Getting started with the STEVAL-SPIN3202 evaluation board, advanced BLDC controller with embedded STM32 MCU

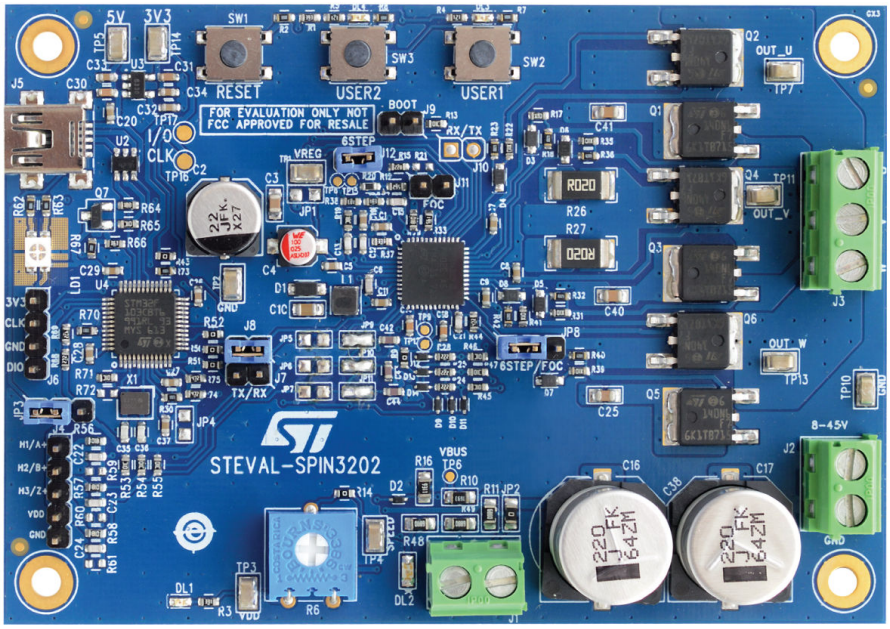
Introduction

The STEVAL-SPIN3202 three-phase brushless DC motor driver board is based on the STSPIN32F0A 3-phase controller with integrated STM32 MCU and STD140N6F7 MOSFETs.

It implements a single shunt resistor current reading topology and provides an easy-to-use solution for the implementation of home appliances, fans, drones, power tools, and low voltage motor driving applications.

The board is designed for sensored or sensorless vector control FOC and six-step algorithms with single shunt sensing.

Figure 1. STEVAL-SPIN3202 evaluation board



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1 Safety and operating instructions

HOT SURFACE

DANGER

1.1 General terms

During assembly, testing, and operation, the evaluation board poses several inherent hazards, including bare wires, moving or rotating parts, and hot surfaces.

Danger: *There is a danger of serious personal injury or death due to electrical shock, property damage, and burnt hazards if the kit or components are improperly used or installed incorrectly.*

In particular:

- Do not touch or modify the hardware when the power supply is present
- Do not connect or disconnect the wirings when the power supply is present
- Do not touch the components or the heatsink
- Do not cover the board
- Do not put the board in contact with flammable materials or with materials releasing smoke when heated
- After operation, allow the board to cool down before touching it

All operations involving transportation, installation and use, and maintenance must be performed by skilled technical personnel able to understand and implement national accident prevention regulations.

For the purposes of these basic safety instructions, “skilled technical personnel” are suitably qualified people who are familiar with the installation, use, and maintenance of power electronic systems.

1.2 Intended use of the evaluation board

The evaluation board is designed for demonstration purposes only and must not be used for electrical installations or machinery.

Technical data and information concerning its usage are detailed in the documentation and should be strictly observed.

1.3 Installing the evaluation board

- The installation and cooling of the evaluation board must be in accordance with the specifications and target application
- The motor-drive converters must be protected against excessive strain. Components should not be bent or altered during transportation or handling
- No contact must be made with other electronic components or conduction materials
- The board contains electrostatically sensitive components that are prone to damage if used incorrectly
- Do not mechanically damage or destroy the electrical components (potential health risks)

1.4 Operating the evaluation board

To properly operate the board, follow these safety rules:

1. Work area safety:
   - The work area must be clean and tidy
   - Do not work alone when boards are energized
   - Protect against inadvertent access to the area where the board is energized using suitable barriers and signs
   - A system architecture that supplies power to the evaluation board must be equipped with additional control and protective devices in accordance with the applicable safety requirements (that is, compliance with technical equipment and accident prevention rules)
   - Use a nonconductive and stable work surface
   - Use adequately insulated clamps and wires to attach measurement probes and instruments
2. Electrical safety:
   - Take care to remove any dirt from the board before use. Only products and tools dedicated to cleaning electronic circuits must be used for this purpose
   - Remove the power supply from the board and electrical loads before wiring and connecting probes or other measuring equipment
   - Once the setup is complete, energize the board
   - Do not touch the evaluation board when it is energized or immediately after it has been disconnected from the voltage supply as several parts and power terminals containing potentially energized capacitors need time to discharge
   - Do not touch the boards after disconnection from the voltage supply as several parts like heatsinks and transformers may still be at dangerous temperature levels
   - The board is not electrically isolated from the DC input
   - The USB interface of the board does not insulate the host computer from the power supply voltage
   - Onboard potentiometer and buttons must be used paying attention to avoiding direct contact with live contacts nearby
3. Personal safety:
   - Always wear suitable personal protective equipment such as insulating gloves and safety glasses
   - Take adequate precautions and install the board in such a way to prevent accidental touch, such as protecting shields

2 Hardware and software requirements

Using the STEVAL-SPIN3202 evaluation board requires the following software and hardware:

- A PC
- A mini-B USB cable to connect the STEVAL-SPIN3202 evaluation board to the PC
- A firmware package based on the STM32 motor control SDK (X-CUBE-MCSDK)
- A 3-phase brushless DC motor with compatible voltage and current ratings
- An external DC power supply

3 Getting started

To use the board:

1. Check the jumper position according to the target configuration (see Section 3.2.1: Six-step/FOC selection)
2. Connect the motor to the J3 connector taking care of the motor phases sequence
3. Supply the board via J2 connector input 1 and 2; the DL1 (red) LED turns on
4. Connect the board to the PC through the USB cable
5. Develop your application using the STM32 motor control SDK X-CUBE-MCSDK.

Note: The board maximum ratings are:

- *Power stage supply voltage (VS) from 6.7 V to 45 V;*
- *motor phase current up to 15 A_{rms}.*

3.1 Hardware description and configuration

Figure 2. STEVAL-SPIN3202 evaluation board: jumper and connector positions

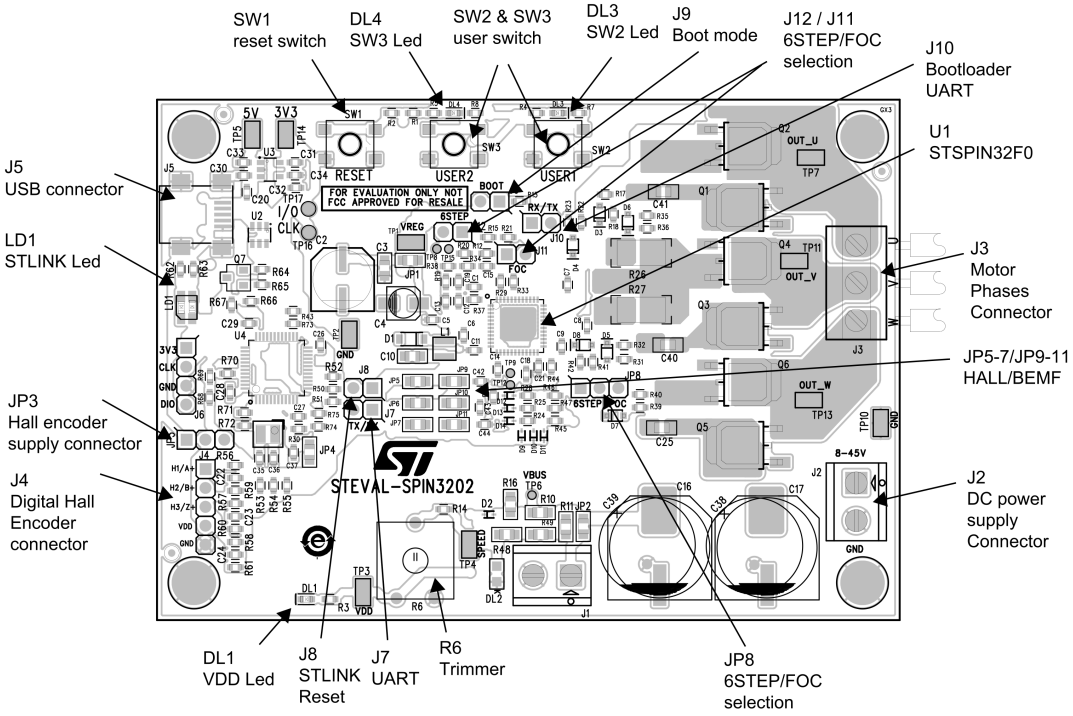


Table 1. Hardware setting jumpers

Jumper	Permitted configurations	Default condition
JP1	Selection of VREG connected to V motor	OPEN
JP2	Selection motor power supply connected to DC power supply	CLOSED
JP3	Selection Hall encoder supply to USB (1)/VDD (3) power supply	1-2 CLOSED
JP4	Selection reset of ST-LINK (U4)	OPEN
JP5	Selection PA0 connected to Hall 1	OPEN
JP6	Selection PA1 connected to Hall 2	OPEN
JP7	Selection PA2 connected to Hall 3	OPEN

Jumper	Permitted configurations	Default condition
JP8	Selection mode 6STEP/FOC	1-2 CLOSED
J11	Selection mode FOC	CLOSED
J12	Selection mode 6STEP	OPEN
JP9	Selection PA0 connected to OUT U	CLOSED
JP10	Selection PA1 connected to OUT V	CLOSED
JP11	Selection PA2 connected to OUT W	CLOSED

Table 2. Connectors, jumpers and test points

Name	Pin	Label	Description
J1	1-2	J1	Motor power supply
J2	1-2	J2	Device main power supply (VM)
J3	1-2-3	U, V, W	3-phase BLDC motor phase connection
J4	1-2-3	J4	Hall sensors/encoder connector
	4-5	J4	Hall sensors/encoder supply
J5	-	J5	USB input ST-LINK
J7	1-2	J7	UART (ST-LINK Virtual COM)
J8	1-2	J8	ST-LINK reset
J9	1-2	BOOT	Boot mode
J10	1-2	RX/TX	Bootloader UART connector
TP1	-	VREG	12 V voltage regulator output
TP2	-	GND	GND
TP3	-	VDD	VDD
TP4	-	SPEED	Speed potentiometer output
TP5	-	5V	USB supply voltage
TP6	-	VBUS	Bus voltage feedback
TP7	-	OUT_U	Output U
TP8	-	TP8	Output op amp sense 2
TP9	-	TP9	PA5 GPIO
TP10	-	GND	GND
TP11	-	OUT_V	Output V
TP12	-	TP12	GPIO BEMF
TP13	-	OUT_W	Output W
TP14	-	3V3	3V3 ST-LINK
TP15	-	TP15	Output op amp sense 3
TP16	-	CLK	SWD_CLK
TP17	-	I/O	SWD_IO

3.2 Circuit description

The STEVAL-SPIN3202 evaluation board provides a complete 3-pahse brushless motor driving solution consisting of an STSPIN32F0A advanced BLDC controller with an embedded STM32 MCU and a triple half-bridge power stage with the STD140N6F7 NMOS.

The STSPIN32F0A autonomously generates all the required supply voltages starting from the motor supply: the internal DC-DC step-down converter provides 3.3 V and the internal linear regulator provides 12 V for the gate drivers.

The current feedback signal conditioning is performed through the operational amplifiers embedded in the device and an internal comparator performs overcurrent protection via the shunt resistor.

Two user buttons, two LEDs and a trimmer are available to implement simple user interfaces (for example, starting/stopping the motor and setting target speed).

The STEVAL-SPIN3202 evaluation board supports the quadrature encoder and digital Hall sensors for motor position feedback. It also provides the circuitry to sense the motor BEMF (sensorless operation).

The board includes an ST-LINK/V2 which allows the user to debug and download firmware without additional hardware.

The board also supports a sensored or sensorless field-oriented control algorithm with single-shunt sensing.

3.2.1 Six-step/FOC selection

The user can select between six-step and field oriented control modes by selecting different jumpers on the STEVAL-SPIN3202 evaluation board.

The FOC mode is selected as per the following configuration:

- jumper connected on J12 open and jumper J11 closed;
- jumper connected on JP8 between pin 2 and 3 (FOC position).

The six-step mode is selected as follows:

- jumper connected on J12 closed and remove jumper from J11;
- jumper connected on JP8 between pin 1 and 2 (six-step position).

3.2.2 Hall/encoder motor speed sensor

The STEVAL-SPIN3202 evaluation board supports the digital Hall and quadrature encoder sensors as motor position feedback.

The sensors can be connected to the STSPIN32F0A by closing jumpers JP5, JP6 and JP7 (open by default).

Note: When JP5, JP6 and JP7 are closed (Hall/encoder mode), JP9, JP10 and JP11should be respectively open (BEMF sensing mode).

The Hall sensor/encoder should be connected to J4 as per the following table.

Table 3. Hall/encoder connector (J4)

Name	Pin	Description
Hall1/A+	1	Hall sensor 1/encoder out A+
Hall2/B+	2	Hall sensor 2/encoder out B+
Hall3/Z+	3	Hall sensor 3/encoder zero feedback
V_{DD} sensor	4	Sensor supply voltage
GND	5	Ground

A protection resistor of 1 kΩ is mounted in series with the sensor outputs.

For sensors requiring an external pull-up, three 10 kΩ resistors are already mounted on the output lines and connected to the VDD voltage. On the same lines, a footprint for pull-down resistors is also available.

JP3 jumper selects the power supply for the sensor supply voltage:

- jumper between pin 1 and pin 2: Hall sensors powered by V_{USB} (5 V)
- jumper between pin 1 and pin 2: Hall sensors powered by V_{DD} (3.3 V)

3.2.3 Overcurrent detection and current sensing measurement

The STEVAL-SPIN3202 evaluation board implements overcurrent protection based on the STSPIN32F0A integrated OC comparator.

To enable the overcurrent protection the jumper JP8 must be closed in 2-3 position. This feature is not available when six-step current mode control is used.

The shunt resistor measures the load current. R26 and R27 resistors bring the voltage signal to the OC_COMP pin. When the peak current flowing through the shunt exceeds the selected threshold, the integrated comparator is triggered and all the high side power switches are disabled.

The current threshold of the STEVAL-SPIN3202 varies according to the STSPIN32F0A OC threshold as listed in the following table.

Table 4. Overcurrent thresholds

PF6	PF7	Internal comp. threshold	OC threshold
0	1	100 mV	10 A
1	0	250 mV	25 A
1	1	500 mV	50 A

3.2.4 Bus voltage sensing circuit

The STEVAL-SPIN3202 evaluation board provides the bus voltage sensing. This signal is set through a voltage divider by the motor supply voltage (V_{BUS}, R10 and R16) and sent to the PB1 GPIO (the ADC channel 9) of the embedded MCU. The signal is also available on TP6.

3.2.5 Hardware user interface

The board provides the following hardware user interface:

- potentiometer (R6 setting, for example, the target speed)
- switch SW1 (to reset STSPIN32F0A MCU and ST-LINK/V2)
- switch SW2 (user button 1)
- Switch SW3 (user button 2)
- LED DL3 (user LED 1, turned on when the user 1 button is pressed too)
- LED DL4 (user LED 2, turned on when the user 2 button is pressed too)

3.2.6 Debug

The STEVAL-SPIN3202 evaluation board embeds an ST-LINK/V2 debugger/programmer.

The ST-LINK/V2 features:

- USB software re-enumeration
- virtual com port interface on USB connected to the STSPIN32F0A (UART1) PB6/PB7 pins
- mass storage interface on USB

The ST-LINK/V2 is supplied by the host PC through the USB cable connected to the board.

LD1 LED signals ST-LINK/V2 communication status:

- Red LED flashing slowly: at power-on before USB initialization
- Red LED flashing quickly: following the first successful communication between the PC and ST-LINK/V2 (enumeration)
- Red LED ON: the initialization between the PC and ST-LINK/V2 is complete
- Green LED ON: successful target communication initialization
- Red/green LED flashing: during communication with target
- Green ON: communication successfully completed

The reset function is activated by removing J8 jumper.

4 Schematic diagrams

Figure 3. **STEVAL-SPIN3202 schematic (1 of 4)**

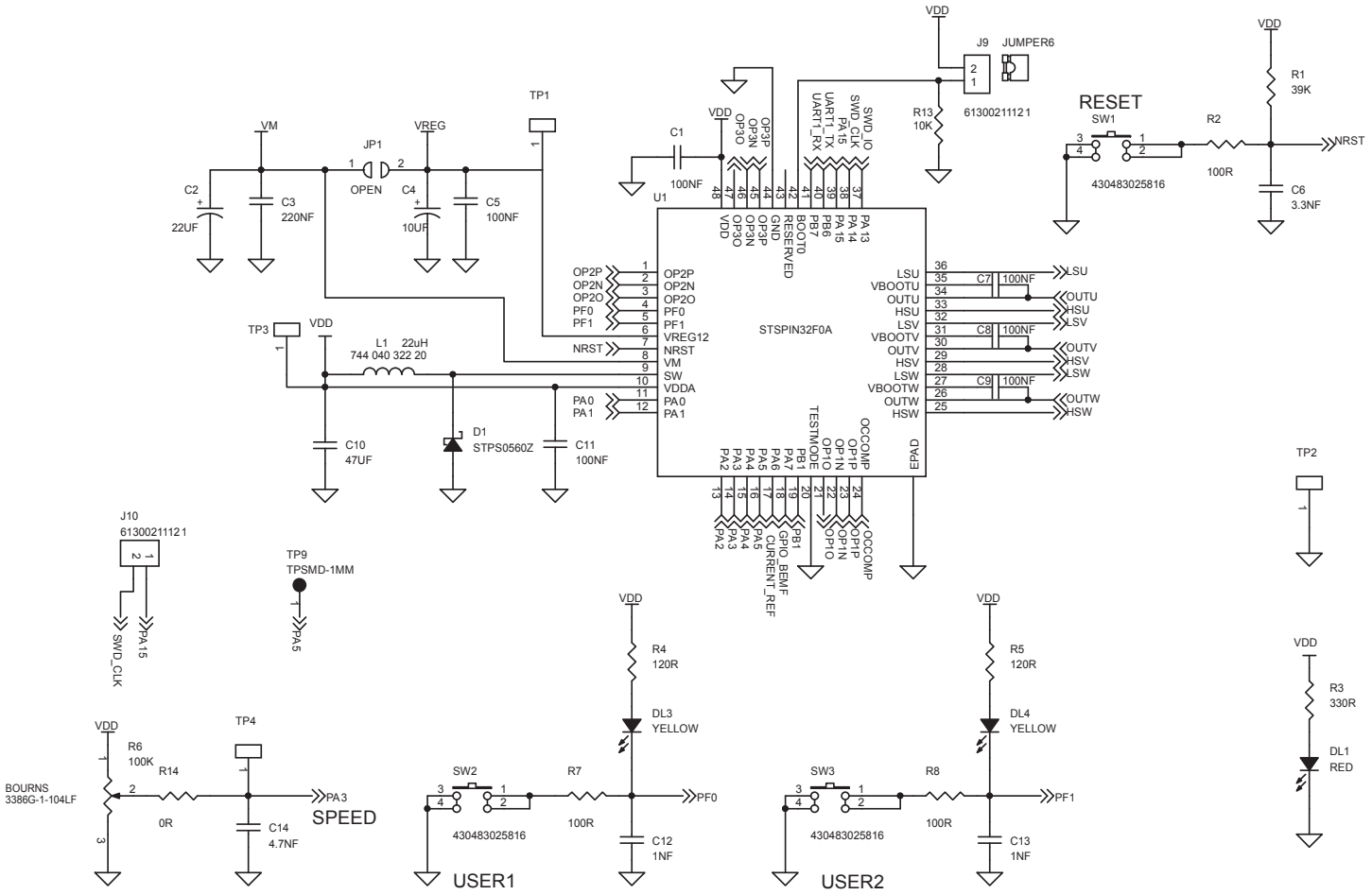


Figure 4. **STEVAL-SPIN3202 schematic (2 of 4)**

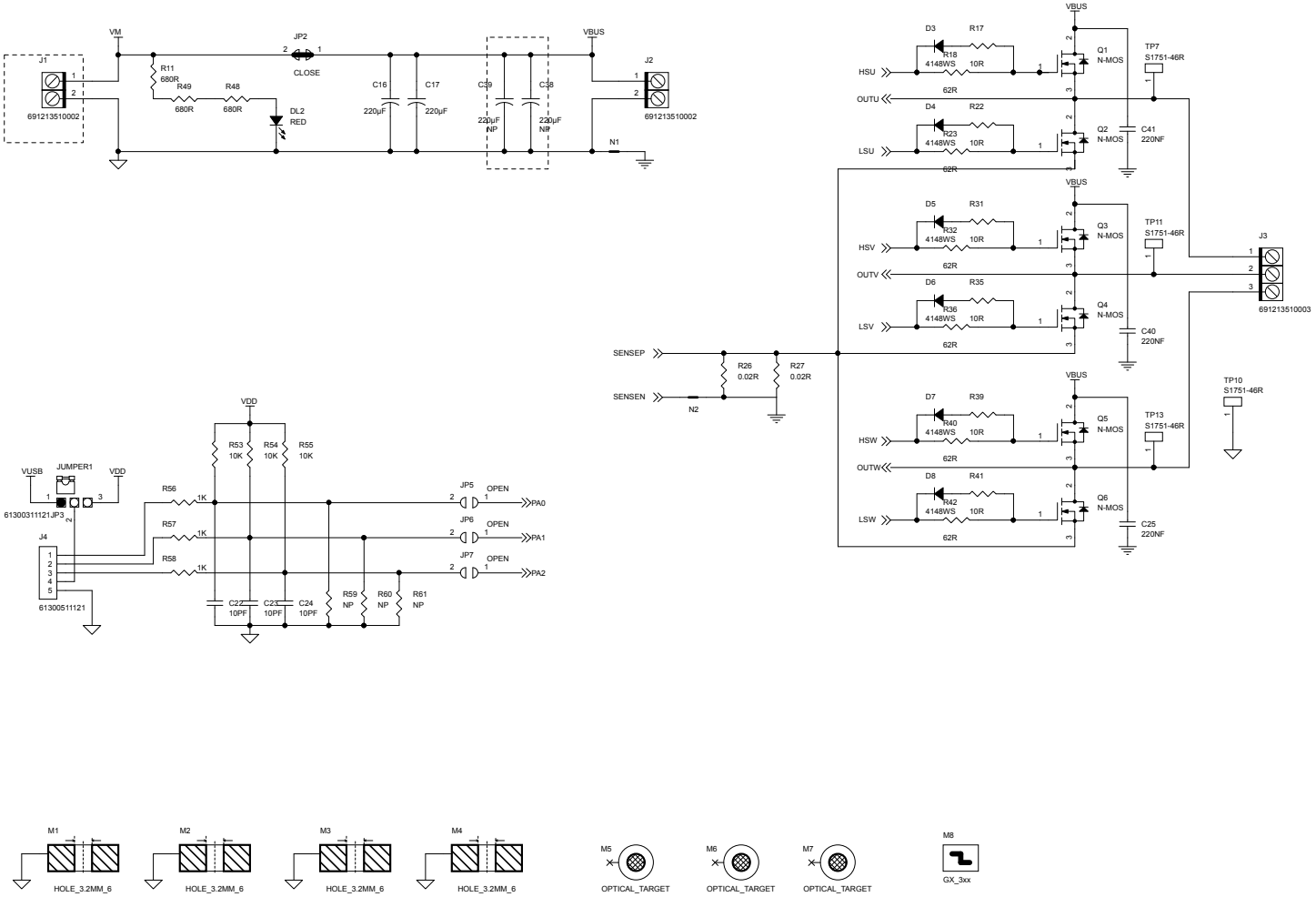
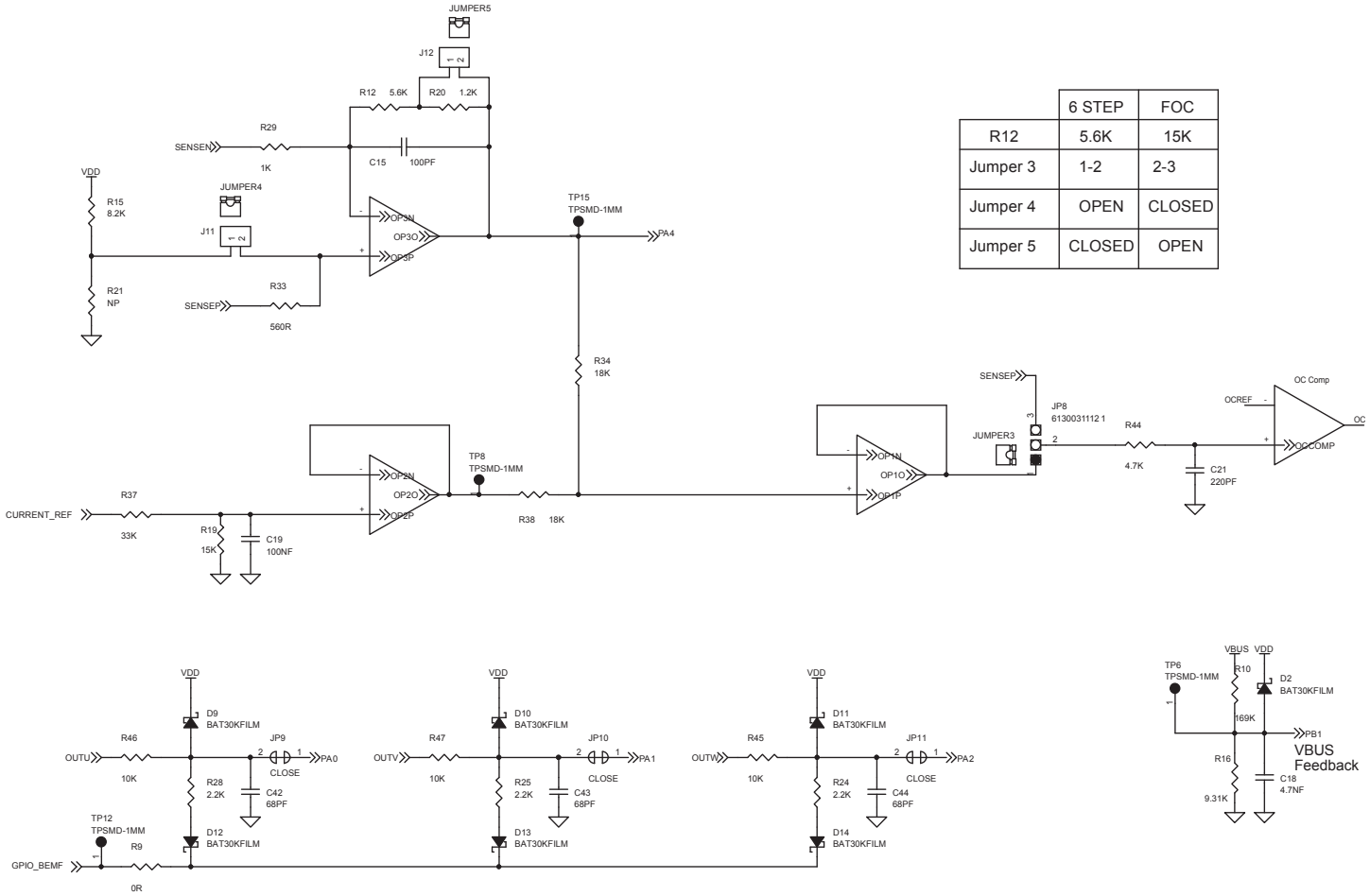
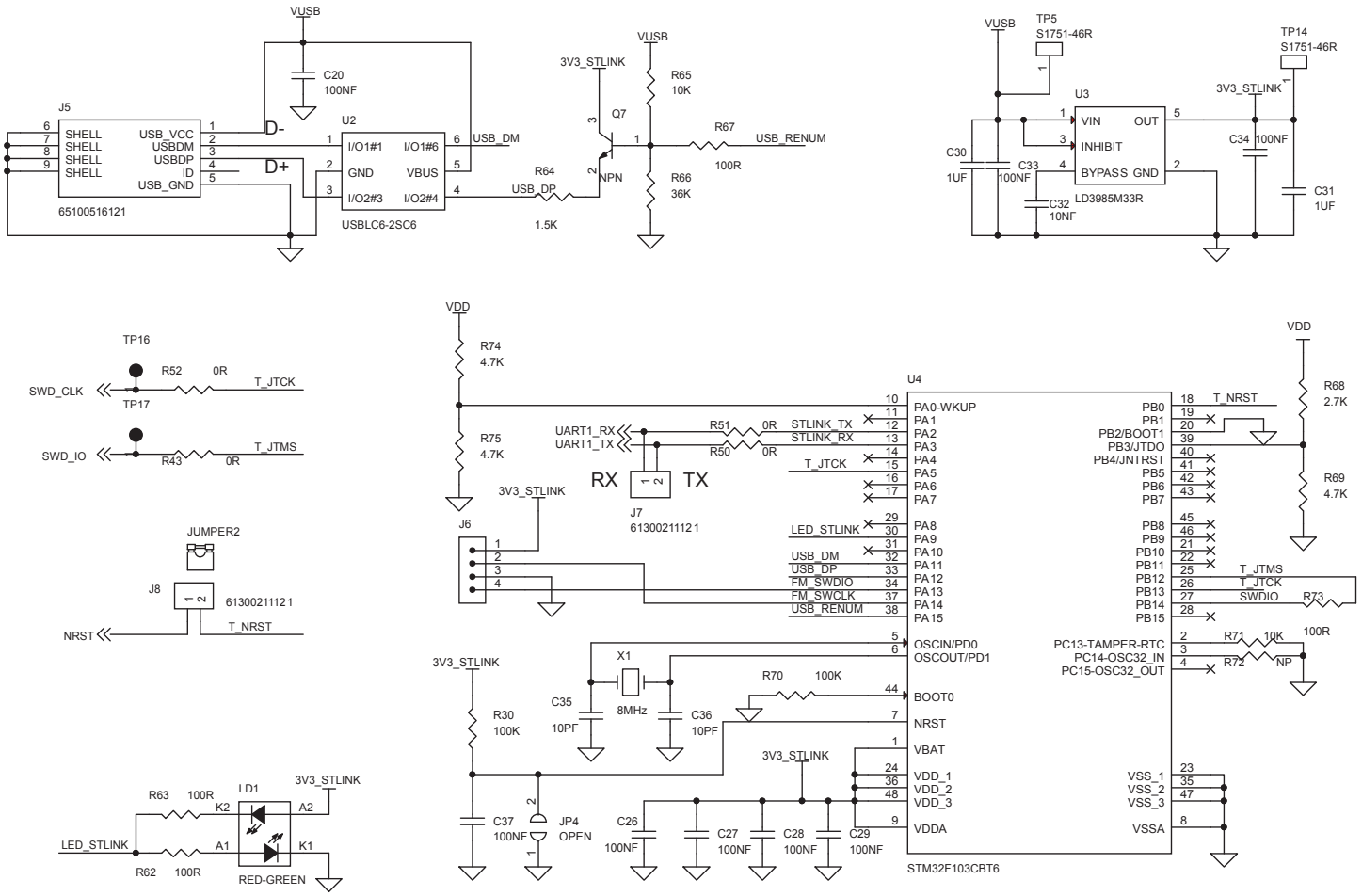


Figure 5. STEVAL-SPIN3202 schematic (3 of 4)



	6 STEP	FOC
R12	5.6K	15K
Jumper 3	1-2	2-3
Jumper 4	OPEN	CLOSED
Jumper 5	CLOSED	OPEN

Figure 6. STEVAL-SPIN3202 schematic (4 of 4)



5 Bill of materials

Table 5. **STEVAL-SPIN3202 bill of materials**

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	15	C1, C5, C7, C8, C9, C11, C19, C20, C26, C27, C28, C29, C33, C34, C37	100nF 50V ±15% 603	Ceramic capacitors	Any	Any
2	1	C2	22µF 63V ±20% L8.3_W8.3_H9.5	Aluminium capacitor	PANASONIC	EEEFK1J220P
3	4	C3, C25, C40, C41	220nF 100V ±15% 805	Ceramic capacitors	Any	Any
4	1	C4	10µF 25V ±20% D4_H5.5	Aluminium capacitor	WURTH	865080440002
5	1	C6	3.3nF 50V ±15% 603	Ceramic capacitor	Any	Any
6	1	C10	47µF 6.3V ±20% 805	Ceramic capacitor	Any	Any
7	2	C12, C13	1 nF 50 V ±15% 603	Ceramic capacitors	Any	Any
8	2	C14, C18	4.7nF 50V ±15% 603	Ceramic capacitors	Any	Any
9	1	C15	100pF 50V ±15% 603	Ceramic capacitor	Any	Any
10	2	C16, C17	220µF 63V ±20% L13.5_W13.5_H15	Aluminium capacitors	PANASONIC	EEVFK1J221Q
11	1	C21	220pF 50V ±15% 603	Ceramic capacitor	Any	Any
12	5	C22, C23, C24, C35, C36	10pF 50V 0.1 603	Ceramic capacitors	Any	Any
13	2	C30, C31	1µF 10V ±15% 603	Ceramic capacitors	Any	Any
14	1	C32	10nF 50V ±15% 603	Ceramic capacitors	Any	Any
15	2	C38, C39	NP 63V ±20% D12.5_H22_P5	Aluminium capacitors	Any	Any
16	3	C42, C43, C44	68PF 50V ±15% 603	Ceramic capacitors	Any	Any
17	1	DL1	RED 603	LED	WURTH	150060RS75000
18	1	DL2	RED 805	LED	WURTH	150080RS75000
19	2	DL3, DL4	YELLOW 603	LED	WURTH	150060YS75000
20	1	D1	STPS0560Z SOD123	60 V, 0.5 A power Schottky rectifier	ST	STPS0560Z
21	7	D2, D9, D10, D11, D12, D13, D14	BAT30KFILM SOD523	30 V, 300 mA SMD general purpose signal Schottky diode	ST	BAT30KFILM

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
22	6	D3, D4, D5, D6, D7, D8	4148WS SOD323	Diodes	Any	Any
23	5	JP1, JP4, JP5, JP6, JP7	OPEN 805	Resistors	Any	Any
24	4	JP2, JP9, JP10, JP11	CLOSE 805	Resistors	Any	Any
25	2	JP3, JP8	61300311121	Headers	WURTH	61300311121
26	6	JUMPER1, JUMPER2, JUMPER3, JUMPER4, JUMPER5, JUMPER6	BLACK	Jumpers	WURTH	60900213621
27	2	J1, J2	691213510002	Screws	WURTH	691213510002
28	1	J3	691213510003	Screw	WURTH	691213510003
29	1	J4	61300511121	Header	WURTH	61300511121
30	1	J5	65100516121	USB	WURTH	65100516121
31	1	J6	61300411121	Header	WURTH	61300411121
32	5	J7, J8, J9, J11, J12	61300211121	Headers	WURTH	61300211121
33	1	J10	NP	Header	WURTH	61300211121
34	1	LD1	RED-GREEN PLCC4	LED	AVAGO	HSMF-A201-A00J1
35	1	L1	22µH 0.6A ±20% L3_W3_H1.5	Inductor	WURTH	744 040 322 20
36	1	M8	GX_3xx	PCB	Any	Any
37	2	N1, N2	NETS_L1_W0.5	Copper	Any	Any
38	6	Q1, Q2, Q3, Q4, Q5, Q6	N-MOS DPAK	N-channel 60 V, 0.0031 Ohm typ., 80 A STripFET F7 power MOSFET in a DPAK package	ST	STD140N6F7
39	1	Q7	NPN SOT23	CMS	ON SEMICONDUCTOR	BC847BL
40	1	R1	39K 1/10W ±5% 603	Resistor	Any	Any
41	7	R2, R7, R8, R62, R63, R67, R73	100R 1/10W ±5% 603	Resistors	Any	Any
42	1	R3	330R 1/10W ±5% 603	Resistor	Any	Any
43	2	R4, R5	120R 1/10W ±5% 603	Resistors	Any	Any
44	1	R6	100K 1/2W 0.1 L9.5_W4.9_H9.5	Trimmer	BOURNS	3386G-1-104-LF
45	6	R9, R14, R43, R50, R51, R52	0R 1/10W ±5% 603	Resistors	Any	Any
46	1	R10	169K 1/8W ±1% 805	Resistor	Any	Any
47	3	R11, R48, R49	680R 1/8W ±5% 805	Resistors	Any	Any

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
48	1	R12	5.6K 1/10W ±5% 603	Resistor	Any	Any
49	9	R13, R45, R46, R47, R53, R54, R55, R65, R71	10K 1/10W ±5% 603	Resistors	Any	Any
50	1	R15	8.2K 1/10W ±5% 603	Resistor	Any	Any
51	1	R16	9.31K 1/8W ±1% 805	Resistor	Any	Any
52	6	R17, R22, R31, R35, R39, R41	10R 1/10W ±5% 603	Resistors	Any	Any
53	6	R18, R23, R32, R36, R40, R42	62R 1/10W ±5% 603	Resistors	Any	Any
54	1	R19	15K 1/10W ±5% 603	Resistor	Any	Any
55	1	R20	1.2K 1/10W ±5% 603	Resistor	Any	Any
56	5	R21, R59, R60, R61, R72	NP 603	Resistors	Any	Any
57	3	R24, R25, R28	2.2K 1/10W ±5% 603	Resistors	Any	Any
58	2	R26, R27	0.02R 2W ±5% 2512	Resistors	Any	Any
59	4	R29, R56, R57, R58	1K 1/10W ±5% 603	Resistors	Any	Any
60	2	R30, R70	100K 1/10W ±5% 603	Resistors	Any	Any
61	1	R33	560R 1/10W ±5% 603	Resistor	Any	Any
62	2	R34, R38	18K 1/10W ±5% 603	Resistors	Any	Any
63	1	R37	33K 1/10W ±5% 603	Resistor	Any	Any
64	4	R44, R69, R74, R75	4.7K 1/10W ±5% 603	Resistors	Any	Any
65	1	R64	1.5K 1/10W ±5% 603	Resistor	Any	Any
66	1	R66	36K 1/10W ±5% 603	Resistor	Any	Any
67	1	R68	2.7K 1/10W ±5% 603	Resistor	Any	Any
68	3	SW1, SW2, SW3	430483025816 L6.2_W6.2_H2.5	Switches	WURTH	430483025816
69	10	TP1, TP2, TP3, TP4, TP5, TP7, TP10, TP11, TP13, TP14	S1751-46R	Test points	HARWIN	S1751-46R
70	5	TP6, TP8, TP9, TP12, TP15	TPSMD-1MM	Test points	Any	Any
71	2	TP16, TP17	NEEDLE-PAD-1.7mm	Test points	Any	Any
72	1	U1	STSPIN32F0A VFQFPN48_L7_W7_P.5	Advanced BLDC controller with embedded STM32 MCU	ST	STSPIN32F0A

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
73	1	U2	USBLC6-2SC6 SOT23-6L	ESD protection for high speed USB 2.0	ST	USBLC6-2SC6
74	1	U3	LD3985M33R SOT23-5	Ultra low drop-low noise BiCMOS voltage regulators low ESR capacitors compatible	ST	LD3985M33R
75	1	U4	STM32F103CBT6 LQFP48	Mainstream performance line, Arm Cortex-M3 MCU with 128 Kbytes of Flash memory, 72 MHz CPU, motor control, USB and CAN	ST	STM32F103CBT6
76	1	X1	8MHz L3.2_W2.5	Quartz	NDK	NX3225GD 8MHz EXS00A-CG04874

Revision history

Table 6. **Document revision history**

Date	Revision	Changes
26-Sep-2017	1	Initial release
21-Jul-2021	2	Updated Section 1 Hardware and software requirements and Section 2 Getting started. Minor text changes.
20-Sep-2022	3	Updated Section 2.1 Hardware description and configuration, Section 2.2.1 Six-step/FOCselection, and Section 3 Schematic diagrams.
15-Oct-2025	4	Updated Section 2: Hardware and software requirements, Section 3: Getting started, Section 3.2: Circuit description and Section 3.2.3: Overcurrent detection and current sensing measurement. Added Section 1: Safety and operating instructions.

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