How to use the six-step brushless motor driver evaluation board for applications based on the STSPIN32F0B BLDC controller

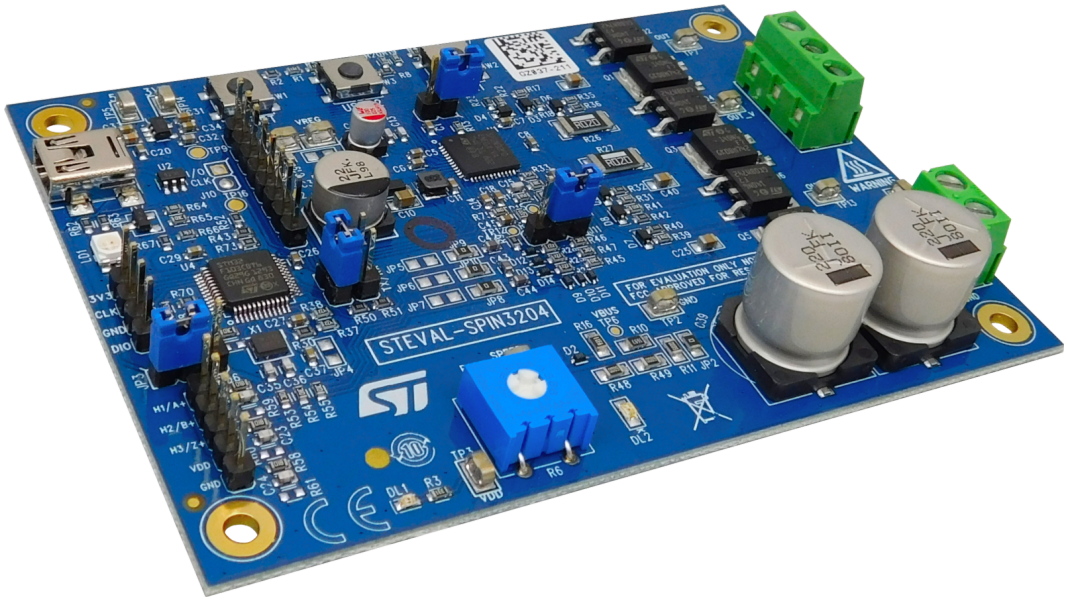
Introduction

The STEVAL-SPIN3204 three-phase brushless DC motor driver board is based on the STSPIN32F0B 3-phase BLDC controller with triple half-bridge gate driver, single shunt resistor current sensing topology and programmable overcurrent protection.

The motor controller system-in-package includes an STM32F031C6 microcontroller ready to execute 6-step, field oriented control (FOC) and other advanced driving algorithms in the firmware, which can be downloaded onto the chip flash memory via the board USB port.

The board is designed to help you test and develop motor control designs for applications such as power tools, home appliances, fans and pumps, with a flexible evaluation platform that even allows you to toggle between external sensor and sensorless position feedback data methods.

Figure 1. STEVAL-SPIN3204 evaluation board

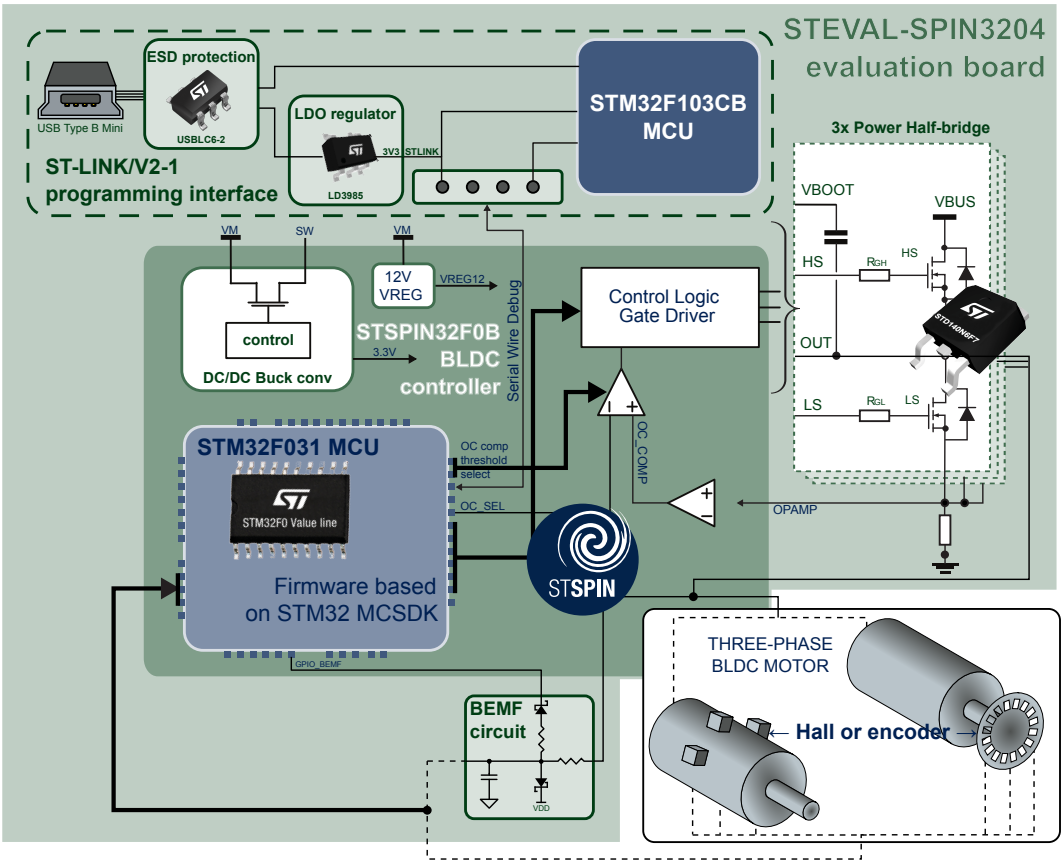


1 Solution overview

The STEVAL-SPIN3204 motor control board can be set up to control a three-phase brushless DC (BLDC) motor based on position feedback data from one of the following sources:

- external quadrature encoders or Hall Effect sensors
- on-board circuitry that senses the back electromotive force (BEMF) generated by the load motor.

Figure 2. STEVAL-SPIN3204 motor control block diagram



The power stage on the board delivers 15 A_{RMS} DC current from three STD140N6F7 MOSFETs in half-bridge configuration managed by the triple half-bridge gate driver on the BLDC controller.

The board senses the current flowing into the motor phases through a shunt resistor, and the resulting signal is amplified, filtered and forwarded to the STSPIN32F0B BLDC controller MCU and control logic gate driver for monitoring and peak current limitation or overcurrent protection, depending on the driving method implemented in the firmware (voltage mode or current mode, respectively). Voltage sensing is implemented through a voltage divider from the motor supply voltage (VBUS) and sent to the BLDC controller MCU for monitoring purposes.

The board also features an embedded ST-LINK/V2-1 programmer/debugger to help you load, test and modify the motor controller firmware.

1.1 Features

- Input voltage from 7 to 45 V
- Output current up to 15 A_{RMS}
- Power stage based on STD140N6F7 MOSFET
- Embedded 3.3 V buck regulator
- Embedded 12 V LDO regulator

- Single shunt current sensing
- Digital Hall sensors and encoder input
- Overcurrent comparator
- Bus voltage sensing
- Embedded ST-LINK/V2-1
- Easy user interface with buttons and trimmer
- RoHS and WEEE compliant

1.2 Hardware user interface

STEVAL-SPIN3204 motor control evaluation board has the following interfaces:

- User button 1 (SW2), which can, for example, be assigned to start motor operation.
  - connected to PF0 GPIO of the STSPIN32F0B
  - user LED 1 (DL3) signals SW2 is closed or the PF0 GPIO is forced low
- User button 2 (SW3), which can, for example be assigned to stop motor operation
  - connected to PF1 GPIO of the STSPIN32F0B
  - user LED 2 (DL4) signals SW3 is closed or the PF1 GPIO is forced low
- A reset switch (SW1) to reset the board and the motor controller.
- A potentiometer (R6) to, for example, adjust the target rotation speed.
  - output voltage can be sensed through PA3 GPIO of the STSPIN32F0B (channel 3 of the ADC)
- Red LED (DL1) to indicate logic power supply (VDD).
- Red LED (DL2) to indicate power connection (VM).
- A USB port and embedded ST-LINK/V2 programmer/debugger to allow you to program and debug the board firmware directly from your PC.
  - red-green LED (LD1) signals programming activity

1.3 STSPIN32F0B advanced single shunt BLDC controller with embedded STM32 MCU

1.3.1 BLDC motor controller description

The STSPIN32F0B is a System-In-Package providing an integrated solution suitable for driving three-phase brushless motors using different driving modes.

It embeds a triple half-bridge gate driver able to drive power MOSFETs with a current capability of 600 mA (sink and source). The high- and low-side switches of same half-bridge cannot be simultaneously driven high thanks to an integrated interlocking function.

An internal DC/DC buck converter provides the 3.3 V voltage suitable to supply both the MCU and external components. An internal LDO linear regulator provides the supply voltage for gate drivers.

The integrated operational amplifier is available for the signal conditioning, e.g. the current sensing across the shunt resistor.

A comparator with a programmable threshold is integrated to perform the overcurrent protection.

The integrated MCU (STM32F031C6 with extended temperature range, suffix 7 version) allows performing field-oriented control, the 6-step sensorless and other advanced driving algorithms. It has the write-protection and read-protection feature for the embedded Flash memory to protect against unwanted writing and/or reading. It is possible to download the firmware on-the-field through the serial interface thanks to the embedded bootloader.

The STSPIN32F0B device also features overtemperature and undervoltage lockout protections and can be put in the standby mode to reduce the power consumption. The device provides 20 general-purpose I/O ports (GPIO) with the 5 V tolerant capability, one 12-bit analog-to-digital converter with up to 9 channels performing conversions in a single-shot or scan modes, 5 synchronizable general-purpose timers and supports an easy to use debugging serial interface (SWD).

1.3.2 STSPIN32F0B block diagrams

Figure 3. **STSPIN32F0B System-In-Package block diagram**

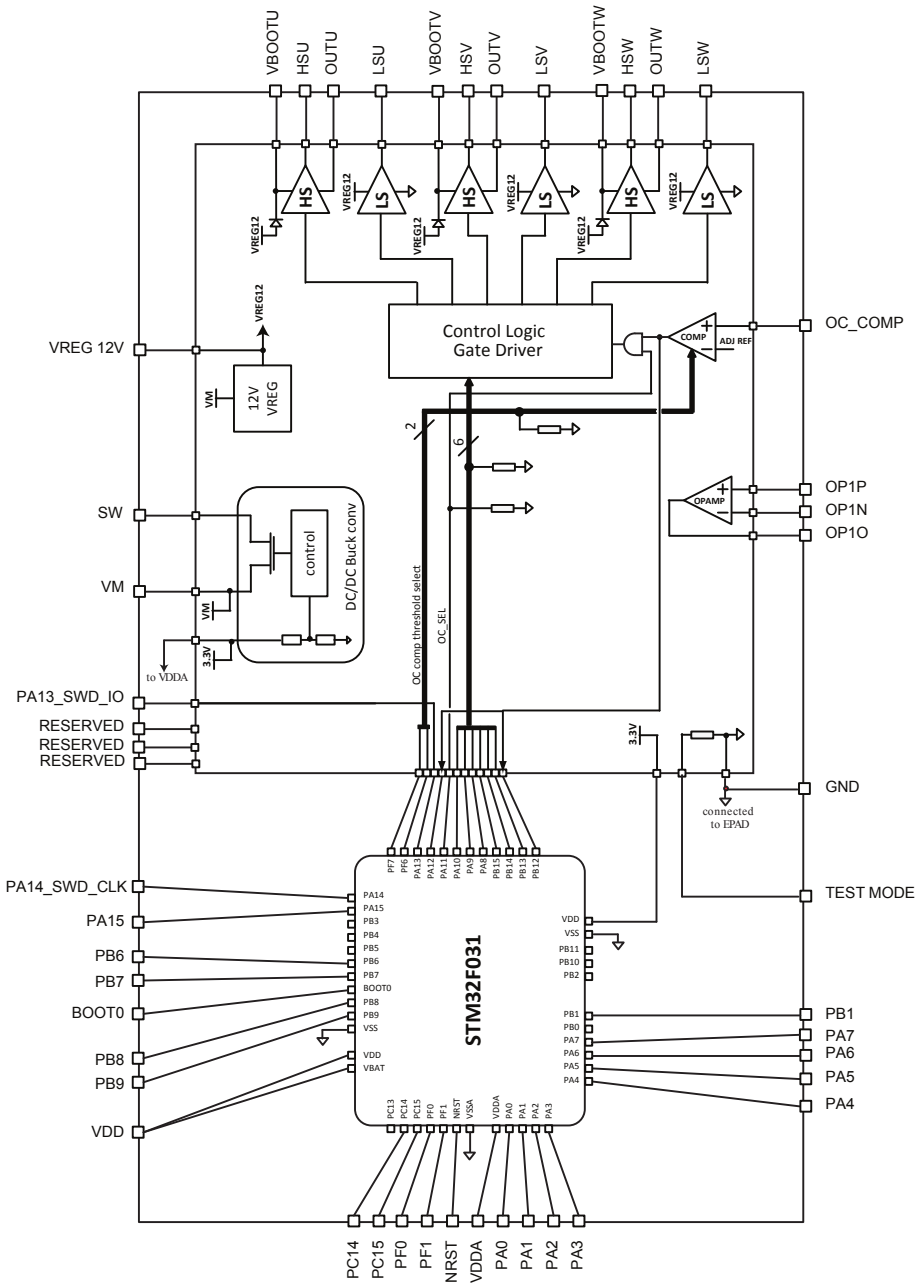
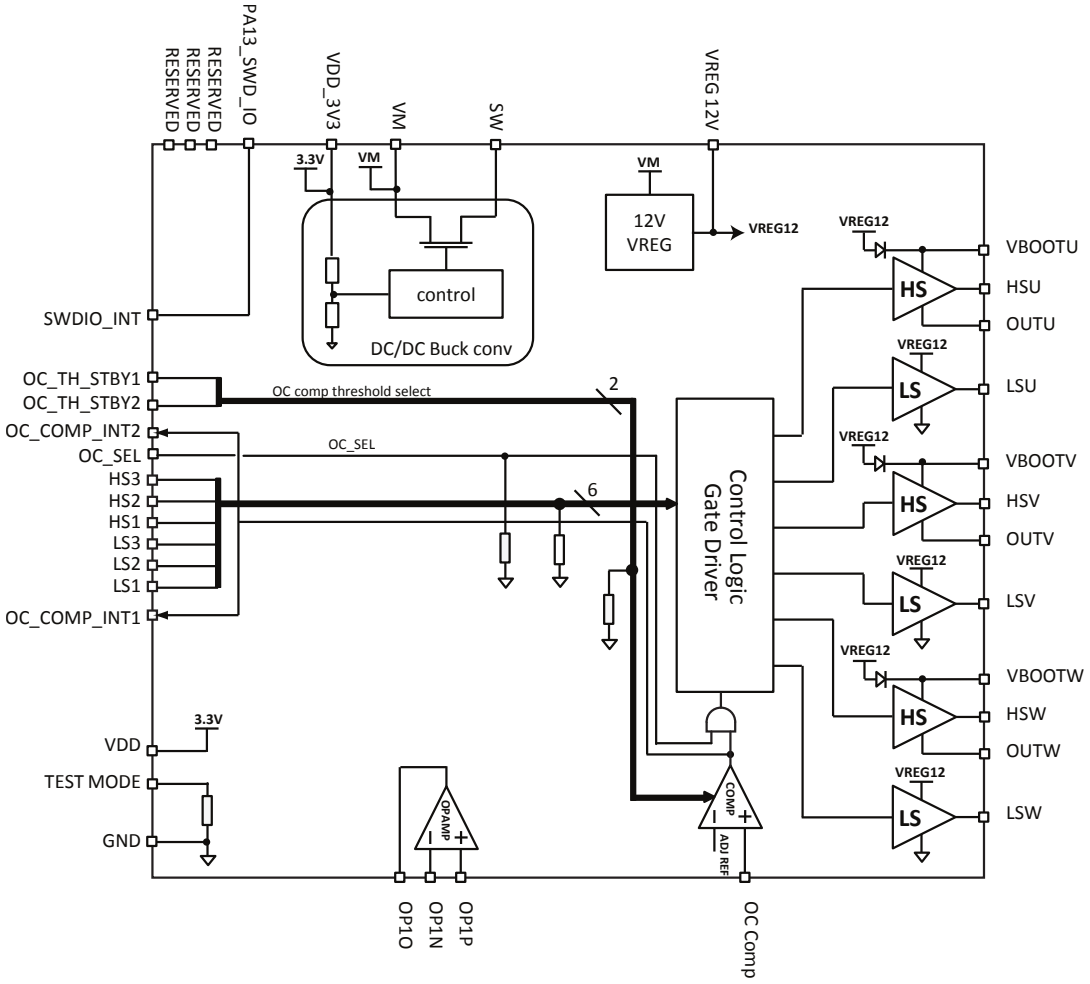


Figure 4. **Analog IC block diagram**



1.4 Overcurrent protection

When the jumper J11 is closed in the 1-2 position, the board is set to use the current sensing for implementing the overcurrent protection.

Load current is forwarded to comparator input according to following formula:

$$V_{OCCOMP} = I_{load} \times R_{shunt} \times G_{OPAMP} = I_{load} \times 10m\Omega \times 3.125 \quad (1)$$

Table 1. **Overcurrent thresholds**

PF6	PF7	Internal comp. threshold	OC threshold
0	1	100 mV	3.2 A
1	0	250 mV	8 A
1	1	500 mV	16 A

The protection can be implemented in one of the following ways:

- Using the protection circuitry integrated in the analog section of the STSPIN32F0B SiP; this feature is enabled by setting the OC_SEL input (PA11) high.
- Using the TIM1_BKIN input.

1.5 Current mode driving (current limiter)

When the jumper J11 is closed in the 2-3 position, the board is set to use the current sensing to implement an adjustable current limiter.

The target of the current limiter depends on the duty-cycle (DC) of the PWM on PA6 GPIO and the comparator internal comparator threshold ($V_{OCCOMPth}$):

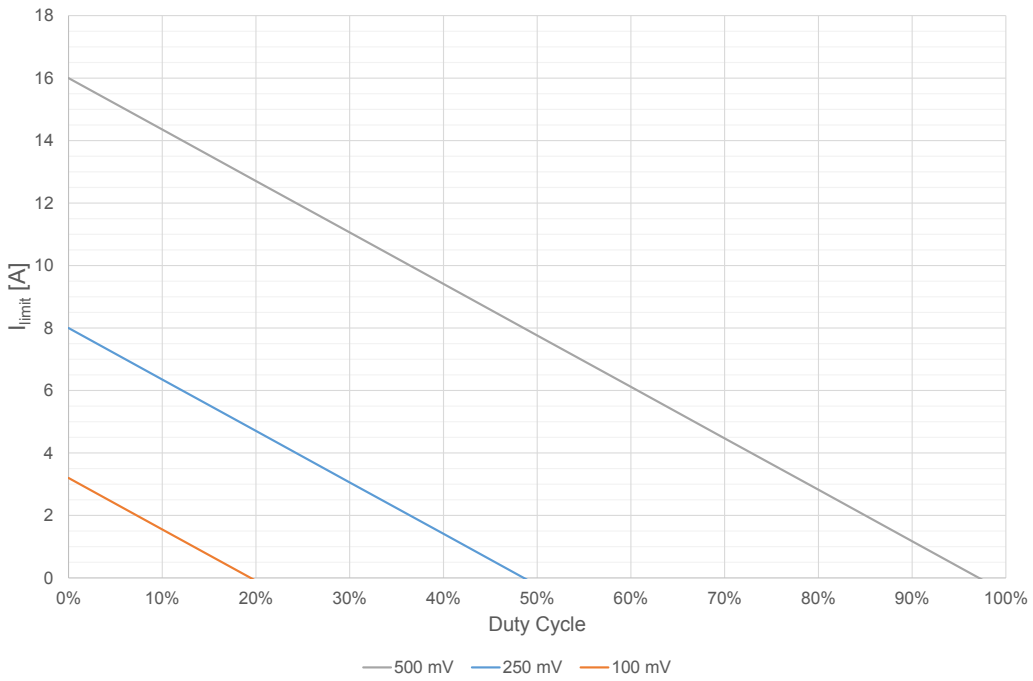
$$I_{limit} = \frac{V_{OCCOMPth} - V_{DD} \times DC \times G_{REF}}{R_{shunt} \times G_{OPAMP}} = \frac{V_{OCCOMPth} - 3.3V \times DC \times 0.156}{10m\Omega \times 3.125} \quad (2)$$

The $V_{OCCOMPth}$ is set through the PF6 and PF7 GPIOs of the embedded MCU.

Table 2. $V_{OCCOMPth}$ settings

PF6	PF7	Internal comp. threshold
0	1	100 mV
1	0	250 mV
1	1	500 mV

Figure 5. Current limiter peak value



The current limiter can be implemented in two ways:

- Using the protection circuitry integrated into the analog part of the STSPIN32F0B SiP; this feature is enabled setting the OC_SEL input (PA11) high.
- Using the TIM1_ETR input.

1.6 Hall effect sensors and Quadrature encoder

The STEVAL-SPIN3204 evaluation board supports digital Hall sensors and quadrature encoder motor position feedback. The sensors can be connected to the STSPIN32F0B by closing jumpers JP5, JP6 and JP7.

Note: When JP5, JP6 and JP7 for Hall/encoder sensing are closed, ensure that JP8, JP9 and JP10 for BEMF sensing are open.

The Hall sensors/encoder should be connected to J4 as shown in the following table.

Table 3. Hall based sensors/Quadrature 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
VDD sensor	4	Sensor supply voltage
GND	5	Ground

A protection series resistor of 1 kΩ is mounted in series with connector inputs.

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 (R59, R60 and R61).

The jumper JP3 selects the supply line for the sensor:

- Jumper between 1-2 pins: sensors powered by VUSB (5 V)
- Jumper between 2-3 pins: sensors powered by VDD (3.3 V)

1.7 Programming and debugging the STSPIN32F0B motor controller

The STEVAL-SPIN3204 evaluation board embeds an ST-LINK/V2-1 debugger/programmer, with the following features:

- USB software re-enumeration
- Virtual com port interface on USB connected to PB6/PB7 pins of the STSPIN32F0B (UART1)
- Mass storage interface on USB

The power supply for the ST-LINK is provided by the host PC through the USB cable connected to the board.

The red-green LED LD1 provides the following ST-LINK communication status information:

- Red LED flashing slowly: at power-on before USB initialization
- Red LED flashing quickly: following first correct communication between the PC and ST-LINK/V2-1 (enumeration)
- Red LED ON: initialization between the PC and ST-LINK/V2-1 is complete
- Green LED ON: successful target communication initialization
- Red/green LED flashing: during communication with target
- Green ON: communication finished and successful.

The reset function is disconnected from the ST-LINK by removing the jumper J8.

2 Get started with the board

2.1 Safety information

Caution: Some of the components mounted on the board may reach hazardous temperatures during operation.
While using the board:

- Do not touch the components.
- 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.

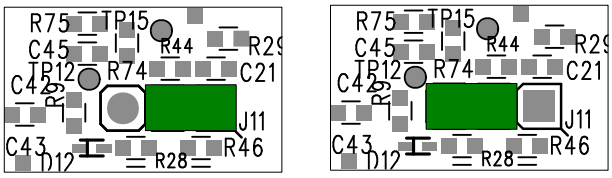
2.2 How to set up and use the board

Using the STEVAL-SPIN3204 evaluation board requires the following items in order to set up a functional system:

- A Windows PC (XP, Vista 7, Windows 8, Windows 10) to install the software package.
- A mini-B USB cable to connect the STEVAL-SPIN3204 board to the PC.
- A firmware package based on STM32 Motor Control SDK (X-CUBE-MCSDK-Y).
- A three phase brushless DC motor with compatible voltage and current ratings.
- An external DC power supply.

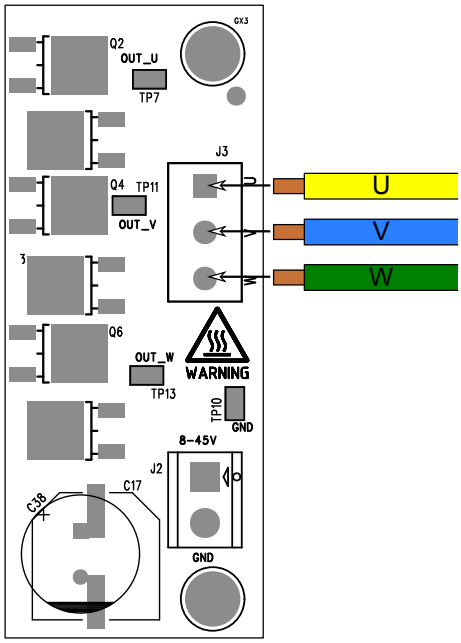
Step 1. Check the jumpers according to the target configurations.

Figure 6. J11 gate driving modes



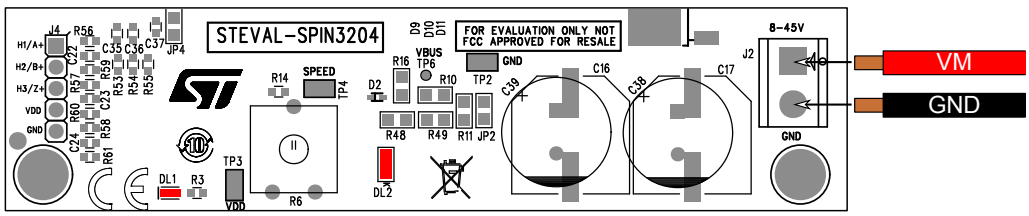
Step 2. Connect the motor to the connector J3.
Be sure to connect the phase wires correctly.

Figure 7. J3 phase wire connections



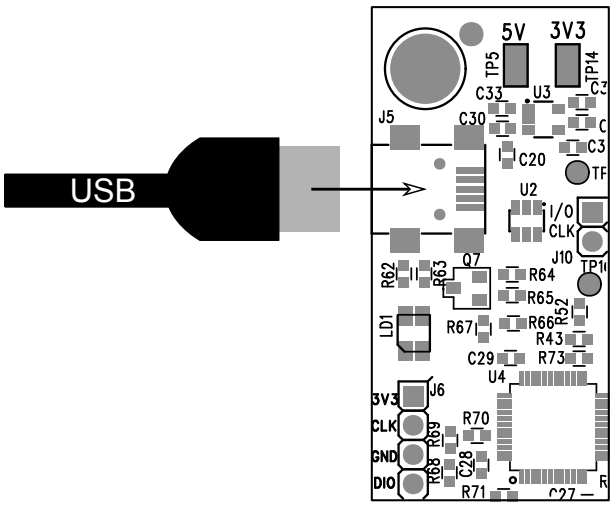
Step 3. Supply the board through the input 1 and 2 of connector J2.
Red LEDs DL1 and DL2 will turn on.

Figure 8. J2 motor power supply



Step 4. Connect the board to the PC through the USB cable.

Figure 9. J5 USB connection



Step 5. Develop your application using the STM32 Motor Control SDK.

RELATED LINKS

3 Hardware description and configuration on page 11

3 Hardware description and configuration

Figure 10. Jumper and connector positions

1. RESET button
2. USER 2 button and LED
3. USER 1 button and LED
4. Boot mode jumper
5. Motor connector
6. Power supply connector
7. Current limiter/Overcurrent selector
8. BEMF sensing/Sensor feedback jumpers
9. VM LED
10. Potentiometer
11. VDD LED
12. Hall effect sensor and encoder connector
13. ST-LINK LED
14. USB connector

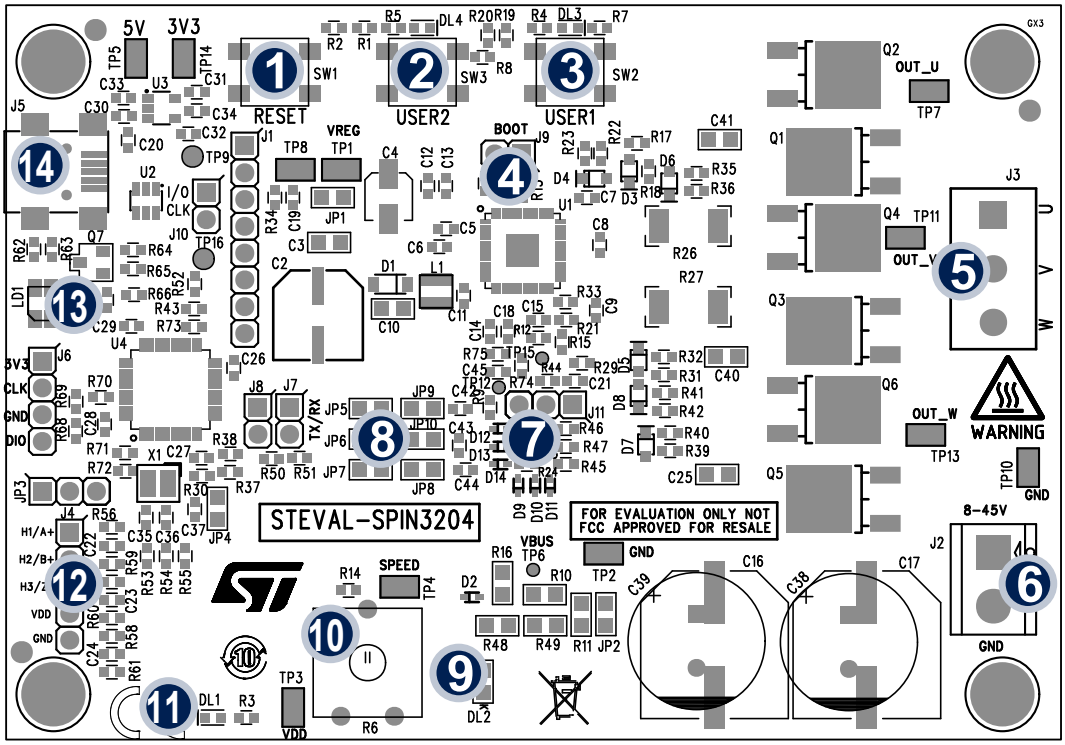


Table 4. Hardware setting jumpers

Jumper	Permitted configurations	Default
JP1	Connects VREG to VM and limits the supply voltage of the board to 15 V.	OPEN
JP2	Connects the supply voltage of the power stage to the STSPIN32F0B main supply (VM).	CLOSED
JP3	Selects Hall encoder supply between 5 V USB (1-2) and 3.3 V VDD (2-3).	1-2
JP4	Resets the ST-LINK microcontroller (U4).	OPEN
JP5, JP6, JP7	Connects PA0/PA1/PA2 to the inputs of J4 connector (Hall-effect sensors and encoder for motor position feedback). When these jumpers are closed, jumpers JP8/JP9/JP10 must be open.	OPEN

Jumper	Permitted configurations	Default
JP8, JP9, JP10	Connects PA0/PA1/PA2 to the BEMF sensing circuitry (sensorless operation). When these jumpers are closed, jumpers JP5/JP6/JP7 ones must be open.	CLOSED
J8	Connects the STSPIN32F0B reset input to the ST-LINK.	CLOSED
J9	Pulls-up the BOOT0 input enabling bootstrap mode.	OPEN
J11	Selects between voltage mode (1-2) and current mode (2-3) operation.	1-2

Table 5. Connectors and test points description

Name	Pin	Label	Description
J1	1		PB8 GPIO
	2		PB9 GPIO
	3		PC14 GPIO
	4		PC15 GPIO
	5		PB1 GPIO
	6		PA5 GPIO
	7		PA3 GPIO
	8		Ground
J2	1	8-45 V	Motor supply voltage (VM)
	2	GND	Motor supply ground
J3	1 - 2 - 3	U, V, W	Motor phase connections
J4	1	HALL1/A+	Hall effect sensor 1 signal Quadrature encoder A signal
	2	HALL2/B+	Hall effect sensor 2 signal Quadrature encoder B signal
	3	HALL3/Z+	Hall effect sensor 3 signal Quadrature encoder index/zero signal
	4	VDD	Hall sensors/encoder supply
	5	GND	Ground
J5	-	J5	Mini-B USB input
J6	1	3V3	ST-LINK supply voltage
	2	CLK	SWCLK of ST-LINK MCU (for recovery only)
	3	GND	GND
	4	DIO	SWDIO of ST-LINK MCU (for recovery only)
J7	1	RX	Virtual COM RX line
	2	TX	Virtual COM TX line
J10	1	I/O	Bootloader UART RX
	2	CLK	Bootloader UART TX
TP1	-	VREG	12 V linear voltage regulator output of STSPIN32F0B
TP2	-	GND	GND
TP3	-	VDD	3.3 V buck converter output of STSPIN32F0B
TP4	-	SPEED	Speed potentiometer output
TP5	-	5V	USB supply voltage

Name	Pin	Label	Description
TP6	-	VBUS	Bus voltage feedback
TP7	-	OUT_U	Power stage output U
TP8	-	TP8	Low pass filtered PB1 GPIO
TP9	-	TP9	SWCLK of STSPIN32F0B
TP10	-	GND	GND
TP11	-	OUT_V	Power stage output V
TP12	-	TP12	GPIO BEMF
TP13	-	OUT_W	Power stage output W
TP14	-	3V3	ST-LINK supply voltage (3.3 V)
TP15	-	TP15	Current sensing OPAMP output
TP16	-	TP16	SWCLK of STSPIN32F0B

4 Schematic diagrams

Figure 11. STEVAL-SPIN3204 schematic - motor controller MCU and interfaces

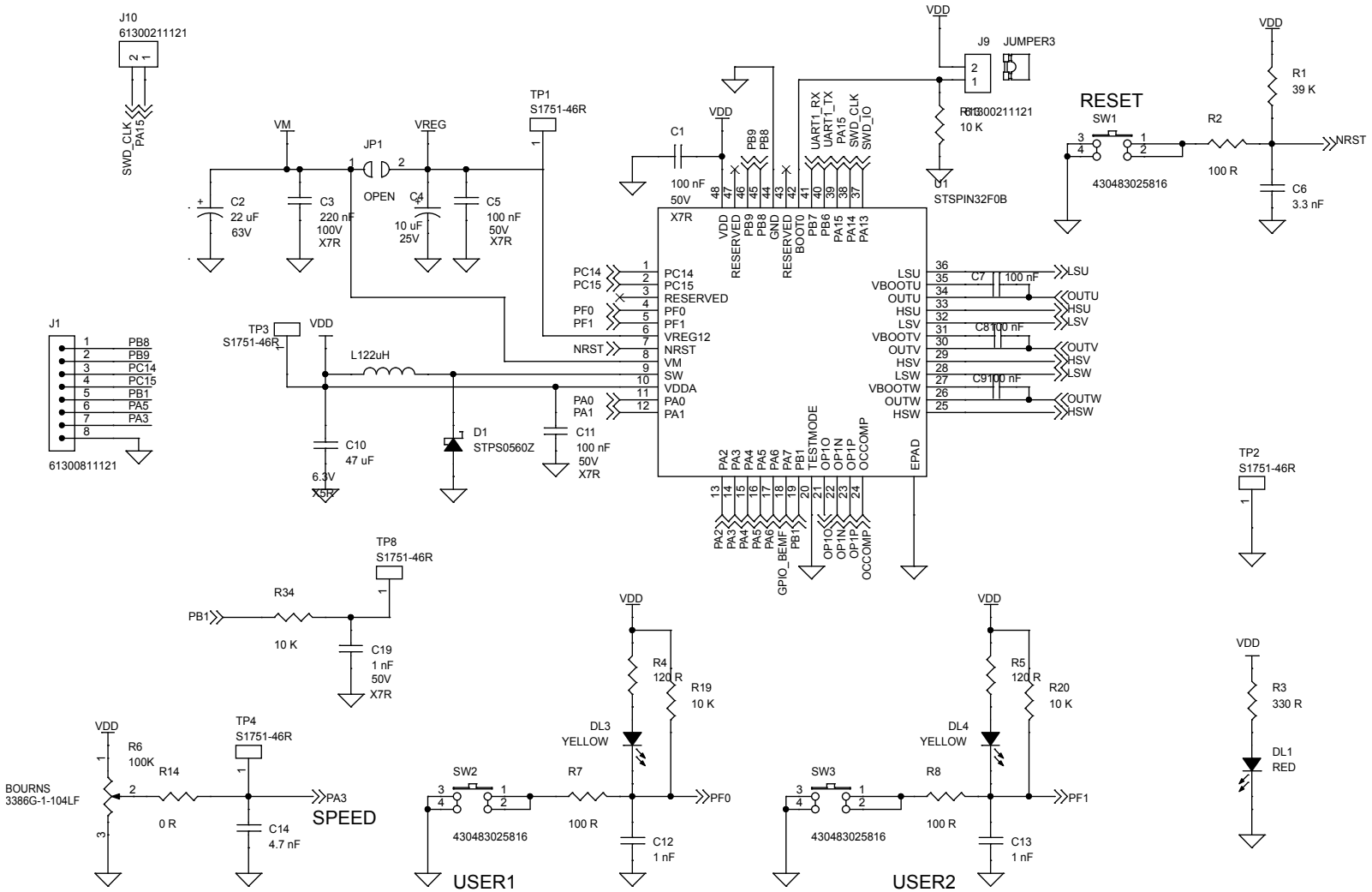


Figure 12. STEVAL-SPIN3204 schematic - power stage and external sensor inputs

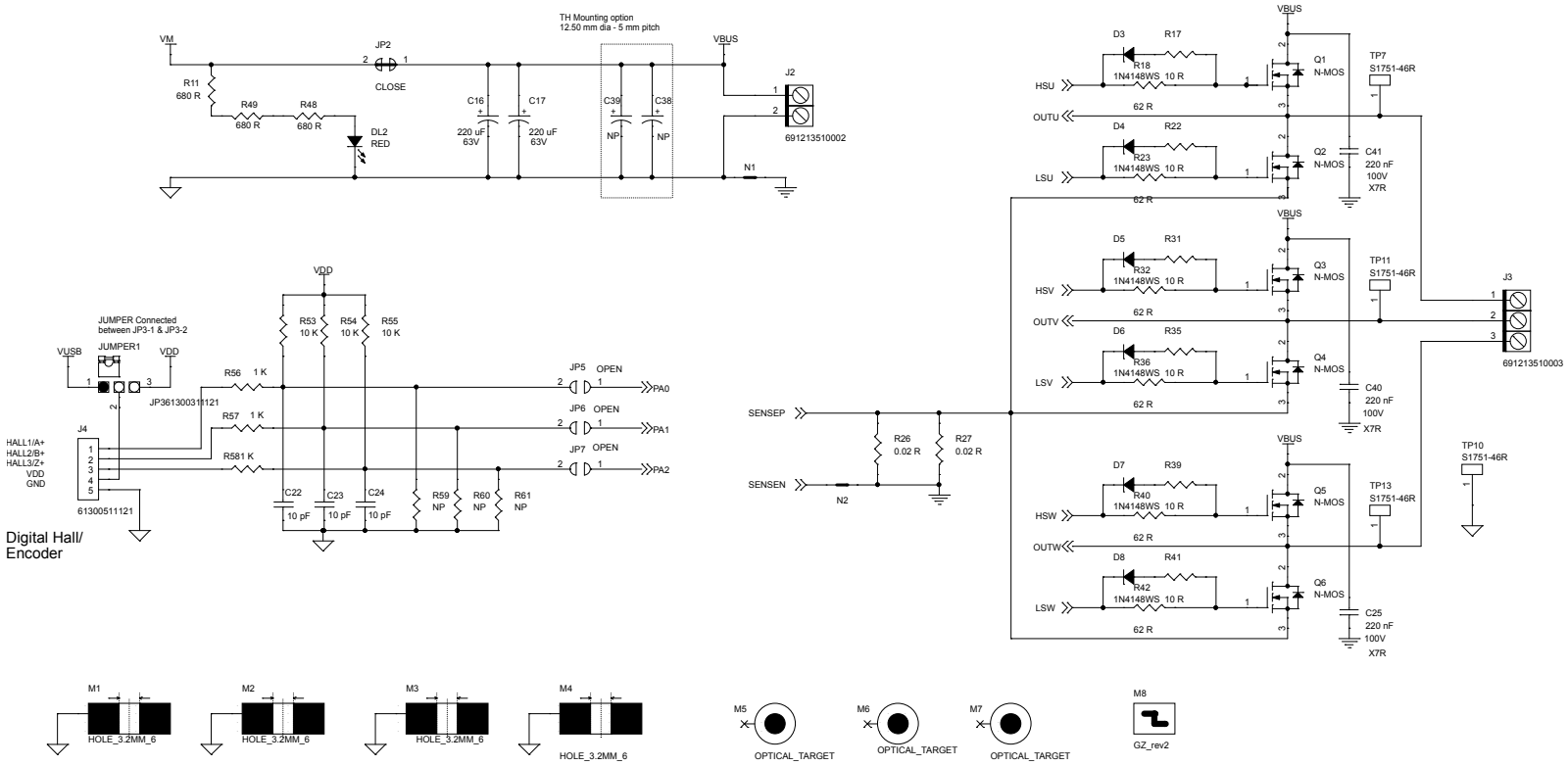


Figure 13. STEVAL-SPIN3204 schematic - current and voltage feedback, and BEMF sensing circuits

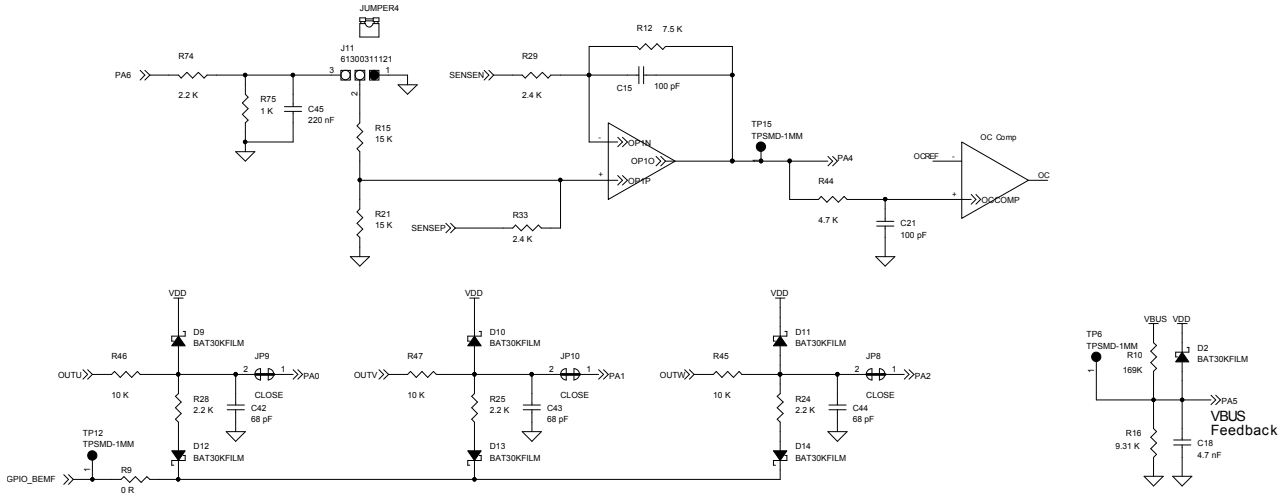
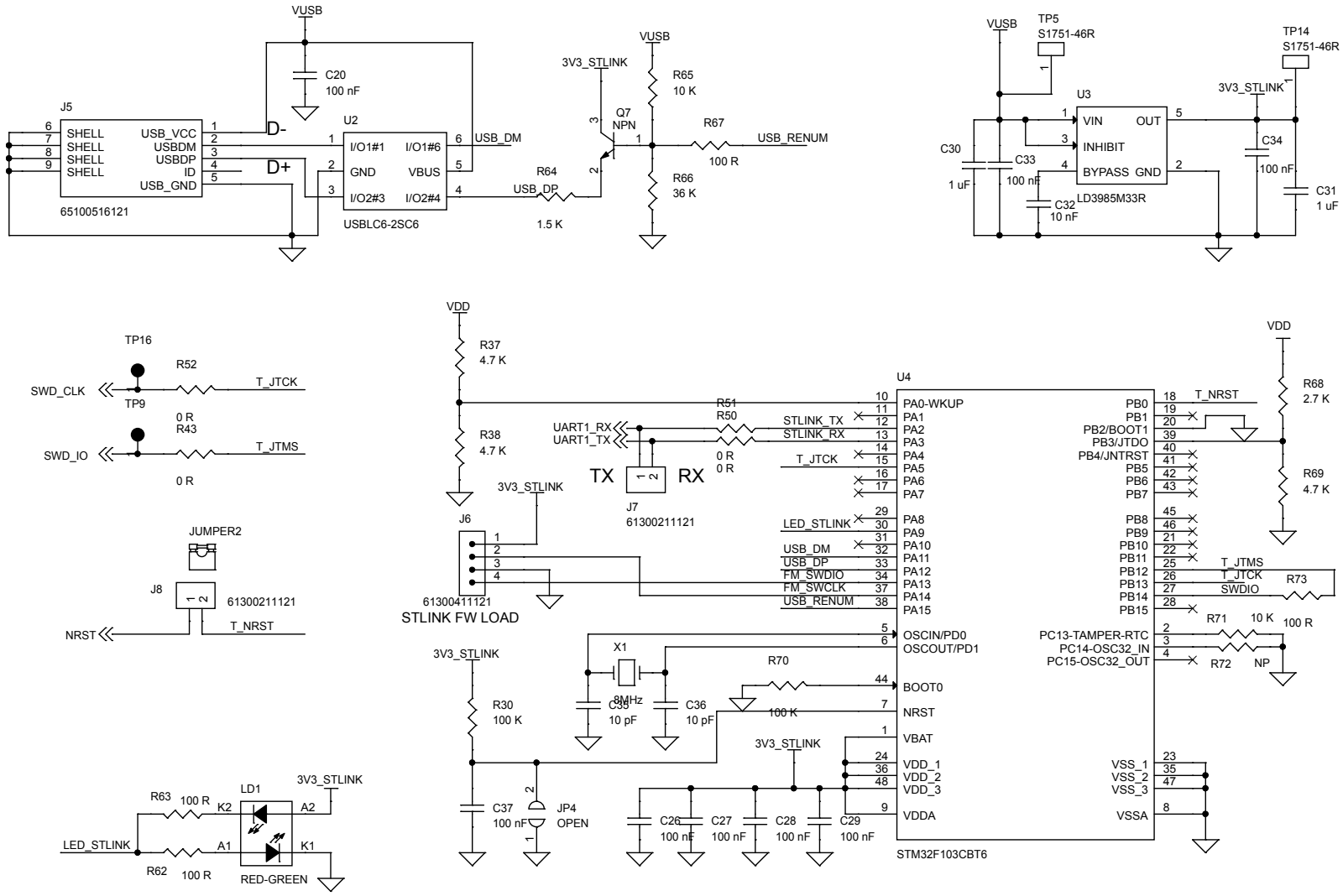


Figure 14. STEVAL-SPIN3204 schematic - ST-LINK



5 Bill of materials

Table 6. **STEVAL-SPIN3204 bill of materials**

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	14	C1, C5, C7, C8, C9, C11, C20, C26, C27, C28, C29, C33, C34, C37	100 nF 50 V ±10% 0603	Ceramic capacitors	Kemet	C0603C104K5RACTU
2	1	C2	22 µF 63 V ±20% L8.3_W8.3_H9.5	Aluminium capacitor	Panasonic	EEEFK1J220P
3	4	C3, C25, C40, C41	220 nF 100 V ±10% 0803	Ceramic capacitors	Kemet	C0805C224K1RACTU
4	1	C4	10 µF 25 V ±20% D4_H5.5	Aluminium capacitor	Wurth Elektronik	865080440002
5	1	C6	3.3 nF 50 V ±20% 0603	Ceramic capacitor	Kemet	C0603C332K5RACTU
6	1	C10	47 µF 6.3 V ±20% 0803	Ceramic capacitor	Murata	GRM21BR60J476ME15K
7	3	C12, C13, C19	1 nF 50 V ±10% 0603	Ceramic capacitors	Kemet	C0603C102K5RACTU
8	2	C14, C18	4.7 nF 50 V ±10% 0603	Ceramic capacitors	Kemet	C0603C472K5RACTU
9	2	C15, C21	100 pF 50 V ±5% 0603	Ceramic capacitors	Kemet	C0603C101J5GACTU
10	2	C16, C17	220 µF 63 V ±20% L13.5_W13.5_H15	Aluminium capacitors	Panasonic	EEVFK1J221Q
11	5	C22, C23, C24, C35, C36	10 pF 50 V ±5% 0603	Ceramic capacitors	Kemet	C0603C100J5GACTU
12	2	C30, C31	1 µF 25 V ±10% 0603	Ceramic capacitors	Kemet	C0603C105K3RACTU
13	1	C32	10 nF 50 V ±10% 0603	Ceramic capacitor	Kemet	C0603C103K5RACTU
14	1	C38	NP 63V D12.5_H22_P5	Ceramic capacitor	Panasonic	
15	1	C39	NP 63V D12.5_H22_P5	Ceramic capacitor	Panasonic	
16	3	C42, C43, C44	68 pF 50 V ±5% 0603	Ceramic capacitors	Kemet	C0603C680J5GACTU
17	1	C45	220 nF 25 V ±10% 0603	Ceramic capacitor	Kemet	C0603C224K3RACTU
18	1	DL1	603	Red LED	Wurth Elektronik	150060RS75000
19	1	DL2	803	Red LED	Wurth Elektronik	150080RS75000
20	2	DL3, DL4	603	Yellow LED	Wurth Elektronik	150060YS75000
21	1	D1	STPS0560Z SOD123	Power Schottky rectifier	ST	STPS0560Z
22	7	D2, D9, D10, D11, D12, D13, D14	BAT30KFILM SOD523	SMD general purpose signal Schottky diode	ST	BAT30KFILM
23	6	D3, D4, D5, D6, D7, D8	1N4148WS SOD323	Diodes	Fairchild Semiconductors	1N4148WS

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
24	5	JP1, JP4, JP5, JP6, JP7	OPEN 0803	Jumpers	Any	
25	4	JP2, JP8, JP9, JP10	CLOSE 0803	Jumpers	Any	
26	2	JP3, J11	61300311121 TH_HEADER_1x3_P 2.54	Header	Wurth Elektronik	61300311121
27	4	JUMPER1, JUMPER2, JUMPER3, JUMPER4	Jumper	Jumpers	Wurth Elektronik	60900213621
28	1	J1	61300811121 TH_HEADER_1x8_P 2.54	Header	Wurth Elektronik	61300811121
29	1	J2	691213510002	Screw	Wurth Elektronik	691213510002
30	1	J3	691213510003	Screw	Wurth Elektronik	691213510003
31	1	J4	61300511121 TH_HEADER_1x5_P 2.54	Header	Wurth Elektronik	61300511121
32	1	J5	65100516121 MINI USB TYPE B SMD	USB	Wurth Elektronik	65100516121
33	1	J6	61300411121 TH_HEADER_1x4_P 2.54	Header	Wurth Elektronik	61300411121
34	3	J7, J8, J9	61300211121 TH_HEADER_1x2_P 2.54	Headers	Wurth Elektronik	61300211121
35	1	J10	NP TH_HEADER_1x2_P 2.54	Header	Wurth Elektronik	61300211121
36	1	LD1	PLCC4	Red/Green LED	Avago	HSMF-A201-A00J1
37	1	L1	22 µH 0.6 A ±20% L3_W3_H1.5	Inductor	Bourns	SRN3015-220M
38	1	M8	GZ_rev2	PCB	Any	
39	2	N1, N2	NETS_L1_W0.5	Copper	Any	
40	6	Q1, Q2, Q3, Q4, Q5, Q6	N-MOS DPAK	STripFET F7 power MOSFET in a DPAK package	ST	STD140N6F7
41	1	Q7	NPN SOT23	CMS	ONSemiconductors	BC847BLT1G
42	1	R1	39 K 1/10 W ±5% 0603	Resistor	Yageo	RC0603JR-0739KL
43	7	R2, R7, R8, R62, R63, R67, R73	100 R 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-07100RL
44	1	R3	330 R 1/10 W ±5% 0603	Resistor	Yageo	RC0603JR-07330RL
45	2	R4, R5	120 R 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-07120RL
46	1	R6	100 K 1/2 W ±10% L9.5_W4.9_H9.5	Trimmer	Bourns	3386G-1-104-LF

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
47	6	R9, R14, R43, R50, R51, R52	0 R 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-070RL
48	1	R10	169 K 1/8 W ±1% 0805	Resistor	Any	RC0805FR-07169KL
49	3	R11, R48, R49	680 R 1/8 W ±5% 0805	Resistors	Yageo	RC0805JR-07680RL
50	1	R12	7.5 K 1/10 W ±5% 0603	Resistor	Yageo	RC0603JR-077K5L
51	12	R13, R19, R20, R34, R45, R46, R47, R53, R54, R55, R65, R71	10 K 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-0710KL
52	2	R15,R21	15 K 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-0715KL
53	1	R16	9.31 K 1/8 W ±1% 0803	Resistor	Yageo	RC0805FR-079K31L
54	6	R17, R22, R31, R35, R39, R41	10 R 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-0710RL
55	6	R18, R23, R32, R36, R40, R42	62 R 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-0762RL
56	4	R24, R25, R28, R74	2.2 K 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-072K2L
57	2	R26, R27	0.02 R 2 W ±1% 2512	Resistors	Yageo	PE2512FKE7W0R02L
58	2	R29, R33	2.4 K 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-072K4L
59	2	R30, R70	100 K 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-07100KL
60	4	R37, R38, R44, R69	4.7 K 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-074K7L
61	4	R56, R57, R58, R75	1 K 1/10 W ±5% 0603	Resistors	Yageo	RC0603JR-071KL
62	4	R59, R60, R61, R72	NP 1/10 W ±5% 0603	Resistors	Any	
63	1	R64	1.5 K 1/10 W ±5% 0603	Resistor	Yageo	RC0603JR-071K5L
64	1	R66	36 K 1/10 W ±5% 0603	Resistor	Yageo	RC0603JR-0736KL
65	1	R68	2.7 K 1/10 W ±5% 0603	Resistor	Yageo	RC0603JR-072K7L
66	3	SW1, SW2, SW3	430483025816 L6.2_W6.2_H2.5	Switch buttons	Wurth Elektronik	430483025816
67	11	TP1, TP2, TP3, TP4, TP5, TP7, TP8, TP10, TP11, TP13, TP14	S1751-46R	Test points	Harwin	S1751-46R
68	3	TP6, TP12, TP15	TPSMD-1MM	Test points	Any	
69	2	TP9, TP16	NEEDLE-PAD-1.7mm	Test points	Any	

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
70	1	U1	STSPIN32F0B VFQFPN48_L7_W7_P.5	Advanced single shunt BLDC controller with embedded STM32 MCU	ST	STSPIN32F0B
71	1	U2	USBLC6-2SC6 SOT23-6L	ESD protection for USB 2.0 high speed	ST	USBLC6-2SC6
72	1	U3	LD3985M33R SOT23-5	Ultra low drop-low noise BiCMOS voltage regulators low ESR capacitor compatible	ST	LD3985M33R
73	1	U4	STM32F103CBT6 LQFP48	Mainstream performance line, ARM Cortex-M3 MCU	ST	STM32F103CBT6
74	1	X1	8MHz L3.2_W2.5	Quartz	NDK	NX3225GD-8MHZ-STD-CRA-3

Revision history

Table 7. **Document revision history**

Date	Version	Changes
06-May-2019	1	Initial release.
19-Jul-2021	2	Updated Section 1 Solution overview and Section 2.2 How to set up and use the board.

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