAP / CERA / 100pF / 50V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 0805(2012) / SMD / -	Wurth Elektronik	885012007057
19	J1	613020243121	WR-PHD 2.54 mm Angled Dual Socket Header	Wurth Elektronik	613020243121
20	L1	10uH	IND / STD / 10uH / 3.05A / 20% / -40°C to 125°C / 100.8Ω / SMD / Inductor, SMD, 2.37 mm pitch, 2 Pin, 4.10 mm L X 4.10 mm W X 3.10 mm H body / SMD / -	Wurth Elektronik	74438357100
21	P1, P3, P10	61300621121	WR-PHD Dual Pin Header, 2.54mm Pitch, Double row, 6 Pins	Wurth Elektronik	61300621121
22	P2, P4, P5, P6	61300421121	Header, 4pins, 2.54mm pitch, Board to Board	Wurth Elektronik	61300421121
37	U1, U2, U3, U4, U5, U6	1ED3122MC12H	Single channel isolated IGBT gate driver IC	Infineon Technologies	1ED3122MC12H

3.4 Connector details

General information about the connectors of the REF-DR3KIMBGSIC2MA evaluation board is provided in the following tables.

Table 6 Power board connectors

PIN	Label	Function
P+,P-	P+,P-	Power supply input for DC link
U,V,W	U,V,W	AC power output for motor
VDD	P24V	Auxiliary power supply input
R24	R24	Source current test point

Table 7 Gate driver board test points

PIN	Label	Function
TP2	GH	High-side gate test point
TP4	GL	Low-side gate test point
TP3	SH	High-side source test point
TP5	SL	Low-side source test point
TP1	GND	Ground test point

Table 8 Gate driver connector J1

Pin number	Pin	Details
1	PWMUH	Gating signal, high side, phase U
2	GND	Ground
3	PWMUL	Gating signal, low side, phase U
4	GND	Ground
5	PWMVH	Gating signal, high side, phase V
6	+3.3V	On board 3.3 V supply
7	PWMVL	Gating signal, low side, phase V
8	+3.3V	On board 3.3 V supply
9	PWMWH	Gating signal, high side, phase W
10	IU+	Shunt voltage phase U
11	PWMWL	Gating signal, low side, phase W
12	IU-	Ground
13	GK	Gatekill signal – active low when overcurrent is detected
14	DCBSENSE	DC bus positive voltage, scaled in 0 - 3.3 V range by a voltage divider
15	VTH	Thermistor input
16	IV+	Shunt voltage phase V
17	IV-	Ground
18	IW+	Shunt voltage phase W
19	IW-	Ground
20	VCC	Defined for 15 V power supply (not used in this board)

4 System performance

Efficiency of the 2nd generation CoolSIC™ MOSFET was proven through a system performance test.

The test platform comprised:

- A DC power supply
- A DC high-voltage power supply
- A precision power analyzer
- A thermal camera
- An RL load
- An oscilloscope
- MADK EVAL-M1_101TF
- REF-DR3KIMBGSIC2MA

The setup and block diagram of the experiment are shown in Figure 13 and Figure 14, respectively.

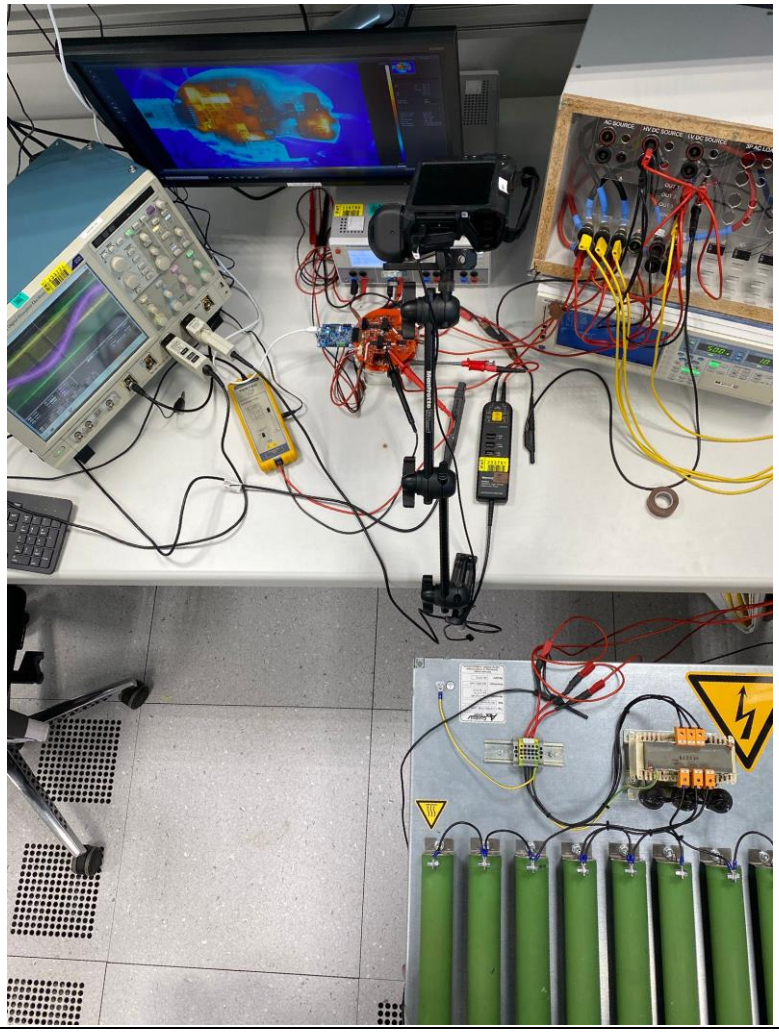


Figure 13 Image of the test setup

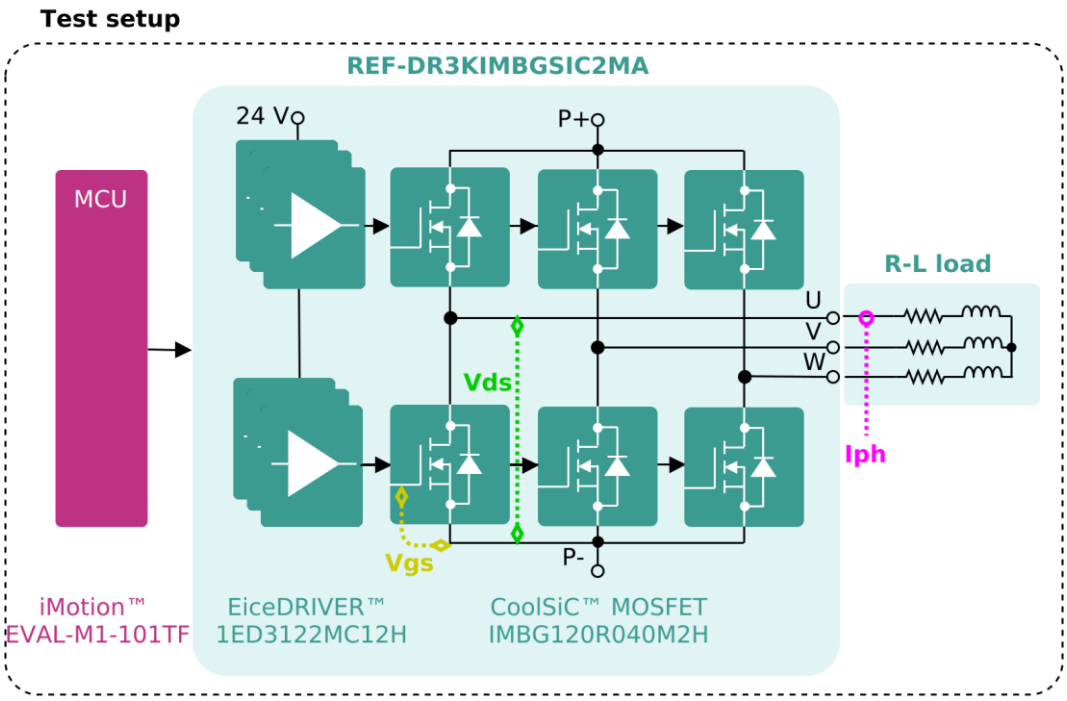


Figure 14 Block diagram of the test setup

The test was performed under the following conditions:

- 600 V DC bus voltage
- 24 V supplied for auxiliary power supply
- Board fan in operation versus board fan not in operation
- 8 kHz switching frequency
- 3 x 33 Ω load resistance

Figure 15 shows the V_{gs} (channel 1) and V_{ds} (channel 4) measured on the low side of the device, and the phase current I_{ph} (channel 3) measured on the U inverter leg.

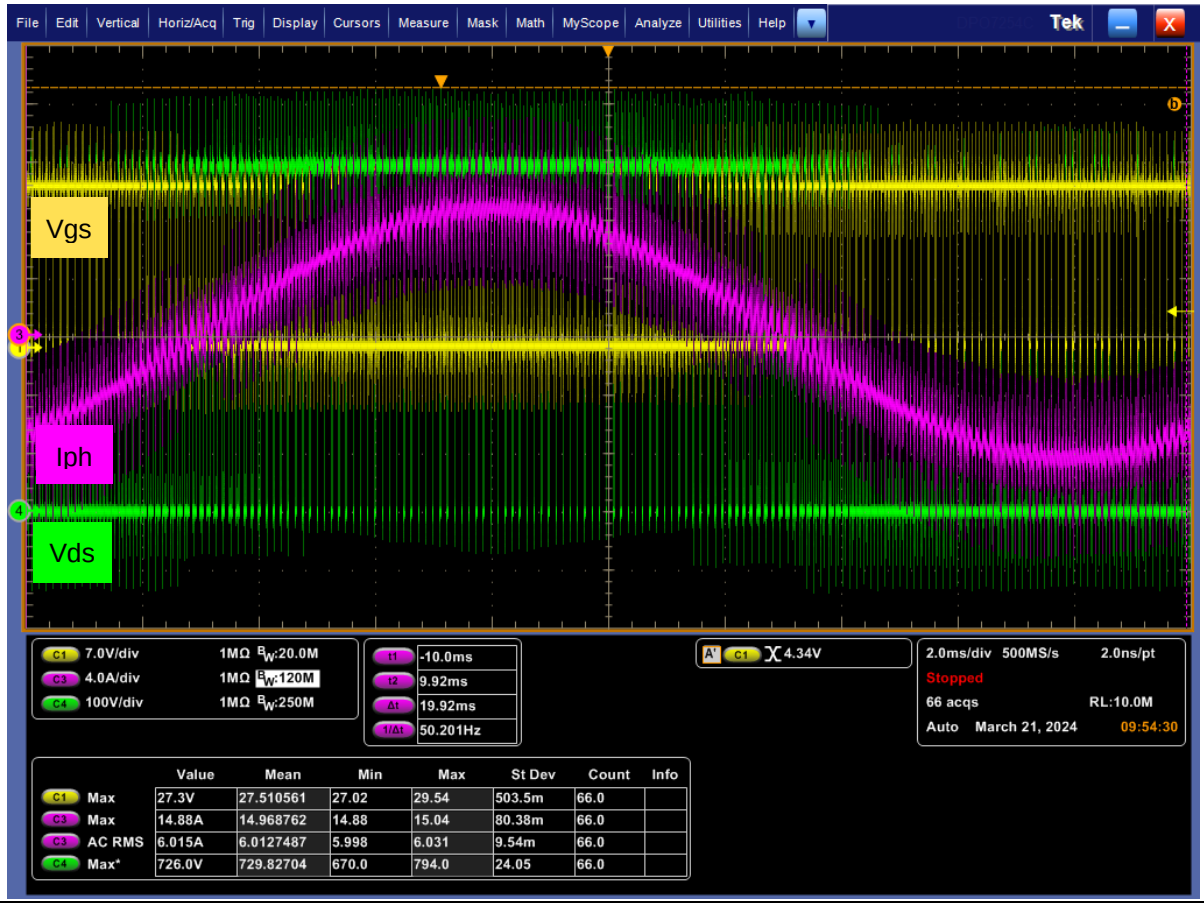


Figure 15 50 Hz phase current

More information was obtained using a precision power analyzer. The results are listed in Table 9.

Table 9 Power analyzer results

	One phase (RMS)	DC link
Voltage	218.12 V	601.6 V
Current	6.46 A	7.12 A
Active power	1.408 kW	4.283 kW

The total output power with the given conditions is 4.2 kW.

Figures 16 and 17 show the images from a thermal camera when the board fan is operational and when it is disconnected, respectively. The spots Sp1 and Sp2 denote the high side and low side MOSFETs in the W inverter leg.

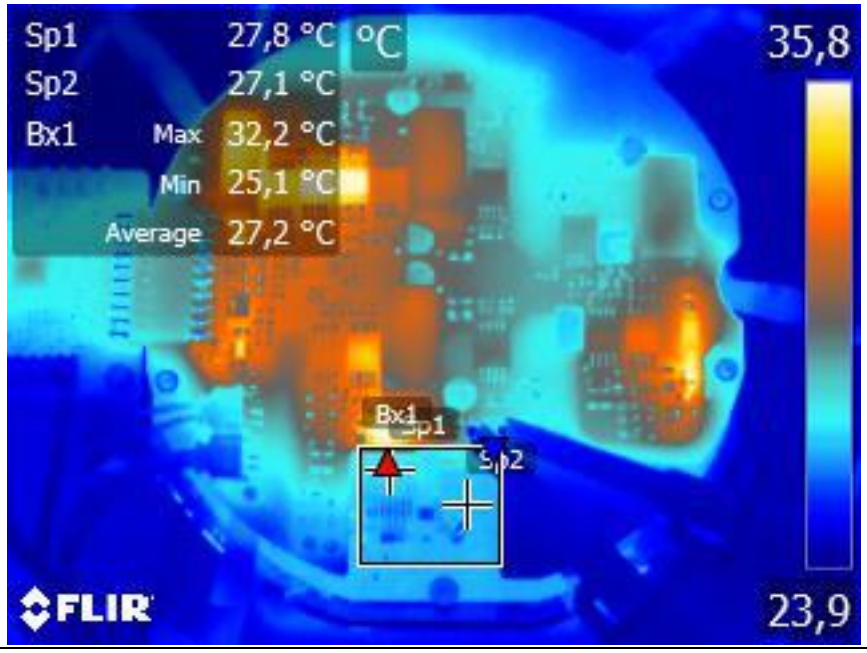


Figure 16 Thermal camera image – 600 VDC, 8 kHz switching frequency, with active fan

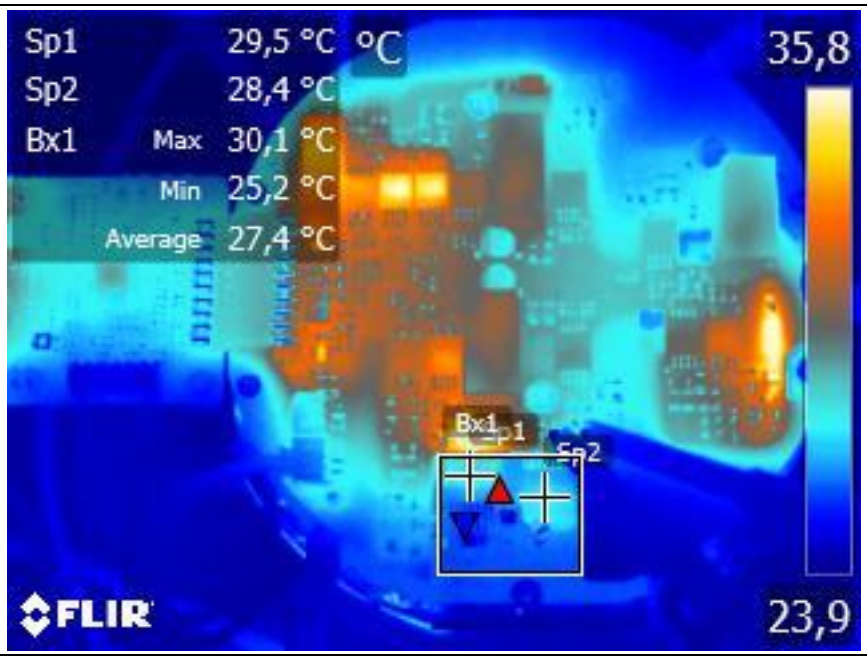


Figure 17 Thermal camera image – 600 VDC, 8 kHz switching frequency, without fan

With active fan high side and low side devices temperatures are respectively 27.8°C and 27.1°C. Without the fan the high side and low side devices temperatures are respectively 29.5°C and 28.4°C. In both cases the temperature does not differ more than 6°C than the ambient temperature.

References

[1] https://www.infineon.com/dgdl/Infineon-IMBG120R040M2H-DataSheet-v01_00-EN.pdf?fileId=8ac78c8c8d1b852e018d2200102020d0

[2] https://www.infineon.com/dgdl/Infineon-1ED31xxMC12H-_1ED-X3_Compact-DataSheet-v01_10-EN.pdf?fileId=5546d46277fc7439017802de09e5671d

[3] [iMOTION™ MADK EVAL-M1-101TF user manual]; https://www.infineon.com/dgdl/Infineon-UG-2020-15_EVAL-M1-101TF-UserManual-v01_00-EN.pdf?fileId=5546d46277921c320177d97457631fd2

Glossary

PCB
Printed circuit board

SMD
Surface mounted device

IMS
Insulated metallic substrate

Revision history

Document revision	Date	Description of changes
1.00	2024-04-17	Initial version
1.1	2024-10-04	Board pictures, BOM, schematics, and layout updated.

Trademarks
All referenced product or service names and trademarks are the property of their respective owners.

Edition 2024-10-14

Published by

Infineon Technologies AG

81726 Munich, Germany

Do you have a question about this document?

Email:

erratum@infineon.com

Document reference

UG 2024-16

Warnings

Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.