Getting started with the X-NUCLEO-IHM07M1 motor driver expansion board based on the L6230 for STM32 Nucleo

Introduction

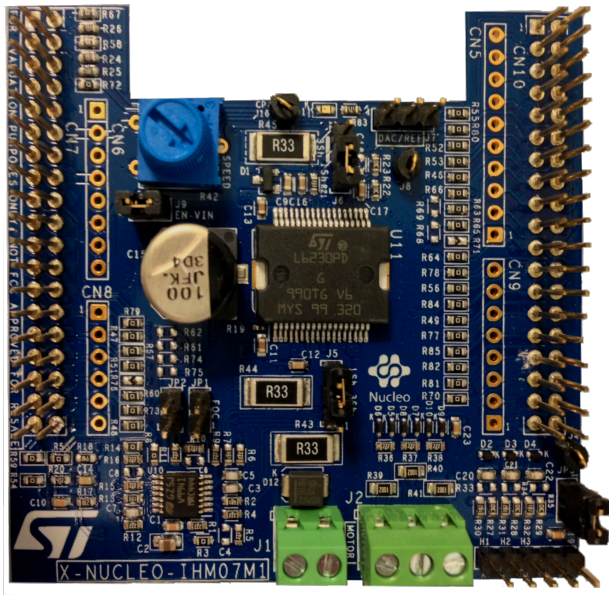
The X-NUCLEO-IHM07M1 is a three-phase brushless DC motor driver expansion board based on the L6230 for STM32 Nucleo. It provides an affordable and easy-to-use solution for driving three-phase brushless DC motor in your STM32 Nucleo project.

The X-NUCLEO-IHM07M1 is compatible with the ST Morpho connector and supports the addition of other boards which can be stacked with onto a single STM32 Nucleo board.

The user can also mount the Arduino UNO R3 connector. The driver used on this expansion board is the L6230, a DMOS fully integrated driver for three-phase brushless DC motors assembled in a PowerSO-36 package (L6230PD), with overcurrent and thermal protection.

The L6230 driver is optimized for six-step and FOC algorithms thanks to independent current sensing.

Figure 1. X-NUCLEO-IHM07M1 three-phase brushless DC motor driver expansion board based on L6230 for STM32 Nucleo



1 Getting started

1.1 Overview

The X-NUCLEO-IHM07M1 expansion board features:

- 3-phase driver for BLDC/PMSM motors
- Nominal operating voltage range from 8 V to 48 VDC
- 2.8 A output peak current (1.4 A_{RMS})
- Operating frequency up to 100 kHz
- Non dissipative overcurrent detection and protection
- Cross-conduction protection
- Thermal measuring and overheating protection
- Compatible with STM32 Nucleo boards
- Fully compatible with STM32 Motor Control SDK
- Equipped with ST morpho connectors
- Three-shunt and single-shunt configurable jumpers for motor current sensing
- Hall/Encoder motor sensor connector and circuit
- Debug connector for DAC, GPIOs, etc.
- Potentiometer available for speed regulation
- User LED
- RoHS compliant

1.2 Target applications

- Low voltage PMSM motor driver
- Low power fans
- Power tools
- Industrial drives

1.3 Electro static discharge (ESD) immunity

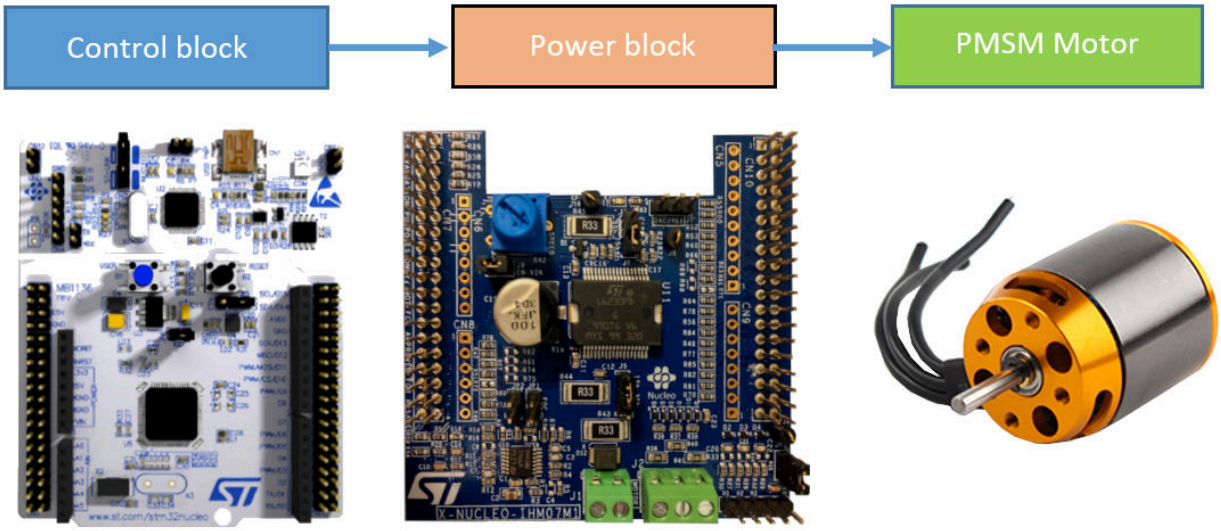
The board is not immune to indirect electrostatic discharges according to EN 61000-4-2 (electrostatic discharges applied to objects adjacent to the board). During the ESD test the board obtained level C, meaning that the board was not damaged during the test, but shut down while the test was performing, with the need to restart it manually after the test. The board required the intervention of the operator to reset it. When an electrostatic discharge is applied to an adjacent object, there is the risk that the board interrupts its functioning, and in this case the intervention of the operator is required to reset the board.

1.4 Architecture

A generic motor control system can be schematized in:

- a **control block** which accepts user commands and drive the motor; an STM32 Nucleo development board provides digital signals to properly implement motor driver control;
- a **power block** which is based on three-phase inverter topology. The power block core consists of the L6230 driver, which contains the necessary active power and analog components to perform low voltage PMSM motor control;
- a **motor** - the X-NUCLEO-IHM07M1 can drive a low voltage BLDC/PMSM motor.

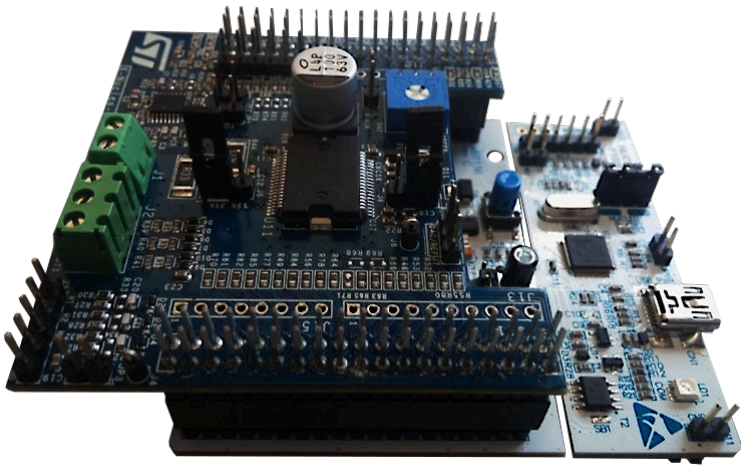
Figure 2. **Motor control system**



1.5 System setup

The X-NUCLEO-IHM07M1 expansion board (power block) has to be connected to an STM32 Nucleo development board (control block) through the ST morpho connector, as shown below.

Figure 3. **X-NUCLEO-IHM07M1 plugged on STM32 Nucleo**



The X-NUCLEO-IHM07M1 is designed to be plugged onto many STM32 Nucleo development boards without modifying any solder bridge. When stacked, the system is ready to operate with a BLDC/PMSM motor.

Note: For software details, refer to STM32 Motor Control SDK.

1.5.1 Hardware settings

Table 1. **Jumper settings**

Jumper	Allowed configurations	Default condition
JP1	Pull-up insertion (BIAS) in current sensing circuit	OPEN
JP2	Op-amp gain modification in current sensing circuit	OPEN
JP3	Pull-up enabling in Hall/Encoder detection circuit	CLOSED

Jumper	Allowed configurations	Default condition
J9	Supply the STM32 Nucleo development board through the X-NUCLEO-IHM07M1 expansion board (1)	OPEN
J5	Single/three shunt configuration. *Note: Set to single shunt by default.*	2-3 CLOSED
J6	Single/three shunt configuration. *Note: Set to single shunt by default.*	2-3 CLOSED
J7	Debug connector for DAC, available for probe connection	OPEN

1. *Remove J9 jumper before powering on J1.*

Caution: When J9 is closed, do not exceed 12 V DC on J1 connector to prevent damaging the STM32 Nucleo board.

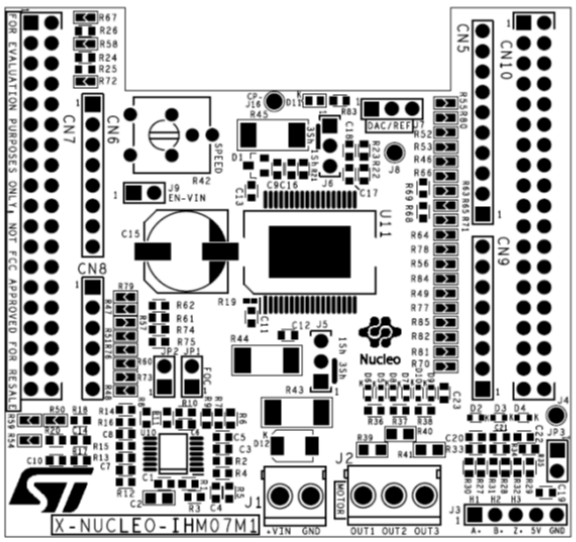
Important: JP5 jumper on the STM32 Nucleo has to be connected between pin 2 and 3 to enable the STM32 Nucleo external power supply.

Table 2. Screw terminal table

Screw terminal	Function
J1	Motor power supply input (8 V- 48 V DC)
J2	3-phase motor connector

Figure 4. X-NUCLEO-IHM07M1 silk-screen (top layer)

CN7
ST Morpho connector
CN6
Arduino UNO Connector
CN8
Arduino UNO Connector
U11
L6230 driver
U10
TSV994IPT op. amp.
J1
Power supply connector
J9
Enable VIN supply voltage
JP1, JP2
Jumpers for FOC
SPEED
Potentiometer



CN10
ST Morpho connector
CN5
Arduino UNO Connector
CN9
Arduino UNO Connector
J2
Motor connector
J3
Hall/Encoder sensor connector
J7
Debug connector
JP3
External pull-up for sensors
J5, J6
Current measure mode (1Sh/3Sh)
D11
LED status indicator

The X-NUCLEO-IHM07M1 expansion board is equipped with ST morpho connectors (CN7 and CN10 male pin headers are accessible on both sides of the board). They connect the power board to the STM32 Nucleo board. All signals and power pins of the MCU are available on the ST morpho connector.

Table 3. ST morpho connector table

Connector	Pin	Signal	Solder bridge
CN7	1	Enable_CH1-L6230	R58
	2	Enable_CH2-L6230	R67
	3	Enable_CH3-L6230	R72

Connector	Pin	Signal	Solder bridge
CN7	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17	Encoder A/Hall H1	R79
	18	Encoder/Hall PS voltage	
	19		
	20		
	21		
	22		
	23	Blue button	
	24		J9
	25		
	26		
	27		
	28	Curr_fdbk_PhA	R47
	29		
	30	VBUS_sensing	R51
	31		
	32	DAC_Ch	R76 N.M.
	33		
	34	BEMF2_sensing	R60
	35	Temperature feedback	R54
	36	Curr_fdbk_PhB	R48
	37	BEMF1_sensing	R59
	38	Curr_fdbk_PhC	R50
CN10	1		
	2		
	3		
	4		
	5		
	6		

Connector	Pin	Signal	Solder bridge
CN10	7		
	8		
	9		
	10		
	11	GPIO/DAC/PWM	R80
	12	CPOUT	R52
	13	DIAG/ENABLE/BKIN1	R53
	14	DIAG/ENABLE/BKIN2	R46
	15	BEMF3_sensing	R63
	16		
	17		
	18		
	19		
	20		
	21	VH_PWM	R64
	22	LED RED	R83
	23	UH_PWM	R56
	24	POTENTIOMETER	R78
	25	Encoder Z/Hall H3	R84
	26	BEMF3_sensing	R66
	27	CURRENT REF	R77
	28	DIAG/ENABLE/BKIN1	R49
	29	GPIO/DAC/PWM	R85
	30	GPIO/DAC/PWM	R82
	31	Encoder B/Hall H2	R81
	32		
	33	WH_PWM	R70
	34		
	35		
	36		
	37		
	38		

2 Circuit description

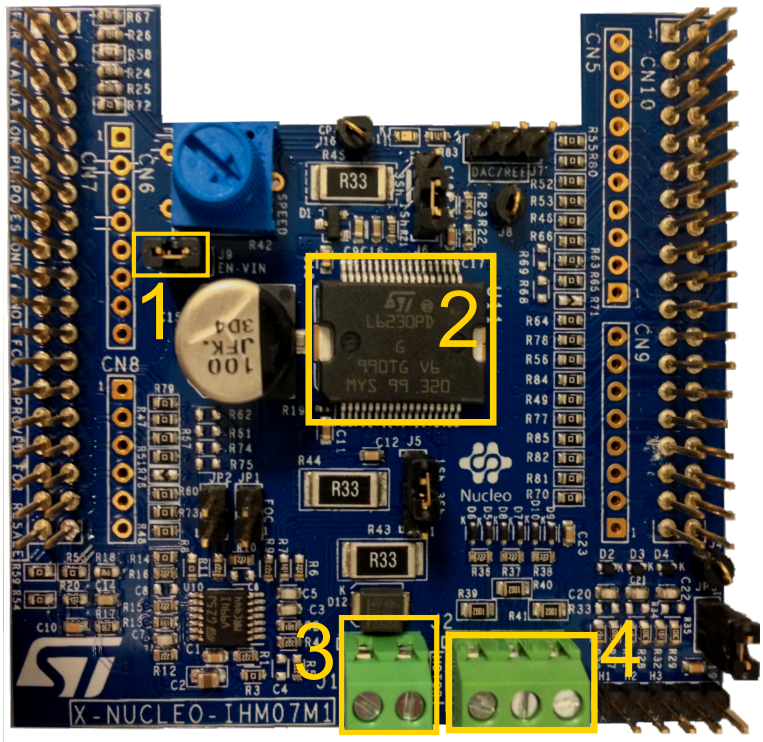
2.1 Power section

2.1.1 L6230 driver with integrated three-phase bridge

The main section is based on the L6230. It is a DMOS fully-configurable driver for three-phase brushless BLDC/ PMSM motors. The supply voltage is provided through an external connector (J1) and with (J9) jumper settings, it is possible to choose if the digital section (STM32 Nucleo board) must be supplied by USB or by the expansion board. For these settings, please refer to Table 1. Jumper settings.

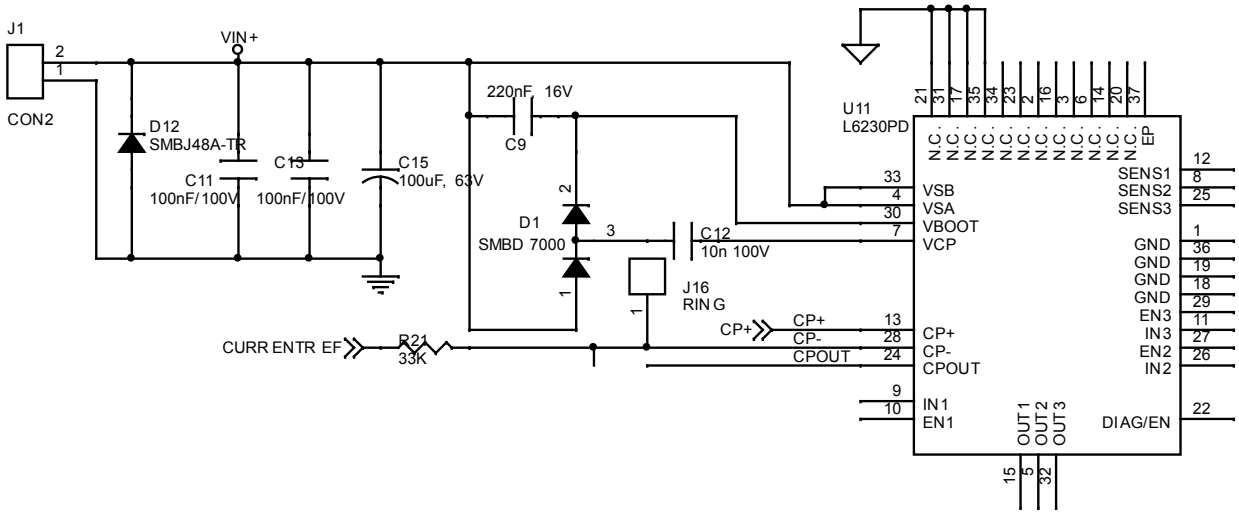
Figure 5. X-NUCLEO-IHM07M1 power section

1. J9 jumper
2. L6230 in PowerSO36 package
3. Power supply input
4. Motor connector



The L6230 integrates a three-phase bridge which consists of six power MOSFETs. Using the N-channel power MOSFET for the upper transistors in the bridge requires a gate drive voltage above the power supply voltage. The bootstrapped supply (VBOOT) is obtained through an internal oscillator and a few external components to implement a charge pump circuit as shown below.

Figure 6. X-NUCLEO-IHM07M1 – charge pump circuit



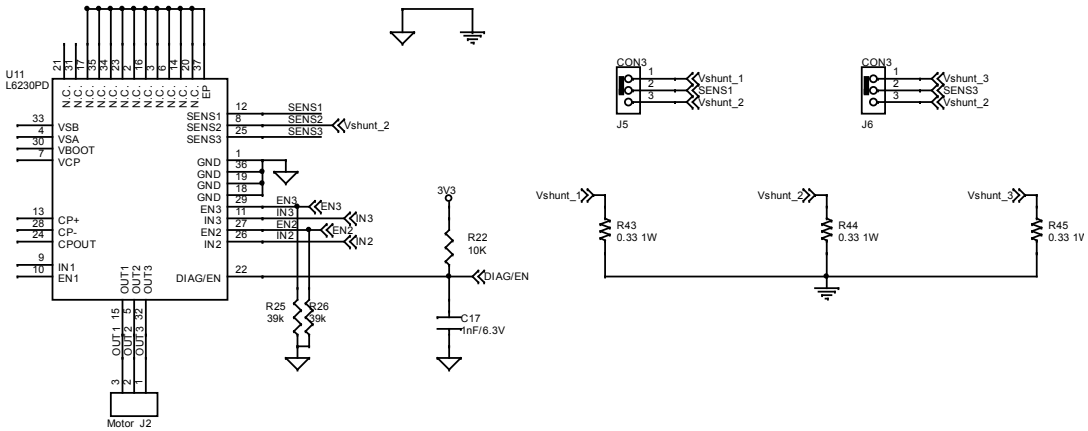
2.1.2 Overcurrent detection (OCP) and current sensing measurement

The L6230 driver implements overcurrent protection with an internal detection circuit that does not require an external resistor.

The current is compared with an embedded current reference and the output signals a fault condition to the DIAG pin that goes to ground. This pin, connected to the STM32 Nucleo board (BKIN timer function), detects this condition and immediately disables the driving signals.

The current sensing input is connected to the sensing resistors Rsense (shown in the figure below). You can choose between three-shunt or single-shunt configuration through J5 and J6 jumpers (refer to Table 1. Jumper settings).

Figure 7. X-NUCLEO-IHM07M1 current sensing circuit



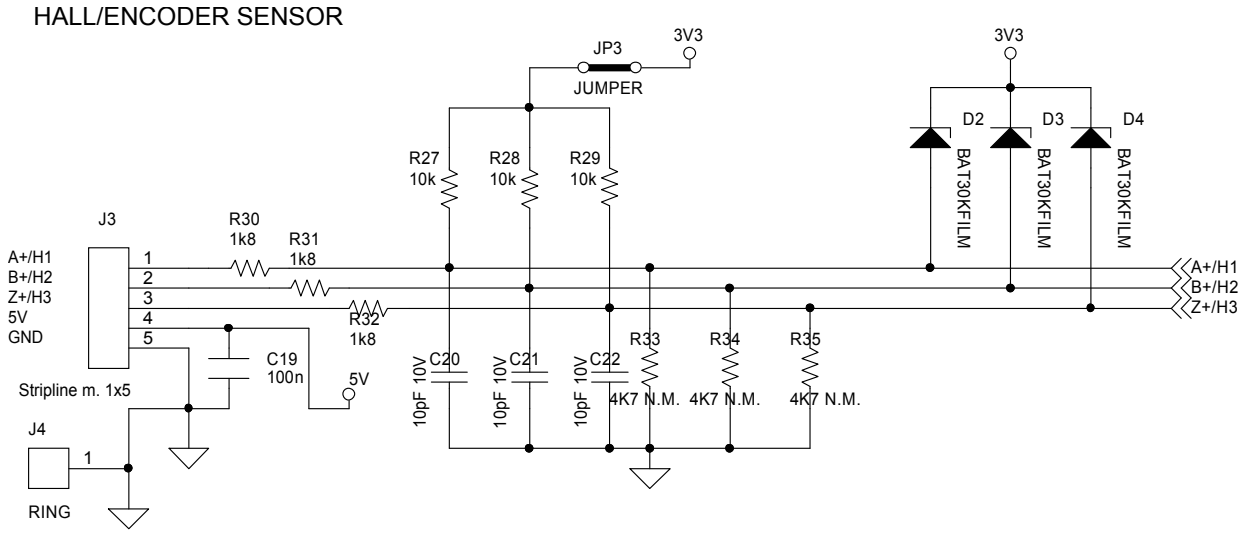
2.2 Analog section

2.2.1 Hall/Encoder motor speed sensor

The X-NUCLEO-IHM07M1 expansion board implements the Hall/Encoder sensor detecting circuit for speed measurement. The motor sensor pins, through J3 connector and an analog circuit, are connected to the STM32 Nucleo board to detect the motor spin; a +5 V and GND are also provided for the sensor power supply.

For sensors that require external pull-up, use JP3 jumper (refer to Table 1. Jumper settings).

Figure 8. X-NUCLEO-IHM07M1 Hall/Encoder sensor circuit

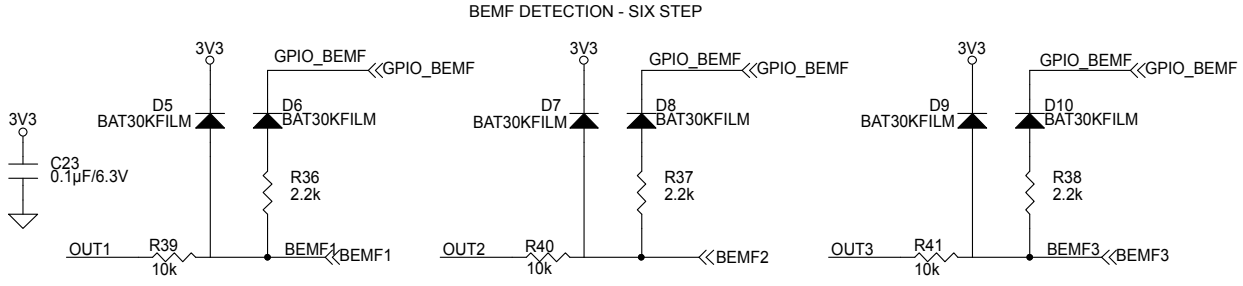


2.2.2 BEMF detection circuit

The X-NUCLEO-IHM07M1 expansion board provides two hardware solutions for motor position measuring: one based on sensors (refer to Section 2.2.1 Hall/Encoder motor speed sensor) and the other based on sensorless detection.

In six-step driving mode, one of the three phases is left in high impedance state. By comparing the voltage of this phase to the center-tap voltage, you can detect the BEMF zero-crossing. This signal is acquired with an analog circuit embedded on the board as shown below.

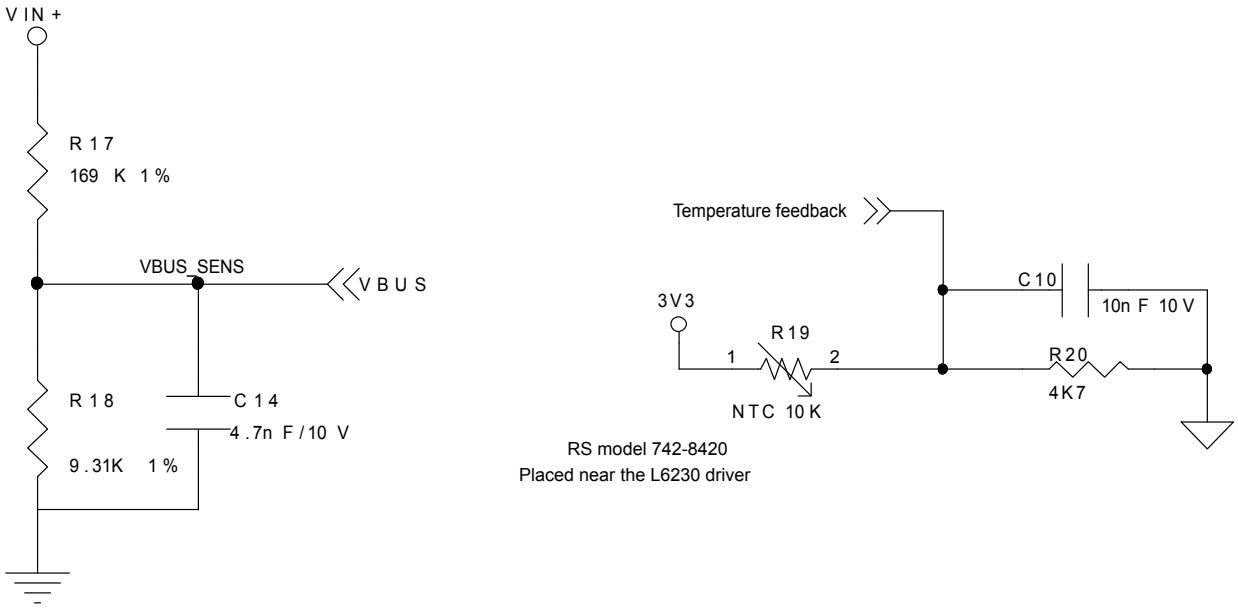
Figure 9. X-NUCLEO-IHM07M1 – BEMF detection circuit



2.2.3 Bus voltage and temperature sensing circuit

The X-NUCLEO-IHM07M1 expansion board provides the hardware for bus voltage sensing and temperature measurement. This signal is acquired with a resistor divider and an embedded NTC (close to L6230 driver) as shown below.

Figure 10. X-NUCLEO-IHM07M1 – VBUS and temperature sensing circuit



3 Schematic diagrams

Figure 11. **X-NUCLEO-IHM07M1 circuit schematic (1 of 4)**

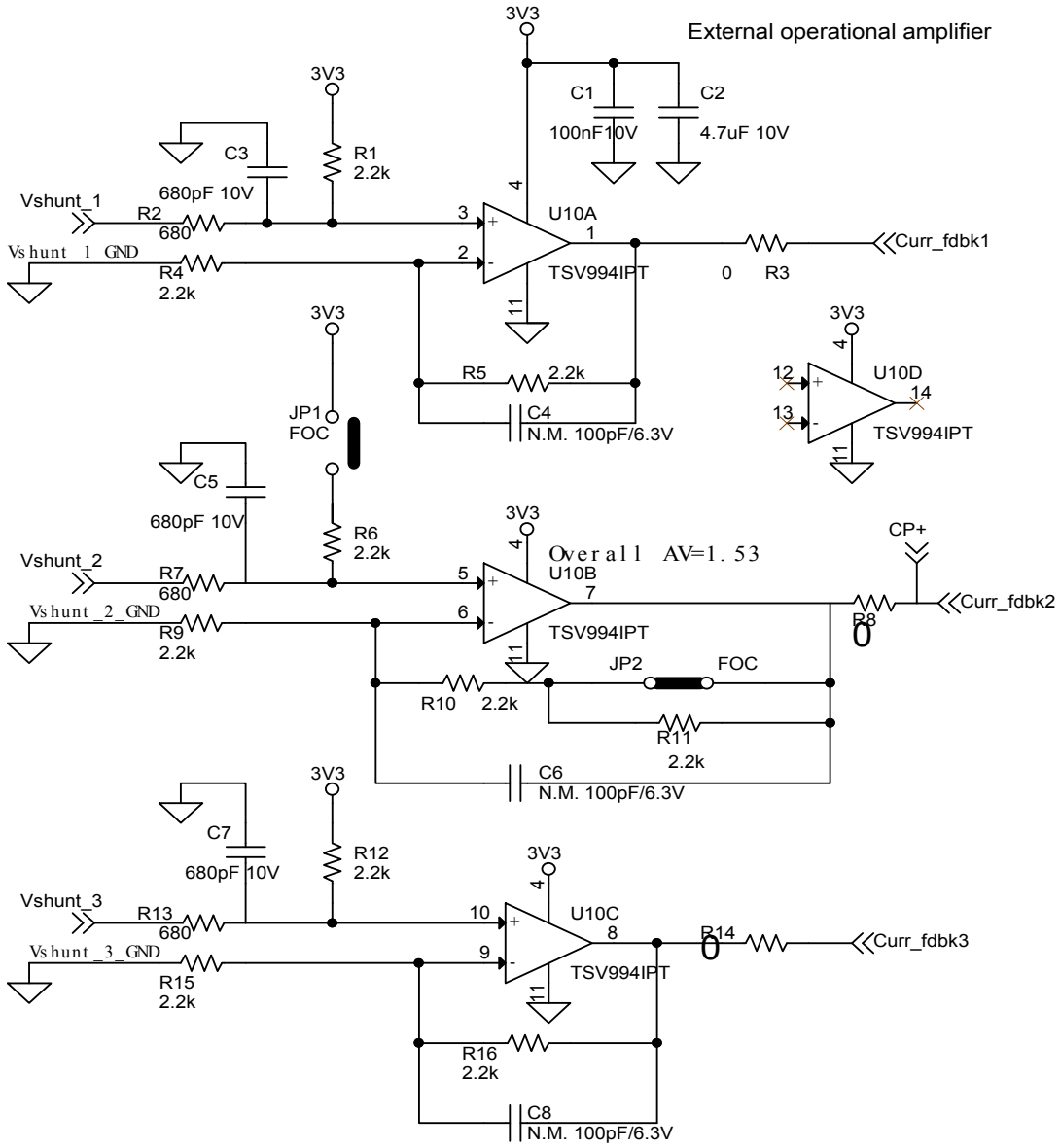


Figure 12. X-NUCLEO-IHM07M1 circuit schematic (2 of 4)

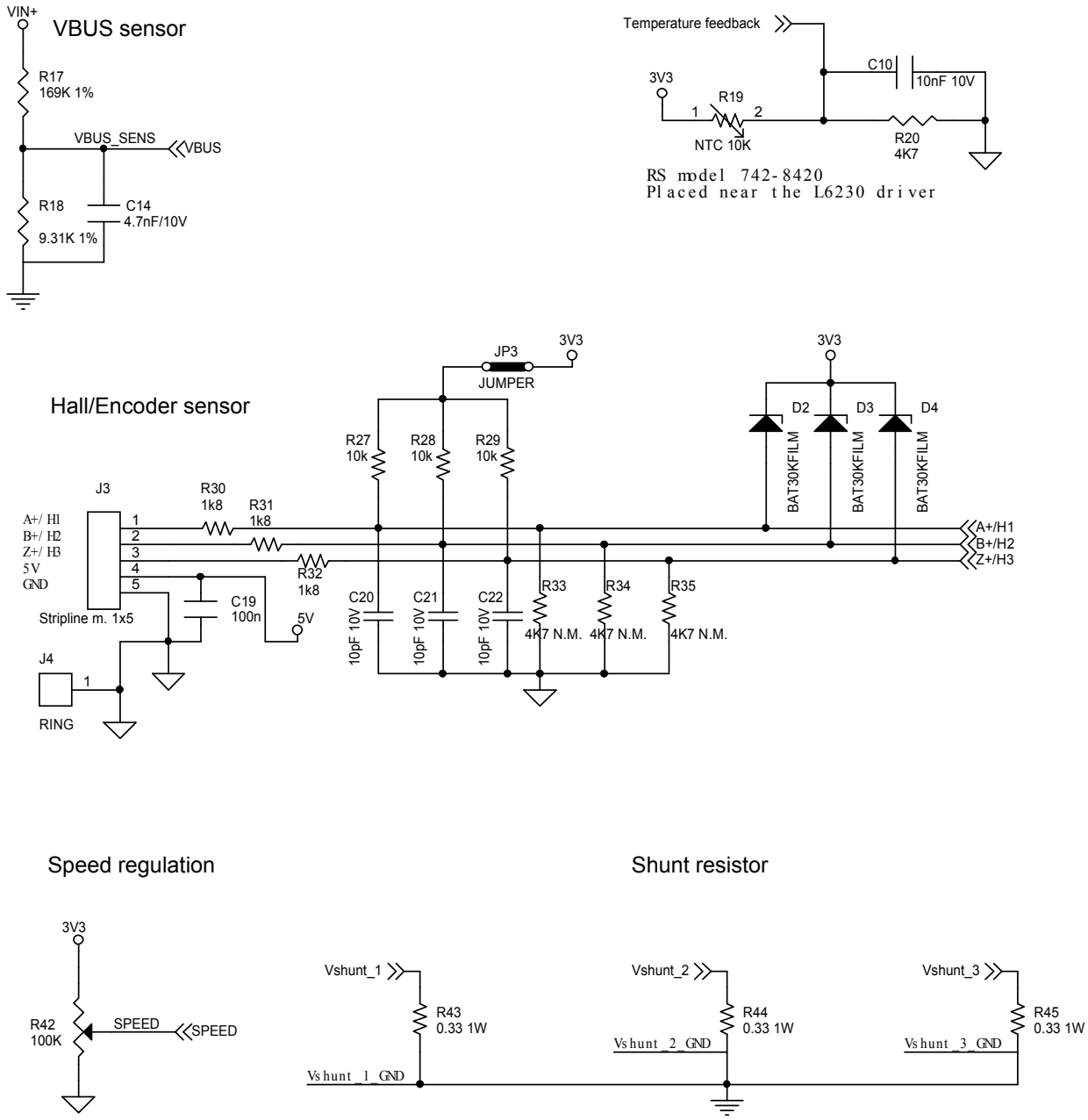
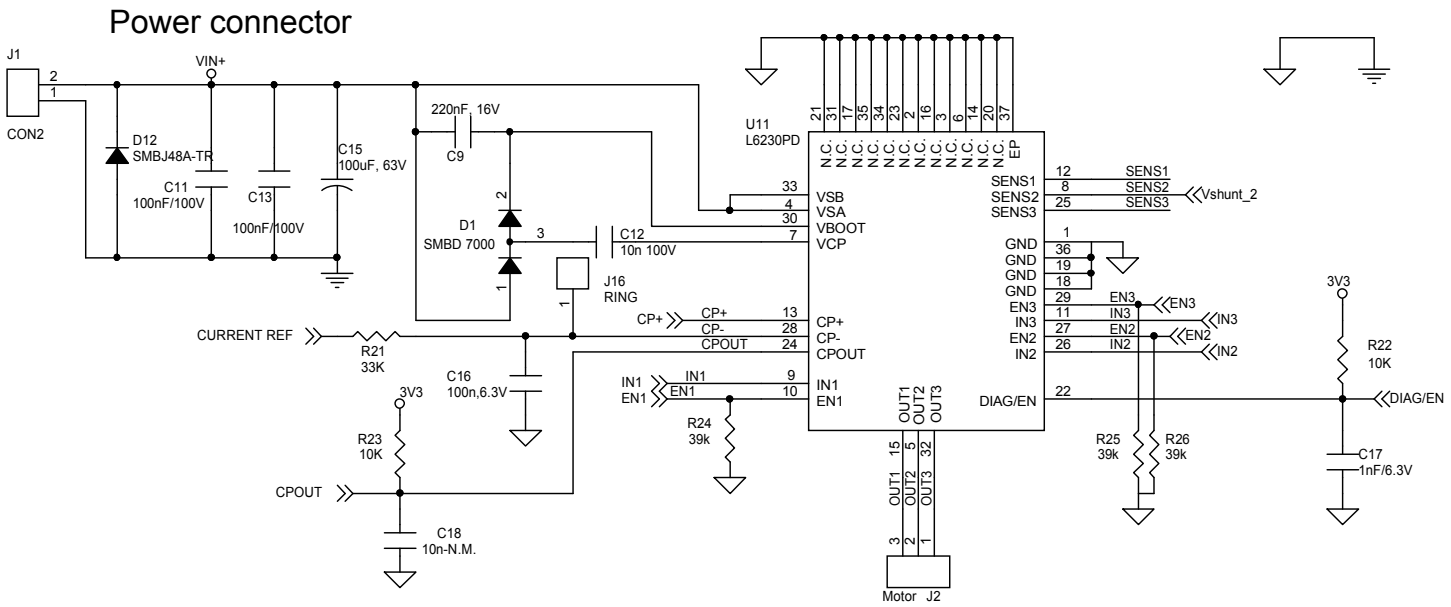
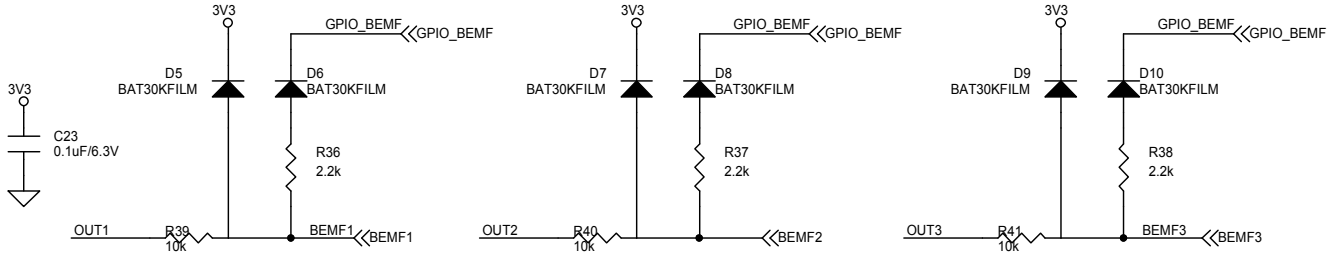


Figure 13. X-NUCLEO-IHM07M1 circuit schematic (3 of 4)

L6230 DMOS driver for three-phase brushless DC motor

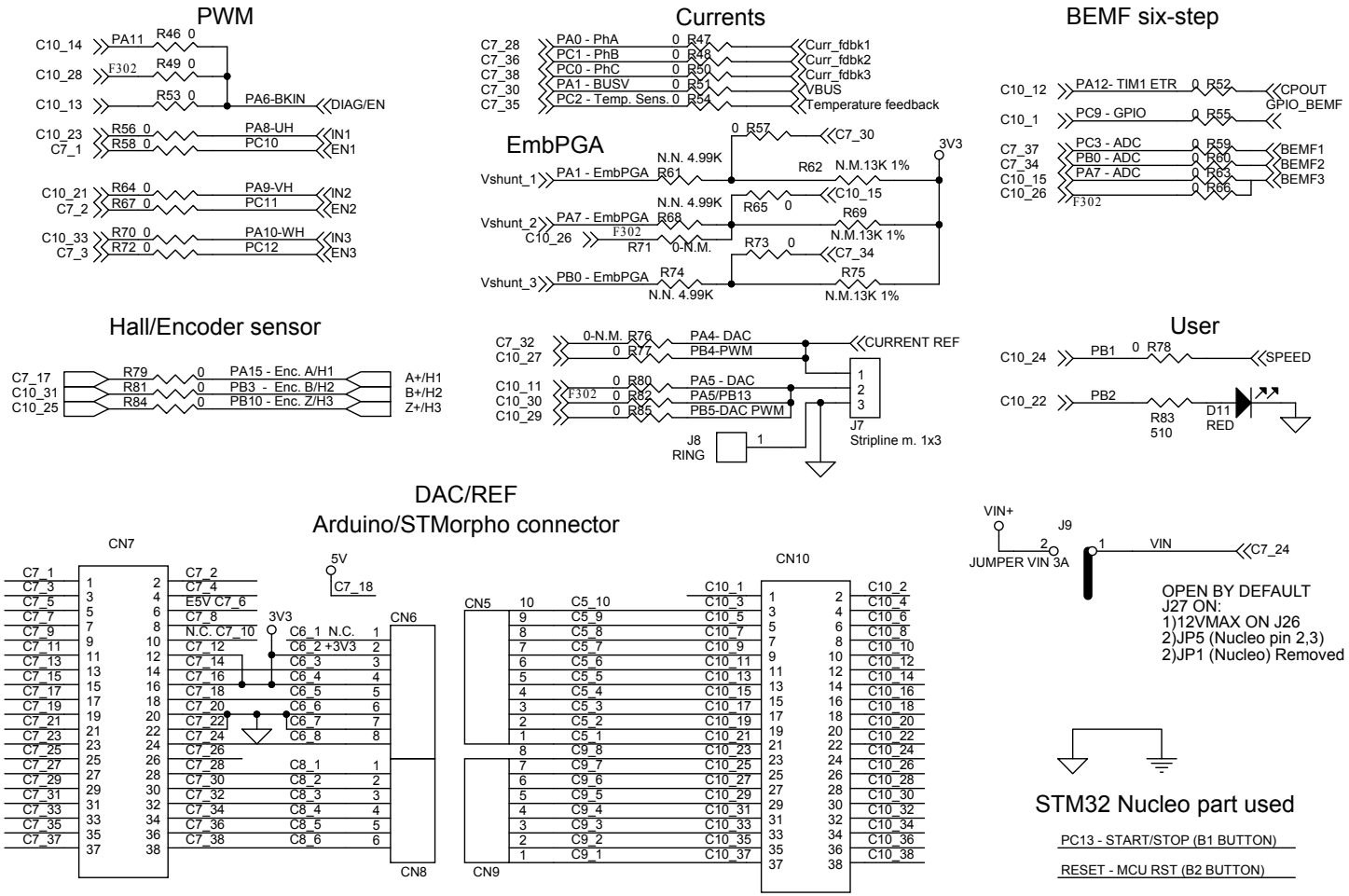


BEMF detection - six step



Single/three shunt configuration

Figure 14. X-NUCLEO-IHM07M1 circuit schematic (4 of 4)



4 Bill of materials

Table 4. **X-NUCLEO-IHM07M1 bill of materials**

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	4	C1, C16, C19, C23	100 nF 10 V X7R ±10% 0603	Ceramic multilayer capacitors	Any	Any
2	1	C2	4.7 µF 10 V X7R ±20% 0805	Ceramic multilayer capacitors	TDK	C2012X7R1A475M125AC
3	3	C3, C5, C7	680 pF 10 V C0G ±5% 0603	Ceramic multilayer capacitors	Any	Any
4	3	C4, C6, C8	100 pF 6.3 V X7R ±10% 0603	Ceramic multilayer capacitors (not mounted)	Any	Any
5	1	C9	220 nF 16 V X7R ±10% 0603	Ceramic multilayer capacitors	Any	Any
6	1	C10	10 nF 10 V ±10% 0603	Ceramic multilayer capacitors	Any	Any
7	1	C18	10 nF 10 V X7R ±10% 0603	Ceramic multilayer capacitors (not mounted)	Any	Any
8	2	C11, C13	100 nF 100 V X7R ±10% 0603	Ceramic multilayer capacitors	Any	Any
9	1	C12	10 n 100 V X7R ±10% 0603	Ceramic multilayer capacitors	Any	Any
10	1	C14	4.7 nF 10 V X7R ±10% 0603	Ceramic multilayer capacitors	Any	Any
11	1	C15	100 µF 63 V 0.2 SMD 10 mm x 10.5 mm	Aluminium electrolytic capacitor	Nichicon	UUX1J101MNL1GS
					Panasonic	EEEFK1J101P
					Farnell	2254433
12	1	C17	1 nF 6.3 V X7R ±10% 0603	Ceramic multilayer capacitor	Any	Any
13	3	C20, C21, C22	10 pF 10 V C0G ±5% 0603	Ceramic multilayer capacitor	Any	Any
14	1	D1	SMBD 7000 220 mA SOT-23	Signal diode	Infineon	SMBD 7000
15	9	D2, D3, D4, D5, D6, D7, D8, D9, D10	BAT30KFILM 30 V 0.3 A SOD-523	30 V, 300 mA SMD general purpose signal Schottky diode	ST	BAT30KFILM
16	1	D11	RED, SMD SMD 0603	LED	Lite-on	LTST-C193KRKT-5A
17	4	JP1, JP2, JP3, J9	2-way strip line male 2.54 mm TH 2.54 mm pitch	Jumpers	Any	Any
18	1	J1	2 way 3.81mm PCB terminal block TH 3.81 mm pitch	Input connector	Any	Any
					4UCONN	12342
19	1	J2	3 way 3.81mm PCB terminal block TH 3.81 mm pitch	Motor connector	Any	Any
					4UCONN	12335

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
20	1	J3	Stripline m. 1x5 5-way strip line 2.54 mm TH 2.54 mm pitch	Jumper	Any	Any
21	3	J4, J8, J16	RING TH	Jumpers	Vero Technologies	20-2137
22	3	J5, J6, J7	CON3 Stripline m. 1x3 3-way strip line 2.54 mm TH 2.54 mm pitch	Jumpers	Any	Any
23	2	CN7, CN10	ST_MORPHO_1 9x2 TH 2.54 mm pitch	38-pin elevated socket morpho connector	Samtec	ESQ-119-24-T-D
24	2	CN6, CN9	CONN8 TH 2.54 mm pitch (not mounted)	8-pin elevated socket	Samtec	ESQ-108-24-T-S
					4UCONN	15284
25	1	CN5	CONN10 TH 2.54 mm pitch (not mounted)	10-pin elevated socket	Samtec	ESQ-110-24-T-S
					4UCONN	15286
26	1	CN8	CONN6 TH 2.54 mm pitch (not mounted)	6-pin elevated socket	Samtec	ESQ-106-24-T-S
					4UCONN	15282
27	13	R1, R4, R5, R6, R9, R10, R11, R12, R15, R16, R36, R37, R38	2.2 kOhm 0.1 W ±1% 0603	SMD resistors	Any	Any
28	3	R2, R7, R13	680 Ohm 0.1 W 0603	SMD resistors	Any	Any
29	34	R3, R8, R14, R46, R47, R48, R49, R50, R51, R52, R53, R54, R55, R56, R57, R58, R59, R60, R63, R64, R65, R66, R67, R70, R72, R73, R77, R78, R79, R80, R81, R82, R84, R85	0 Ohm 0.1 W 0603	SMD resistors	Any	Any
30	1	R17	169 kOhm 0.1 W ±1% 0603	SMD resistor	Vishay	CRCW0603169KFKEA
31	1	R18	9.31 kOhm 0.1 W ±1% 0603	SMD resistor	Panasonic	ERJ3EKF9311V
32	1	R19	NTC 10 kOhm ±1%	NTC thermistor	TDK	NTCG103JF103F
33	1	R20	4.7 kOhm 0.1 W 0603	SMD resistor	Any	Any
34	1	R21	33 kOhm 0.1 W 0603	SMD resistor	Any	Any

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
35	5	R22, R23, R27, R28, R29	10 kOhm 0.1 W 0603	SMD resistors	Any	Any
36	3	R39, R40, R41	10 kOhm 0.25 W 0805	SMD resistors	Panasonic	ERJT06J103V
37	3	R24, R25, R26	39 kOhm 0.1 W 0603	SMD resistors	Any	Any
38	3	R30, R31, R32	1.8 kOhm 0.1 W 0603	SMD resistors	Any	Any
39	3	R33, R34, R35	4.7 kOhm 0.1 W 0603	SMD resistors (not mounted)	Any	Any
40	1	R42	100 kOhm 1/2 W ±10%	Trimmer resistor	Bourns	3386P-1-104LF
41	3	R43, R44, R45	0.33 Ohm 1 W ±1% 2512	Shunt resistor	Panasonic	ERJ1TRQFR33U
42	3	R61, R68, R74	4.99 kOhm 0.1W 0603	SMD resistors (not mounted)	Any	Any
43	3	R62, R69, R75	13 kOhm 0.1W 0603	SMD resistors (not mounted)	Any	Any
44	2	R71, R76	0.1 W N.M. 0603	SMD resistors (not mounted)	Any	Any
45	1	R83	510 Ohm 0.1 W 0603	SMD resistor	Any	Any
46	1	U10	TSV994IPT TSSOP	Wide bandwidth (20 MHz) rail-to-rail input/output 5 V CMOS op-amp	ST	TSV994IPT
47	1	U11	PowerSO	DMOS driver for three-phase brushless DC motors	ST	L6230PD
48	6		Female 2.54 mm	Jumper	Any	Any
49	1		SMBJ48A-TR SMB	600 W, 48 V TVS in SMB	ST	SMBJ48A-TR

5 Regulatory compliance information

Notice for US Federal Communication Commission (FCC)

For evaluation only; not FCC approved for resale

FCC NOTICE - This kit is designed to allow:

(1) Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and

(2) Software developers to write software applications for use with the end product.

This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter 3.1.2.

Notice for Innovation, Science and Economic Development Canada (ISED)

For evaluation purposes only. This kit generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to Industry Canada (IC) rules.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

Notice for the European Union

This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS) according to standards EN 55032:2015+A11:2020 (Class B), EN 55035:2017+A11:2020 and EN IEC 63000:2018.

CE

Revision history

Table 5. **Document revision history**

Date	Version	Changes
17-Sep-2015	1	Initial release.
20-Jul-2021	2	Updated *Introduction*, *Section 1.1 Overview*, *Section 1.4 System setup*, *Section 1.4.1 Hardware settings* and *Section 2.1.1 L6230 driver with integrated three-phase bridge*. Text changes throughout the document.
20-Nov-2023	3	Added Section 1.3 Electro static discharge (ESD) immunity. Minor text changes.
15-Dec-2023	4	Added Section 5 Regulatory compliance information.