DEMO_100W_BLDC

Low cost FOC sensorless demo board with CoolMOS™ CE

About this document

This application note introduces a complete system level solution to drive a BLDC fan motor in cooling applications. It also describes how to quickly get started integrating this demonstration PCB and take advantage of Infineon's CoolMOS™ CE MOSFETs and XMC1000 series microcontroller.

Scope and purpose

To show the efficiency, present a thermal solution for the inverter stage with Infineon's CoolMOS™ CE MOSFETs and show how the control reduces reverse current hard commutation stress by offering a synchronous rectification algorithm to a sensorless Field Orientated Control (FOC) BLDC with current feedback loop by using the XMC1000 series microcontroller. This enables manufacturers to minimize time-to-market and also reduce the Bill of Materials (BOM) by 10%.

Intended audience

Cooling fan manufacturers who intend to reduce the system cost and improve the efficiency, which in turn provides longer run time and reduced time-to-market.

Table of contents

1 Features

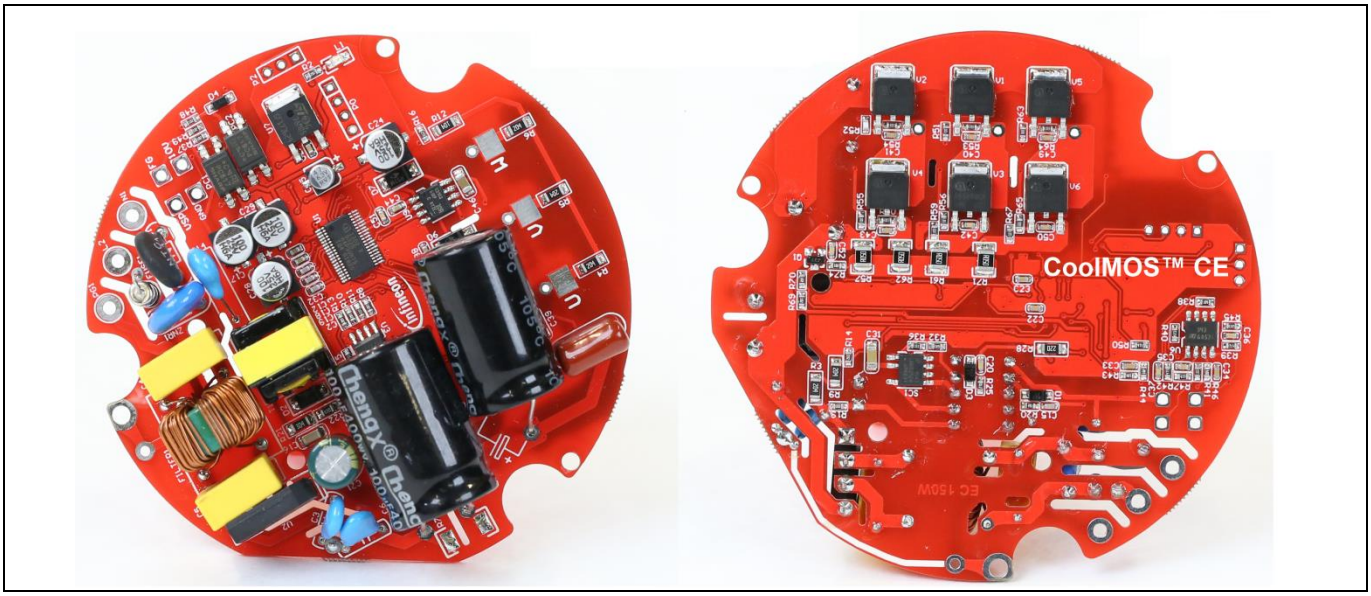

Figure 1 Demo board overview

- Maximum input voltage: 265 V_{AC} or 370 V_{DC}
- Minimum input voltage: 85 V_{AC} or 120 V_{DC}
- Output power for applied motor: up to 100 W
- +15 V auxiliary power supply based on a non-isolated buck configuration
- Compact design using 650 V CoolMOS™ CE, op amp for current sensing and comparator
- On-board demodulator for speed and on/off control using potentiometer
- High efficiency and cost effective
- Hardware overcurrent protection
- Overvoltage and undervoltage detection
- Based on 32-bit ARM® Cortex®-M0 core based microcontroller
- Firmware based on XMC1000 PMSM FOC (field oriented control) motor control library
- Fully customized for ceiling fan and outdoor air conditioning fan applications
- FOC sensorless algorithm
- PCB size customized for cooling fan design
- PCB diameter: 87 mm

2 Description

The 100 W BLDC fan motor drive demo board accepts 220 V_{AC} input and delivers 100 W max output power to drive a 3-phase BLDC/PMSM fan motor in sensorless FOC mode for the ceiling fan and air conditioning outdoor fan applications. Due to the CoolMOS™ CE and XMC1000 microcontroller used, this board not only offers a synchronous rectification algorithm to reduce reverse current hard commutation stress and sensorless FOC BLDC control, but also a minimum BOM reduction of 10% resulting in a reliable and compact system design, which meets the minimum requirements for cooling fan applications.

2.1 Summary of features

Here is presented a list of summary features:

- Low BOM cost contributed by CoolMOS™ CE and the XMC™ algorithm
- Near to production solution
- Sensorless FOC BLDC

2.2 Benefits

The demo board offers the following benefits:

- High efficiency
- Cost effective
- Simplified design
- Accelerated time-to-market

2.3 Target applications

The demo board targets cooling applications, especially:

3-phase BLDC fan

3 Board schematics

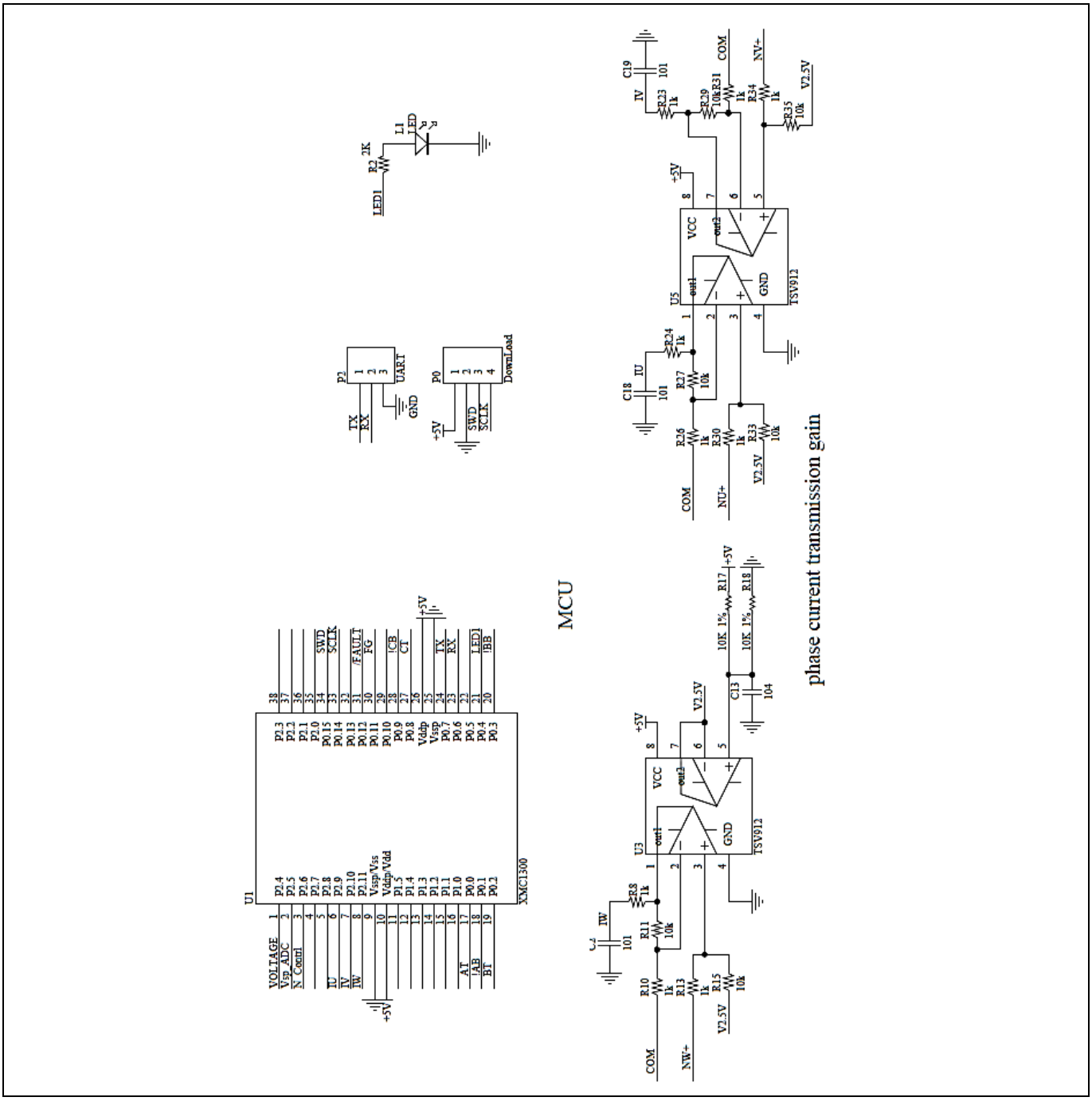

Figure 2 Microcontroller

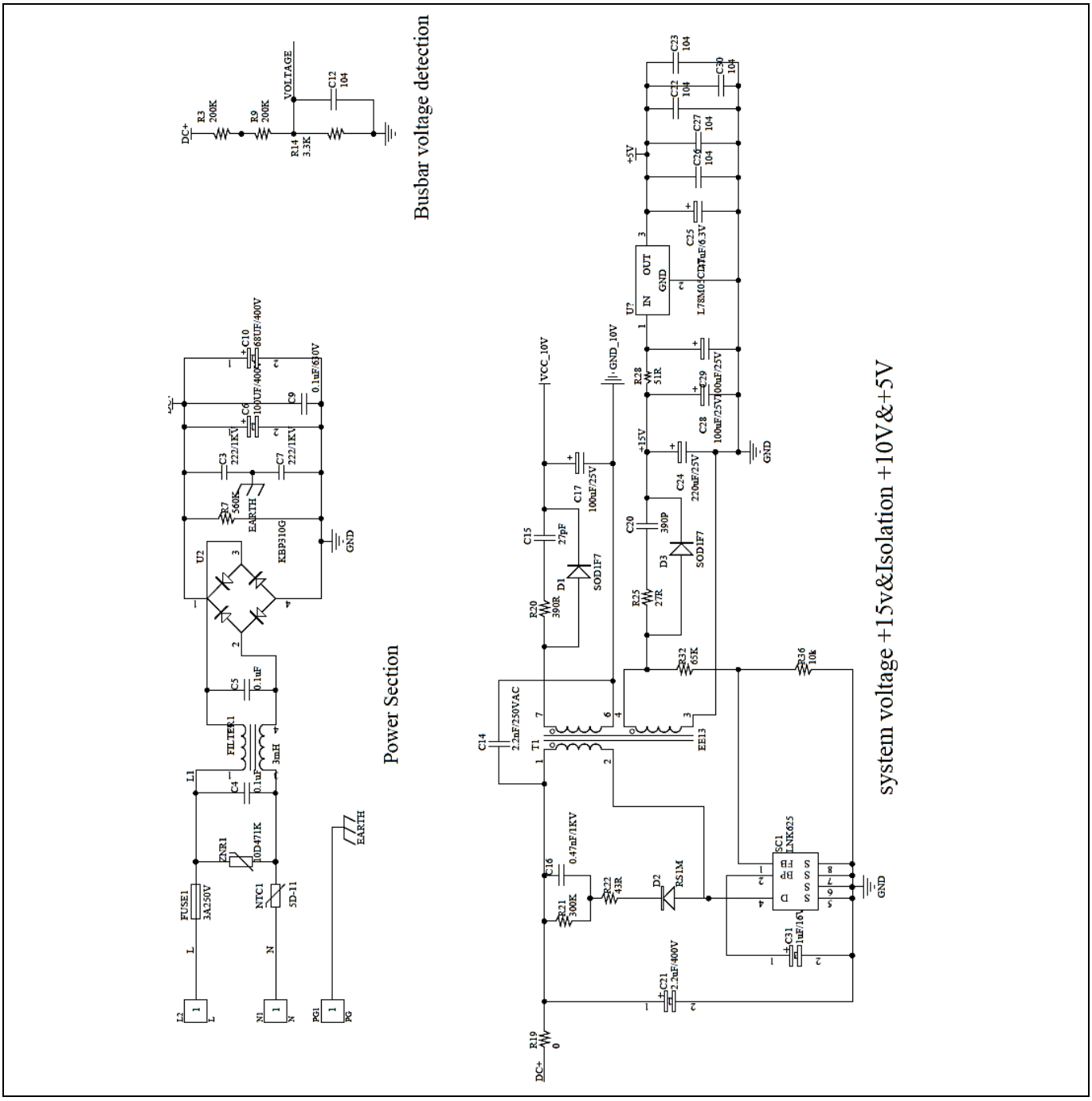

Figure 3 Power section

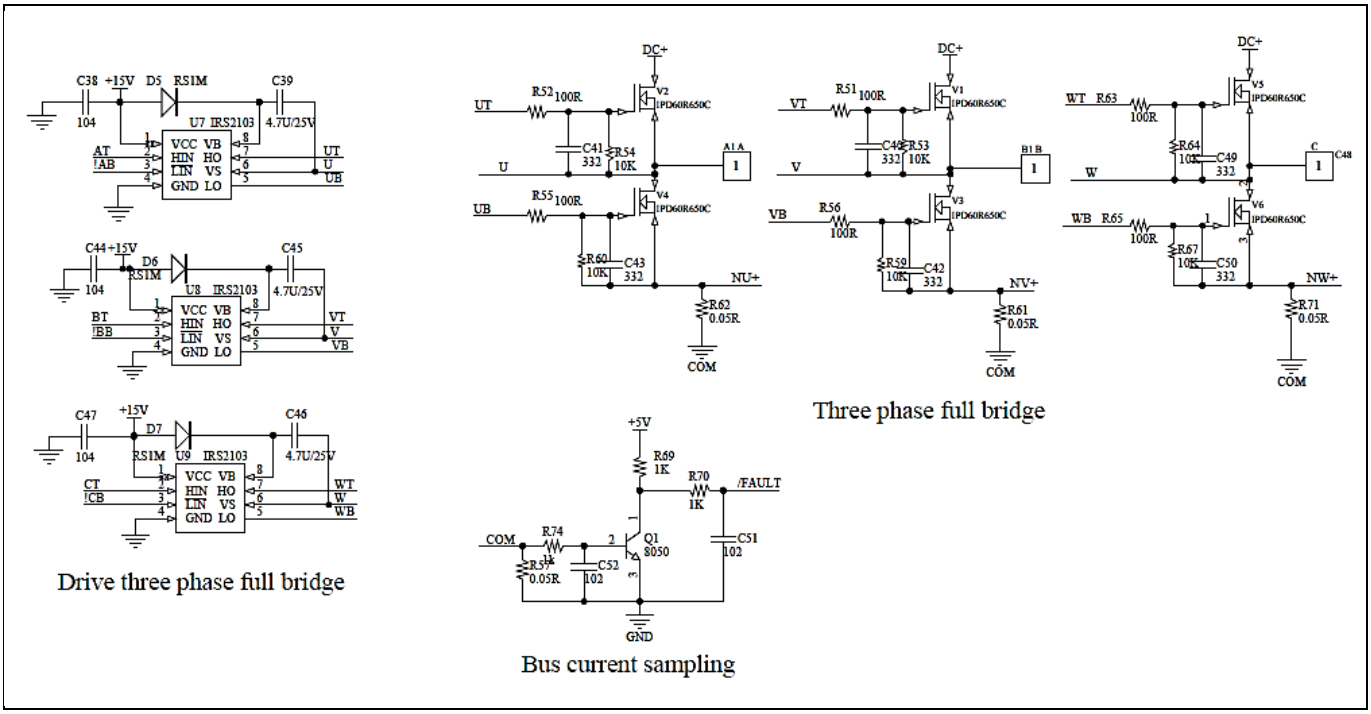

Figure 4 Inverter section

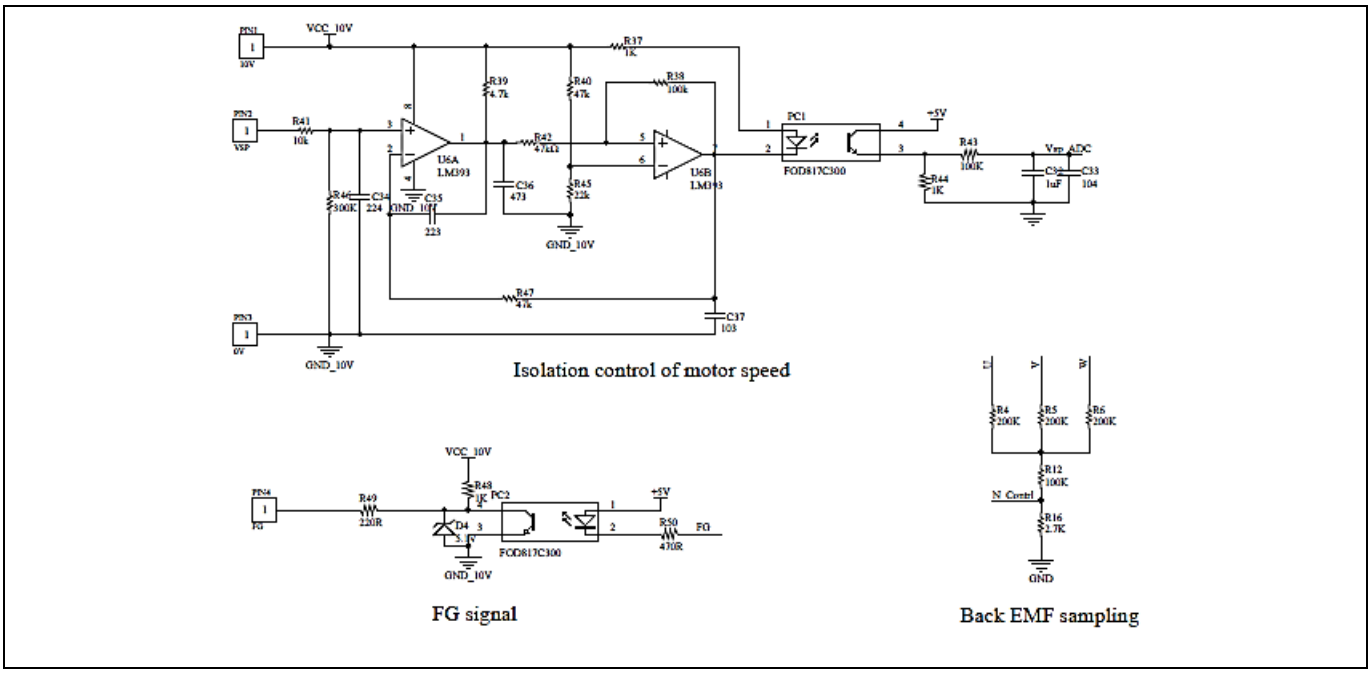

Figure 5 Motor control section

4 Getting started

1. Connect a 1 k Ω potentiometer to be able to control the speed of the fan.
2. Connect the 3-phase motor on the outputs U, V, W.
3. Connect a 220 V_{AC} source to the input ports.
4. The firmware is pre-downloaded.

The FOC software starts the motor with V/F control (open loop), and then transitions to FOC control (closed loop).

4.1 Description of board connections

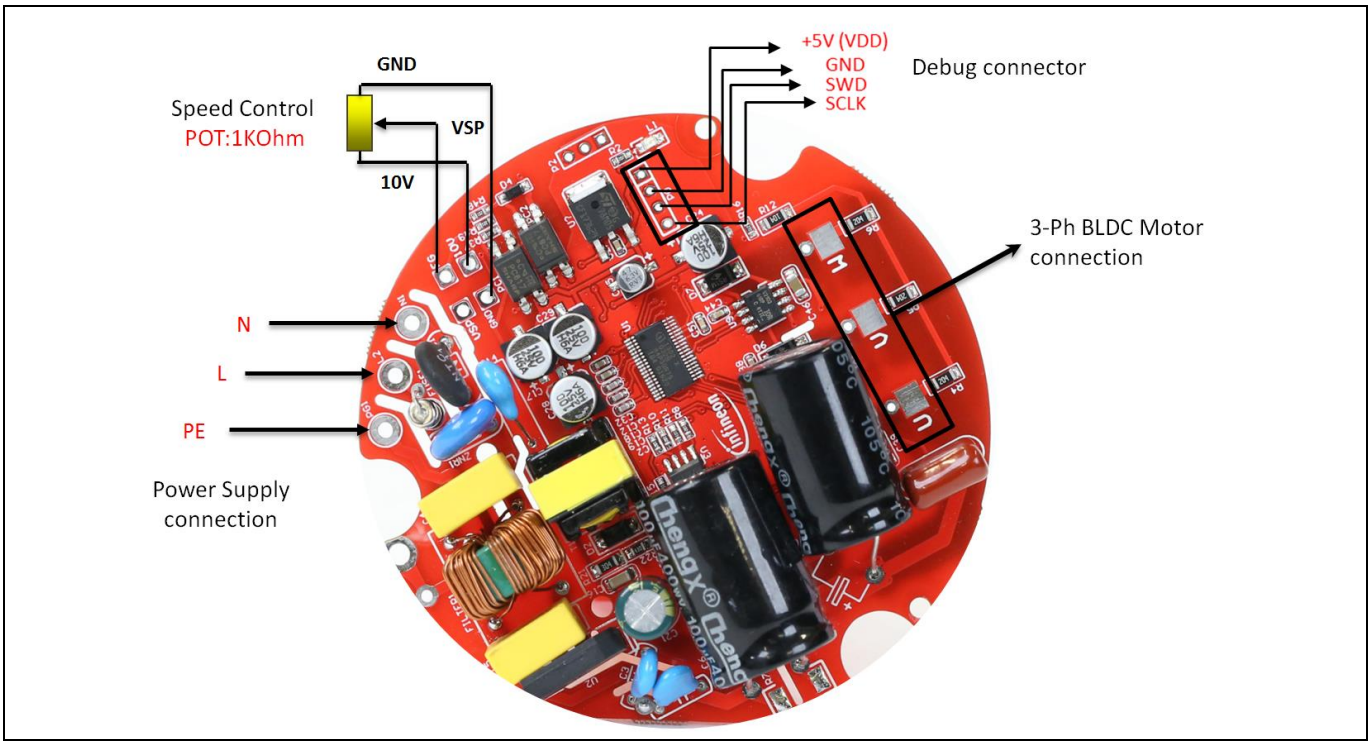

Figure 6 Description of board connections

5 Measurements

The double layer BLDC 100 W demo board was tested by driving a BLDC fan motor using FOC.The temperature reached steady state before reading the temperature on the CoolMOS™ devices. After measurement the load is increased by 10 W input power P_{AC}. For details about the measurement sequence, see Table 2.

Table 1 : Measurement equipment list parameters

Name	Remark
BLDC fan motor	
Power	110 W
Power factor	0,81
Number of poles	4 pole pairs
Phase resistance	27 Ω
Phase inductance	0.09 H
Maximum speed	2000 RPM
Phase connection (U,V,W,N)	Star connection
Power analyzer Yokogawa WT3000	
Voltage range	600 V
Current range	5 A
Line filter	50 Hz
Output 3 phase wirings	3P4 W
Input 1 phase wirings	1P1 W
Temperature measurement equipment	
Thermocouples	J-type GG-JI-36-SLE
Temperature measure unit	A55003830
Thermal camera	FLIR

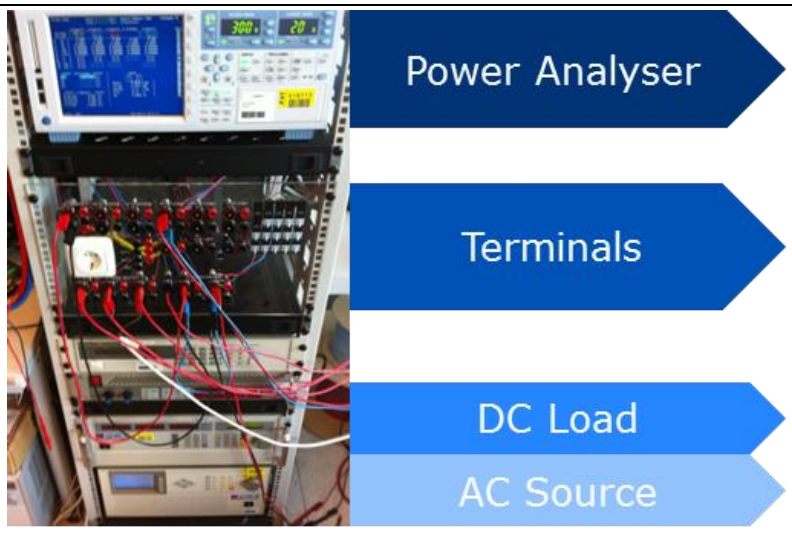

Figure 7 Measurement equipment

5.1 Setup

The demo board was tested on a test bench developed by Infineon that simulates a real cooling fan application. The board is designed for a 100 W output and consists of an input rectifier stage and an inverter stage. The CoolMOS™ devices are driven by a 600 V gate driver IC from Infineon (IRS2103) and the modulation pattern is provided by an Infineon microcontroller (XMC1300) mounted on the same board. No heatsink is required, just thermal vias through the PCB. The control method is sensorless FOC using a shunt based feedback loop. The board is driving a 100 W BLDC fan motor. The efficiency is monitored by Yokogawa WT3000 power meter and case temperature is monitored by an infrared camera.

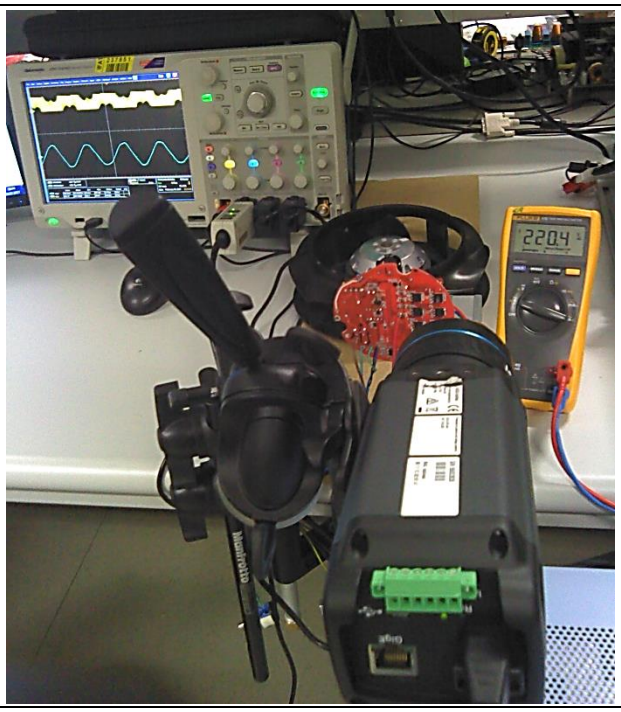

Figure 8 Test set up for the application measurements

5.2 Thermal behavior

The temperature distribution is quite uniform, as demonstrated by detailed analysis of the thermal images:

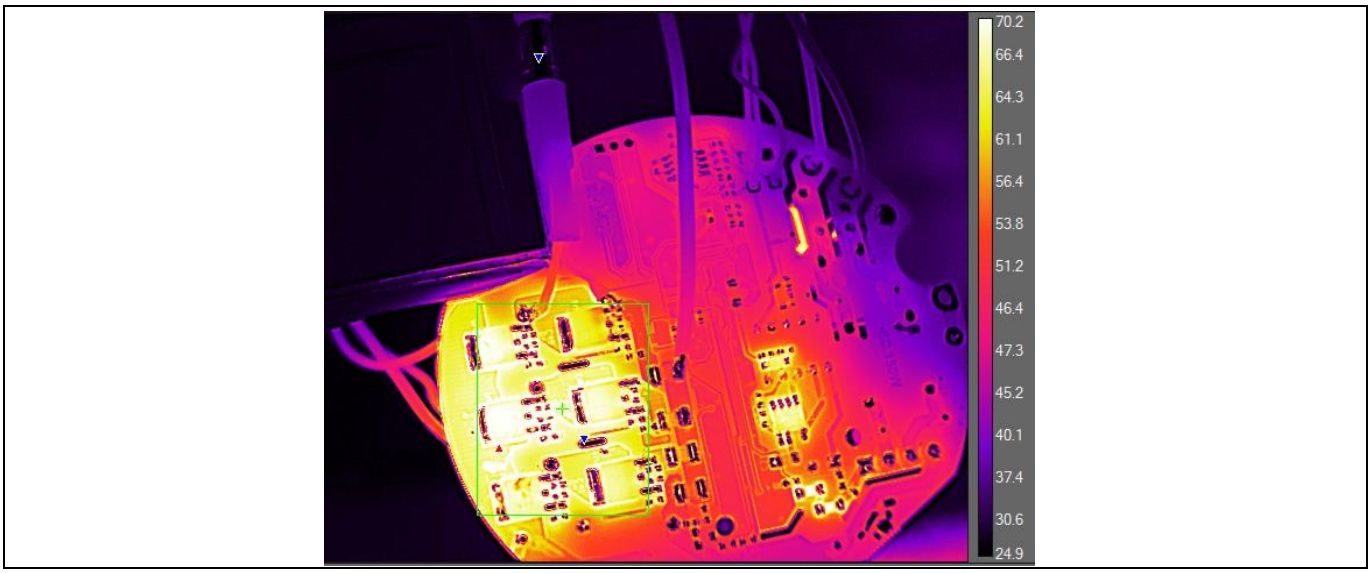

Figure 9 Thermal images at P_{in}=50 W, f_sw=15 kHz, T_{max}=70.2°C

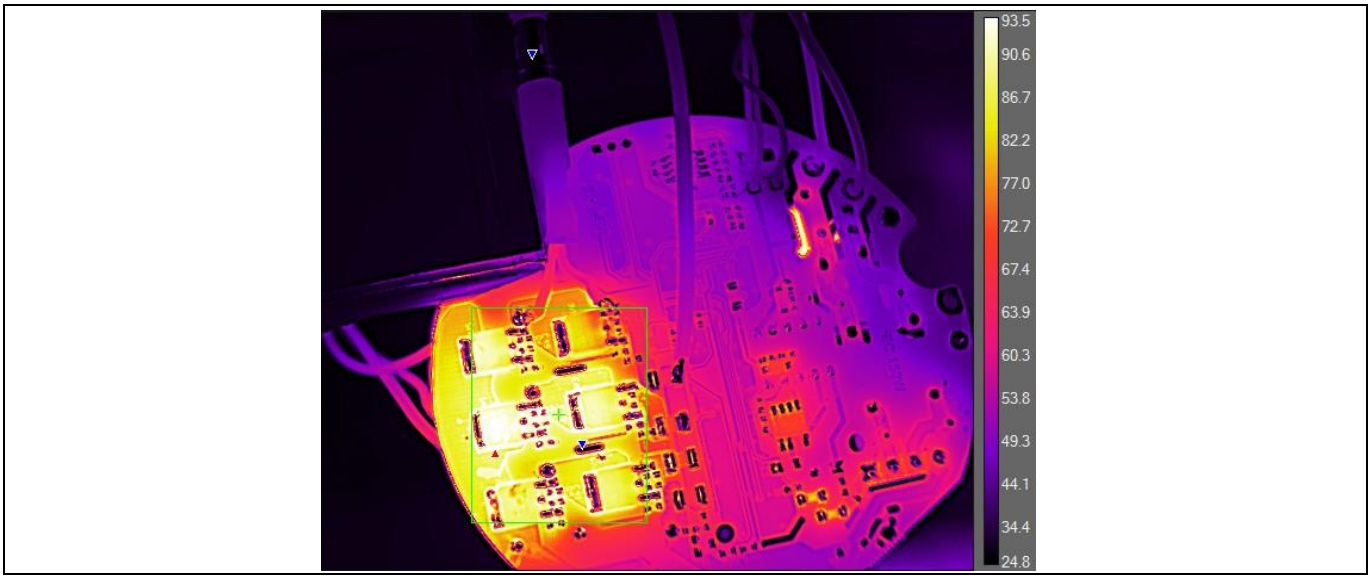

Figure 10 Thermal images at Pin=100 W, f_sw=15 kHz, Tmax=93.5°C

5.3 Efficiency

The test was performed with a 220 V_{AC} input up to 100 W load, with an ambient temperature of 25°C and a switching frequency of 15 kHz. The efficiency calculation includes the losses of the power switch and the recification, as well as driving and power supply losses. As such, the overall inverter efficiency is displayed.

Table 2 Efficiency measurement, f_sw = 15 kHz, IPD65R650CE

PDC [W]	Phase IDC [Arms]	IAC [Arms]	Efficiency [%]
25	0,09	0,23	81,2
35	0,13	0,32	85
45	0,18	0,42	87,6
55	0,22	0,50	88,7
75	0,35	0,67	90,2
100	0,42	0,77	90,9

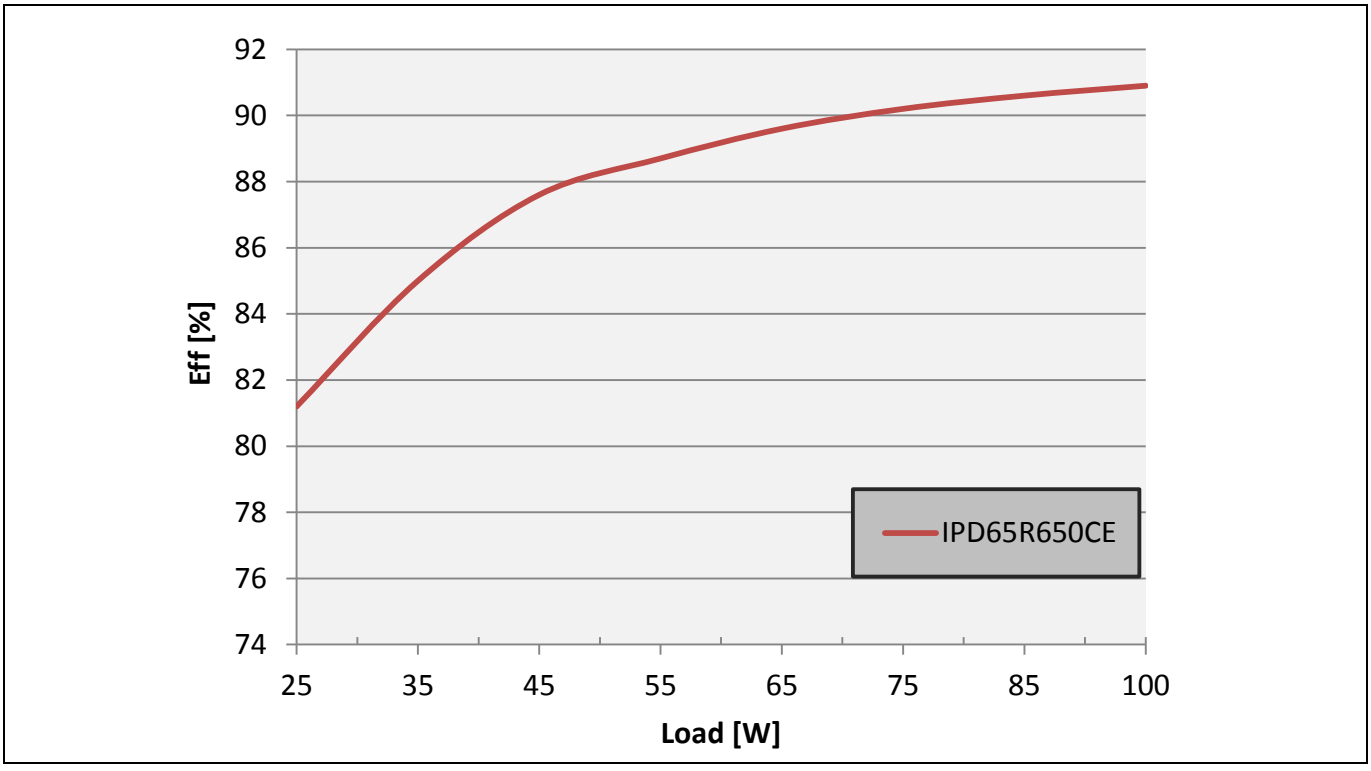

Figure 11 Efficiency measurement curve f_sw = 15 kHz, IPD65R650CE

6 Useful material and links

Where to find more information: www.infineon.com/ce

Figure 12 Infineon's CoolMOS™ CE product information

- Product information (parts, selection, x-reference, …)
- Application information (benefits, demo boards, …)

7 BOM

No.	Ref.	Description	Package	Manufacturer
1	V1, V2, V3, V4, V5, V6	IPD60R650C	TO-252AA	Infineon
2	U?	L78M05	TO-252AA	Infineon
3	U1	XMC1302_TSSOP38	TSSOP38	Infineon
4	U3, U5	TSV912	SO-8	ST
5	SC1	LNK625	SO-8	POWER INTEGRATIONS
6	U6	LM393	SO-8	ST
7	240/2W	3 A,250 V		FUSE
8	L1	LED	SMD0805	
9	NTC1	5D-11		VARISTOR
10	C2, C18, C19	101	SMD0805	Any
11	C3, C7	222/1 KV	SMD0805	Any
12	C4, C5	0.1 uF	SMD0805	Any
13	C6	100 uF/400 V	SMD0805	Any
14	C9	0.1 uF/630 V	SMD0805	Any
15	C10	68 uF/400 V	SMD0805	Any
16	C12, C13, C22, C23, C26, C27, C30, C33, C38, C44, C47	104	SMD0805	Any
17	C14	2.2 nF/250 V_{AC}	SMD0805	Any
18	C15	27 pF	SMD0805	Any
19	C16	0.47 nF/1K V	SMD0805	Any
20	C17, C29	100 uF/25 V	SMD0805	Any
21	C20	390 PF	SMD0805	Any
22	C21	2.2 uF/400 V	SMD0805	Any
23	C24	220 uF/25 V	SMD0805	Any
24	C25	47 uF/6.3 V	SMD0805	Any
25	C28	100 uF/25 V	SMD0805	Any
26	C31	1 uF/16 V	SMD0805	Any
27	C32	1 uF	SMD0805	Any
28	C34	224	SMD0805	Any
29	C35	223	SMD0805	Any
30	C36	473	SMD0805	Any
31	C37	103	SMD0805	Any
32	C39, C45, C46	4.7 U/25 V	SMD0805	Any
33	C40, C41, C42, C43,	332	SMD0805	Any

	C49, C50			
34	U2	KBP310G	SMD0805	Diode Bridge
35	C51, C52	102	SMD0805	Any
36	R2	2 K	SMD0805	Any
37	R3, R4, R5, R6, R9	200 K	SMD0805	Any
38	R7	560 K	SMD0805	Any
39	R8, R10, R13, R23, R24, R26, R30, R31, R34, R37, R44, R48, R69, R70, R74	1 k	SMD0805	Any
40	R11, R15, R27, R29, R33, R35, R36, R41, R53, R54, R59, R60, R64, R67	10 k	SMD0805	Any
41	R12	100 K	SMD0805	Any
42	R14	3.3 K	SMD0805	Any
43	R16	2.7 K	SMD0805	Any
44	R17, R18	10 K 1%	SMD0805	Any
45	R19	0	SMD0805	Any
46	R20	390R	SMD0805	Any
47	R21	300 K	SMD0805	Any
48	R22	43R	SMD0805	Any
49	R25	27R	SMD0805	Any
50	R28	51R	SMD0805	Any
51	R32	65 K	SMD0805	Any
52	R38, R43	100k	SMD0805	Any
53	R39	4.7k	SMD0805	Any
54	R40, R47	47k	SMD0805	Any
55	R42	47k	SMD0805	Any
56	R45	22k	SMD0805	Any
57	R46	300K	SMD0805	Any
58	R49	220R	SMD0805	Any
59	R50	470R	SMD0805	Any
60	R51, R52, R55, R56, R63, R65	100R	SMD0805	Any
61	R57, R61, R62, R71	0.05R	SMD0805	Any
62	T1	EE13		Three-winding Transformer
63	Q1	8050	SOT-23-A	NPN Bipolar Transistor
64	PC1, PC2	FOD817C300	SO-4	Any
65	FILTER1	T381	EMI10*12	Any

66	D1, D3	SOD1F7	SOD-123	Any
67	D2, D5, D6, D7	RS1M	DO-214	Any

8 Revision history

Major changes since the last revision

Page or reference	Description of change
1.0	Application Note created

Edition 2017-02-23

Published by

Infineon Technologies AG

81726 Munich, Germany

Do you have a question about this document?

Email: erratum@infineon.com

Document reference
AN_201702_PL52_008

IMPORTANT NOTICE

The information contained in this application note is given as a hint for the implementation of the product only and shall in no event be regarded as a description or warranty of a certain functionality, condition or quality of the product. Before implementation of the product, the recipient of this application note must verify any function and other technical information given herein in the real application. 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) with respect to any and all information given in this application note.

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.

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.