Getting started with the EVSPIN32G4, EVSPIN32G4NH

Introduction

The EVSPIN32G4 is an evaluation board based on the STSPIN32G4 system-in-package and STL110N10F7 power MOSFETs. The STSPIN32G4 integrates in a 9x9 mm VFQFPN package, a triple high performance half-bridge gate driver with a rich set of programmable features and one mixed signal STM32G431 microcontroller.

The integrated operational amplifiers for current sensing, the drain-source voltage sensing of each power MOSFET and comparators for overcurrent protection make it a true fully integrated solution for motor control.

Thanks to the integrated voltage regulators both the gate driver and control logic supplies can be generated starting from the motor supply without dedicated circuitry.

The board ensures a full evaluation of the STSPIN32G4 and is designed for driving three-phase brushless DC motors and provides an easy-to-use solution for STSPIN32G4 evaluation in different applications such as power tools, e-Bikes, fans, and home appliances.
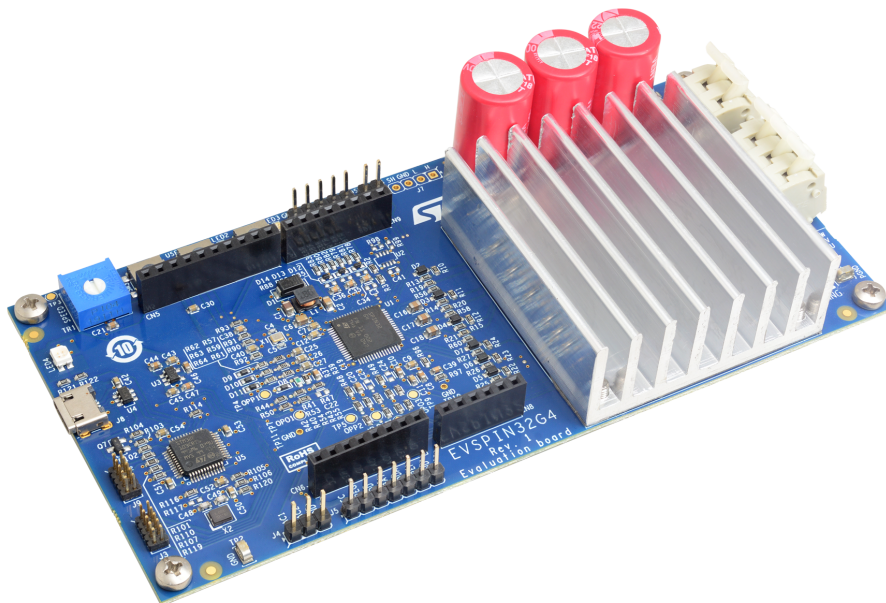
The board can be configured in three-shunt or single-shunt supporting both sensor-less and sensor-based control algorithms.

The Arduino UNO connector enables the EVSPIN32G4 to be interfaced with expansion boards, such as MEMS sensors or Bluetooth transceivers, while predisposition for CAN bus allows interconnection with master or slave modules to build complex motion control systems.

The on-board ST-Link V2 programmer speeds up and simplifies the debugging of microcontroller firmware.

The EVSPIN32G4NH evaluation board is equivalent to EVSPIN32G4 in terms of features with the exception of reduced current rating since it does not include the heatsink. The following details reported in this manual mainly refer to EVSPIN32G4 but implicitly apply to EVSPIN32G4NH unless otherwise noted.

Figure 1. EVSPIN32G4

UM2850 - Rev 1 - April 2021
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1 Safety and operating instructions

DANGER   HOT SURFACE   HIGH VOLTAGE

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 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 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 (i.e., 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.

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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

A list of acronyms and definitions used in this document is seen in Table 1. EVSPIN32G4 schematic (2 of 6): Power stage

Table 1. List of acronyms and definitions

Acronym	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 which 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 5). Each phase of a three-phase motor is usually driven by a half-bridge structure.
MCU	Micro-Controller Unit
OPAMP	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 EVSPIN32G4 evaluation board requires the following software and hardware:

- A Windows® PC (Windows 10) to install the software package.
- A micro-B USB cable to connect the EVSPIN32G4 evaluation board to the PC.
- A three-phase brushless DC motor with compatible voltage and current ratings.
- An external DC power supply with cables to connect the evaluation board.
- The software X-CUBE-MCSDK (Motor Control Software Development Kit) version 5.Y.0 or greater to easily generate firmware for the board with selected motor based on Field Oriented Control algorithm.

4 Getting started

To use the board:

1. Connect the motor to CON1 connector taking care of the sequence for motor windings.
2. Connect the board to the PC through the micro-B USB cable.
3. Develop your application. The software X-CUBE-MCSDK allows to easily generate firmware for the board.
4. Supply the board via CON2 connector taking care of polarity; LED1 (red) turns on to indicate the presence of supply voltage.
5. Upload the firmware via integrated ST-Link debugger on the STSPIN32G4 with dedicated tool such as STM32CubeProgrammer and run the motor.

Ratings of the board are listed in Table 2. The EVSPIN32G4NH is the board version without heatsink.

Table 2. EVSPIN32G4 specifications

Parameter		Value
Supply voltage	Nominal	From 10 V to 75 V
Maximum output current with heatsink (EVSPIN32G4)	Peak	35 A
	Continuous [1]	20 A_{rms}
Maximum output current without heatsink (EVSPIN32G4NH)	Peak	25 A
	Continuous [1]	15 A_{rms}

1. *Maximum current at ambient temperature of 25°C. Actual maximum current could be limited by power dissipation.*

5   Hardware description and configuration

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

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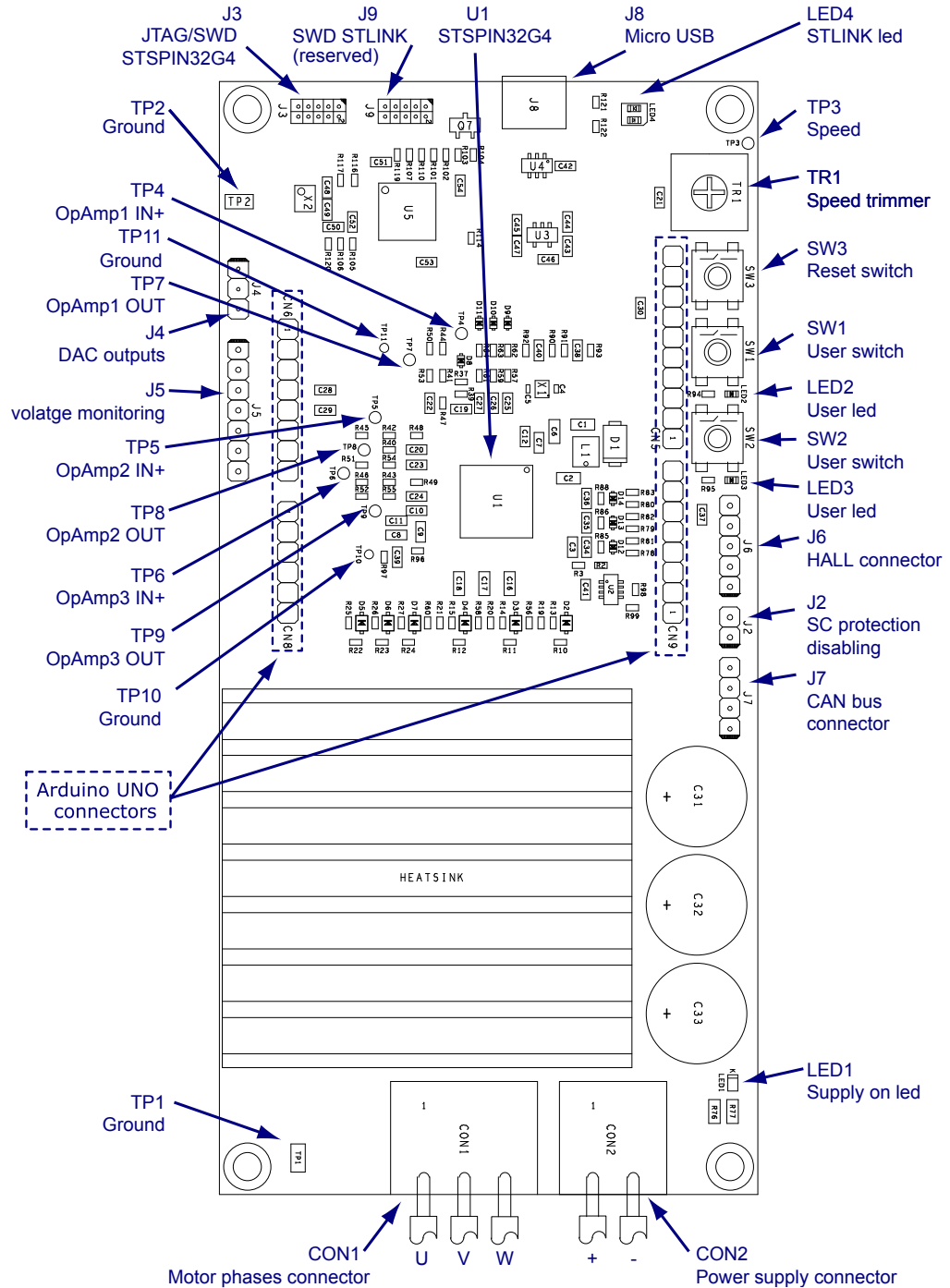
5.1 Connectors and test points

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

Table 3. Connectors

Name	Pin	Label	Description
CON1	1	U	Motor winding 1
	2	V	Motor winding 2
	3	W	Motor winding 3
CON2	1	VM	DC supply voltage up to +75V
	2	GND	DC supply ground
J2	1	DIS	Short-circuit protection disabling. Default enabled (jumper OPEN)
	2	VDSMON	Short-circuit protection threshold voltage
J3	-	-	JTAG/SWD connector for STSPIN32G4
J4	1	DAC1	Microcontroller DAC output 1
	2	DAC2	Microcontroller DAC output 2
	3	GND	Ground
J5	1	VCC	Buck converter output voltage
	2	VREG	LDO regulator input voltage
	3	VDD	LDO regulator output voltage (3.3V)
	4	VBAT	Microcontroller battery backup domain voltage
	5	VDDA	Microcontroller analog domain voltage
	6	VREF	Microcontroller analog reference voltage
	7	GND	Ground
J6	1	H1	HALL-effect sensor 1 / encoder out A+
	2	H2	HALL-effect sensor 2 / encoder out B+
	3	H3	HALL-effect sensor 3 / encoder zero feedback
	4	VH	Sensors supply voltage
	5	GND	Sensors ground
J7	1	H	CAN bus signal high
	2	L	CAN bus signal low
	3	GND	CAN bus ground
	4	SH	CAN bus shielding
J8	-	-	Micro USB connector
J9	-	-	SWD ST-Link (reserved)

Table 4. Test points

Name	Description
TP1	Power ground
TP2	Ground
TP3	Voltage of the speed trimmer
TP4	Voltage of operational amplifier 1 not inverting input
TP5	Voltage of operational amplifier 2 not inverting input
TP6	Voltage of operational amplifier 3 not inverting input
TP7	Voltage of operational amplifier 1 output
TP8	Voltage of operational amplifier 2 output
TP9	Voltage of operational amplifier 3 output
TP10	Ground
TP11	Ground

5.2 User interface

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

- Trimmer TR1: to set, for example, the target speed
- Switch SW1: user switch 1
- Switch SW2: user switch 2
- Switch SW3: to reset STSPIN32G4 MCU
- LED1: system red LED, turned on when supply voltage is present
- LED2: user yellow LED, turned on when the user switch 1 is pressed too
- LED3: user yellow LED, turned on when the user switch 2 is pressed too.

5.3 Onboard debugger

The EVSPIN32G4 evaluation board embeds an ST-Link /V2-1 programmer and debugger which is ready for use.

The ST-Link features are:

- USB software re-enumeration
- Virtual COM port interface on USB connected to the STSPIN32G4 PA9/PA10 pins (UART1)
- Mass storage interface on USB allowing binary upload on the STSPIN32G4

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

The LED4 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 (enumeration)
- Red LED ON: the initialization between the PC and ST-Link is complete
- Green LED ON: successful target communication initialization
- Red/green LED flashing: during communication with target
- Green ON: communication successfully completed

The board provides the J3 connector to directly interface an external debugger to STSPIN32G4 instead of using the embedded ST-Link debugger. In this case the solder jumpers R109, R111, R112, R113, R115, R118 on the bottom side of the board must be open to avoid possible conflicts between the ST-Link and the external debugger.

Warning:

When using the external debugger pay attention to connect J3 instead of J9. A wrong programming on J9 may cause the embedded ST-Link to permanently stop working.

5.4 Hall / encoder sensors

The EVSPIN32G4 evaluation board supports the digital Hall or quadrature encoder sensors as motor position feedback. Refer to J6 connector in Table 3 for sensors wiring.

For sensors requiring an external pull-up, three 10 kΩ resistors are already mounted on the output lines and connected to the VDD voltage. Each line is filtered by an RC low-pass filter given by R81, R82, R83 and C34, C35 and C36. On the same lines, footprints for pull-down resistors are also available (R85, R86 and R88).

The solder jumpers R84, R87 and R89 on the bottom side of the board, allow to select the sensors supply voltage (only one solder jumper must be mounted):

- R84 mounted (default configuration): Sensors powered by VUSB (5 V)
- R87 mounted: Sensors powered by VCC (8 V to 15 V)
- R89 mounted: Sensors powered by VDD (3.3 V)

Sensors' outputs are connected to PB6, PB7 and PB8 pins of the STSPIN32G4 and can be routed to channels TIM_CH1, TIM_CH2 and TIM_CH3 of timer TIM4 respectively.

5.5 Overcurrent protection

The EVSPIN32G4 evaluation board implements double protection of the power stage from overcurrent condition thanks to:

1. Drain-source voltage monitoring of each power MOSFET.
2. Three fast rail-to-rail comparators sensing the shunt resistor current.

5.5.1 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 pin of the STSPIN32G4, through the resistor divider given by R2 and R3. The threshold can be measured via pin 2 of J2 connector and is approximately 1.03 V.

The deglitch filtering time can be programmed via firmware as 2 µs, 3 µs, 4 µs and 6 µs (default).

The protection remains latched when triggered and the STSPIN32G4 may return operative forcing all the driving inputs low for at least 100 µs 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 associated shunt resistor contributes to the measure.

Although not recommended, the protection can be disabled closing jumper J2.

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

5.5.2 Embedded comparators

The EVSPIN32G4 evaluation board implements overcurrent protection based on the comparators integrated in the STSPIN32G4.

The load current for each motor winding is measured via the voltage drop produced on shunt resistors. When one peak current exceeds a selected threshold, the protection is triggered and PWM signals are stopped.

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 device where the current measures from shunt resistors are available (test points TP4, TP5 and TP6) while negative inputs can be internally connected to DAC channels or a partition of the internal reference voltage, V_{refint}, to set a proper overcurrent threshold.

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

(1)

$$I_{OC} = \left(V_{TH} - V_{REF+} \cdot \frac{R47//R44}{R41 + R47//R44} \right) \cdot \frac{R44 + R47//R41}{R47//R41} \cdot \frac{1}{R_S}$$

- I_{0C} is the resulting overcurrent threshold
- V_{TH} is the threshold voltage applied to the comparator negative input
- V_{REF+} is the voltage of VREFP pin (3.3 V by default)
- R_S is the value of the shunt resistor (5 mΩ by default)
- $R47$, $R44$, $R41$, for U phase. Become respectively $R48, R45, R42$ for V and $R49, R46, R43$ for W.

Overcurrent thresholds computed for different threshold voltages are reported in Table 5.

Table 5. Overcurrent thresholds

Threshold	Peak current
DAC	(V_{DAC} - 0.198 V) * 227 A/V
V_{refint}	229 A
3/4 V_{refint}	161 A
1/2 V_{refint}	92 A
1/4 V_{refint}	23 A

Note: *The protection is not enabled by default. The comparators must be configured via firmware to stop PWM generation of timer TIM1. For details refer to the STM32G4 reference manual.*

5.6 Motor current sensing

The EVSPIN32G4 evaluation 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 6, the sensing is based on the operational amplifiers (OPAMPs) integrated in STSPIN32G4. *Three configurations* are possible, refer to the following sections.

5.6.1 *1st configuration* - Two stand-alone operational amplifiers

Two operational amplifiers 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, e.g. U and V and derive W current, or rather implement a multiplexing of the operational amplifiers. With reference to Table 6 the not-inverting inputs of OPAMP1 can be alternatively connected to PA1 or PA7 while not-inverting input of OPAMP2 can be connected to PA7 or PB0. For the gain of the network refer to the next case.

Table 6. **Multiplexing of operational amplifiers**

Measured current with OPAMP1	Measured current with OPAMP2	Derived current
U by 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)

5.6.2 *2nd configuration* - **Three stand-alone operational amplifiers**

In this configuration all three operational amplifiers integrated in STSPIN32G4 are used. A differential current sensing is implemented for better rejection of common mode signal.

The operational amplifier outputs PA2, PA6 and PB1 (test points TP7, TP8 and TP9) 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:

(2)

$$\frac{V_O}{I} = G \cdot R_S = 7.3 \cdot 5m\Omega = 0.0365 \, \frac{V}{A}$$

- V_o is the amplified output voltage
- I is the current flowing in motor winding
- G is the gain of the amplifying network (e.g. R53/R50 for U phase)
- R_s is the parallel of the two shunt resistors (e.g. R31//R32 for U phase).

Footprints are available to mount filtering capacitors on the operational amplifier feedback (C22, C23 and C24).

5.6.3 *3rd configuration* - **Three PGAs**

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

Resistor networks on the operational amplifiers not-inverting pins should be modified to have operational amplifier output voltage in idle state close to $V_{REF+}/2$ to optimize ADC dynamic range. Table 7 can be used to adjust resistor values according to selected PGA gain (values are proportional to integrated resistors of PGA).

With the resistor values reported in the table below the gain of the network can be derived by Eq. (3):

(3)

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

- 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 parallel of the two shunt resistors (R31//R32 for U phase).

Table 7. **Suggested resistor values for positive input biasing with PGA**

PGA gain	R44, R45, R46	R41, R42, R43, R47, R48, R49	Gain [V/A][1]
2	10 kΩ	20 kΩ	0.005
4	10 kΩ	60 kΩ	0.015
8	1 kΩ	14 kΩ	0.035
16	1 kΩ	30 kΩ	0.075
32	1 kΩ	61 kΩ	0.16
64	1 kΩ	120 kΩ	0.32

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 5.5.2 .

When the board is used in high current applications it is recommended to also connect the inverting input of PGAs to shunt resistors implementing differential current measurement. To use this configuration, change R50, R51 and R52 to 0 Ω and remove R53, R54, and R55.

5.7 Single-shunt conversion

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

1. Remove the heatsink and the thermal interposer to simplify the following two steps (not applicable for EVSPIN32G4NH).
2. Close the two solder jumpers JP1 and JP2 located on the bottom 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.
3. Disconnect shunt resistors R31, R32, R35 and R36.
4. Mount again the heatsink with thermal interposer (not applicable for EVSPIN32G4NH).

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

5.8 Bus voltage sensing

The EVSPIN32G4 evaluation board provides the sensing of bus voltage that can be used in firmware to protect in case of undervoltage. This signal is set through a voltage divider with attenuation 0.04 by the motor supply voltage (resistors R37 and R39) and sent to PA0 pin of the microcontroller. PA0 can be connected to the positive input of comparator COMP3 or to channel 1 of ADC1 and ADC2.

5.9 PCB temperature sensing

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

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

(4)

$$T(V_{PC4}) = \frac{1}{\frac{1}{\beta} \cdot ln\left(\frac{R40 \cdot \left(\frac{V_{REFP}}{V_{PC4}} - 1\right)}{R_{NTC}^0}\right) + \frac{1}{T^0}}$$

- $T(V_{PC4})$ 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 to 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 3.

Figure 3. Thermistor temperature with respect to voltage on PC4 pin
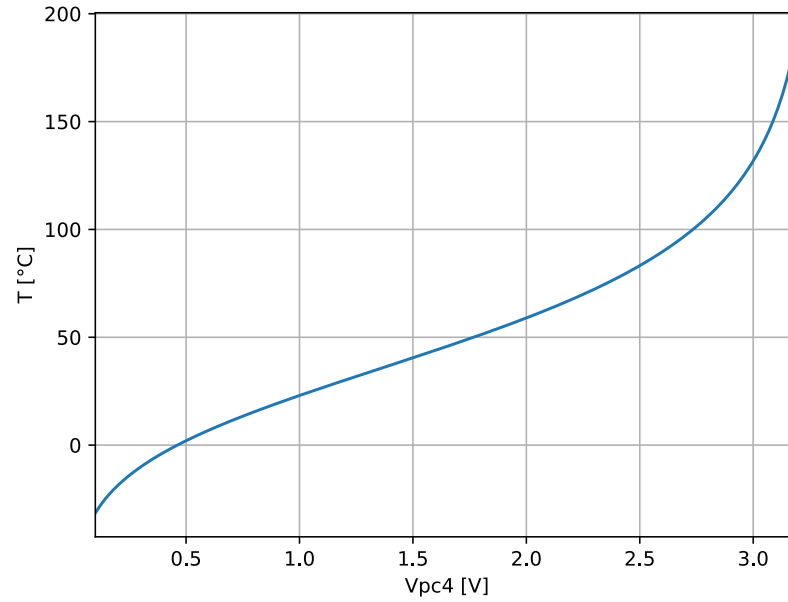
5.10 Arduino UNO connector

The EVSPIN32G4 evaluation board provides a connector for Arduino UNO compatible expansion boards. The pin map is available in Table 8. When PF0 and PF1 are used with the Arduino UNO connector the X1 crystal should be removed. All solder jumpers of the Arduino UNO connector are located on the bottom side of the board.

Table 8. Arduino UNO pin map

Pin	Connection
IOREF	VDD via R65 solder jumper
NRST	PG10
3.3V	VDD
5V	5V from ST-Link
GND	Ground
VIN	Disconnected by default (VREGIN via R66 solder jumper)
AREF	VREF+ analog reference voltage
A0	Disconnected by default (PC3 via R67 solder jumper)
A1	Disconnected by default (PF0 via R68 solder jumper)
A2	Disconnected by default (PF1 via R69 solder jumper)
A3	Disconnected by default (PC0 via R70 or PA3 via R73 solder jumpers)
A4	Disconnected by default (PC1 via R71 or PC5 via R74 solder jumpers)
A5	Disconnected by default (PC2 via R72 or PB2 via R75 solder jumpers)
D0	PA10
D1	PA9
D2	PC14
D3	PB10
D4	PC15
D5	PA12
D6	PA11
D7	PA8
D8	PD2
D9	PA5
D10	PA4
D11	PB5
D12	PB4
D13	PB3
D14	PB9
D15	PA15

Some Arduino extension boards have form factor which hinders connector mating due to heatsink placement. To use these extension boards three alternatives are suggested:

1. Remove the heatsink. This reduces power dissipation of the board and its maximum current rating consequently.
2. Use low profile heatsink.
3. Mate on CN5, CN6, CN8 and CN9 of EVSPIN32G4 the connectors reported in Table 9 to stack up the Arduino extension board on top of the heatsink.

Table 9. Suggested connectors for Arduino board mating

EVSPIN32G4 connector	Manufacturer	Part number
CN5	SAMTEC	SSQ-110-04-F-S
CN6, CN9	SAMTEC	SSQ-108-04-F-S
CN8	SAMTEC	SSQ-106-04-F-S

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 (not mounted).

R98 can be mounted in case bus termination is needed. Connections to CAN bus are available via J7 connector which also provides one terminal for cable shielding with optional connection to board ground via solder jumper R100.

6 Bill of material

Table 10. EVSPIN32G4 bill of materials

Item	Q.ty	Reference	Description	Value
1	1	CN5	Sil socket straight 10 pos, 2.54 mm	STRIP-P2_54-10P-FEMALE
2	2	CN6, CN9	Sil socket straight 8 pos, 2.54 mm	STRIP-P2_54-8P-FEMALE
3	1	CN8	Sil socket straight 6 pos, 2.54 mm	STRIP-P2_54-6P-FEMALE
4	1	CON1	5.0 mm Horizontal Entry Screwless Connector	2834082-2-TE
5	1	CON2	5.0 mm Horizontal Entry Screwless Connector	2834082-1-TE
6	1	C1	SMT ceramic capacitor 0805	10 µF, 25 V, 10%
7	4	C2, C13, C14, C15	SMT ceramic capacitor 0805	220 nF, 100 V, 10%
8	4	C3, C22, C23, C24	SMT ceramic capacitor 0603	N.M.
9	2	C4, C5	SMT ceramic capacitor 0402	6.8 pF, 6.3 V, 0.25 pF
10	1	C6	SMT ceramic capacitor 0805	10 µF, 6.3 V, 10%
11	16	C7, C9, C11, C12, C28, C29, C30, C40, C42, C43, C45, C50, C51, C52, C53, C54	SMT ceramic capacitor 0603	100 µF, 6.3 V, 10%
12	4	C8, C10, C44, C46	SMT ceramic capacitor 0603	1 µF, 6.3 V, 10%
13	3	C16, C17, C18	SMT ceramic capacitor 0805	1 µF, 25 V, 10%
14	3	C19, C20, C21	SMT ceramic capacitor 0603	33 nF, 6.3 V, 10%
15	3	C25, C26, C27	SMT ceramic capacitor 0603	82 nF, 6.3 V, 5%
16	3	C31, C32, C33	THT Electrolytic Capacitor D500p200	220 µF, 100 V, 20%
17	5	C34, C35, C36, C38, C39	SMT ceramic capacitor 0603	1 nF, 6.3 V, 10%
18	1	C37	SMT ceramic capacitor 0603	100 nF, 25 V, 10%
19	1	C41	SMT ceramic capacitor 0603	N.M.
20	1	C47	SMT ceramic capacitor 0603	10 nF, 6.3 V, 10%
21	2	C48, C49	SMT ceramic capacitor 0603	100 pF, 6.3 V, 10%
22	1	D1	High voltage Power Schottky Rectifier	STPS1H100A, 100 V
23	6	D2, D3, D4, D5, D6, D7	Small signal Schottky diode	BAT48, 40 V
24	7	D8, D9, D10, D11, D12, D13, D14	Small signal Schottky diodes	BAT30K, 30 V
25	1	HS1 [1]	Heatsink	RAWA410-0
26	2	JP1, JP2	SMT jumper	OPEN
27	1	J1	Jumper	OPEN
28	1	J2	Strip connector 2 pos, 2.54 mm	STRIP 1x2
29	2	J3, J9	Strip connector 2x5, pitch 2.54 mm	STRIP 2x5
30	1	J4	Strip connector 3 pos, 2.54 mm	STRIP 1x3

Item	Q.ty	Reference	Description	Value
31	1	J5	Strip connector 7 pos, 2.54 mm	STRIP 1x7
32	1	J6	Strip connector 5 pos, 2.54 mm	STRIP 1x5
33	1	J7	Strip connector 4 pos, 2.54 mm	N.M.
34	1	J8	USB RECEPTACLE-MINI B	Micro USB Type B
35	1	LED1	WL-SMCW SMT Mono-color Chip LED Waterclear	RED
36	2	LED2, LED3	WL-SMCW SMT Mono-color Chip LED Waterclear	YELLOW
37	1	LED4	LED indicators, PLCC-4 Red/Yellow Green	RED-GREEN
38	1	L1	WE-PD2 SMT Power Inductor	18 µH, 1 A
39	3	NET1, NET2, NET3	PCB short	N.M.
40	1	NTC1	NTC Thermistor 0603	10 k, 1%
41	6	Q1, Q2, Q3, Q4, Q5, Q6	N-channel 100 V, 5 mΩ typ., 107 A STripFET F7 Power MOSFET	STL110N10F7
42	1	Q7	NPN General Purposes Transistor	BC847B
43	13	R1, R6, R7, R8, R9, R38, R65, R84, R109, R111, R112, R113, R118	SMT resistor 0805	0 Ω, 0.1 W, 5%
44	7	R2, R41, R42, R43, R47, R48, R49	SMT resistor 0603	22 kΩ, 0.1 W, 1%
45	1	R3	SMT resistor 0603	10 kΩ, 0.1 W, 1%
46	9	R10, R11, R12, R19, R20, R21, R22, R23, R24	SMT resistor 0603	0 Ω, 0.1 W, 5%
47	6	R13, R14, R15, R25, R26, R27	SMT resistor 0603	33 Ω, 0.1 W, 5%
48	6	R16, R17, R18, R28, R29, R30	SMT resistor 0805	N.M.
49	6	R31, R32, R33, R34, R35, R36	SMT resistor 2512	10 m, 3 W, 1%
50	1	R37	SMT resistor 0603	72.3 kΩ, 0.1 W, 1%
51	1	R39	SMT resistor 0603	3.01 kΩ, 0.1 W, 1%
52	3	R40, R105, R106	SMT resistor 0603	4.7 kΩ, 0.1 W, 1%
53	6	R44, R45, R46, R50, R51, R52	SMT resistor 0603	1.5 kΩ, 0.1 W, 1%
54	3	R53, R54, R55	SMT resistor 0603	11 kΩ, 0.1 W, 1%
55	3	R56, R58, R60	SMT resistor 0603	68 k, 0.1 W, 1%
56	3	R57, R59, R61	SMT resistor 0603	27 kΩ, 0.1 W, 1%
57	3	R62, R63, R64	SMT resistor 0603	3.9 kΩ, 0.1 W, 1%
58	15	R66, R67, R68, R69, R70, R71, R72, R73, R74, R75, R87, R89, R100, R108, R115	SMT resistor 0805	N.M.
59	2	R76, R77	SMT resistor 0805	4.7 kΩ, 0.5 W, 5%
60	8	R78, R79, R80, R81, R82, R83, R101, R116	SMT resistor 0603	10 kΩ, 0.1 W, 5%
61	4	R85, R86, R88, R117	SMT resistor 0603	N.M.
62	5	R90, R93, R97, R119, R120	SMT resistor 0603	100 kΩ, 0.1 W, 5%
63	3	R91, R92, R96	SMT resistor 0603	200 Ω, 0.1 W, 5%

Item	Q.ty	Reference	Description	Value
64	2	R94, R95	SMT resistor 0603	120 Ω, 0.1 W, 5%
65	1	R98	SMT resistor 0603	N.M , 0.1 W, 5%
66	1	R99	SMT resistor 0603	10 kΩ , 0.1 W, 5%
67	4	R102, R114, R121, R122	SMT resistor 0603	100 Ω, 0.1 W, 5%
68	1	R103	SMT resistor 0603	36 kΩ, 0.1 W, 5%
69	1	R104	SMT resistor 0603	1.5 kΩ, 0.1 W, 5%
70	1	R107	SMT resistor 0603	4.7 kΩ, 0.1 W, 5%
71	1	R110	SMT resistor 0603	2.7 kΩ, 0.1 W, 5%
72	8	SC1, SC2, SC3, SC4, SC5, SC6, SC7, SC8	M3 Cheese-head screw	M3
73	4	SP1, SP2, SP3, SP4	M3 F-F Hexagonal spacer 20 mm	222424
74	3	SW1, SW2, SW3	TACTILE SWITCHES - 6x6 J-bend SMT	6x6 J-bend SMT
75	1	TIM1 [1]	Thermally conductive Gap filler, 150x150 mm sp.0,5 mm.	7074645
76	2	TP1, TP2	40x71 mils SMD PAD	TP-SMD-S1751-46R
77	7	TP3, TP4, TP5, TP6, TP7, TP8, TP9	Test point - PCB 1.5 mm diameter	N.M.
78	2	TP10, TP11	TP for Probe	N.M.
79	1	TR1	3/8 Square Trimpot trimming potentiometer, side adjust	100 kΩ
80	**1**	**U1**	**Three-phase brushless motor controller embedding STM32G431 MCU**	**STSPIN32G4**
81	1	U2	TCAN33x 3.3-V CAN Transceivers with CAN FD (Flexible Data Rate)	N.M.
82	1	U3	Ultra-low drop and low noise BiCMOS voltage regulators	LD3985M33R
83	1	U4	Very low capacitance ESD protection	USBLC6-2SC6
84	1	U5	Medium-density performance line ARM®-based 32-bit MCU with 128 KB Flash, USB, CAN, 7 timers, 2 ADCs, 9 com. interfaces	STM32F103CBT6
85	1	X1	IoT OPTIMIZED LOW PROFILE QUARTZ CRYSTAL	24 MHz
86	1	X2	CRYSTAL 8.0000MHZ 8PF SMD	8 MHz

1. *Not provided with EVSPIN32G4NH.*

7 Schematics

Figure 4. EVSPIN32G4 schematic (1 of 6): STSPIN32G4

Figure 5. **EVSPIN32G4 schematic (2 of 6): Power stage**
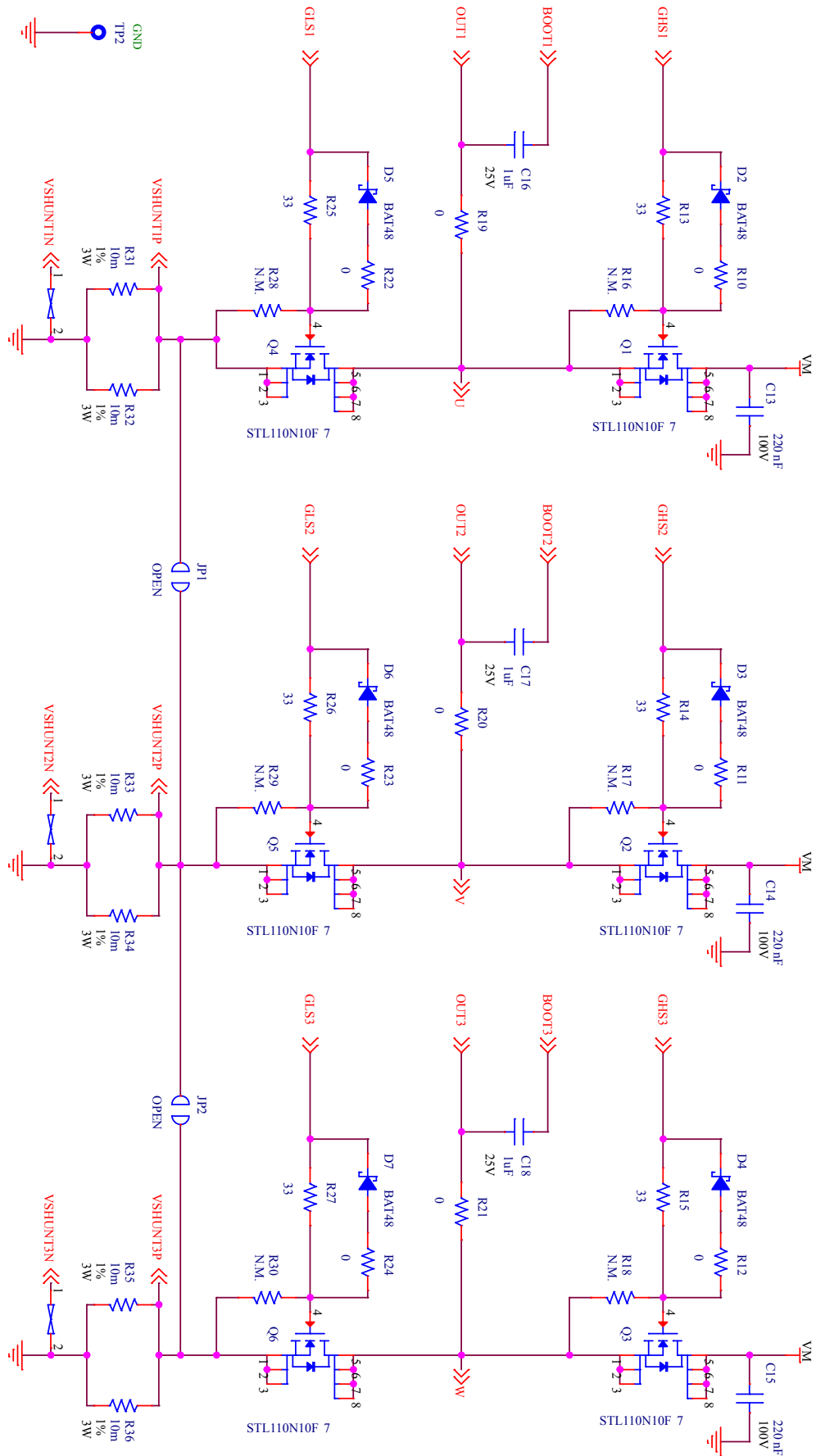
Figure 6. EVSPIN32G4 schematic (3 of 6): Sensing
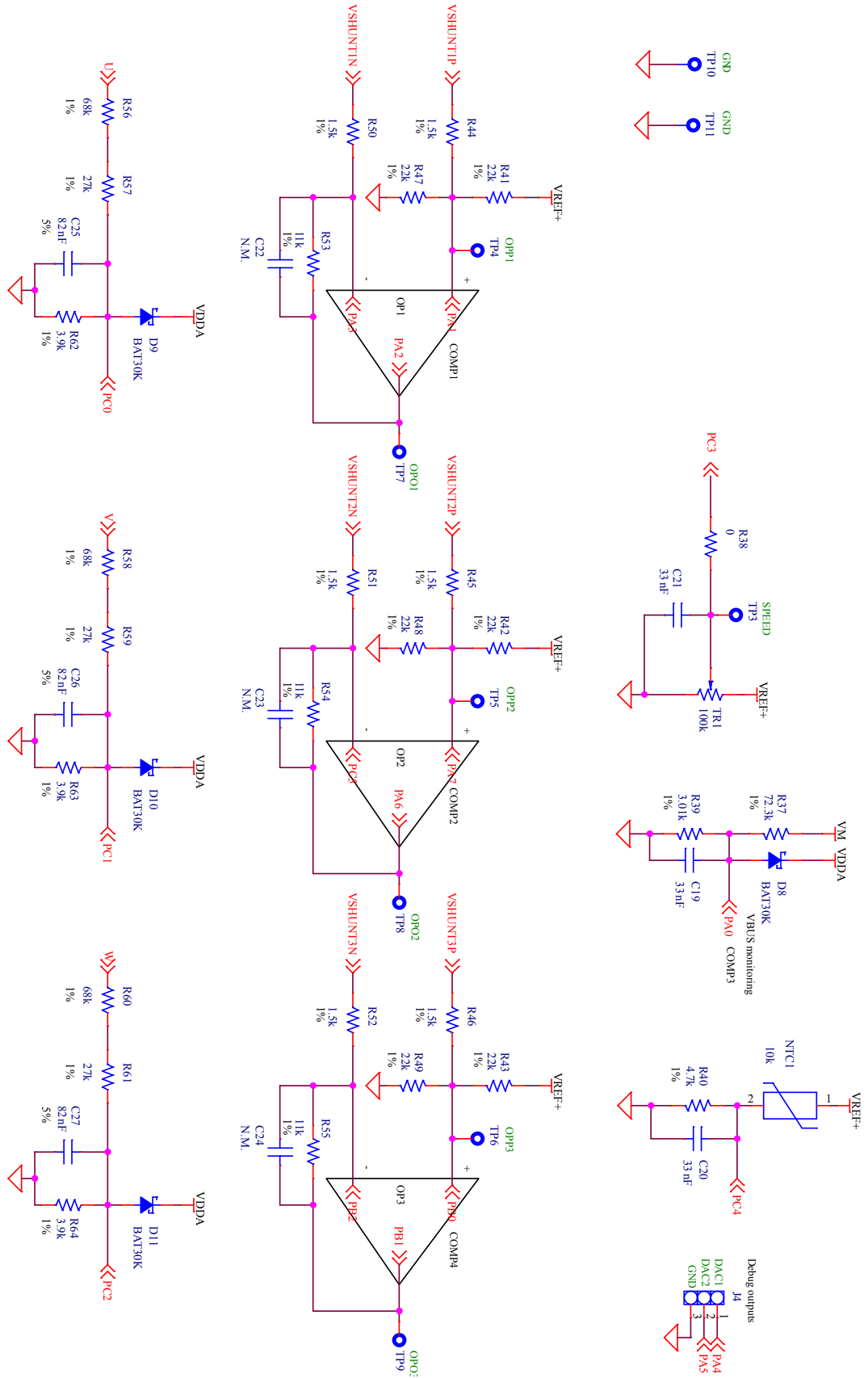
Figure 7. EVSPIN32G4 schematic (4 of 6): Arduino connector

Figure 8. EVSPIN32G4 schematic (5 of 6): Inputs and outputs

Figure 9. **EVSPIN32G4 schematic (6 of 6): STLINK**
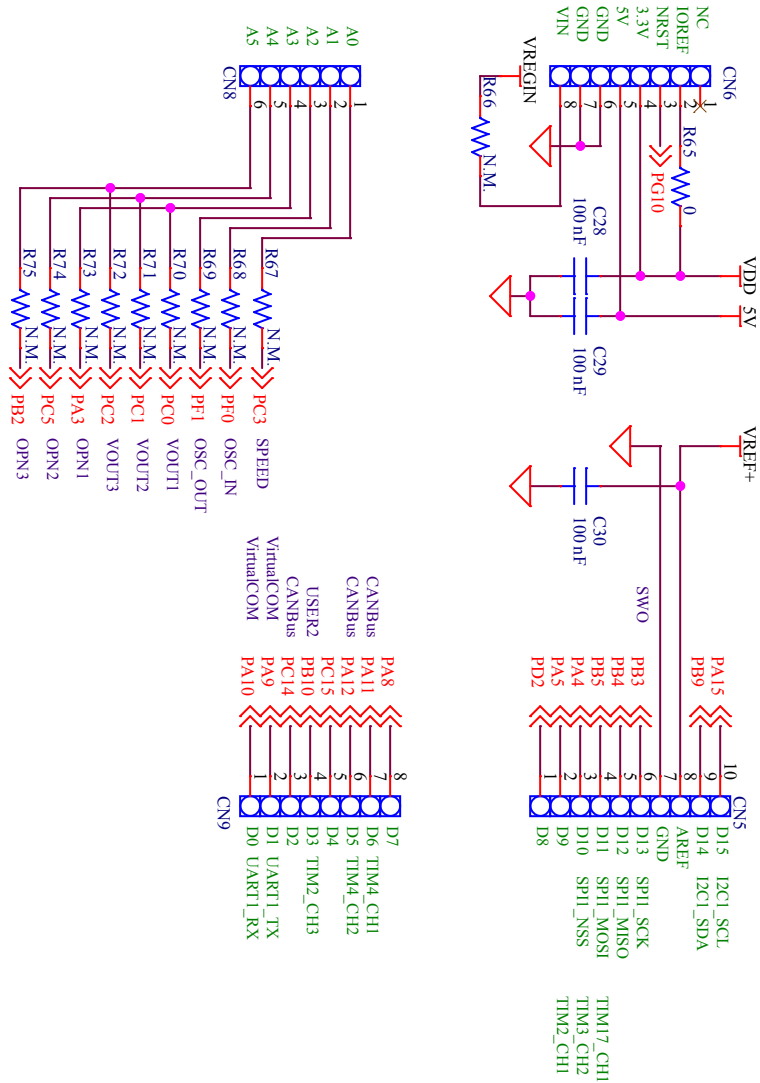
Revision history

Table 11. Document revision history

Date	Version	Changes
27-Apr-2021	1	Initial release.

Contents

Contents

List of tables

List of figures

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