Getting started with the EVSPIN32G4-DUAL

Introduction

The EVSPIN32G4-DUAL is a dual-motor demonstration board based on STSPIN32G4 and STDRIVE101.

The STSPIN32G4 is 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 STDRIVE101 is a triple half-bridge gate driver in a compact 4x4 VFQFPN package featuring 600 mA current capability and embedded protections.

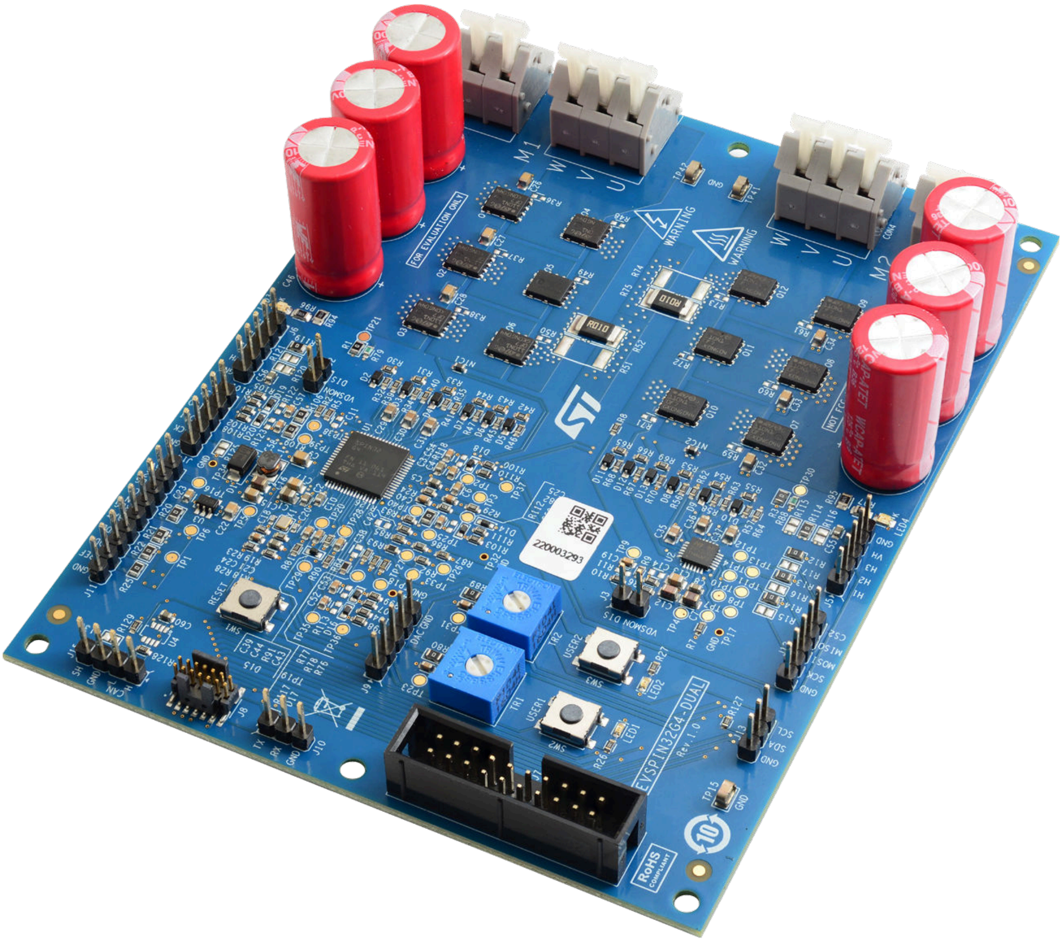
The two power stages based on STL110N10F7 power MOSFETs can simultaneously operate up to 10 A_{RMS} output current and 74 V supply voltage, providing dedicated sensing for temperature and bus voltage, drain-source voltage monitoring of power MOSFETs and overcurrent protection.

The board allows sensor-less operation with single-shunt current sensing, taking advantage of operational amplifiers in the STSPIN32G4, as well as sensor-based control algorithms thanks to dedicated inputs for each motor, including Hall sensors, incremental encoders and absolute encoders, via SSI communication interface.

The integrated voltage regulators generate the gate driver and control logic supplies directly from the motor supplies, without further circuitry required.

The predisposition for CAN bus enables the EVSPIN32G4-DUAL to easily connect with master or slave modules, and build complex motion control systems.

Figure 1. EVSPIN32G4-DUAL demonstration board



1 Safety and operating instructions

1.1 General terms

Warning: *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, property damage or death due to electrical shock 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 AC/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 AC line. This prevents shock from occurring as a result of 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 evaluation board is designed for demonstration 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. In particular, 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 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 setup, wiring or configuration paying attention to high voltage sections.
   - Once the setup 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 boards after disconnection from the voltage supply as several parts like heat sinks and transformers may still be very hot.
The kit is not electrically isolated from the AC/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, for example, insulating gloves and safety glasses.
   - Take adequate precautions and install the board in such a way to prevent accidental touch. Use protective shields such as, for example, insulating box with interlocks if necessary.

2 Acronyms and definitions

Table 1. List of acronyms and definitions

Term	Description
ADC	Analog to Digital Converter.
CAN	Controller Area Network communication standard used for data transmission among electronic control units connected in a local network.
FOC	Field Oriented Control driving algorithm for three-phase motors 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	Microcontroller Unit
OPAMP	Operational Amplifier
PGA	Programmable Gain Amplifier.
PWM	Pulse Width Modulation
Shunt resistor	The resistor 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-DUAL evaluation board requires the following software and hardware:

- A Windows ® PC (Windows 10) to install the software package.
- One STLINK-V3SET debugger/programmer or equivalent.
- Two 3-phase brushless DC motors with compatible voltage and current ratings.
- An external DC power supply with cables to connect the evaluation board.

4 Getting started

To use the board:

1. Connect the two motors to CON3 and CON4 connectors respecting the sequence for motor windings.
2. Connect the programmer and debugger to the board using connector J8 or alternatively J7.
3. Develop your application.
4. Supply the board via CON1 and CON2 connectors respecting polarity; LED3 and LED4 indicate the presence of supply voltage.
5. Upload the firmware onto the STSPIN32G4 microcontroller with a dedicated tool such as STM32CubeProgrammer
6. Run the motor.

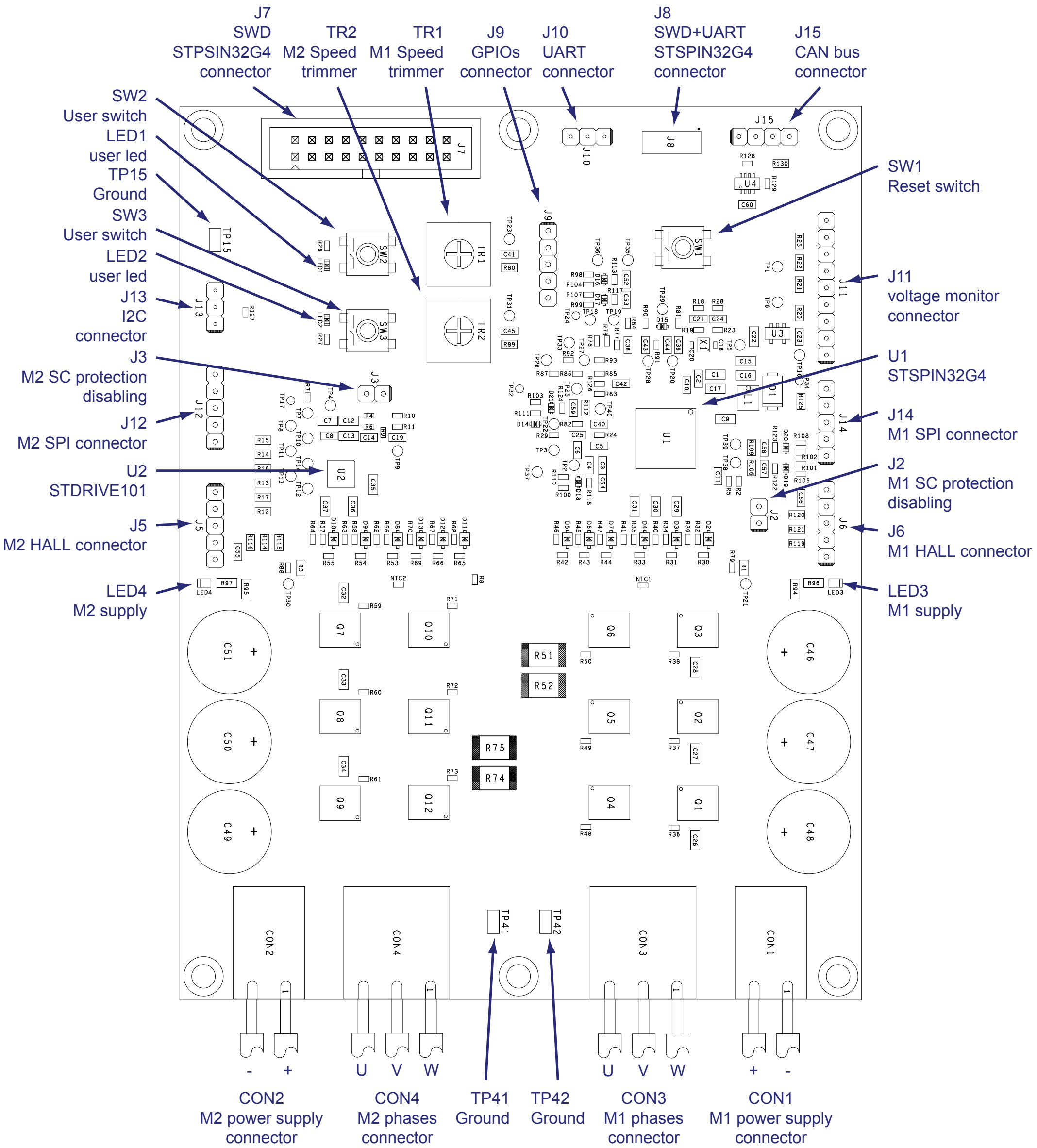
Table 2. EVSPIN32G4-DUAL specifications

Parameter		Value
Supply voltage	Nominal	From 10 V to 74 V
Maximum current	Peak	17 A
	Continuous [(1)]	10 A_{rms}

1. Maximum current at 25°C ambient temperature. Actual value may be limited by power dissipation.

5 Hardware description and configuration

Figure 2. **Connectors, jumpers, LEDs, switches and test points**



5.1 Connectors and test points

Table 3. **Connectors**

Name	Pin	Label	Description
CON1	1	GND	DC supply ground
	2	VM	DC supply voltage of motor 1
CON2	1	VM	DC supply voltage of motor 2
	2	GND	DC supply ground
CON3	1	W	Motor 1 winding 3
	2	V	Motor 1 winding 2

Name	Pin	Label	Description
CON3	3	U	Motor 1 winding 1
CON4	1	W	Motor 2 winding 3
	2	V	Motor 2 winding 2
	3	U	Motor 2 winding 1
J2	1	DIS	Short circuit protection disabling for motor 1. Default enabled (jumper OPEN)
	2	VDSMON	Short circuit protection threshold voltage
J3	1	DIS	Short circuit protection disabling for motor 2. Default enabled (jumper OPEN)
	2	VDSMON	Short circuit protection threshold voltage
J5	1	M2_H1	Hall-effect sensor 1 / encoder out A+ of motor 2
	2	M2_H2	Hall-effect sensor 2 / encoder out B+ of motor 2
	3	M2_H3	Hall-effect sensor 3 / encoder zero feedback of motor 2
	4	M2_VH	Sensors supply voltage of motor 2
	5	GND	Sensors ground
J6	1	M1_H1	Hall-effect sensor 1 / encoder out A+ of motor 1
	2	M1_H2	Hall-effect sensor 2 / encoder out B+ of motor 1
	3	M1_H3	Hall-effect sensor 3 / encoder zero feedback of motor 1
	4	M1_VH	Sensors supply voltage of motor 1
	5	GND	Sensors ground
J7	-	-	20 pin SWD connector for STSPIN32G4
J8	-	-	14 pin SWD and UART connector for STSPIN32G4
J9	1	-	PD2 pin of STSPIN32G4
	2	-	PB7 pin of STSPIN32G4
	3	-	PC3 pin of STSPIN32G4
	4	DAC	DAC output by pin PA4 of STSPIN32G4
	5	GND	Ground
J10	1	TX	UART signal TX
	2	RX	UART signal RX
	3	GND	UART ground
J11	1	5V	5V output of LDK715M50R regulator
	2	REG12	12V output of STDRIVE101 LDO regulator
	3	VCC	Output voltage of STSPIN32G4 Buck converter
	4	VREGIN	Input voltage of STSPIN32G4 LDO regulator
	5	VBAT	Microcontroller battery backup domain voltage
	6	VDD	3.3V output of STSPIN32G4 LDO regulator
	7	VDDA	Microcontroller analog domain voltage
	8	VREF	Microcontroller analog reference voltage
	9	GND	Ground
J12	1	CS2	SPI CS signal for motor 2 absolute encoder
	2	MISO	SPI MISO signal for motor 2 absolute encoder
	3	MOSI	SPI MOSI signal for motor 2 absolute encoder
	4	SCK	SPI Clock signal for motor 2 absolute encoder

Name	Pin	Label	Description
J12	5	GND	SPI Ground
J13	1	SCL	I^2C signal SCL
	2	SDA	I^2C signal SDA
	3	GND	I^2C ground
J14	1	CS1	SPI signal CS for motor 1 absolute encoder
	2	MISO	SPI signal MISO for motor 1 absolute encoder
	3	MOSI	SPI signal MOSI for motor 1 absolute encoder
	4	SCK	SPI signal Clock for motor 1 absolute encoder
	5	GND	SPI ground
J15	1	H	CAN bus signal high
	2	L	CAN bus signal low
	3	GND	CAN bus ground
	4	SH	CAN bus shielding

Table 4. **Test points**

Name	Description
TP1	Voltage of VDD supply
TP2	Voltage of VDDA supply
TP3	Voltage of VERF+ supply
TP4	Voltage of REG12 supply
TP5	Voltage of VCC supply
TP6	Voltage of VREGIN inputs
TP7	nFAULT pin of STDRIVE101
TP8	INH1 input of STDRIVE101
TP9	Input voltage of STDRIVE101 overcurrent comparator
TP10	INH2 input of STDRIVE101
TP11	INH3 input of STDRIVE101
TP12	INL3 input of STDRIVE101
TP13	INL2 input of STDRIVE101
TP14	INL1 input of STDRIVE101
TP15	Ground
TP16	5V supply
TP17	Ground
TP18	Voltage of Operational Amplifier 1 non-inverting input
TP19	Voltage of Operational Amplifier 1 output
TP20	Voltage of motor 1 NTC
TP21	Bus voltage of motor 1
TP22	Attenuated bus voltage of motor 1
TP23	Voltage of trimmer 1
TP24	Ground
TP25	Voltage of Operational Amplifier 1 inverting input

Name	Description
TP26	Voltage of Operational Amplifier 2 non-inverting input
TP27	Voltage of Operational Amplifier 2 output
TP28	Voltage of motor 2 NTC
TP29	Attenuated bus voltage of motor 2
TP30	Bus voltage of motor 2
TP31	Voltage of trimmer 2
TP32	Ground
TP33	Voltage of Operational Amplifier 2 inverting input
TP34	Ground
TP35	Motor 1 Hall sensor 1
TP36	Motor 1 Hall sensor 2
TP37	Motor 1 Hall sensor 3
TP38	Motor 2 Hall sensor 2
TP39	Motor 2 Hall sensor 2
TP40	Motor 2 Hall sensor 3
TP41	Power ground
TP42	Power ground

5.2 User interface

The board provides following user interface components:

- Trimmer TR1: to set, for example, the target speed of motor 1.
- Trimmer TR1: to set, for example, the target speed of motor 2.
- Switch SW1: to reset the STSPIN32G4.
- Switch SW2: user switch 1.
- Switch SW3: user switch 2.
- LED1: user yellow LED, also turns on when user switch 1 is pressed.
- LED2: user yellow LED, also turns on when user switch 2 is pressed.
- LED3: system red LED, turns on when supply voltage of motor 1 is present.
- LED4: system red LED, turns on when supply voltage of motor 2 is present.

5.3 Programming and debugging

The EVSPIN32G4-DUAL evaluation board provides two connectors to program and debug firmware:

- J7, Legacy Arm 20 pin connector featuring SWD interface of SPIN32G4.
- J8, STDC14 connector including both SWD and UART interfaces.

The STLINK-V3SET debugger/programmer can be used to connect J7 or J8. When selecting J7, it is possible to use UART on the J10 connector if VCP (Virtual Comm Port) is also required for communication with PC.

5.4 Hall sensors and encoders

The EVSPIN32G4-DUAL evaluation board supports 3 different type of sensors for position feedback:

1. Digital Hall sensors.
2. Quadrature encoder.
3. Absolute encoders with Synchronous Serial Interface (SSI).

Inputs for digital Hall sensors or quadrature encoders are available by default on J6 and J5 connectors for motor 1 and motor 2, respectively (see Table 3).

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 and footprints for pull-down resistors are also available.

The sensor supply voltage is selected through one of the following solder jumpers:

- 5V (default configuration): R119 for motor 1 and R114 for motor 2.
- VCC (8 V to 15 V): R120 for motor 1 and R115 for motor 2
- VDD (3.3 V): R121 for motor 1 and R116 for motor 2.

Note: Only one solder jumper must be mounted

Sensor outputs for motor 1 are connected to the PB4, PB5 and PB0 pins of the microcontroller and can be routed to the respective TIM_CH1, TIM_CH2 and TIM_CH3 channels of timer TIM3, while sensor outputs for motor 2 are connected to PA0, PA1 and PB10 pins of the microcontroller and can be routed to the respective TIM_CH1, TIM_CH2 and TIM_CH3 channels of timer TIM2.

To use absolute SSI encoders, the solder jumpers R106, R109 and R112 must be removed and inputs for motor 1 Hall sensors and quadrature encoder are disabled. The SPI1 peripheral can be shared between two absolute encoders with dedicated chip select pin (refer to J12 and J14 in Table 3 for connection details).

Note: Absolute SSI encoders may require an external RS422/485 transceiver not provided with the board.

5.5 Overcurrent protection

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

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

5.5.1 Drain-source voltage monitoring

The STSPIN32G4 and STDRIVE101 embed circuitry which measures the voltage between the drain and the source of each MOSFET (V_{DS}) for comparison with a set threshold. When the MOSFET is turned on and its V_{DS} is greater than the threshold, the anomalous condition is detected and following a deglitch time the protection is triggered in which all MOSFETs are turned off regardless of the driving inputs.

The threshold is set on the SCREF pins of the STSPIN32G4 and STDRIVE101 through the resistor dividers given by R2 and R5 for motor 1 or R4 and R6 for motor 2. The thresholds can be measured via pin 2 of J2 and J3 connectors and are approximately 1.03 V.

The STSPIN32G4 allows setting the deglitch filtering time via firmware to 2 µs, 3 µs, 4 µs or 6 µs (default), while the STDRIVE101 implements a fixed filtering time of 4.4 µs (typ.).

The protections remain latched when triggered: the STSPIN32G4 returns to an operational state by forcing all the driving inputs low for at least 100 µs or via firmware, while the STDRIVE101 must enter and leave standby.

The voltage drop on each low-side MOSFETs is measured between its drain and GND, so the voltage drop on the shunt resistor contributes to the measurement.

Although not recommended, the protections can be disabled by closing jumpers J2 and J3.

For details regarding V_{DS} monitoring, refer to the STSPIN32G4 and STDRIVE101 datasheets.

5.5.2 Embedded comparators

The evaluation board implements overcurrent protection with comparator integrated in the STSPIN32G4 for motor 1 and comparator in the STDRIVE101 for motor 2. The current of both motors is measured via the voltage drop produced on respective shunt resistors. When peak current exceeds a selected threshold, the protection is triggered.

The protection on motor 1 is not enabled by default: the fast COMP2 rail-to-rail comparator in the STSPIN32G4 must be configured via firmware to stop PWM generation of timer TIM1. The positive input of the comparator must be connected to the PA3 pin of the microcontroller, where the current measurements across the shunt resistor is available (test points TP18), while negative input can be internally connected to the DAC channel or a partition of the internal reference voltage, V_{refint}, to set an appropriate overcurrent threshold.

With reference to Figure 4, the overcurrent threshold can be derived with the following equation:

$$I_{OC} = \left(V_{TH} - V_{REF} + \cdot \frac{R77//R78}{R76 + R77//R78}\right) \cdot \frac{R77 + R76//R78}{R76//R78} \cdot \frac{1}{R_S} \quad (1)$$

- I_{OC} 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 (10 mΩ by default)

Overcurrent thresholds computed for different threshold voltages are given in the following table.

Table 5. Overcurrent thresholds

Threshold	Peak current
DAC	(V_{DAC} - 0.206 V) · 114 A/V
V_{refint}	113 A
3/4 V_{refint}	79 A
1/2 V_{refint}	45 A
1/4 V_{refint}	11 A

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

The protection of motor 2 is active by default: STDRIVE101 detects an overcurrent condition when the voltage on its CP pin (test point TP9) rises above the internal voltage threshold and automatically switches off all GHSx and GLSx outputs. With reference to Figure 6, the overcurrent threshold can be derived by the following equation:

$$I_{OC} = \left(V_{REF} - V_{DD} \cdot \frac{R8//R11}{R11 + R8//R11}\right) \cdot \frac{R8 + R10//R11}{R10//R11} \cdot \frac{1}{R_S} \quad (2)$$

- I_{OC} is the resulting overcurrent threshold
- V_{REF} is the internal threshold voltage applied to the comparator negative input (typ. 505 mV)
- V_{DD} is the voltage of REG3V3 pin (typ. 3.3 V)
- R_S is the value of the shunt resistor (10 mΩ by default)

The R11 resistor is not mounted by default, so the overcurrent threshold is 22 A since R8//R11=R8 and R10//R11=R10.

To avoid spurious triggering of the protection, a filter time of 2 µs is implemented via capacitor C19.

5.6 Current sensing

The evaluation board manages the sensing of current flowing through motor windings in both directions, as required by Field Oriented Control algorithms. With reference to schematic in Figure 6, the sensing is based on the operational amplifiers (OPAMPs) integrated in the STSPIN32G4 microcontroller. A differential current sensing method is implemented for better rejection of common mode signals with OPAMP1 and OPAMP2 dedicated to motor 1 and motor 2, respectively.

The output of OPAMP1, PA2 (test point TP19), can be connected to channel 3 of ADC1, while the PA6 output of OPAMP2 (test point TP27) can be connected to channel 3 of ADC2 to implement current measurements.

The gain of the network is:

$$\frac{V_O}{I} = G \cdot R_S = 7 \cdot 10 m\Omega = 0.07 \frac{V}{A} \quad (3)$$

- V_O is the amplified output voltage
- I is the current flowing in motor winding
- G is the gain of the amplifying network (R84/R83 for motor 1 and R93/R92 for motor 2)
- R_S is the value of shunt resistors (10 mΩ by default)

Footprints are available to mount filtering capacitors on OPAMP feedback (C38 and C42).

5.7 Bus voltage sensing

The evaluation board provides the sensing of bus voltages that can be used by firmware to implement undervoltage protection. These signals are set through a voltage divider with attenuation 0.04 by the motor supply voltage (resistors R79, R82 and R88, R91), filtered (capacitors C40 and C44) and sent to microcontroller pins PB1 (test point TP22) for motor1 and PC1 (test point TP29) for motor 2. PB1 can be connected to the positive input of comparator COMP1 or to channel 12 of ADC1, while PC1 can be connected to the positive input of comparator COMP3 or to channel 7 of ADC2.

5.8 PCB temperature sensing

The board provides NTC thermistors placed near the power stages to sense the temperature of surrounding MOSFETs. The thermistors can be used by firmware to implement thermal shutdown and protect the power stages in case of overheating. The signals for motor 1 and motor 2 are available on PC0 (test point TP20) and PC2 (test point TP28) pins of the MCU, and can be routed to channel 6 of ADC1 and channel 8 of ADC2, respectively.

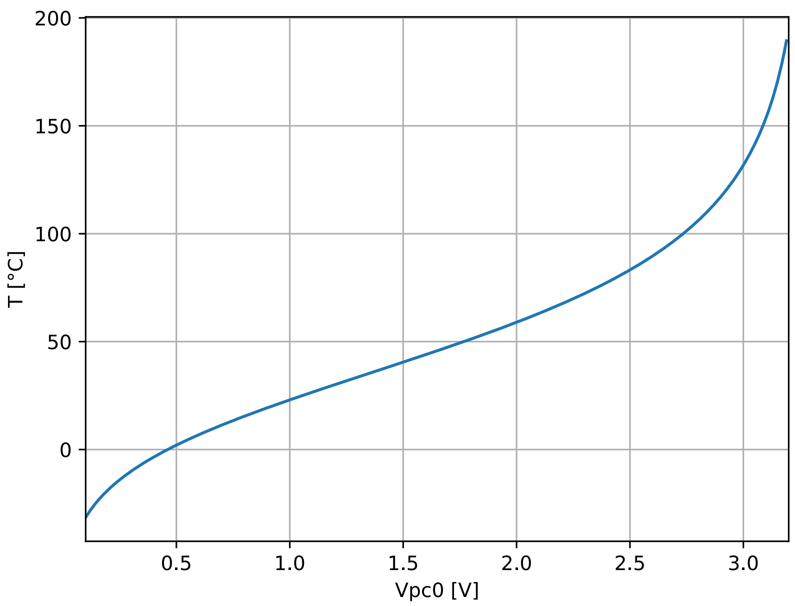
The following equation, derived from the β model for NTC thermistors, can be used to obtain temperature estimates from voltage values on PC0 or PC2:

$$T(V_{PC0}) = \frac{1}{\frac{1}{\beta} \cdot ln\left(\frac{R40 \cdot \left(\frac{V_{REFP}}{V_{PC0}} - 1\right)}{R^0_{NTC}}\right) + \frac{1}{T^0}} \quad (4)$$

- $T(V_{PC0})$ is the estimated temperature in Kelvin
- V_{PC0} is the voltage on PC0 pin (PC2 for motor 2)
- ß is 3455 K, the β constant of selected NTC thermistor in the range 25°C – 100°C
- $R^0{}_{NTC}$ is 10 kΩ, the thermistor resistance at 298 K
- T^0 is 298 K

The following figure shows a plot of the above equation.

Figure 3. Thermistor temperature with respect to voltage on PC0 or PC2 pins



5.9 Input strategy selection

By default, the board is configured to drive STDRIVE101 via ENx/INx mode. All enable signals ENx are shorted together and driven by the microcontroller through pin PB7, while PWM signals are generated via channel 1, 2 and 3 of timer TIM8 on PA15, PB8 and PB9 pins. Referring to Table 6, when enable signals are low, the gate driver outputs GHSx and GLSx are disabled, regardless of the INx inputs, while PWM signals are provided to outputs with enable signals high. A deadtime of 530 µs (typ.) is inserted between a MOSFET turn off and the turn on of its counterpart.

Table 6. ENx and INx inputs truth table

ENx	INx	GHSx	GLSx	Half-bridge condition
L	X	L	L	Disabled
H	L	L	H	Low-side on
H	H	H	L	High-side on

It is possible to drive STDRIVE101 using INxH/INxL mode by removing R12, R13, R14, R106, R109 and mounting R9, R15, R16 and R1 as zero ohm resistors. With reference to Table 7, digital inputs provide direct driving of high-side and low-side MOSFETs with interlocking to prevent accidental cross conduction of the power stage. Unlike the previous driving mode, the deadtime must be directly applied by the microcontroller.

Table 7. INxL and INxH inputs truth table

INxH	INxL	GHSx	GLSx	Half-bridge condition
L	L	L	L	Disabled
L	H	L	H	Low-side on
H	L	H	L	High-side on
H	H	L	L	Disabled (interlocking)

Note: In this configuration, it is not possible to use Hall sensors and quadrature encoder for motor 2 or absolute encoders.

5.10 CAN bus

The STSPIN32G4 integrates an FDCAN communication interface to manage the data layer of the 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 by default).

R128 can be mounted if bus termination is required. Connection to the CAN bus is available via J15 connector, which also provides a terminal for cable shielding with optional connection to board ground via solder jumper R130.

6 Bill of material

Table 8. EVSPIN32G4-DUAL bill of materials

Item	Q.ty	Reference	Description	Value
1	2	CON1, CON2	SERIE 4147 - 5.00 MM SCREWLESS 45° ENTRY 2.00 MM² WIRES WR-TBL	691414720002B
2	2	CON3, CON4	SERIE 4147 - 5.00 MM SCREWLESS 45° ENTRY 2.00 MM² WIRES WR-TBL	691414720003B
3	1	C1	SMT ceramic capacitor 0805	10 µF, 6.3 V, 10%
4	6	C2, C3, C5, C10, C21, C60	SMT ceramic capacitor 0603	100 nF, 6.3 V, 10%
5	3	C4, C6, C23	SMT ceramic capacitor 0603	1 µF, 6.3 V, 10%
6	2	C7, C16	SMT ceramic capacitor 0805	10 µF, 25 V, 10%
7	1	C8	SMT ceramic capacitor 0603	100 nF, 25 V, 10%
8	7	C9, C26, C27, C28, C32, C33, C34	SMT ceramic capacitor 0805	220 nF, 100 V, 10%
9	4	C11, C14, C38, C42	SMT ceramic capacitor 0603	N.M.
10	1	C12	SMT ceramic capacitor 0805	1 µF, 100 V, 10%
11	1	C13	SMT ceramic capacitor 0805	100 nF, 100 V, 10%
12	3	C15, C17, C22	SMT ceramic capacitor 0805	100 nF, 25 V, 10%
13	2	C18, C20	SMT ceramic capacitor 0402	6.8 pF, 6.3 V, 0.25 pF
14	1	C19	SMT ceramic capacitor 0603	2.2 nF, 6.3 V, 10%
15	8	C24, C25, C52, C53, C54, C57, C58, C59	SMT ceramic capacitor 0603	1 nF, 6.3 V, 10%
16	6	C29, C30, C31, C35, C36, C37	SMT ceramic capacitor 0805	1 µF, 25 V, 10%
17	6	C39, C40, C41, C43, C44, C45	SMT ceramic capacitor 0603	33 nF, 6.3 V, 10%
18	6	C46, C47, C48, C49, C50, C51	THT Electrolytic Capacitor D500p200	100 µF, 100 V, 20%
19	2	C55, C56	SMT ceramic capacitor 0603	100 nF, 25 V, 10%
20	1	D1	High Voltage Power Schottky Rectifier	STPS1H100A, 100 V
21	12	D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13	Small signal Schottky diode	BAT48, 40 V
22	8	D14, D15, D16, D17, D18, D19, D20, D21	Small signal Schottky diodes	BAT30K, 30 V
23	2	J1, J4	Jumper	OPEN
24	2	J2, J3	Strip connector 2 pos, 2.54 mm	STRIP 1x2
25	5	J5, J6, J9, J12, J14	Strip connector 5 pos, 2.54 mm	STRIP 1x5
26	1	J7	Male Box Header	2x10 header
27	1	J8	SMT Micro Header pitch 1.27 mm	SAMTEC FTSH-107-01-L-DV-K-A
28	2	J10, J13	Strip connector 3 pos, 2.54 mm	STRIP 1x3
29	1	J11	Strip connector 9 pos, 2.54 mm	STRIP 1x9
30	1	J15	Strip connector 4 pos, 2.54 mm	STRIP 1x4
31	2	LED1, LED2	WL-SMCW SMT Mono-color Chip LED Waterclear	YELLOW
32	2	LED3, LED4	WL-SMCW SMT Mono-color Chip LED Waterclear	RED
33	1	L1	WE-PD2 SMT Power Inductor	18 µH, 1 A
34	2	NET2, NET3	PCB Net	N.M.

Item	Q.ty	Reference	Description	Value
35	2	NTC1, NTC2	NTC Thermistor	10 kΩ, 1%
36	12	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12	N-channel 100 V, 5 mΩ typ., 107 A STripFET F7 Power MOSFET	STL110N10F7
37	16	R1, R3, R12, R13, R14, R20, R21, R22, R25, R80, R89, R106, R109, R112, R114, R119	SMT resistor 0805	0 Ω, 0.1 W, 5%
38	2	R2, R4	SMT resistor 0603	22 kΩ, 0.1 W, 1%
39	3	R5, R6, R10	SMT resistor 0603	10 kΩ, 0.1 W, 1%
40	14	R7, R98, R99, R100, R101, R102, R103, R104, R105, R107, R108, R110, R111, R129	SMT resistor 0603	10 kΩ, 0.1 W, 5%
41	5	R8, R77, R83, R86, R92	SMT resistor 0603	1 kΩ, 0.1 W, 1%
42	1	R9	SMT resistor 0603	51 kΩ, 0.1 W, 5%
43	1	R11	SMT resistor 0603	N.M.
44	9	R15, R16, R17, R115, R116, R120, R121, R125, R130	SMT resistor 0805	N.M.
45	3	R18, R28, R29	SMT resistor 0603	100 kΩ, 0.1 W, 5%
46	3	R19, R23, R24	SMT resistor 0603	200 Ω, 0.1 W, 5%
47	3	R26, R27, R128	SMT resistor 0603	120 Ω, 0.1 W, 5%
48	18	R30, R31, R33, R39, R40, R41, R42, R43, R44, R53, R54, R55, R62, R63, R64, R65, R66, R69	SMT resistor 0603	0 Ω, 0.1 W, 5%
49	12	R32, R34, R35, R45, R46, R47, R56, R57, R58, R67, R68, R70	SMT resistor 0603	33 Ω, 0.1 W, 5%
50	12	R36, R37, R38, R48, R49, R50, R59, R60, R61, R71, R72, R73	SMT resistor 0603	N.M.
51	2	R51, R74	SMT resistor 2512	N.M.
52	2	R52, R75	SMT resistor 2512	0.01 Ω, 2 W, 1%
53	4	R76, R78, R85, R87	SMT resistor 0603	14 kΩ, 0.1 W, 1%
54	2	R79, R88	SMT resistor 0603	72.3 kΩ, 0.1 W, 1%
55	2	R81, R90	SMT resistor 0603	4.7 kΩ, 0.1 W, 1%
56	2	R82, R91	SMT resistor 0603	3.01 kΩ, 0.1 W, 1%
57	2	R84, R93	SMT resistor 0603	7 kΩ, 0.1 W, 1%
58	4	R94, R95, R96, R97	SMT resistor 0805	4.7 kΩ, 0.5 W, 5%
59	6	R113, R117, R118, R122, R123, R124	SMT resistor 0603	N.M.
60	2	R126, R127	SMT resistor 0603	2.2 kΩ, 0.1 W, 5%
61	6	SC1, SC2, SC3, SC4, SC5, SC6	M3 Cheese-head screw	M3
62	6	SP1, SP2, SP3, SP4, SP5, SP6	M3 F-F Hexagonal spacer 20 mm	222424
63	3	SW1, SW2, SW3	TACTILE SWITCHES - 6x6 J-bend SMT	430483025816
64	35	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP16, TP18, TP19, TP20, TP21, TP22, TP23, TP25, TP26, TP27, TP28, TP29, TP30, TP31, TP33, TP35, TP36, TP37, TP38, TP39, TP40	Test point PCB - 1.5 mm diameter	N.M.
65	3	TP15, TP41, TP42	40x71 mils SMD PAD	TP-SMD-S1751-46R

Item	Q.ty	Reference	Description	Value
66	4	TP17, TP24, TP32, TP34	Test Point PCB	N.M.
67	2	TR1, TR2	3/8 Square Trimpot trimming potentiometer, side adjust	100 kΩ
68	1	U1	3-phase brushless motor controller embedding STM32G4 MCU	STSPIN32G4
69	1	U2	Three-phase gate driver	STDRIVE101
70	1	U3	High input voltage 85 mA LDO linear regulator	LDK715M50R
71	1	U4	TCAN33x 3.3-V CAN Transceivers with CAN FD (Flexible Data Rate)	N.M.
72	1	X1	LOW PROFILE QUARTZ CRYSTAL	24.000MHZ

7 Schematics

Figure 4. EVSPIN32G4-DUAL schematic (1 of 4): STSPIN32G4 and STDRIVE101

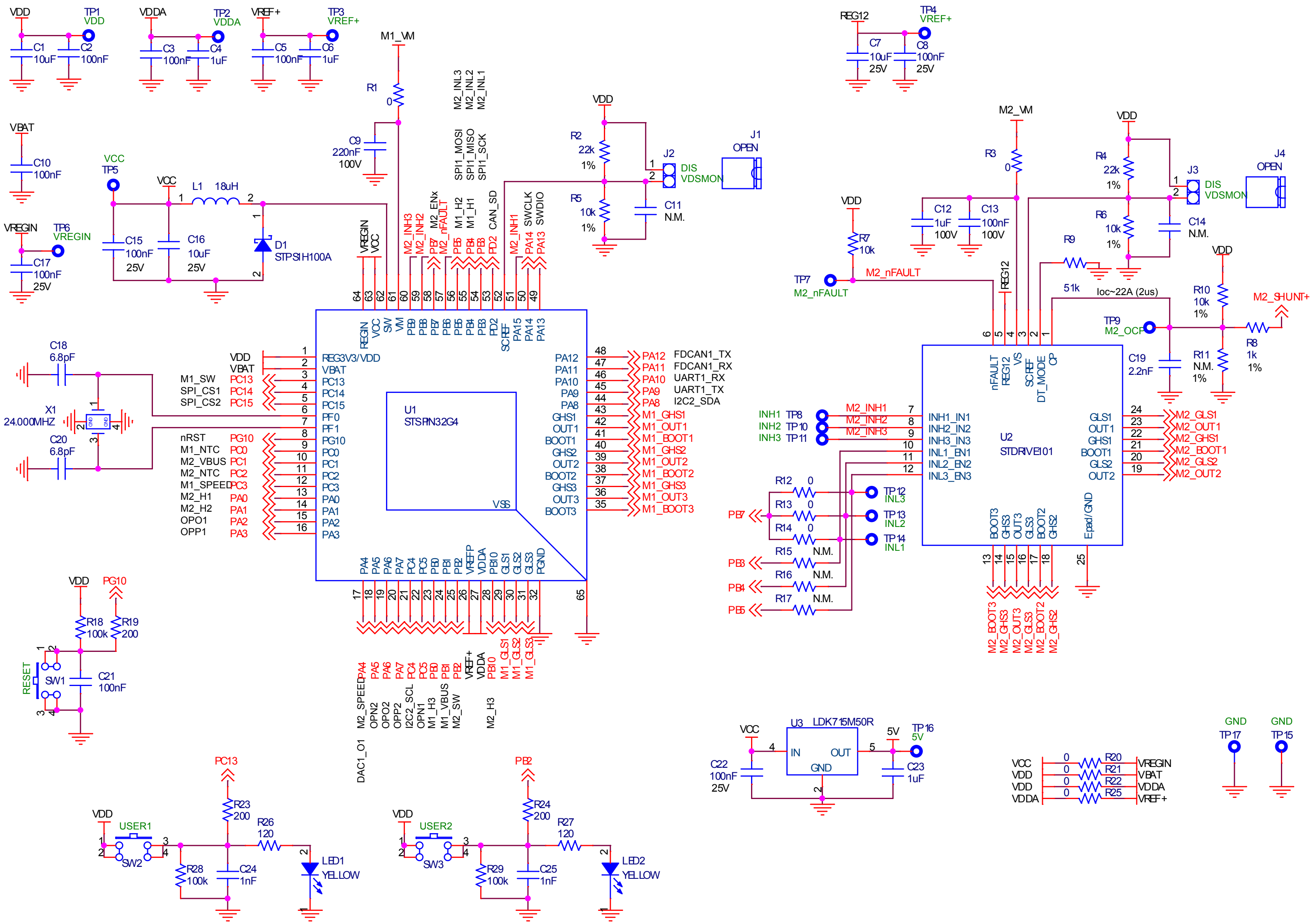


Figure 5. **EVSPIN32G4-DUAL schematic (2 of 4): Power stages**

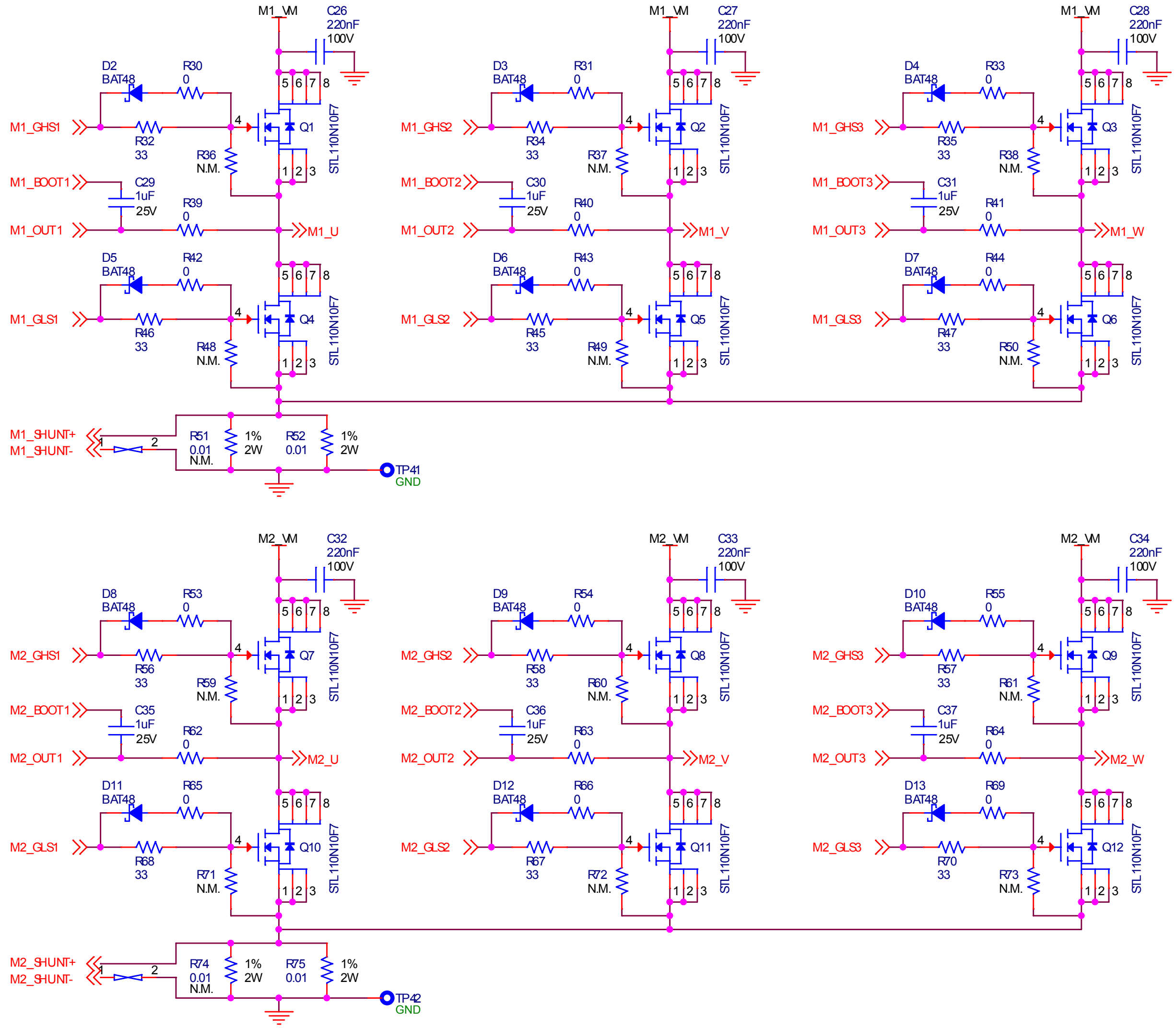


Figure 6. **EVSPIN32G4-DUAL schematic (3 of 4): Sensing**

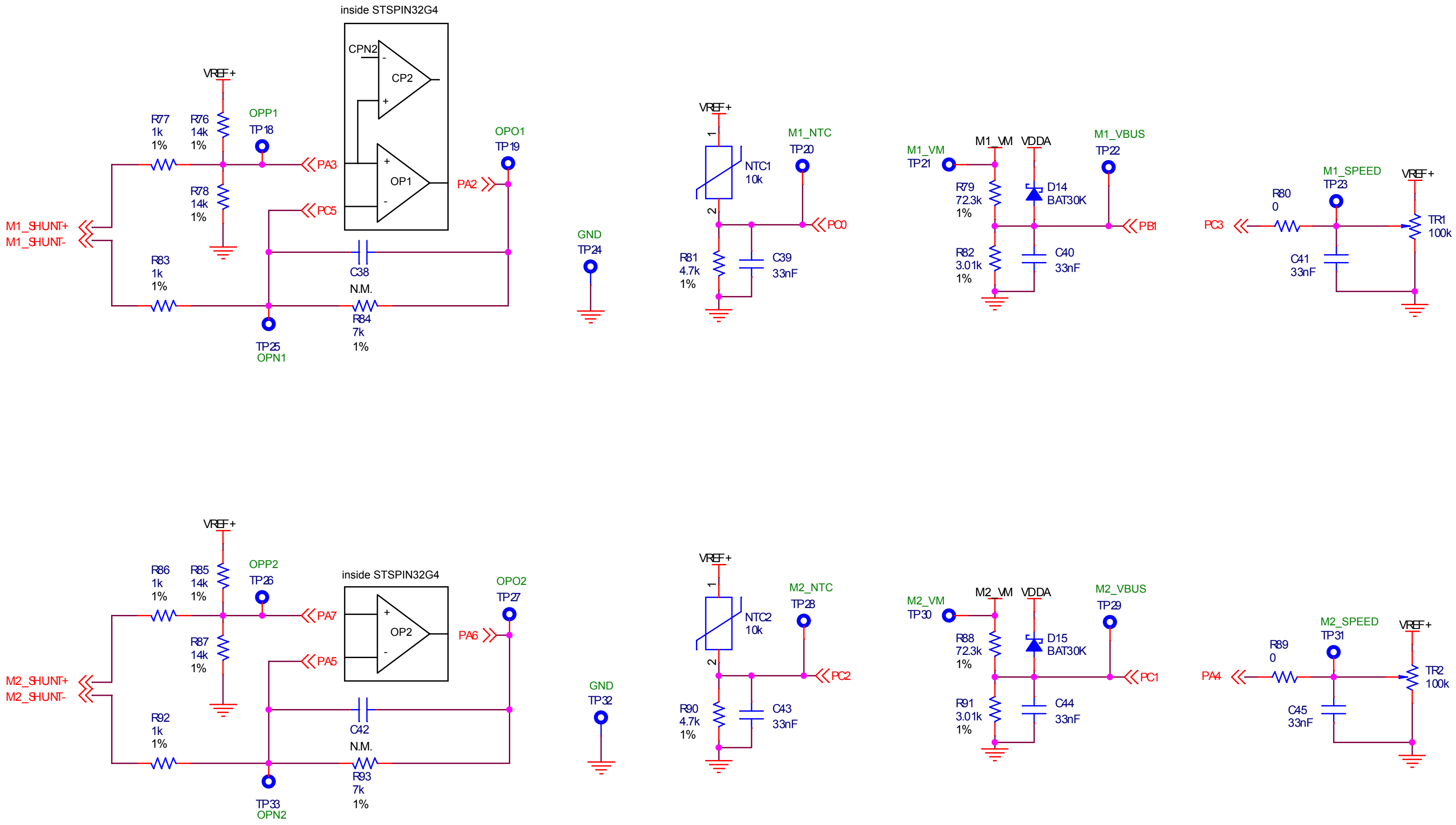
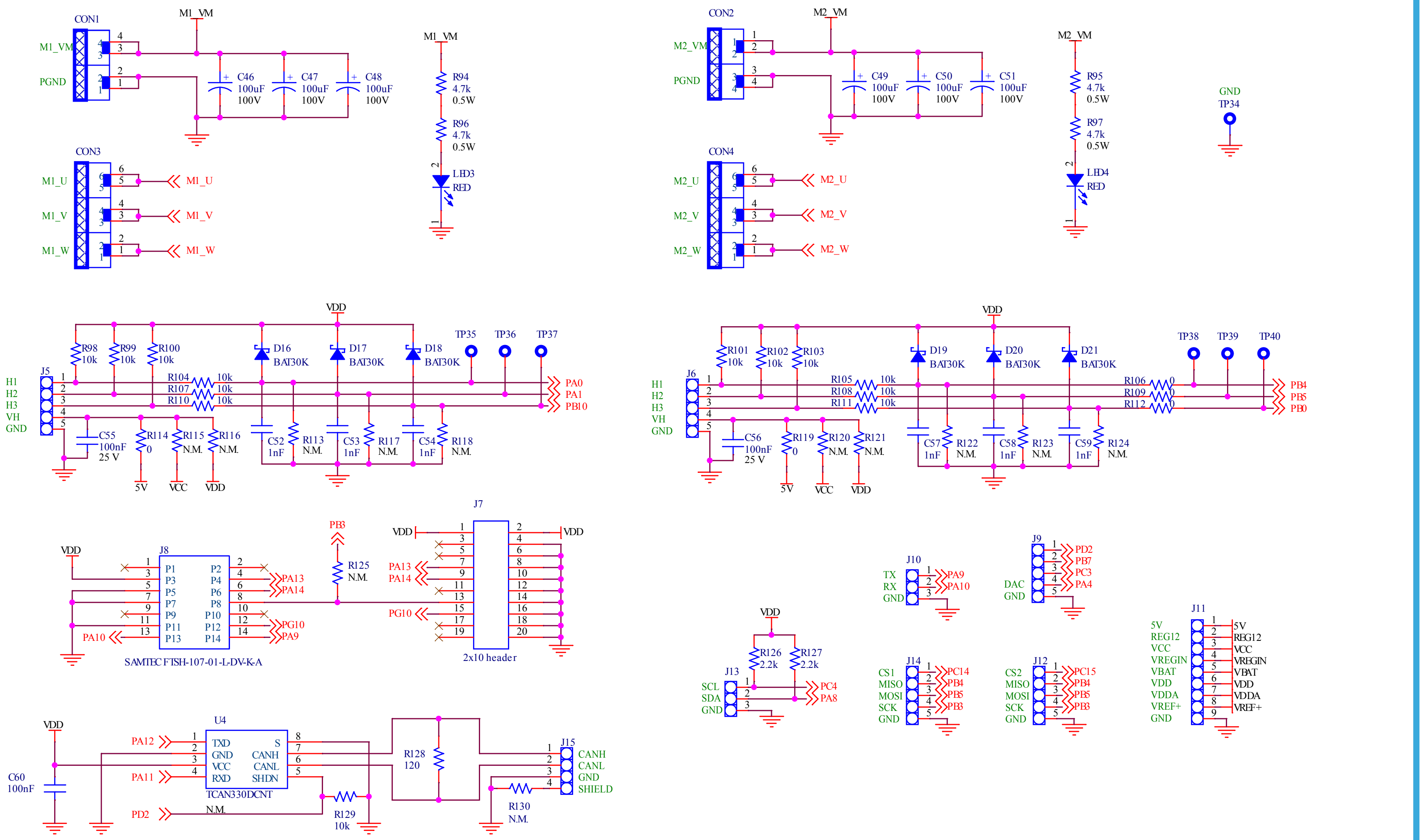


Figure 7. **EVSPIN32G4-DUAL schematic (4 of 4): Inputs and outputs**



Revision history

Table 9. **Document revision history**

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

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