

# EVAL-M1-05F310

## iMOTION™ Modular Application Design Kit

### About this document

#### Scope and purpose

This application note provides an overview of the evaluation board EVAL-M1-05F310 including its main features, key data, pin assignments and mechanical dimensions.

EVAL-M1-05F310 is a complete power evaluation board including three CIPOS™ Nano 100V half-bridge modules for motor drive application. In combination with either EVAL-M1-1302 or EVAL-M1-099M it features and demonstrates Infineon's CIPOS™ technology for motor drive.

The evaluation board EVAL-M1-05F310 was developed to support customers during their first steps designing applications with IRSM005-301MH CIPOS™ Nano power modules.

#### Intended audience

This application note is intended for all technical specialists working with the EVAL-M1-05F310 board.







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# 1 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 1**      **Precautions**

	<p><b>Attention:</b> <i>The ground potential of the EVAL-M1-05F310 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. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.</i></p>
	<p><b>Attention:</b> <i>EVAL-M1-05F310 system contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait three 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.</i></p>
	<p><b>Attention:</b> <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><b>Attention:</b> <i>The surfaces of the drive may become hot, which may cause injury.</i></p>
	<p><b>Attention:</b> <i>EVAL-M1-05F310 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><b>Attention:</b> <i>A drive, incorrectly applied or installed, can result in 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.</i></p>

**Safety precautions**

	<p><b><i>Attention: Remove and lock out power from the drive before you disconnect or reconnect wires or perform service. Wait three 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.</i></b></p>
	<p><b><i>Attention: EVAL-M1-05F310 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></b></p>

## 2 Introduction

The EVAL-M1-05F310 evaluation board is a part of the iMOTION™ Modular Application Design Kit for motor control (iMOTION™ MADK).

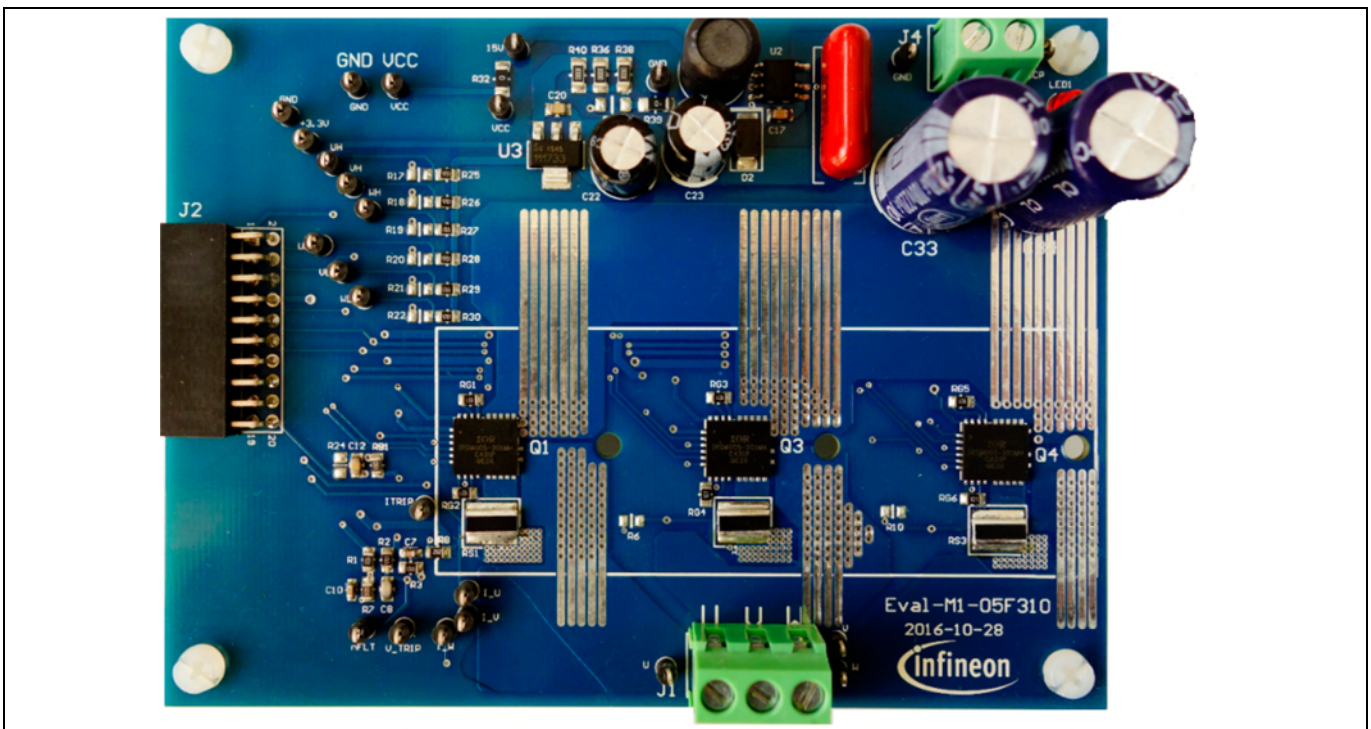
The MADK platform is intended to use various power stages with different control boards. These boards can easily be interfaced through the 20 pin iMOTION™ MADK-M1 interface connector.

This evaluation board is designed to give comprehensible solutions of a power stage featuring CIPOS™. It provides a DC input and 3-phase output for power. It contains three emitter-shunts for current sensing and a voltage divider for DC-link voltage measurement.

The EVAL-M1-05F310 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-M1-05F310. The design was tested as described in this document but not qualified regarding safety requirements or manufacturing and operation over the whole operating temperature range or lifetime. The boards provided by Infineon are subject to functional testing only.

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



**Figure 1 Evaluation board EVAL-M1-05F310**

Figure 1 shows the picture of evaluation board EVAL-M1-05F310. This board is compatible with surface mount CIPOS™ modules. This document explains the features and details of this board in combination with CIPOS™ Nano IRSM005-301MH. The difference between these modules is current and voltage. Ratings and other details of the board are explained in the subsequent sections.

**Main features**

### 3 Main features

EVAL-M1-05F310 is a complete power evaluation board including a 3-phase IPM for motor drive application. The kit demonstrates Infineon's IPM technology for motor drives.

Main features of CIPOS™ Nano Intelligent Power Module IRSM005-301MH are:

- MOSFET Drain-to-Source Voltage 100V
- Maximum DC current at 25°C case temperature  $I_c = 30A$
- Up to 165W power output at 10 kHz PWM frequency
- Package with low thermal resistance and minimal parasitics
- Independent gate driver in phase with logic input
- Gate drive supply range from 10V to 20V
- Propagation delay matched to defined spec
- 3V, 5V and 15V logic input compatible
- Under-voltage lockout protection inside the driver
- On board overcurrent protection
- Exposed driver outputs and HEXFET gate terminals for  $dV/dt$  setting through a resistor

The evaluation board characteristics are:

- Up to 165W motor power range
- Possibility to easy change between 3 Leg shunt to single shunt configuration
- Compatible with the following CIPOS™ Nano module:  
IRSM005-301MH                      30A / 16mΩ, 100V
- RoHS complaint
- PCB is 118 x 85 mm and has two layers with 35 μm copper each

Main features

3.1 Key data

Figure 2 provides the overview of the IRSM005-301MH internal electrical schematics. For further information regarding these CIPOS™ like static and dynamic electrical behavior, as well as thermal and mechanical characteristics please refer to the datasheet of the IRSM005-301MH.

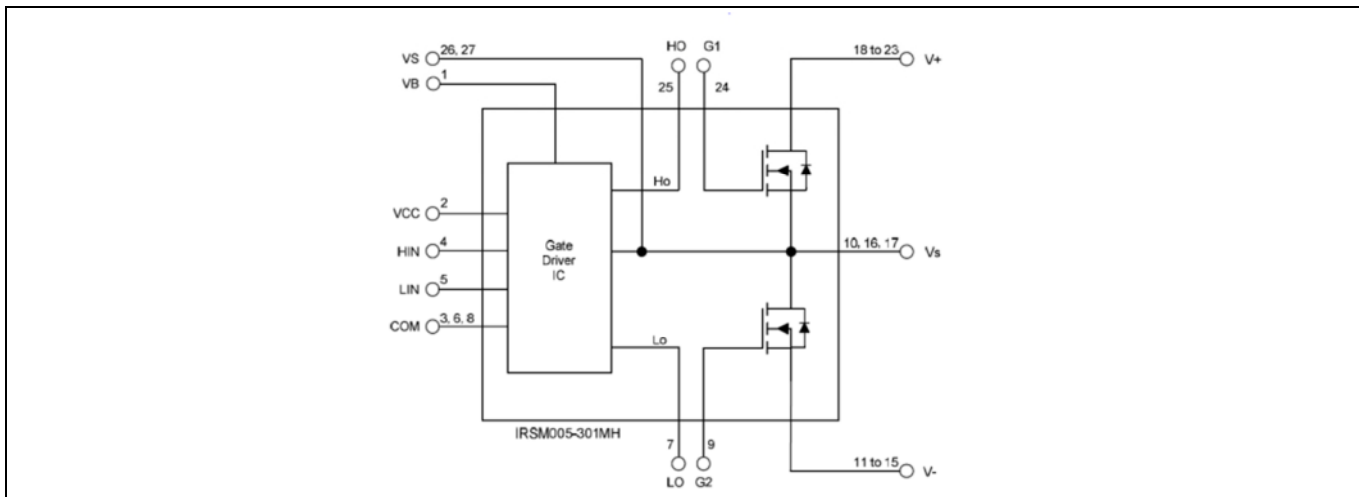


Figure 2 CIPOS™ Nano internal electrical schematic

Table 2 Provide the absolute maximum ratings of the IRSM005-301MH.

Table 2 Absolute Maximum Ratings of IRSM005-301MH

Symbol	Description	Min	Max	Unit
V <sub>DS</sub>	MOSFET Drain-to-Source Voltage	--	100	V
I <sub>o</sub>	Maximum DC Current per MOSFET @ T <sub>C</sub> =25°C (Note1)	--	30	A
P <sub>d</sub>	Maximum Power Dissipation per MOSFET @ T <sub>C</sub> =100°C	--	13.5	W
T <sub>J</sub> (MOSFET & IC)	Operating Junction Temperature	--	150	°C
T <sub>S</sub>	Storage Temperature range	-40	150	°C
V <sub>B</sub>	High Side Floating Supply Voltage	-0.3	V <sub>S</sub> +20	V
V <sub>S</sub>	High Side Floating Supply Offset Voltage	V <sub>B</sub> -20	V <sub>B</sub> +0.3	V
V <sub>CC</sub>	Low Side Fixed Supply voltage	-0.3	20	V
V <sub>IN</sub>	Low Input Voltage of LIN, HIN	-0.3	V <sub>CC</sub> +0.3V	V

Note 1: Calculated based on maximum junction temperature. Bond wires current limit is 20A.

**Main features**

Table 3 depicts the recommended operating conditions of IRSM005-301MH.

**Table 3 Recommended operating conditions of CIPOS™ Nano IRSM005-301MH**

Symbol	Description	Min	Typ	Max	Unit
VB	High Side Floating Supply Voltage	VS +10	VS +15	VS +20	V
Vs	High Side Floating Supply Offset Voltage	Note1	--	100	V
Vcc	Low Side and Logic fixed Supply Voltage	10	15	20	V
LIN	Logic input Voltage LIN, HIN	COM	--	Vcc	V
HIN	High side PWM pulse width	1	--	--	µs
Dead time	Suggested dead time between LIN and HIN	0.3	0.5	--	µs

Table 4 shows the important specifications of the evaluation board EVAL-M1-05F310.

**Table 4 Eval-M1-05F310 board specifications**

Parameters	Values	Conditions / comments
<b>Output Power</b>		
Watts (Note2)	165W	IRSM005-301MH
Current (Note2)	5.5A*	IRSM005-301MH *rms, DcBus=64V, Fc=16kHz, 3-phase PWM, ΔTca=70C, Ta=25C
<b>Power device</b>		
IRSM005-301/800MH	27L µIPM	
<b>DC Bus voltage</b>		
Maximum DC bus voltage	80V	With IRSM005-301MH modules mounted
Minimum DC bus voltage	36V	With IRSM005-301MH, only if on board generated 15V supply is used.
<b>Current feedback</b>		
Current sensing device Rs1,Rs2,Rs3	10 mΩ	Three leg shunt configuration is set. To implement single shunt, remove RS2 and RS3 and include R6 and R10 resistors (0 Ω)
<b>Protections</b>		
Output current trip level	20Apk	Configure by changing shunt resistors
<b>On board power supply</b>		
3.3V	3.3V+/-5%, Max 50mA	Used for Eval-M1-05F310
15V	15V+/-5%, Max 20mA	Used for interface signals with control board and alarm signal (I_TRIP)
<b>PCB characteristics</b>		

**Main features**

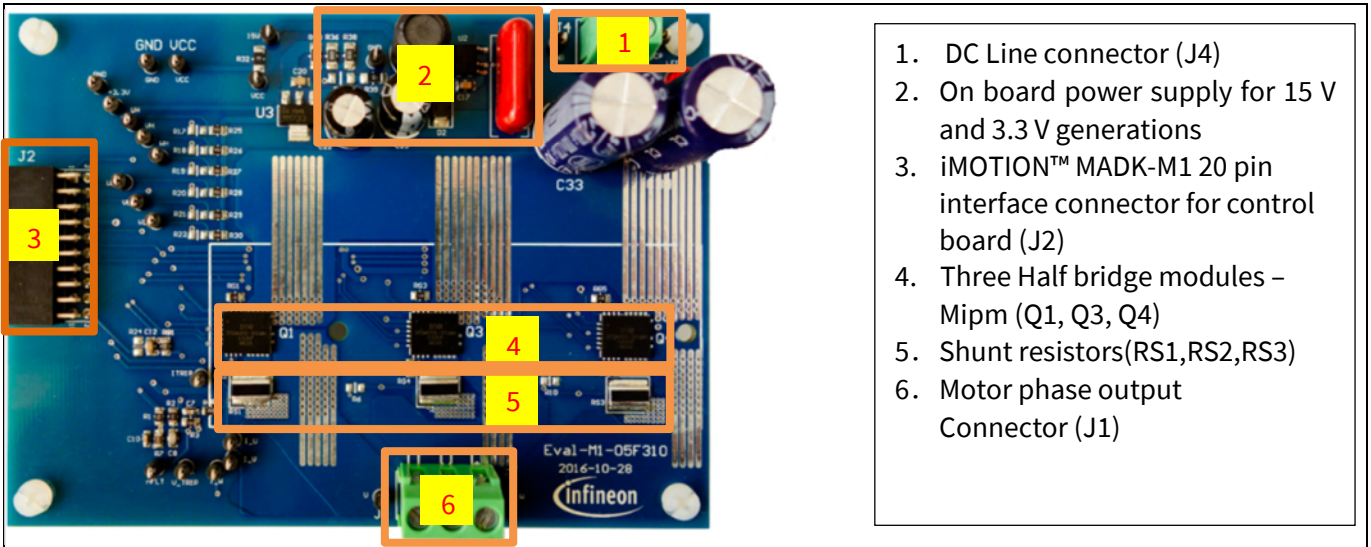
<b>Parameters</b>	<b>Values</b>	<b>Conditions / comments</b>
Material	FR4, 1.6MM thickness Copper thickness = 1oz (35um)	
Dimension	118mmx85mm	
<b>System environment</b>		
Ambient temperature	0-70°C	95%RH Max (Non-Condensing)

Note2: please refer to IRSM005-301datasheet and uIPM HB application note rev04 SR for data about maximum current and power, changing Fc, modulation,  $\Delta T_{ca}$ , use of a heat sink.

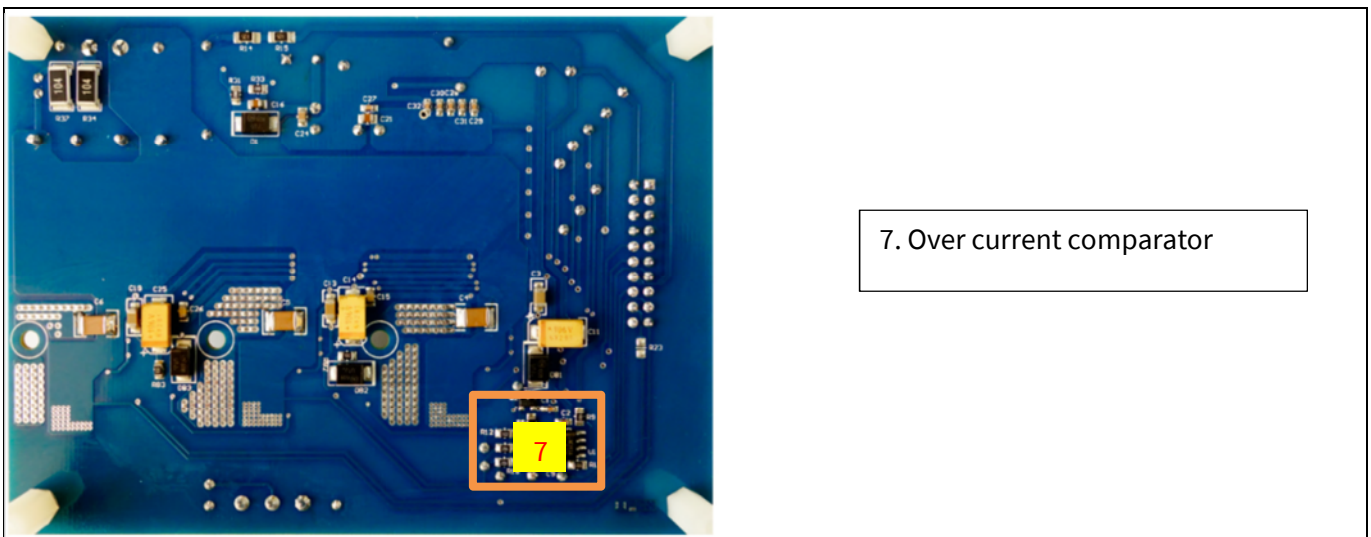


### Main features

Figure 3 and Figure 4 hint out the functional groups of the EVAL-M1-05F310 evaluation board.



**Figure 3 Functional groups of the EVAL-M1-05F310 evaluation board's top side**



**Figure 4 Functional groups of the EVAL-M1-05F310 evaluation board's bottom side**

## 4 Pin assignments

General information about the connectors of the EVAL-M1-05F310 evaluation board is reported.

Table 5 Include the details of the DC input connector J4-DC.

Table 6 denotes the details of the motor side connector J1.

**Table 5 J4- DC input connector**

S. No.	Pin	Details
1	GND	DC - connector
2	DCP	DC + connector

**Table 6 J1- Motor side connector**

S. No.	Pin	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 power board.

**Table 7 J2- iMOTION™ MADK-M1 20 pin interface connector for power board**

Pin	Name	Pin Name Connectors
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	3.3V power supply
7	PWMVL	3.3 V compatible logic input for low side gate driver-Phase V
8	+3.3V	3.3V power supply
9	PWMWH	3.3 V compatible logic input for high side gate driver-Phase W
10	IU+	Shunt voltage phase U
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	VTH	Input, Voltage input of Power Module's Temperature sense
16	IV+	Shunt voltage phase V
17	IV-	Ground
18	IW+	Shunt voltage phase W
19	IW-	Ground
20	VCC	Defined for 15 V Power Supply

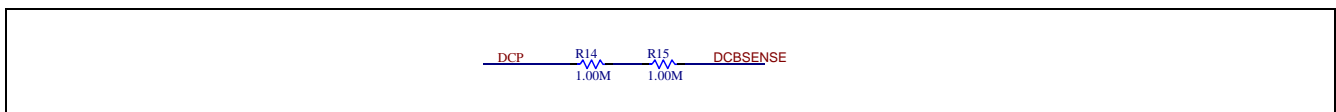
## 5 Schematics and Layout

To meet individual customer requirements and make the EVAL-M1-05F310 evaluation board a basis for development or modification, all necessary technical data like schematics, layout and components are included in this chapter.

### 5.1 DC-Link Voltage Measurement

Pin 14 of connector J2 provides access to the DC-link voltage. Three possible feedback cases are associated with this pin.

Figure 5 provides the DC bus sense resistor details.

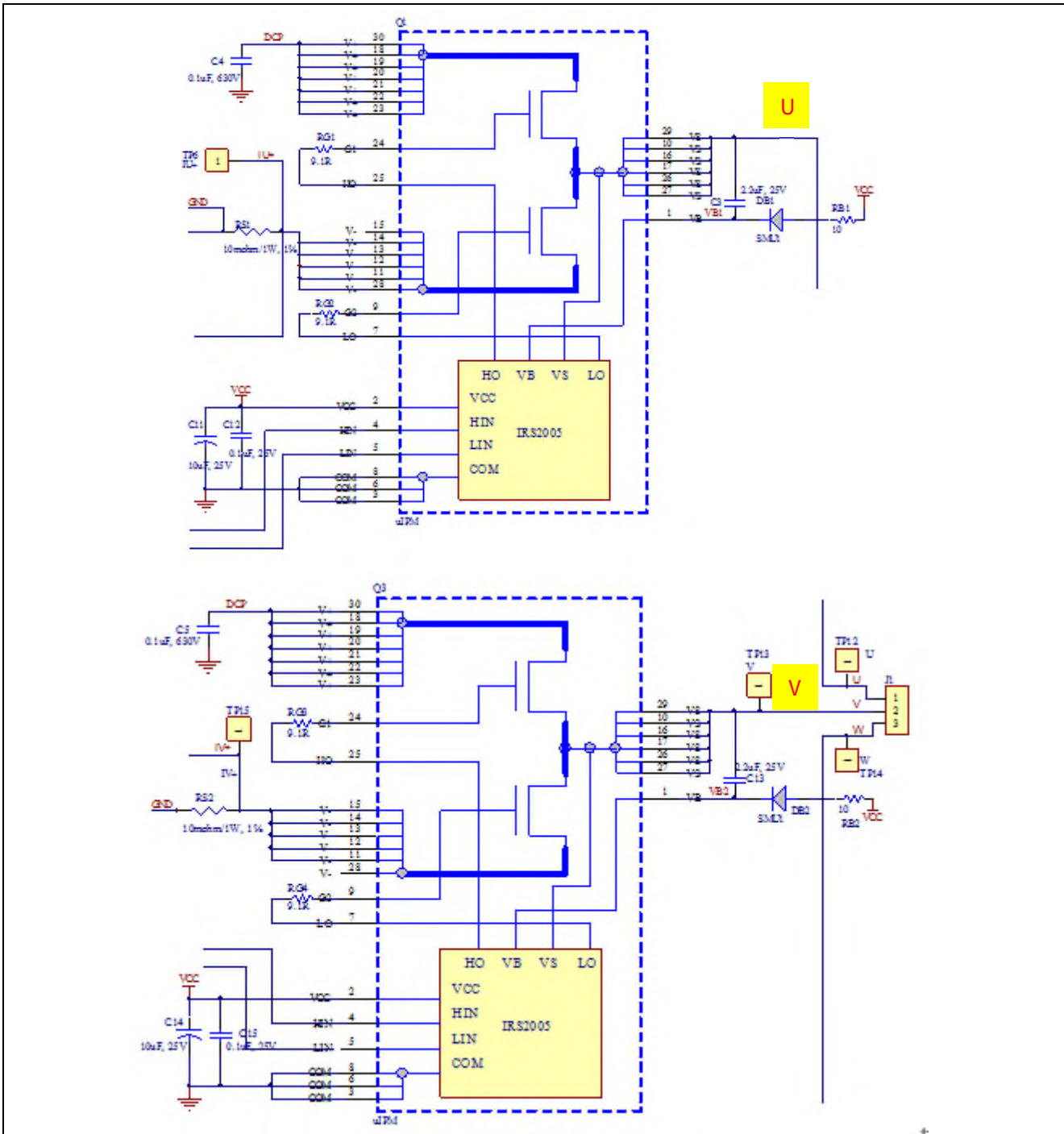


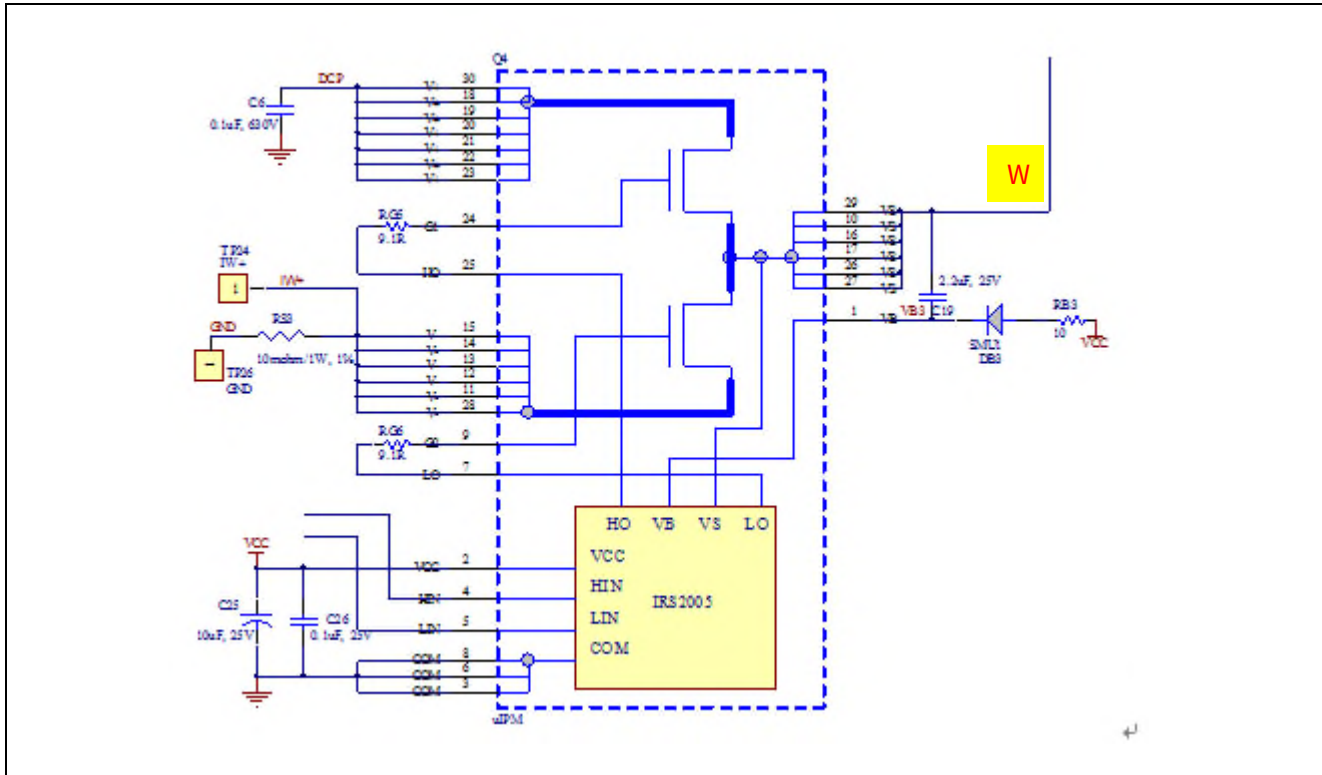
**Figure 5 DC bus sense resistor on EVAL-M1-05F310 evaluation board**

- If a pull down resistor of 4.87 kΩ referred to ground is inserted either on the Eval-M1-05F310 evaluation board or the additional control board, DCBSENSE positive voltage results scaled in the range of 0-3.3V on the pin.
- If no pull-down resistor of 4.87 kΩ is present on the Eval-M1-05F310 evaluation board or the additional control board, the DCBSENSE -pin remains high voltage (up to DC input).
- If no feedback is desired on the DCBSENSE-pin, please remove either R14 or R15 or both of them.

## 5.2 Inverter section using CIPOS™ Nano

The inverter section is implemented using the CIPOS™ Nano as sketched in Figure 6. Three half bridge modules as 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 C3, C13 and C19 are used as bootstrap capacitors to provide the necessary floating supply voltages VBU, VBV and VBW respectively.

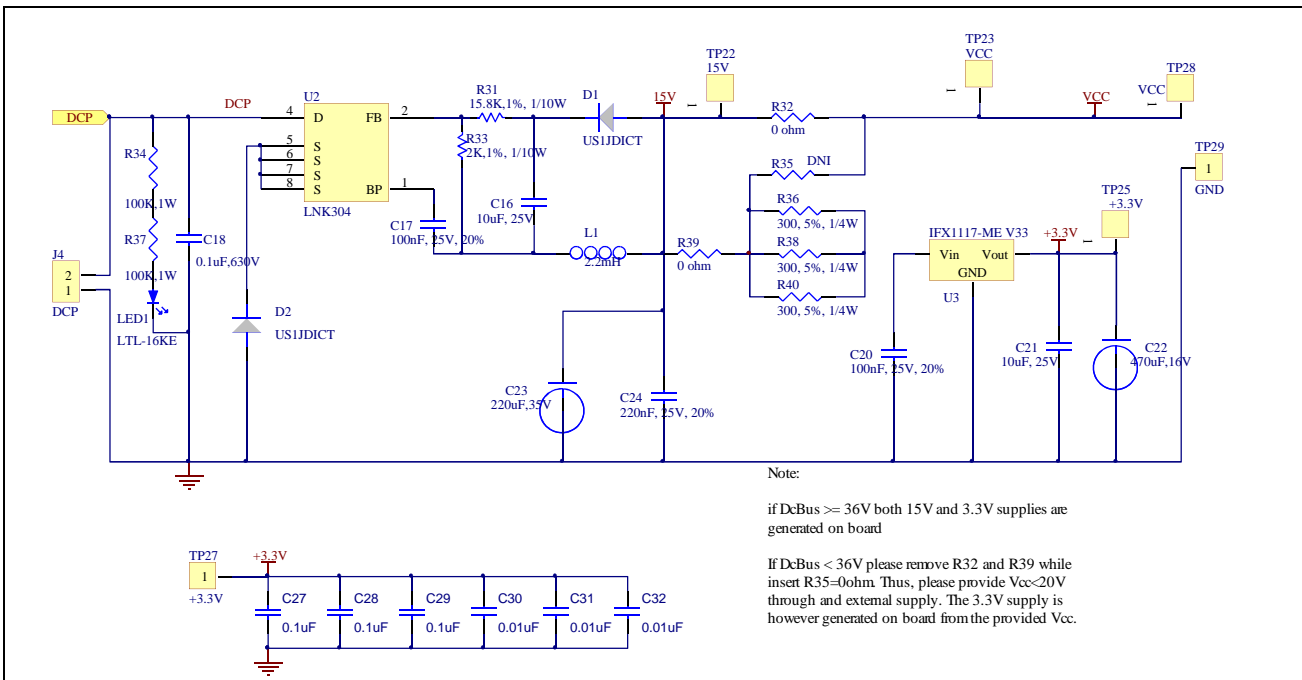




**Figure 6 Schematic of the 3-phase inverter section using CIPOS™ Nano on EVAL-M1-05F310 evaluation board**

### 5.3 Power supply

Figure 7 depicts the schematic of the power supply available on the EVAL-M1-05F310 board. The circuit includes a LNK304 that is used to generate 15 V (VCC) directly from the DC bus. VCC is connected to the gate drivers inside the CIPOST™ Nano. The linear regulator IFX1117-ME V33 generates 3.3 V from VCC. The 3.3 V power supply is used in the over current comparator circuit. Led LED1 is used to signal whether the board is powered or not. Both, VCC and 3.3 V are also present on the 20 pin interface connector J2 to power circuitry on the controller board.

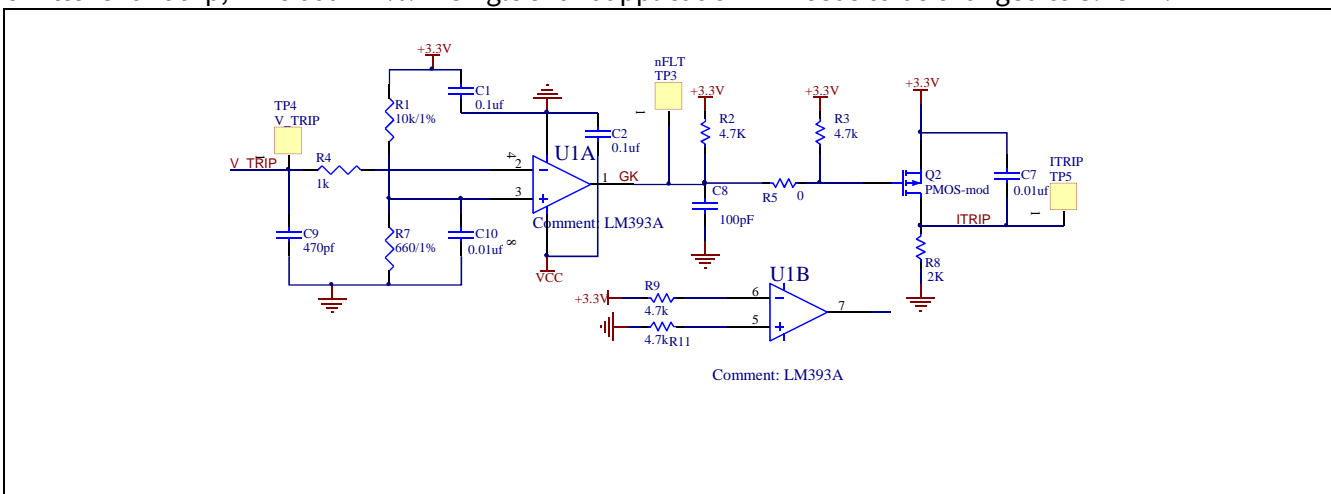


**Figure 7 Power supply section of the EVAL-M1-05F310 evaluation board**

### 5.4 Over current protection circuitry

Figure 8 displays the over current protection circuitry. The open collector output GK of the comparator is pulled up to 3.3V and filtered through resistor R2 and capacitor C8.

The comparator threshold can be set through the voltage divider provided by resistors R1 and R7. By default for emitter shunt trip, R7 is 660R 1 %. In single shunt application R7 needs to be changed to 3.48kΩ.

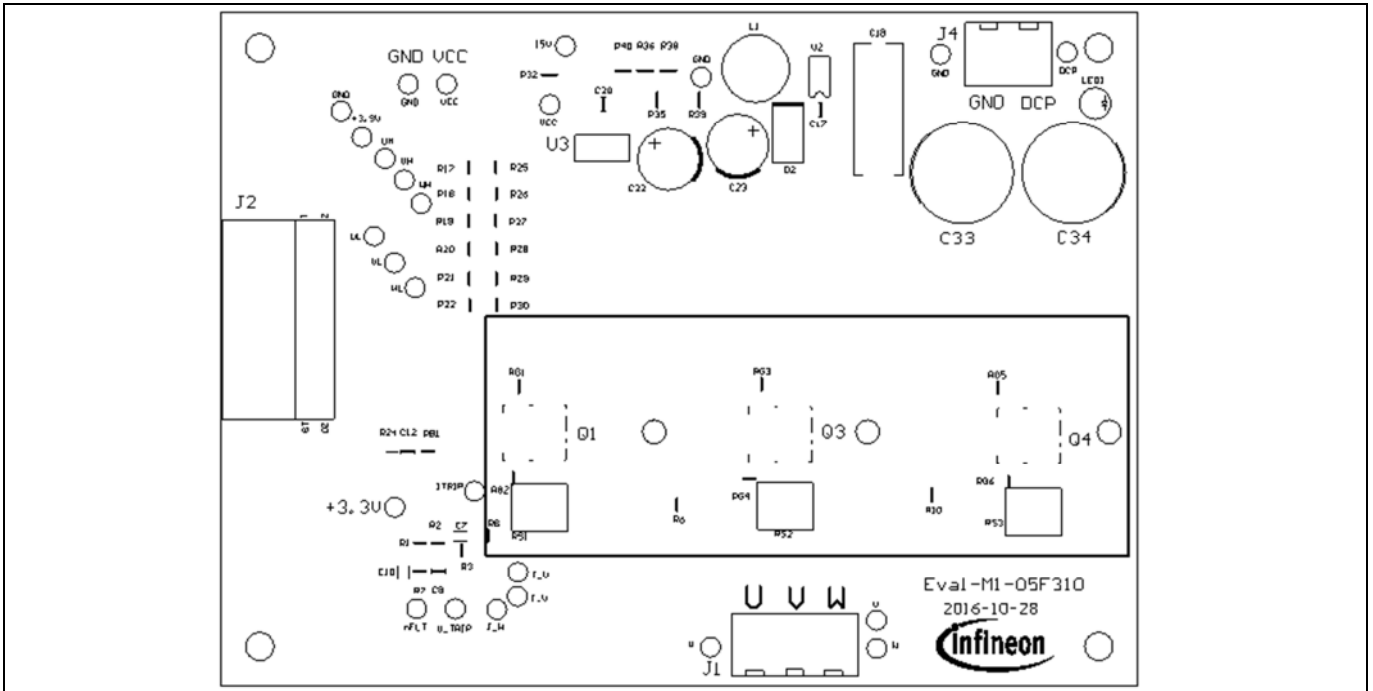


**Figure 8 Over current protection circuit on the EVAL-M1-05F310 evaluation board**

**5.5 PCB Layout**

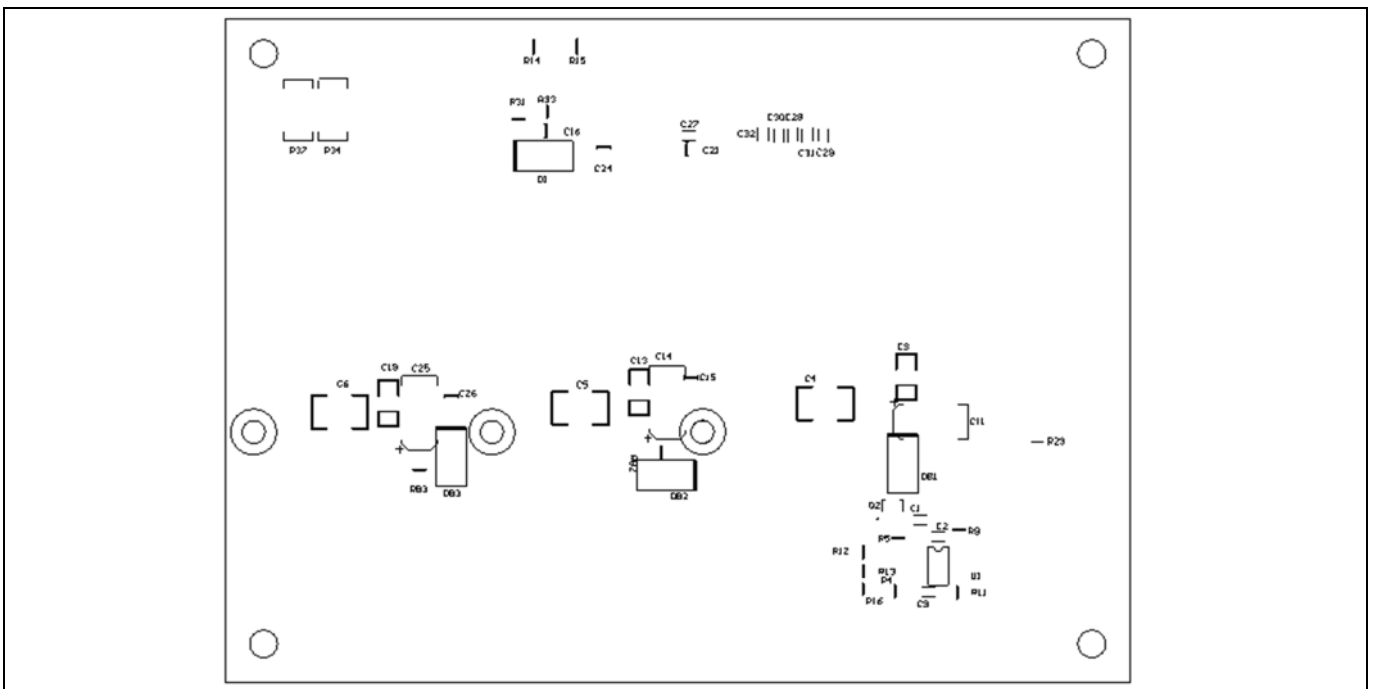
The layout of this board can be used for different voltage or power classes of power board. The PCB has two electrical layers with 35µm copper by default and its size is 118 × 85mm. The PCB board thickness is 1.6mm. Get in contact with our technical support team to get more detailed information and the latest Gerber-files.

Figure 9 illustrates the top assembly print of the evaluation board.



**Figure 9 Top assembly print of the EVAL-M1-05F310 evaluation board**

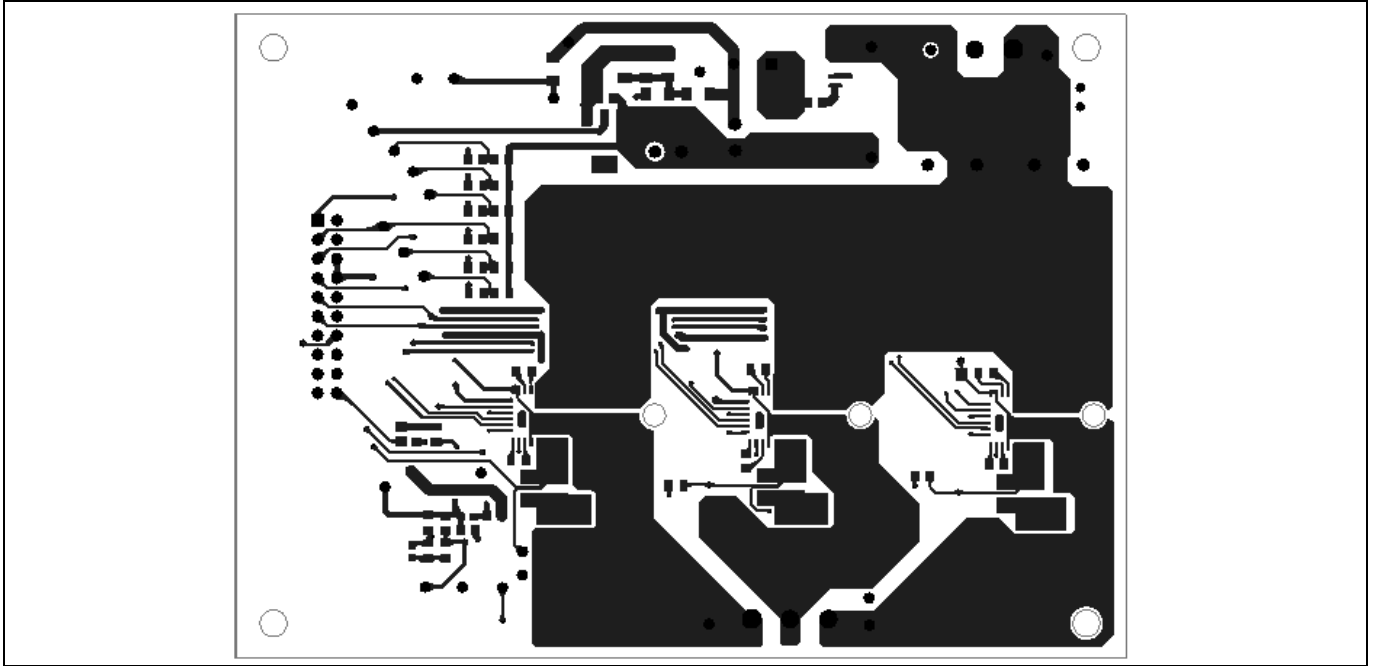
Figure 10 depicts the bottom assembly print of the evaluation board.



**Figure 10 Bottom assembly print of the EVAL-M1-05F310 evaluation board**

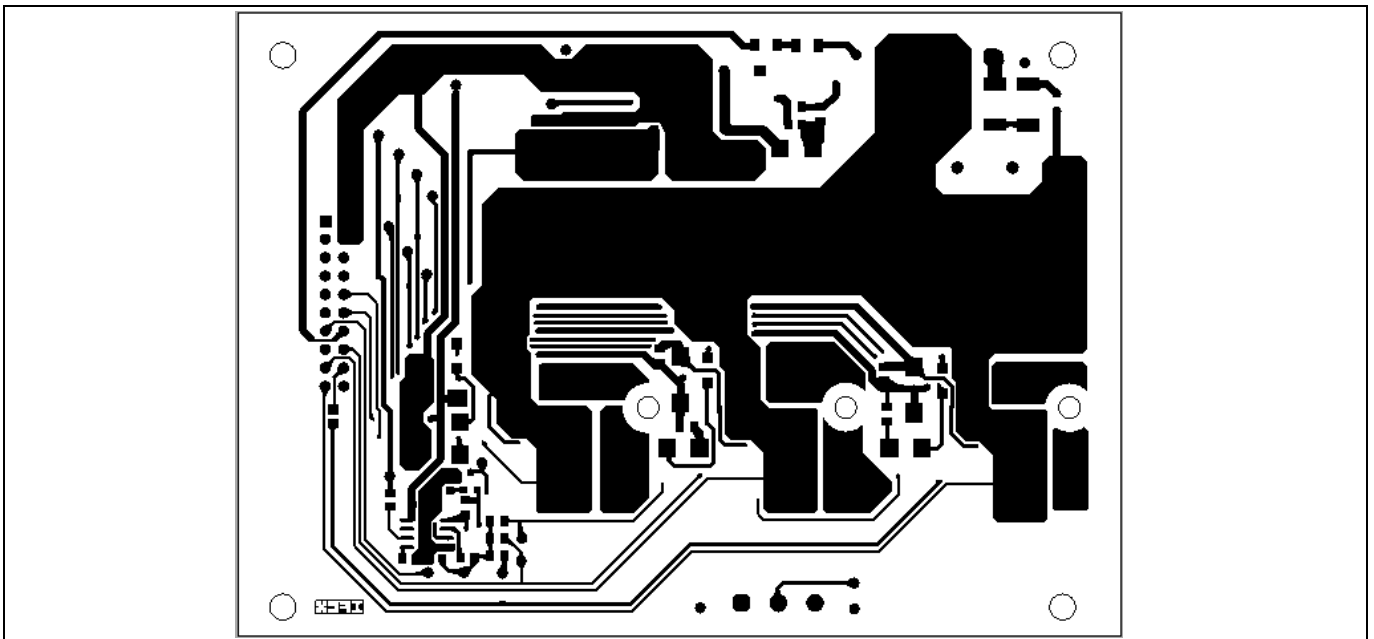


The top layer routing of the PCB is provided in the following Figure 11.



**Figure 11 Top layer routing of the EVAL-M1-05F310 evaluation board**

Figure 12 illustrates the bottom layer routing of the PCB.



**Figure 12 Bottom layer routing of the EVAL-M1-05F310 evaluation board**



## 6 Bill of Materials of EVAL-M1-05F310

Table 8 provides the complete bill of materials for the EVAL-M1-05F310 board.

**Table 8 Bill of materials**

No.	Qty.	Part description	Designator	Part Number	Manufacturer
1	5	CAP CER 0.1μF 50V X7R 0603	C1, C2, C27, C28, C29	C0603C104M5RACTU	Kemet
2	3	CAP CER 2.2μF 50V X7R 1206	C3, C13, C19	C1206C225K5RACAUTO	Kemet
3	3	CAP CER 0.1μF 630V X7R 1812	C4, C5, C6	C1812C104KBRACTU	Kemet
4	5	CAP CER 10000pF 50V X7R 0603	C7, C10, C30, C31, C32	C0603C103K5RACTU	Kemet
5	1	CAP CER 100pF 50V NP0 0805	C8	C0805C101J5GACTU	Kemet
6	1	CAP CER 470pF 50V X7R 0805	C9	C0805C471K5RACTU	Kemet
7	3	CAP TANT 10μF 25V 10% 2917	C11, C14, C25	T491D106K025AT	Kemet
8	2	CAP CER 10μF 25V X5R 0805	C16, C21	C0805C106M3PAC7800	Kemet
9	1	CAP FILM 0.1μF 10% 630VDC RADIAL	C18	ECQ-E6104KFW	Panasonic Electronic Components
10	3	CAP CER 0.1μF 25V X7R 0805	C12, C15, C26	C0805C104K3RACTU	Kemet
11	1	CAP ALUM 470μF 20% 16V RADIAL	C22	16ZLH470MEFC8X11.5	Rubycon
12	2	CAP CER 0.1μF 25V X7R 0805	C17, C20	C0805C104K3RACTU	Kemet
13	1	CAP ALUM 220μF 20% 35V RADIAL	C23	35ZLH220MEFC8X11.5	Rubycon
14	2	CAP ALUM 220μF 20% 100V RADIAL	C33, C34	ECA-2AM221	Panasonic Electronic Components
15	1	CAP CER 0.22μF 16V X7R 0805	C24	C0805C224K4RACTU	Kemet
16	5	DIODE GEN PURP 600V 1A SMB	D1, D2, 'DB1, DB2, DB3	MURS160-13-F	Yageo
17	1	CONN FEMALE 20POS DL .1" R/A TIN	J2	PPTC102LJBN-RC	Sullins Connector Solutions
18	1	TERM BLOCK 5.08MM 3POS SIDE ENTY	J1	282837-3	TE Connectivity AMP Connectors
19	1	TERM BLOCK 5.08MM	J4	282837-2	TE Connectivity

**EVAL-M1-05F310****iMOTION™ Modular Application Design Kit****Bill of Materials of EVAL-M1-05F310**

No.	Qty.	Part description	Designator	Part Number	Manufacturer
		2POS SIDE ENTY			AMP Connectors
20	1	FIXED IND 2.2MH THROUGH HOLE	L1	RLB0914-222KL	Bourns Inc
21	1	LED RED DIFF 3MM ROUND T/H	LED1	LTL-16KE	Lite-On Inc
22	3	IRSM005- 301MH/IRSM005-800MH	Q1, Q3, Q4	Half Bridge Module	Infineon Technologies
23	1	IRLNL6402TRPBF-1	Q2	P-Channel MOSFET	Infineon Technologies
24	1	RES SMD 10 kΩ1% 1/8W 0805	R1	ERJ-6ENF1002V	Panasonic Electronic Components
25	10	RES SMD 4.7 kΩ1% 1/8W 0805	R2, R3, R9, R11, R25, R26, R27, R28, R29, R30	ERJ-6ENF4701V	Panasonic Electronic Components
26	4	RES SMD 1 kΩ1% 1/8W 0805	R4, R12, R13, R16	ERJ-6ENF1001V	Panasonic Electronic Components
27	10	DIN	R6, R10, R17, R18, R19, R20, R21, R22, R23, R24	R0805	Yageo
28	2	RES SMD 2 kΩ1% 1/8W 0805	R8,R33	RC0805FR-072KL	Yageo
29	2	RES SMD 1M Ω 1% 1/8W 0805	R14,R15	REJ-6ENF1004V	Panasonic Electronic Components
30	1	RES SMD 15.8 kΩ1% 1/8W 0805	R31	RC0805FR-0715K8L	Yageo
31	2	RES SMD 0.0 OHM JUMPER 1/4W 1206 NO ASS.	R32,R39	RMCF1206ZT0R00	Stackpole Electronics Inc.
32	2	RES SMD 100 kΩ5% 1W 2512	R34, R37	ERJ-1TYJ104U	Panasonic Electronic Components
33	1	DIN	R35	R1206	Yageo
34	3	RES SMD 300 Ω 5% 1/4W 1206	R36, R38, R40	RC1206JR-07300RL	Yageo
35	3	RES SMD 10 Ω 5% 1/8W 0805	RB1, RB2, RB3	ERJ-6GEYJ100V	Panasonic Electronic Components
36	6	RES SMD 100 Ω 5% 1/8W 0805	RG1, RG2, RG3, RG4, RG5, RG6	ERJ-6GEYJ101V	Panasonic Electronic Components
37	3	1225 1% TCR150 0.01Ω	RS1, RS2, RS3	CS25FTFR010N	Viking
38	15	TEST POINT PC	DCP, ITRIP,	5002	Keystone

**EVAL-M1-05F310****iMOTION™ Modular Application Design Kit****Bill of Materials of EVAL-M1-05F310**

<b>No.</b>	<b>Qty.</b>	<b>Part description</b>	<b>Designator</b>	<b>Part Number</b>	<b>Manufacturer</b>
		MINI .040"D BLACK	GND,U,V,W,UH,VH,WH, UL,VL,WL,15V,VCC,+3.3V		Electronics
39	1	IC DUAL DIFF COMPARATOR 8-SOIC	U1	LM393ADR	Texas Instruments
40	1	IC OFFLINE SWIT OCP 8SOIC	U2	LNK304DN	Power Integrations
41	1	Wide Input Range Low Noise 500mA LDO	U3	IFX1763XEJ V33	Infineon Technologies



## **7 Reference**

[1] Datasheet of Infineon IRSM005-301MH/IRSM005-800MH-CIPOS™ Nano, is available for download on Infineon's website

[2] Application Note of AN2016-24 for EVAL-M1-05-65D power board, is available for download on Infineon's website



## Revision History

### Major changes since the last revision

<b>Version number</b>	<b>Revision Date</b>	<b>Revision description</b>
1.0	2017-03-28	First release

#### Trademarks of Infineon Technologies AG

AURIX™, C166™, CanPAK™, CIPOS™, CoolGaN™, CoolMOS™, CoolSET™, CoolSiC™, CORECONTROL™, CROSSAVE™, DAVE™, DI-POL™, DrBlade™, EasyPIM™, EconoBRIDGE™, EconoDUAL™, EconoPACK™, EconoPIM™, EiceDRIVER™, eupec™, FCOS™, HITFET™, HybridPACK™, Infineon™, ISOFACE™, IsoPACK™, i-Wafer™, MIPAQ™, ModSTACK™, my-d™, NovalithIC™, OmniTune™, OPTIGA™, OptiMOS™, ORIGA™, POWERCODE™, PRIMARION™, PrimePACK™, PrimeSTACK™, PROFET™, PRO-SIL™, RASIC™, REAL3™, ReverSave™, SatRIC™, SIEGET™, SIPMOS™, SmartLEWIS™, SOLID FLASH™, SPOC™, TEMPFET™, thinQ!™, TRENCHSTOP™, TriCore™.

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