EVAL-M7-HVIGBT-INV user guide

Evaluation power board with M7 connector

About this document

Scope and purpose

This user guide provides an overview of the evaluation board EVAL-M7-HVIGBT-INV, including its main features, key-technical data, pin assignments, and mechanical dimensions.

EVAL-M7-HVIGBT-INV is an evaluation power board with Infineon's latest 600 V TRENCHSTOP™ reverse conducting drive 2 (RC-D2) IGBT. This board features and demonstrates Infineon's reverse conducting technology for inverter circuitry at hard switching condition. The RC-D2 is cost effective monolithically integrated IGBT with diode. The IGBTs used on this board are PG-TO252-3 (DPAK) packages. This board is suitable for driving fan, pump, and other smaller motors. The output power is up to 200 W without any heatsink at 8 kHz carrier frequency.

The evaluation board EVAL-M7-HVIGBT-INV was developed to support users during their first steps in designing applications with running any permanent magnet motor via sensorless sinusoidal field-oriented control.

Intended audience

This evaluation board is intended for all technical specialists who are familiar with motor control and power electronics converter systems and this board is intended to be used under laboratory conditions.

Evaluation Board

This board will be used during design in, for evaluation and measurement of characteristics, and proof of data sheet specifications.

Note: PCB and auxiliary circuits are NOT optimized for final customer design.

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Safety precautions

Note: 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

The EVAL-M7-HVIGBT-INV is an evaluation power board with M7 connector. Please refer to Chapter 2.2.1 for the details of M7 connector pinout assignment. This evaluation power board was designed to be driven by M7 connector compatible control board. Such as EVAL-M7-D111T smart-driver control board, of course, other control board which are M7 connector compatible can also be used to drive this power board. The power board can handle up to 200 W output power when the carrier frequency is 8 kHz without any external heatsink.

The main device on the evaluation board is the Infineon's latest 600 V TRENCHSTOP™ reverse conducting drive 2 (RC-D2) IGBT. The part number is IKD04N60RC2. The RC-D2 IGBT with the monolithically integrated diode offers improvements of the performance, controllability, and reliability. This IGBT has very tight parameter distribution and can operate range up to 20 kHz. The maximum junction temperature is 175℃. 3 µs short circuit capability offers better robust for the applications which occur short circuit condition. The integrated diode technology is suitable for consumer drives. The optimized current rating makes the IGBT is more competitive in terms of price and performance. So the RC-D2 IGBT is cost effective for the consumer drives application, such as air conditioning, refrigerator, and general purpose drives. The key features and functionality of this board are described in Chapter 1.3 with the main features of this document (UG-2021-23). The remaining chapters provide information on how to set up and use this evaluation board, and how to copy and/or modify the design according to specific user requirements.

Figure 1 depicts the evaluation board EVAL-M7-HVIGBT-INV. This document describes the features and design of the board.

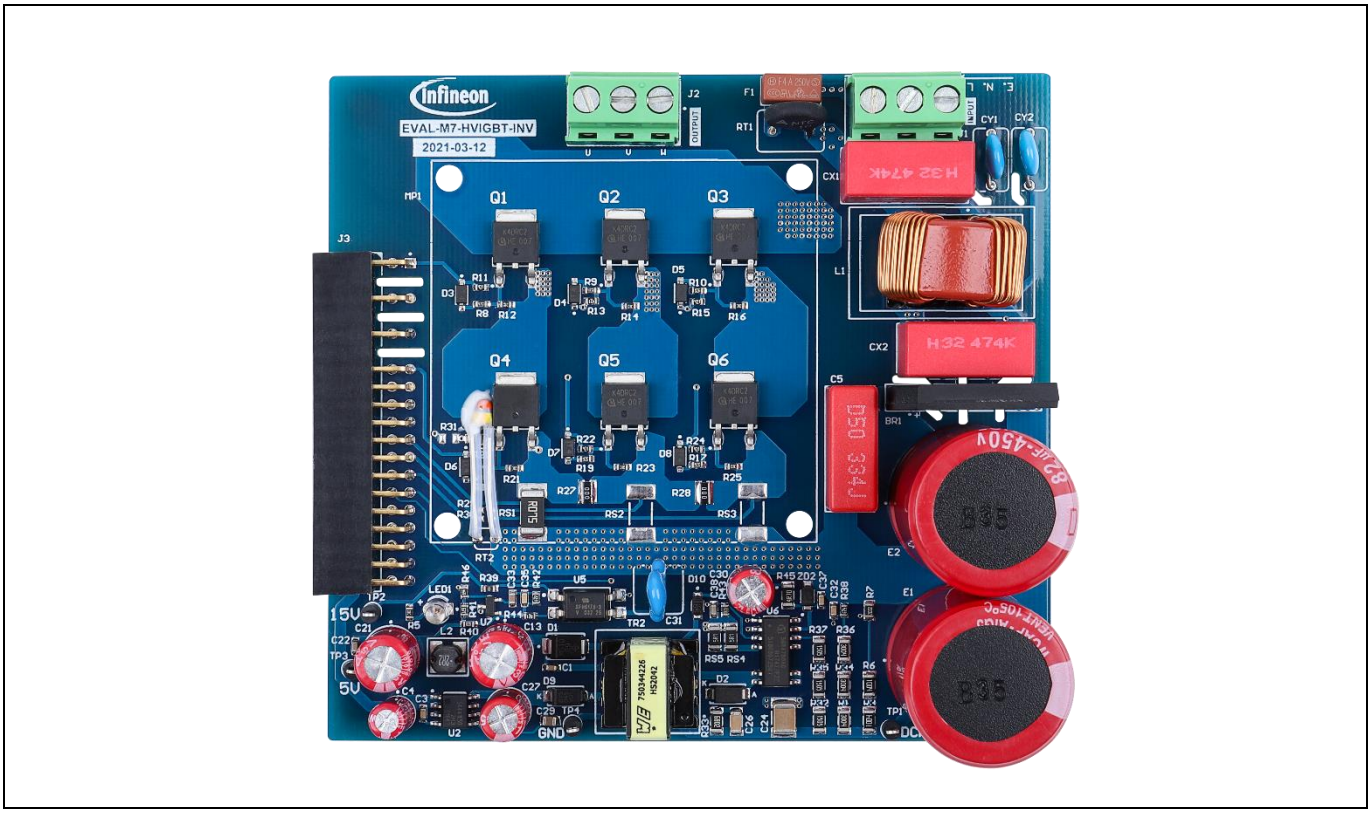


Figure 1 Evaluation board of EVAL-M7-HVIGBT-INV

1.1 Scope of supply

The scope of supply comprises only the board, as shown in Figure 1. The detailed ordering information is indicated in Table 2.

If users don't have the control board, the Infineon smart driver control board EVAL-M7-D111T can be used to evaluate this power board. The ordering information can be found in the following link

Table 2 Ordering information

Base part number	Package	Standard pack		Orderable part number
		Form	Quantity	
EVAL-M7-HVIGBT-INV		Boxed	1	SP005572494
IKD04N60RC2	PG-TO252-3	Taped		

1.2 Block diagram

Figure 2 shows the block digram of EVAL-M7-HVIGBT-INV and connections with the control board. Here an example control board can be EVAL-M7-D111T which is used for motor drive with sensorless or rotor angle and speed feedback. IMD111T has 5 V output internal (maximum 20 mA capability). The 5 V power supply on the EVAL-M7-HVIGBT-INV board is an optional for the application needs more current output capability or the control board without 5 V output power supply.

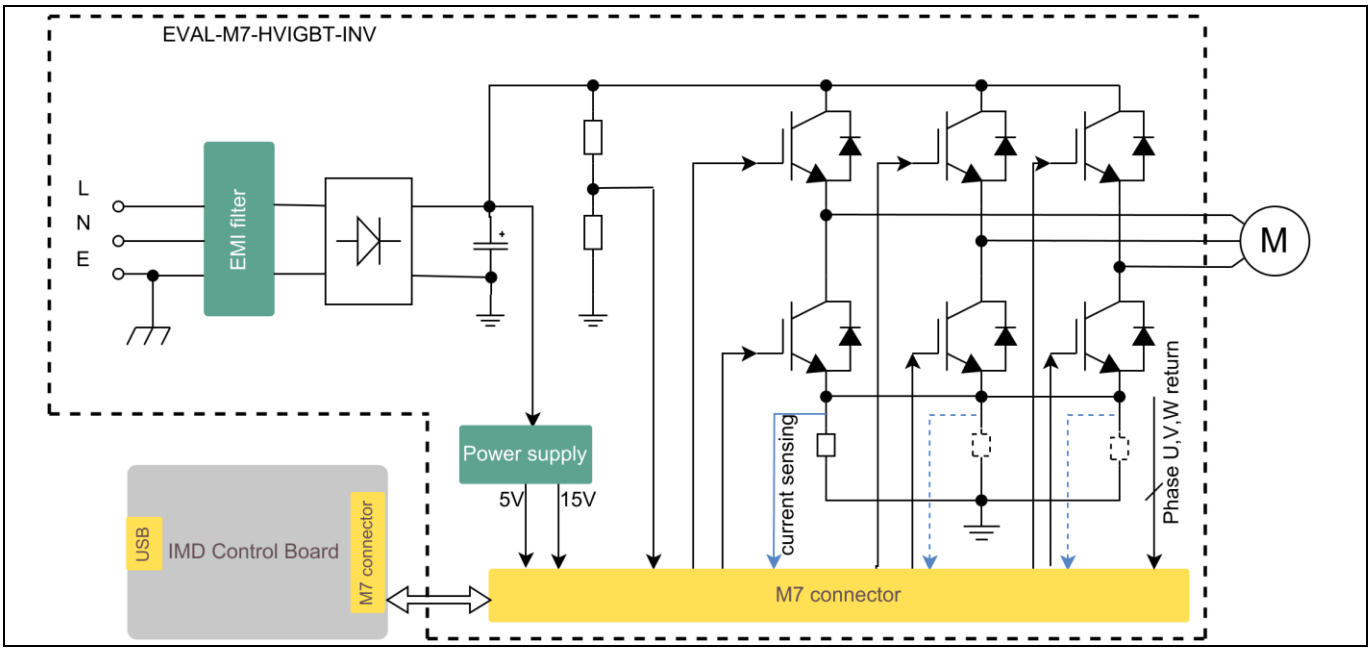


Figure 2 EVAL-M7-HVIGBT-INV block diagram

1.3 Main features

EVAL-M7-HVIGBT-INV is an evaluation board using Infineon's latest 600 V TRENCHSTOP™ reverse conducting drive 2 (RC-D2) IGBT. This board is suitable for PMSM or BLDC motor control for home appliances, fans, pumps, etc.

The main features of the RC-D2 IGBT IKD04N60RC2 include:

- Very tight parameter distribution
- Operating range up to 20 kHz
- Maximum junction temperature 175°C

- Short circuit capability of 3 µs
- Humidity robust design
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models: http://www.infineon.com/rc-d2

The main features of the EVAL-M7-HVIGBT-INV evaluation board include:

- Cost effective RC-D2 IGBT used for the inverter section
- Single shunt or leg shunt current feedback configuration are alternatives
- 5 V and 15 V output power supply on the board
- PCB size is 96 mm x 103 mm, 2 layers, 1 oz copper
- RoHS-compliant

1.4 Board parameters and technical data

Table 3 depicts the evaluation board parameters and technical details.

Table 3 Board specification

Parameter	Symbol	Conditions	Value	Unit
Input AC voltage	V_{IN}	220 V_{AC} input	220±15%	V_{AC}
15 V output voltage	+15V	Maximum 100 mA output current	15±5%	V
5 V output voltage	+5V	Maximum 150 mA output current	5±5%	V
Maximum input power	P_{IN}	8 kHz carrier frequency without any external heatsink	200	W
Max. output phase current	I_{phase_rms}	T_A=20℃, T_C=100℃, air cooling	1.3	A
Max. DC bus voltage	$V_{DC(max)}$	DC bus capacitor is 450 V rated voltage	400	V
Max. switching frequency	f_{SW}	V_{CC}=15V	20	kHz
PCB characteristics				
Material		1.6 mm thickness, 1 oz copper, 2 layers	FR4	
Dimensions		Length × width × height	103 × 96 × 42	mm
System environment				
Ambient temperature	T_{amb}	Non-condensing, maximum RH 95%	0 ~ 50	℃

2 System and functional description

2.1 Commissioning

The EVAL-M7-HVIGBT-INV evaluation board is only a power board without control function. So it should be used with M7 connector compatible control board. Figure 3 is an example system setup with Infineon iMOTION™ smart driver IMD111T control board EVAL-M7-D111T. The IMD111T is motion control engine (MCE) as ready-to-use solution for variable speed drives. When users try to drive the power board with the EVAL-M7-D111T control board, they can find the Infineon user guide UG-2021-17 for the details of the control board. The IMD111T control board user guide describes how to use iMOTION™ tools to run the board.

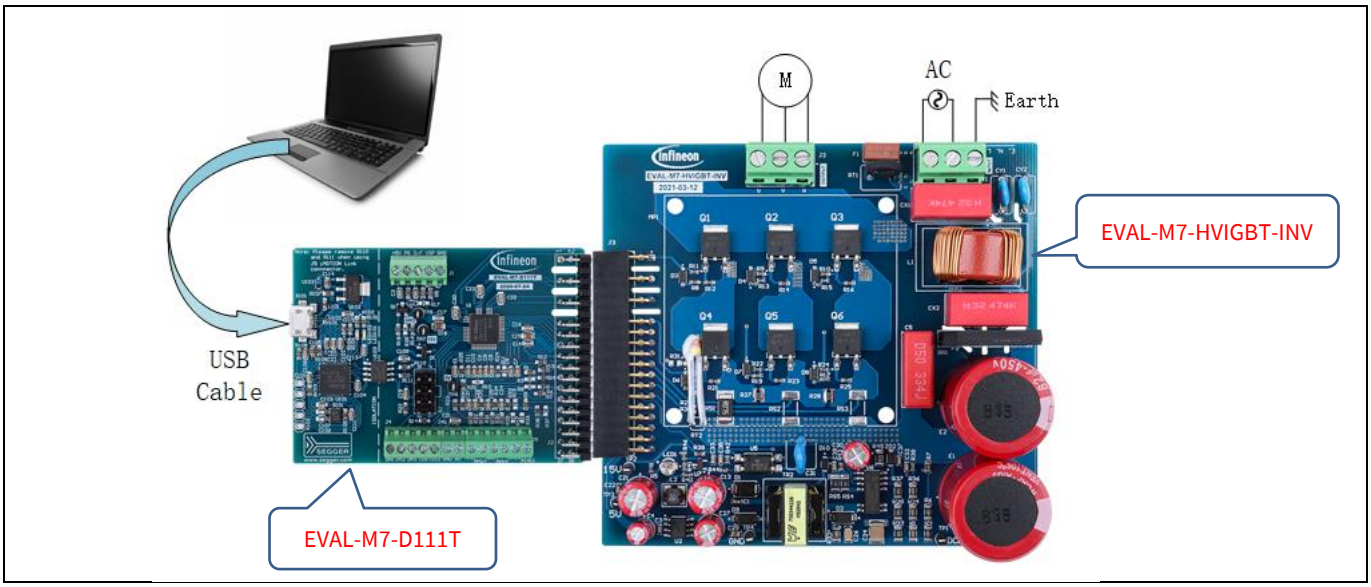


Figure 3 System setup example

2.2 Getting started with IMD controller board EVAL-M7-D111T

Here is an example explanation for the system setup and how to use MCEWizard and MCEDesigner tools for users' motor parameter creation and tuning. The controller board is EVAL-M7-D111T. Figure 3 shows the system setup.

2.2.1 System set up

Before using EVAL-M7-D111T IMD controller board to evaluate this power board, users should install the iMOTION™ development tools (MCEWizard and MCEDesigner) on their computer. The iMOTION™ development tools can be downloaded from Infineon website (link). Then the following steps need to be executed to run the motor. Refer to Chapters 2.2.1.1 and 2.2.1.2 as well as to the MCEWizard and MCEDesigner user guide for more information.

1. Get the latest "IMD111T Software Package" available on the www.infineon.com/imotion-software website.

2. Connect PC and evaluation board via USB cable or iMOTION™ link.

3. Connect the AC source and target motor.

4. Use MCEWizard to calculate and create a parameter text file. See chapter MCEWizard setup overview of Chapter 2.1.2.1 for more details.

5. Power-on the system and start MCEDesigner tool to open MCEDesigner default configuration file (.irc) for IMD111T smart driver.

6. Program the firmware and calculated parameters into the flash. See chapter on MCEDesigner setup overview of Chapter 2.2.1.2 for more details.

7. After programming successfully, click on the hammer icon to clear the fault signals if there is a red light at the bottom of MCEDesigner. When the entire system is ready, start the motor by clicking the green traffic light. Clicking the red traffic light stops the motor.

2.2.1.1 MCEWizard setup overview

MCEWizard defines control gains, limits and fault levels based on real number inputs, and converts gains and levels to parameter counts based on hardware and control limit settings. MCEWizard also exports parameters and variable scale factors to the MCEDesigner.

- Double-click the MCEWizard shortcut on Windows desktop, the MCEWizard welcome page is shown as in Figure 4.
- If users have the evaluation design kit MCEWizard configuration file, they only need to click the “Open System Configuration File” button and changes the user’s motor parameters under test.
- But if users do not have this evaluation design kit MCEWizard configuration file, they need to click the button “File” and select “Create System Configuration File”. Then follow the pop-up window prompt to complete the configuration step by step.

For this system setup, if users do not have the MCEWizard configuration file, they should click “File” and select “Create System Configuration File”, then select the IMD111T device in the pop-up window. Next, click OK and return to the welcome page, then select “Customized Design for Expert User”. Click the Next button to answer all the questions concerning the hardware design and user test motor specification.

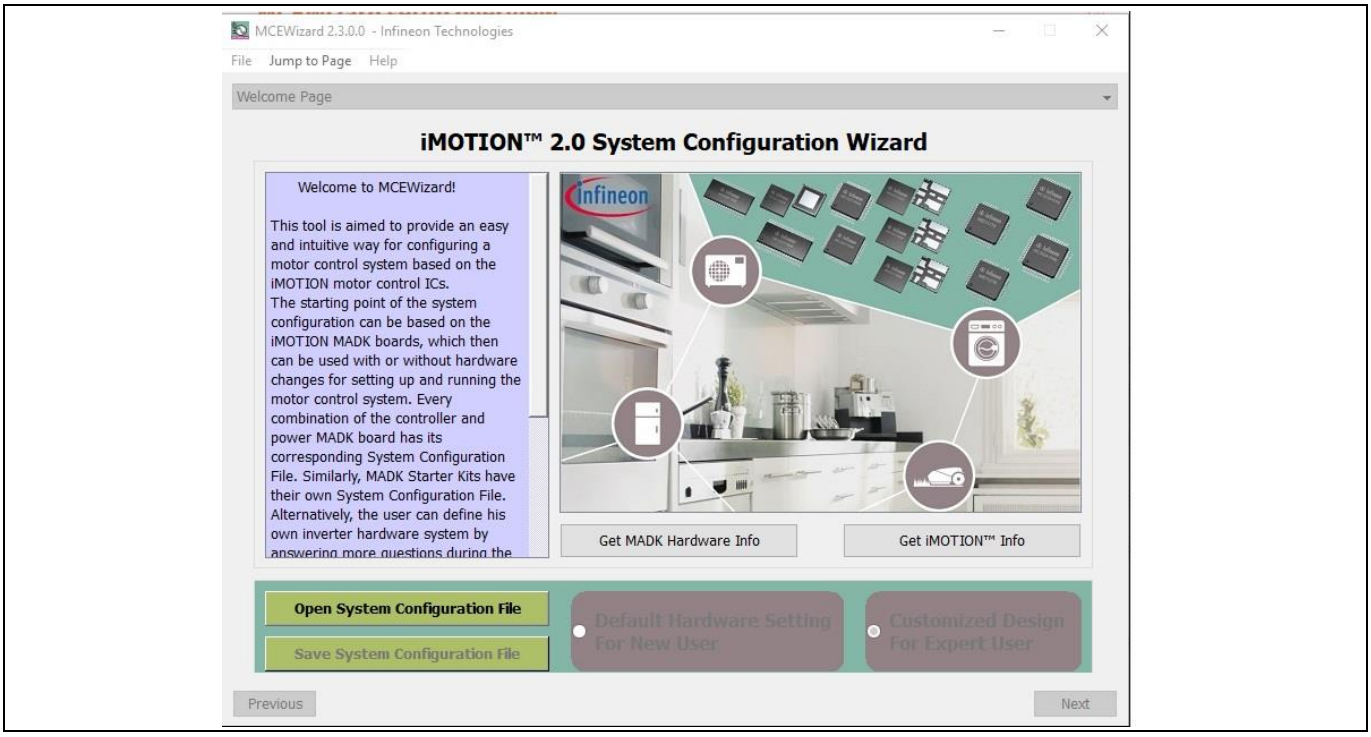


Figure 4 MCEWizard welcome page

Table 4 lists key questions which need to be answered in the MCEWizard in order to set up the system based on the evaluation board. The remaining group of questions also need to be answered (such as OV/UV protection, fault conditions, startup setting, etc.).

Table 4 MCEWizard setup overview table

Parameter	Value	Comment
Motor1 PWM frequency, current sensing configuration and control input on Option page	Fc<20 kHz, UART/VSP/duty/frequency Single/leg-shunt configuration	Key for selecting IC working status
User motor parameters	Depends on the motor under test	Such as rated current, poles Lq, Ld, maximum RPM, etc.
DC bus sensing high resistor	2000 kΩ on board	These resistors are on the power board.
DC bus sensing low resistor	12.7 kΩ on board	The resistor is on the power board.
Motor current input scaling	68.8 mV/A	Depends on hardware design, single-shunt configuration
Current input to ADC offset voltage	274 mV	Depends on hardware design
Overcurrent trip level	1.23 A	Depends on rated current of power board and motor
Catch spin	Enable/disable	

After answering all the questions, users will go to the “Verify & Save Page” (see Figure 5). On that page, users need to click the “Calculate Parameters” button to create the parameters. Then they can click the “Export to MCEDesigner File” button to export and save the parameter text file.

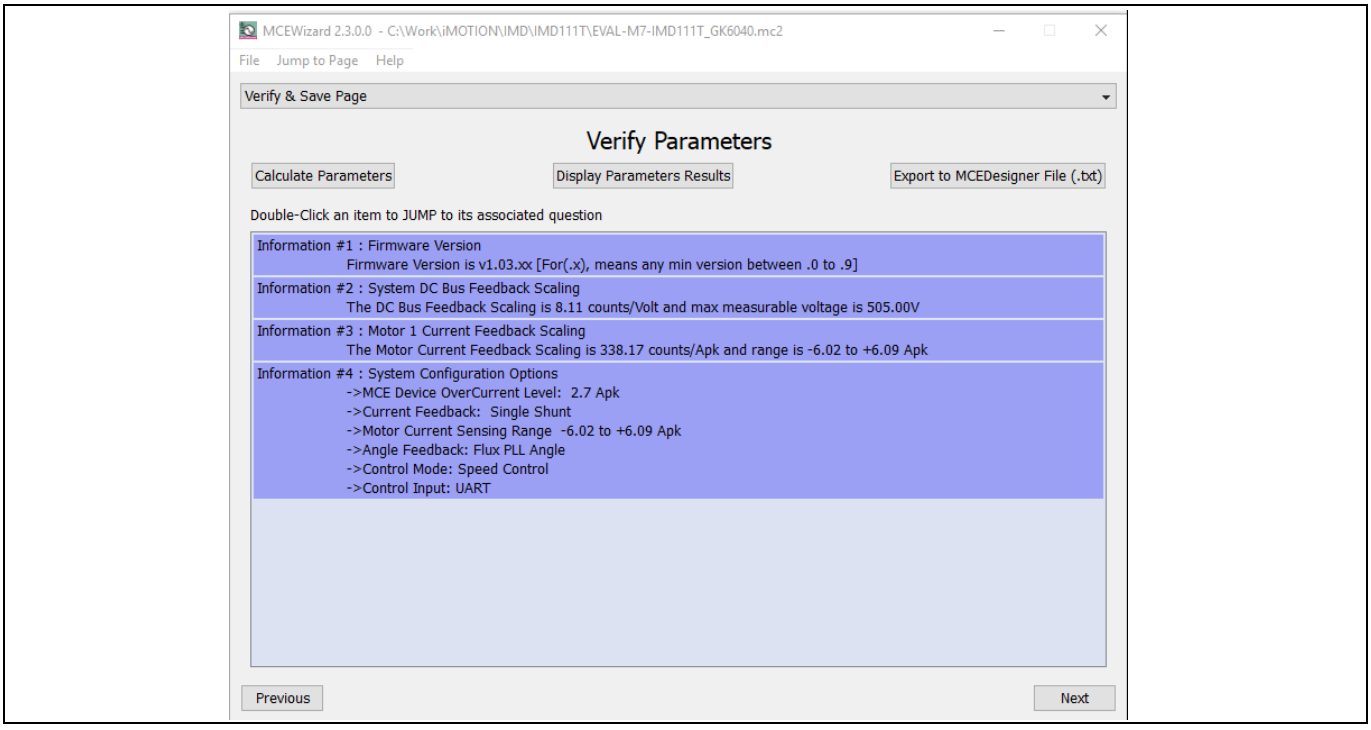


Figure 5 Verify & Save page of MCEWizard

2.2.1.2 MCEDesigner setup overview

MCEDesigner is a tool that can be used for programming code and tuning the evaluation board, including the possibility to read from 16-bit MCE variable registers, and to read/write to MCE parameter registers. MCEDesigner displays both real and counts value for all variable registers, and selects parameter registers. The count value means to convert the real value to digital number. The registers' value format can be selected from "Performance > Tuning Value Format" pop-up window.

After installing the MCEDesigner installer, there will be a shortcut on the Windows desktop. A quick start of MCEDesigner is as following steps:

- Double-click on the shortcut to open MCEDesigner.
- Open the MCEDesigner default configuration file (.irc) for IMD111T smart driver (IMD111T_V1.03.01.irc included in the firmware zip folder downloaded from the Infineon website).
- Select the available COM port in "Performance > Connection" pop-up window

The MCEDesigner window appears as shown in Figure 6.

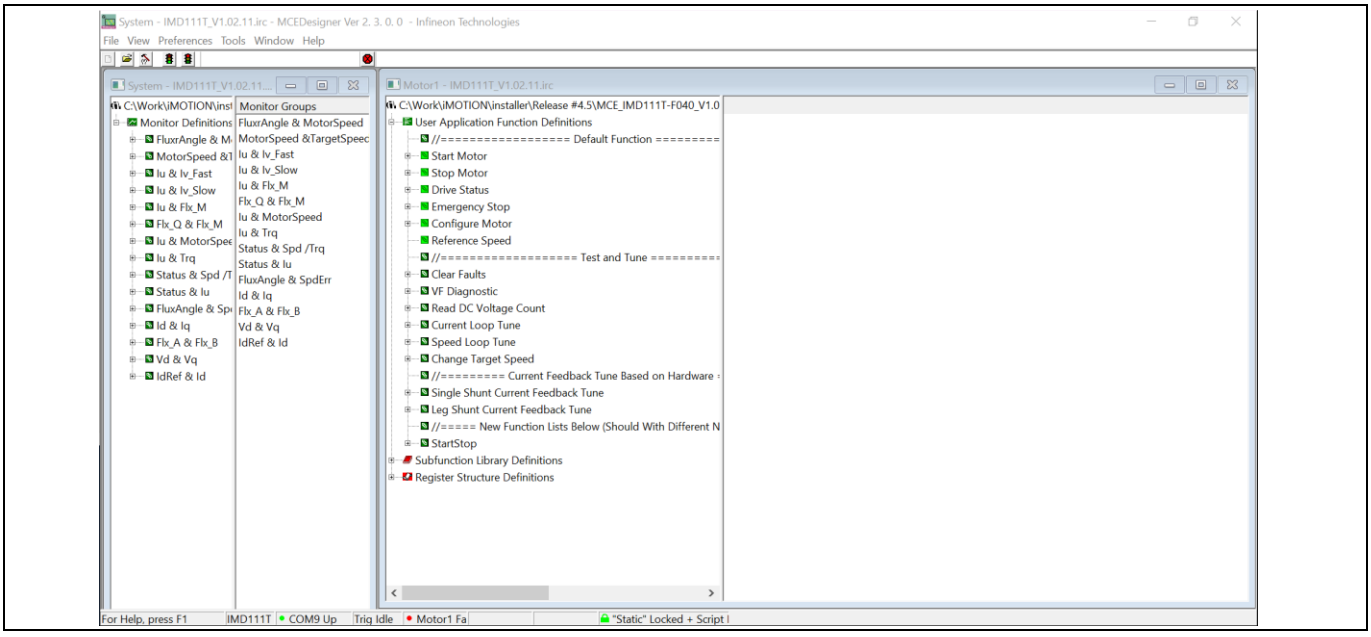


Figure 6 MCEDesigner window page

For the next step, the users need to program the firmware (.ldf file) and parameters (.txt file) into flash.

- Please click on the "Tools" menu in the "System" window and select "Programmer" from the pull-down list.
- Choose the relevant ldf file and text file,
- Then click the Start button to program the ldf and text files.

The ldf file can be downloaded from the Infineon website. The txt file was created by the MCEWizard as described in Chapter 2.2.1.1. The programming window is shown in Figure 7 below.

After firmware and parameters are programmed, the system will be ready to run the motor. Users can click the green traffic light to start the motor or click the red traffic light to stop the motor. Users can now check the waveform of phase current, Flx_M, motor speed, and other registers' values when they double-click the monitor items in the system window.

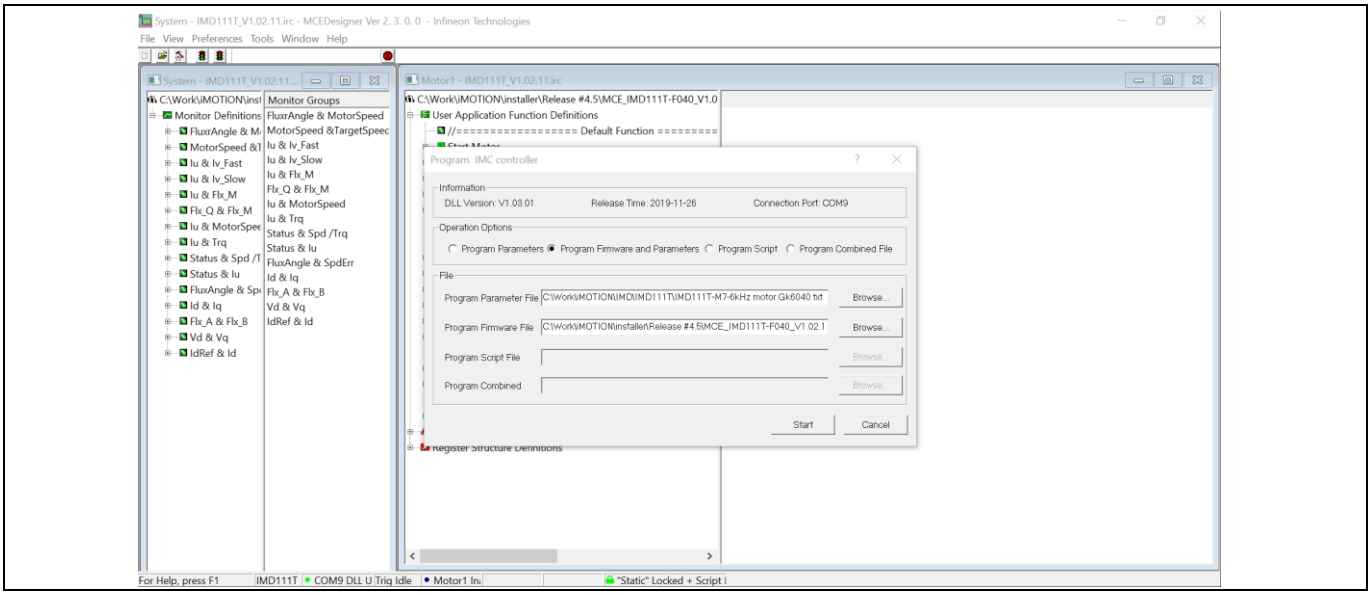


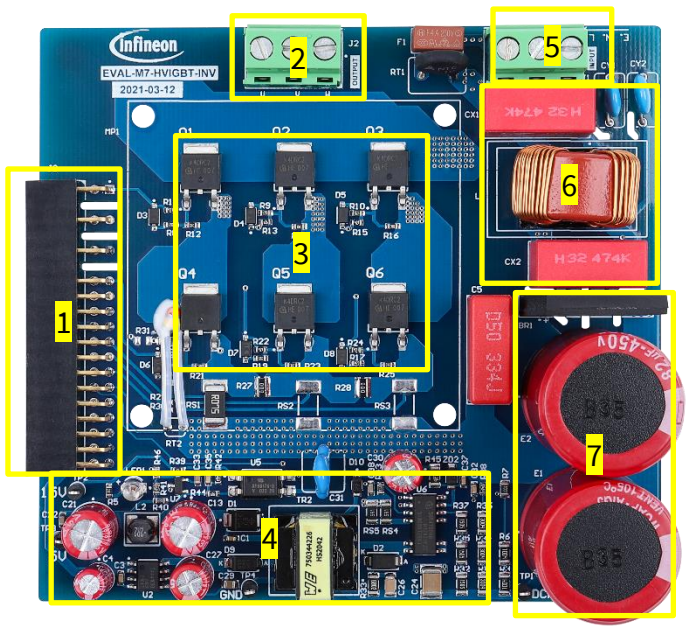
Figure 7 Programming window

2.3 Description of the functional blocks

This chapter covers the hardware design of the EVAL-M7-HVIGBT-INV in more detail. Users can understand the functional groups of this power board. So they can use this board to evaluate the performance easily. And it is also helpful for users to develop their solution based on the evaluation board design

2.3.1 EVAL-M7-HVIGBT-INV functional groups

Figure 8 points out the evaluation board of EVAL-M7-HVIGBT-INV functional group.



1. M7 connector
2. Inverter output connector
3. Inverter function
4. Auxiliary power supply
5. 220 V_{AC} input connector
6. EMI filter
7. Rectifier bridge & bus capacitors

Figure 8 Functional groups

There are 3 connectors on the EVAL-M7-HVIGBT-INV board. All connector pin assignments are described in Table 5~Table 7.

Table 5 $220V_{AC}$ input connector-J1

Pin Number	Symbol	Assignment
1	E	Earth
2	N	Neutral
3	L	Line

Table 6 Inverter output connector-J2

Pin Number	Symbol	Assignment
1	U	U phase output
2	V	V phase output
3	W	W phase output

Table 7 M7 connector-J3

Pin Number	Symbol	Assignment
1	GUH	U phase high-side gate PWM
2	VSV	U phase high-side floating return
3, 4, 7, 8, 11, 12	-	Not used.
5	GVH	V phase high-side gate PWM
6	VSV	V phase high-side floating return
9	GWH	W phase high-side gate PWM
10	VSW	W phase high-side floating return
13	GUL	U phase low-side gate PWM
14	GVL	V phase low-side gate PWM
15	GWL	W phase low-side gate PWM
16	COM	Gate driver low-side return
17, 18, 32	GND	Ground
19	VDD	Internal LDO output
20	VDD1	External VDD supply voltage
21	IU+	U phase current-sensing signal positive
22	IU-	U phase current-sensing signal negative
23	IV+	V phase current-sensing signal positive
24	IV-	V phase current-sensing signal negative

Pin Number	Symbol	Assignment
25	IW+	W phase current-sensing signal positive
26	IW-	W phase current-sensing signal negative
27	VTH	NTC output voltage
28	VDC	V_{bus} voltage sensing
29	GK	inverter gate kill signal
30	VCC	Gate driver supply voltage
31	PFCG0	PFC gate driving PWM 0 (not used for this board)
33	PFCG1	PFC gate driving PWM 1 (not used for this board)
34	PFCGK	PFC gate kill signal (not used for this board)
35	IPFC+	PFC current-sensing positive (not used for this board)
36	IPFC-	PFC current-sensing negative (not used for this board)
37	VAC1	AC voltage-sensing input 1 (not used for this board)
38	VAC2	AC voltage-sensing input 2 (not used for this board)

2.3.2 Bus voltage feedback

EVAL-M7-HVIGBT-INV evaluation board includes bus voltage feedback circuitry. It is a voltage divider. The high side resistor is two 1 MΩ resistors (R3, R6) in series and low side resistor (R7) is one 20 kΩ. Figure 9 shows the bus voltage feedback on the board. Please pay attention the low side resistor is on this power board and it is different from some power board that the low side resistor is on the control board. The example control board EVAL-M7-D111T has no low side resistor and only keep a decoupling capacitor closing to the IMD111T bus voltage feedback input pin. So when users use different control board, they should keep in mind the low side resistor where it is and make sure get the right feedback voltage.

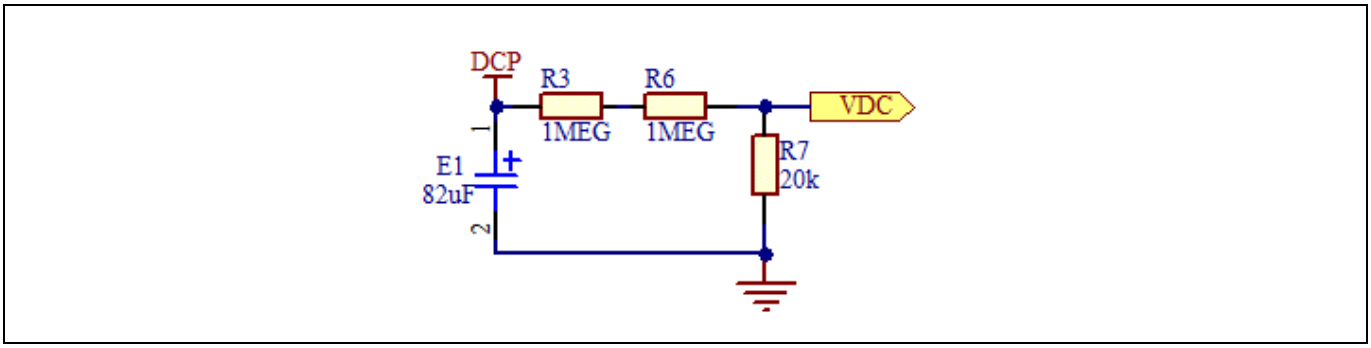


Figure 9 Bus voltage feedback

2.3.3 Current feedback configuration

There are two current feedback configuration on this EVAL-M7-HVIGBT-INV power board. One is single-shunt current feedback configuration. The other is leg-shunt current feedback configuration. The single shunt configuration is default setting on the board. When users want to use leg-shunt configuration, they should remove the resistors R26, R27, and R27 first. Then they should solder the resistors R29, R30, R31, RS2, and RS3. The value is 0 Ω for R29, R30, and R30. RS2 and RS3 are 75 mΩ. Please refer to the schematics for the details in Chapter 3.

Figure 10 is the single shunt current sensing circuit. According to MCEWizard question 83 explanation, the current input scaling can be calculated as:

$$Current\ input\ scaling = G_{ext} \times Rs = \frac{R12}{R15 + R12} \times RS2 = \frac{22.1}{2 + 22.1} \times 75 = 68.8\ mA/V$$

And offset voltage calculated is:

$$Voff = \frac{\mathrm{R15}}{\mathrm{R15} + \mathrm{R12}} \times VDD = \frac{2}{2 + 22.1} \times 5 = 0.415\ V = 415\ mV$$

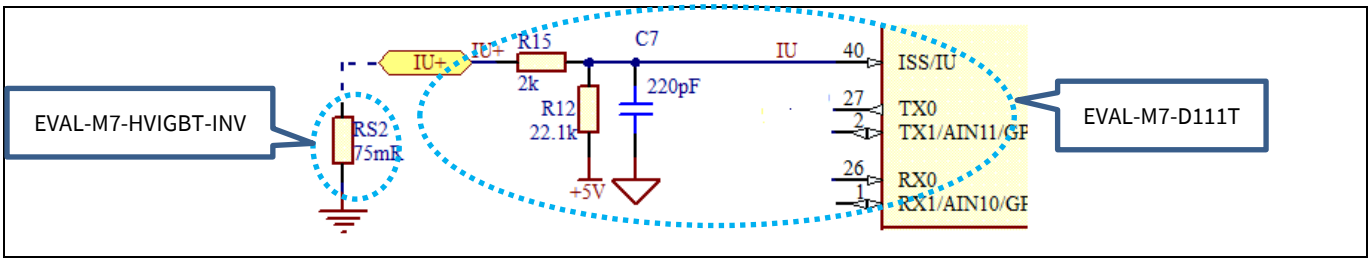


Figure 10 Current sensing-single shunt

2.3.4 Temperature measured with NTC on board

In order to measure the switch IGBT case temperature, a NTC was assembled on the board closing to the U phase low side IGBT. The NTC was placed on the board as the Figure 11. It is very close to IGBTwith glove. But there is a little gap between NTC and IGBT case. So the tolerance will be occurred between the measured case temperature and the real IGBT case temperature. The pull up resistor on the EVAL-M7-D111T control board is 4.87 kΩ. The connection between the NTC and control board shows in Figure 11. According to NTC datasheet, Table 8 gives the NTC resistance values at intermediate temperature in case users to calculate divider voltage.

According to the connection as showed in Figure 12, the NTC character on the board has been tested to get a relationship between NTC resistor dropped voltage and maximum IGBT case temperature. So users can get the hottest IGBT temperature via measuring the NTC dropped voltage. And users can also set the over temperature threshold that they want to protect the system.

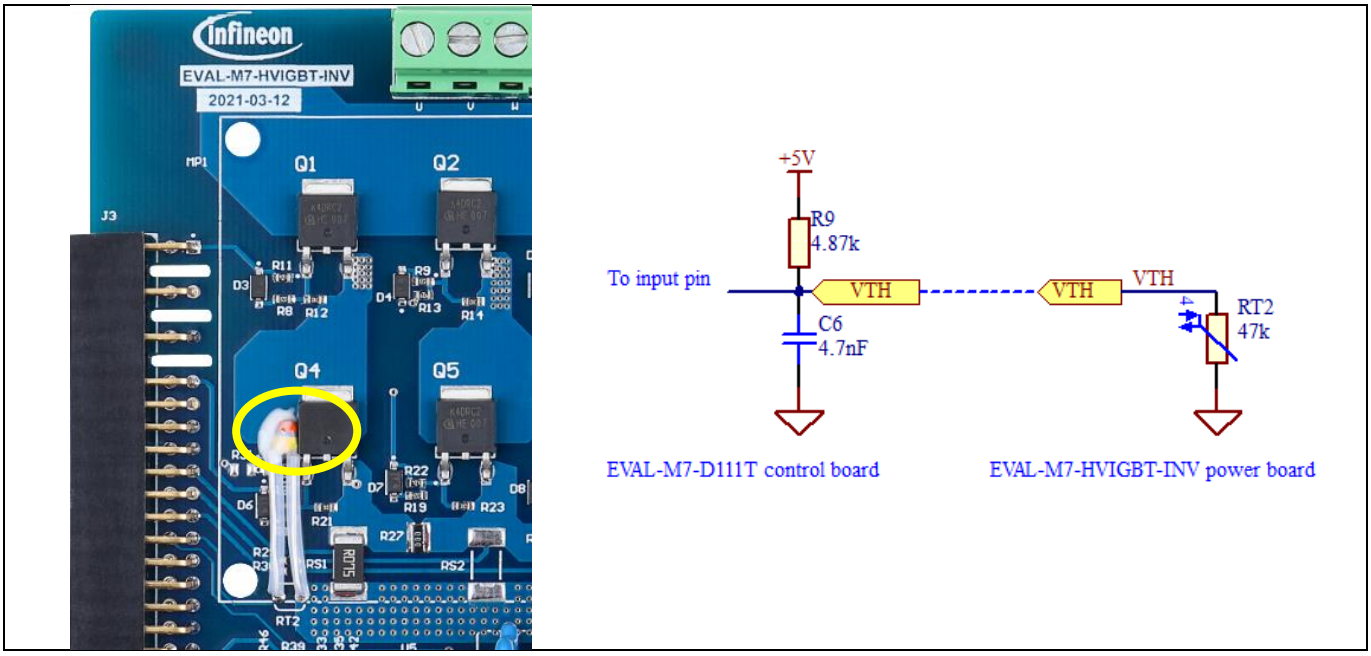


Figure 11 NTC placed on the board and voltage divider circuit

Table 8 NTC resistance values at intermediate temperature

T_{OPER} (℃)	15	20	25	30	35	40	45	50	55	60
R_T (kΩ)	74.4	58.95	47.00	37.71	30.43	24.70	20.15	16.53	13.63	11.30
T_{OPER} (℃)	65	70	75	80	85	90	95	100	105	110
R_T (kΩ)	9.404	7.865	6.607	5.573	4.721	4.015	3.427	2.936	2.525	2.179

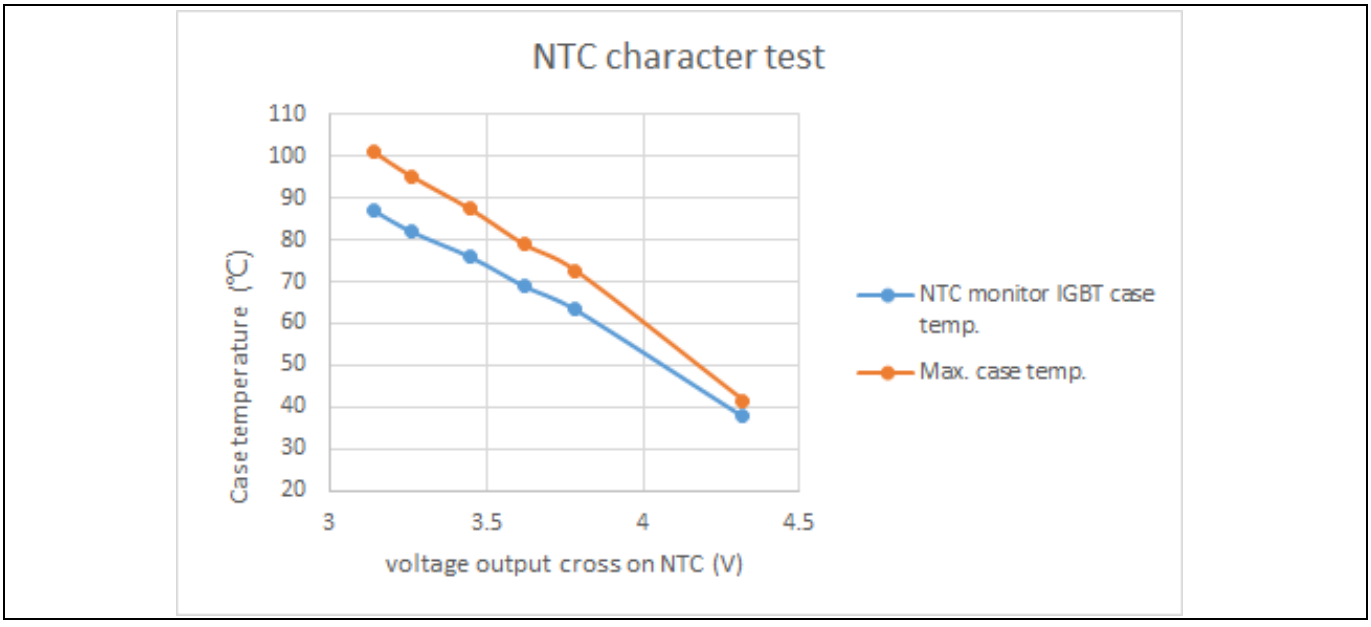


Figure 12 NTC character test on the board

2.3.5 DC power supply

This evaluation board EVAL-M7-HVIGBT-INV is dedicate to under 300 W motor applications at 220 V_{AC} input. So it is designed with two 82 µF bus capacitors. When the users want to use this board to evaluate higher power over 300 W, they should consider the effect of the higher bus voltage ripple at heavy load.

Figure 13 shows the measured bus voltage ripple is 14.5% at 300 W load and 220 VAC input condition (45 V/310 V = 14.5%).

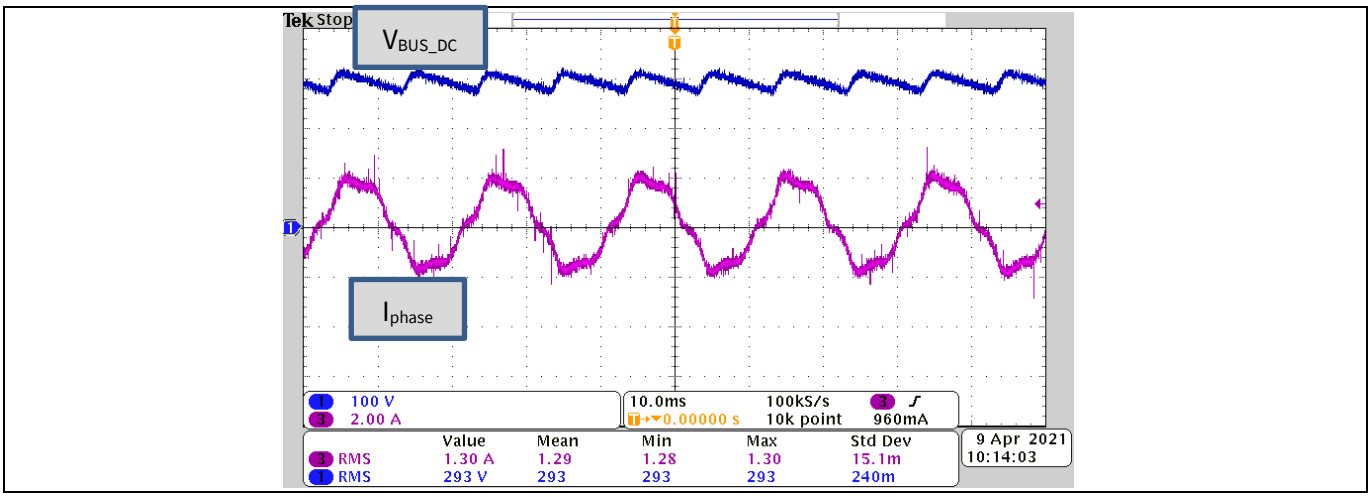


Figure 13 Bus voltage ripple test

2.3.6 Protection function

For this power board EVAL-M7-HVIGBT-INV, it has no any external hardware protection function on board. Such as over current, over/under voltage, phase loss, rotor lock, and other protection function, these protection function are all completed by the control board when using EVAL-M-D111T control board for evaluation. The over current and over/under voltage protection threshold can be set in the MCEWziard. And also users can enable/disable the protection functions as phase loss, rotor lock etc. All the protection functions which IMD111T included can be set in the MCEWizard. Figure 14 shows the over current trip level setting page in MCEWizard.

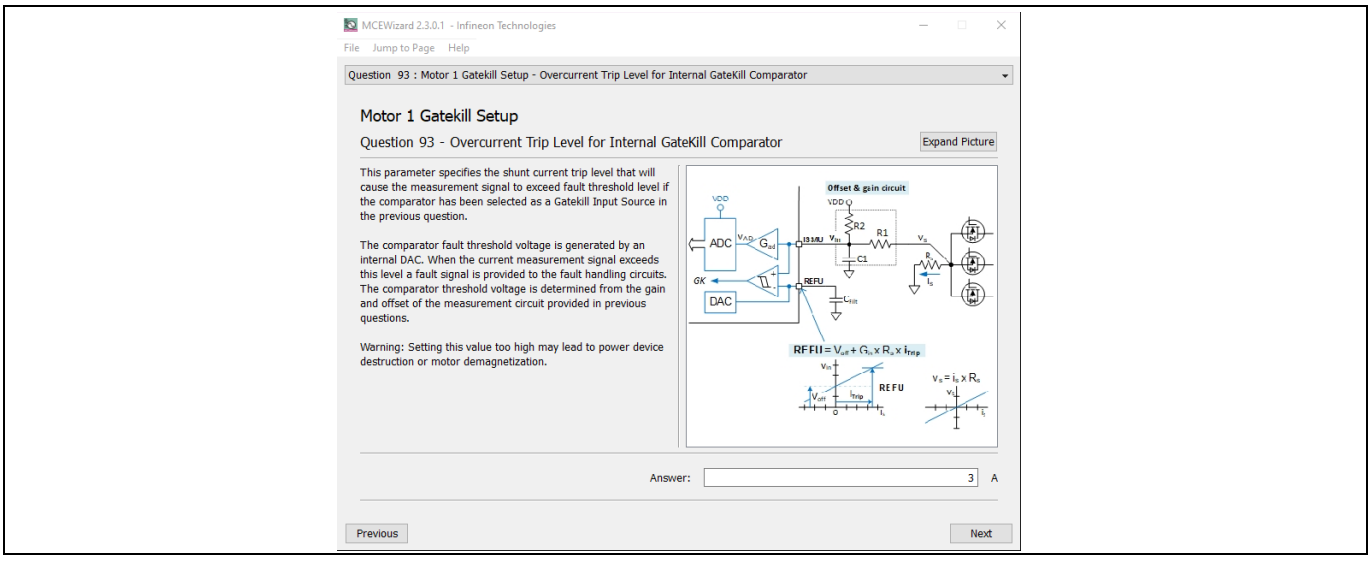


Figure 14 Over current trip level setting in MCEWizard

3 System design

3.1 Schematics

The schematics of EVAL-M7-HVIGBT-INV power board include EMI filter, rectifier-bridge, inverter section, and auxiliary power supply. Figure 15 shows the inverter section schematics of the EVAL-M7-HVIGBT-INV. Figure 16 is the auxiliary power supply schematics. The power supply has two outputs: 15 V and 5 V.

The complete schematic diagrams are available on the download section of the Infineon homepage. A log-in is required to download this material.

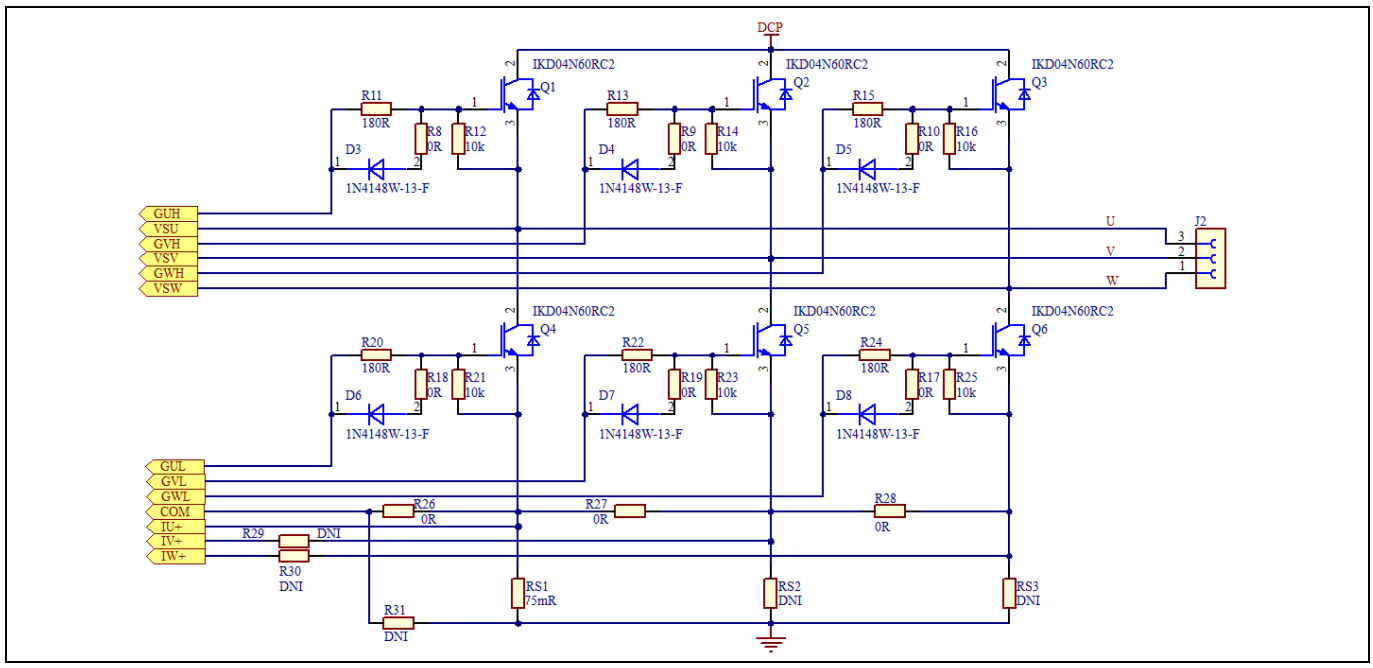


Figure 15 Inverter section schematics

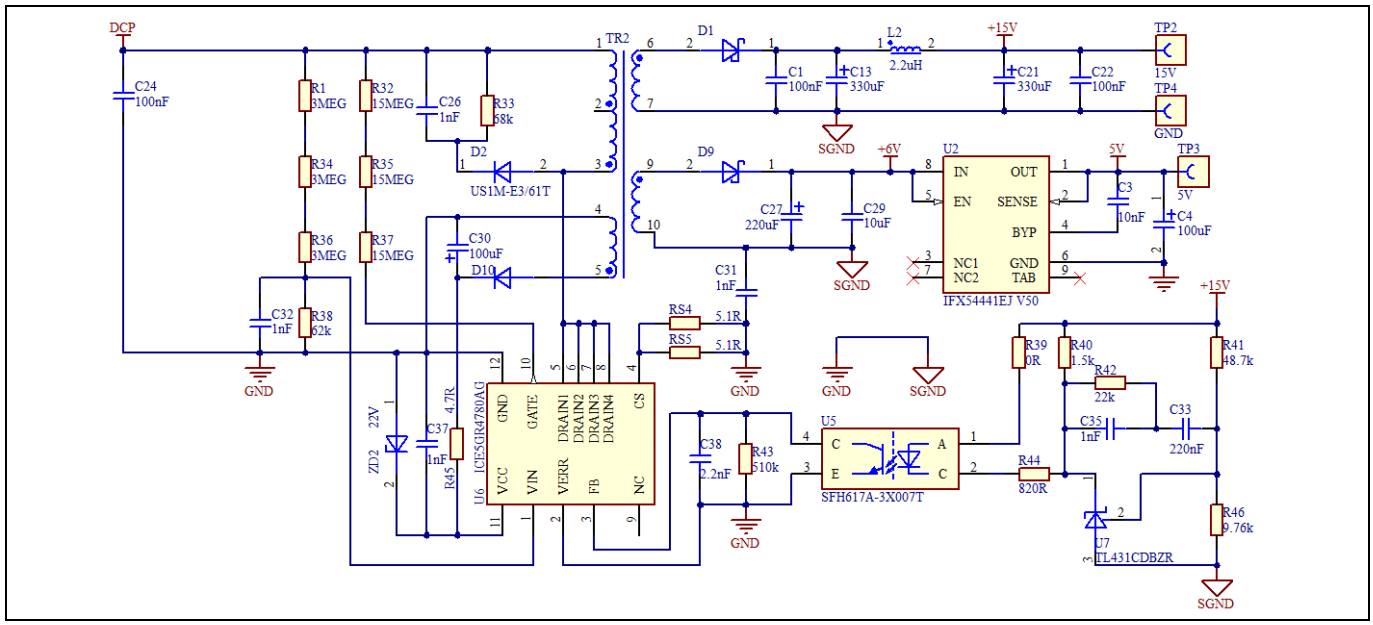


Figure 16 Auxiliary power supply

3.2 Layout

The EVAL-M7-HVIGBT-INV board consists of two copper PCB layers. The copper thickness is 35 µm and the board size is 103 mm x 96 mm. The board material is FR4 grade with 1.6 mm thickness. Check Infineon's website or contact Infineon's technical support team for more detailed information. The Gerber files are available on the download section of the Infineon homepage. A log-in is required to download this material.

The top layer and bottom layer PCB layout are shown in Figure 17 and Figure 18. For the power board PCB layout, users should connect the signal ground and power ground at one single point to keep low noise for the current-feedback sensing. The current-feedback trace should be short and close to ground copper. This can make sure to introduce less noise into current feedback loop. A lower current feedback noise is benefit to motor control performance.

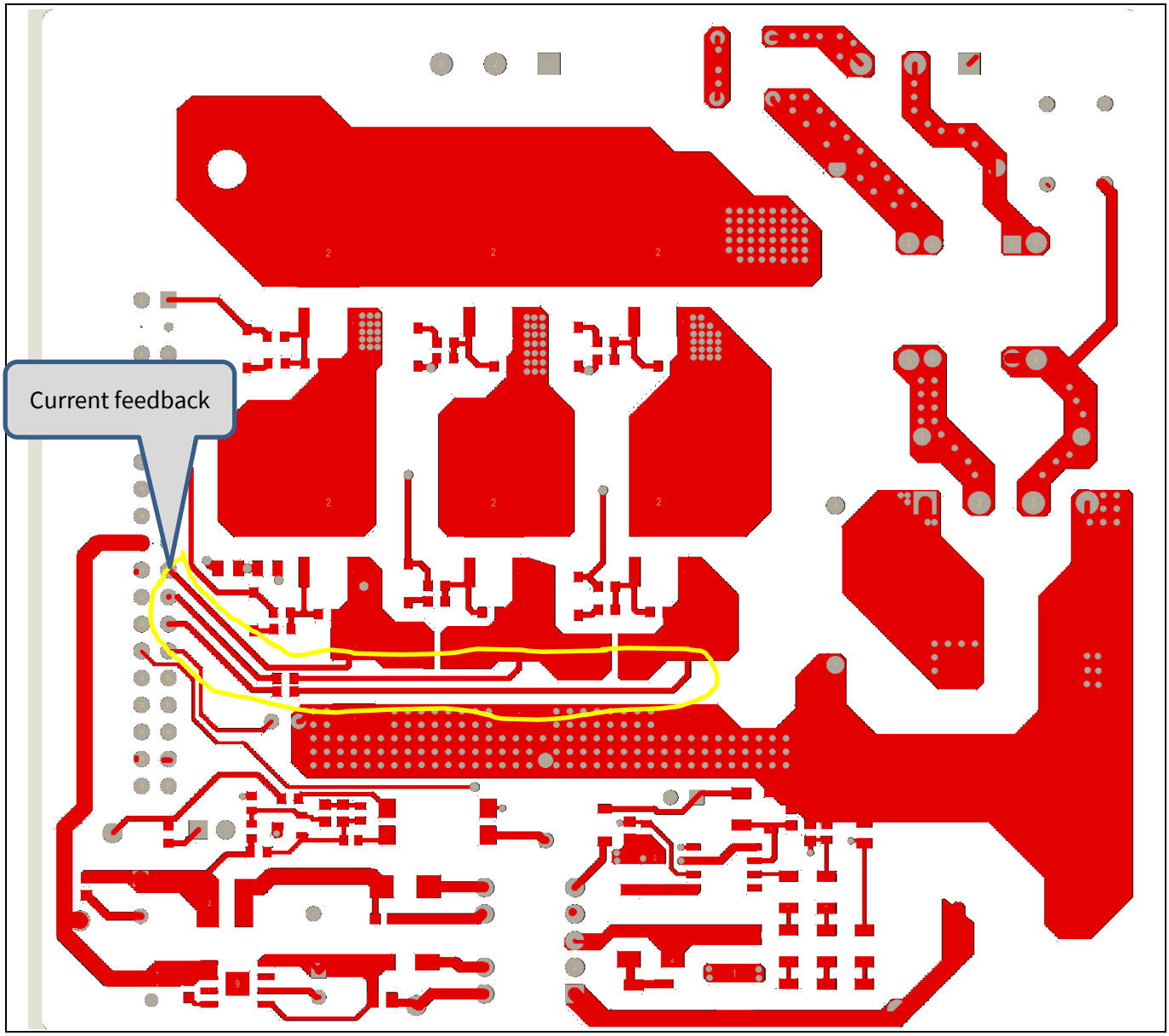


Figure 17 Top layer

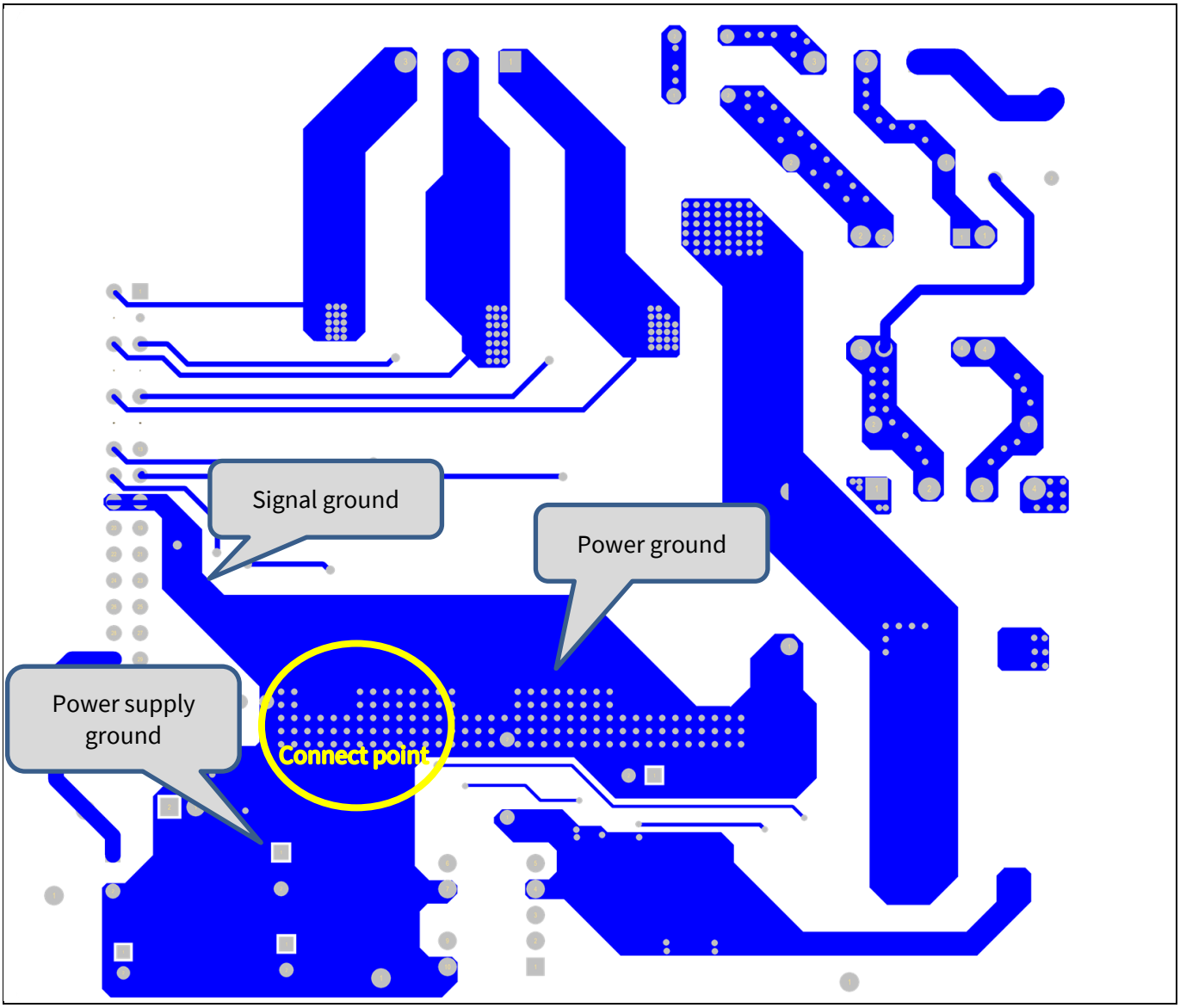


Figure 18 Bottom layer

3.3 Bill of material

The bill of material is available in the download section of the Infineon homepage. A log-in is required to download the material. Table 9 is the BOM of EVAL-M7-HVIGBT-INV board.

Table 9 BOM of the most important parts of the evaluation board EVAL-M7-HVIGBT-INV

S. No.	Ref Designator	Description	Manufacturer	Manufacturer P/N
1	Q1, Q2, Q3, Q4, Q5, Q6	TRENCHSTOP RC-Series for hard switching applications, VCE 600V, IC 4A	Infineon	IKD04N60RC2
2	U6	Fixed Frequency 700 V/800 V CoolSET,lowest standby power <100 mW	Infineon	ICE5GR4780AG
3	U2	Wide Input Range Low Noise 300mA 5V LDO	Infineon	IFX54441EJ V50

S. No.	Ref Designator	Description	Manufacturer	Manufacturer P/N
4	TR2	Flyback Transformer , Offline aux SMPS for server, PC power applications	Wurth Elektronik	750344226
5	E1, E2	CAP / ELCO / 82 uF / 450 V / 20% / - / -25℃ to 105℃ /	Wurth Elektronik	861021483005
6	J1, J2	Horizontal Cable Entry With Rising Cage Clamp - WR-TBL, 3Pins	Wurth Elektronik	691216510003S
7	CX1, CX2	CAP / FILM / 470nF / 630V / 10% / MKP (Metallized Polypropylene)	Wurth Elektronik	890324025039CS
8	BR1	4 Amp Single Phase Glass Passivated Bridge Rectifier, 600V	Micro Commercial Components	GBU4J-BP
9	C1, C22	CAP / CERA / 100nF / 50V / 10% / X7R (EIA) / -55℃ to 125℃ / 603(1608) / SMD / -	AVX	06035C104K4Z2A
10	C3	CAP / CERA / 10nF / 50V / 10% / X7R (EIA) / -55℃ to 125℃ / 0603 / SMD / -	AVX	06035C103K4Z2A
11	C4	CAP / ELCO / 100uF / 16V / 20% / Aluminium electrolytic / -40℃ to 85℃ / 2.00mm C X 0.50mm W 5.00mm Dia X 12.50mm H / THT / -	Wurth Elektronik	860010473007
12	C5	CAP / FILM / 330nF / 400V / 5% / - / -40℃ to 105℃ / 15.00mm C X 0.80mm W 18.00mm L X 7.00mm T X 14.00mm H / THT / -	Wurth Elektronik	890283325008CS
13	C13, C21	CAP / ELCO / 330uF / 25V / 20% / Aluminiumelectrolytic / -40℃ to 85℃ / 3.50mm C X 0.60mm W 8.00mm Dia X 13.00mm H / THT / -	Wurth Elektronik	860010474012
14	C24	CAP / CERA / 100nF / 630V / 10% / X7R (EIA) / -55℃ to 125℃ / 1812 / SMD / -	Wurth Elektronik	885342211006
15	C26	CAP / CERA / 1nF / 630V / 10% / X7R (EIA) / -55℃ to 125℃ / 1206(3216) / SMD / -	MuRata	GRM31BR72J102KW01
16	C27	CAP / ELCO / 220uF / 16V / 20% / Aluminiumelectrolytic / -40℃ to 85℃ / 2.50mm C X 0.50mm W 6.30mm Dia X 12.50mm H / THT / -	Wurth Elektronik	860010373010
17	C29	CAP / CERA / 10uF / 16V / 10% / X5R (EIA) / -55℃ to 85℃ / 0805(2012) / SMD / -	MuRata	GRM219R61C106KA73
18	C30	CAP / ELCO / 100uF / 35V / 20% / Aluminiumelectrolytic / -40℃ to 85℃ / 2.50mm C X 0.50mm W 6.30mm Dia X 12.50mm H / - / -	Wurth Elektronik	860010573007
19	C31	CAP / CERA / 1nF / / 20% / E (JIS) / -40℃ to 125℃ / 7.50mm C X 0.60mm W 7.00mm L X 7.00mm T X 10.00mm H / THT / -	MuRata	DE6E3KJ102MN3A

S. No.	Ref Designator	Description	Manufacturer	Manufacturer P/N
20	C32	CAP / CERA / 1nF / 16V / 10% / X7R (EIA) / -55℃ to 125℃ / 0603(1608) / SMD / -	Kemet	C0603C102K4RACTU
21	C33	CAP / CERA / 220nF / 25V / 10% / X5R (EIA) / -55℃ to 85℃ / 0603(1608) / SMD / -	MuRata	GRM188R61E224KA88
22	C35, C37	CAP / CERA / 1nF / 25V / 5% / C0G (EIA) / NP0 / -55℃ to 125℃ / 0603(1608) / SMD / -, CAP / CERA / 1nF / 25V / 5% / C0G (EIA) / NP0 / -55℃ to 125℃ / 0603(1608) / SMD / -	MuRata	GRM1885C1E102JA01
23	C38	CAP / CERA / 2.2nF / 50V / 10% / X5R (EIA) / -55℃ to 85℃ / 0603(1608) / SMD / -	MuRata	GRM188R61H222KA01
24	CY1, CY2	CAP / CERA / 2.2nF / 1kV / 20% / Y5U (EIA) / -40℃ to 125℃ / 7.50mm C X 0.60mm W 9.00mm L X 5.00mm T X 13.00mm H / - / -	Vishay	VY2222M35Y5US6TL7
25	D1	High Voltage Surface-Mount Schottky Rectifier, VRRM 100V	Vishay	SS2H10-E3/52T
26	D2	Surface Mount Ultrafast Rectifier 1.0A/1000V	Vishay	US1M-E3/61T
27	D3, D4, D5, D6, D7, D8	Surface Mount Fast Switching Diode	Diodes Incorporated	1N4148W-13-F
28	D9	Surface-Mount Schottky Barrier Rectifier, VRRM 45V	Vishay	BYS10-45-E3/TR3
29	D10	Super Fast Recovery Diode, VR 200 V, IF 1 A	ROHM Semiconductors	RF071MM2STR
30	F1	RES / STD / - / - / - / - / -55℃ to 125℃ / 5.08mm C X 0.60mm W 8.50mm L X 4.00mm T X 7.90mm H / - / -	Hollyland (China) Electronics Technology Corp.,Ltd	5EF-040H
31	J3	The part can be named as M7-38-F, Connector, 38 pins, 2.54 mm pitch, Board to Board, Right Angle	Sullins	PPTC192LJBN-RC
32	L1	IND / STD / 5mH / 2.5A / 30% / -40℃ to 125℃ / 95mR / THT / Inductor, THT, 4 pin, 13.80 mm L X 23.00 mm W X 25.50 mm H body / THT / -	Wurth Elektronik	744823305
33	L2	IND / STD / 2.2uH / 2.5A / 20% / -40℃ to 125℃ / 71mR / SMD / Inductor, SMD; 2-Leads, 4.50 mm L X 4 mm W X 3.50 mm H body / SMD / -	Wurth Elektronik	744773022
34	LED1	LED 3mm Red Through Hole Lamp	LiteOn Optoelectronics	LTL-1CHEE
35	R1, R34, R36	RES / STD / 3MEG / 250mW / 1% / 100ppm/K / -55℃ to 155℃ / 1206 / SMD / -	Vishay	CRCW12063M00FK
36	R3, R6	RES / STD / 1MEG / 250mW / 1% / 100ppm/K / -55℃ to 155℃ / 1206 / SMD / -	Vishay	CRCW12061M00FK

S. No.	Ref Designator	Description	Manufacturer	Manufacturer P/N
37	R5, R12, R14, R16, R21, R23, R25	RES / STD / 10k / 100mW / 1% / 100ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Yageo	RC0603FR-0710KL
38	R7	RES / STD / 20k / 125mW / 1% / 100ppm/K / -55℃ to 155℃ / 0805 / SMD / -	Vishay	CRCW080520K0FK
39	R8, R9, R10, R17, R18, R19	RES / STD / 0R / 100mW / 0R / 0ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Yageo	RC0603JR-070RL
40	R11, R13, R15, R20, R22, R24	RES / STD / 180R / 100mW / 1% / 100ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Yageo	RC0603FR-07180RL
41	R39	RES / STD / 0R / 100mW / 0R / 0ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Yageo	RC0603JR-070RL
42	R31	RES / STD / 0R / 125mW / 0R / 0ppm/K / -55℃ to 155℃ / 0805 / SMD / -	Yageo	RC0805JR-070RL
43	R26	RES / STD / 0R / 125mW / 0R / 0ppm/K / -55℃ to 155℃ / 0805 / SMD / -	Yageo	RC0805JR-070RL
44	R27, R28	RES / - / 0R / 500mW / - / - / - / 0612 / SMD / -	Vishay	RCL06120000Z0EA
45	R29, R30	RES / STD / 0R / 100mW / 0R / 0ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Yageo	RC0603JR-070RL
46	R32, R35, R37	RES / STD / 15MEG / 250mW / 5% / 200ppm/K / -55℃ to 155℃ / 1206 / SMD / -	Yageo	RC1206JR-0715ML
47	R33	RES / STD / 68k / 250mW / 1% / 100ppm/K / -55℃ to 155℃ / 1206 / SMD / -	Vishay	CRCW120668K0FK
48	R38	RES / STD / 62k / 100mW / 1% / 100ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Vishay	CRCW060362K0FK
49	R40	RES / STD / 1.5k / 100mW / 1% / 100ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Yageo	RC0603FR-071K5L
50	R41	RES / STD / 48.7k / 100mW / 1% / 100ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Vishay	CRCW060348K7FK
51	R42	RES / STD / 22k / 100mW / 1% / 100ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Vishay	CRCW060322K0FK
52	R43	RES / STD / 510k / 100mW / 1% / 100ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Vishay	CRCW0603510KFK
53	R44	RES / STD / 820R / 100mW / 1% / 100ppm/K / -55℃ to 155℃ / 0603 / SMD / -	Vishay	CRCW0603820RFK
54	R45	RES / STD / 4.7R / 250mW / 1% / 100ppm/K / -55℃ to 155℃ / 1206 / SMD / -	Vishay	CRCW12064R70FK
55	R46	RES / STD / 9.76k / 100mW / 1% / 100ppm/K / -55℃ to 155℃ / 0603 /	Vishay	CRCW06039K76FK

S. No.	Ref Designator	Description	Manufacturer	Manufacturer P/N
		SMD / -		
56	RS1	RES / STD / 75mR / 3W / 1% / 50ppm/K / -55℃ to 170℃ / 2512 / SMD / -	Bourns	CRA2512-FZ-R075ELF
57	RS2, RS3	RES / STD / 75mR / 3W / 1% / 50ppm/K / -55℃ to 170℃ / 2512 / SMD / -	Bourns	CRA2512-FZ-R075ELF
58	RS4, RS5	RES / STD / 5.1R / 250mW / 1% / 100ppm/K / -55℃ to 155℃ / 1206 / SMD / -	Vishay	CRCW12065R10FK
59	RT1	RES / NTC / 10R / 1.8W / 20% / - / - 55℃ to 170℃ / 5.25mm C X 0.60mm W 9.50mm L X 4.5mm T X 14mm H / - / -	TDK Corporation	B57235S0100M000
60	RT2	RES / NTC / 47k / 500mW / - / - / -40℃ to 125℃ / 2.54mm C X 0.60mm W 3.30mm L X 3.00mm T X 9.00mm H / THT / -，3%	Vishay	NTCLE100E3473HB0
61	TP1, TP2, TP3, TP4	Test Point THT, Black	Keystone Electronics Corp.	5001
62	U5	Optocoupler, Phototransistor Output, High Reliability, 5300 VRMS, 110 ℃ Rated	Vishay	SFH617A-3X007T
63	U7	Precision Programmable Reference	Texas Instruments	TL431CDBZR
64	ZD2	Zener Diode with Surge Current Specification	Vishay	BZD27C22P-HE3-08

4 System performance

4.1 dv/dt test

The dv/dt is important for the motor control system. The motor application requires the switching dv/dt below 5 V/ns. That can improve the motor control reliability. But please note lower dv/dt will increase the IGBT switching losses. The turn on dv/dt of the EVAL-M7-HVIGBT board is measured 3.8 V/ns. Figure 19 is dv/dt test waveform.

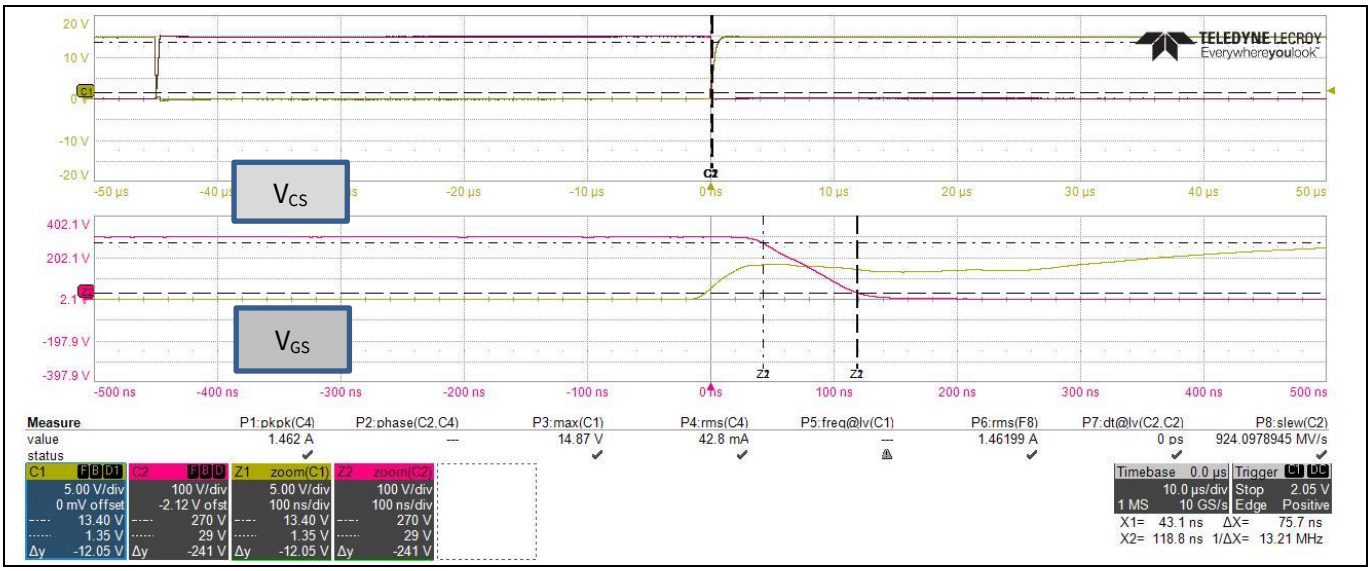
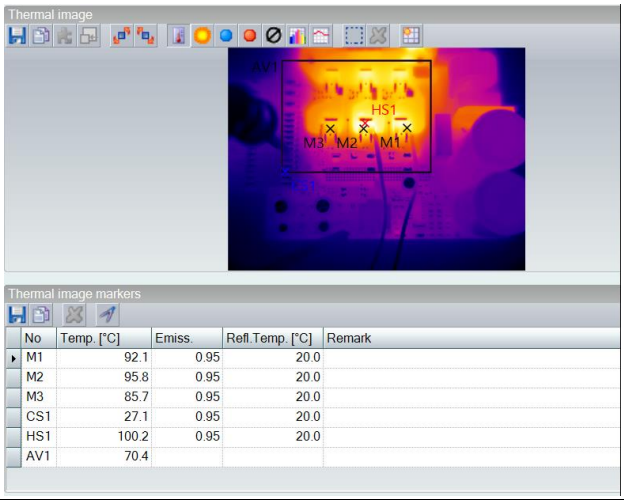


Figure 19 EVAL-M7-HVIGBT-INV dv/dt test waveform

4.2 Thermal performance test

For the EVAL-M7-HVIGBT-INV power board thermal performance test, the input power and motor phase current were measured when the IGBT case temperature was raised up to 100℃. And the power board was tested in different carrier frequency. The PWM frequency is from 4kHz to 16 kHz under testing procedure. But please keep in mind, this power board can be run up to 20 kHz and the output power capability will drop down accordingly. Figure 20 is a thermal test snap shot at the condition of 220 V_{AC} input, 8 kHz carrier frequency, and 200 W input power. The hot point of the power board is 100.2℃ when the room temperature is 23℃. Of course the board can output more power when using cooling fan or heatsink. A heatsink space was reserved on the board. Users can add a heatsink to increase the board output power. Please pay attention to using a thermal pad when adding the heatsink.



No	Temp. [°C]	Emiss.	Refl.Temp. [°C]	Remark
M1	92.1	0.95	20.0	
M2	95.8	0.95	20.0	
M3	85.7	0.95	20.0	
CS1	27.1	0.95	20.0	
HS1	100.2	0.95	20.0	
AV1	70.4			

Figure 20 Thermal test

4.3 Test results

The output power capability of the EVAL-M7-HVIGBT-INV power board was tested at different carrier frequency. And the IGBT case temperature is up to 100℃ under test. All the tests are in room temperature and without any heatsink or cooling fan. Figure 21 shows the increasment of IGBT case temperature vs input power at different PWM frequency. Figure 22 is motor phase current at different PWM frequency.

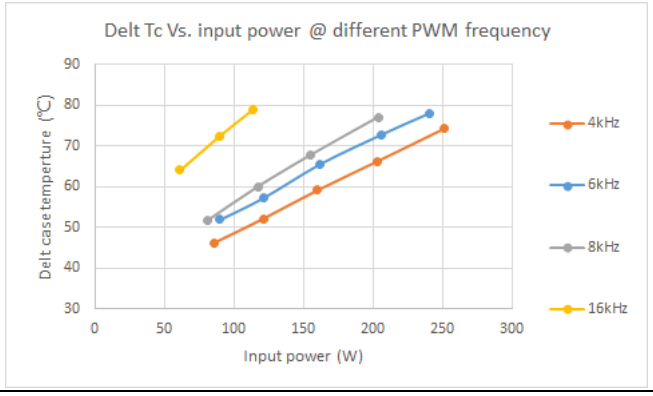


Figure 21 IGBT ΔT_C Vs. input power

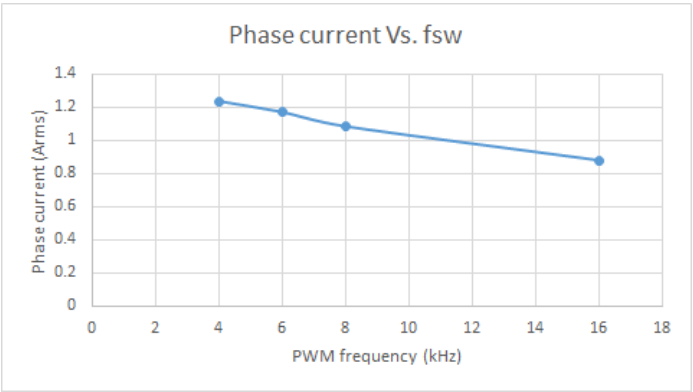


Figure 22 Phase current Vs. carrier frequency

5 References and appendices

5.1 References

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[5] Infineon Technologies AG. AppNote (2020): MCEDesigner application guide. V2.3 www.infineon.com

5.2 Ordering details and other additional information

The board is now available for customers in small order quantities. Design data are available in the download section of the Infineon homepage. A log-in is required to download the material.

In order to initiate the testing, customers are advised to order this board from the link below:

Buy online: link, or https://www.infineon.com/madk

Revision history

Document version	Date of release	Description of changes
V1.0	2021	First release

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