User manual

Getting started with the EVLSPIN32G4-ACT

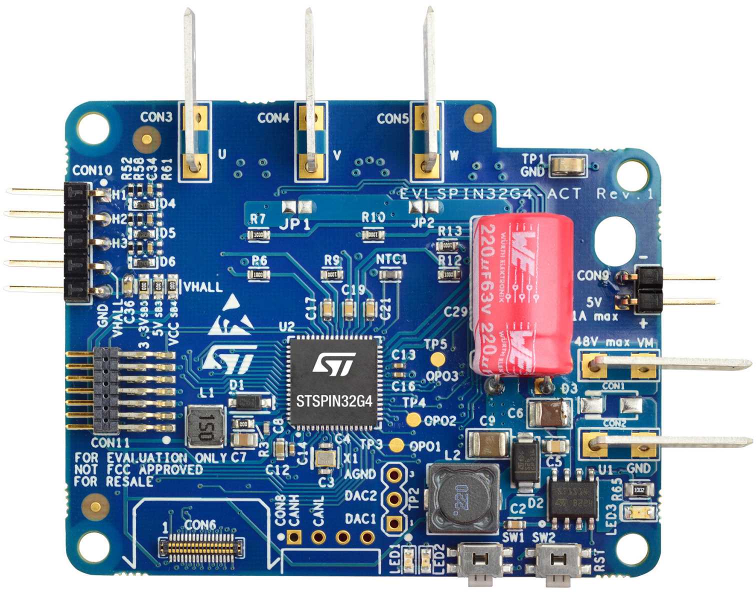
Introduction

The EVLSPIN32G4-ACT is a reference design for implementing next generation smart actuators, based on the STSPIN32G4, a system-in-package integrating in a 9x9 mm VFQFPN package, a triple high-performance half-bridge gate driver with a rich set of programmable features and a mixed signal STM32G431 microcontroller.

The board is designed to drive three-phase brushless motors up to 5 A_{rms} output current and 48 V supply input delivering a total power of 250W in a very compact form factor (62 mm x 50 mm). Monitoring is available for the power stage in case of overheating, overvoltage, and overcurrent. The sensing of motor winding currents can be selected between three-shunt or single-shunt topology. The board is ready for FOC and 6-step control algorithms and can run in sensor-less and sensor-based mode using Hall sensors or quadrature encoder.

Thanks to a smooth interfacing with STWIN.box development kit and a complete software and firmware ecosystem, the motor inverter is empowered by wired and wireless connectivity (RS485, UART, USB, CAN, and Bluetooth® Low Energy, Wi-Fi, NFC), a plethora of inertial end environmental sensors (accelerometer, gyroscope, inclinometer, magnetometer, humidity, temperature, pressure), and data storage onboard (microSD™ card) making EVLSPIN32G4-ACT a perfect suit for cutting edge motor control solutions such as IoT, condition monitoring, and predictive maintenance.

Figure 1. EVLSPIN32G4-ACT



1 Safety and operating instructions

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 danger of serious personal injury or death due to electrical shock, property damage and burn hazards if the kit or components are improperly used or installed incorrectly*

The kit is not electrically isolated from the high-voltage supply DC input. The evaluation board is directly linked to the mains voltage. No insulation is ensured between the accessible parts and the high voltage. All measuring equipment must be isolated from the mains before powering the board. When using an oscilloscope with the demo, it must be isolated from the DC line. This prevents the occurrence of shock when touching any single point in the circuit but does not prevent shock when touching two or more points in the circuit. All operations involving transportation, installation, 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 evaluation board

The board is designed for evaluation purposes only and must not be used for electrical installations or machinery. Technical data and information concerning the power supply conditions 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 isolating distances altered during transportation or handling.
- No contact must be made with other electronic components and contacts.
- 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 operate properly 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 non-conductive and stable work surface.
   - Use adequately insulated clamps and wires to attach measurement probes and instruments.

2. Electrical safety:
   – Remove power supply from the board and electrical loads before performing any electrical measurement.
   – Proceed with the arrangement of measurement set-up, wiring, or configuration paying attention to high voltage sections.
   – Once the set-up is complete, energize the board.

Danger: *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 board after disconnection from the voltage supply as several parts like heatsinks and transformers may still be very hot. The kit is not electrically isolated from the DC input. The USB interface of the board does not insulate host computer from high voltage. When the board is supplied at a voltage outside the ELV range, a proper insulation method such as a USB isolator must be used to operate the board.*

3. Personal safety:
   – Always wear suitable personal protective equipment such as insulated gloves and safety glasses.
   – Take adequate precautions and install the board in such a way to prevent accidental touch. Use protective shields such as an insulating box with interlocks if necessary.

2 Acronyms and definitions

The list of acronyms and definitions used in this document is seen in Table 1.

Table 1. List of acronyms and definitions

	Description
ADC	Analog-to-digital Converter
CAN	Controller area network. It is a robust communication standard used for data transmission among electronic control units connected in a local network.
FOC	Field Oriented Control. It is a driving algorithm for three-phase motors that allows to control the position of the rotor magnetic field with respect to the stator magnetic field.
Half-bridge	Structure composed by one high-side and one low-side MOSFET connected (refer to Figure 6). Each phase of a three-phase motor is usually driven by a half-bridge structure.
MCU	Microcontroller Unit
op amp	Operational Amplifier
PGA	Programmable Gain Amplifier
PWM	Pulse Width Modulation
Shunt resistor	The shunt resistor is placed on the source of the low-side MOSFET, to measure the current flowing in the load.

3 Hardware and software requirements

The use of the EVLSPIN32G4-ACT board requires the following software and hardware:

- A Windows® PC (Windows 10) to install the software package.
- One STLINK-V3SET debugger/programmer or equivalent.
- One three-phase brushless DC motor with compatible voltage and current ratings.
- An external DC power supply with cables.
- STWIN.box, STEVAL-STWINBX1, to implement a fully connected smart actuator (optional).

4 Getting started

To use the board:

1. Connect the three motor terminals to the connectors CON3, CON4, and CON5 taking care of windings sequence.
2. Connect the programmer and debugger to the board using connector CON11.
3. Develop your application or use the MCSDK 6.2 or greater to easily generate a 6-step or FOC firmware that is ready to use.
4. Supply the board via CON1 and CON2 connectors taking care of polarity; the red LED3 turns on to indicate presence of supply voltage.
5. Upload the firmware on the STSPIN32G4 microcontroller with a dedicated tool such as STM32CubeProgrammer and run the motor.

Ratings of the board are listed in the following Table 2.

Table 2. EVLSPIN32G4-ACT specifications

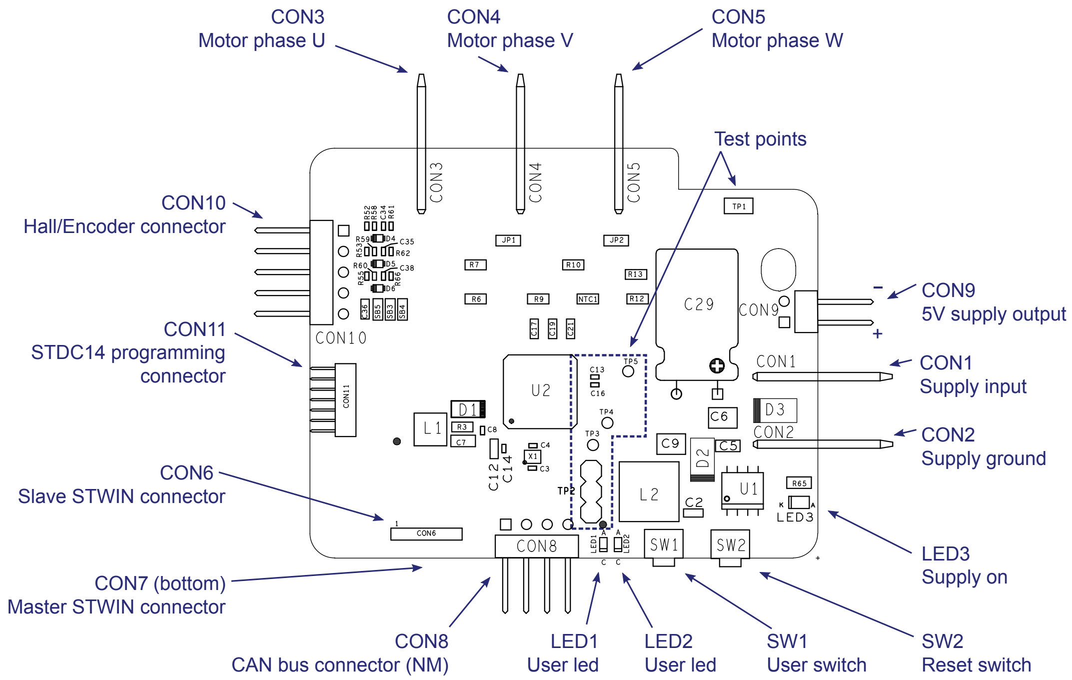
Parameter		Value
Input voltage	Nominal	From 10 V to 48 V
Output current	Peak	7 A
	Continuous(1)	5 A_{rms}
Output power	Continuous(1)	250 W

1. With ambient temperature of 25 °C.

5 Hardware description and configuration

An overview of the board with placement of main components is available in Figure 2.

Figure 2. Position of: connectors, LEDs, switches, and test points



5.1 Connectors and test points

Table 3 provides the description of the connectors available on the board while test points are presented in the following Table 4.

Table 3. Connectors

Name	Pin	Label	Description
CON1	-	VM	DC input supply voltage
CON2	-	GND	Ground
CON3	-	U	Output for motor winding 1
CON4	-	V	Output for motor winding 2
CON5	-	W	Output for motor winding 3
CON6	-	SLV	Flex cable connector, slave side for mating to STWIN.box
CON7	-	MST	Flex cable connector, master side for mating to sensor board
CON8	1	CANH	CAN bus signal high
	2	CANL	CAN bus signal low
	3	-	CAN bus ground
	4	-	CAN bus cable shielding
CON9	1	+	5V supply output at 1A maximum
	2	-	Ground
CON10	1	H1	Hall-effect sensor 1 / encoder out A+
	2	H2	Hall-effect sensor 2 / encoder out B+

Name	Pin	Label	Description
CON10	3	H3	Hall-effect sensor 3 / encoder zero feedback
	4	VHALL	Sensors supply voltage
	5	GND	Sensors ground
CON11	-	-	STDC14 connector for programming and debugging STSPIN32G4

Table 4. Test points

Label	Description
GND	Ground
DAC1	DAC output 1
DAC2	DAC output 2
AGND	Analog ground
OPO1	Output of operational amplifier 1
OPO2	Output of operational amplifier 2
OPO3	Output of operational amplifier 3

5.2 User interface

The board provides the following components to interface with the user:

- Switch SW1: user switch 1.
- Switch SW2: to reset STSPIN32G4.
- LED1: user green LED.
- LED2: user yellow LED, turned on when the user switch 1 is pressed too.
- LED3: system red LED, turned on when supply voltage is present.

5.3 Programming and debugging

The EVLSPIN32G4-ACT board provides a CON11 connector to program firmware on the STSPIN32G4. CON11 provides an STDC14 pinout featuring both SWD and UART interfaces that simplify communication with the PC through the virtual COM port. One STLINK-V3SET debugger/programmer can be mated to CON11 using its flat cable. The mating of this flat cable with CON11 must be with the plastic notch toward the upper side.

5.4 Hall sensors and encoders

The EVLSPIN32G4-ACT board supports two types of sensors for position feedback of the motor:

1. Digital Hall sensors.
2. Quadrature encoder.

Inputs for digital Hall sensors or quadrature encoders are available on CON10 connector (Table 3).

For sensors requiring an external pull-up, three 10 kΩ resistors are already mounted on the output lines and connected to the 3.3 V voltage. Each line is filtered by an RC low-pass filter and footprints for pull-down resistors are also available.

Solder jumpers allow to select the sensors supply voltage (only one solder jumper must be mounted):

- SB3 closed for 5 V supply (default configuration).
- SB4 closed for VCC (8 V to 15 V) supply.
- SB5 closed for 3.3 V supply.

Sensor outputs are connected to PB6, PB7, and PB8 pins of the microcontroller and can be routed to channels TIM_CH1, TIM_CH2, and TIM_CH3 of timer TIM4 respectively.

5.5 Connection with STWIN.box and sensor board

The board features two board-to-FPC/board-to-board (0.4 mm pitch) 34-pin connectors, CON6 and CON7, allowing to easily expand system functionality. These connectors include communication interfaces I²C, SPI, and UART, as well as digital IOs, analog line and power supplies as detailed in Table 5.

Table 5. Pinout of 34 pin connectors

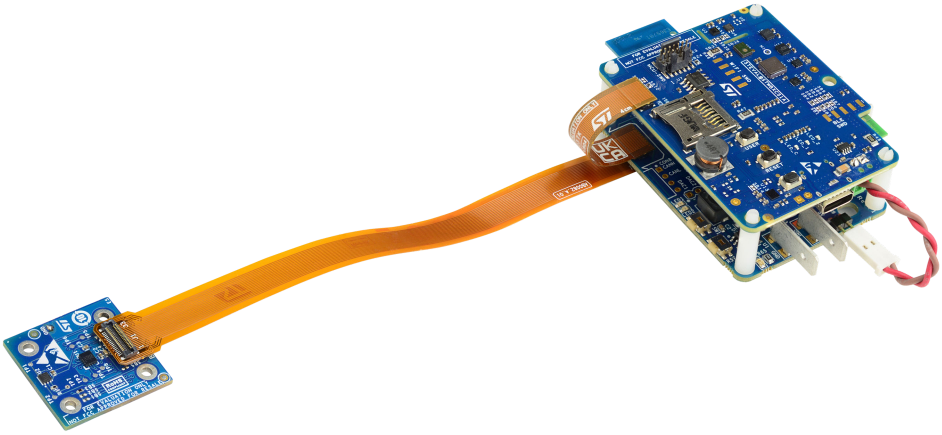
Pin	CON6 function	STSPIN32G4 pin	CON7 function
1	Ground	-	Ground
2	Ground	-	Ground
3	-	-	-
4	-	REGIN	5V supply
5	Bypass only	-	Bypass only
6	-	REG3V3	3.3V supply
7	Bypass only	-	Bypass only
8	I²C interface SDA signal	PB9	I²C interface SDA signal
9	UART interface Rx signal	PA10 / PA9	UART interface Tx signal
10 11	INT_EX digital signal	PC15	INT_EX digital signal
11	UART interface Tx signal	PA9 / PA10	UART interface Rx signal
12	GPIO1_EX digital signal	PC0	GPIO1_EX digital signal
13	Bypass only	-	Bypass only
14	ADC_EX analog signal	PC1	ADC_EX analog signal
15	-	-	-
16	PWM_EX digital signal	PB10	PWM_EX digital signal
17	GPIO3_EX digital signal	PC2	GPIO3_EX digital signal
18	GPIO2_EX digital signal	PC3	GPIO2_EX digital signal
19	SPI interface CS signal	PD2	SPI interface CS signal
20	-	-	-
21	SPI interface MOSI signal	PB5	SPI interface MOSI signal
22	Bypass only	-	Bypass only
23	SPI interface MISO signal	PB4	SPI interface MISO signal
24	Bypass only	-	Bypass only
25	SPI interface SCLK signal	PB3	SPI interface SCLK signal
26	Bypass only	-	Bypass only
27	I²C interface SCL signal	PA15	I²C interface SCL signal
28	Bypass only	-	Bypass only
29	-	REG3V3	3.3V supply
30	Bypass only	-	Bypass only
31	-	REGIN	5V supply
32	-	-	-
33	Ground	-	Ground
34	Ground	-	Ground

The connector CON6 that is positioned on the top layer of the board allows for mating with the STWIN.box board through the flexible cable FLX1 provided in the kit.

The connector CON7 that is positioned below CON6 on the bottom layer of the board, allows for mating with an external sensor board like the STEVAL-C34AT01 through the flex cable provided within the sensor board kit (STEVAL-C34KAT1).

Refer to Figure 3 for proper mating of EVLSPIN32G4-ACT with STWIN.box and sensor board.

Figure 3. Mating of EVLSPIN32G4-ACT with STWIN.box and STEVAL-C34AT01



Warning: *The flex cable and its 34-pin connectors as well as the complementary connectors on the boards could be easily damaged in case of improper mating. Care must be paid when connecting and disconnecting the flex cable or during handling of the assembly. The safest way to disconnect the cable is by pulling it next to the connectors using tweezers.*

Three connection schemes are possible:

1. Master mode: The EVLSPIN32G4-ACT is connected only to the sensor board through CON7. The EVLSPIN32G4-ACT supplies the sensor board and communicates with it as a master.
2. Slave mode: The EVLSPIN32G4-ACT is connected only to the STWIN.box through CON6. Each board has independent supply and EVLSPIN32G4-ACT communicates with STWIN.box as a slave.
3. Pass-through mode: The EVLSPIN32G4-ACT is connected to STWIN.box and sensor board respectively through CON6 and CON7. The EVLSPIN32G4-ACT supplies the sensor board and the STWIN.box can communicate as master with both the slaves EVLSPIN32G4-ACT and sensor board.

When using slave mode or pass-through mode it is possible to supply the STWIN.box through the 5 V voltage regulator of EVLSPIN32G4-ACT. In this case, use the wire jumper CN6 provided in the kit to connect CON9 of EVLSPIN32G4-ACT to the screw connector CON2 of STWIN.box. To facilitate the wiring, this screw connector is positioned close to the corresponding connector of EVLSPIN32G4-ACT when using the four board spacers (SP1, SP2, SP3, and SP4) provided in the kit as shown in Figure 3. The PCB of EVLSPIN32G4-ACT has one hole close to CON9 allowing to use a screwdriver after staking up the boards.

Protection series resistors (from R35 to R48) are provided on all signal lines connecting the STSPIN32G4. These resistors protect in case of conflicting levels between master and slave sides limiting the current flowing through device pins. This could occur in case of wrong mating orientation for the 34-pin connectors or in case of wrong device configuration, for example, one end of the line is pulled low by STWIN.box microcontroller, and the other end is simultaneously pulled high by STSPIN32G4.

5.6 Overcurrent protection

The EVLSPIN32G4-ACT board implements double protection of the power stage from overcurrent condition thanks to:

1. Drain-source voltage monitoring of each power MOSFET.
2. Comparators sensing the shunt current.

5.6.1 Drain-source voltage monitoring

The STSPIN32G4 embeds a circuitry which measures the voltage between the drain and the source of each MOSFET (V_{DS}) and compares it with a specified threshold. When the MOSFET is turned on and its V_{DS} is greater than the threshold, the anomalous condition is detected, and the protection is triggered after a deglitch time: all MOSFETs are turned off whatever the driving inputs.

The threshold is set on the SCREF pins of the STSPIN32G4 at approximately 1.03 V, through the resistor dividers given by R4 and R5.

The STSPIN32G4 provides configurable deglitch filtering time via firmware to 2 µs, 3 µs, 4 µs, and 6 µs (default).

The protections remain latched when triggered: the STSPIN32G4 returns operative forcing all the driving inputs low for at least 100 us or via firmware procedure.

The voltage drop on each low-side MOSFET is measured between its drain and GND, therefore the voltage drop on the shunt resistor contributes to the measure.

Although not recommended, the protections can be disabled replacing R4 with a jumper and removing R5.

For details about V_{DS} monitoring refer to the STSPIN32G4 datasheet.

5.6.2 Embedded comparators

The EVLSPIN32G4-ACT board implements overcurrent protection with the comparator integrated in the STSPIN32G4. The motor current is measured via the voltage drop produced on shunt resistors. When peak current exceeds a selected threshold, the protection is triggered.

The protection requires the configuration of the fast rail-to-rail comparators COMP1, COMP2, and COMP4. The positive inputs of the comparators must be connected to PA1, PA7, and PB0 pins of the microcontroller where the current measures from shunt resistors are available while negative inputs can be internally connected to DAC channels or a partition of the internal reference voltage, Vrefint, to set a proper overcurrent threshold.

With reference to Figure 6, the overcurrent threshold can be derived with the following Eq. (1).

Equation 1

$$\boldsymbol{I_{OC}} = \left(\boldsymbol{V_{TH}} - \boldsymbol{V_{REF+}} \cdot \frac{\boldsymbol{R15//R18}}{\boldsymbol{R17 + R15//R18}}\right) \cdot \frac{\boldsymbol{R15 + R17//R18}}{\boldsymbol{R17//R18}} \cdot \frac{1}{\boldsymbol{R_S}} \quad (1)$$

- $\boldsymbol{I_{OC}}$ is the resulting overcurrent threshold.
- $\boldsymbol{V_{TH}}$ is the threshold voltage applied to the comparator negative input.
- $\boldsymbol{V_{REF+}}$ is the voltage of VREFP pin (3.3 V by default).
- $\boldsymbol{R_S}$ is the value of the shunt resistor (20 mΩ by default).

Overcurrent thresholds computed for different threshold voltages are reported in Table 6.

Table 6. Overcurrent thresholds

Threshold	Peak current
DAC	$(V_{DAC}$ - 0.150 V) · 55 A/V
V_{refint}	58 A
3/4 V_{refint}	42 A
1/2 V_{refint}	25 A
1/4 V_{refint}	8 A

To avoid spurious triggering of the protection, a digital deglitch filtering or blanking can be also configured. For details refer to the STM32G4 reference manual.

5.7 Current sensing

The EVLSPIN32G4-ACT board provides the sensing of current flowing through motor windings in both directions as required by the Field Oriented Control algorithm.

With reference to the schematic in Figure 7, the sensing is based on the operational amplifiers (op amps) integrated in the STM32G431 microcontroller. Three configurations are possible.

5.7.1 Two standalone op amps

Two op amps can be used to acquire currents of two motor windings at a time and derive the third. In this configuration it is possible to always acquire the same currents, for example, U and V and derive W current, or rather implement a multiplexing of op amps. With reference to Table 7 the non-inverting inputs of OPAMP1 can be alternatively connected to PA1 or PA7 while non-inverting input of OPAMP2 can be connected to PA7 or PB0. For the gain of the network refer to the next case.

Table 7. Multiplexing of op amps

Measured current with OPAMP1	Measured current with OPAMP2	Derived current
U on PA1	V by PA7	W = -(U+V)
V by PA7	W by PB0	U = -(V+W)
U by PA1	W by PB0	V = -(U+W)

5.7.2 Three standalone op amps

In this configuration all three op amps integrated in the STM32G431 microcontroller are used. A differential current sensing is implemented for better rejection of common-mode signal.

The op amp outputs PA2, PA6, and PB1 (test points TP3, TP4, and TP5) can be routed to channel 1 of ADC1, channel 3 of ADC2 and channel 12 of ADC1 respectively to implement current measurements.

According to Eq. (2), the gain of the network is:

Equation 2

$$\frac{V_O}{I} = G * R_S = 10 * 20 m\Omega = 0.2 \frac{V}{A} \quad (2)$$

- V_O is the amplified output voltage.
- I is the current flowing through motor winding.
- G is the gain of the amplifying network.
- R_S is the value of shunt resistor.

Footprints are available to mount filtering capacitors on op amps' feedback (C23, C25, and C27).

5.7.3 Three PGAs

The operational amplifiers embedded in the STSPIN32G4 can be configured in Programmable Gain Amplifier (PGA) mode. In this case, the external feedback networks are not needed and the op amp outputs can also be internally connected to ADCs.

Resistor networks on the op amps' non-inverting pins should be modified to have op amp output voltage in idle state close to VREF+/2 to optimize ADC dynamic range. The following Table 8 can be used to adjust resistor values according to the selected PGA gain (values are proportional to integrated resistors of PGA).

With the resistor values reported in table the gain of the network is:

Equation 3

$$\frac{V_O}{I} = \left(G - 1\right) * R_S \quad (3)$$

- V_O is the amplified output voltage.
- I is the current flowing in motor winding.
- G is the PGA gain in inverting configuration.
- R_S is the value of shunt resistor.

Table 8. Suggested resistor values for positive input biasing with PGA

PGA gain	R15, R22, R28	R17, R18, R24, R25, R30, R31	Gain [V/A][(1)]
2	10k	20k	0.02
4	10k	60k	0.06

PGA gain	R15, R22, R28	R17, R18, R24, R25, R30, R31	Gain [V/A][1]
8	**1k**	**14k**	**0.14**
16	1k	30k	0.3
32	1k	61k	0.62
64	1k	120k	1.26

1. *Computed with Eq. (3)*

In case shunt resistors are not changed, a PGA gain of 8 is suggested. For computation of new overcurrent thresholds see Section 5.6.2.

5.8 Single shunt conversion

The board is configured for three-shunt operations but can be easily converted to single-shunt as described below:

- Close the two solder jumpers JP1 and JP2 located on the top side of the board in proximity of the shunt resistors. Make sure to close both the solder jumpers for their entire length to ensure good electrical connection and to avoid malfunctions.
- Disconnect shunt resistors R8 and R14.

The board is now converted to single-shunt with OPAMP2 used to amplify the signal from shunt R11.

5.9 Bus voltage sensing

The EVLSPIN32G4-ACT board provides the sensing of bus voltage that can be used in firmware to protect in case of undervoltage or overvoltage. This signal is set through a voltage divider with attenuation 0.04 by the motor supply voltage (resistors R20 and R21) and sent to the PA0 pin of the microcontroller. PA0 can be connected to the positive input of comparator COMP3 or to channel 1 of ADC1 and ADC2.

5.10 PCB temperature sensing

The board provides one NTC thermistor placed in proximity of the power stage to sense the temperature of the surrounding MOSFETs. The thermistor can be used in firmware to implement thermal shutdown and protect the power stage in case of overheating. The NTC signal is available on the PC4 pin of the MCU and can be routed to channel 5 of ADC2.

The following Eq. (4), derived from β model of NTC thermistor, can be used to obtain temperature estimate from voltage value on PC4:

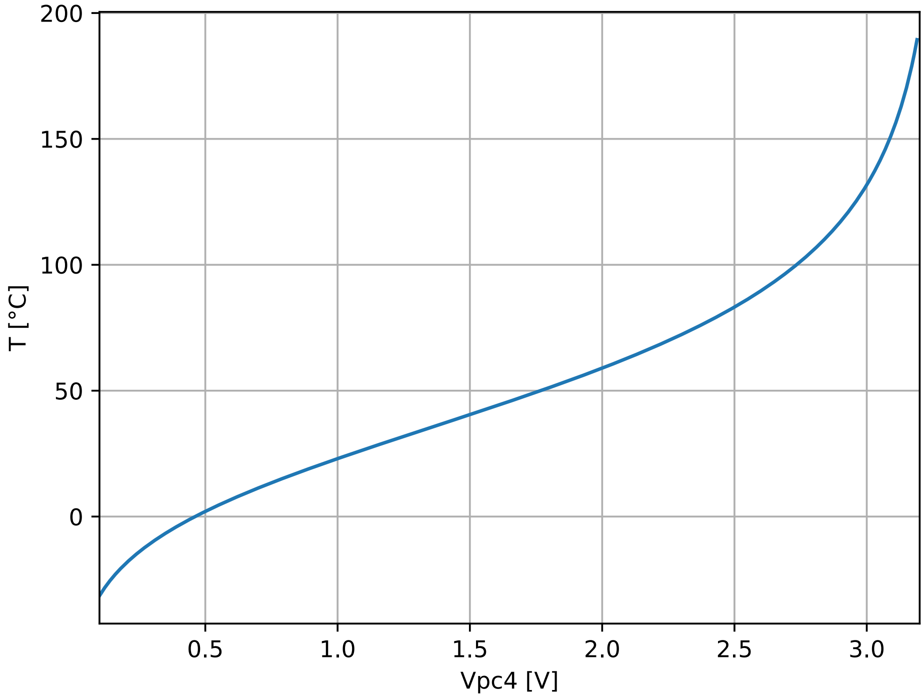
Equation 4

$$T\left(\mathrm{V_{PC4}}\right) = \frac{1}{\frac{1}{\beta} \cdot \ln\left(\frac{R27 \cdot \left(\frac{V_{REFP}}{V_{PC0}} - 1\right)}{R_{NTC}^{0}}\right) + \frac{1}{T^{0}}} \qquad (4)$$

- $T(V_{PC4})$ is the estimated temperature in Kelvin.
- V_{PC4} is the voltage on PC4 pin.
- β is 3455 K, the β constant of selected NTC thermistor in the range 25 °C – 100 °C.
- R_{NTC}^{0} is 10 kΩ, the thermistor resistance at 298 K.
- T^{0} is 298 K.

Plot of above Eq. (4) is shown in Figure 4.

Figure 4. Thermistor temperature with respect to voltage on PC4 pin



5.11 CAN bus predisposition

A predisposition for CAN bus is available on the board.

The STSPIN32G4 integrates one FDCAN communication interface to manage data layer of CAN protocol. The interface is compliant with ISO 11898-1: 2015 (CAN protocol specification version 2.0 part A, B) and CAN FD protocol specification version 1.0. The physical layer of the CAN protocol is managed by an external transceiver, the TCAN330.

R50 can be mounted in case bus termination is needed. Connection to the CAN bus is available via the CON8 connector which also provides one terminal for cable shielding with optional connection to board ground via solder jumper SB2.

6 Bill of material

Table 9. **EVLSPIN32G4-ACT bill of materials**

Item	Q.ty	Reference	Description	Value
1	5	CN1, CN2, CN3, CN4, CN5	Insulated female Faston wire to board connector, 6.35 x 0.8mm Tab size, 1.5mm² to 2.5mm²	267-4170
2	1	CN6	Wire jumper, pitch 2.54mm, length 10mm, 26 - 20 AWG	
3	5	CON1, CON2, CON3, CON4, CON5	Tab FASTON .250 Series	928814-1
4	1	CON6	High current connectors for board-to-FPC/for board-to-board P4SP (0.4mm pitch)	AXF6G3412A
5	1	CON7	High current connectors for board-to-FPC/for board-to-board P4SP (0.4mm pitch)	AXF5G3412A
6	1	CON8	2.54mm pitch C-Grid III header, single row, right-angle, 4 circuits, 0.38µm gold selective plating	N.M.
7	1	CON9	2.54mm pitch C-Grid III header, single row, right-angle, 2 circuits, 0.38µm gold selective plating	61300211021
8	1	CON10	2.54mm pitch C-Grid III header, single row, right-angle, 5 circuits, 0.38µm gold selective plating	61300511021
9	1	CON11	Surface mount micro header (1.27mm) .050" pitch FTSH series	FTSH-107-01-L-DH
10	1	C1	SMT ceramic capacitor 0402	1nF, 25V, 10%
11	1	C2	SMT ceramic capacitor 0603	100nF, 25V, 10%
12	2	C3, C4	SMT ceramic capacitor 0402	6.8pF, 6.3V, 0.25pF
13	1	C5	SMT ceramic capacitor 0805	100nF, 100V, 10%
14	1	C6	SMT ceramic capacitor 1210	4.7uF, 100V, 10%
15	1	C7	SMT ceramic capacitor 0805	10uF, 25V, 10%
16	1	C8	SMT ceramic capacitor 0402	N.M.
17	1	C9	SMT ceramic capacitor 1210	47u, 16V, 20%
18	4	C10, C18, C20, C22	SMT ceramic capacitor 0805	220nF, 100V, 10%
19	4	C11, C23, C25, C27	SMT ceramic capacitor 0402	N.M.
20	1	C12	SMT ceramic capacitor 0603	2.2uF, 6.3V, 10%
21	4	C13, C14, C16, C37	SMT ceramic capacitor 0402	100nF, 6.3V, 10%
22	1	C15	SMT ceramic capacitor 0603	1uF, 6.3V, 10%
23	3	C17, C19, C21	SMT ceramic capacitor 0603	1uF, 25V, 10%
24	2	C24, C26	SMT ceramic capacitor 0402	33nF, 6.3V, 10%
25	1	C28	SMT ceramic capacitor 0402	100nF, 6.3V, 10%
26	1	C29	THT electrolytic capacitor	220uF, 60V, 20%
27	2	C30, C31	SMT ceramic capacitor 0603	10nF, 100V, 10%
28	2	C32, C36	SMT ceramic capacitor 0603	100nF, 25V, 10%
29	4	C33, C34, C35, C38	SMT ceramic capacitor 0402	1nF, 6.3V, 10%
30	1	D1	Schottky rectifier SOD-123	STPS0560Z
31	1	D2	Low drop power Schottky rectifier SMA	STPS2L60

Item	Q.ty	Reference	Description	Value
32	1	D3	Transient voltage suppressor diode SMA	N.M.
33	3	D4, D5, D6	Small signal Schottky diodes SOD-523	BAT30K
34	1	FLX1	Flexible cable for STWIN.box, 40mm length	STEVAL-FLTCB04
35	2	JP1, JP2	SMT jumper 0805	Open
36	1	LED1	Chip LED 0603	Green
37	1	LED2	Chip LED 0603	Yellow
38	1	LED3	Chip LED 0805	Red
39	1	L1	WE-LQS SMT semi-shielded power inductor	15uH, 1.4A, 20%
40	1	L2	Robust SMT shielded power inductor	22uH, 1.41A, 20%
41	3	NET1, NET2, NET3	PCB short	N.M.
42	1	NTC1	NTC thermistor 0603	10k, 1%
43	6	Q1, Q2, Q3, Q4, Q5, Q6	N-channel 100V, 14.5 mohm typ., 12A, STripFET F7 DeepGATE power MOSFET	STL60N10F7
44	2	R1, R27	SMT resistor 0402	4.7k, 0.064W, 1%
45	7	R2, R15, R16, R22, R23, R28, R29	SMT resistor 0402	1.5k, 0.064W, 1%
46	1	R3	SMT resistor 0603	0, 0.1W, 5%
47	1	R4	SMT resistor 0402	22k, 0.064W, 1%
48	1	R5	SMT resistor 0402	10k, 0.064W, 1%
49	6	R6, R7, R9, R10, R12, R13	SMT resistor 0603	100, 0.1W, 5%
50	3	R8, R11, R14	SMT resistor 1206	20m, 1W, 1%
51	6	R17, R18, R24, R25, R30, R31	SMT resistor 0402	30k, 0.064W, 1%
52	3	R19, R26, R32	SMT resistor 0402	15k, 0.064W, 1%
53	1	R20	SMT resistor 0402	72.3k, 0.064W, 1%
54	1	R21	SMT resistor 0402	3.01k, 0.064W, 1%
55		R33, R34	SMT resistor 0402	4.7k, 0.064W, 5%
56	16	R35, R36, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R48, R57, R64	SMT resistor 0402	200, 0.064W, 5%
57	1	R49	SMT resistor 0402	10k, 0.064W, 5%
58	1	R50	SMT resistor 0402	N.M.
59	2	R51, R63	SMT resistor 0402	100k, 0.064W, 5%
60	6	R52, R53, R55, R58, R59, R60	SMT resistor 0402	10k, 0.064W, 5%
61	1	R54	SMT resistor 0402	120, 0.064W, 5%
62	1	R56	SMT resistor 0402	330, 0.064W, 5%
63	3	R61, R62, R66	SMT resistor 0402	N.M.
64	1	R65	SMT resistor 0805	10k, 0.5W, 5%
65	2	SB1, SB3	SMT resistor 0603	0, 0.1W, 5%

Item	Q.ty	Reference	Description	Value
66	3	SB2, SB4, SB5	SMT resistor 0603	N.M.
67	4	SP1, SP2, SP3, SP4	Nylon spacer	701514000
68	2	SW1, SW2	WS-TASU SMT tact switch	434351045816
69	1	TP1	40x71 mils SMD PAD	S1751-46
70	1	TP2	Strip connector 3 pos, 2.54mm	N.M.
71	3	TP3, TP4, TP5	Test point - PCB 1.5mm diameter	N.M.
72	1	U1	Step-down switching regulator	ST1S14PHR
73	1	U2	**Three-phase brushless motor controller embedding STM32G4 MCU**	**STSPIN32G4**
74	1	U3	TCAN33x 3.3-V CAN transceivers with CAN FD	N.M.
75	1	X1	Low profile quartz crystal	24MHz

7 Schematics

Figure 5. EVLSPIN32G4-ACT schematic (1 of 4): STSPIN32G4

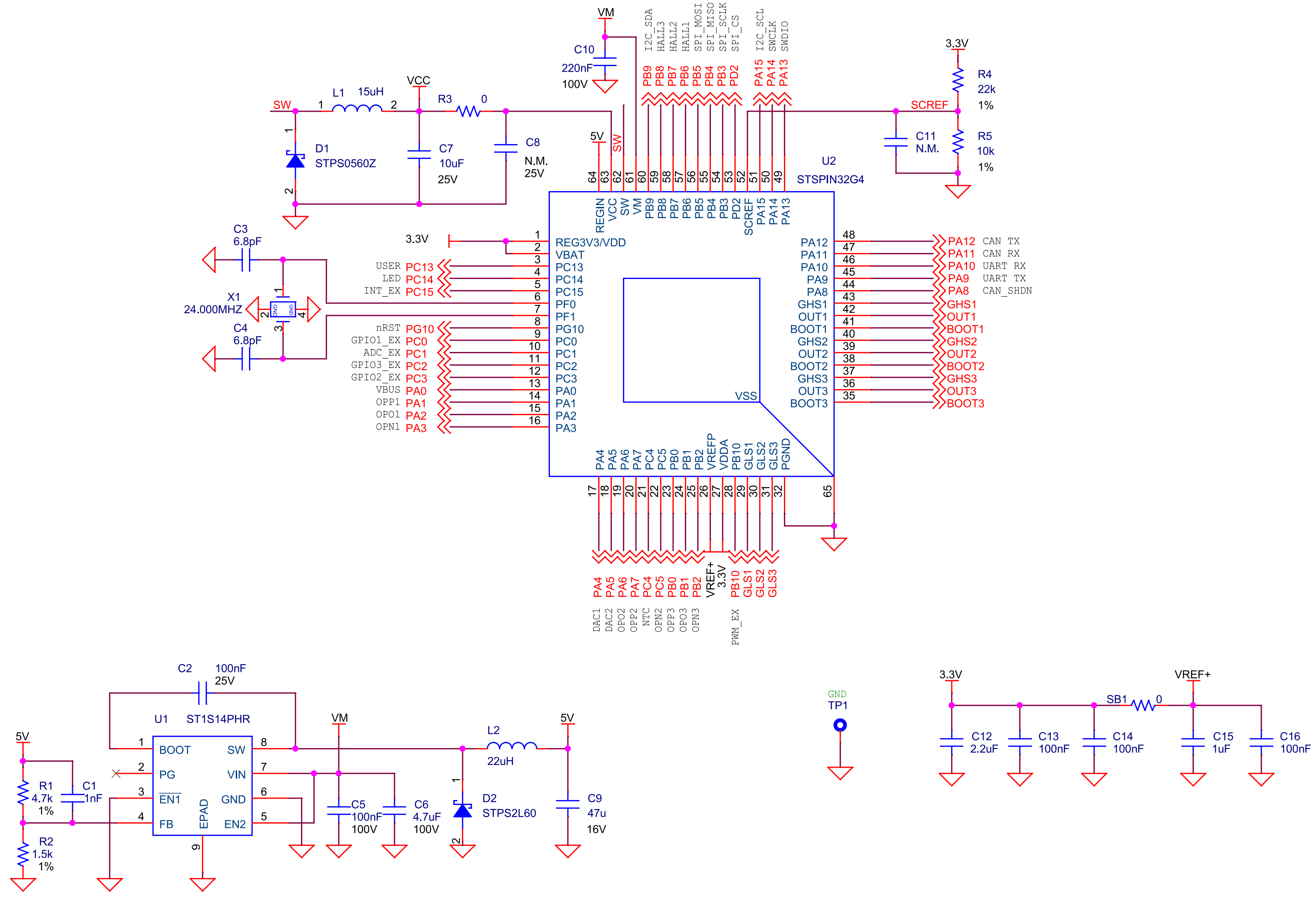


Figure 6. EVLSPIN32G4-ACT schematic (2 of 4): Power stage

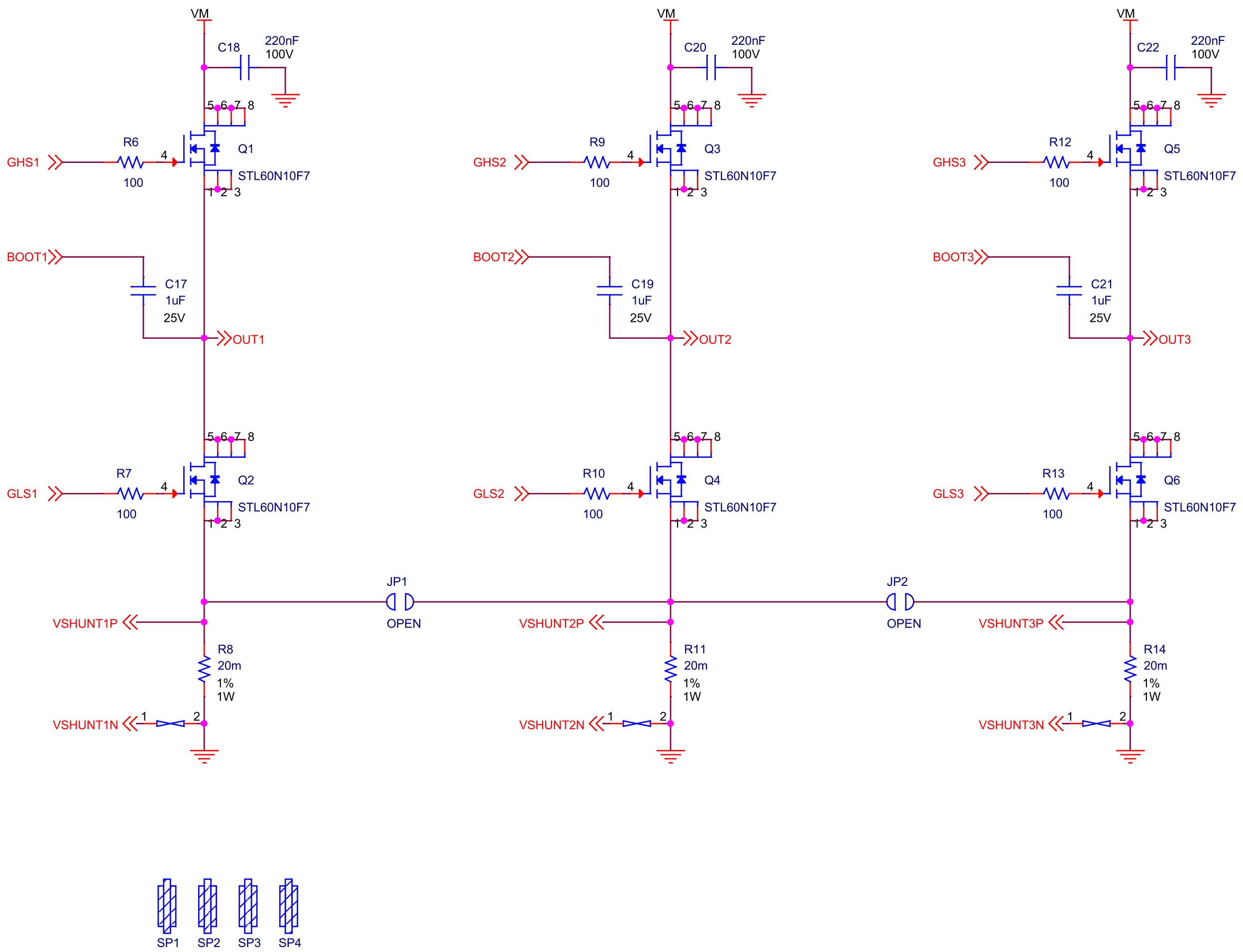
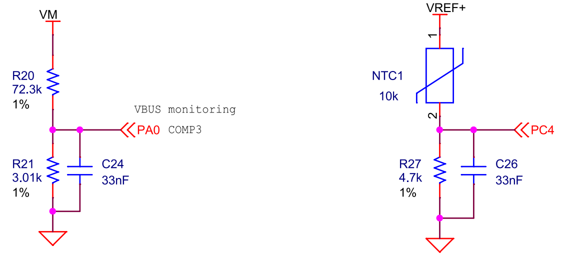
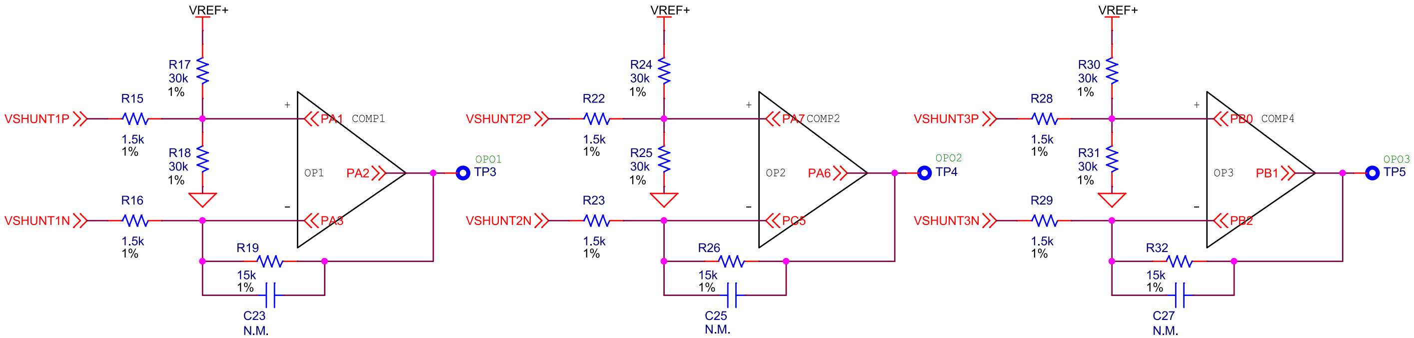


Figure 7. EVLSPIN32G4-ACT schematic (3 of 4): Sensing

Current sensing circuitry topology

	3 OpAmp	2 OpAmp (OP1 + OP2)	PGA
IN1+	PA1	PA1	PA1
IN1-	PA3		
OUT1	PA2	PA2	
IN2+	PA7	PA7	PA7
IN2-	PC5		
OUT2	PA6	PA6	
IN3+	PB0	PB0	PB0
IN3-	PB2		
OUT3	PB1		





Debug outputs

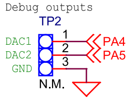
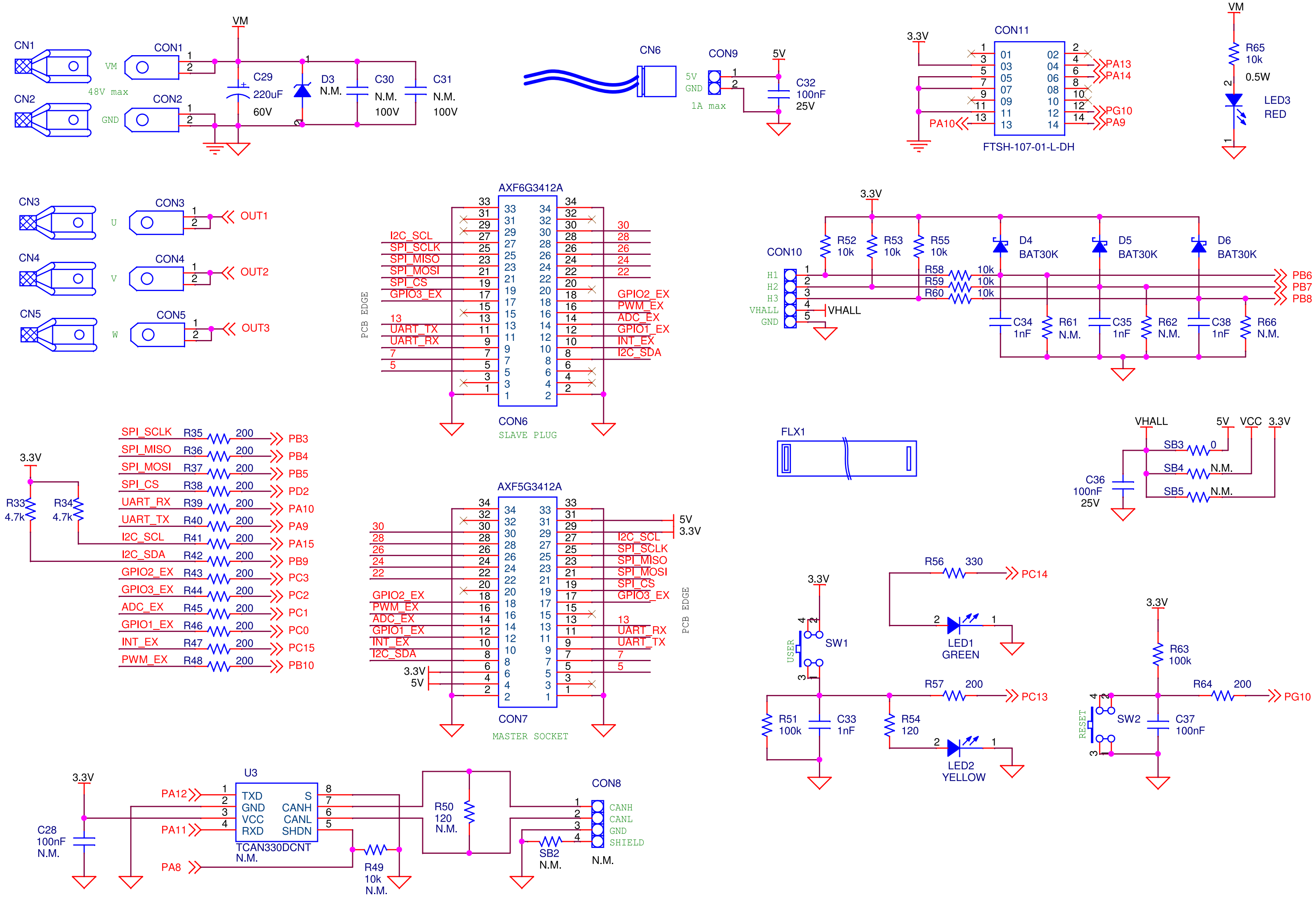


Figure 8. EVLSPIN32G4-ACT schematic (4 of 4): Inputs and outputs



Revision history

Table 10. **Document revision history**

Date	Version	Changes
07-Sep-2023	1	Initial release.

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