

EVAL-IMM101T User Manual

iMOTION™ MADK Starter Kit for IMM101T Smart IPMs

About this document

Scope and purpose

This application note provides an overview of the evaluation board EVAL-IMM101T including its main features, key technical data, pin assignments and mechanical dimensions.

EVAL-IMM101T is a full-featured Starter Kit including an IMM101T Smart IPM which provides a fully-integrated, turnkey high-voltage motor drive solution designed for high-performance, high-efficiency PMSM/BLDC motor drive applications such as fans, pumps and compressors. EVAL-IMM101T also comprises other necessary circuitry required for “out-of-the-box” evaluation of IMM101T Smart IPMs, such as rectifier and EMI filter stage, as well as isolated debugger section with USB connection to the PC.

The Starter Kit EVAL-IMM101T was developed to support customers during their first steps designing applications with IMM101T Smart IPM.

The available variants of the IMM101T Starter Kit are listed in Table 1:

Table 1 EVAL-IMM101T Starter Kit variants

Sales Name	iMOTION Device	Output Rating	$R_{DS(ON)}$ Typ at 25°C
EVAL-IMM101T-015	IMM101T-015M	500V / 1A	4.8 Ω
EVAL-IMM101T-046	IMM101T-046M	600V / 4A	1.26 Ω

All the information provided in this User Manual applies to both versions of the Starter Kit unless explicitly stated that the specific information is valid only for one particular variant.

Intended audience

This application note is intended for all technical specialists who are familiar with motor control and high power electronics converter and the EVAL-IMM101T evaluation board is intended to be used under laboratory conditions only by trained specialists.

Important notice**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 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.

Safety precautions

Safety precautions

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

Table 2 Precautions








	<p>Attention: <i>The ground potential of the EVAL-IMM101T system is biased to a negative DC bus voltage potential. When measuring voltage waveform by oscilloscope, the scope's ground needs to be isolated. Failure to do so may result in personal injury or death and equipment damage</i></p>
	<p>Attention: <i>Only personnel familiar with the drive and associated machinery should plan or implement the installation, start-up and subsequent maintenance of the system. Failure to comply may result in personal injury and/or equipment damage.</i></p>
	<p>Attention: <i>The surfaces of the drive may become hot, which may cause injury.</i></p>
	<p>Attention: <i>EVAL-IMM101T system contains parts and assemblies sensitive to Electrostatic Discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to applicable ESD protection handbooks and guidelines.</i></p>
	<p>Attention: <i>Wiring or application errors such as under sizing the motor, supplying an incorrect or inadequate DC supply or excessive ambient temperatures may result in system malfunction.</i></p>
	<p>Attention: <i>Wait three minutes after removing power from the power drive 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.</i></p>
	<p>Attention: <i>EVAL-IMM101T system is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials which are unnecessary for system installation may result in overheating or abnormal operating condition.</i></p>

Table of contents

Table of contents

About this document	1
Important notice	2
Safety precautions	3
Table of contents	4
1 Introduction	5
2 Main features	6
3 Pin assignments	9
4 Schematics and Layout	12
4.1 DC-Link Voltage Measurement	14
4.2 EMI filter.....	14
4.3 Inverter section using Smart IPM.....	14
4.4 Auxiliary power supply.....	15
4.5 Current measurement shift stage and Overcurrent threshold.....	16
5 Thermal Characterization	18
5.1 Thermal Characteristic.....	21
6 Thermal Protection	22
7 Getting started with EVAL-IMM101T	24
7.1 Setting up the system.....	24
8 PCB Layout	28
9 Application Diagrams and Application Use Cases	30
9.1 Application Diagrams.....	30
9.2 IMM101T Application Use Cases	31
9.2.1 Sensorless Single Shunt.....	31
9.2.2 Sensorless Leg Shunt	32
9.2.3 Configuration with 2 Hall Sensors	33
10 Bill of Materials of EVAL-IMM101T	34
11 Reference	38
Revision history	39

Introduction

1 Introduction

The EVAL-IMM101T Starter Kit is designed to give an easy-to-use motor drive solution based on the Infineon's IMM101T Smart IPM. The board is equipped with all assembly groups for sensorless field oriented control (FOC). It contains a single-phase AC-connector, EMI filter, rectifier and 3-phase output for connecting the motor. The power stage also contains source shunt for current sensing and a voltage divider for DC-link voltage measurement.

The features of this board are described in the design feature chapter of this document, whereas the remaining paragraphs provide information which helps users 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-IMM101T. The design was tested as described in this document but not qualified regarding safety requirements or manufacturing and operation over the whole operating temperature range or lifetime. The boards provided by Infineon are only subject to functional testing.

Evaluation boards are not subject to the same procedures as regular products regarding Returned Material Analysis (RMA), Process Change Notification (PCN) and Product Discontinuation (PD). Evaluation boards are intended to be used under laboratory conditions and only by trained specialists.

The combination of the MCE2.0 iMOTION™ motion control engine integrated into IMM101T devices, together with the gate driver and six MOSFETs offers a complete motor drive system in a compact 12 x 12mm² surface mount package, minimizing external components count and PCB area.

The block diagram of the EVAL-IMM101T is depicted in Figure 1.

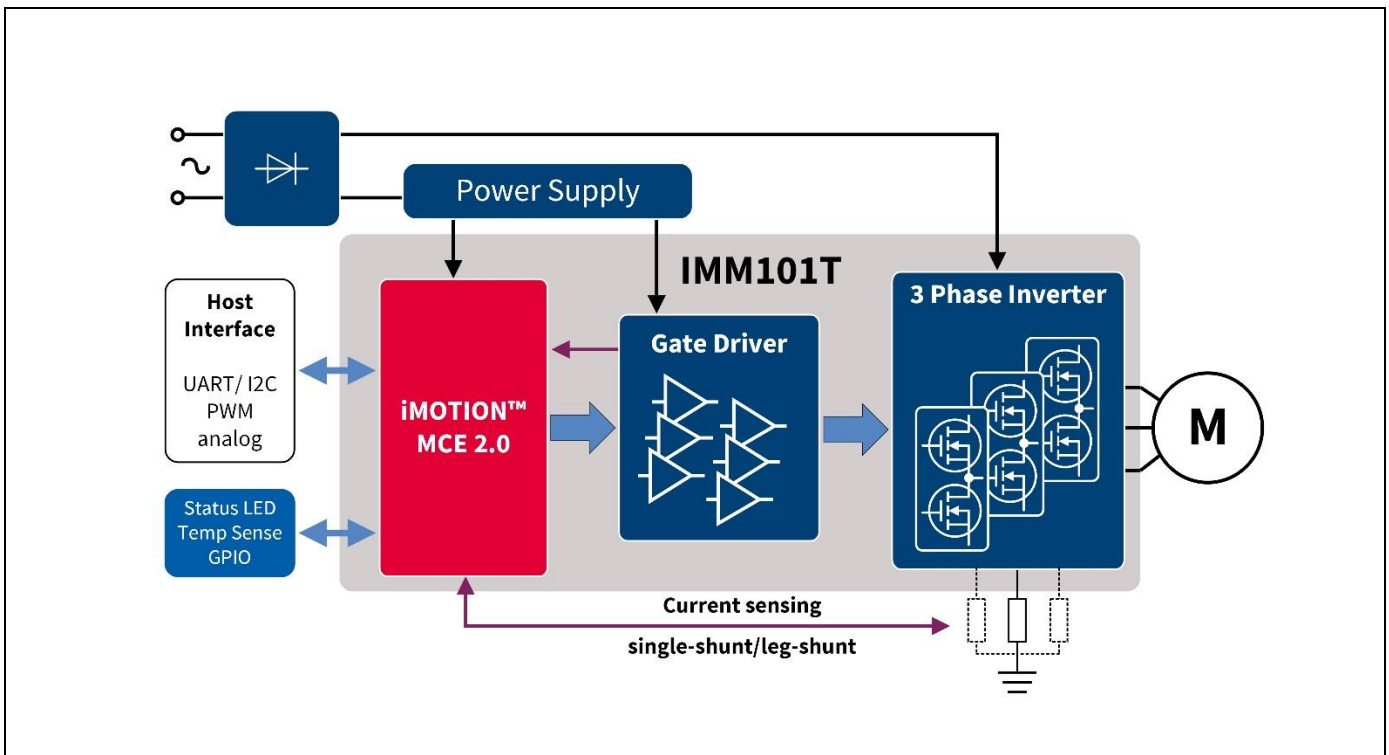


Figure 1 EVAL-IMM101T block diagram

Main features

2 Main features

EVAL-IMM101T Starter Kits are intended for evaluation of the IMM101T series of iMOTION™ Smart IPMs. The main features of IMM101T series are:

- Motion control engine (MCE2.0) as ready-to-use controller solution for variable speed drives
- Field oriented control (FOC) for permanent magnet synchronous motor (PMSM)
- Space vector PWM with sinusoidal commutation and integrated protection features
- Current sensing via single or leg shunt through direct interface
- Sensorless operation
- Support for digital hall sensors
- Integrated analog comparators for over-current protection
- Over-/Undervoltage protection
- Rotor lock protection
- Built-in Temperature sensor (Over-temperature protection)
- Undervoltage lockout
- Integrated minimum deadtime
- Shoot-through prevention
- 3 different power MOSFET options: 4.8Ω/500V, 1.26Ω/650V and 0.86Ω/650V (typical values at 25°C)
- 3.3V or 5.0V supply voltage options for controller
- 15V supply voltage for gate driver
- Integrated bootstrap diode structure
- Flexible host interface options for speed commands: UART, SPI, PWM or analog signal
- Class B pre-certification for MCE2.0 firmware
- Isolation 1500V_{RMS} 1min
- Very compact 12x12mm² PQFN package

The evaluation board main characteristics are:

- Nominal input voltage 110V_{AC} - 230V_{AC}
- On-board EMI filter
- Single shunt current sensing configuration by default
- Voltage divider for DC-link voltage sensing
- Measurement test-points compatible with standard oscilloscope probes
- On-board debugger with 1kV isolation for isolated communication to PC via USB
- NTC to reduce inrush current
- PCB size is 88.9mm x 89.5mm, 2 layers, 2oz copper
- RoHS compliant

Main features

Table 3 lists all the important specifications of the evaluation board EVAL-IMM101T.

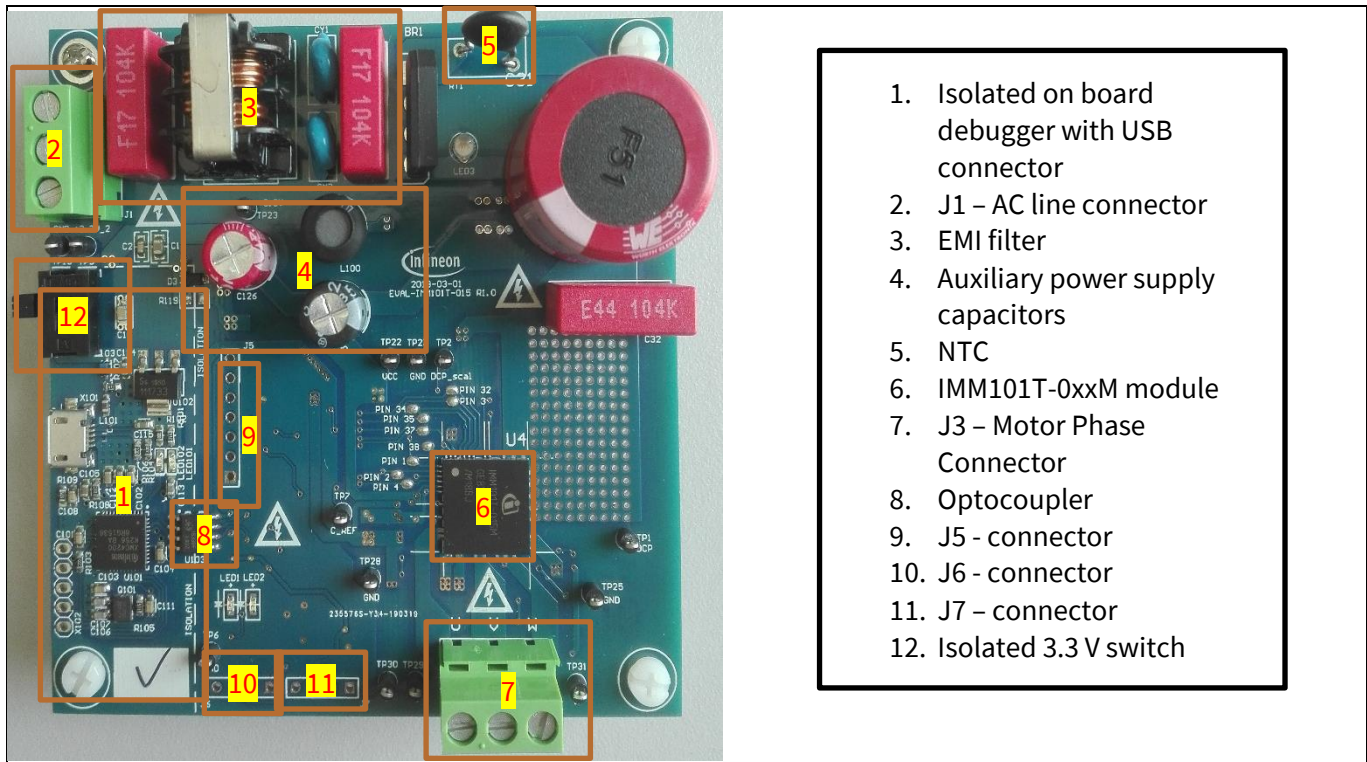
Table 3 EVAL-IMM101T specifications

Parameters	Device	Values	Conditions
Input			
Voltage	EVAL-IMM101T-015	110 – 230 V _{AC}	
	EVAL-IMM101T-046		
Output			
Current per phase	EVAL-IMM101T-015	355 mA _{rms}	t _{amb} = 25°C, t _{hotspot} = 105°C, V _{DCbus} = 300 V, 2phase modulation, 6kHz PWM
	EVAL-IMM101T-046	600 mA _{rms}	
DC Bus Voltage			
Maximum DC bus voltage	EVAL-IMM101T-015	380 V	
	EVAL-IMM101T-046		
Minimum DC bus voltage	EVAL-IMM101T-015	120 V	
	EVAL-IMM101T-046		
Current feedback			
Current sensing resistor RS1	EVAL-IMM101T-015	500 mΩ	The current sensing default configuration is single shunt, only RS1 is mounted
	EVAL-IMM101T-046	250 mΩ	
On board power supply			
15 V	EVAL-IMM101T-015	15V±5%, max. 50mA	Used for Smart IPM gate driver
	EVAL-IMM101T-046		
3.3 V	EVAL-IMM101T-015	3.3V±2%, max. 20mA	Supplying the 3.3V to the controller
	EVAL-IMM101T-046		
PCB characteristics			
Material	EVAL-IMM101T-015	FR4, 2 layers, 2oz opper	
	EVAL-IMM101T-046		
Dimension	EVAL-IMM101T-015	88.9mm x 89.5mm	
	EVAL-IMM101T-046		
System enviroment			
Ambient temperature	EVAL-IMM101T-015	From 0 to 60°C	Non-condensing, maximum RH of 95%
	EVAL-IMM101T-046		

EVAL-IMM101T
Smart IPM evaluation board application note

Main features

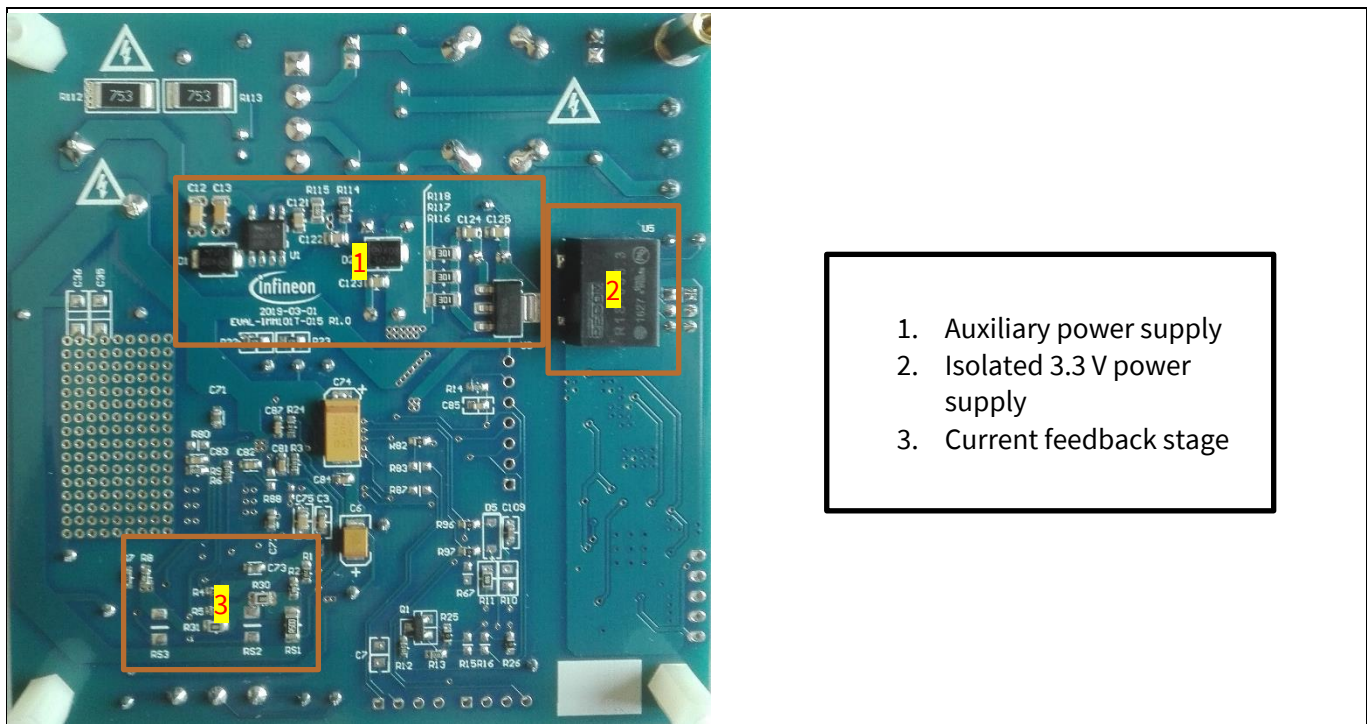
Figure 2 points out the functional groups on the top side of the EVAL-IMM101T evaluation board.



1. Isolated on board debugger with USB connector
2. J1 – AC line connector
3. EMI filter
4. Auxiliary power supply capacitors
5. NTC
6. IMM101T-0xxM module
7. J3 – Motor Phase Connector
8. Optocoupler
9. J5 - connector
10. J6 - connector
11. J7 – connector
12. Isolated 3.3 V switch

Figure 2 Functional group of the EVAL-IMM101T top side

Figure 3 points out the functional groups on the bottom side of the EvalIMM101T evaluation board.



1. Auxiliary power supply
2. Isolated 3.3 V power supply
3. Current feedback stage

Figure 3 Functional group of the EVAL-IMM101T bottom side

Pin assignments

3 Pin assignments

Table 4 Pinout description for IMM101T – single motor control use case – typical configuration

Pin	Name	Type	Description
1	Vbus scaled	I	Vbus scaled ADC input
2	CREF	I/O	Analog Overcurrent Comparator threshold DAC
3	V _{DD}	P	Digital V _{DD} input [3.3V – 5.0V]
4	P1.7	I/O	Digital Input --- Analog and Digital Output
5	Vcc	P	15V gate driver power supply input
6	V _{SS1}	P	Gate Driver Power ground, connect externally via PCB to pin 36
7	VbV	P	V phase bootstrap capacitor positive
8	VbW	P	W phase bootstrap capacitor positive
9,10	VsU	P	U phase output
11,12	VrU	P	Leg U return – Low-Side MOS source
13,14	VrV	P	Leg V return – Low-Side MOS source
15,16, 40	VsV	P	V phase output and V phase bootstrap capacitor negative
17,18,19	VsW	P	W phase output and W phase bootstrap capacitor negative
20,21	VrW	P	Leg W return – Low-Side MOS source
22~29	Vbus	P	DC bus voltage
30, 39	VsU	P	U phase bootstrap capacitor negative
31	VbU	P	U phase bootstrap capacitor positive
32	RX0	I	Serial Port Receive input
33	TX0	O	Serial Port transmit output
34	Vsp	I	Analog Voltage Set Point Input
35	IW (or H0)	I	Analog Current sense input phase W or Hall0 input
36,41	V _{SS2}	P	Signal ground --- Connect externally via PCB to pin 6
37	IV (or H1)	I	Analog Current sense input phase V or Hall1 input
38	ISS or IU	I	Analog Current sense input phase U or single Shunt

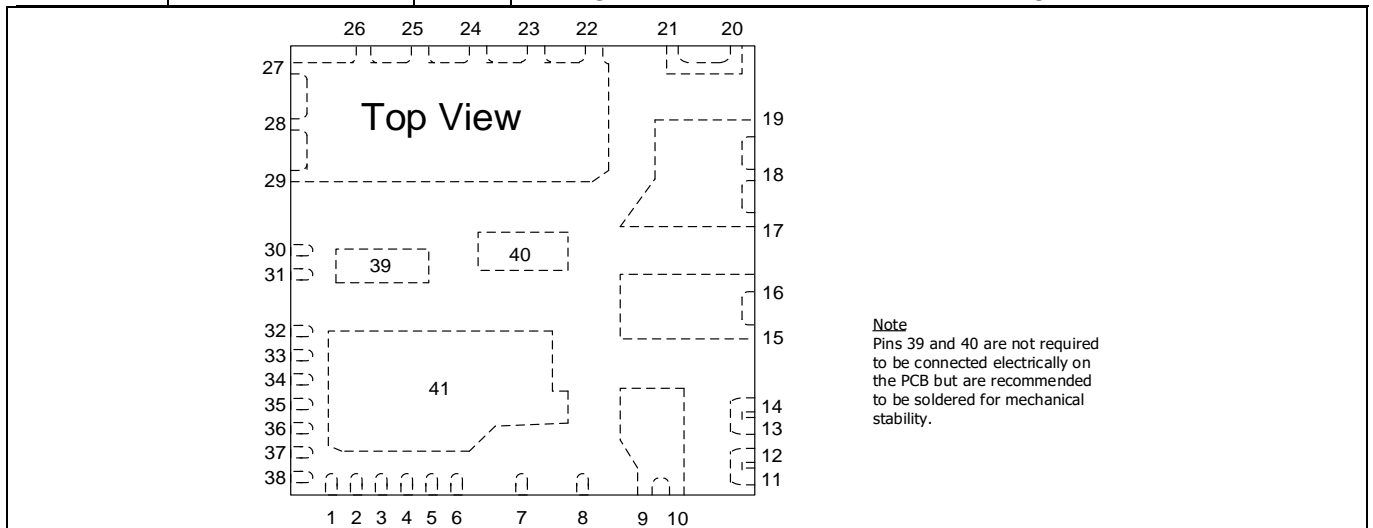


Figure 4 IMM101T series pinout

Pin assignments

General information about the connectors of the EVAL-IMM101T evaluation board is listed in Table 5, Table 6, Table 8, Table 9 and Table 10. Table 7 describes how to connect iMOTION link to J6.

Table 5 J5 connector description

Pin	Name	Details
1	GND	Ground
2	D_F_VSP_IN	Input for Duty, Frequency and Analog Vsp control filtered
3	PGOUT	Pulses per revolution
4	DIR	Direction pin
5	FG	Pulses per revolution, open drain output 15 V tolerant
6	VSP_DUTY_FREQ	Input for Duty, Frequency and Analog Vsp control
7	3.3 V	On board 3.3 V supply

Table 6 J6 connector description

Pin	Name	Details
1	P0.14	RXD0 for UART communication
2	GND	Ground
3	3.3 V	On board 3.3 V supply
4	P0.15	TXD0 for UART communication

Note: If J6 is used for UART communication, R96 and R97 have to be removed.

Infineon also provides iMOTION link debugger tool. In order to use iMOTION link, you have to make an adapted cable by following connections as table 7, and please remove R96 and R97. Refer to iMOTION link user manual for pin definition.

Table 7 J6 connect to iMOTION link port

Pin # of J6	Name	Pin # of iMOTION link
1	P0.14	7
2	GND	5
3	3.3 V	6
4	P0.15	8

Table 8 J7 connector description

Pin	Name	Details
1	HALL1	Hall sensor connection to pin P2.6
2	HALL0	Hall sensor connection to pin P2.2
3	GND	Ground
4	3.3 V	On board 3.3 V supply

Note: If Hall sensors are used, R83 = 0 Ω and R87 = 0 Ω have to be mounted while R82 has to be removed.

Pin assignments

Table 9 J3 connector description

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 10 J1 connector description

Pin	Name	Details
1	EARTH	Earth ground
2	LINE	AC line input (110 V – 240 V)
3	NEUTRAL	AC neutral input

Schematics and Layout

4 Schematics and Layout

To meet individual customer requirements and make the EVAL-IMM101T evaluation board a basis for development or modification of their own boards, all necessary technical data like schematics, layout and components are included in this chapter. In Figure 5, Figure 6 and Figure 7, an overview of the different parts of the EVAL-IMM101T are presented; the details will be analyzed in the following chapters:

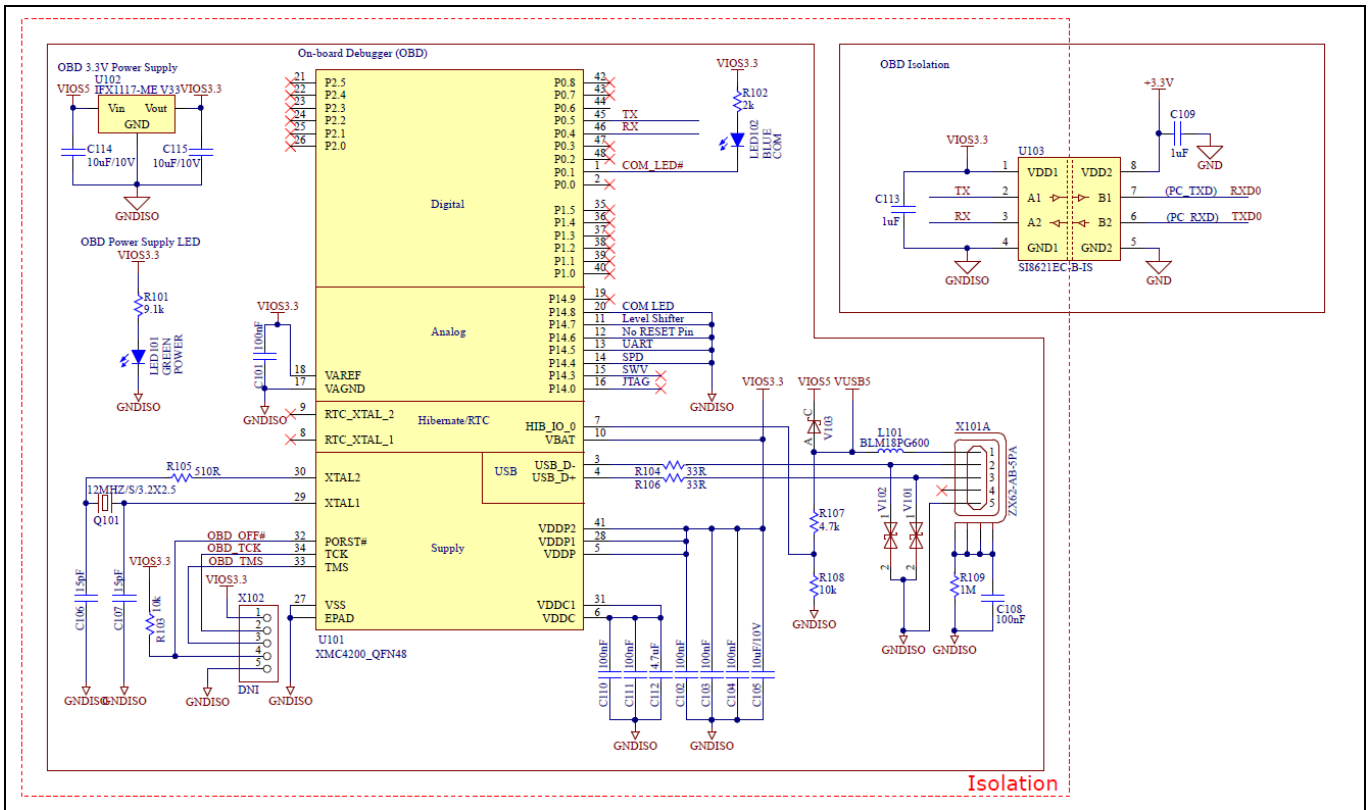


Figure 5 Isolated debug part overview

Schematics and Layout

4.1 DC-Link Voltage Measurement

Figure 8 provides the DC bus sense resistor details.

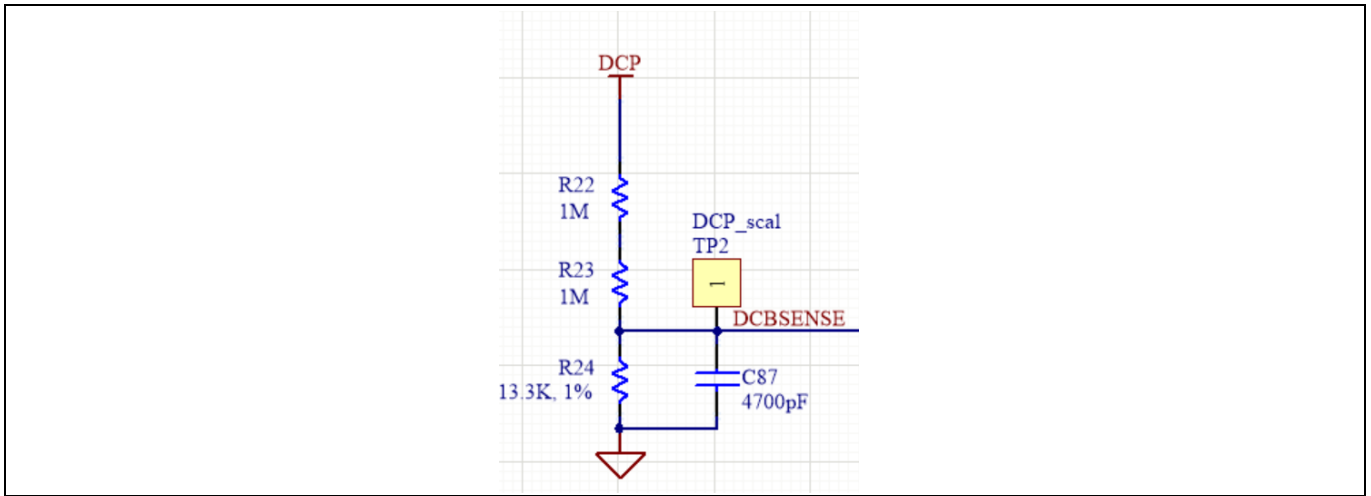


Figure 8 DC bus sense resistor on EVAL-IMM101T evaluation board

The DCBSENSE voltage is read by pin P2.10 of the controller. With 13.3 kΩ as pull down resistor, the DCBSENSE voltage results in the range of 0 to 3.3 V on the pin reflecting a DC bus voltage range of 0 to 500 V.

4.2 EMI filter

Figure 9 depicts the schematic from the AC line input connector J1 to the rectified DC bus voltage. This circuitry includes a passive EMI filter consisting of elements CX1, CX2, L1, CY1 and CY2, a 2A/600 V rectifier (BR1), a NTC resistor RT1, two ceramic capacitances C12 and C13, a film capacitance C32 and an electrolytic capacitance C31 for buffering the rectified DC bus voltage DCP.

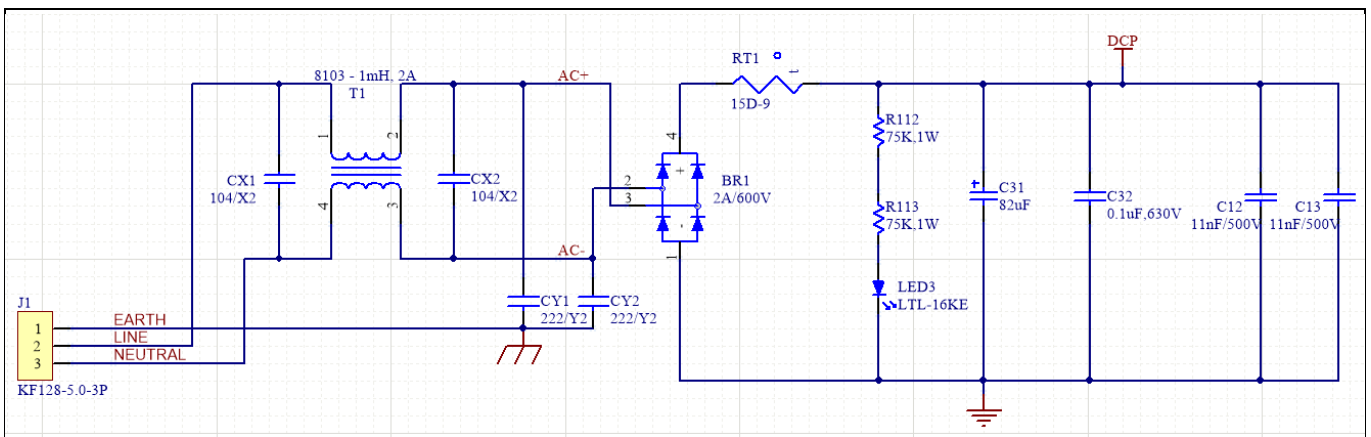


Figure 9 Schematic for EMI filter and AC/DC section of the EVAL-IMM101T evaluation board

4.3 Inverter section using Smart IPM

The inverter section is implemented as sketched in Figure 10. The three phase inverter consist of six MOSFETs with the following blocking voltage and $R_{DS(on)}$ (typical value at 25°C) according to the part number:

- IMM10xT-015M – output rating: 500 V/4.8 Ω $R_{DS(on)}$
- IMM10xT -046M – output rating: 600 V/1.26 Ω $R_{DS(on)}$

Schematics and Layout

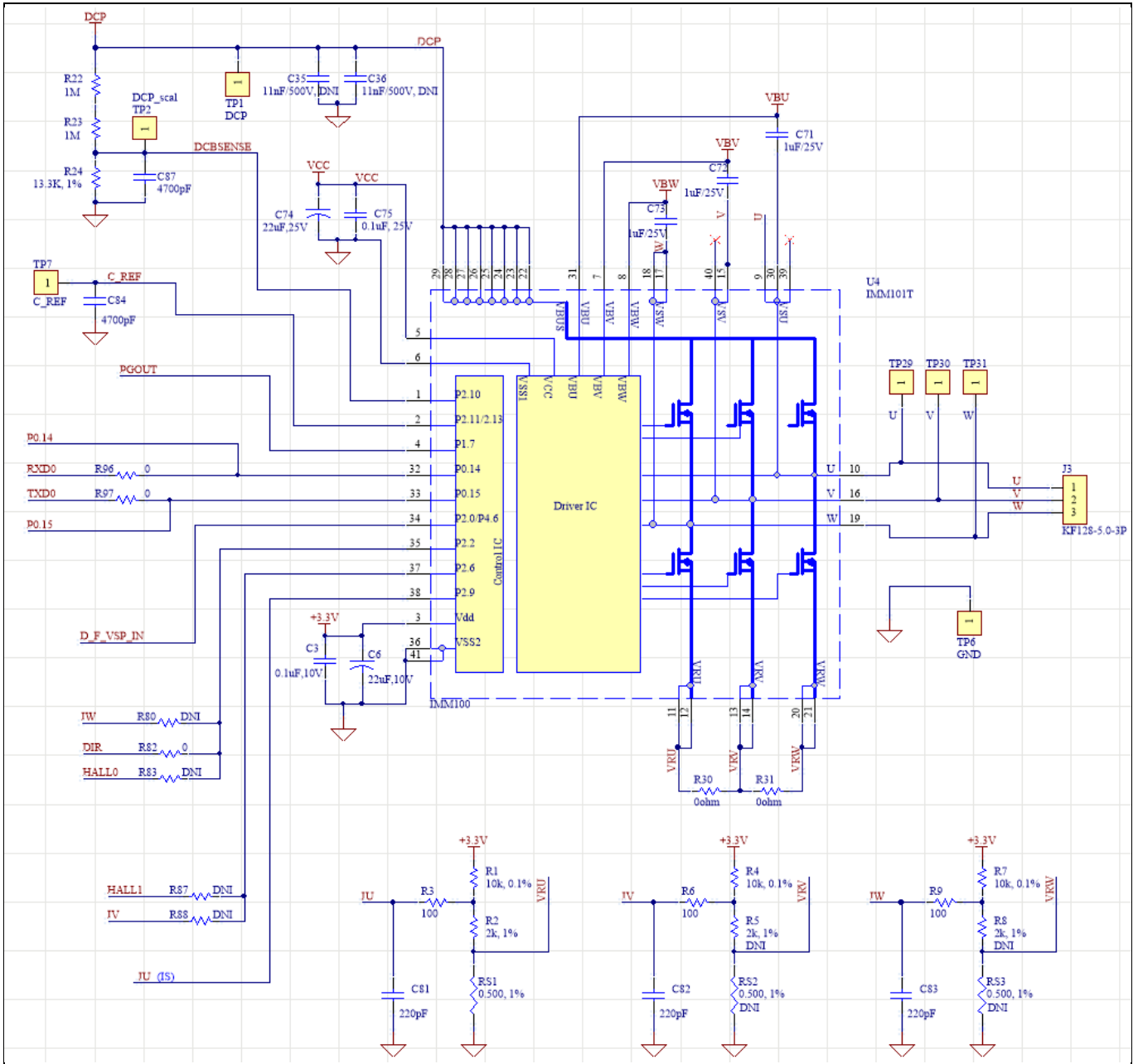


Figure 10 Schematic of the 3-phase inverter section using Smart IPM IMM101T on EVAL-IMM101T

4.4 Auxiliary power supply

Figure 11 depicts the schematic of the auxiliary power supply available on the EVAL-IMM101T board. The circuit includes a LNK304 that is used to generate 15 V directly from the DC bus. V_{CC} is connected to the gate driver inside the Smart IPM using pin 5 of the module. The linear voltage regulator LD1117S33 generates 3.3 V from 15 V power supply V_{CC}. The 3.3 V supplies the control IC inside the Smart IPM.

Schematics and Layout

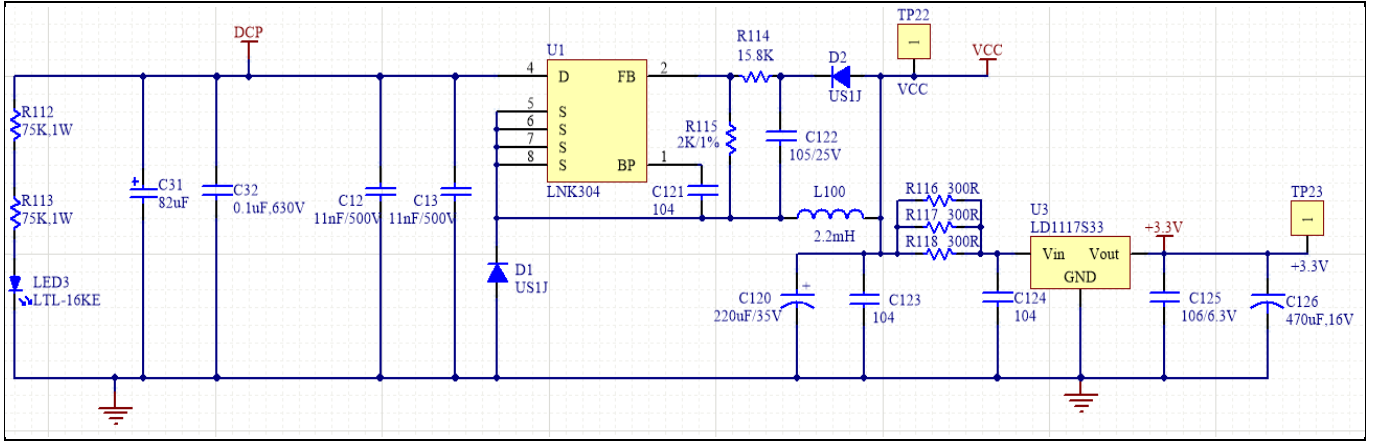


Figure 11 Power supply section of the EVAL-IMM101T evaluation board

The 3.3 V can be generated also via isolated on board power supply (R1S-0533) enabling the switch on the left side of the board. In particular the isolated on board power supply is fed by the 5 V of the USB connection. This feature allows to communicate with the module even if it is not connected to the power AC line and it is particularly useful for firmware and parameters programming. Figure 12 depicts the schematic of the isolated on board power supply and the related switch.

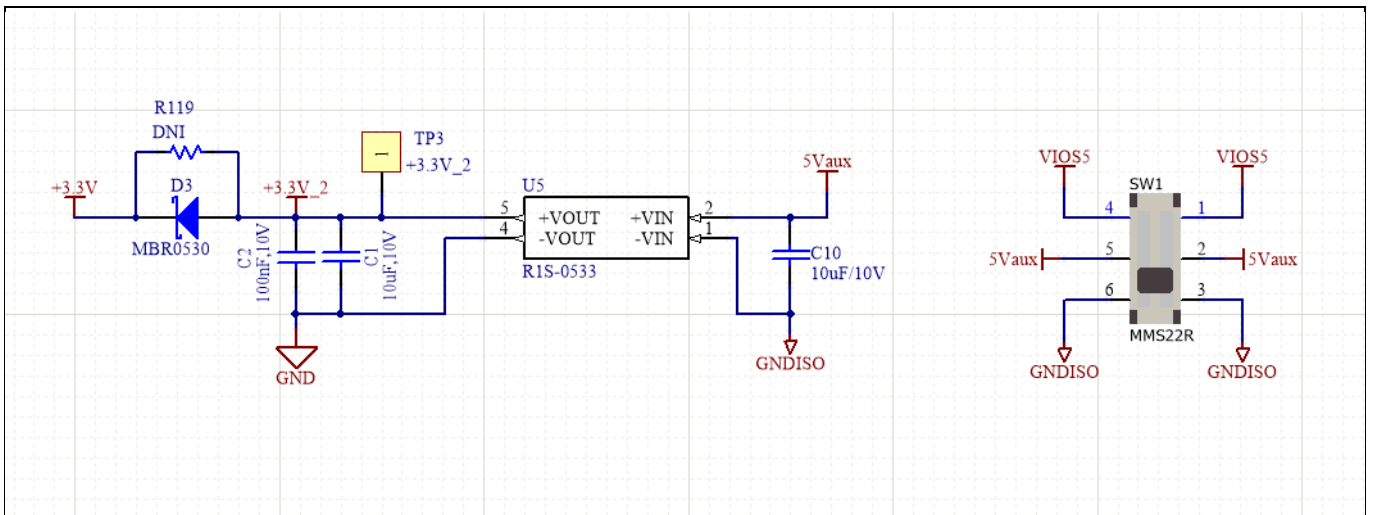


Figure 12 Isolated 3.3 V power supply and related switch of the EVAL-IMM101T evaluation board

4.5 Current measurement shift stage and Overcurrent threshold

Figure 13 provides the details of the current measurement shift stage:

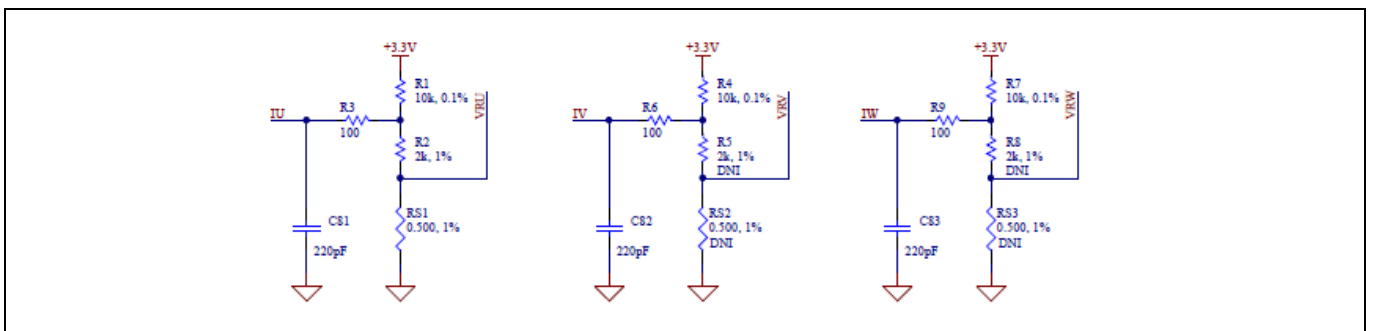


Figure 13 Current measurement shift stage

Schematics and Layout

In leg shunt configuration, the resistors RS1, RS2 and RS3 are purposed to generate voltages proportional to the source currents of the low side power MOSFETs. These voltages are shifted using the shift stages in Figure 13 and they are measured at pins P2.9, P2.6, P2.2 respectively.

In single shunt configuration, resistor RS1 is purposed to generate a voltage proportional to the sum of the source currents of the low side power MOSFETs. This voltage is shifted using the shift stage in Figure 13 and it is measured at pin P2.9 (P2.6, P2.2 are used only for leg shunt).

The shift stage is made of a voltage divider and a low pass filter; using the superposition theorem, it is possible to calculate the input current scaling and the shift stage offset. The input current scaling can be calculated using the following formula:

$$\text{Input Current Scaling} = RS_{1,2,3} \frac{R_{1,4,7}}{R_{1,4,7} + R_{2,5,8}} V/A$$

The ADC dynamic range can be calculated using the following formula:

$$\text{ADC range} = \frac{\text{Input Current Scaling}}{3.3 V} \times \text{Internal Gain} \times (2^{12} - 1) \text{ counts/A}$$

The Internal Gain can be set via MCEWizard and the default value for the EVAL-IMM101T is equal to 3. Particular attention has to be paid in setting the Internal Gain to avoid to saturate the ADC; this causes a continuous GateKill fault status in MCEDesigner.

The shift stage offset can be calculated using the following formula:

$$\text{Shift Stage Offset} = \frac{R_{2,5,8}}{R_{1,4,7} + R_{2,5,8}} \times 3.3 V$$

In single shunt configuration, RS2, RS3, R5 and R8 are not inserted.

The overcurrent comparator reference voltage can be calculate using the following formula:

$$\text{OVC Threshold} = (I_{u,v,w \text{ MAX peak}} \times \text{Input Current Scaling} + \text{Shift Stage Offset}) V$$

Thermal Characterization

5 Thermal Characterization

Figure 14, Figure 15, Figure 16, Figure 17, Figure 18, Figure 19 show the thermal characterizations of the three part numbers. The tests reported in Figure 14, Figure 15, Figure 16 have been performed under the following conditions: $t_{amb}=25^{\circ}\text{C}$, different phase current values until the case reaches 105°C , two PWM frequencies (6 and 16kHz) and two different modulation types (3-phase modulation and 2-phase flat bottom modulation). The tests reported in Figure 17, Figure 18, Figure 19 have been performed under the following conditions: $t_{amb}=60^{\circ}\text{C}$, different phase current values until the case reaches 105°C , two PWM frequencies (6 and 16kHz) and two different modulation type (3-phase modulation and 2-phase flat bottom modulation). 2-ph flat bottom modulation allows the reduction of the switching losses compared with 3-phase SVPWM (symmetrical placement of zero vectors). For the test with $t_{amb}=60^{\circ}\text{C}$, the 3-phase modulation has not been used. For all the tests, the phase current has been limited to 600 mArms in order to avoid damage to the motor used for the tests. A FR4 PCB with 2oz copper has been used and the PCB layout is shown in Figure 20.

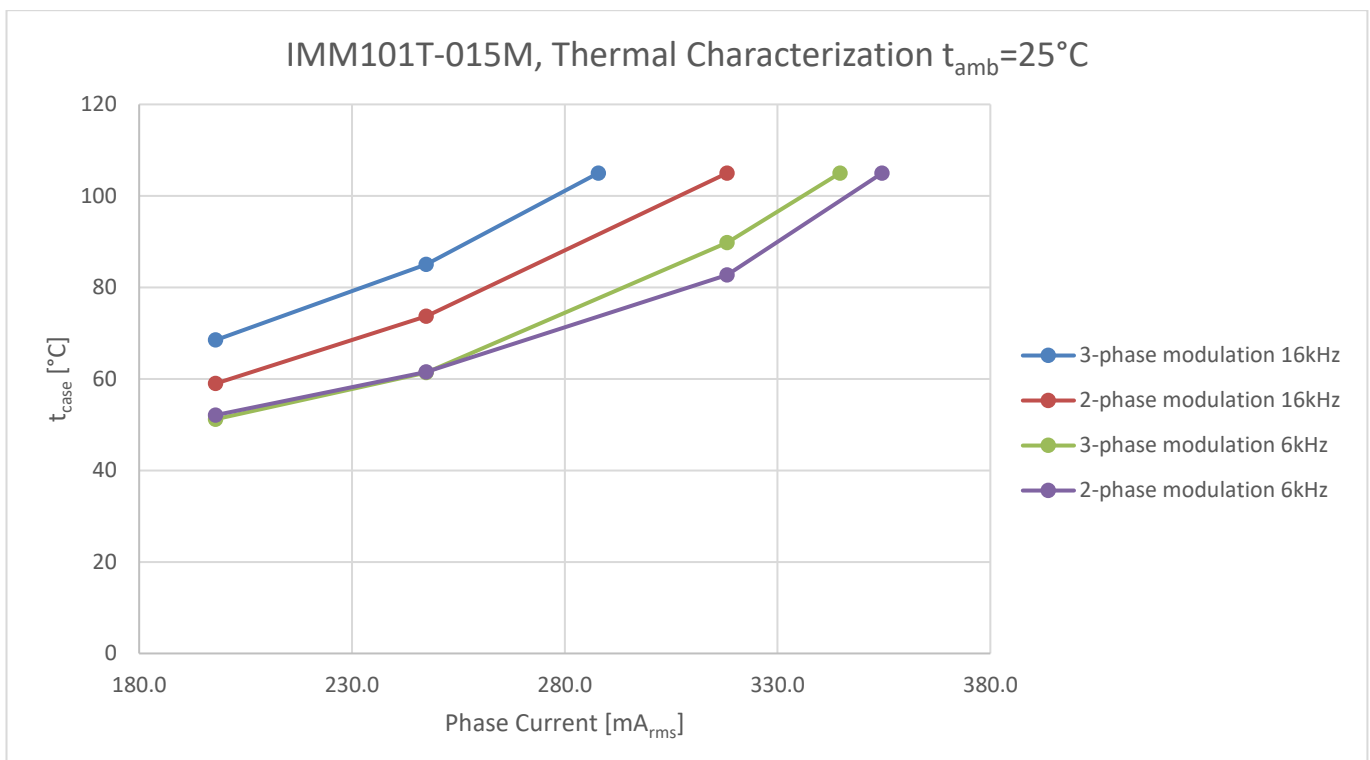


Figure 14 IMM101T-015M Thermal Characterization, $t_{amb}=25^{\circ}\text{C}$, different phase current values until the case reaches 105°C , FR4 PCB with 2oz copper

Thermal Characterization

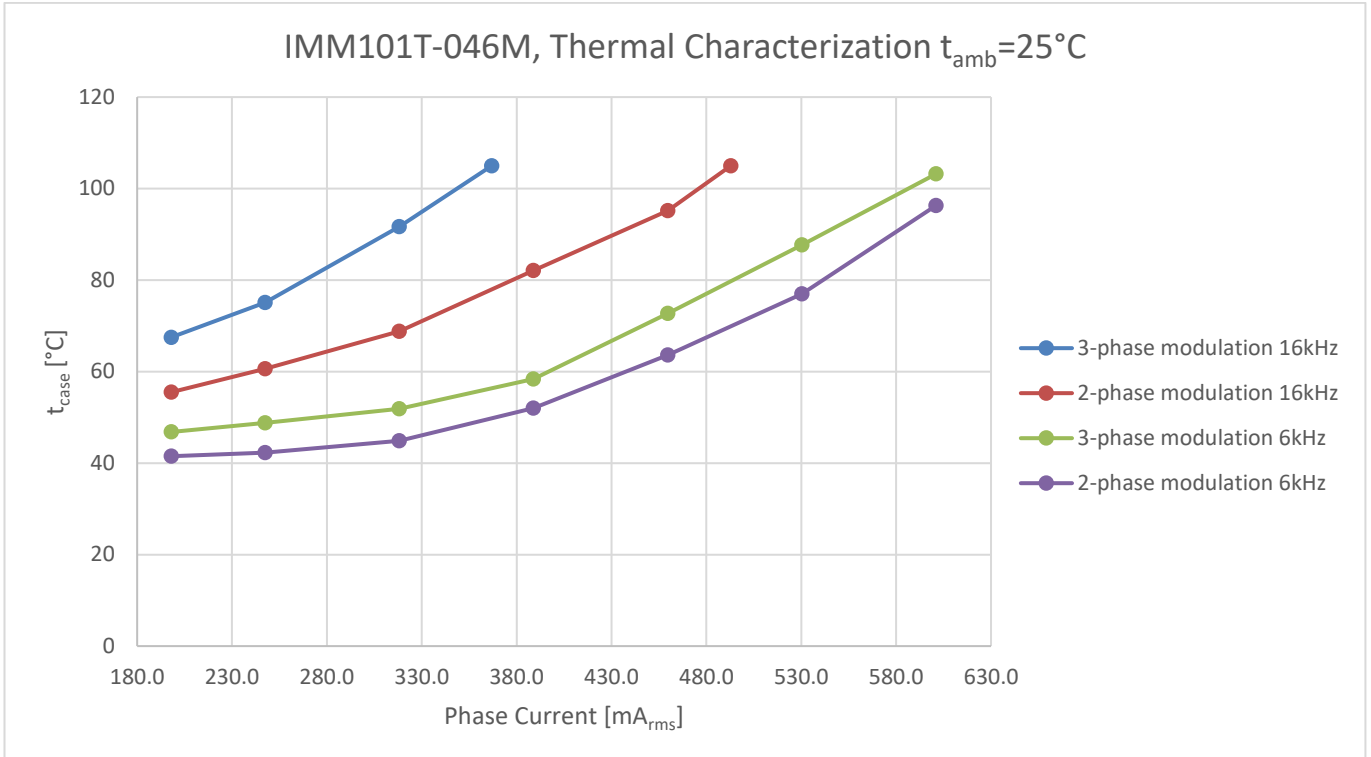


Figure 15 IMM101T-046M Thermal Characterization, $t_{amb}=25^{\circ}\text{C}$, different phase current values until the case reaches 105°C , FR4 PCB with 2oz copper

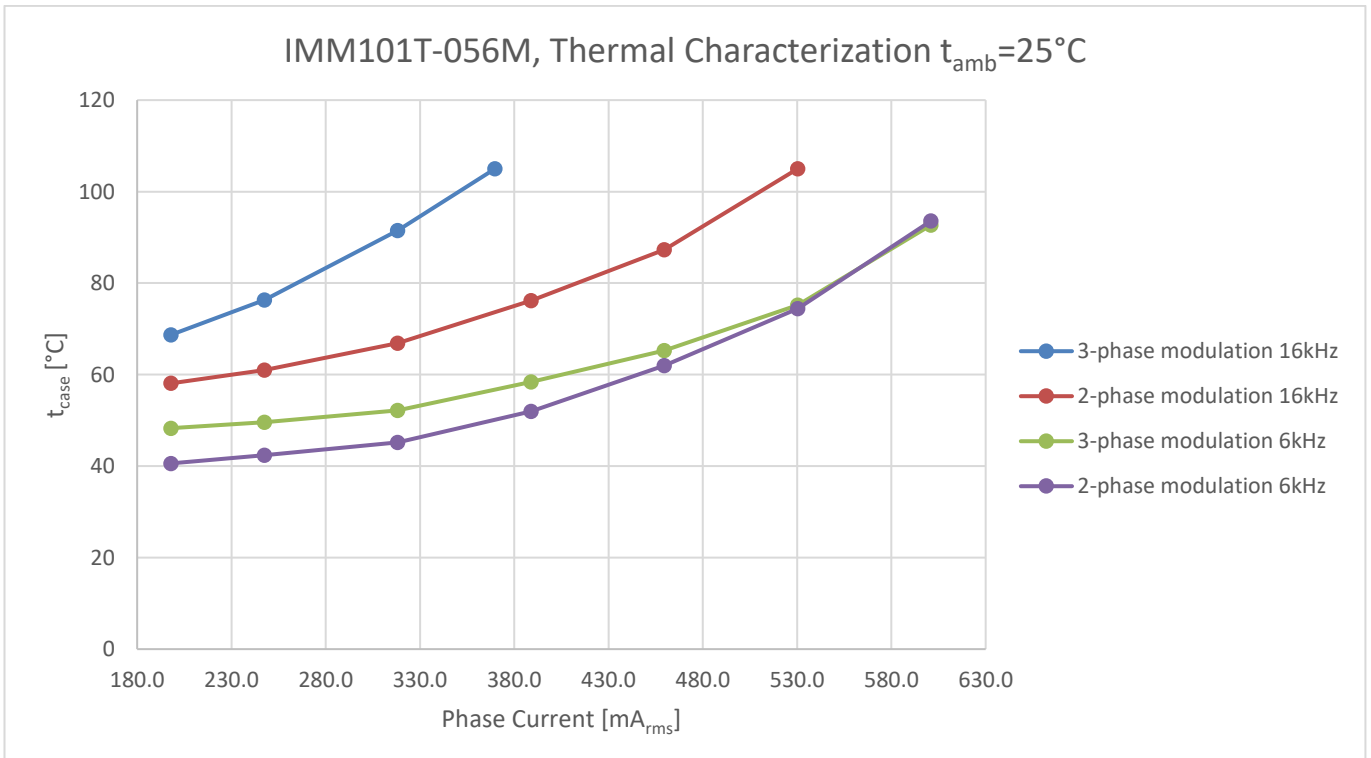


Figure 16 IMM101T-056M Thermal Characterization, $t_{amb}=25^{\circ}\text{C}$, different phase current values until the case reaches 105°C , FR4 PCB with 2oz copper

Thermal Characterization

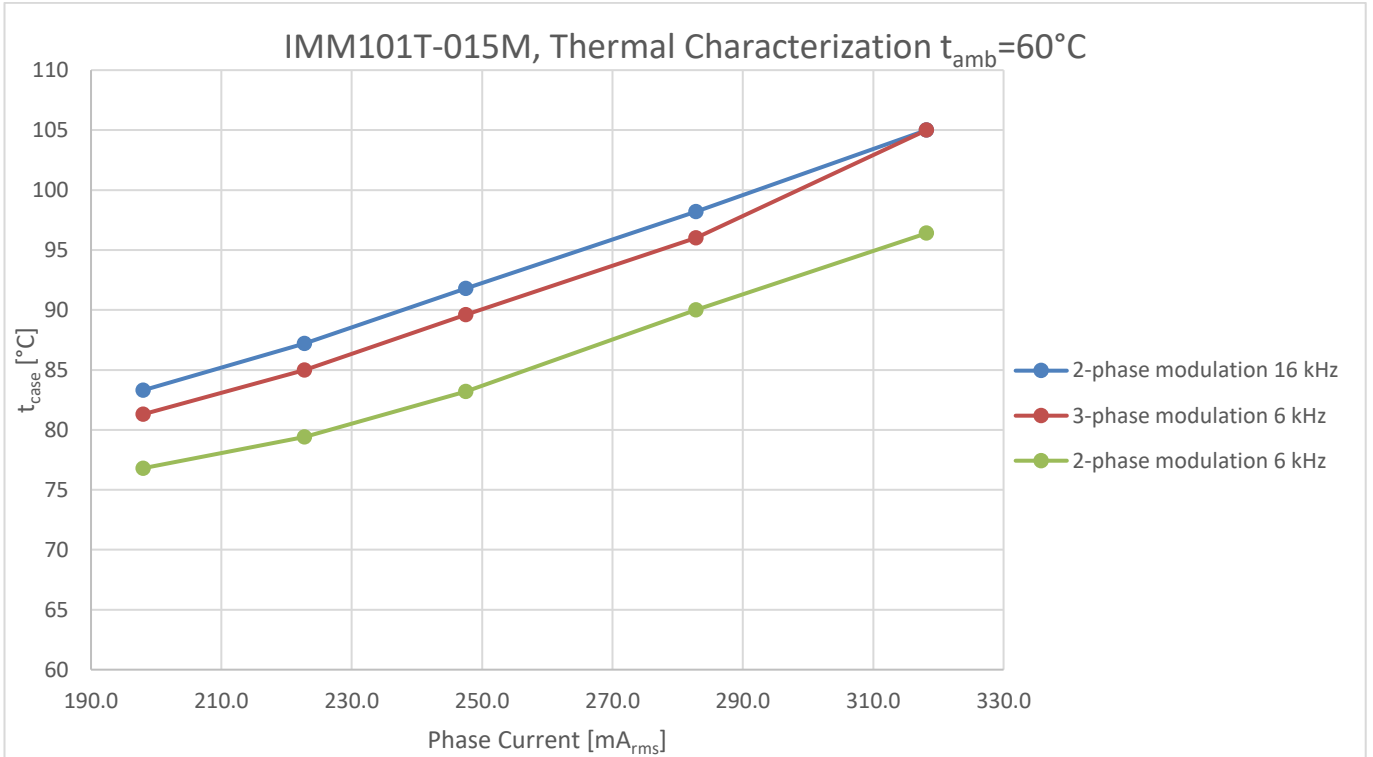


Figure 17 IMM101T-015M Thermal Characterization, $t_{amb}=60^{\circ}\text{C}$, different phase current values until the case reaches 105°C , FR4 PCB with 2oz copper

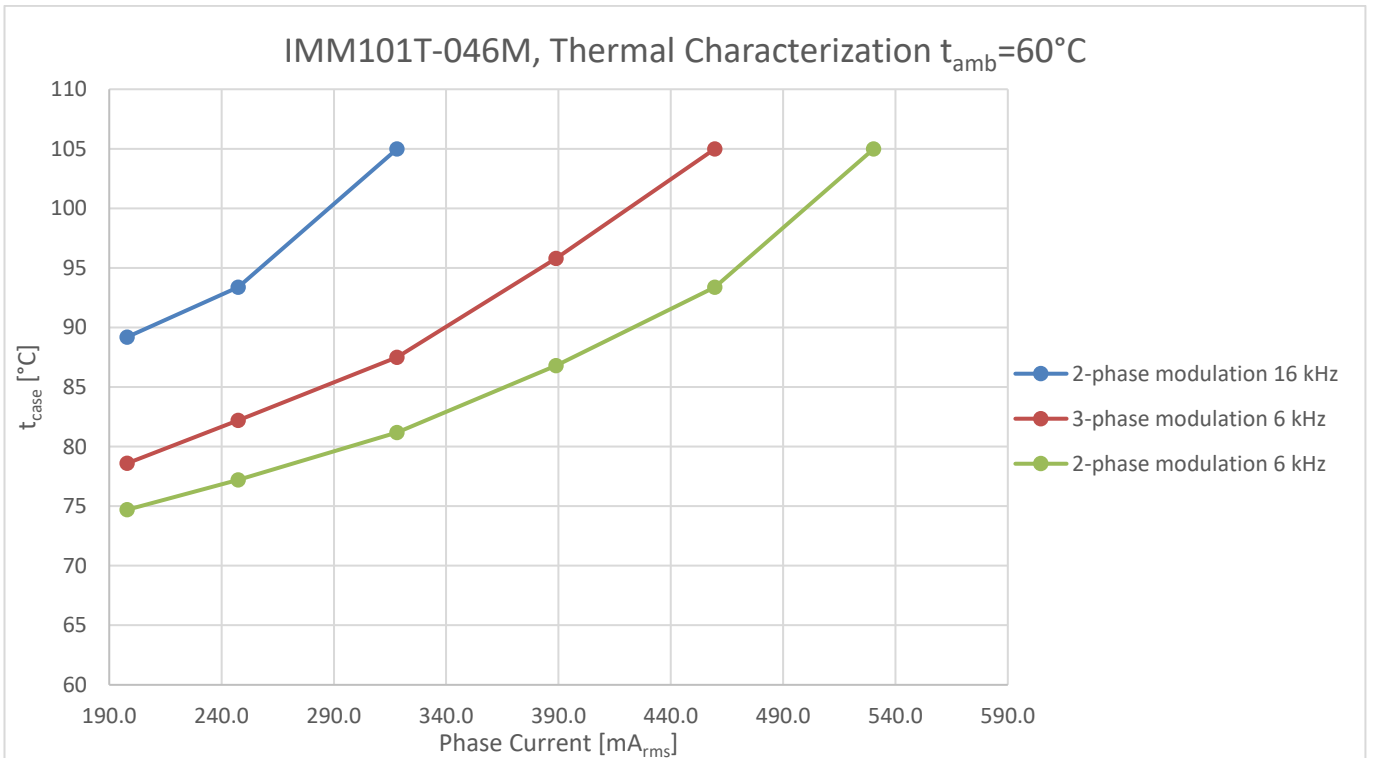


Figure 18 IMM101T-046M Thermal Characterization, $t_{amb}=60^{\circ}\text{C}$, different phase current values until the case reaches 105°C , FR4 PCB with 2oz copper

Thermal Characterization

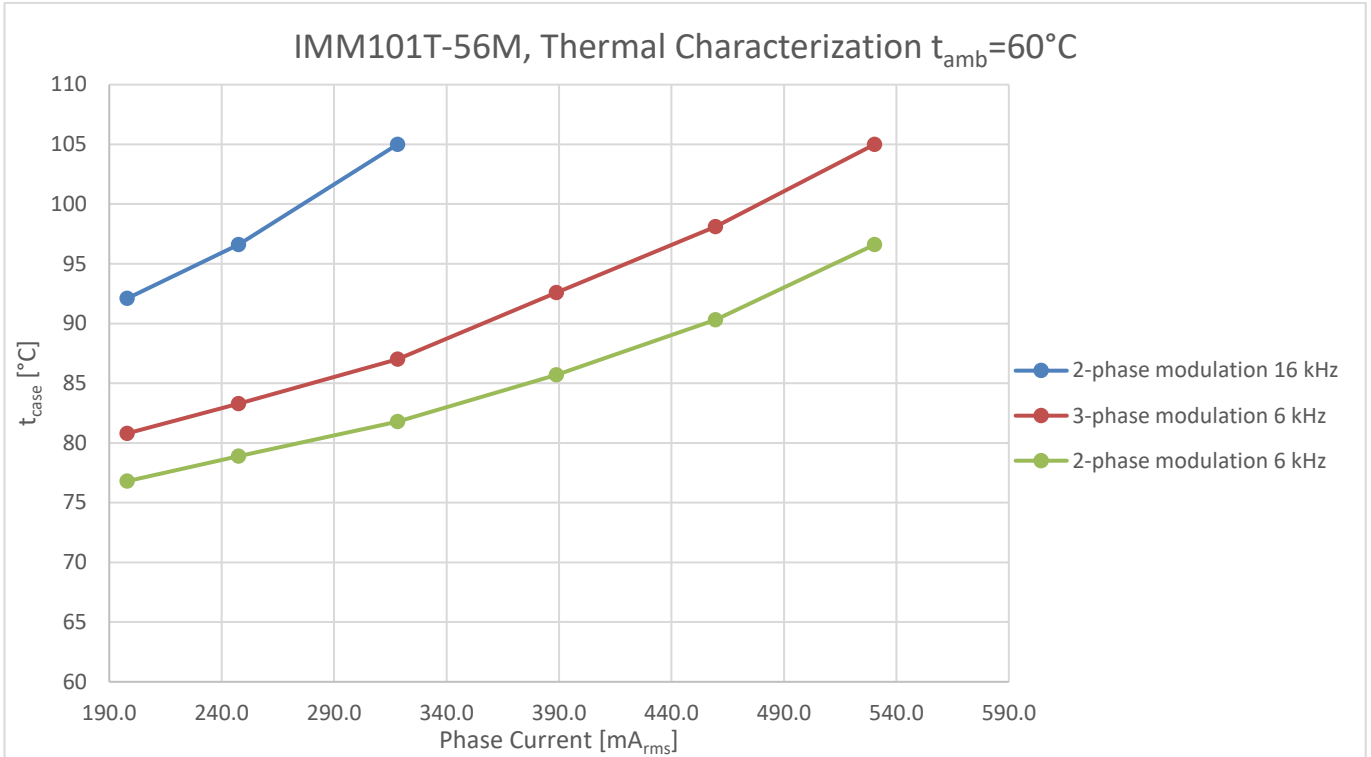


Figure 19 IMM101T-056M Thermal Characterization, $t_{amb}=60^{\circ}\text{C}$, different phase current values until the case reaches 105°C , FR4 PCB with 2oz copper

5.1 Thermal Characteristic

Table 1 Thermal Characteristics

Symbol	Description	Min	Typ	Max	Units
$R_{th(J-amb)}$	Total Thermal Resistance Junction to Ambient	---	27.7	---	$^{\circ}\text{C}/\text{W}$

The previous value of $R_{th(J-amb)}$ has been obtained under the following testing condition: $t_{amb}=25^{\circ}\text{C}$, $t_{hotspot}=51.6^{\circ}\text{C}$ and a dissipated power of 1W. A FR4 PCB with 2oz copper has been used and the PCB layout is shown in Figure 20.

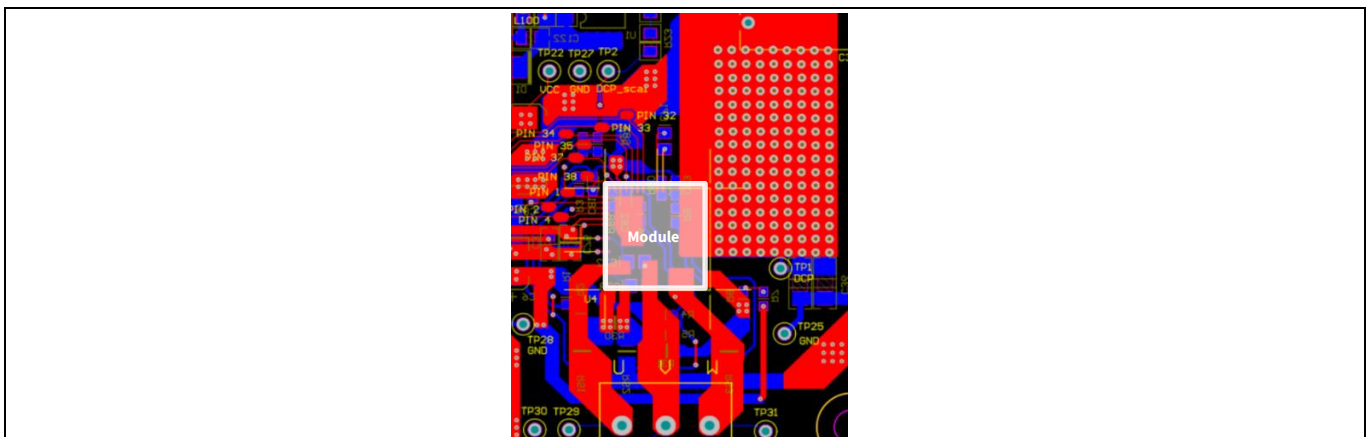


Figure 20 PCB layout used for thermal characterization: 2oz copper, 2 layers. DcBus Pad: 3,0 cm x 1,8 cm on both layers with 144 vias.

Thermal Protection

6 Thermal Protection

The IMM101T devices feature an integrated temperature sensor which allows to monitor the internal temperature of the module. The device temperature can be accessed using both MCEDesigner and the script enginlanguage. The particular register name for this functionality is InternalTemp and the register value is already in Kelvin [K].

In order to enable the over-temperature protection for the EVAL-IMM101T Starter Kit, a corresponding script file (.mcs) has been pre-loaded into the IMM101T IC mounted on the EVAL-IMM101T Starter kit, together with the latest IMM101T Software Package (v1.2.1 at the time of the release). The script function needs to be enabled in the MCEWizard Options page during the system setup, **otherwise the over-temperature protection will not be active**. In the future, the over-temperature protection will be implemented in the MCE firmware, so this script-based protection will not be needed anymore. Please always download the latest MCE software package for IMM101T from the Infineon website (www.infineon.com/imotion-software) and refer to the corresponding iMOTION™ MCE Software Reference Manual to get the list of all supported features. Also refer to the “How to use iMOTION™ Script Language” application note for more details about iMOTION Script functionality.

The script which is used for the over-temperature protection is shown below: the script is implemented to stop the motor when the measured temperature reaches 80°C (shut down temperature) and to restart the motor when the measured temperature goes below 60°C (restart temperature). Please note that the measured temperature is the controller temperature, whereas the hottest spot of the module is on the power switches. Based on expertimental results, the shut down temperature set in this case (80°C measured on controller) corresponds to the power switches temperature around 105°C.

```
#SET SCRIPT_USER_VERSION (1.00) /*Script version value should be 255.255*/
#SET SCRIPT_TASK0_EXECUTION_PERIOD (2) /*Script execution time for Task0
in mS, maximum value 65535*/
#SET SCRIPT_TASK1_EXECUTION_PERIOD (1) /*Script execution time for Task1
in 10mS, maximum value 65535*/
#SET SCRIPT_START_COMMAND (0x1) /* Start command, Task0 : Bit0, Task1 :
Bit1; if bit is set, script executes after init */
#SET SCRIPT_TASK0_EXECUTION_STEP (6) /* Script Task0 step, This defines
number of lines to be executed every 1mS*/
#SET SCRIPT_TASK1_EXECUTION_STEP (11) /* Script Task1 step, This defines
number of lines to be executed every 10mS*/

Script_Task0_init()
{
    int t_hyst, t_shutdown, flag, temperature; /*Local variables
declaration*/

    /*Local variables initialization*/
    t_hyst=333; /*60°C, please insert the value in Kelvin*/
    t_shutdown=353; /*80°C, please insert the value in Kelvin*/
    flag=0;
    temperature=0;
}
```

Thermal Protection

```
Script_Task0 ()
{
    temperature=InternalTemp;

    if((temperature<t_hyst)&&(flag==1)) /*If t_hyst<temperature<t_shutdown
and the motor is in stop condition, it is not possible to restart*/
    {
        flag=0;
        Command=1;
    }

    if(temperature>t_shutdown) /*If temperature>t_shutdown, motor is
stopped*/
    {
        Command=0;
        flag=1;
    }

    if(flag==1)
    {
        Command=0;
    }
}
```

Note: *The script function in MCEWizard Options page has to be enabled in order to allow the script functionality to be active. If this function is not enabled, the script won't be executed even if it is correctly downloaded into the flash.*

Note: *If another script is downloaded into the module, the over-temperature protection script will be overwritten and the protection will no longer be available.*

Note: *The listing above corresponds to the script version at the time of the board release, which may change in the future. The most actual source code of this script and any other script for the EVAL-IMM101T will be made available in the "Tools & Software" section of the EVAL-IMM100 Website in the "EVAL-IMM100 Script Package" file.*

Note: *The firmware programming procedure erases the flash content. Therefore, each time the MCE firmware is programmed into the device, also the script has to be compiled and downloaded into the flash memory at the same time, in order to have over-temperature protection. Also, the script function in MCEWizard Options page has to be enabled*

7 Getting started with EVAL-IMM101T

The IMM101T devices are shipped with firmware and default parameters already programmed. The following steps have to be performed in order to achieve a usable motor controller IC:

- Programming of the Motion Control Engine (MCE)
- Programming of parameter sets for system and motor
- Programming of any customer scripts (optional)
- Programming of the combined file for an integrated system (optional)

The iMOTION™ Software Tools MCEDesigner and MCEWizard are required in order to initially setup the system, as well as to control and fine-tune the system performance to match users exact needs. These tools are available for download via Infineon website (<http://www.infineon.com/imotion-software>). All supported tool and software versions 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 IMM101T device. J-Link driver will be installed during the MCEDesigner installation. In case the driver is not installed properly, please go to [SEGGER J-Link website](#) to download and install the latest J-Link “Software and Documentation pack for Windows”.

This chapter provides more details on setting up the system and getting started with iMOTION™ development platform.

Note: Firmware update is recommended before using the Starter Kit in order to work with the latest firmware release available.

7.1 Setting up the system

After downloading and installing the iMOTION™ PC Tools (MCEWizard and MCEDesigner), following steps need to be executed in order to run the motor. Refer to MCEWizard and MCEDesigner documentation for more information.

Getting started with EVAL-IMM101T

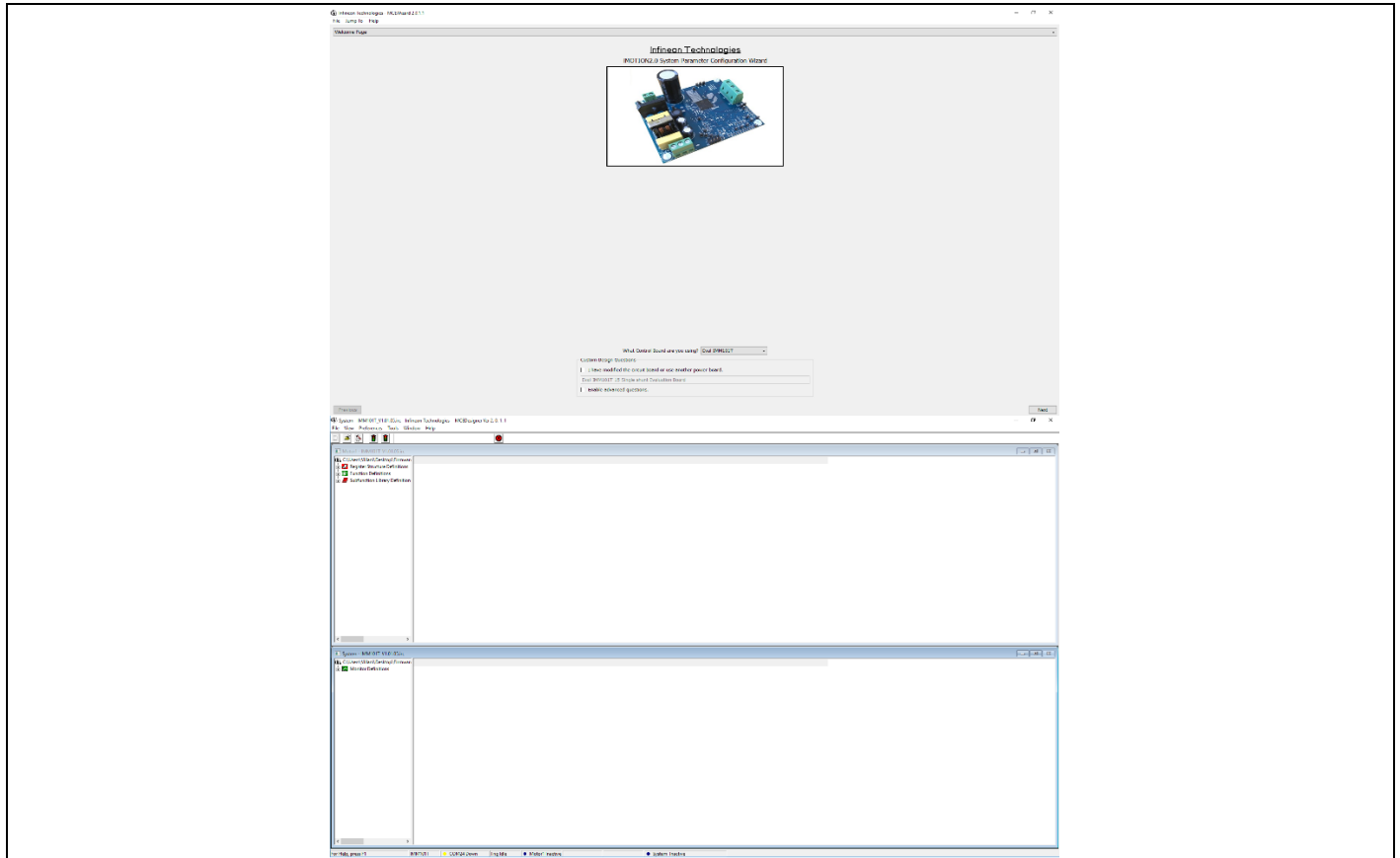


Figure 21 MCEWizard and MCEDesigner welcome pages

The steps needed to run the motor are:

1. Connect PC-USB connector on the on-board debugger to the PC via USB cable
2. 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.
3. After system and operating parameters are set, go in the “Verify & Save Page” and click on “Calculate” button. If no errors are reported, it is possible to save the drive parameter set into your project directory by clicking “Export to Designer file (.txt)” (Figure 22); if some error is detected, double click on the error message (highlighted in red) and adjust the related parameter. Saved Drive System Parameter File will be later used by the MCEDesigner.

Getting started with EVAL-IMM101T

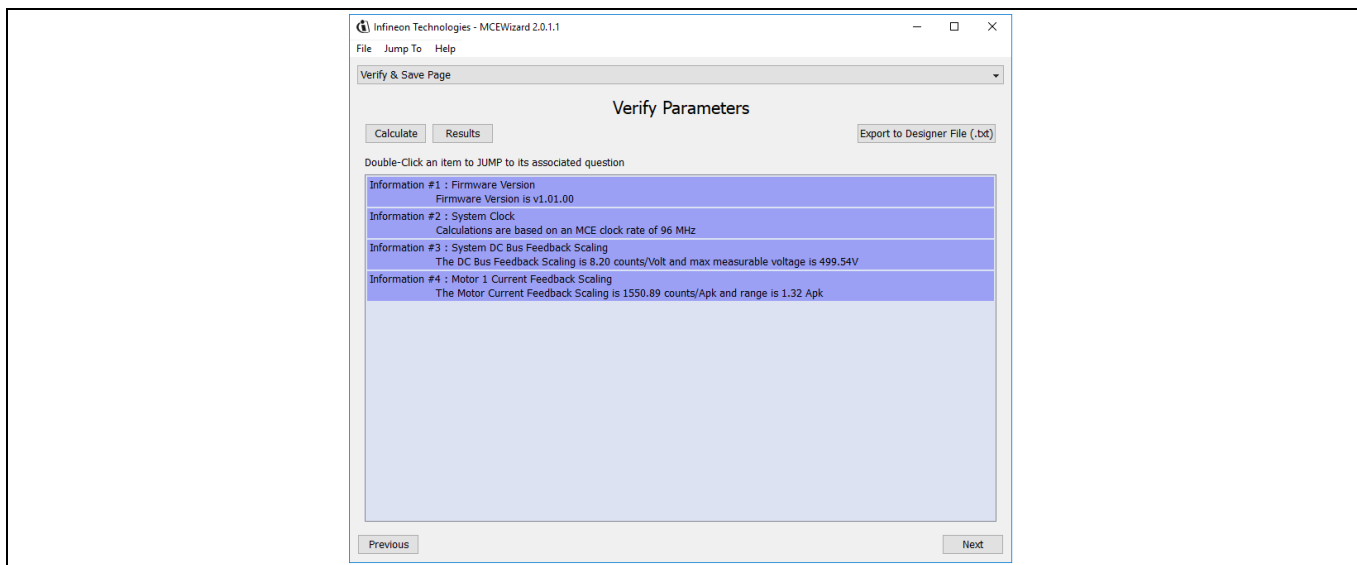


Figure 22 MCEWizard Verify and Save page

4. Connect motor phase outputs to the motor
5. Connect AC power to power input connector and power on the system or give the 3.3 V supply to the controller switching on the switch on the left side of the board (the communication is in any case isolated).
6. Start MCEDesigner tool and open MCEDesigner default configuration file (.irc) for IMM101T device (IMM101T_Vxxx.irc) by clicking “File” > “Open”. IMM101T_Vxxx.irc file is included in “IMM101T MCE Software Package” downloaded in step 1
7. MCEDesigner should automatically connect to the EVAL-IMM101T evaluation 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 COM port by doing the following steps: click on the “System” window and then click on Preferences > Connection > Connect using and chose one of the other available COM ports from the drop-down list
8. If the firmware has been erased from the module, a warning message will pop up saying “Target device firmware and parameters file are not programmed! Please program firmware and parameters file” (Figure 23)

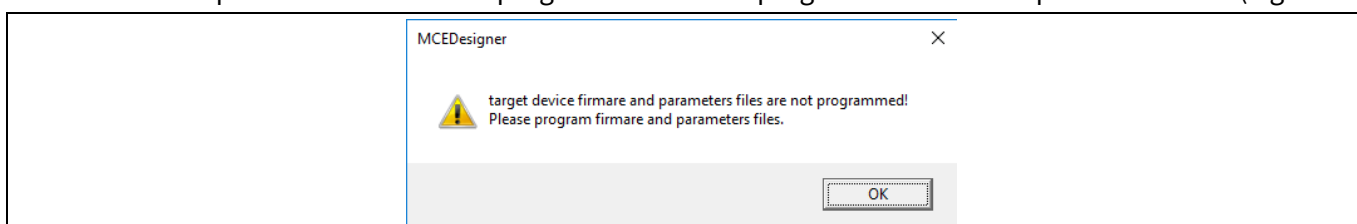


Figure 23 MCEDesigner warning message

9. Use the following steps to program the firmware and the parameters file into the internal Flash memory of iMOTION™ Control IC: click on system page, click “Tools” > “Programmer” and select “Program Firmware and Parameters” (Figure 24). The encrypted firmware is available in “IMM101T MCE Software Package” downloaded in step 1 as .ldf file. Regarding the parameters file, browse and select the .txt file created in step 4

Getting started with EVAL-IMM101T

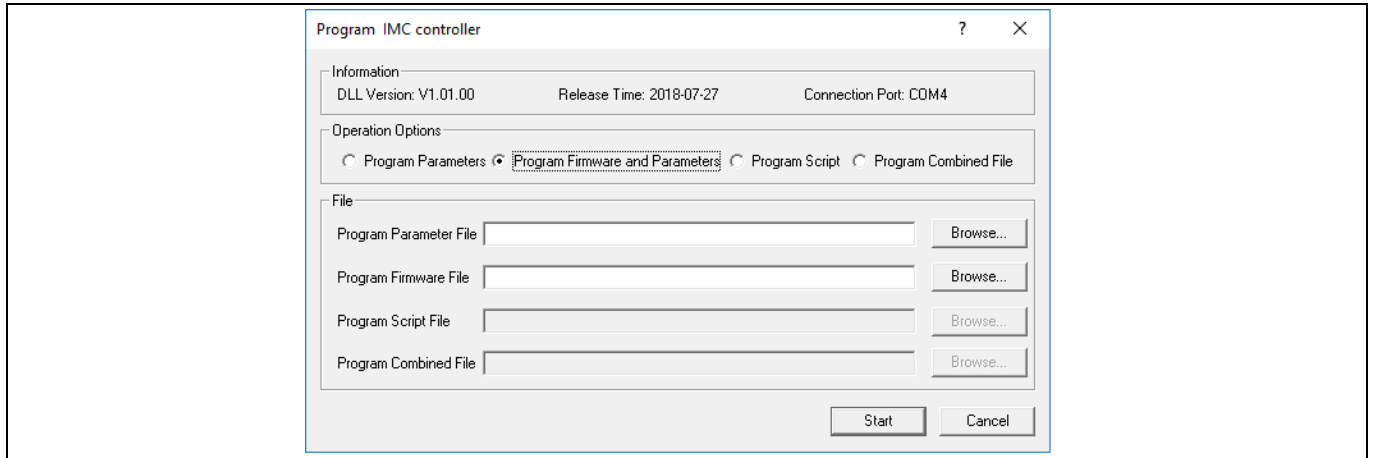


Figure 24 MCEDesigner programmer page

10. Start the motor by clicking the green traffic light button in the control bar
11. Once the firmware has been programmed, in case a new parameters file has to be programmed, follow the same instructions given in step 9. In this case, firmware programming is no more needed and it is possible to select the first option “Program Parameters”
12. In case of firmware update, follow the instructions given in step 9

Note: For detailed information on controller programming, refer to AN2018-33 iMOTION™ 2.0 Device Programming, MCEDesigner documentation and MCEWizard documentation.

PCB Layout

8 PCB Layout

The layout of this board can be used for different voltage or power classes. The power PCB is a two layer PCB. Get in contact with our technical support team to get more detailed information and the latest Gerber-files.

Figure 25 illustrates the top assembly print of the evaluation board

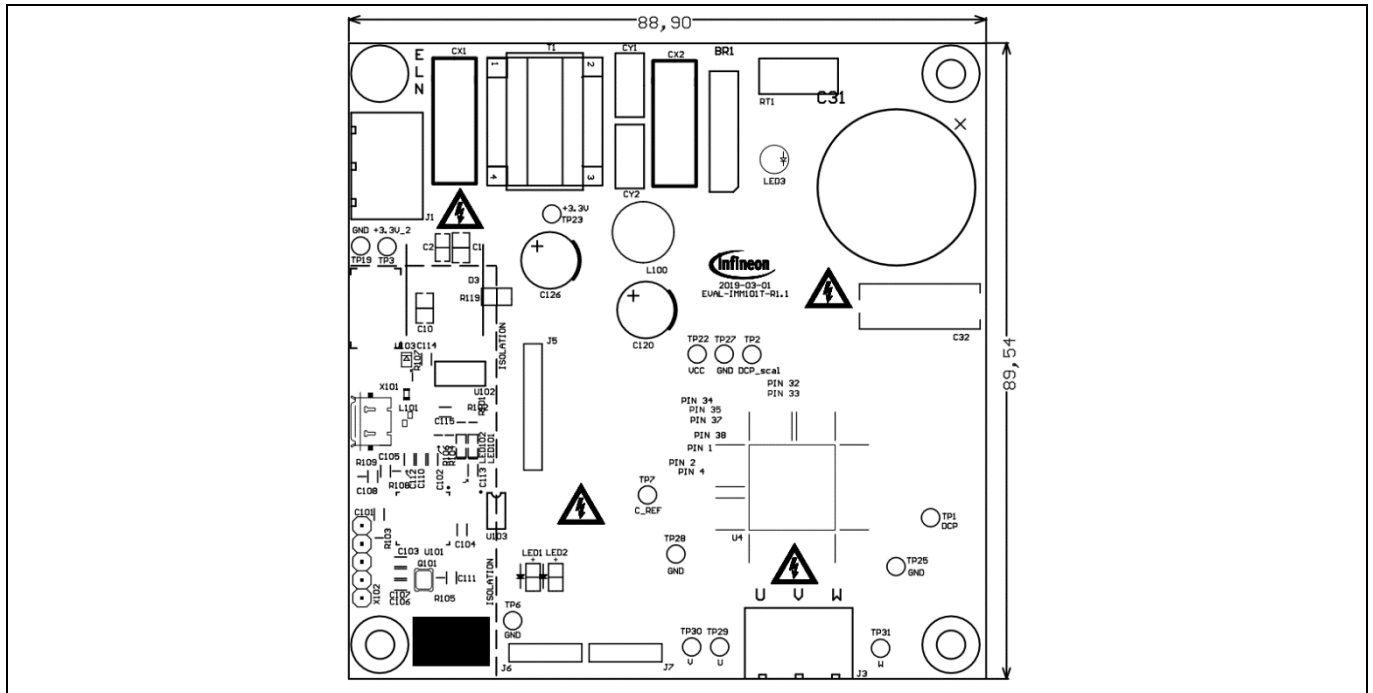


Figure 25 Top assembly print of the EVAL-IMM101T evaluation board

Figure 26 depicts the bottom assembly print of the evaluation board.

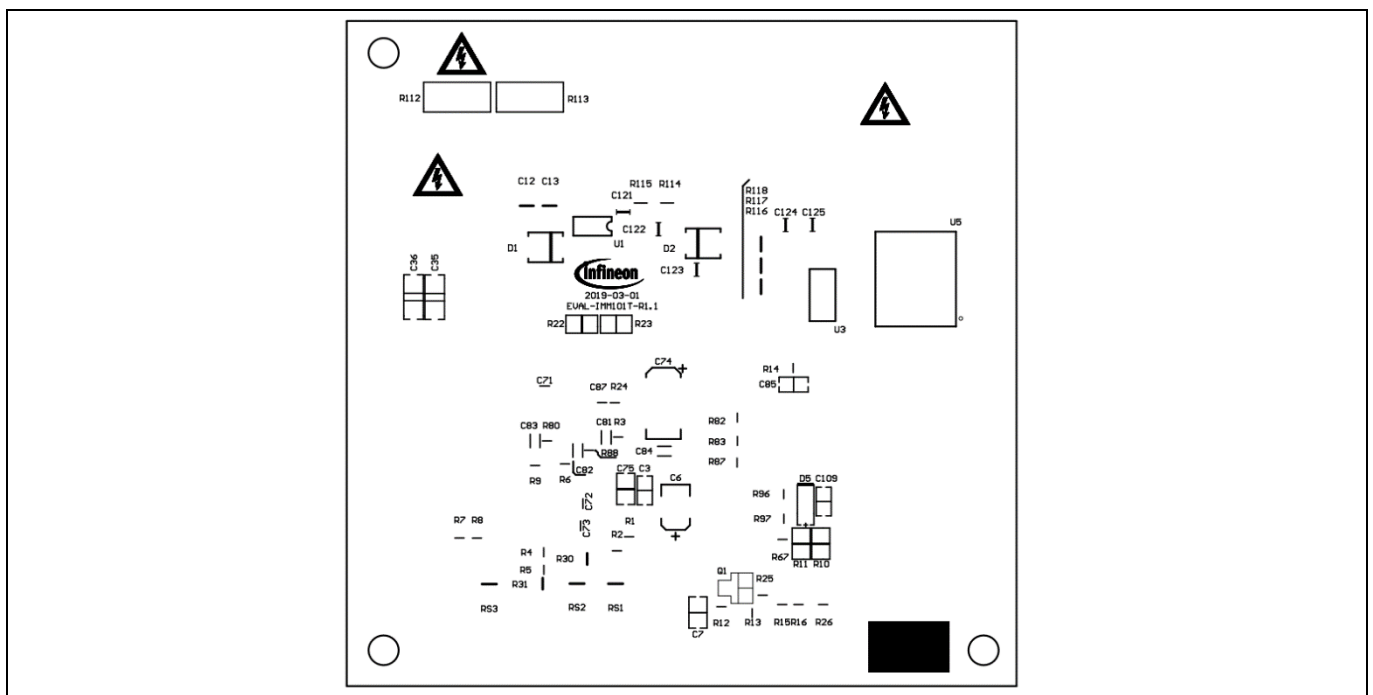


Figure 26 Bottom assembly print of the EVAL-IMM101T evaluation board

PCB Layout

The top layer of the PCB is provided in Figure 27.

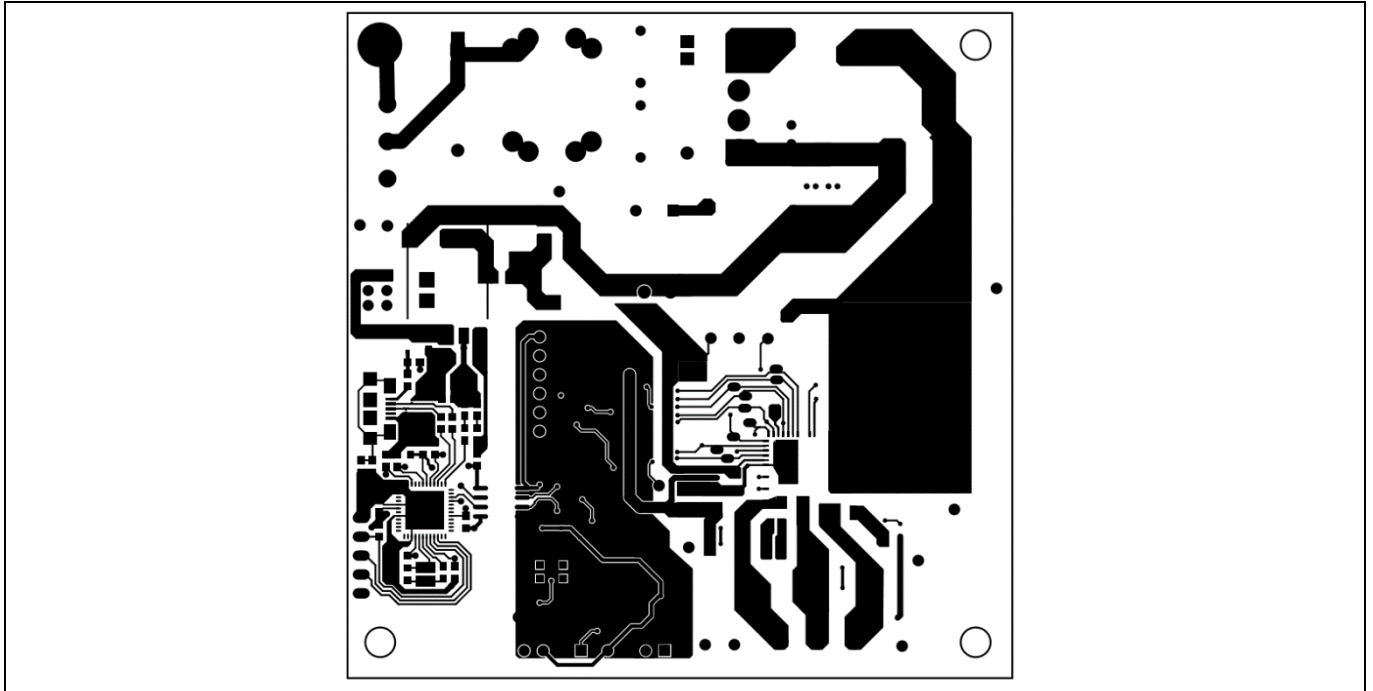


Figure 27 Top layer of the EVAL-IMM101T

Figure 28 illustrates the bottom layer routing of the PCB.

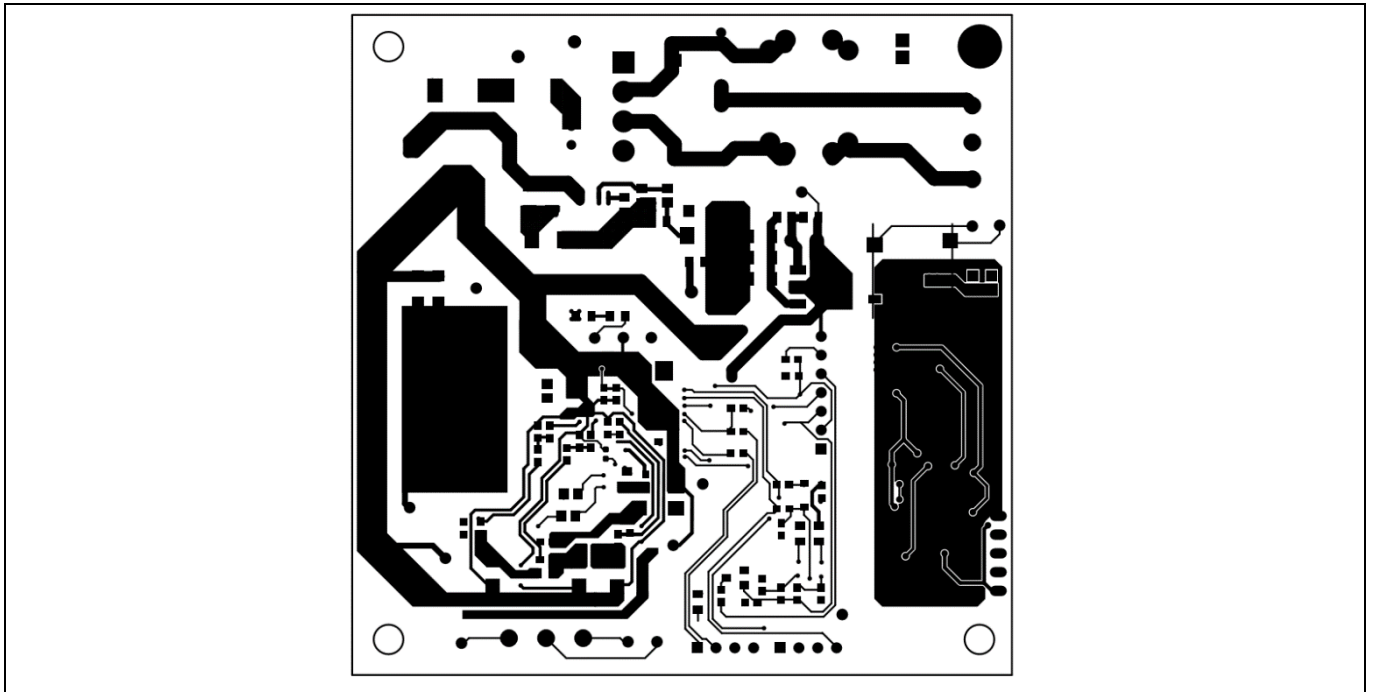


Figure 28 Bottom layer of EVAL-IMM101T

9 Application Diagrams and Application Use Cases

9.1 Application Diagrams

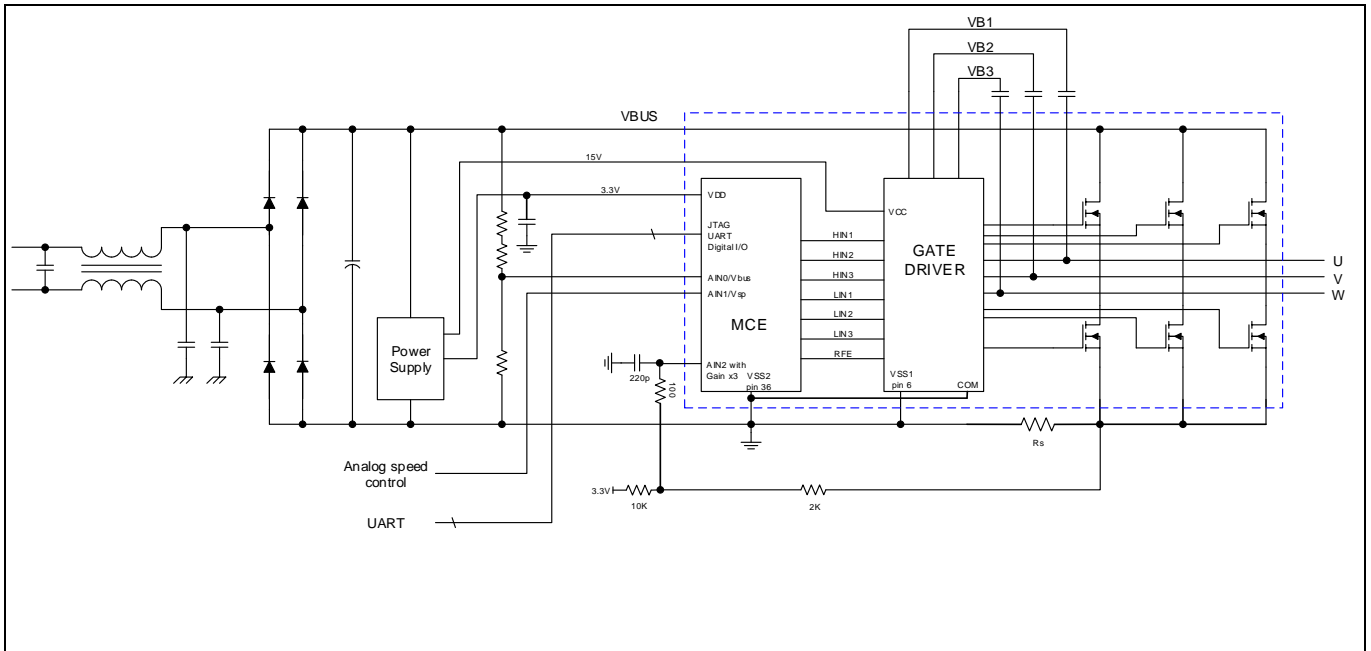


Figure 29 Application Block Diagram using IMM101T - Single Shunt Configuration

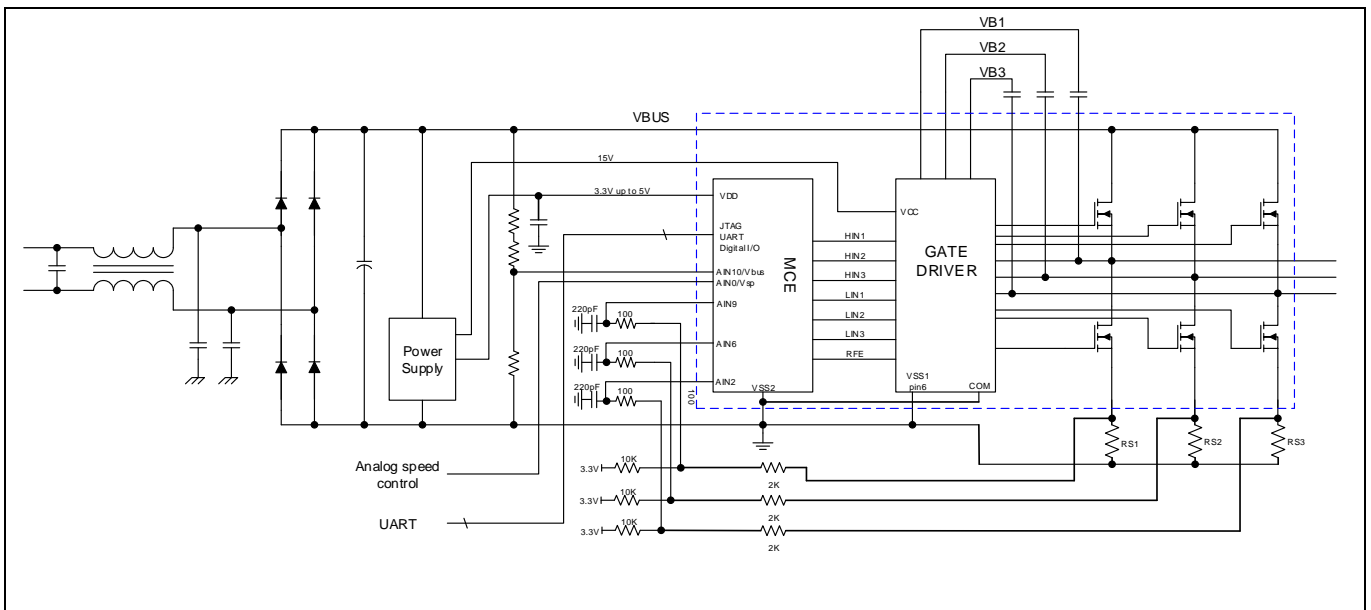


Figure 30 Application Block Diagram using IMM101T - Leg Shunts Configuration

9.2.2 Sensorless Leg Shunt

The sensorless leg shunts configuration may be used in applications where only very low acoustic noise is required.

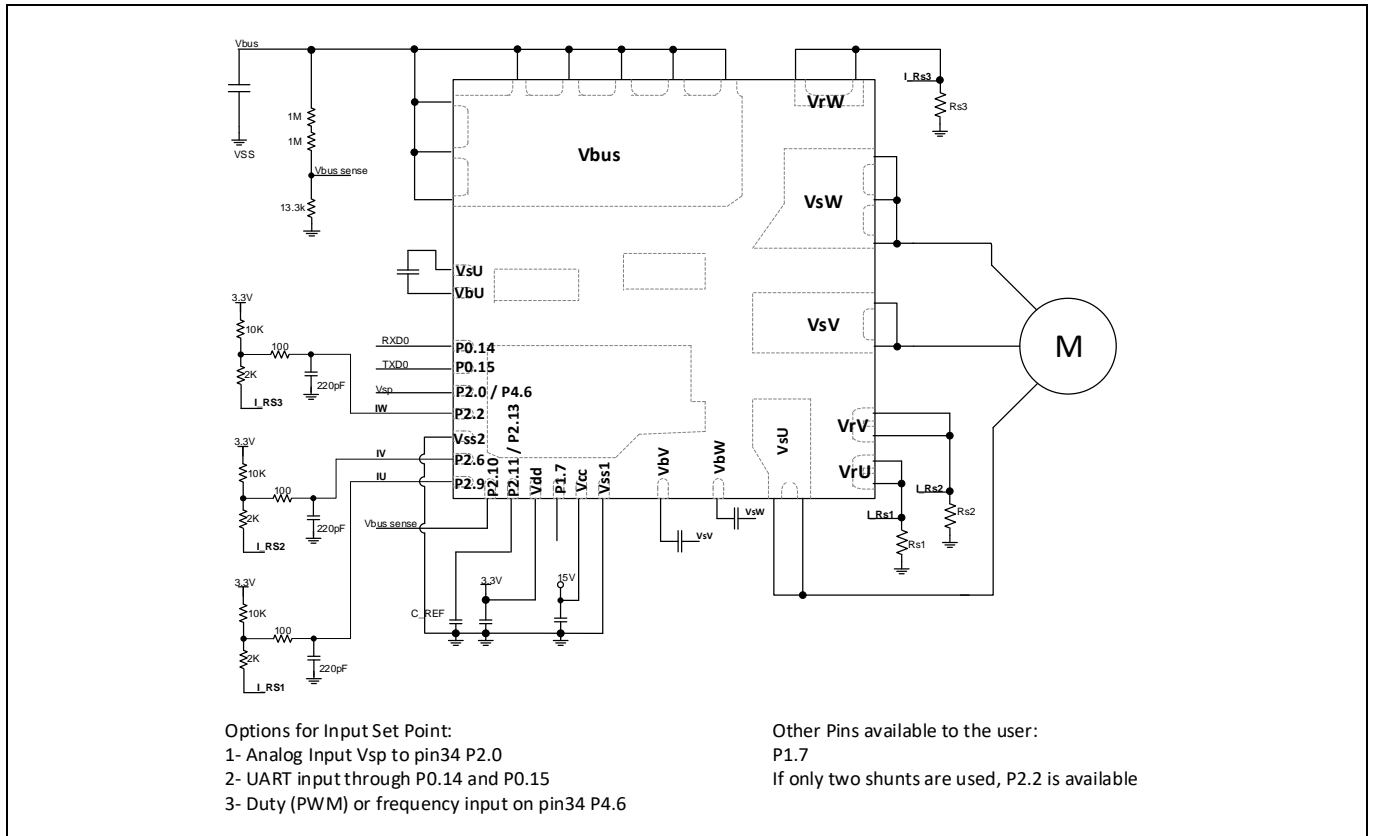


Figure 32 IMM101T Sensorless, three leg shunts configuration

EVAL-IMM101T’s current sensing configuration is single shunt by default. To use leg shunt configuration, follow these steps:

- Remove R30 and R31
- Mount R80 and R88 equal to 0 Ω
- Mount RS2 and RS3

Bill of Materials of EVAL-IMM101T

10 Bill of Materials of EVAL-IMM101T

Table 11 Bill of materials

No.	Qty.	Part description	Designator	Part Number	Manufacturer
1	1	KBP206G 2A 600V DIP-4	BR1	KBP206G	Yunhui
2	1	CAP CER 10UF 10V X5R 0805	C1	885012107010	Würth Electronics Inc.
3	2	CAP CER 0.1UF 10V X7R 0603	C2, C3	885012206020	Würth Electronics Inc.
4	1	CAP TANT 22UF 10% 25V 2917	C74	T491D226K025AT	KEMET
5	1	CAP TANT 22UF 10% 10V 1411	C6	TPSB226M010R0400	AVX Corporation
6	1	CAP CER 10UF 10V X5R 1206	C10	885012108010	Würth Electronics Inc.
7	4	CAP CER 0.012µF 500V X7R 1206	C12, C13, C35, C36	1206J5000123MDR	Knowles Syfer
8	1	CAP ALUM 82UF 20% 450V SNAP	C31	861221483002	Würth Electronics Inc.
9	1	0.1µF Film Capacitor 630V Polyester,	C32	890303425004CS	Würth Electronics Inc.
10	3	CAP CER 1UF 25V X5R 0805	C71, C72, C73	885012107015	Würth Electronics Inc.
11	1	CAP CER 0.1UF 25V X7R 0805	C75	885012207072	Würth Electronics Inc.
12	3	CAP CER 220PF 25V COG/NP0 0603	C81, C82, C83	885012006040	Würth Electronics Inc.
13	2	CAP CER 4700PF 25V COG/NP0 0805	C84, C87	885012007044	Würth Electronics Inc.
14	1	CAP CER 2200PF 25V COG/NP0 0805	C85	885012007042	Würth Electronics Inc.
15	7	CAP CER 0.1UF 50V X7R 0603	C101, C102, C103, C104, C108, C110, C111	885012206095	Würth Electronics Inc.
16	3	CAP CER 10UF 10V X5R 0603	C105, C114, C115	C0603C106M8PAC7867	KEMET
17	2	CAP CER 15PF 25V COG/NP0 0603	C106, C107	885012006033	Würth Electronics Inc.
18	2	CAP CER 1UF 25V X5R 0603	C109, C113	885012106022	Würth Electronics Inc.

Bill of Materials of EVAL-IMM101T

No.	Qty.	Part description	Designator	Part Number	Manufacturer
19	1	CAP CER 4.7UF 10V X5R 0603	C112	885012106012	Würth Electronics Inc.
20	1	CAP ALUM 220UF 20% 35V RADIAL	C120	860020574012	Würth Electronics Inc.
21	3	CAP CER 0.1UF 50V X7R 0805	121, C123, C124	885012207098	Würth Electronics Inc.
22	1	CAP CER 1UF 25V X5R 0805	C122	885012107015	Würth Electronics Inc.
23	1	CAP CER 10UF 6.3V X5R 0805	C125	885012107004	Würth Electronics Inc.
24	1	CAP ALUM 220µF 16V RADIAL	C126	860080374009	Würth Electronics Inc.
25	2	CAP FILM 0.1UF 10% 275VAC RADIAL	CX1, CX2	890324025017CS	Würth Electronics Inc.
26	2	CAP CER 2200pF 250VAC RADIAL	CY1, CY2	DE2E3KY222MN3A M02F	Murata Electronics North America
27	2	Diode Standard 600V 1A Surface Mount SMA	D1, D2	US1J-13-F	Diodes Incorporated
28	1	DIODE SCHOTTKY 30V 500MA SOD123	D3	MBR0530	ON Semiconductor
29	2	SERIE 2165S - 5.08 MM - HORIZONTAL CABLE ENTRY WITH RISING CAGE CLAMP - WR-TBL	J1, J3	691216510003S	Würth Electronics Inc.
30	1	FIXED IND 2.2mH THROUGH HOLE	L100	RLB0914-222KL	Bourns Inc.
31	1	FERRITE BEAD 60 OHM 0603 1LN	L101	BLM18PG600SN1D	Murata Electronics North America
32	1	LED RED CLEAR 0603 SMD	LED1	150060RS75000	Würth Electronics Inc.
33	2	LED GREEN CLEAR 0603 SMD	LED2, LED101	150060GS75000	Würth Electronics Inc.
34	1	LED RED CLEAR T/H	LED3	151034RS03000	Würth Electronics Inc.
35	1	LED BLUE CLEAR 0603 SMD	LED102	150060BS75000	Würth Electronics Inc.
36	1	CRYSTAL 12.0000MHZ 8PF SMD	Q101	NX3225GA-12MHZ-STD-CRG-2	NDK America, Inc.
37	5	RES SMD 10Kohm 1/10W 0603 1%	R1, R4, R7, R103, R108	RT0603DRD0710KL	Yageo
38	4	RES SMD 2Kohm 1/10W 0603 1%	R2, R5, R8, R102	RC0603FR-072KL	Yageo

Bill of Materials of EVAL-IMM101T

No.	Qty.	Part description	Designator	Part Number	Manufacturer
39	5	RES SMD 100ohm 1/10W 0603 1%	R3, R6, R9, R12, R13	RT0603DRD07100R L	Yageo
40	2	DNI	R10, R119		Yageo
41	1	RES SMD 9.1Kohm 1/8W 0805	R11	RC0805JR-079K1L	Yageo
42	1	RES SMD 47ohm 1/10W 0603 5%	R14	RT0603BRD0747RL	Yageo
43	2	RES SMD 1M OHM 1% 1/10W 0603	R22, R23	RC0603FR-071ML	Yageo
44	1	RES SMD 13.3K OHM 1% 1/10W 0603	R24	RC0603FR-0713K3L	Yageo
45	5	RES SMD 0 OHM JUMPER 1/10W 0603	R25, R26, R82, R96, R97	RC0603JR-070RL	Yageo
46	2	RES SMD 0 OHM JUMPER 1/8W 0805	R30, R31	RC0805JR-070RL	Yageo
47	1	RES SMD 9.1K OHM 5% 1/10W 0603	R101	RC0603JR-079K1L	Yageo
48	2	RES SMD 33 OHM 1% 1/10W 0603	R104, R106	RC0603FR-0733RL	Yageo
49	1	RES SMD 510 OHM 5% 1/10W 0603	R105	RC0603JR-07510RL	Yageo
50	1	RC0603JR-074K7L	R107	RC0603JR-074K7L	Yageo
51	1	RES SMD 1M OHM 1% 1/10W 0603	R109	RC0603FR-071ML	Yageo
52	2	RES SMD 75K OHM 5% 1W 2512	R112, R113	RC2512JK-0775KL	Yageo
53	1	RES SMD 15.8K OHM 1% 1/8W 0805	R114	RC0805FR-0715K8L	Yageo
54	1	RES SMD 2K OHM 5% 1/8W 0805	R115	RC0805JR-072KL	Yageo
55	3	RES SMD 300 OHM 5% 1/4W 1206	R116, R117, R118	RC1206JR-07300RL	Yageo
56	3	RES 0.5 OHM 1% 1/4W 1206(EVAL-IMM101T-015)	RS1, RS2 (DNI), RS3 (DNI)	RL1206FR-070R5L	Yageo
57	3	RES 0.25 OHM 1% 1/4W 1206(EVAL-IMM101T-046)	RS1, RS2 (DNI), RS3 (DNI)	RL1206FR-070R25L	Yageo
58	14	TEST POINT PC MINI .040"D WHITE	TP1, TP2, TP3, TP6, TP7, TP19,	5002	Keystone Electronics

Bill of Materials of EVAL-IMM101T

No.	Qty.	Part description	Designator	Part Number	Manufacturer
			TP23 TP25, TP22, TP27, TP28, TP29, TP30, TP31,		
59	1	NTC 15Ω 9MM DIA	RT1	NTC15D-9	SHIN-HANG
60	1	SWITCH SLIDE DPDT 300MA 30V	SW1	MMS22R	APEM Inc.
61	1	8103-RC	T1	JWMILLER_8103	Bourns, Inc.
62	1	DC/DC 1kV UNREG 5Vin 3.3Vout	U5	R1S-053.3-R	RECOM Power
63	1	DGTL ISO 3.75KV GEN PURP 8SOIC	U103	SI8621EC-B-IS	Silicon Labs
64	1	CONN RCPT USB2.0 MICRO AB SMD RA	X101	ZX62-AB-5PA	Hirose Electric Co Ltd
65	2	IC REG LINEAR 3.3V 1A SOT223-4	U3,U102	IFX1117MEV33HTM A1	Infineon Technologies
66	1	IC MCU 32BIT 256KB FLASH 48VQFN	U101	XMC4200-Q48F256 BA	Infineon Technologies
67	2	TVS DIODE 17VC WLL-2-1	V101, V102	ESD237-B1-W0201	Infineon Technologies
68	1	DIODE SCHOTTKY 30V 1A SOD323-2	V103	BAS3010A-03W	Infineon Technologies
69	1	Smart Intelligent Power Module for Motor Drive, PG-IQFN-38-1	U4	IMM101T0xxMXUM A1	Infineon Technologies

Reference

11 Reference

- [1] Datasheet of Infineon Smart IPM IMM10xT-0xxM
- [2] Application Note AN2018-33, iMOTION™ 2.0 Device Programming
- [3] MCEWizard_V2.0.1.1 User Guide
- [4] MCEDesigner_V2.0.1.1 Application Guide
- [5] How to Use iMOTION™ Script Language Application Note
- [6] AN2018-12 iMOTION™ Link User Manual_V1.1_EN

Notice:

Infineon's Product Registration is online now. Register your board and download more information.

Three easy steps are required for registration:

1. Go to www.infineon.com and click on 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
V1.0	2019-07-17	Initial version
V1.1	2019-07-22	Typo corrections
V1.2	2021-03-17	Add iMOTION Link connection as table 7. Correct definition of table 6, add Important notice

Trademarks

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

Edition 2019-06-18

**Published by Infineon Technologies AG
81726 Munich, Germany**

**© 2019 Infineon Technologies AG All
Rights Reserved.**

**Do you have a question about any aspect
of this document?**

Email: erratum@infineon.com

Document reference

IFX-vqf1553180223116

IMPORTANT NOTICE

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics ("Beschaffenheitsgarantie").

With respect to any examples, hints or any typical values stated herein and/or any information regarding the application of the product, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights of any third party.

In addition, any information given in this document is subject to customer's compliance with its obligations stated in this document and any applicable legal requirements, norms and standards concerning customer's products and any use of the product of Infineon Technologies in customer's applications.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

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