

EVAL-M1-05F804R user guide

iMOTION™ modular application design kit

About this document

Scope and purpose

This user guide provides an overview of the evaluation board EVAL-M1-05F804R including its main features, key data, pin assignments and mechanical dimensions.

EVAL-M1-05F804R is a power evaluation board from the modular application design kit including M1 connector, which is the iMOTION standard interface, and three CIPOS™ Nano 40 V half-bridge modules for motor drive applications. In combination with either EVAL-M1-101T or other control boards with M1 connector compatible, it features and demonstrates Infineon's CIPOS™ Nano IPM technology for motor drives.

The evaluation board EVAL-M1-05F804R was developed to support customers during their first steps designing applications with IRSM005-800MH CIPOS™ Nano power modules.

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 the EVAL-M1-05F804R board.

Evaluation board

This board is to 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.

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

Table 1 **Ordering information**

Part number	Symbol	Package	quantity
EVAL-M1-05F804R		Carton box	1
IRSM005-800MH	U1,U2,U3	QFN 7x8	3
BAS3005A-02V	D1,D2,D3,D7,D8,D9,D10,D11	SC79	8

Important notice

The Evaluation Boards and Reference Boards as well as the information in this document are solely intended to support designers of applications in evaluating the use of products from Infineon Technologies for their intended applications.

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 accepts that the Evaluation Boards and Reference Boards are not intended to be used in life-endangering applications such as medical, nuclear, military, life-critical or other applications, where failure of the Evaluation Boards and Reference Boards, or any results from the use thereof, can reasonably be expected to result in personal injury.

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 non-infringement 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.

The evaluation at a glance

Safety precautions

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

Table 2 Safety precautions

	Warning: The evaluation 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: 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 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 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 under sizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.
	Caution: The evaluation 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

About this document.....	1
Important notice	2
Safety precautions.....	3
Table of contents.....	4
1 The evaluation at a glance.....	5
1.1 Block diagram.....	6
1.2 Main features	6
1.3 Key data	7
1.4 EVAL-M1-05F804R board specification	7
2 System and functional description	9
2.1 Description of the functional blocks.....	9
2.1.1 Pin assignments	9
2.1.3 iMOTION™ development tools and software	11
2.1.4 MCEWizard setup overview.....	11
2.1.5 MCEDesigner setup overview	13
2.2 Trace function from MCEDesigner.....	15
2.3 T_{CMAX} vs I_{OUT} at different PWM carrier frequency.....	17
2.4 IPM cooling options.....	17
2.4.1 Self-cooling.....	17
2.4.2 Heat sink installation	17
2.4.3 Fan cooling	18
3 Details of the schematics, layout, BOM and connectors	19
3.1 Inverter section using CIPOS™ Nano	19
3.2 DC/DC.....	19
3.3 DC-link voltage measurement	20
3.4 Current sense and amplifying.....	20
3.5 Current feedback on EVAL-M1-101T	21
3.6 OCP, GK and Iocp setup	23
3.6.1 OCP and setup.....	23
3.6.2 PWM shut-down and GK output	23
3.6.3 OCP setup in MCEWizard.....	24
3.7 EVAL-M1-05F804R SPWM input and power output	26
3.8 NTC thermistor characteristics and overheating protection calculation	26
3.9 Layout	28
3.10 Bill of material	29
4 Ordering details and other information	31
5 References	32
Revision history.....	33

1 The evaluation at a glance

The EVAL-M1-05F804R evaluation board is a part of the iMOTION™ modular application design kit for motor control (iMOTION™ MADK).

The MADK platform is intended for use in various power stages with different control boards. These boards can easily be interfaced through the 20-pin iMOTION™ MADK-M1 interface connector.

This evaluation board is designed to give comprehensible solutions for the power section featuring by CIPOS™ Nano. It provides a DC input and 3-phase output for power. It contains a single shunt for current sensing and a voltage divider for DC-link voltage measurement.

The EVAL-M1-05F804R evaluation board is available from Infineon. 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-M1-05F804R. The design was tested as described in this document but not qualified in terms of 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 by specialists only.

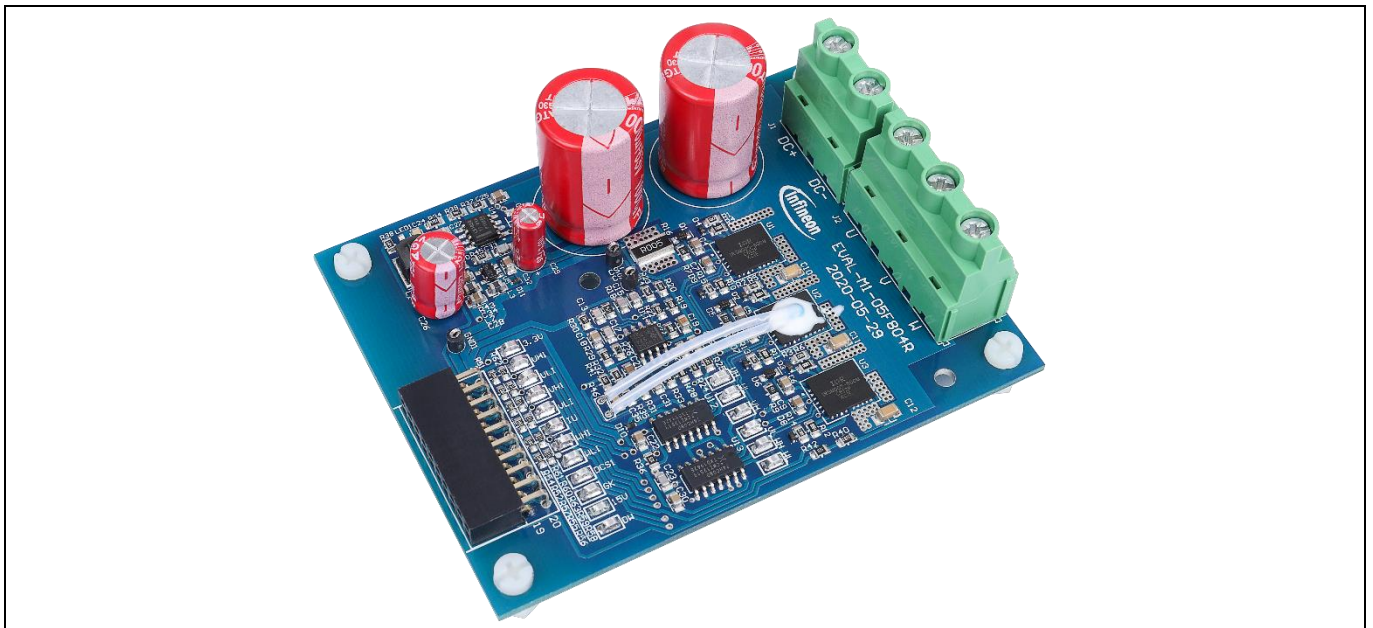


Figure 1 Evaluation board EVAL-M1-05F804R

Figure 1 shows the picture of evaluation board EVAL-M1-05F804R. This board is compatible with surface-mount CIPOS™ modules. This document explains the features and details of this board in combination with CIPOS™ Nano IRSM005-800MH. Ratings and other details of the board are explained in the subsequent sections.

The evaluation at a glance

1.1 Block diagram

This board requires a DC voltage input and have the three-phase AC output to drive motor. The on-board DC/DC converter generates 15 V for driver and 3.3 V for controller through M1 connector. The board diagram is shown in Figure 2.

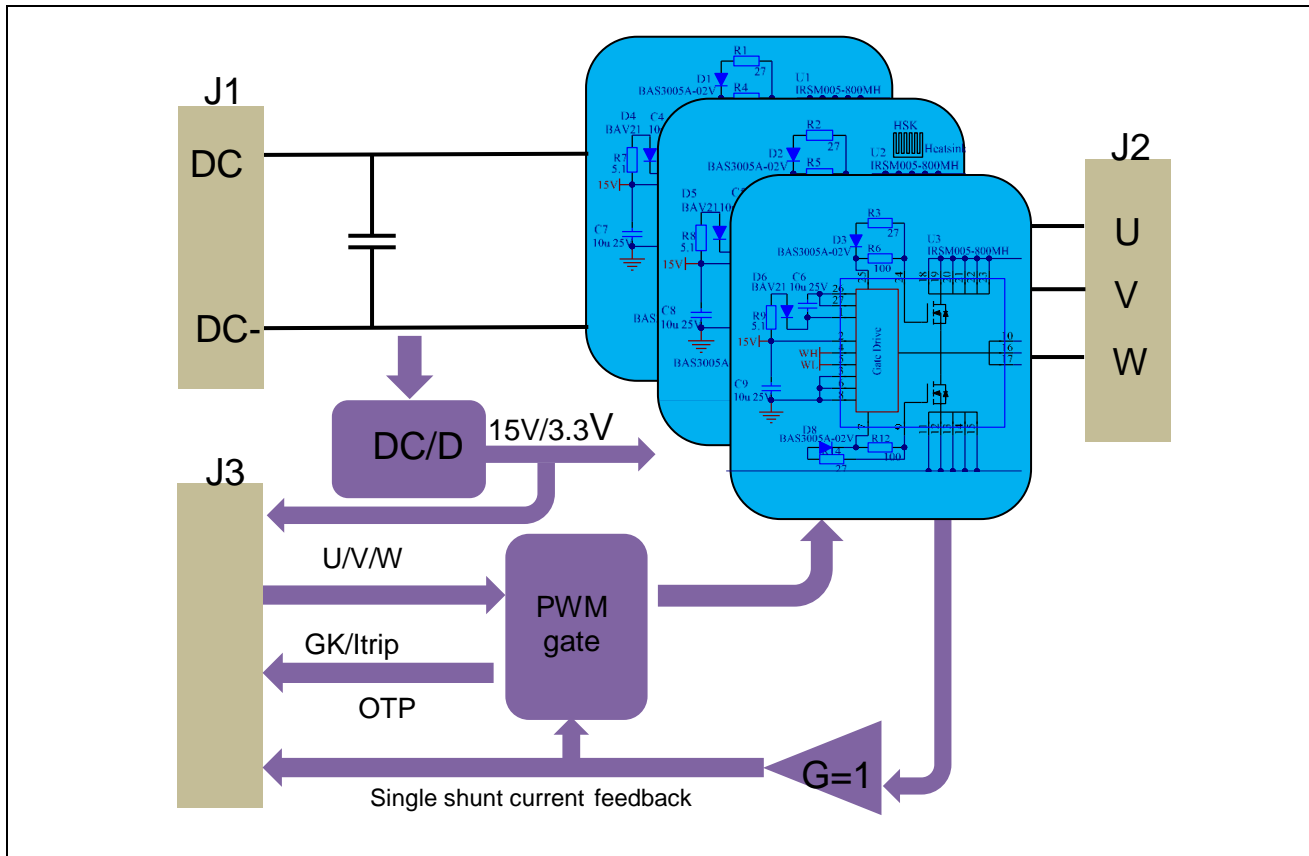


Figure 2 The block diagram of EVAL-M1-05F804R

1.2 Main features

EVAL-M1-05F804R is a complete power evaluation board including a 3-phase IPM for motor drive applications. The kit demonstrates Infineon's IPM technology for motor drives.

Main features of CIPOS™ Nano intelligent power module IRSM005-800MH include:

- MOSFET drain-to-source voltage 40 V
- Maximum DC current at 25°C case temperature $I_C = 80$ A (Bond wires current limit is 49 A)
- Package with low thermal resistance and minimal parasitic inductance
- Independent gate driver in phase with logic input
- Gate drive supply is 15 V
- 3.3 V logic input compatible
- Propagation delay matches to defined specification
- Under-voltage lockout protection inside the driver
- Exposed driver outputs and HEXFET gate terminals for dv/dt setting via a resistor

The evaluation at a glance

1.3 Key data

Figure 3 provides the overview of the IRSM005-800MH internal electrical schematics. For further information regarding these CIPOS™ such as static and dynamic electrical behavior, as well as thermal and mechanical characteristics please refer to the datasheet of the IRSM005-800MH.

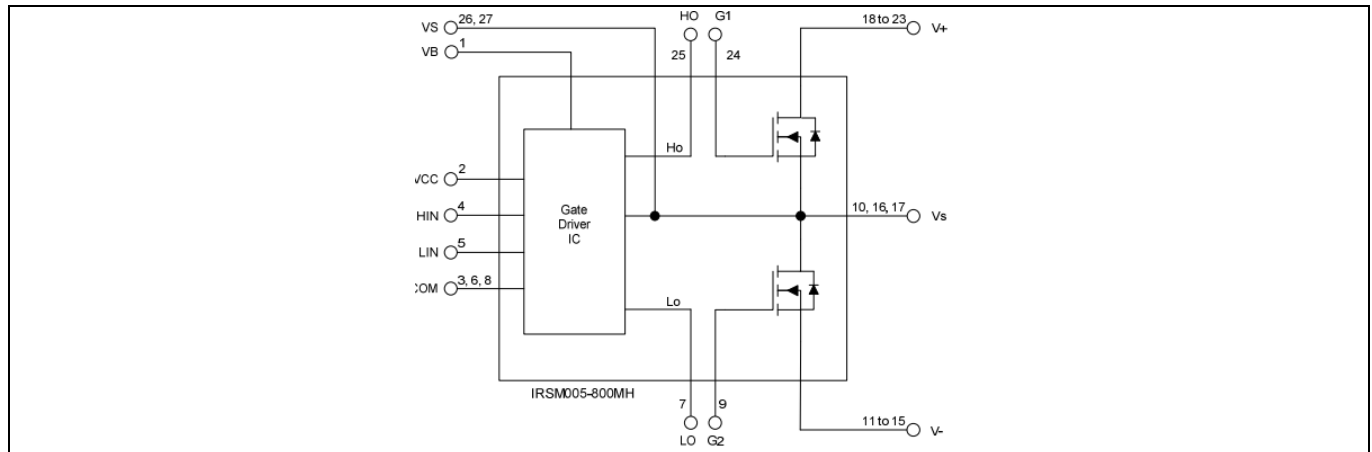


Figure 3 CIPOS™ Nano internal electrical schematics

Table 3 Absolute maximum ratings of IRSM005-800MH

Symbol	Description	Min	Max	Unit
V_{DS}	MOSFET drain-to-source voltage	--	40	V
I_o	Maximum DC current per MOSFET @ $T_c = 25\text{ °C}$ (Note 1)	--	80	A
P_d	Maximum power dissipation per MOSFET @ $T_c = 100\text{ °C}$	--	13	W
T_J (MOSFET & IC)	Operating junction temperature	--	150	°C
T_s	Storage temperature range	-40	150	°C
V_B	High-side floating supply voltage	-0.3	$V_S + 20$	V
V_S	High-side floating supply offset voltage	$V_B - 20$	$V_B + 0.3$	V
V_{CC}	Low-side fixed supply voltage	-0.3	20	V
V_{IN}	Low input voltage of LIN, HIN	-0.3	$V_{CC} + 0.3V$	V

1.4 EVAL-M1-05F804R board specification

Table 4 is specification list for this evaluation board.

Table 4 EVAL-M1-05F804R board specifications

Parameters	Values	Conditions / Comments
Input		
Voltage	6- 30 V_{rms}	Lower DC input, less motor power output
Input current	10.5 A_{rms}	Input 24 V_{DC} , $T_a = 25\text{ °C}$
Output		

The evaluation at a glance

Parameters	Values	Conditions / Comments
Power (3-phase)	240 W	Input 24 V _{DC} , f _{PWM} =9 kHz, T _a =25°C, T _{case} = 100°C Without heat sink
Current per phase	10.2 A _{rms}	Input 24 V _{DC} , F _{PWM} =9 kHz, T _a =25°C, T _{case} = 100°C without heat sink
DC bus voltage		
Maximum DC bus voltage	32 V	
Current feedback		
Inverter current sensing resistor R16	2.7 mΩ	
Protections		
Output current trip level	18 A _{peak}	Level by external comparator circuit
Temperature trip level	100°C	Users need to consider the temperature gap by NTC sensor; it is recommended to set at 105°C or less
On-board power supply		
15 V	15 V ± 5 %, max. 50 mA	Used for IPM and 3.3 V DC/DC
3.3 V	3.3 V ± 5 %, max. 120 mA	Used for IMC controller and protection circuits
PCB characteristics		
Material	FR4, 2 oz.	2 layers
Dimensions	91 mm × 69 mm x 1.6 mm	
System environment		
Ambient temperature	From 0 to 50°C	Non-condensing, maximum RH of 75%

2 System and functional description

2.1 Description of the functional blocks

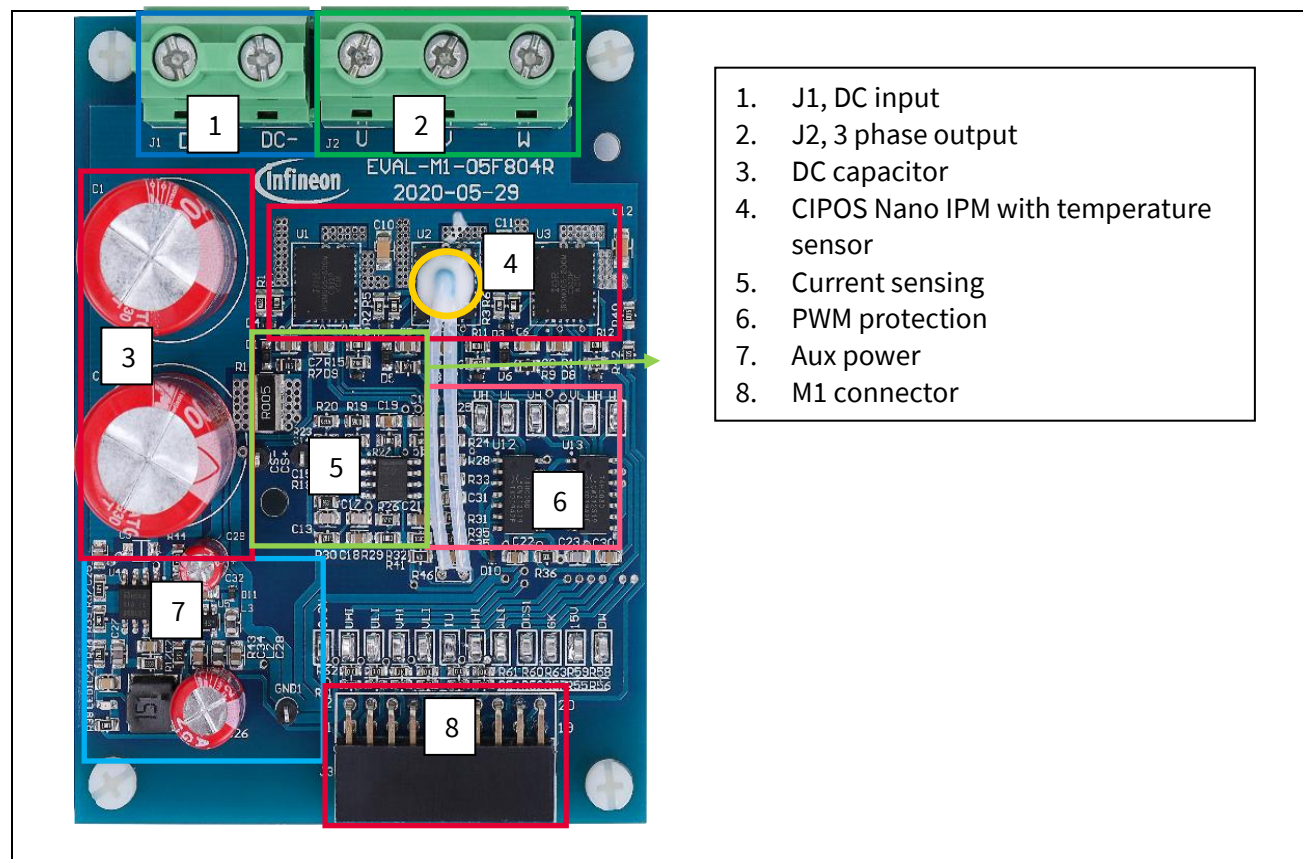


Figure 4 EVAL-M1-05F804R function blocks

2.1.1 Pin assignments

General information about the connectors of the EVAL-M1-05F804R evaluation board is reported. Table 5 includes details of the DC input connector J1-DC. Table 6 provides details of the motor-side connector J2.

Table 5 J1- DC input connector

Pin	Name	Details
1	DC+	DC +connector
2	DC-	DC - connector

Table 6 J2- Motor side connector

Pin	Name	Details
1	U	Connected to motor phase U
2	V	Connected to motor phase V
3	W	Connected to motor phase W

Table 7 provides the pin assignments of the iMOTION™ MADK-M1 20-pin interface connector J3. This connector is the interface to the control board.

Table 7 J3- iMOTION™ MADK-M1 20 pin interface connector for power board

Pin	Name	Description
1	PWMUH	3.3 V compatible logic input for high-side gate driver-Phase U
2	GND	Ground
3	PWMUL	3.3 V compatible logic input for low-side gate driver-Phase U
4	GND	Ground
5	PWMVH	3.3 V compatible logic input for high-side gate driver-Phase V
6	+3.3V	3.3 V power supply
7	PWMVL	3.3 V compatible logic input for low-side gate driver-Phase V
8	+3.3V	3.3 V power supply
9	PWMWH	3.3 V compatible logic input for high-side gate driver-Phase W
10	IU+	Shunt voltage+
11	PWMWL	3.3 V compatible logic input for low-side gate driver-Phase W
12	IU-	Ground
13	GK	Gatekill
14	DCBSENSE	Input, DC bus voltage to AIN1 after 2Mohm registers
15	V _{TH}	Input, voltage input of power module's temperature sense
16	IV+	OPEN
17	IV-	OPEN
18	IW+	OPEN
19	IW-	OPEN
20	V _{CC}	Defined for 15 V power supply

2.1.2 System connection:

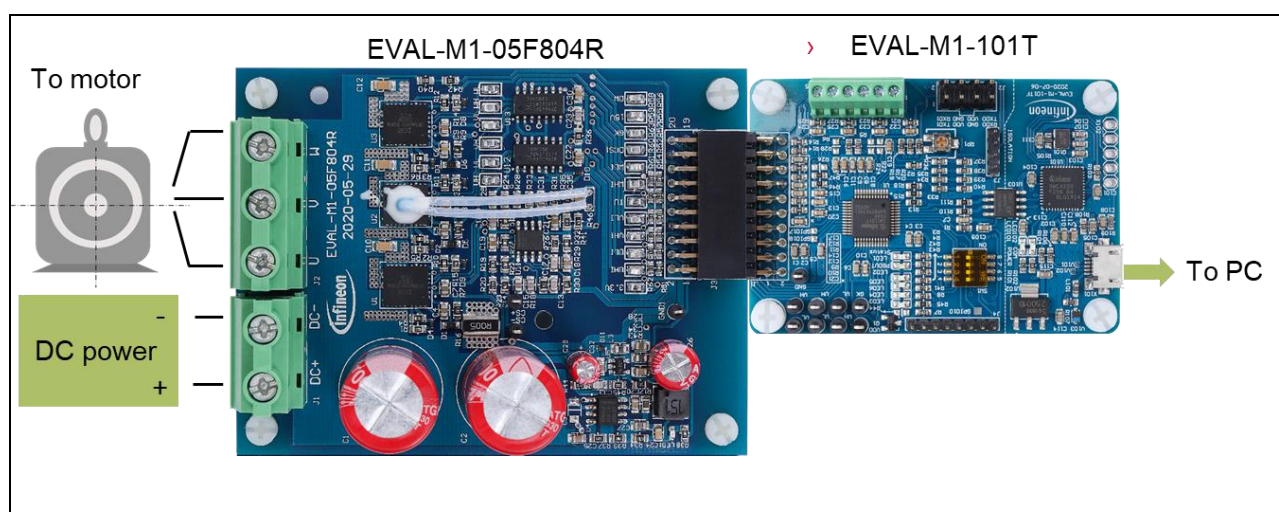


Figure 5 System connection example using EVAL-M1-101T and EVAL-M1-05F804R

System and functional description

Here is the link for EVAL-M1-101T and software for reference via the Infineon website:

(<https://www.infineon.com/cms/en/product/evaluation-boards/eval-m1-101t/>)

1. Get the latest “IMC101T-T038 MCE Software Package” which is available on www.infineon.com/imotion-software website.
2. Connect PC-USB connector on the on-board debugger to the PC via USB cable.
3. Connect EVAL-M1-101T’s M1 20-pin interface connector (J2) to power board (For example EVAL-M1-05F804R, see Figure 4).
4. Use MCEWizard to enter the target motor’s system and operating parameters, as well as evaluation board’s hardware parameters, which will then be used to calculate controller’s digital parameter set representing complete motor drive system. First click “Calculate” button on the “Verify & Save Page” and then save the drive parameter set into your project directory by clicking “Export to Designer file (.txt)”. Saved Drive System Parameter File will be later used by the MCEDesigner. Refer to Chapter 2.1.3 or the MCEWizard User Guide for more details.
5. Connect motor phase outputs to the motor.
6. Connect DC power to power input connector and power-on system.
7. Start MCEDesigner tool and open MCEDesigner default configuration file (.irc) for IMC101T-T038 controller (IMC101T_Vxxx.irc) by clicking “File” > “Open.” IMC101T_Vxxx.irc file is included in the “IMC101T-T038 MCE Software Package” downloaded in step 1.
8. MCEDesigner should automatically connect to the EVAL-M1-101T control board using default COM port (indicated by green circle next to “COMx Up” status in the bottom frame of the MCEDesigner GUI). If it cannot establish the connection, change the COM port as follows: (“System” window active) > Preferences > Connection > Connect using (Choose one of the other available COM ports from the drop-down menu).
9. Use following steps to program the system parameters into the internal SRAM of iMOTION™ IC: Click “Tools” > “Programmer” and select “Program Parameters.” Browse and select the System Drive Parameters .txt file created in step 4. See chapter MCEDesigner setup overview 2.1.4 for more details.
10. Start the motor by clicking the green traffic light button in the control bar.
11. Stop the motor by clicking the red traffic light button in the control bar.

2.1.3 iMOTION™ development tools and software

The iMOTION™ development tool installers for MCEDesigner and MCEWizard are available for download via Infineon iMOTION™ website (<http://www.infineon.com/imotion-software>). All supported tools and software variants are listed there. Please visit this page periodically to check for tool/software updates.

Isolated on-board debugger provides the USB to UART bridge between the PC and the target iMOTION™ device with 1kV DC galvanic isolation between the motor drive system (hot side) and the PC/debugger (cold) side. On-board debugger uses the SEGGER J-Link driver for UART communication with IMC101T-T038. J-Link driver will be installed during the MCEDesigner installation. In case the driver is not installed properly, please go to the SEGGER J-Link website to download and install the latest J-Link “Software and Documentation pack for Windows.”

2.1.4 MCEWizard setup overview

After installing the MCEWizard, the shortcut for MCEWizard appears on the Windows desktop. Double click the shortcut to open the MCEWizard and configure the parameters for evaluation boards or motor. Figure 6 shows

System and functional description

the “Welcome Page” for MCEWizard, where the MADK control board or power board can be selected from the pull-down list. Infineon continues to release new MADK controller and power boards. Therefore, it is possible that some of the latest power boards have not been pre-configured in the MCEWizard tool, and cannot be selected from the pull-down menu. In that case, the user should select another power board (as similar as possible) and follow the MCEWizard setup steps by entering the parameter values that are specific to the chosen board. Make sure both “I have modified the circuit board” and “Enable advanced question” checkmarks are selected. Please refer to the Application Note of the corresponding power board for additional information.

After selecting the MADK control and the power board, start the MCEWizard system setup procedure by clicking the “Next” button in the right bottom corner as shown in Figure 6.

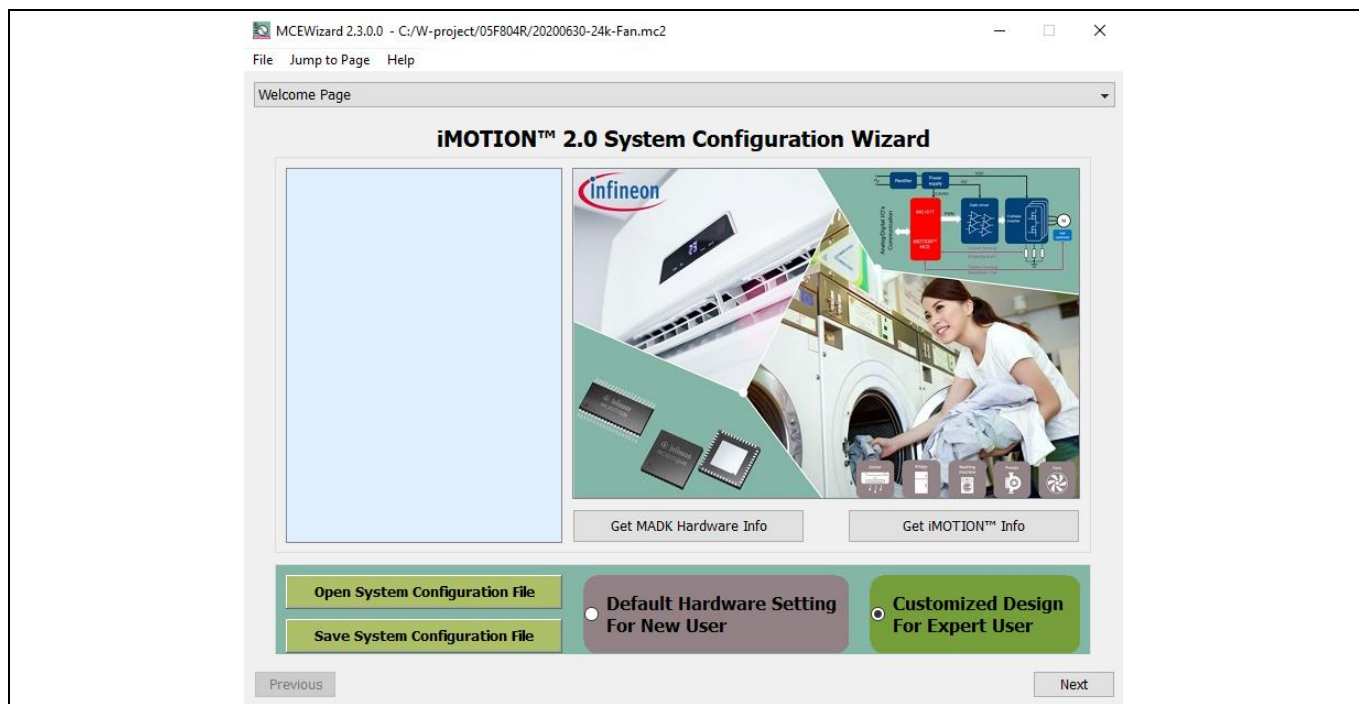


Figure 6 Welcome page of MCEWizard

iMOTION™ MADK system enables users to easily test different combinations of control and power boards with their motors. Users should be familiar with the system-level parameters that are related to the motor used. There is a very limited number of parameters that are specific to the control board or power board hardware. Table 9 provides the MCEWizard setup overview for hardware related parameters specific to the EVAL-M1-05F804R power board. Similar tables will be available in each control board’s Application Note. A combination of this table and the corresponding table of the control board provides sufficient information to set up the MADK-based motor drive system rapidly.

Table 8 MCEWizard setup overview table

Parameter	Value	Comment
Control board selecting	EVAL-M1-101T for example	
Power board selecting	EVAL-M1-05F804R	If the board is not available, select similar power board
Motor 1 shunt configuration	Single shunt	
Controller supply voltage	+3.3 V	
Max DC bus voltage	30 V	

System and functional description

DC bus sensing high side resistor	510 kΩ	
DC bus sensing low side resistor	Refer to the control board user manual	
NTC temperature shutdown value	Refer to the control board user manual	
Gate sense low-side devices	High is true	
Gate sense high-side devices	High is true	
Motor 1 current input	Calculated in the corresponding section in control board user manual	

After all the MCEWizard questions are answered, the “Verify & Save Page” will be shown as in Figure 7.

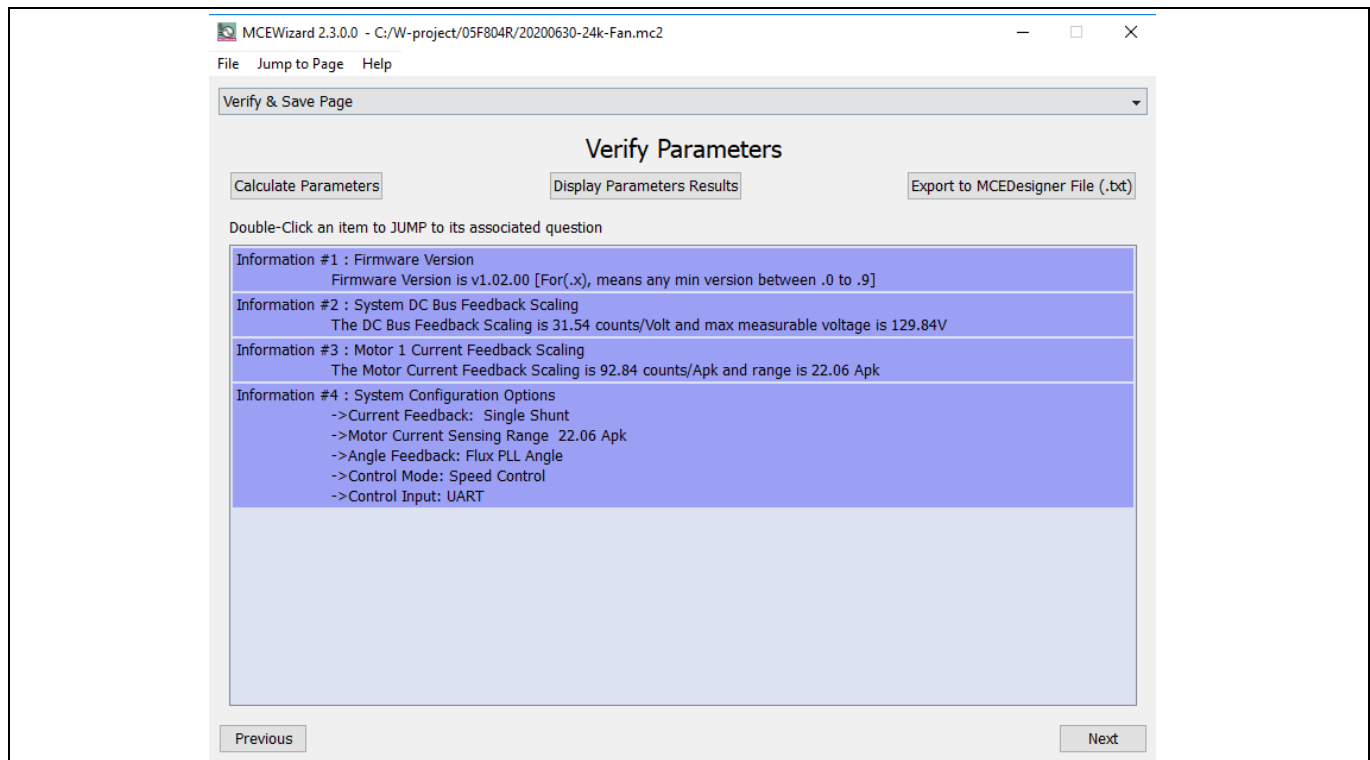


Figure 7 “Verify and save page” for MCEWizard

Click “Calculate Parameters” button and “Export to Designer File (.txt)” button to save the parameter file, which will be used by the MCEDesigner in the next steps.

2.1.5 MCEDesigner setup overview

After installing MCEDesigner installer, there is a shortcut for the MCEDesigner on Windows desktops. Double-click the shortcut to open MCEDesigner and then open “IMC101T_xx.irc” file as shown in Figure 8.

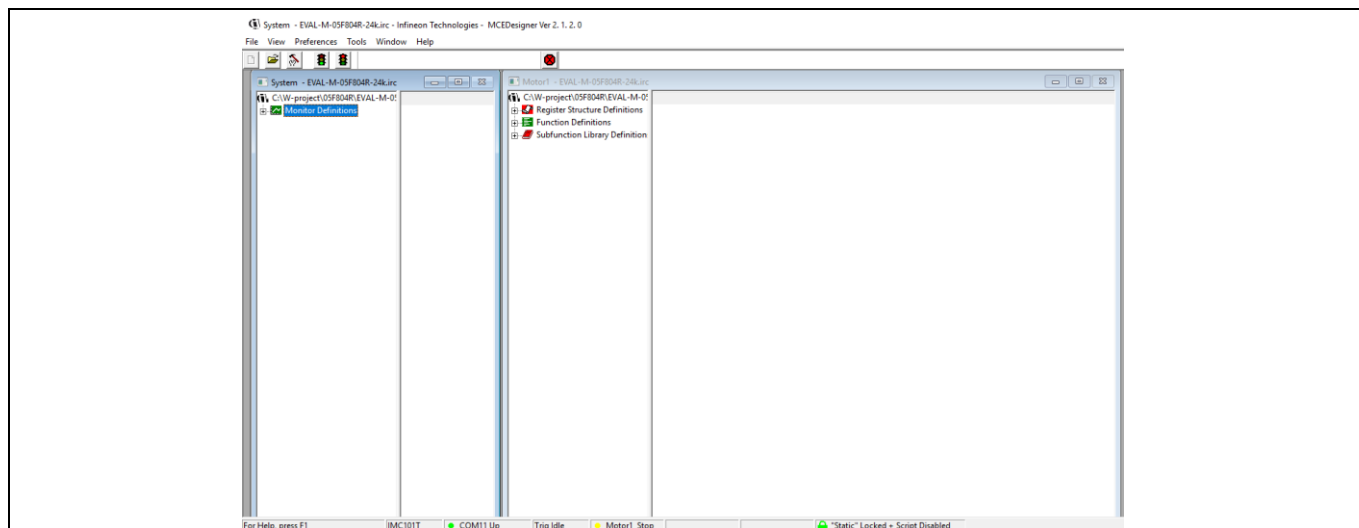


Figure 8 MCEDesigner's main display for EVAL-M1-101T

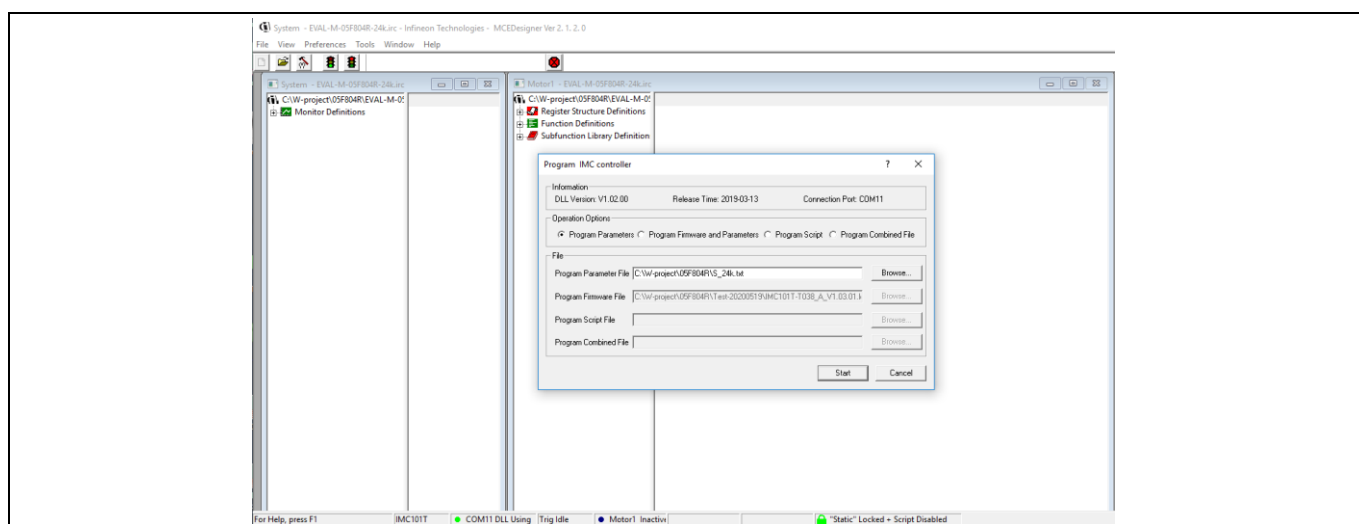


Figure 9 "Program IMC Controller" pop-up window

After the Drive System Parameter file has been programmed into the IMC101 controller, and the motor drive system is powered, the MCEDesigner can be used to start/stop the motor, display motor current traces, change the motor speed, modify drive parameters and many other functions. Please refer to the MCEDesigner documentation for more details.

Note: On-board debugger section of the EVAL-M1-101T has galvanic isolation from the controller section and the attached power board. In order to program the parameters or firmware to the IMC101T controller, the 3.3 V DC voltage needs to be supplied to the controller section of the EVAL-M1-101T. This voltage can either be supplied by the power board (MADK power boards are designed to supply the 3.3 V to the control board through M1 connector) or by feeding the 3.3 V DC voltage to the control board through some of the available 3.3 V access/test points if the power board is not attached to the EVAL-M1-101T control board.

To program new firmware and the drive system parameters into the IMC101T, please click "Tools" menu and select "Programmer" in the pull-down list. The pop-up window "Program IMC controller" will show up as in Figure 10. Click on the "Program Firmware and Parameter" radio button, and select the Drive System Parameter file created using MCEWizard by clicking on the "Browse" button on the row of "Program Parameter File," and then select the firmware file by clicking on the "Browse" button on the row of "Program Firmware File." Finally, click on the "Start" button to program the parameter file into the IMC101T IC.

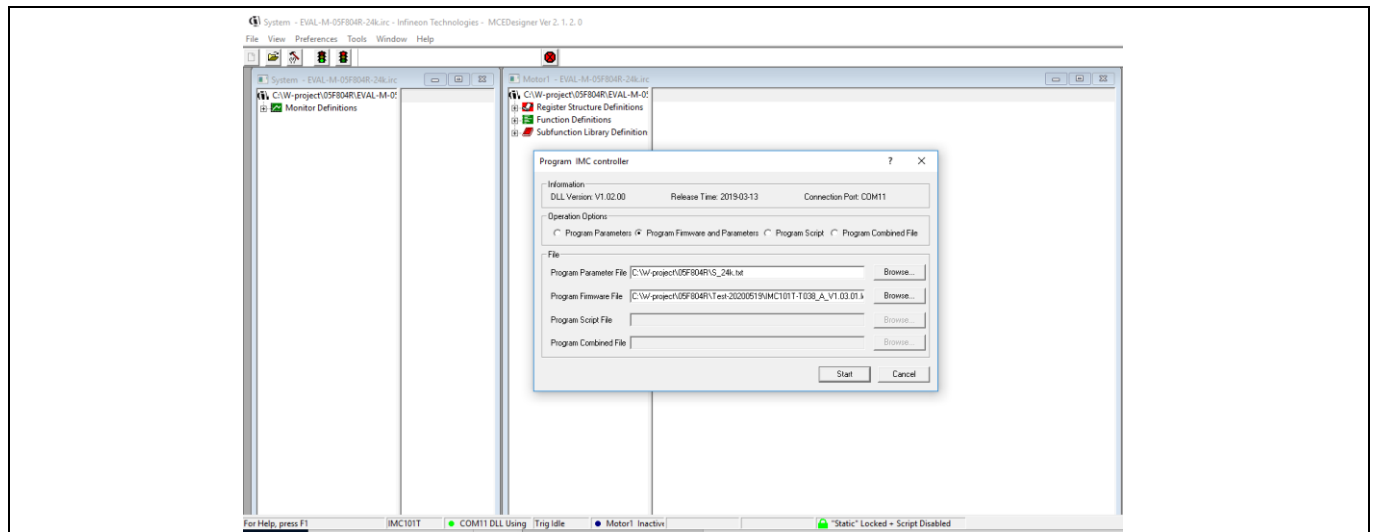


Figure 10 Program firmware and parameter in “Program IMC Controller” pop-up window

2.2 Trace function from MCEditor

MCEditor has a trace function to catch parameter change during system operation. It helps to debug the system and check the PCB layout/parameters.

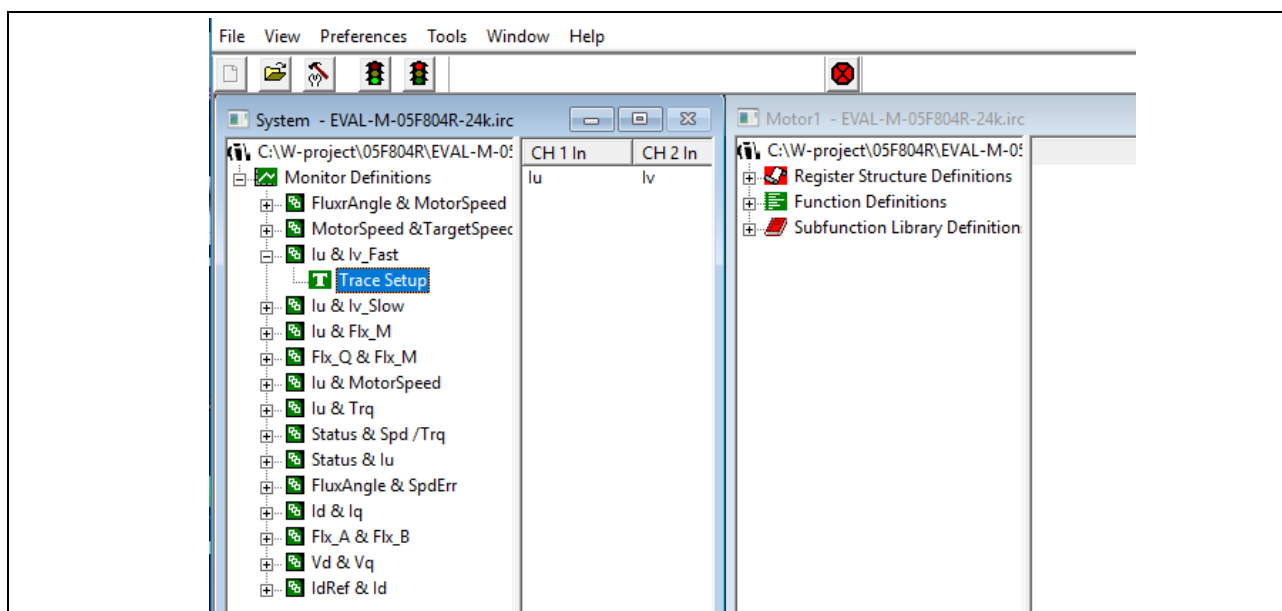


Figure 11 Trace function of MCEditor

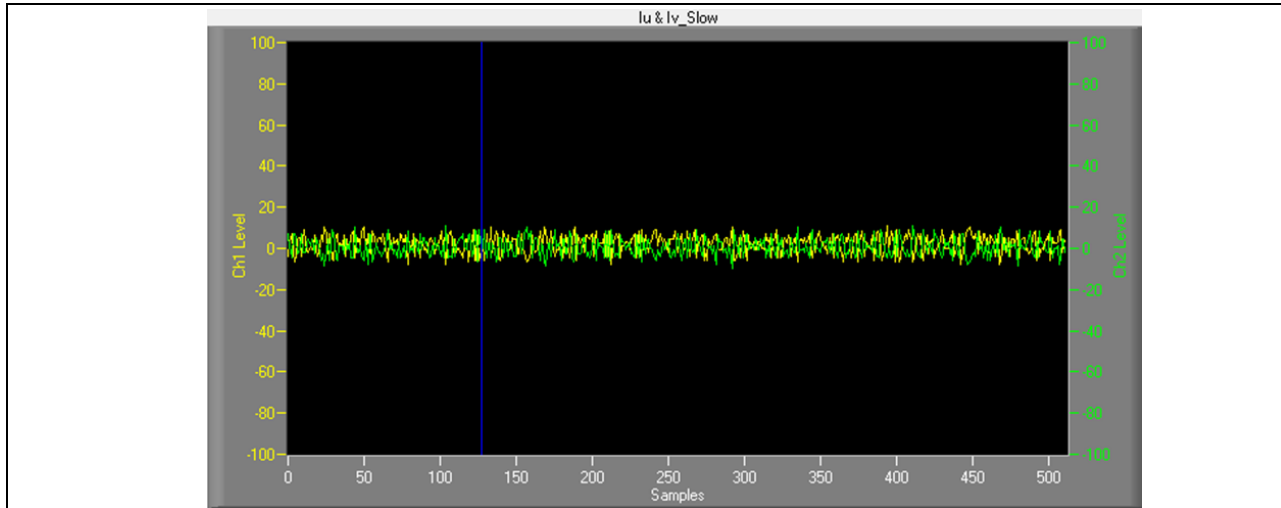


Figure 12 Iu and Iv static noise from MCEDesigner

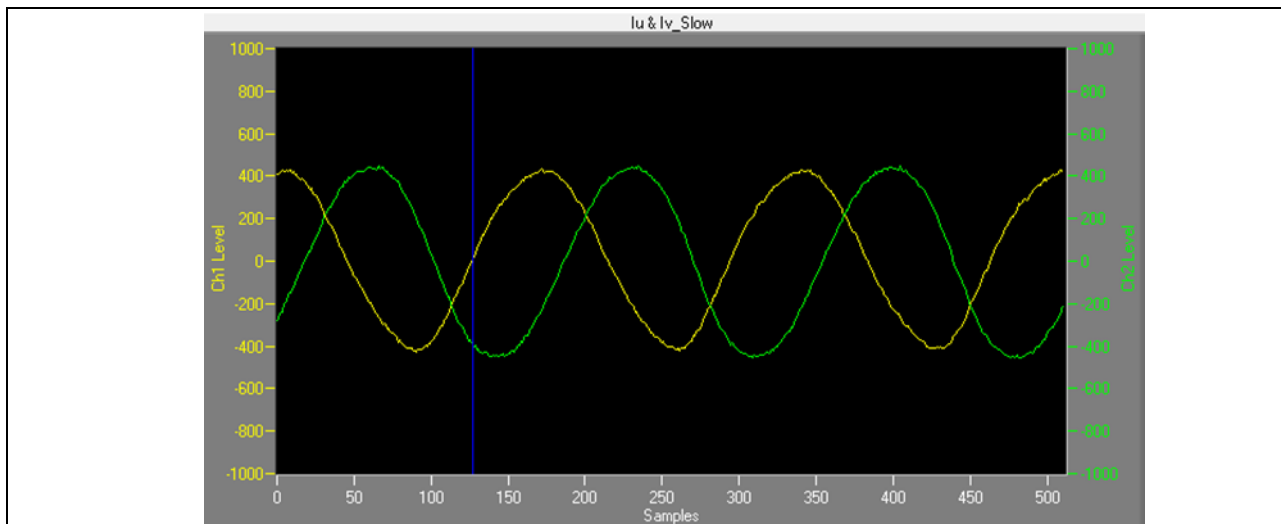


Figure 13 Iu and Iv waveform from MCEDesigner @ 6.5 A, DC input 24 V, F_{PWM}=9 kHz

This is a typical current waveform of a sinusoidal brushless motor driven by the EVAL-M1-05F804R + EVAL-M1-101T with iMOTION™ software. (<https://www.infineon.com/cms/en/product/power/motor-control-ics/digital-motor-controller-imotion/imc101t-t038/>).

2.3 $T_{C_{MAX}}$ vs I_{OUT} at different PWM carrier frequency

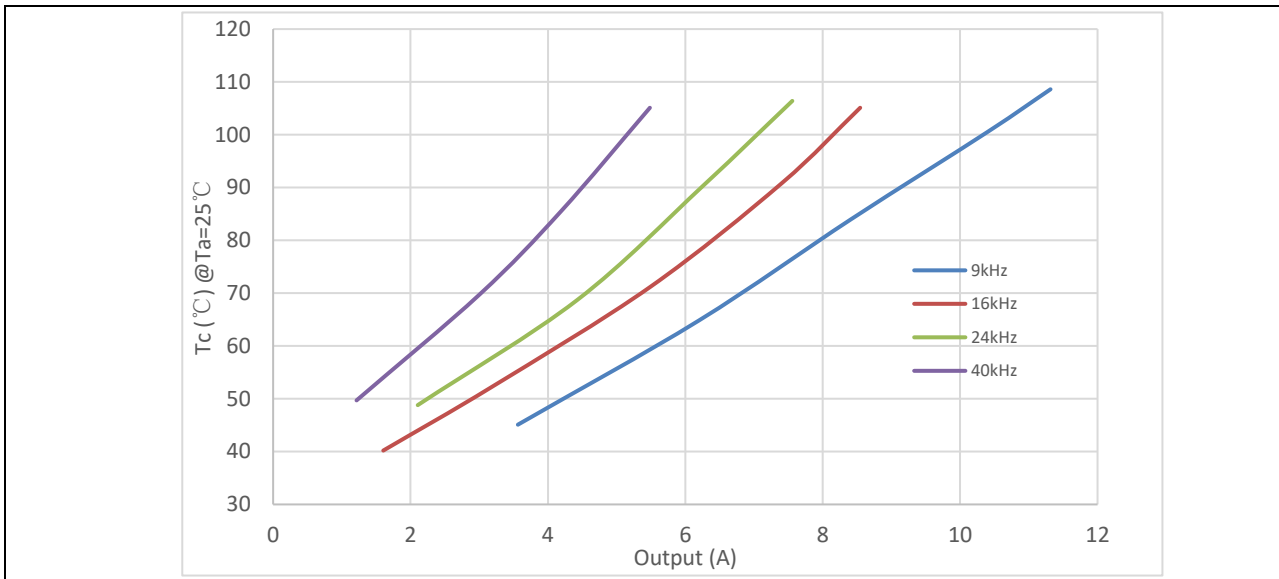


Figure 14 T_c of module vs output current at different carrier frequencies at $T_a=25^\circ\text{C}$, 24 VDC

2.4 IPM cooling options

EVAL-M1-05F804R has 3 cooling options for high-power applications.

- 1) Self-cooling (default)
- 2) Heat sink cooling
- 3) Fan cooling

2.4.1 Self-cooling

IRSM005-800MH is the double-sided cooling on the PCB done by copper and vias. For 0~10.2 A loading (input: DC 24 V, FPWM=9 kHz, $T_a=25^\circ\text{C}$, $T_c \leq 100^\circ\text{C}$), the EVAL-M1-05F804R can operate well with PCB copper heat dissipation and does not need an additional heat sink.

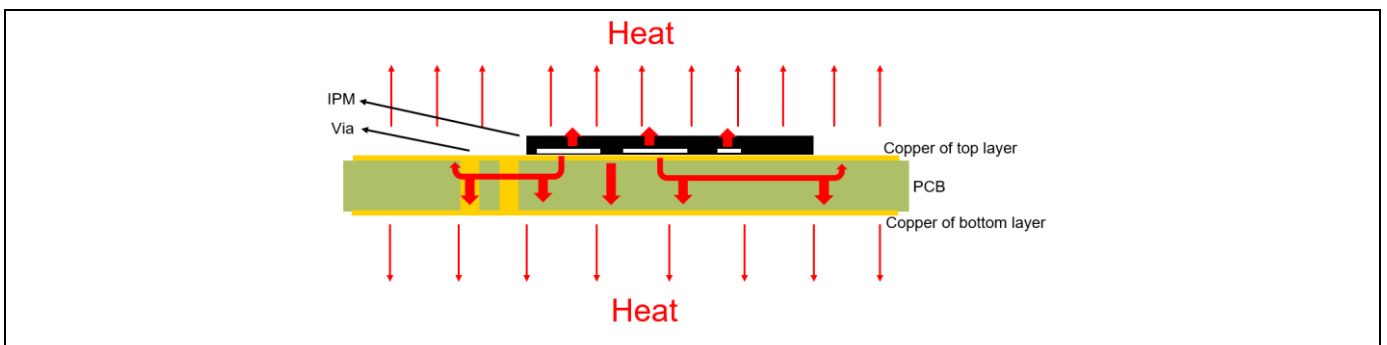


Figure 15 IRSM005-800MH heat conduction and cooling via two-layer PCB copper

2.4.2 Heat sink installation

For higher-current and low-temperature rise applications, the EVAL-M1-05F804R reserves 50 mmX50 mm space on the bottom side of the PCB for mounting a heat sink; see the white lined square below in Figure 16.

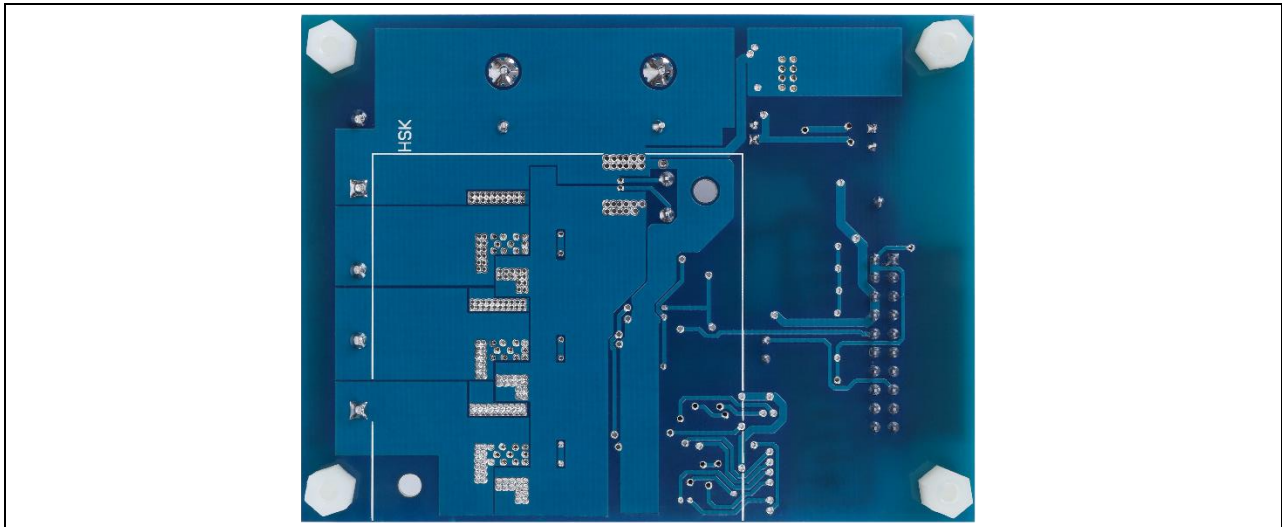


Figure 16 White lined square of installed heat sink

This evaluation board reserves space for mounting an additional heat sink to extend output power. Figure 16 shows how to mount the heat sink. Please note the isolation thermal pad is required to isolate the PCB circuit to heat sink.

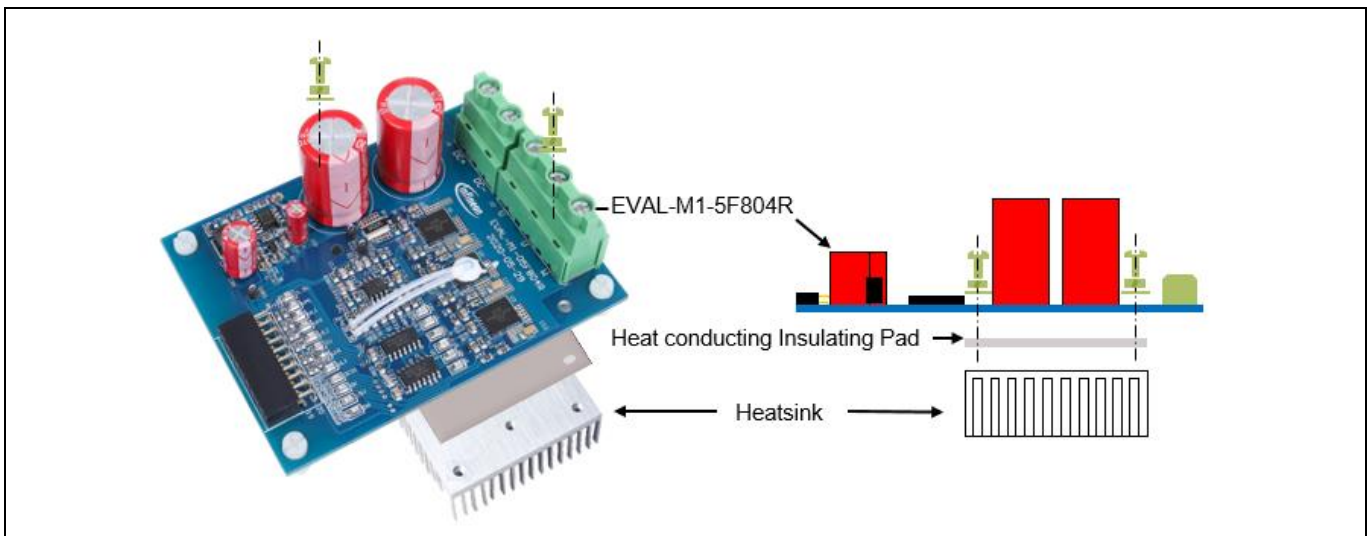


Figure 17 Heat sink installation schematic diagram with EVAL-M1-05F310R

- Notes:
- 1) Heat sink size: $\leq 50 \text{ mm(L)} \times 50 \text{ mm(W)} \times 20 \text{ mm(H)}$
 - 2) Insulating pad: $\geq 50 \text{ mm} \times 50 \text{ mm} \times 0.5 \text{ mm}$
 - 3) Remove test point: CS+, CS-
 - 4) Screw: M3×10

2.4.3 Fan cooling

Whether in self-cooling or heat-sink mode, EVAL-M1-05F804R supports additional fan cooling.

In the fan cooling mode, please set up Tc limit lower than 85 °C so as not to overheat the MOSFET.

3 Details of the schematics, layout, BOM and connectors

The following section introduces key functions of board. The complete schematic is available on the download section of the Infineon homepage. A log-in is required to download this material

3.1 Inverter section using CIPOS™ Nano

The inverter section is implemented using the CIPOS™ Nano as sketched in Figure 18. Three half-bridge modules are used as the 3-phase inverter bridge section. Every half-bridge module includes two power MOSFETs and one half-bridge gate driver. The shunt resistor section is also given. The three capacitors C4, C5 and C6 are used as bootstrap capacitors to provide the necessary floating supply voltages VBU, VBV and VBW respectively.

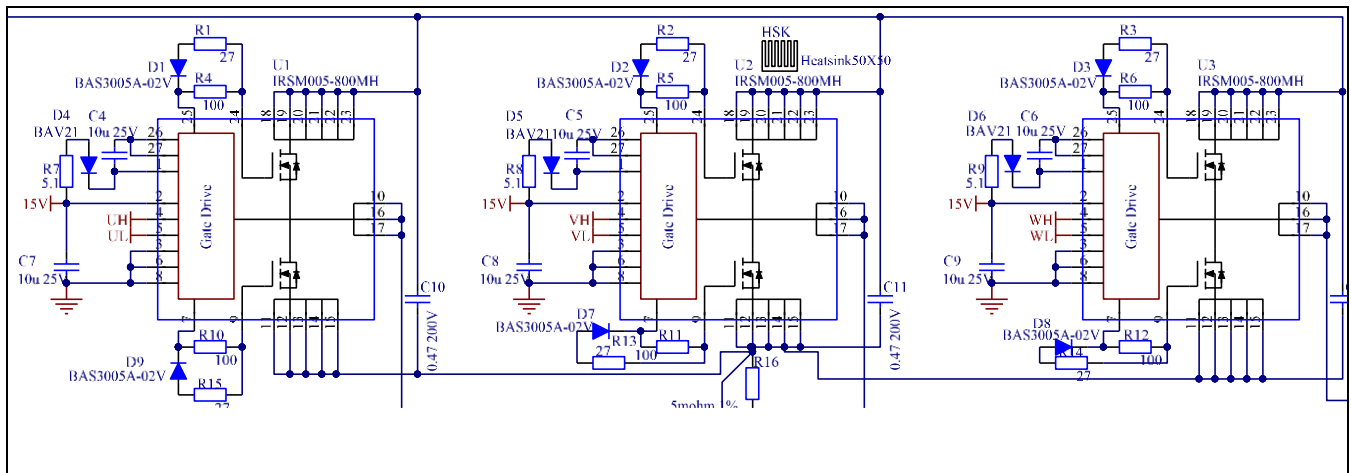


Figure 18 Schematic of the inverter section

3.2 DC/DC

Figure 19 depicts the schematic of the power supply available on the EVAL-M1-05F804R board. The circuit includes LM5163 that is used to generate +3.3 V from the DC bus. The +3.3 V power supply is used in +15 V and the overcurrent comparator circuit. LMR64010 is used to generate 15 V from +3.3 V. 15 V is connect to the gate drivers inside the CIPOS™ Nano. Led LED1 is used to signal whether the board is powered or not. Both 15 V and +3.3 V are also present on the 20-pin interface connector J3 to power circuitry on the controller board. Figure 20 shows the voltage ramp during power on.

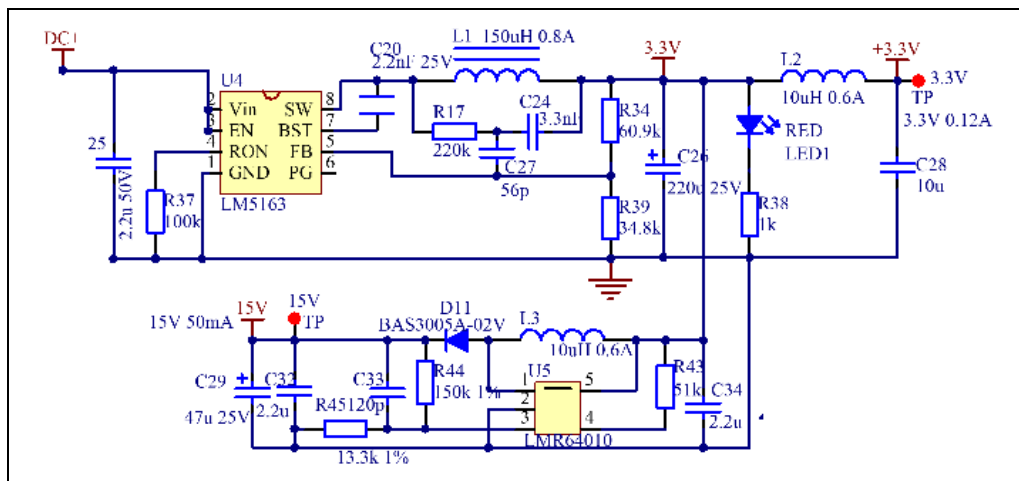


Figure 19 Power supply section

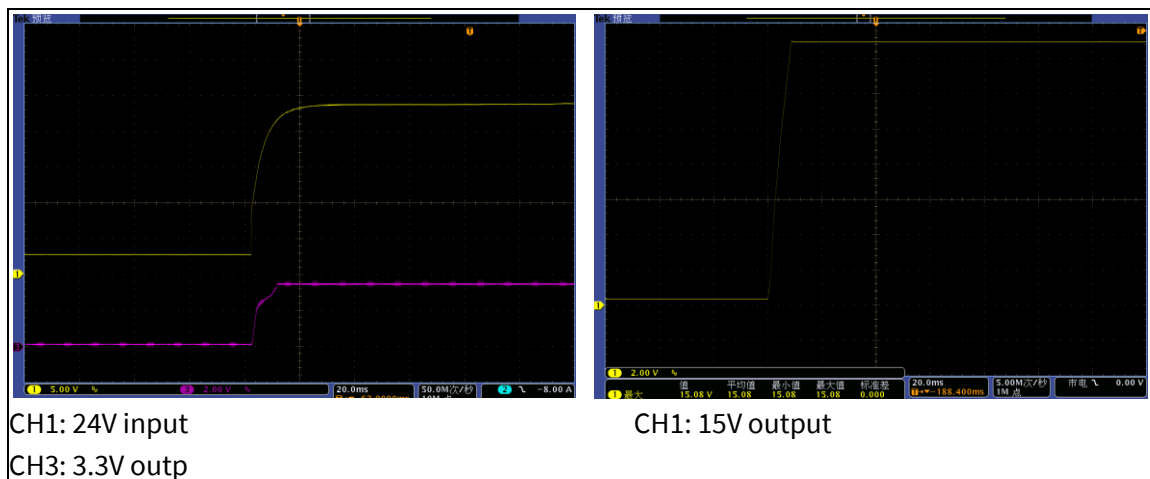


Figure 20 Aux. power supply start up at 24 V DC input

3.3 DC-link voltage measurement

Pin 14 of connector J3 provides access to the DC-link voltage. Three possible feedback cases are associated with this pin.

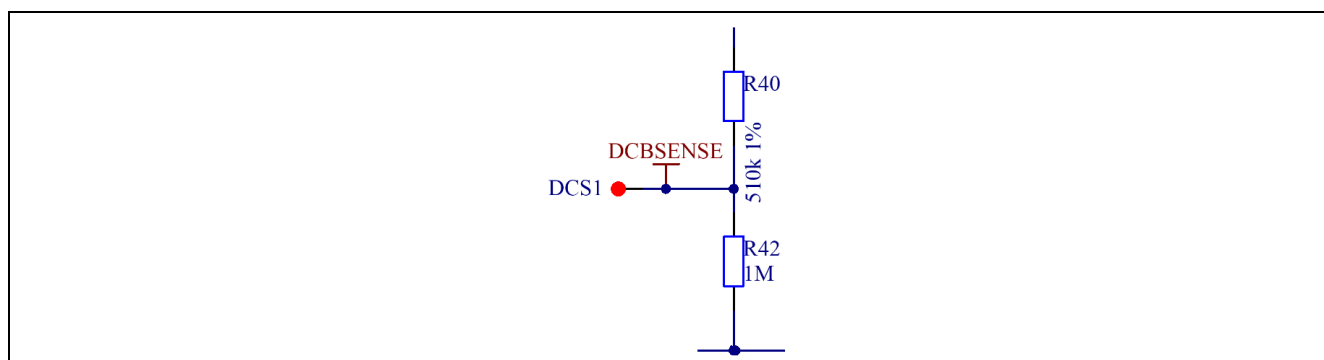


Figure 21 DC bus sense

R42 is the safety resistance on the connection port when the connector is open. The DC bus-sensing, low-side resistance is $R48 // R1$ (EVAL-M1-101T). So it is $1 \text{ M} // 13.3 \text{ k} = 13.13 \text{ k}\Omega$

3.4 Current sense and amplifying

The current feedback of EVAL-M1-05F804R is signal-shunt sensing by R16. It is 5 mΩ. The current output IU+ and IU- goes to J3.

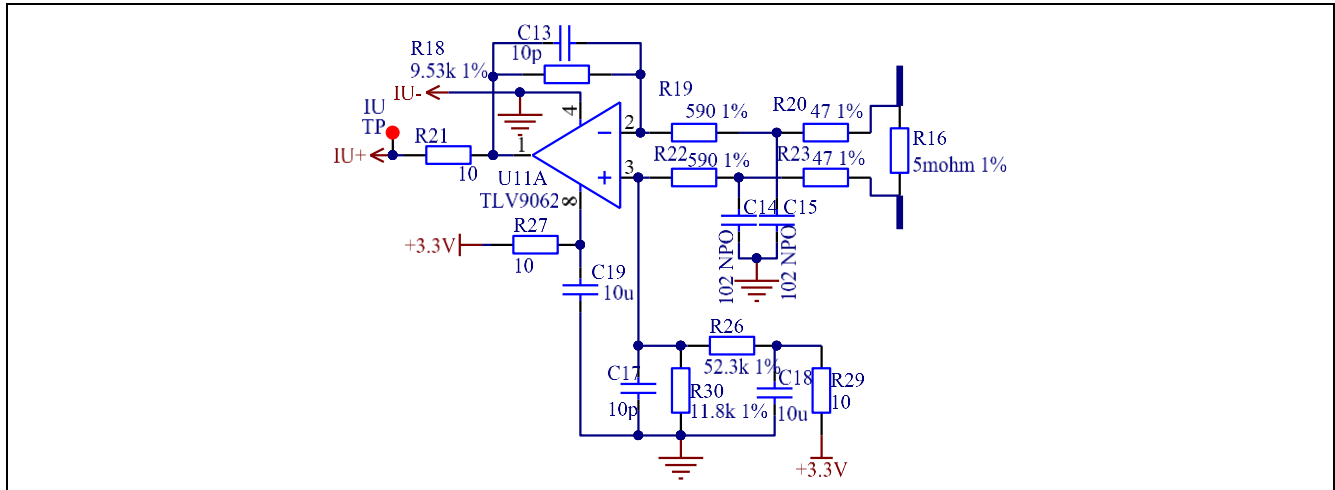


Figure 22 Current sense and signal amplification

An LPF consists of R20/R23/C14/C15 to remove EMC noise from R16. The current amplifier consists of R18/R19/R20/R22/R23/C13 U1A for lower noise and proportional amplifier.

The gain of the amplifier is:

$$G = (R18+R19+R20)/(R19+R20) = 15.96$$

The current scaling is:

$$V_{\text{shunt1}} = R16 \cdot A = 79.8 \text{ mV/A}$$

Static status:

$$V_o = R30/(R26+R29+R30) \cdot 3.3 \text{ V} = 0.607 \text{ V}$$

The response time:

$$T_o = 1/(GBWP/(A - 1)) = 1.5 \text{ us}$$

R21 is matching resistor of U1A output. The GBWP is gain bandwidth of U1.

3.5 Current feedback on EVAL-M1-101T

The circuit below shows the feedback current signal to the control board. The offset circuit consists of R6 and 3.3 V.

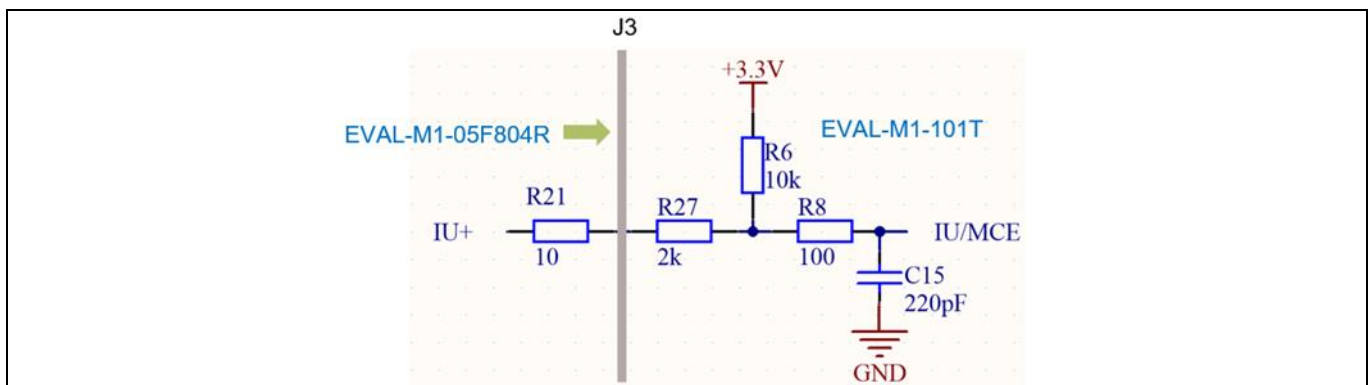


Figure 23 Current signal transmission between EVAL-M1-05F804R and EVAL-M1-101T

The attenuation of the current signal:

$$\alpha = \frac{R_6}{R_6 + R_{21} + R_{27}} = 0.833$$

Total gain at MCU input:

$$\Sigma A = \alpha \times A = 13.29$$

Total sensitivity of current scaling at MCE input:

$$V_{\text{shunt}} = R_{16} \times \Sigma A = 66.4 \text{ mV/A}$$

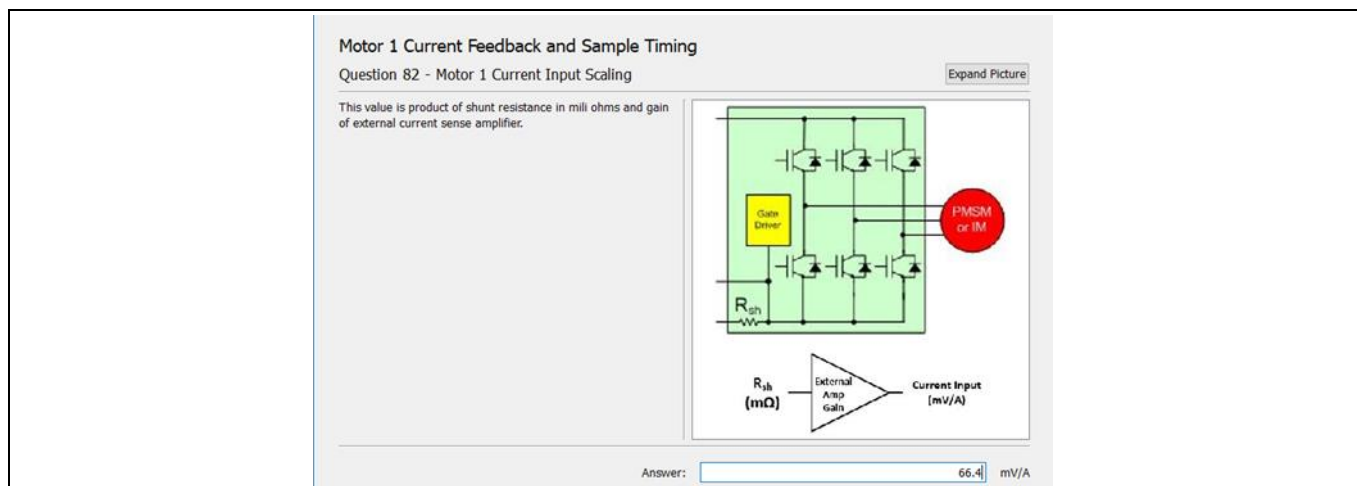


Figure 24 Current input scaling setup in MCEWizard

The current offset to IU input:

$$V_{\text{offset}} = (3.3 \text{ V} - 0.6 \text{ V}) \times \frac{R_{21} + R_{27}}{R_6 + R_{21} + R_{27}} + 0.6 \text{ V} = 1.06 \text{ V}$$

Since control board ADC range is 3.3 V, we have to select internal gain of control board to “1.”

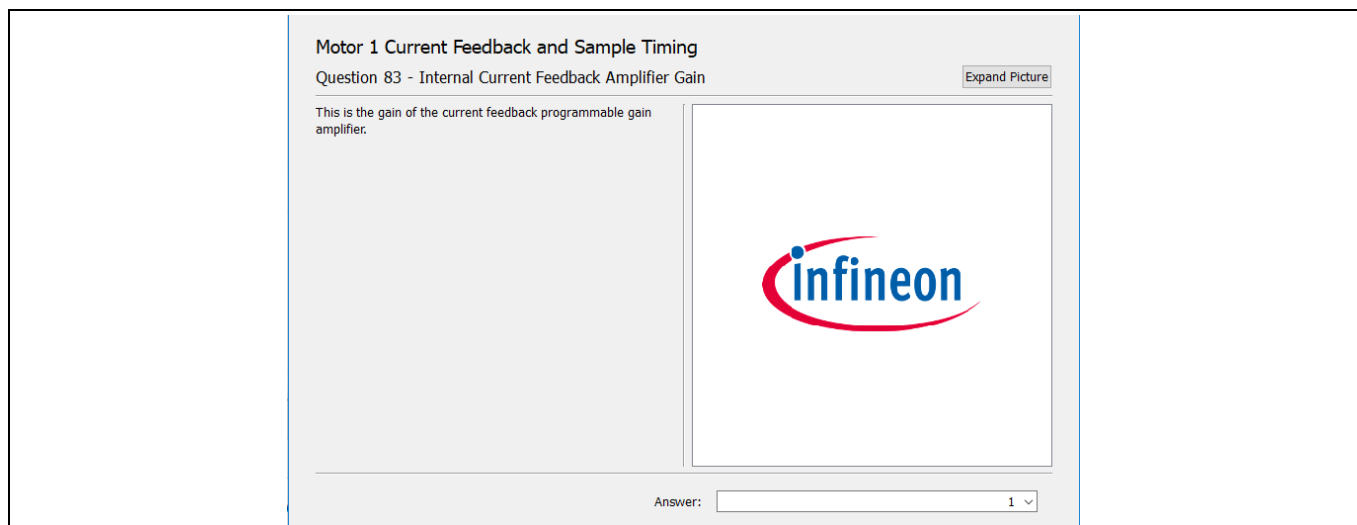


Figure 25 Setup current signal gain to “1”

3.6 OCP, GK and I_{ocp} setup

Figure 26 is the overcurrent protection (OC) and gatekill (GK) circuit. The PWMUH, PWMUL, PWMVH, PWMVL, PWMWH, PWMWL are three-phase 3.3 V level PWM from J3 (from EVAL-M1-101T). UH, UL, VH, VL, WH, WL is 3.3 V level PWM to U1, U2, U3 (IPM). R51, R52, R54, R55, R56, R57 are input resistances for damping noise from connections. R58, R59, R60, R61, R62, R63 are pull-down resistors for preventing noise from input open (J3).

3.6.1 OCP and setup

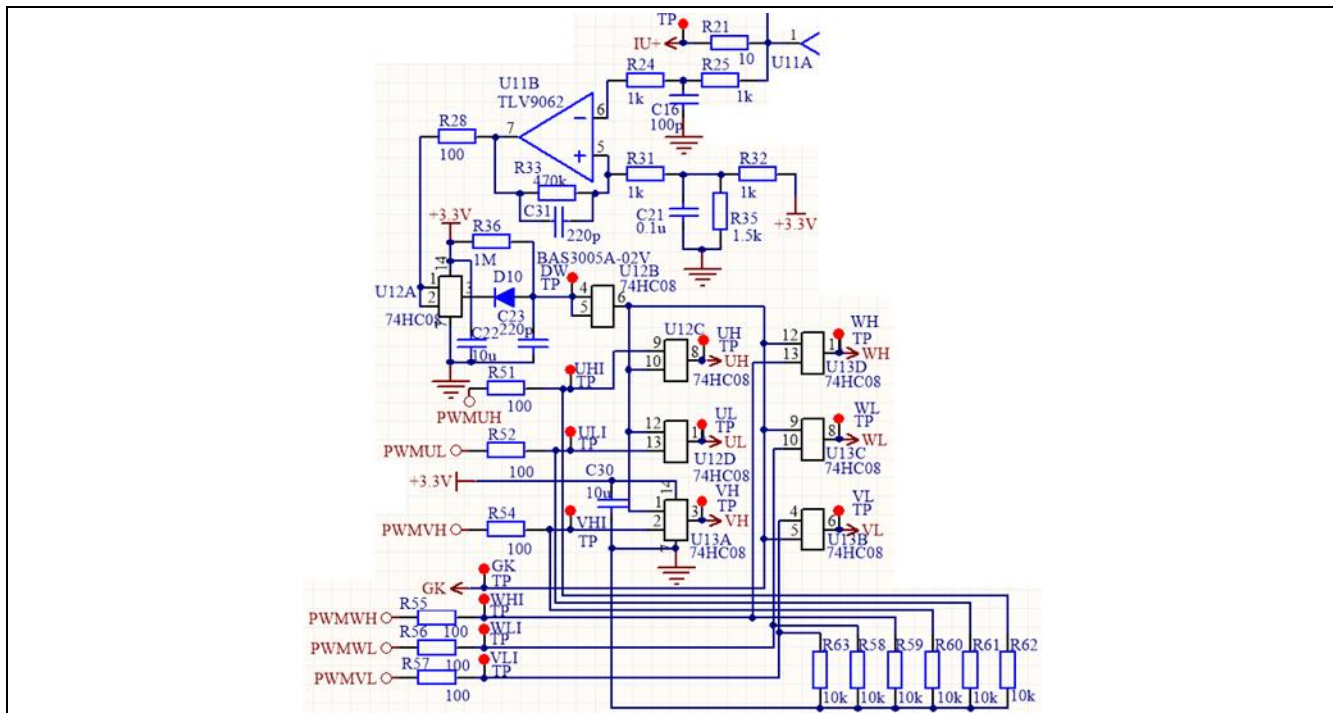


Figure 26 Overcurrent and GK/PWM shut down

U11B had set to high speed Schmitt comparator. The threshold is:

$$I_{TRIP_{TH}} = R_{35} / (R_{32} + R_{35}) * 3.3 \text{ V} = 1.98 \text{ V}$$

The reflected overcurrent threshold:

$$I_{oc_{TH}} = (V_{oc_{TH}} - V_o) / V_{shunt} = 17.2 \text{ A}$$

The response time:

$$TD = R_{25} * C_{16} = 100 \text{ nS}$$

When shunt current is over 17.2 A, U11B #7 pin output “0.”

3.6.2 PWM shut-down and GK output

U12A is a buffer circuit for the comparator. When overcurrent occurs, U11B pin 7 outputs “0,” C23 will be rapidly discharged. A logic “0” signal appears on the output of U12B. This is a shut-down signal for all PWM inputs. This is also a gatekill signal to J3 to inform the control board to stop PWM output. The total delay time of the shut-down is:

$$\Sigma TD = T_o + TD = 1.5 \text{ us} + 0.1 \text{ us} = 1.6 \text{ us}$$

When the overcurrent is removed. U11B will go logic “1.” C23 will be charged by R36. The charge time constant is:

$$T_{up} = C23 * R36 = 220 \mu s$$

For each overcurrent, U12B will output about 220 μs “0” for shut down PWM and call MCE by J3.

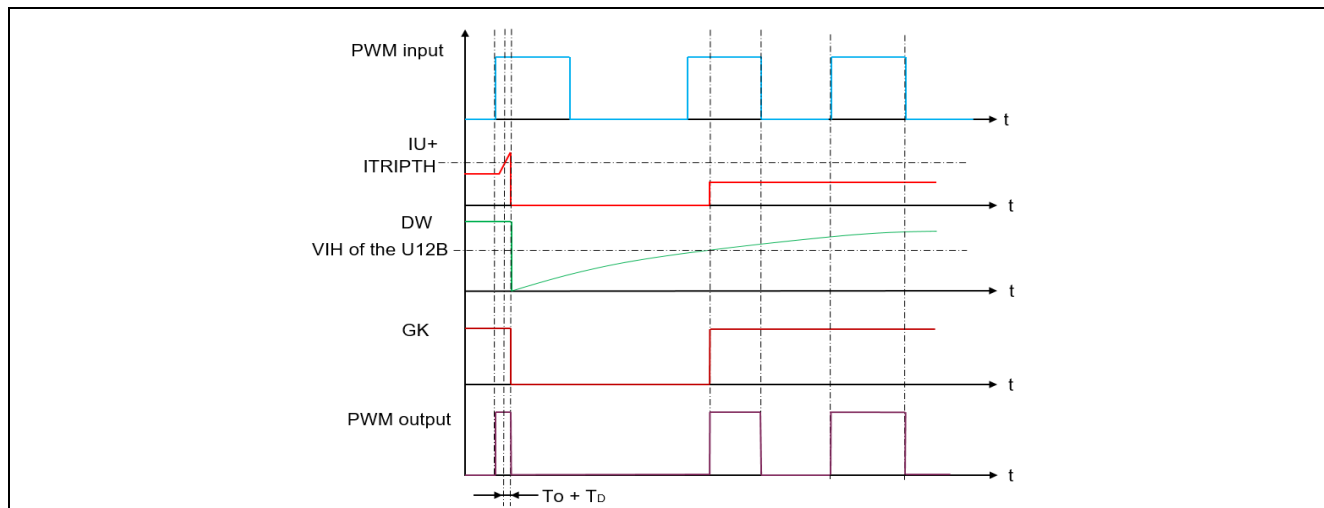


Figure 27 Logic of PWM input/output and DW/GK pin

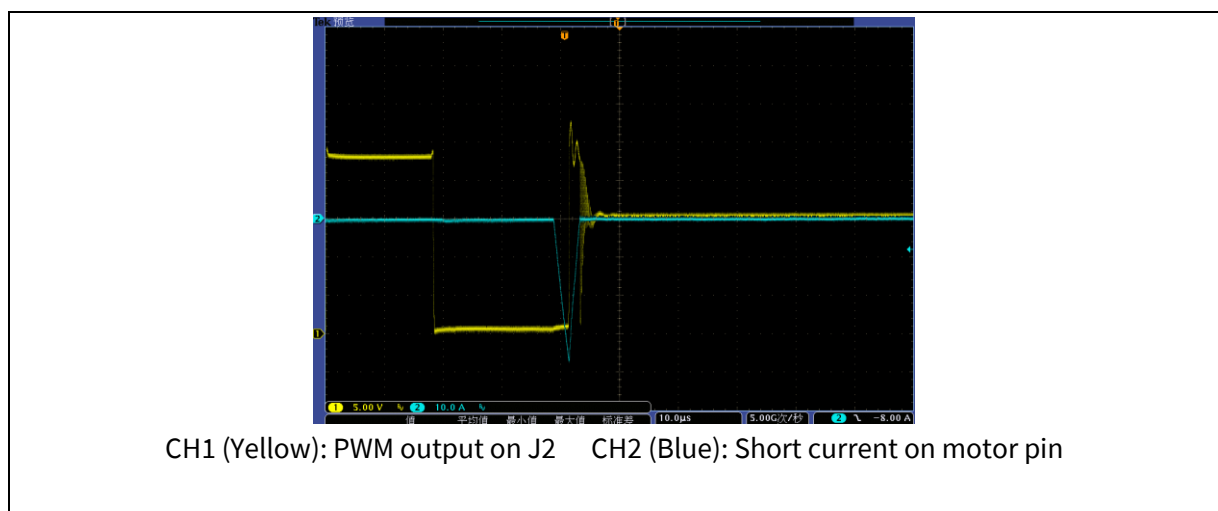


Figure 28 Waveform of overcurrent and PWM shut-down

3.6.3 OCP setup in MCEWizard

For EVAL-M1-101T, it has an internal comparator. The default value of threshold is 1.8 V (reflects 17 A).

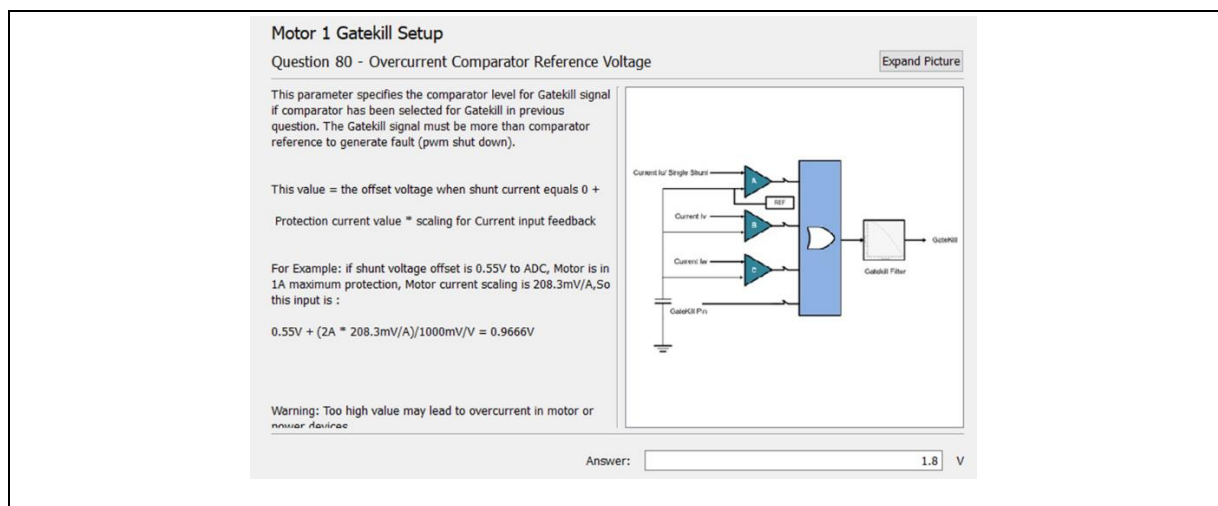


Figure 29 Overcurrent setup in MCEWizard

To calculate the overcurrent protection threshold for MCEWizard based on EVAL-M1-05F804R board, use the formula below to calculate voltage threshold value based on selected overcurrent (I_{OCP}).

$$V_{ref} = V_{offset} + V_{shunt2} \times I_{OCP} = 1.06 + 66.4 \times I_{OCP} / 1000$$

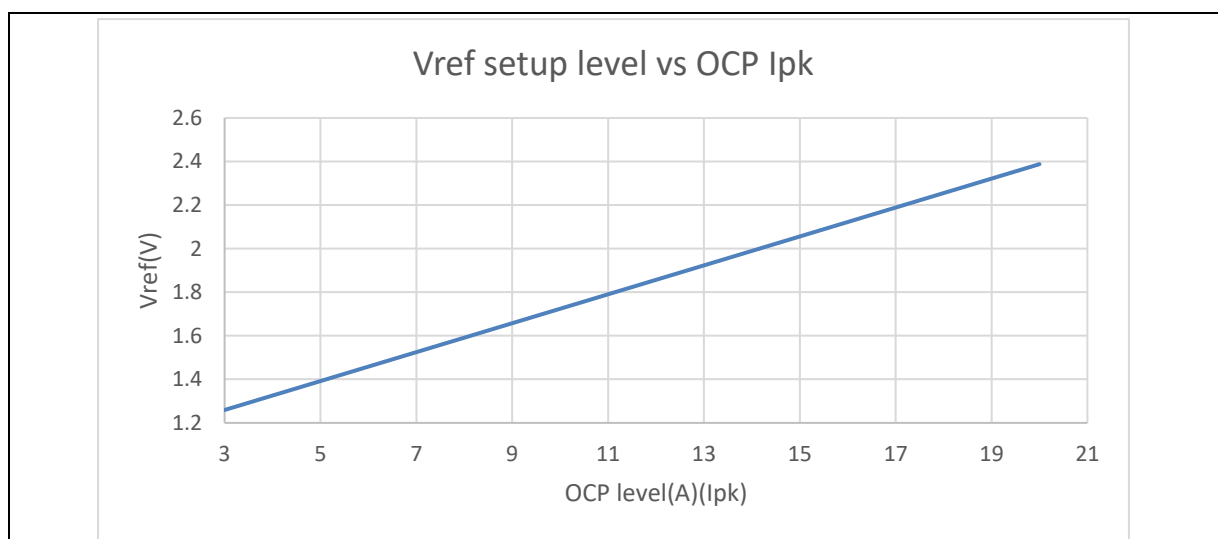


Figure 30 Vref vs overcurrent (I_{OCP})

3.7 EVAL-M1-05F804R SPWM input and power output

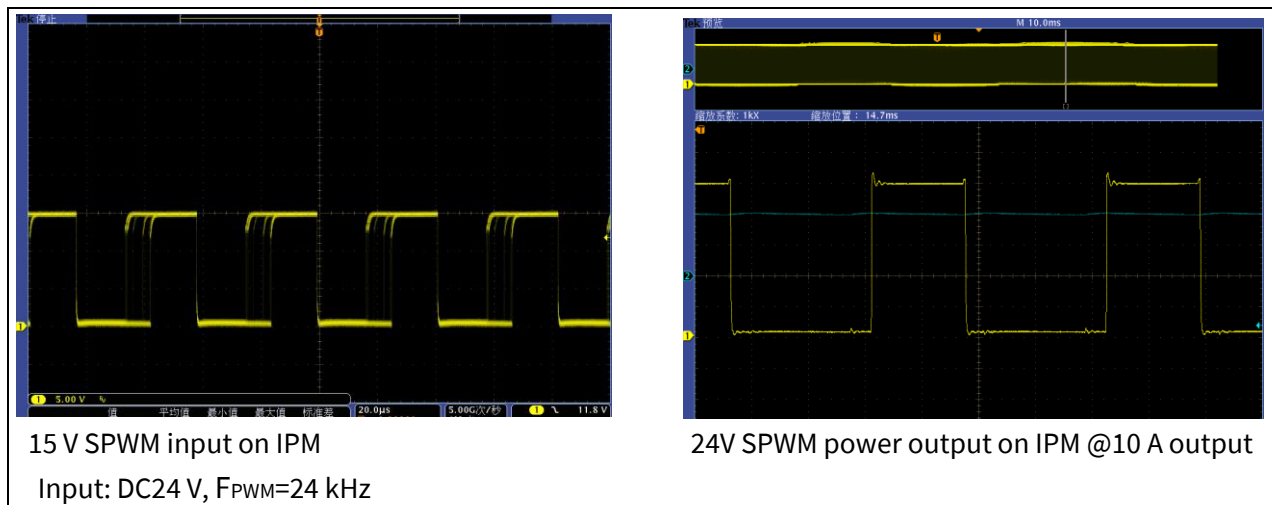


Figure 31 IRSM005F-800MH gate drive and power output

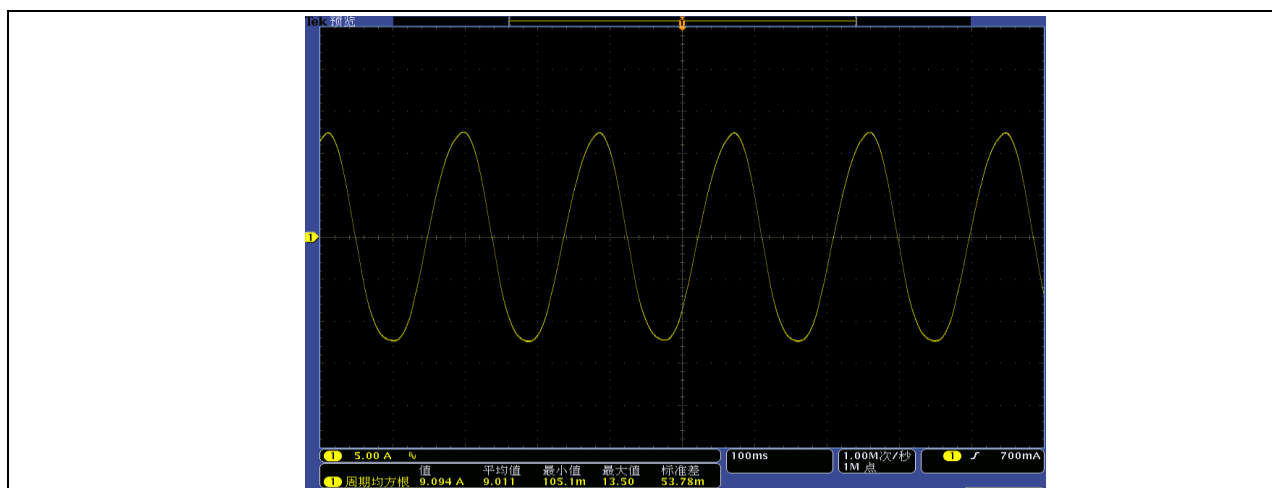


Figure 32 IRSM005-800MH output power current @ Input: DC24 V, $F_{PWM}=9$ kHz, $I_{out}=9.1$ A

This is a typical sinusoidal current waveform of a brushless motor from the EVAL-M1-05F310R and EVAL-M1-101T with iMOTION™ software.

3.8 NTC thermistor characteristics and overheating protection calculation

EVAL-M1-05F804R has an NTC (R50) to measure T_c for over-temperature protection on top of U2. This temperature value is sent to EVAL-M1-101T. The part number is NTC is NXRT 15WF 104FA1B.

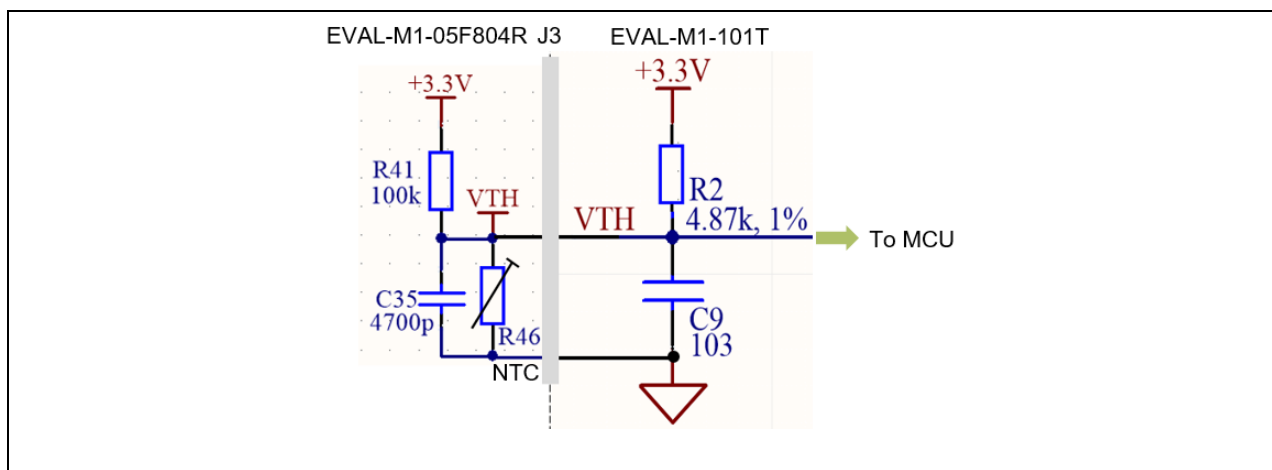


Figure 33 NTC(R46) on EVAL-M1-05F804R and connect to EVAL-M1-101T via J3

VTH output in J3 open and connect to EVAL-M1-101T:

Table 9 MCEWizard setup overview table

Temperature (°C)	Resistance (kΩ)	V _{out} (J3 open)(mV)	V _{out} (J3 connected)(mV)
25	100	1650	3154
50	33.195	822	2895
60	22.224	600	2730
70	15.184	435	2527
80	10.566	315	2292
90	7.481	230	2036
100	5.384	169	1772
110	3.934	125	1513
120	2.916	94	1273
125	2.522	81	1161

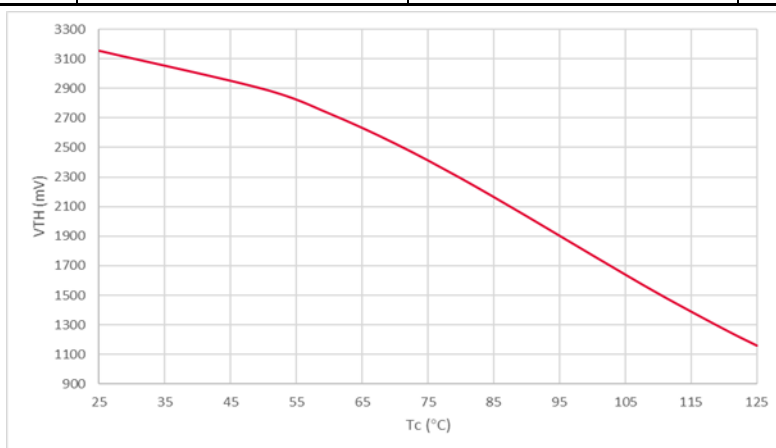


Figure 34 VTH output to EVAL-M1-101T

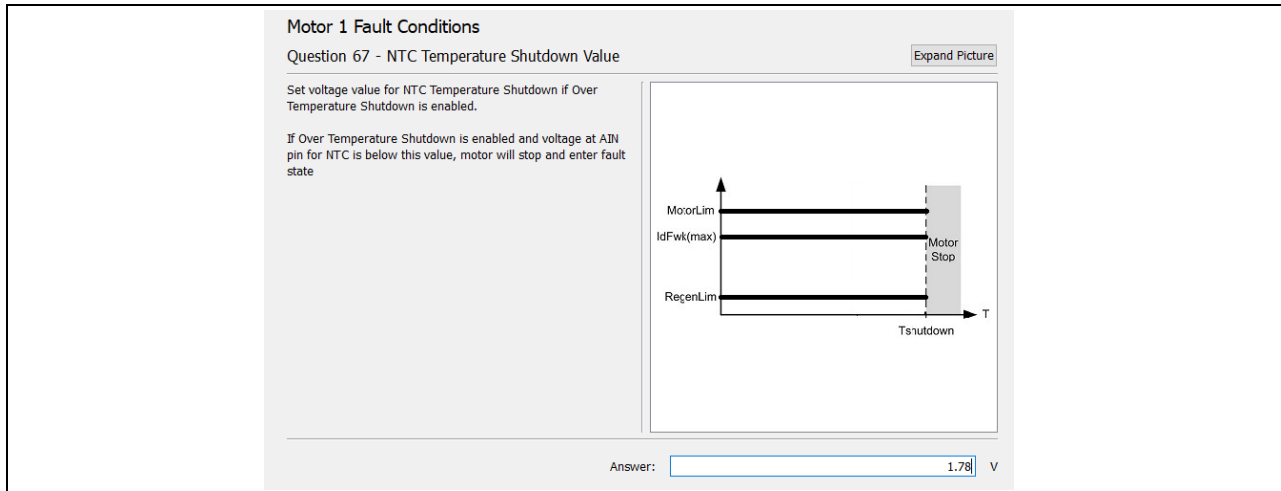


Figure 35 NTC temperature shutdown on MCEWizard

3.9 Layout

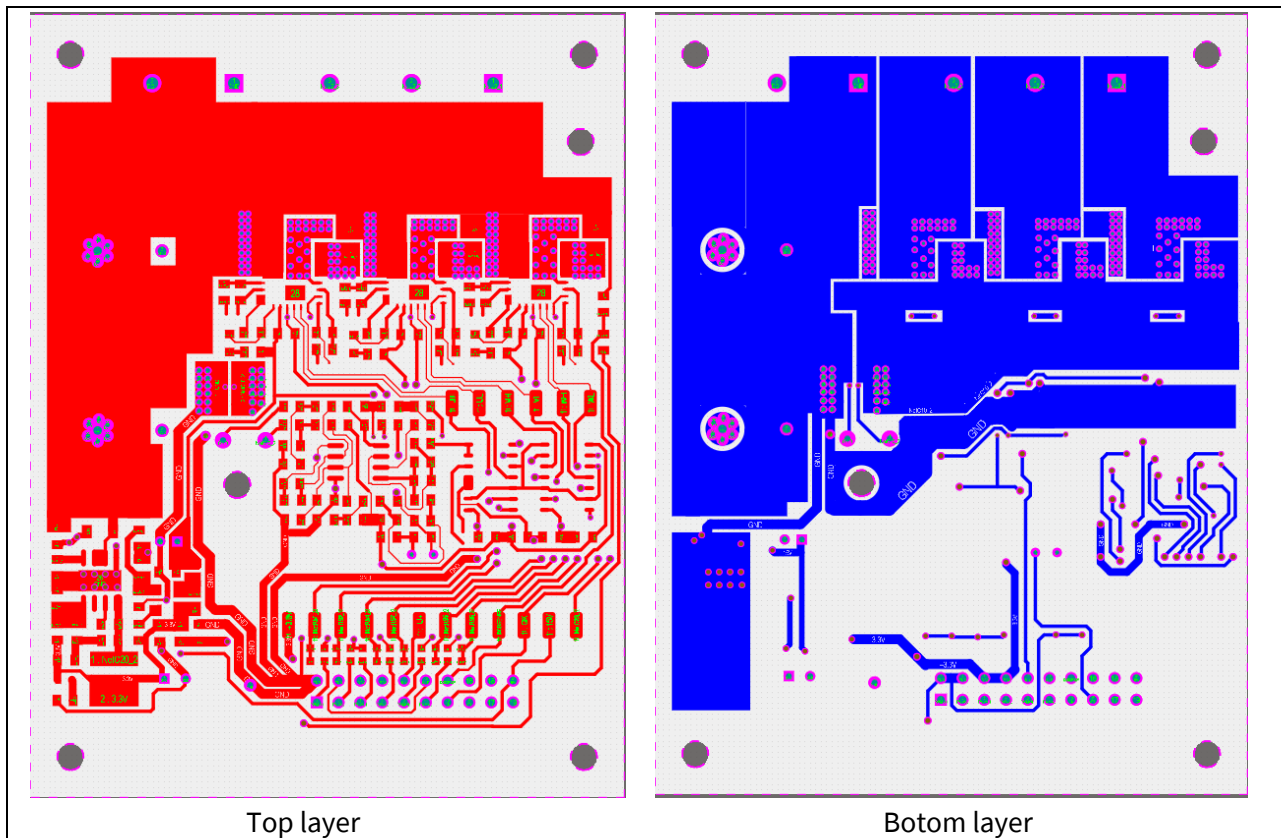


Figure 36 PCB copper layout

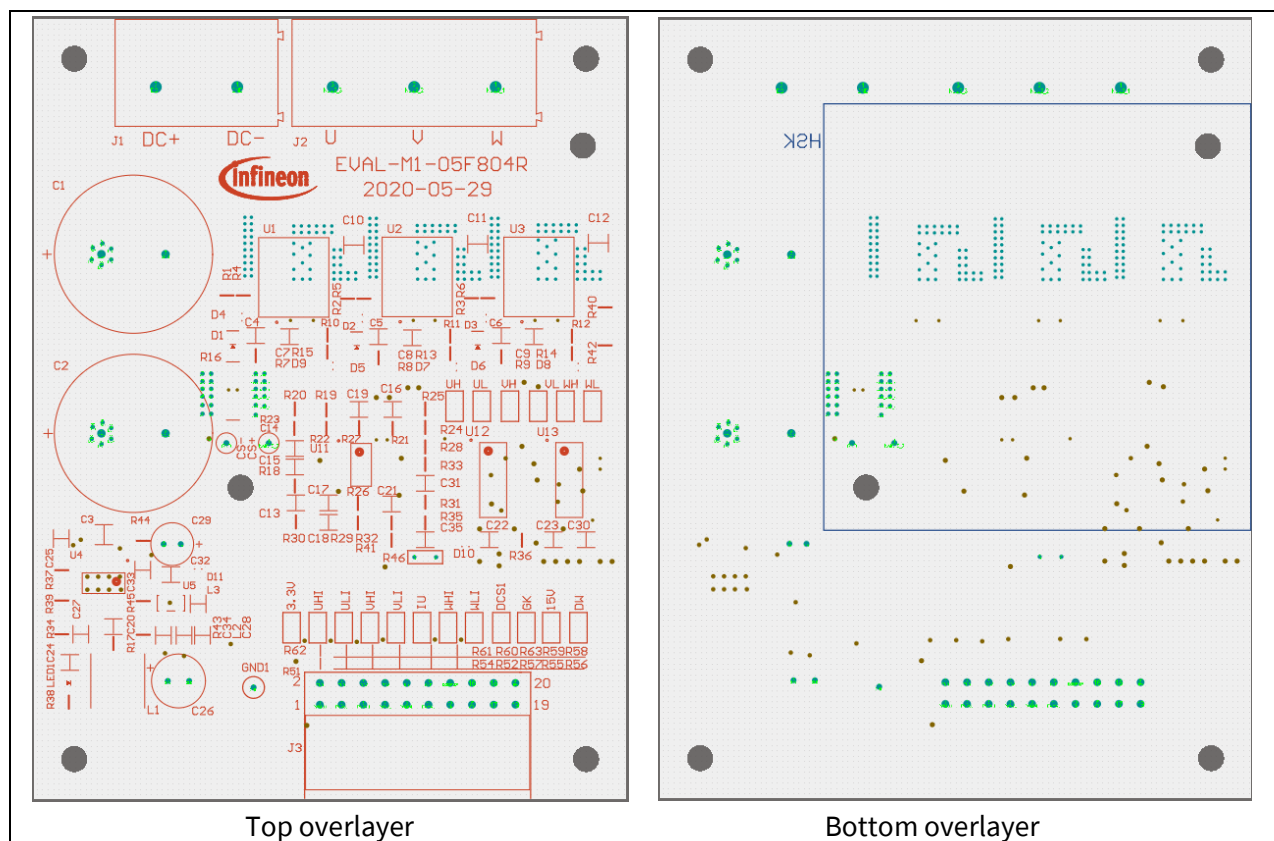


Figure 37 PCB overlayer

3.10 Bill of material

The complete bill of material is available on the download section of the Infineon homepage. A log-in is required to download this material. Table 10 shows some key components of this board.

Table 10 Key components of EVAL-M1-05F804R

Comment	Designator	Qty	Description	Footprint	Manufacturer	Part number
1000u 63V	C1, C2	2	Electrolytic capacitor	WCAP-AT1H_18x25	Würth Elektronik	860010780024
220u 25V	C26	1	Electrolytic capacitor	CAP-E_6.3x2.5x11 mm	Würth Elektronik	860010473011
47u 25V	C29	1	Electrolytic capacitor	CAP-E_5x2x11mm	Würth Elektronik	860020472006
BAS3005A-02V	D1, D2, D3, D7, D8, D9, D10, D11	8		INF-SC79_V	Infineon	BAS3005A-02V

BAV21	D4, D5, D6	3		D0805		
CON-2PIN	J1	1	2-pin	CON-2Pin-9.52MM	Würth Elektronik	691250910002
CON-3PIN	J2	1	3-pin	CON-3Pin-9.52MM	Würth Elektronik	691250910003
Header 20	J3	1	Header, 20-Pin	HDR_MADK_M 1-90-F	Würth Elektronik	613020243121
150uH 0.8A	L1	1	74404064151	WE-LQS_6045	Würth Elektronik	74404064151
10uH 0.6A	L2, L3	2	74479777310A	L0805	Würth Elektronik	74479777310A
5mohm 1%	R16	1		WRIS-PWMC_1225_H=0.2mm		
NXRT 15WF 100k 1%	R46	1		NTC-H		
IRSM005-800MH	U1, U2, U3	3		IFX-PQFN-7x8	Infineon	IRSM005-800MH
74HC08	U12, U13	2		INF-PG-DSO-14-22_L		

4 Ordering details and other information

The power board is now available for customers in small order quantities. PCB and Gerber details are also available and can be shared with customers after a suitable agreement has been reached.

In order to initiate the testing, customers are advised to order the following items:

- EVAL-M1-05F804R
- Buy online: www.infineon.com.com/MADK

References

5 References

- [1] Datasheet of Infineon IPM IRSM005-800MH is available for download on Infineon's website
- [2] EVAL-M1-101T user manual is available for download on Infineon's website
- [3] EVAL-M1-183M user manual is available for download on Infineon's website

Attention: *Infineon's product registration is now done online. You can register your board and download further information.*

There are three easy steps to register:

1. Go to www.infineon.com/login to myinfineon
2. Click on "Product Registration"
3. Choose your board and enter board series number; download the related information package

Revision history

Revision history

Document version	Date of release	Description of changes
1.0	2020-09-04	First release

Trademarks

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

Edition 2020-09-04

Published by
Infineon Technologies AG
81726 Munich, Germany

© 2020 Infineon Technologies AG.
All Rights Reserved.

Do you have a question about this document?

Email: erratum@infineon.com

Document reference
UG-2020-25

For further information on the product, technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies office (www.infineon.com).

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.

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Infineon:](#)

[EVALM105F804RTOB01](#)