UM2278
User manual

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

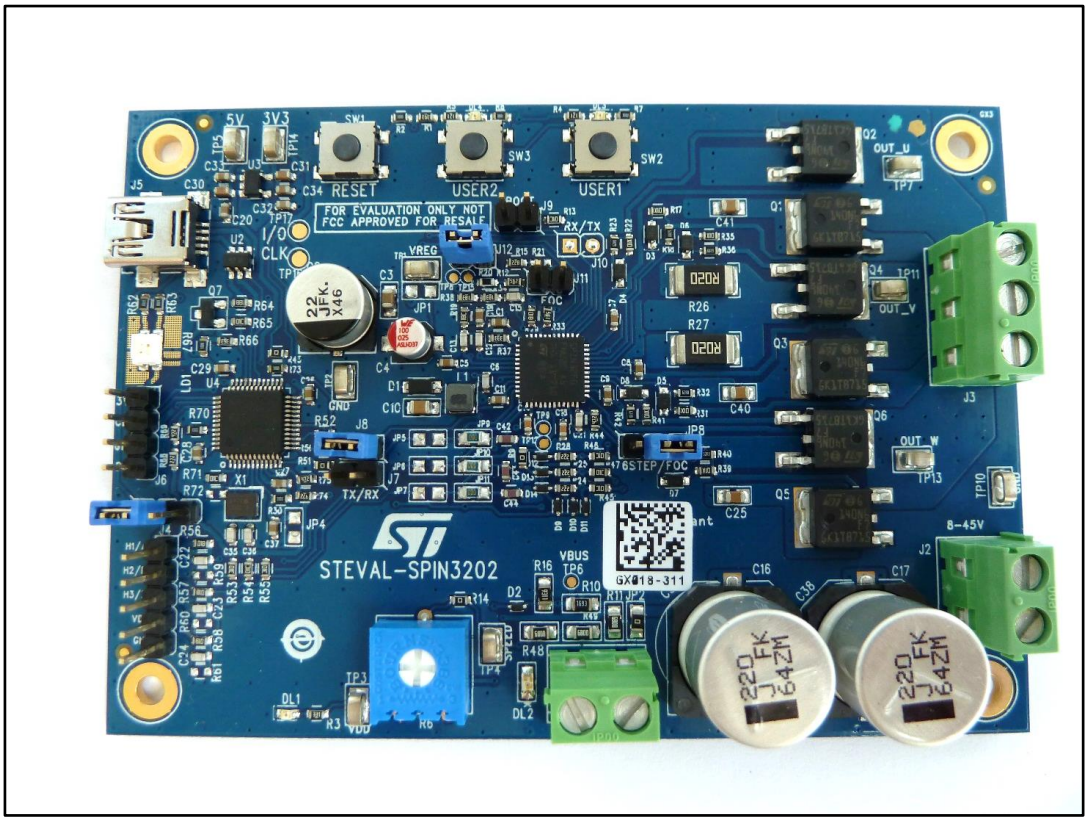
Introduction

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

It implements a single shunt resistor current reading topology and provides an easy-to-use solution for device evaluation in different applications such as home appliances, fans, drones and power tools.

The board is designed for the sensored or sensorless six-step algorithm and Field Oriented Control with single shunt current sensing.

Figure 1: STEVAL-SPIN3202 evaluation board



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1 Hardware and software requirements

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

- a Windows ® PC (XP, Vista 7 , Windows 8, Windows 10) to install the software package;
- a mini-B USB cable to connect the STEVAL-SPIN3202 evaluation board to the PC;
- the STSW-SPIN3202 firmware example or the STM32 PMSM six-step software development kit (STSW-STM32100) (both available on *www.st.com*);
- a 3-phase brushless DC motor with compatible voltage and current ratings;
- an external DC power supply.

2 Getting started

To use the board:

1. Check the jumper position according to the target configuration (see *Section 2.2.1: "STEP/FOC selection"*)
2. Connect the motor to 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 code examples provided. The STSW-SPIN3202 firmware example also provides pre-compiled binaries that are ready-to-use.

The board maximum ratings are:

- power stage supply voltage (VS) from 6.7 V to 45 V;
- motor phase current up to 15 Arms.

2.1 Hardware description and configuration

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

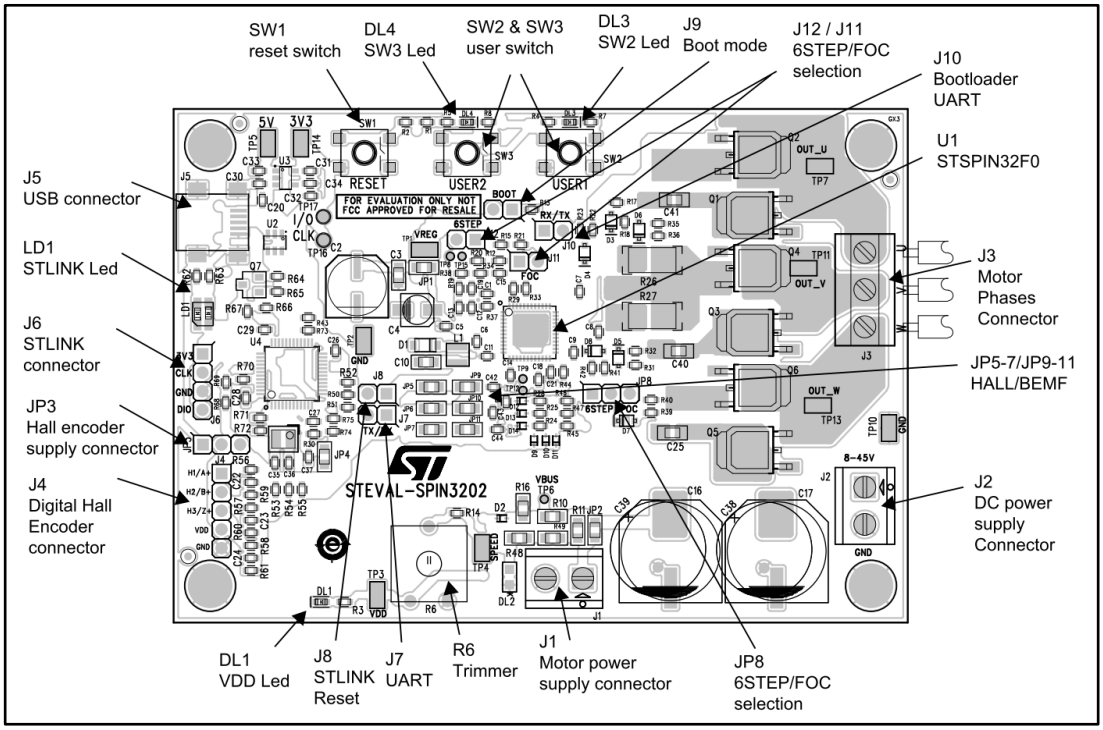


Table 1: Hardware setting jumpers

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
JP8	Selection mode 6STEP(1)/FOC (3)	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	Hallsensors/encoder connector
	4-5	J4	Hall sensors/encoder supply
J5	-	J5	USB input ST-LINK
J6	1	3v3	ST-LINK power supply
	2	CLK	SWCLK of ST-LINK
	3	GND	GND
	4	DIO	SWDIO of 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

Name	Pin	Label	Description
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

2.2 Circuit description

The STEVAL-SPIN3202 evaluation board provides a complete single-shunt six-step solution consisting of an STSPIN32F0A (advanced BLDC controller with an embedded STM32 MCU) and a triple half-bridge power stage with the NMOS STD140N6F7.

The STSPIN32F0A autonomously generates all the required supply voltages starting from the motor supply: the internal DC/DC buck 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 (e.g., starting/stopping the motor and set 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 any extra hardware.

The board also supports sensored or sensorless Field Oriented Control algorithm with single-shunt sensing.

2.2.1 STEP/FOC selection

The user can select between six-step and Field Oriented Control modes by selecting different jumpers on the board.

By default, the six-step mode is selected as per the following configuration:

- jumper connected on J12 open and jumper J11 closed;
- jumper connected on JP8 between pin 1 and 2 (6 STEP position).

The Field Oriented Control mode is selected as follows:

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

2.2.2 Hall/encoder_connector 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).

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.

The jumper JP3 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)

2.2.3 Overcurrent detection and current sensing measurement

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

The shunt resistor measures the load current. Resistors R26 and R27 bring the voltage signal to the OC_COMP pin. When the peak current flowing though 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	20 A
1	0	250 mV	65 A
1	1	500 mV	140 A

2.2.4 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 (VBUS, R10 and R16) and sent to the PB1 GPIO (the ADC channel 9) of the embedded MCU. The signal is also available on the TP6.

2.2.5 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)

2.2.6 Debug

The STEVAL-SPIN3202 evaluation board embeds an ST-LINK/V2-1 debugger/programmer.

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

The LED LD1 provides ST-LINK communication status information:

- 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/V2-1 (enumeration)
- Red LED ON: the 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 successfully completed

The reset function is activated by removing the jumper J8.

2.2.7 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	CER	N.A.	100NF_50V_X7R_0603
2	1	C2	22µF 63V ±20% L8.3_W8.3_H9.5	ALU	PANASONIC	EEEFK1J220P
3	4	C3, C25, C40, C41	220nF 100V ±15% 805	CER	N.A.	220NF_100V_X7R_0805
4	1	C4	10µF 25V ±20% D4_H5.5	ALU	WURTH	865080440002
5	1	C6	3.3nF 50V ±15% 603	CER	N.A.	3.3NF_50V_X7R_0603
6	1	C10	47µF 6.3V ±20% 805	CER	N.A.	47UF_6.3V_X5R_0805
7	2	C12, C13	1 nF 50 V ±15% 603	CER	N.A.	1NF_50V_X5R_0603
8	2	C14, C18	4.7nF 50V ±15% 603	CER	N.A.	4.7NF_50V_X7R_0603
9	1	C15	100pF 50V ±15% 603	CER	N.A.	100PF_50V_X5R_0603
10	2	C16, C17	220µF 63V ±20% L13.5_W13.5_H15	ALU	PANASONIC	EEVFK1J221Q
11	1	C21	220pF 50V ±15% 603	CER	N.A.	220PF_50V_X7R_0603
12	5	C22, C23, C24, C35, C36	10pF 50V 0.1 603	CER	N.A.	10PF_50V_COG_0603
13	2	C30, C31	1µF 10V ±15% 603	CER	N.A.	1UF_10V_X7R_0603
14	1	C32	10nF 50V ±15% 603	CER	N.A.	10NF_50V_X7R_0603
15	2	C38, C39	NP 63V ±20% D12.5_H22_P5	ALU	N.A.	220UF_63V_RADIAL_D12.5_H22_P5
16	3	C42, C43, C44	68PF 50V ±15% 603	CER	N.A.	68PF_50V_X7R_0603
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

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
20	1	D1	STPS0560Z SOD123	SCHOTTKY	ST	STPS0560Z
21	7	D2, D9, D10, D11, D12, D13, D14	BAT30KFILM SOD523	SCHOTTKY	ST	BAT30KFILM
22	6	D3, D4, D5, D6, D7, D8	4148WS SOD323	DIODE	N.A.	4148WS
23	5	JP1, JP4, JP5, JP6, JP7	OPEN 805	RES	N.A.	TIN-DROP OPEN
24	4	JP2, JP9, JP10, JP11	CLOSE 805	RES	N.A.	TIN-DROP CLOSE
25	2	JP3, JP8	61300311121	HEADER	WURTH	61300311121
26	6	JUMPER1 JUMPER2 JUMPER3 JUMPER4 JUMPER5 JUMPER6	BLACK	JUMPER	WURTH	60900213621
27	2	J1, J2	691213510002	SCREW	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	HEADER	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	N.A.	PCB GX rev3 - 2 layers
37	2	N1, N2	NETS_L1_W0.5	COPPER	N.A.	NETS_L1_W0.5
38	6	Q1, Q2, Q3, Q4, Q5, Q6	N-MOS DPAK	CMS	ST	STD140N6F7
39	1	Q7	NPN SOT23	CMS	ON SEMICONDUCTOR	BC847BL
40	1	R1	39K 1/10W ±5% 603	RES	N.A.	39K_5%_0603

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
41	7	R2, R7, R8, R62, R63, R67, R73	100R 1/10W ±5% 603	RES	N.A.	100R_5%_0603
42	1	R3	330R 1/10W ±5% 603	RES	N.A.	330R_5%_0603
43	2	R4, R5	120R 1/10W ±5% 603	RES	N.A.	120R_5%_0603
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	RES	N.A.	0R_5%_0603
46	1	R10	169K 1/8W ±1% 805	RES	N.A.	169K_1%_0805
47	3	R11, R48, R49	680R 1/8W ±5% 805	RES	N.A.	680R_5%_0805
48	1	R12	5.6K 1/10W ±5% 603	RES	N.A.	5.6K_5%_0603
49	9	R13, R45, R46, R47, R53, R54, R55, R65, R71	10K 1/10W ±5% 603	RES	N.A.	10K_5%_0603
50	1	R15	8.2K 1/10W ±5% 603	RES	N.A.	8.2K_5%_0603
51	1	R16	9.31K 1/8W ±1% 805	RES	N.A.	9.31K_1%_0805
52	6	R17, R22, R31, R35, R39, R41	10R 1/10W ±5% 603	RES	N.A.	10R_5%_0603
53	6	R18, R23, R32, R36, R40, R42	62R 1/10W ±5% 603	RES	N.A.	62R_5%_0603
54	1	R19	15K 1/10W ±5% 603	RES	N.A.	15K_5%_0603
55	1	R20	1.2K 1/10W ±5% 603	RES	N.A.	1.2K_5%_0603
56	5	R21, R59, R60, R61, R72	NP 603	RES	N.A.	R_NP_0603
57	3	R24, R25, R28	2.2K 1/10W ±5% 603	RES	N.A.	2.2K_5%_0603
58	2	R26, R27	0.02R 2W ±5% 2512	RES	N.A.	0R02_1%_2512
59	4	R29, R56, R57, R58	1K 1/10W ±5% 603	RES	N.A.	1K_5%_0603

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
60	2	R30, R70	100K 1/10W ±5% 603	RES	N.A.	100K_5%_0603
61	1	R33	560R 1/10W ±5% 603	RES	N.A.	560R_5%_0603
62	2	R34, R38	18K 1/10W ±5% 603	RES	N.A.	18K_5%_0603
63	1	R37	33K 1/10W ±5% 603	RES	N.A.	33K_5%_0603
64	4	R44, R69, R74, R75	4.7K 1/10W ±5% 603	RES	N.A.	4.7K_5%_0603
65	1	R64	1.5K 1/10W ±5% 603	RES	N.A.	1.5K_5%_0603
66	1	R66	36K 1/10W ±5% 603	RES	N.A.	36K_5%_0603
67	1	R68	2.7K 1/10W ±5% 603	RES	N.A.	2.7K_5%_0603
68	3	SW1, SW2, SW3	430483025816 L6.2_W6.2_H2.5	BUTTON	WURTH	430483025816
69	10	TP1, TP2, TP3, TP4, TP5, TP7, TP10, TP11, TP13, TP14	S1751-46R	TEST POINT	HARWIN	S1751-46R
70	5	TP6, TP8, TP9, TP12, TP15	TPSMD-1MM	TEST POINT	N.A.	TPSMD-1MM
71	2	TP16, TP17	NEEDLE-PAD-1.7mm	TEST POINT	N.A.	NEEDLE-PAD-1.7mm
72	1	U1	STSPIN32F0A VFQFPN48_L7_W7_P.5	DRIVER	ST	STSPIN32F0A
73	1	U2	USBLC6-2SC6 SOT23-6L	TVS/ESD/EMI	ST	USBLC6-2SC6
74	1	U3	LD3985M33R SOT23-5	CONVERTER	ST	LD3985M33R
75	1	U4	STM32F103CB T6 LQFP48	MCU	ST	STM32F103CBT6
76	1	X1	8MHz L3.2_W2.5	QUARTZ	NDK	NX3225GD 8MHz EXS00A-CG04874

2.2.8 Schematic diagrams

Figure 3: STEVAL-SPIN3202 schematic (1 of 4)

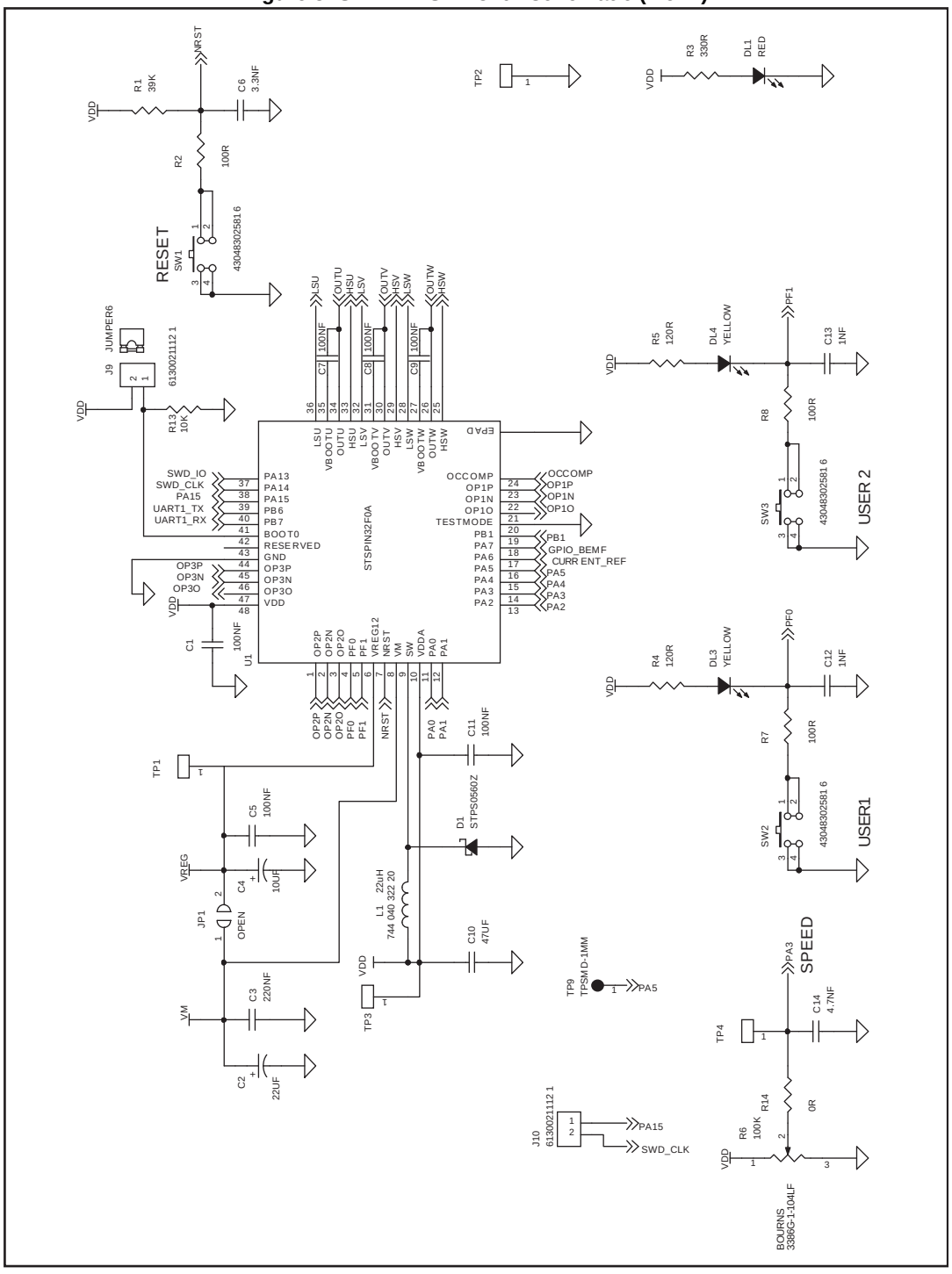


Figure 4: STEVAL-SPIN3202 schematic (2 of 4)

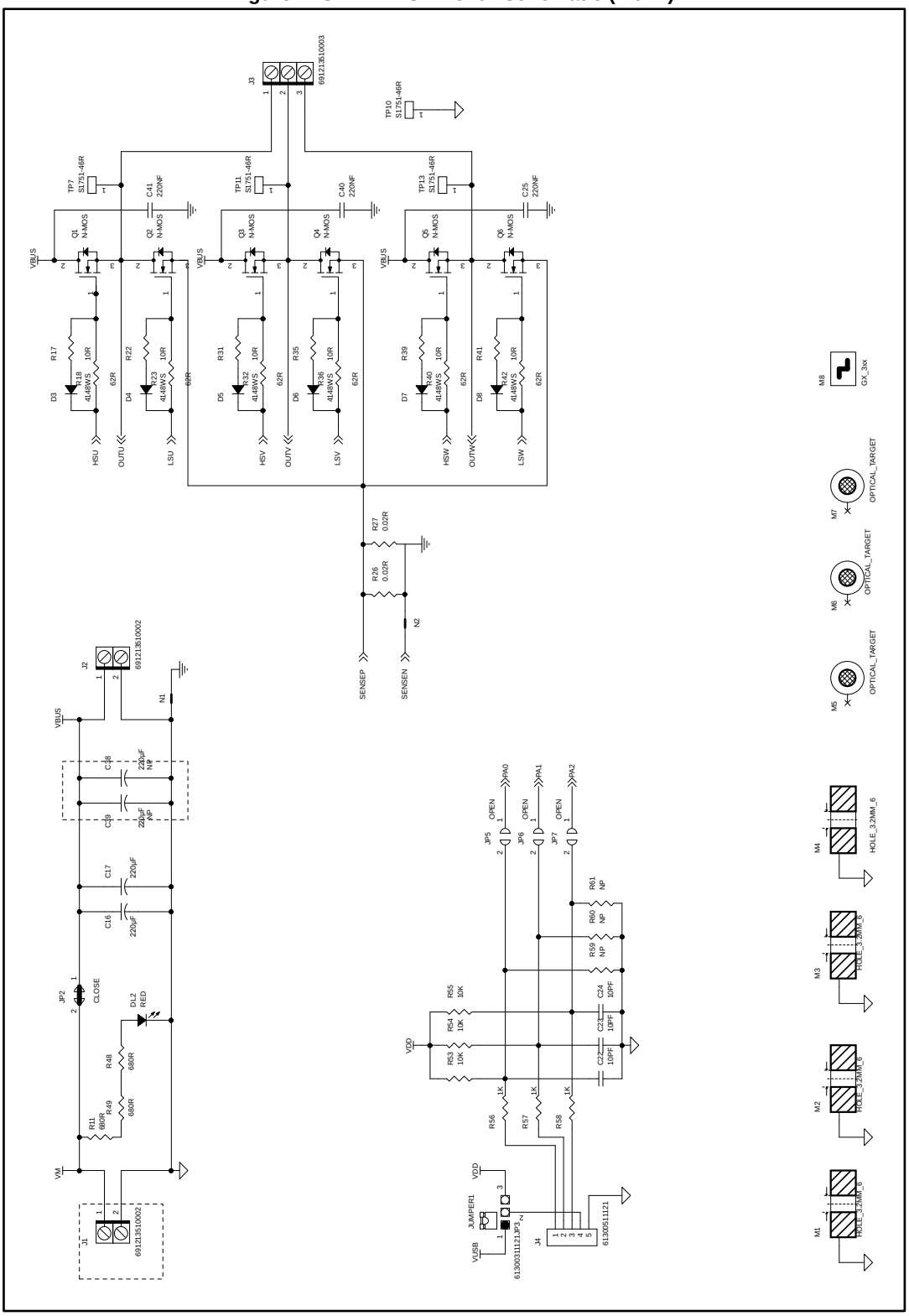
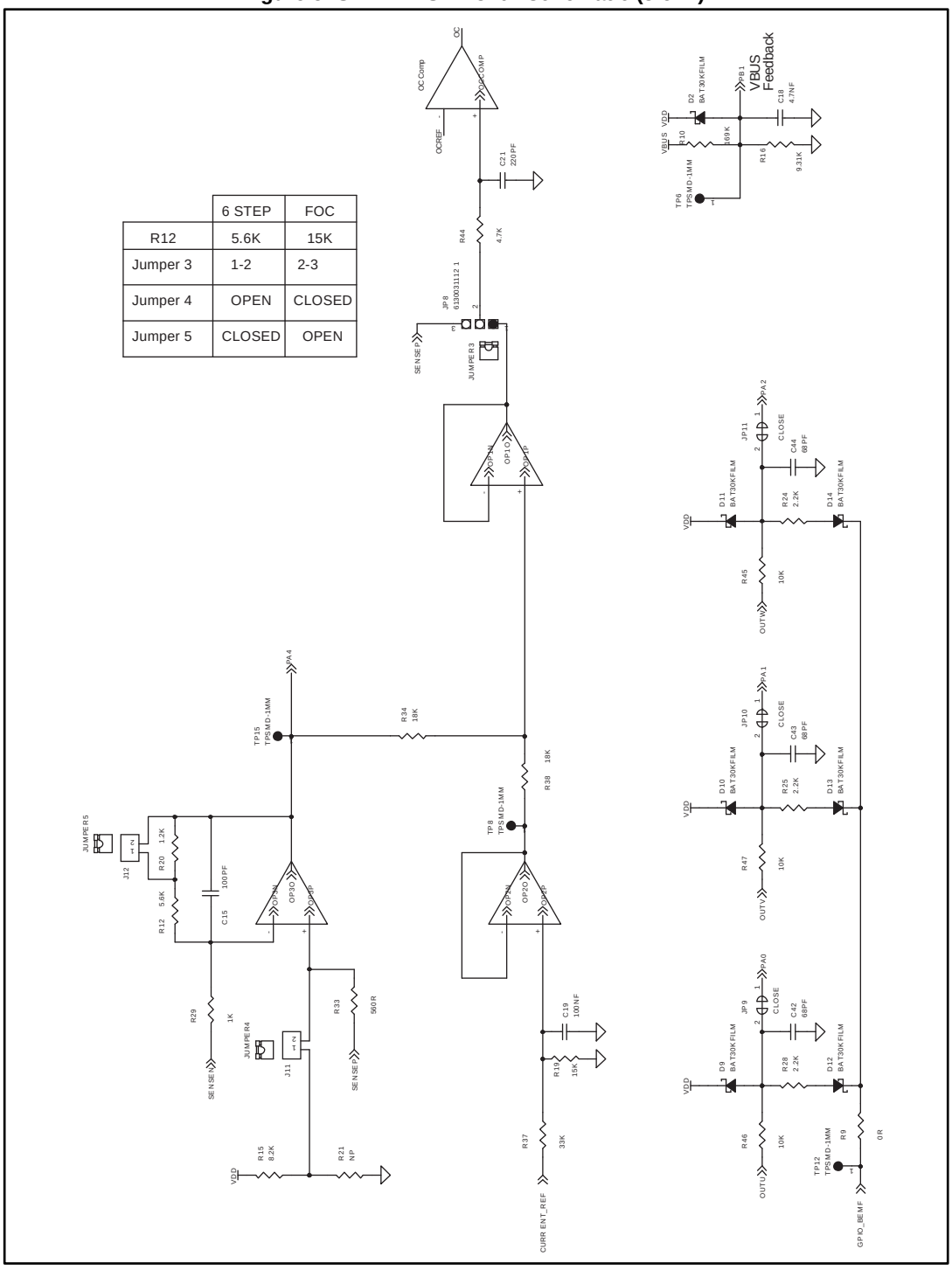
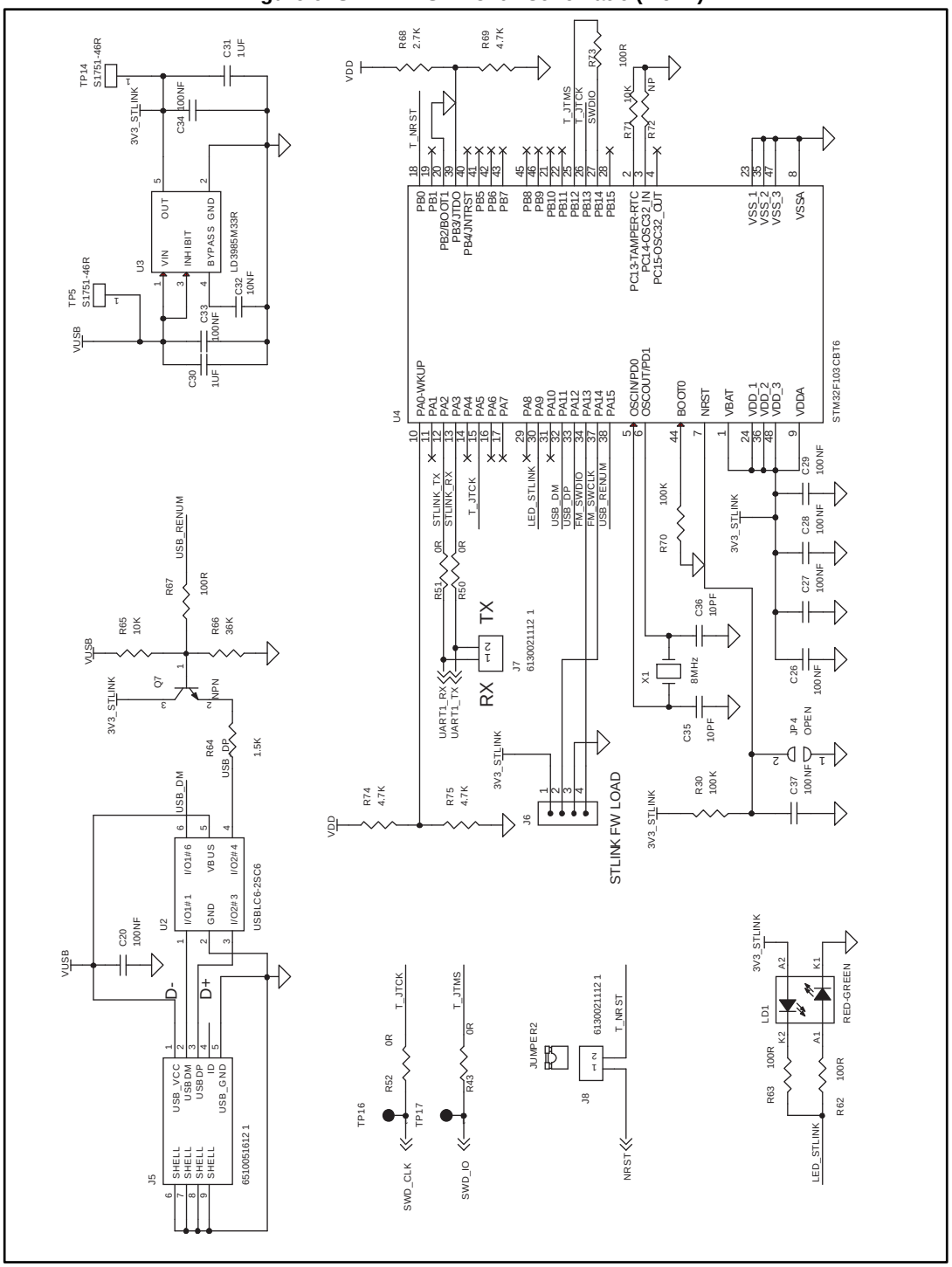


Figure 5: STEVAL-SPIN3202 schematic (3 of 4)



	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)



3 Revision history

Table 6: Document revision history

Date	Revision	Changes
26-Sep-2017	1	Initial release

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