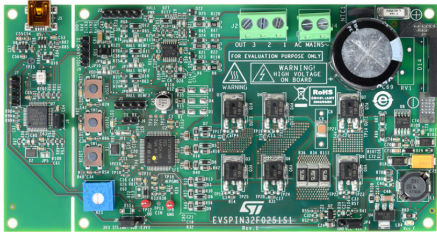


3-phase inverter based on STSPIN32F0251



Features

- Input voltage from 20 V to 120 V DC/AC
- STD17NF25 MOSFETs power stage featuring:
 - $V_{DS} = 250 \text{ V}$
 - $R_{DS(on)} \text{ max.} = 0.165 \Omega$
- Overcurrent threshold set to $16 A_{peak}$
- Dual footprint for IGBT/MOSFET package:
 - DPAK
 - PowerFlat 6x5
- Single-shunt current sensing, suitable for:
 - Sensored or sensorless 6 steps algorithm
 - Single-shunt vector (FOC) algorithm
- Smart shutdown overcurrent protection
- Digital Hall sensors and encoder input
- Bus voltage sensing
- 15 V VCC and 3.3 V VDD supplies
- Embedded ST-LINK/V2-1
- Easy user interface with buttons and trimmer
- RoHS compliant

Product status link

[EVSPIN32F0251S1](#)

Application

- Battery operated and 110 Vac supplied power and garden tools
- Industrial fans and pumps
- Home appliances
- Industrial and home automation

Description

The **EVSPIN32F0251S1** board is a 3-phase complete inverter based on the STSPIN32F0251 controller, which embeds a 3-phase 250 V gate driver and a Cortex®-M0 STM32 MCU. The power stage features STD17NF25 MOSFETs, but can be populated with any IGBT or Power MOSFET in DPAK or powerFLAT 6x5 package.

The board has a single-shunt sensing topology, and both the field-oriented control (FOC) and sensored or sensorless 6-step control can be implemented. This allows driving permanent magnet synchronous motors (PMSMs) and brushless DC (BLDC) motors.

The evaluation board is compatible with a wide range input voltage from 20 V to 120 V DC/AC, and includes a power supply stage with the VIPER013BLS in buck configuration to generate +15 V and +3.3 V supply voltage required by the application.

Debug and configuration of FW can be performed with standard STM32 tools through the detachable STLINK-debugger. SWD and UART TX-RX connectors are also available.

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 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 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 Schematic diagram

Figure 1. EVSPIN32F0251S1 schematic – Driver output stage

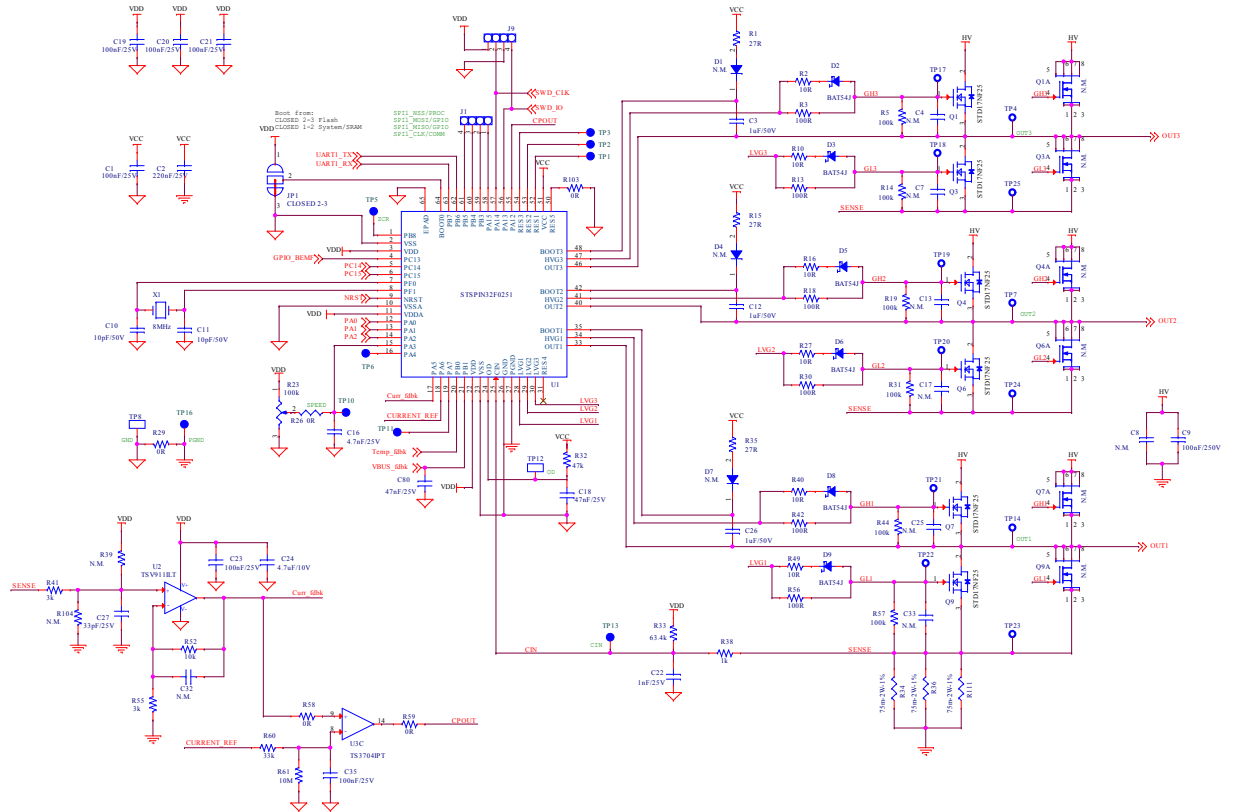


Figure 2. EVSPIN32F0251S1 schematic – Feedback network

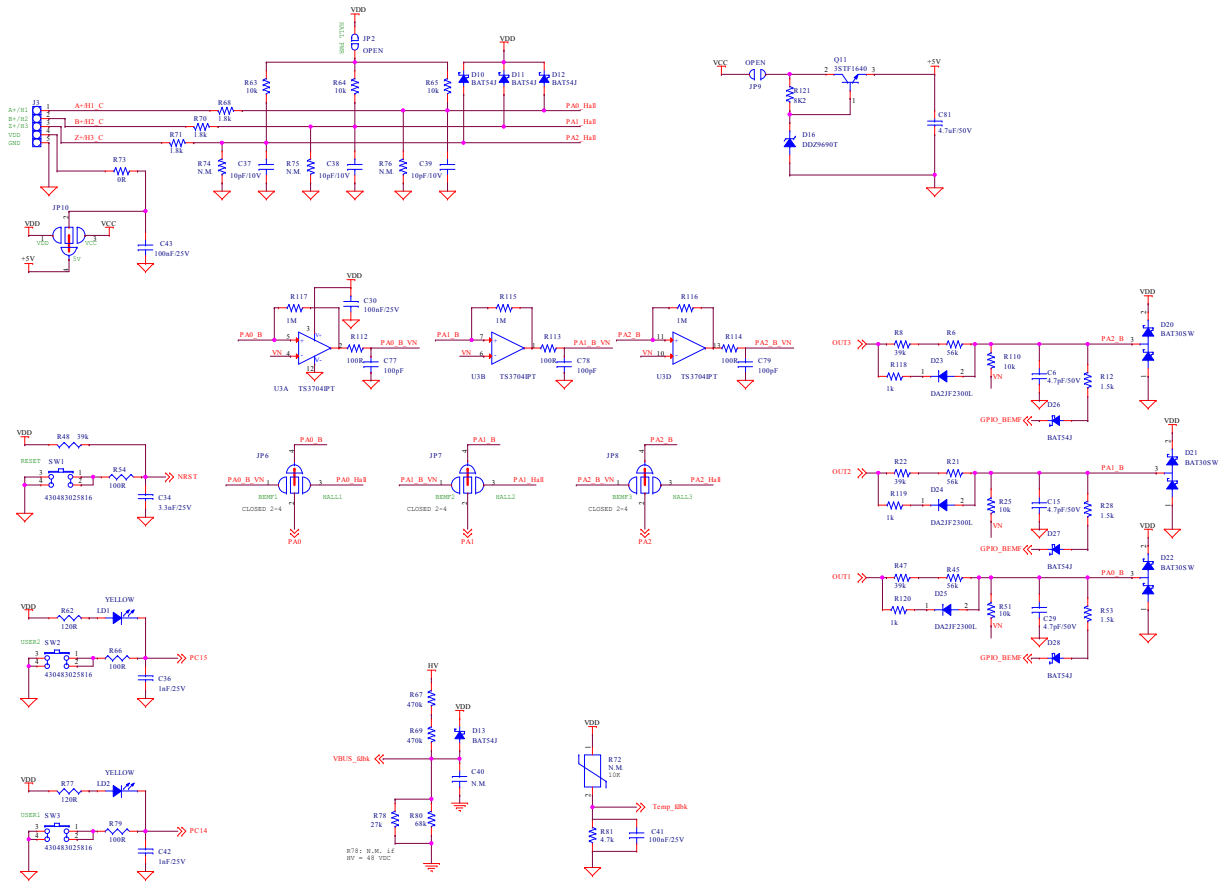


Figure 3. EVSPIN32F0251S1 schematic – Power Supply

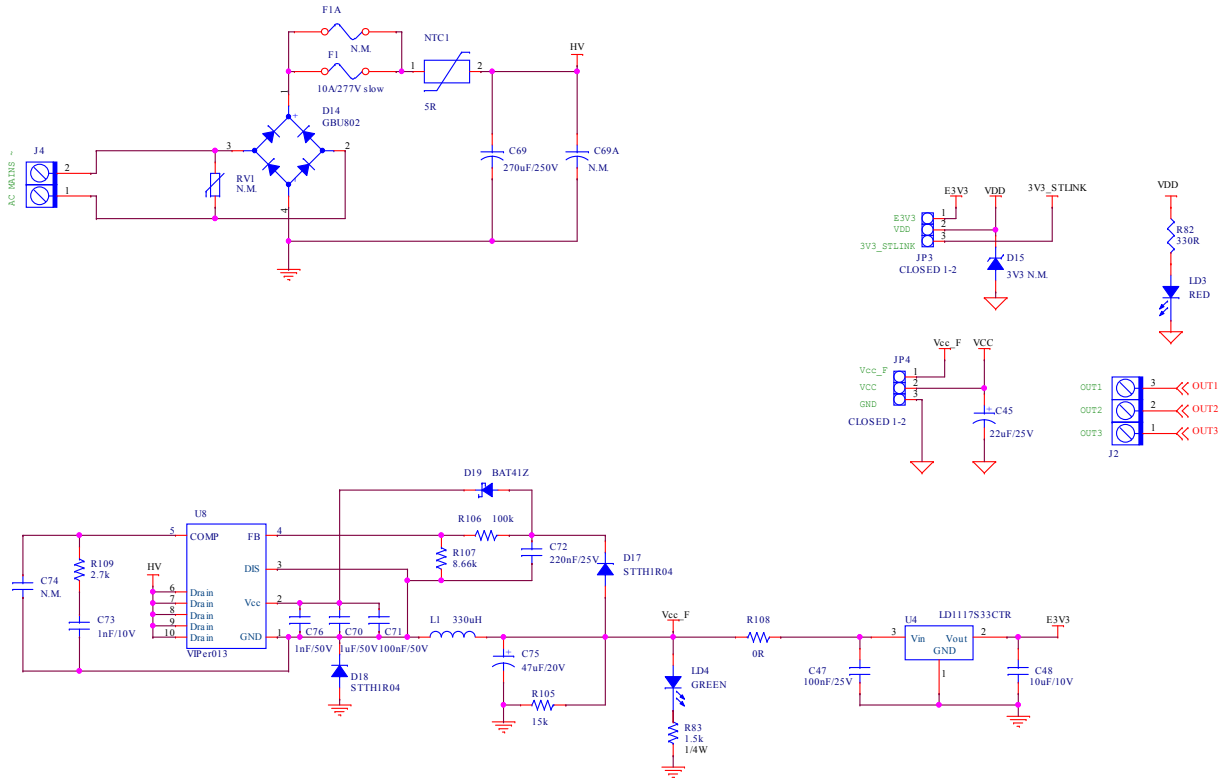
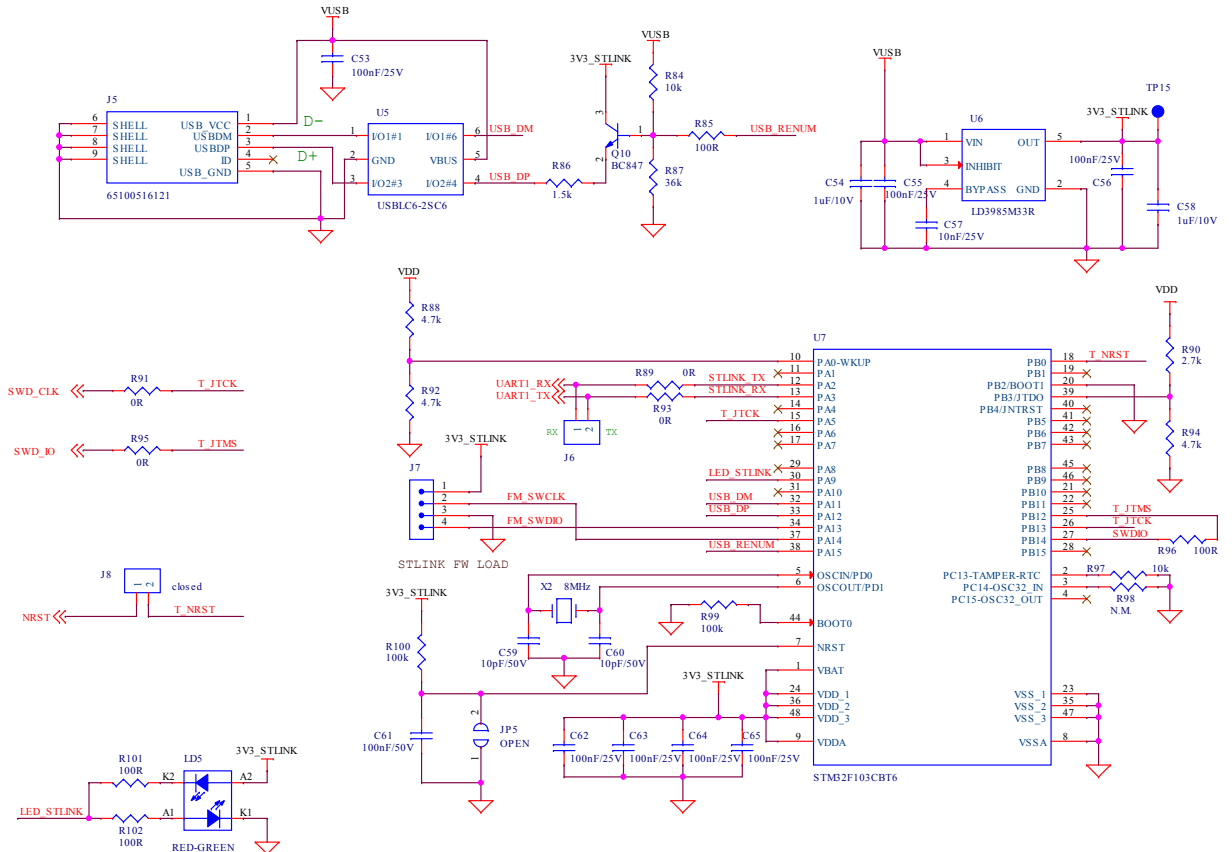


Figure 4. EVSPIN32F0251S1 schematic – STLINK debugger



3 Bill of material

Table 1. Bill of Materials – Components common to all device variants

| Reference | Part Value | Description | Package | Manufacturer | Part Number |
|--|------------|--|----------------------|------------------|--------------------------|
| C1, C19, C20, C21, C23, C30, C35, C41, C43, C47, C53, C55, C56, C62, C63, C64, C65 | 100nF/25V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206071 |
| C2,C72 | 220nF/25V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206073 |
| C3, C12, C26, C70 | 1uF/50V | SMT ceramic capacitor | Size 0805 | Wurth Elektronik | 885012207103 |
| C4,C7,C13, C17, C25, C32, C33, C40, C74 | N.M. | SMT ceramic capacitor | Size 0603 | | |
| C6, C15, C29 | 4.7pF/50V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012006049 |
| C8 | N.M. | Film capacitor | 4x13 mm, Pitch 10 mm | Wurth Elektronik | 890334023006 |
| C9 | 100nF/250V | SMT ceramic capacitor | Size 1210 | TDK | CGA6M3X7R2E104M2 00AE |
| C10,C11, C59, C60 | 10pF/50V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012006051 |
| C16 | 4.7nF/25V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206063 |
| C18,C80 | 47nF/25V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206069 |
| C22,C36, C42 | 1nF/25V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206059 |
| C24 | 4.7uF/10V | SMT ceramic capacitor | Size 0805 | Wurth Elektronik | 885012207025 |
| C27 | 33pF/25V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012006035 |
| C34 | 3.3nF/25V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206062 |
| C37,C38, C39 | 10pF/10V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012006002 |
| C45 | 22uF/25V | SMT aluminum elect. capacitor | 5x5.4 mm | Wurth Elektronik | 865090442004 |
| C48 | 10uF/10V | SMT ceramic capacitor | Size 1206 | Wurth Elektronik | 885012208018 |
| C54,C58 | 1uF/10V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206026 |
| C57 | 10nF/25V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206065 |
| C61 | 100nF/50V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206095 |
| C69A | N.M. | THT electrolytic capacitor | Radial p7.5 d18h25 | Rubycon | 450BXW68MEFC18X2 5 |
| C69 | 270uF/250V | THT electrolytic capacitor | Radial p10 d22h27 | Nichicon | LGN2E271MELZ25 |
| C71 | 100nF/50V | SMT ceramic capacitor | Size 0805 | Wurth Elektronik | 885012207098 |
| C73 | 1nF/10V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206008 |
| C75 | 47uF/20V | Low ESR series of robust MnO2 solid electrolyte capacitors | D / E | AVX | TPS Series or equivalent |
| C76 | 1nF/50V | SMT ceramic capacitor | Size 0603 | Wurth Elektronik | 885012206083 |
| C77,C78, C79 | 100pF | SMT ceramic capacitor | Size 0603 | | |

| Reference | Part Value | Description | Package | Manufacturer | Part Number |
|---|--------------------|---|----------------------|---|------------------|
| C81 | 4.7uF/50V | SMT ceramic capacitor | Size 1206 | Wurth Elektronik | 885012208094 |
| D1,D4,D7 | N.M. | Turbo 2 ultrafast high-voltage rectifier | SMA | STMicroelectronics | STTH1L06A |
| D2,D3,D5, D6, D8, D9, D10, D11, D12, D13, D26, D27, D28 | BAT54J | 40V, 300mA small signal Schottky SMT Diode | SOD-323 | STMicroelectronics | BAT54JFILM |
| D14 | GBU802 | 8A glass passivated bridge rectifiers | GBU | Diodes Incorporated or Taiwan Semiconductor | GBU802 or GBU803 |
| D15 | 3V3 N.M. | Zener | SOD-123 | | |
| D16 | DDZ9690T | Surface mount Zener diode | SOD523 | Diodes Incorporated | DDZ9690T-7 |
| D17,D18 | STTH1R04 | Ultrafast recovery diode, 1A 400 V | SMA | STMicroelectronics | STTH1R04A |
| D19 | BAT41Z | 100V, 200mA Low capacitance small signal Schottky diode | SOD-123 | STMicroelectronics | BAT41ZFILM |
| D20,D21, D22 | BAT30SW | Small signal Schottky diodes | SOT-323 | STMicroelectronics | BAT30SWFILM |
| D23,D24, D25 | DA2JF2300L | 300V fast recovery diode | SC-90A (SMini2-F5-B) | Panasonic | DA2JF2300L |
| F1A | N.M. | Time-lag radial lead micro fuse, 250Vac | RST-Bel Fuse | Bel Fuse | 0697-xx |
| F1 | 10A/277 V slow | Surface mount fuse, time-lag T, 250Vac125Vdc | UMT250-Shurter | Schurter | 3403.0176.24 |
| JP1 | Closed 2-3 | SMT jumper | Soldering pad | | |
| JP2 | Open | SMT jumper | Soldering pad | | |
| JP3,JP4 | Closed 1-2 | Strip connector 3 pos, 2.54mm | 1x3 pins | Wurth Elektronik | 61300311121 |
| JP5 | Open | SMT jumper | Soldering pad | | |
| JP6,JP7, JP8 | Closed 2-4 | Jumper to solder | Soldering pads | | |
| JP9 | Open | SMT jumper | | | |
| JP10 | Closed 2-4 | Jumper to solder | Soldering pads | | |
| J1,J7,J9 | STRIP 1x4 | Strip connector 4 pos, 2.54mm | 1x4 pins | Wurth Elektronik | 61300411121 |
| J2 | MORSV-508-3P_screw | Connector terminal block T.H. 3 positions 5.08mm | 3 poles, pitch 5.08 | Wurth Elektronik | 691213510003 |
| J3 | STRIP 1x5 | Strip connector 5 pos, 2.54mm | 1x5 pins | Wurth Elektronik | 61300511121 |
| J4 | MORSV-508-2P_screw | Connector terminal block T.H. 2 positions 5.08mm | 2 poles, pitch 5.08 | Wurth Elektronik | 691213510002 |
| J5 | 6510051612 1 | Mini USB 2.0 type B SMD | Mini USB B | Wurth Elektronik | 65100516121 |

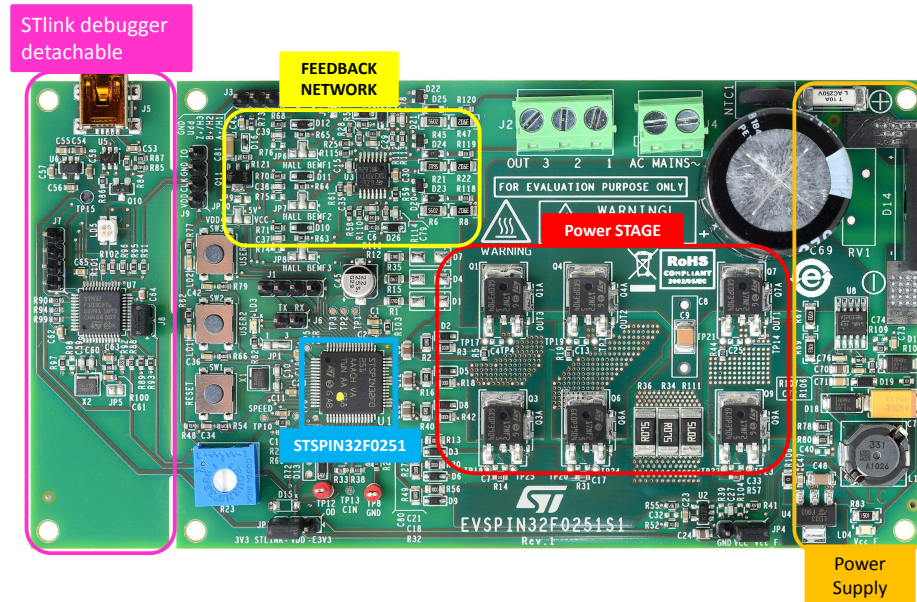
| Reference | Part Value | Description | Package | Manufacturer | Part Number |
|---|------------|--|---------------------|-------------------------|-----------------|
| J6 | STRIP 1x2 | Strip connector 2 pos, 2.54mm | 1x2 pins | Wurth Elektronik | 61300211121 |
| J8 | Closed | Strip connector 2 pos, 2.54mm | 1x2 pins | Wurth Elektronik | 61300211121 |
| LD1,LD2 | Yellow | Yellow LED | Size 0603 | Wurth Elektronik | 150060YS75000 |
| LD3 | Red | Red LED | Size 0603 | Wurth Elektronik | 150060RS75000 |
| LD5 | Red-green | LED indicators, PLCC-4 red/ yellow green | PLCC 4 | Avago | HSMF-A201-A00J1 |
| LD4 | Green | Green LED | Size 0805 | Wurth Elektronik | 150080GS75000 |
| L1 | 330uH | SMD Power inductors for Automotive/Industrial applications | | TAIYO YUDEN | EST1060T331MDGA |
| NTC1 | 5R | NTC thermistors for inrush current limiting | Pitch 5.08 mm | TDK | B57235S0509M000 |
| Q1,Q3,Q4, Q6, Q7, Q9 | STD17NF25 | N-channel 250V, 0.140 O typ., 17A STRipFET™ II Power MOSFETs | DPAK | STMicroelectronics | STD17NF25 |
| Q1A,Q3A, Q4A, Q6A, Q7A, Q9A | N.M. | N-channel Power MOSFET | PowerFLAT 6x5 | STMicroelectronics | |
| Q10 | BC847 | General purpose_45V_100mA_225m W | SOT23 | ON SEMICONDUCTO R | BC847BL |
| Q11 | 3STF1640 | Low voltage high performance NPN power transistor | SOT-89 | STMicroelectronics | 3STF1640 |
| RV1 | N.M. | Varistor | Pitch 2.3x7.5 mm | | |
| R1,R15,R35 | 27R | SMT resistor | Size 0805 | | |
| R2,R10, R16, R27, R40, R49 | 10R | SMT resistor | Size 0805 | | |
| R3,R13, R18, R30, R42, R56 | 100R | SMT resistor | Size 0805 | | |
| R5,R14,R19, R31, R44, R57, R99, R100, R106 | 100k | SMT resistor | Size 0603 | | |
| R6,R21, R45 | 56k | SMT resistor | Size 1206 | | |
| R8,R22,R47 | 39k | SMT resistor | Size 1206 | | |
| R12,R28, R53, R68, R70, R71 | 1.8k | SMT resistor | Size 0603 | | |
| R23 | 100k | Square trimpot trimming potentiometer | 3386P | BOURNS | 3386P-1-104-LF |
| R25,R51, R52, R63, R64, R65, R84, R97, R110 | 10k | SMT resistor | Size 0603 | | |
| R26,R29, R58, R59, R73, R89, R91, R93, R95 | 0R | SMT resistor | Size 0603 | | |
| R32 | 47k | SMT resistor | Size 0603 | | |
| R33 | 63.4k | SMT resistor | Size 0603 | | |

| Reference | Part Value | Description | Package | Manufacturer | Part Number |
|--|------------------|--------------------------------------|---------------------------|------------------|--------------|
| R34,R36, R111 | 75m-2W-1% | SMT resistor | Size 2512 | | |
| R38,R118, R119, R120 | 1k | SMT resistor | Size 0603 | | |
| R39,R74, R75, R76, R98, R104 | N.M. | SMT resistor | Size 0603 | | |
| R41,R55 | 3k | SMT resistor | Size 0603 | | |
| R48 | 39k | SMT resistor | Size 0603 | | |
| R54,R66, R79, R85, R96, R101, R102, R112, R113, R114 | 100R | SMT resistor | Size 0603 | | |
| R60 | 33k | SMT resistor | Size 0603 | | |
| R61 | 10M | SMT resistor | Size 0603 | | |
| R62,R77 | 120R | SMT resistor | Size 0603 | | |
| R67,R69 | 470k | SMT resistor | Size 1206 | | |
| R72 | N.M. | NTC resistor | Size 0805 | | |
| R81,R88, R92, R94 | 4.7k | SMT resistor | Size 0603 | | |
| R78 | 27k | SMT resistor | Size 0805 | | |
| R80 | 68k | SMT resistor | Size 0805 | | |
| R82 | 330R | SMT resistor | Size 0603 | | |
| R83 | 1.5k | SMT resistor | Size 1206 | | |
| R86 | 1.5k | SMT resistor | Size 0603 | | |
| R87 | 36k | SMT resistor | Size 0603 | | |
| R90,R109 | 2.7k | SMT resistor | Size 0603 | | |
| R103 | 0R | SMT resistor | Size 0603 | | |
| R105 | 15k | SMT resistor | Size 0603 | | |
| R107 | 8.66k | SMT resistor | Size 0603 | | |
| R108 | 0R | SMT resistor | Size 0805 | | |
| R115,R116, R117 | 1M | SMT resistor | Size 0603 | | |
| R121 | 8K2 | SMT resistor | Size 0603 | | |
| SW1,SW2, SW3 | 4304830258 16 | Tactile switches - 6x6 J-bend SMT | | Würth Elektronik | 430483025816 |
| TP1 | TPHIN1 | Test point - PCB 1mm diameter | Copper pad | | |
| TP2 | TPHIN2 | Test point - PCB 1mm diameter | Copper pad | | |
| TP3 | TPHIN3 | Test point - PCB 1mm diameter | Copper pad | | |
| TP4,TP7, TP14, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP24, TP25 | N.M. | TP for probe | Diam. 1.27, Hole 0.8mm | | |

| Reference | Part Value | Description | Package | Manufacturer | Part Number |
|------------|------------------|--|------------------|--------------------|-------------------------|
| TP5 | PB8 | Test point - PCB 1mm diameter | Copper pad | | |
| TP6 | PA4 | Test point - PCB 1mm diameter | Copper pad | | |
| TP8,TP12 | TPTH-ANELLO-1mm | THT ring test point | | Keystone | 5003 |
| TP10 | PA3 | Test point - PCB 1mm diameter | Copper pad | | |
| TP11 | PA7 | Test point - PCB 1mm diameter | Copper pad | | |
| TP13 | GPIO_ZCR | Test point - PCB 1mm diameter | Copper pad | | |
| TP15 | NEEDLE-PAD-1.7mm | Test point - PCB 1.7mm diameter | Copper pad | | |
| TP16 | PGND | Test point - PCB 1mm diameter | Copper Pad | | |
| U1 | STSPIN32F0251 | 250V 3-phase controller with ARM Cortex MCU | TQFP64-10x10x1.0 | STMicroelectronics | STSPIN32F0251/TR |
| U2 | TSV911ILT | Single rail-to-rail input/output 8MHz operational amplifiers | SOT23-5 | STMicroelectronics | TSV911ILT |
| U3 | TS3704IPT | Micropower quad CMOS voltage comparators | TSSOP14 | STMicroelectronics | TS3704IPT |
| U4 | LD1117S33CTR | 800mA, 3.3V adjustable and fixed low drop positive voltage regulator | SOT-223 | STMicroelectronics | LD1117S33CTR |
| U5 | USBLC6-2SC6 | Very low capacitance ESD protection | SOT23-6L | STMicroelectronics | USBLC6-2SC6 / Y |
| U6 | LD3985M33R | Ultra low drop and low noise BiCMOS Voltage Regulators | SOT23-5L | STMicroelectronics | LD3985M33R |
| U7 | STM32F103CBT6 | Medium-density performance line ARM®-based 32-bit MCU with 128 KB Flash, USB, CAN, 7 timers, 2 ADCs, 9 com. interfaces | LQFP48 - 7x7 mm | STMicroelectronics | STM32F103CBT6 |
| U8 | VIPer013 | Energy saving off-line high voltage converter | SSOP10 | STMicroelectronics | VIPer013BLS/TR |
| X1,X2 | 8MHz | Crystal 8.0000MHZ 8PF SMD | 2.5x3.2 mm | NDK | NX3225GD-8MHZ-STD-CRA-3 |
| | | Rubber feet | | Hammond | 1421T6CL |
| J8,JP3,JP4 | | Female jumper isolated, pitch 2.54mm | | Assmann WSW | AKSCT/Z BLACK |
| | | P.C.B. EVSPIN32F0251S1 Rev.1.0 | | STMicroelectronics | |

4 Layout and component placements

Figure 5. EVSPIN32F0251S1 – Board functions description



Warning:

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.

Figure 6. EVSPIN32F0251s – Layout (component placement top view)

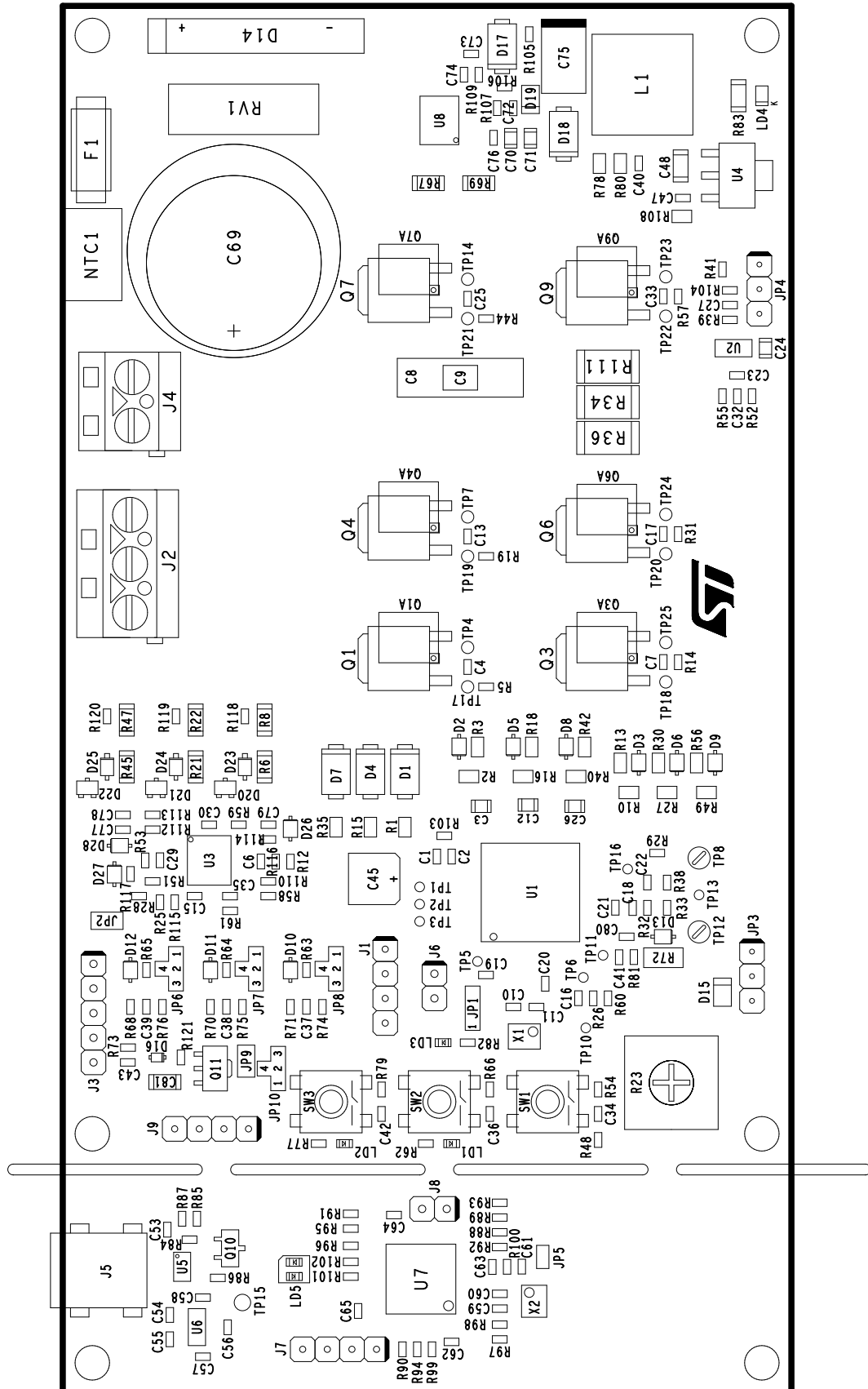


Figure 7. EVSPIN32F0251s – Layout (top layer)

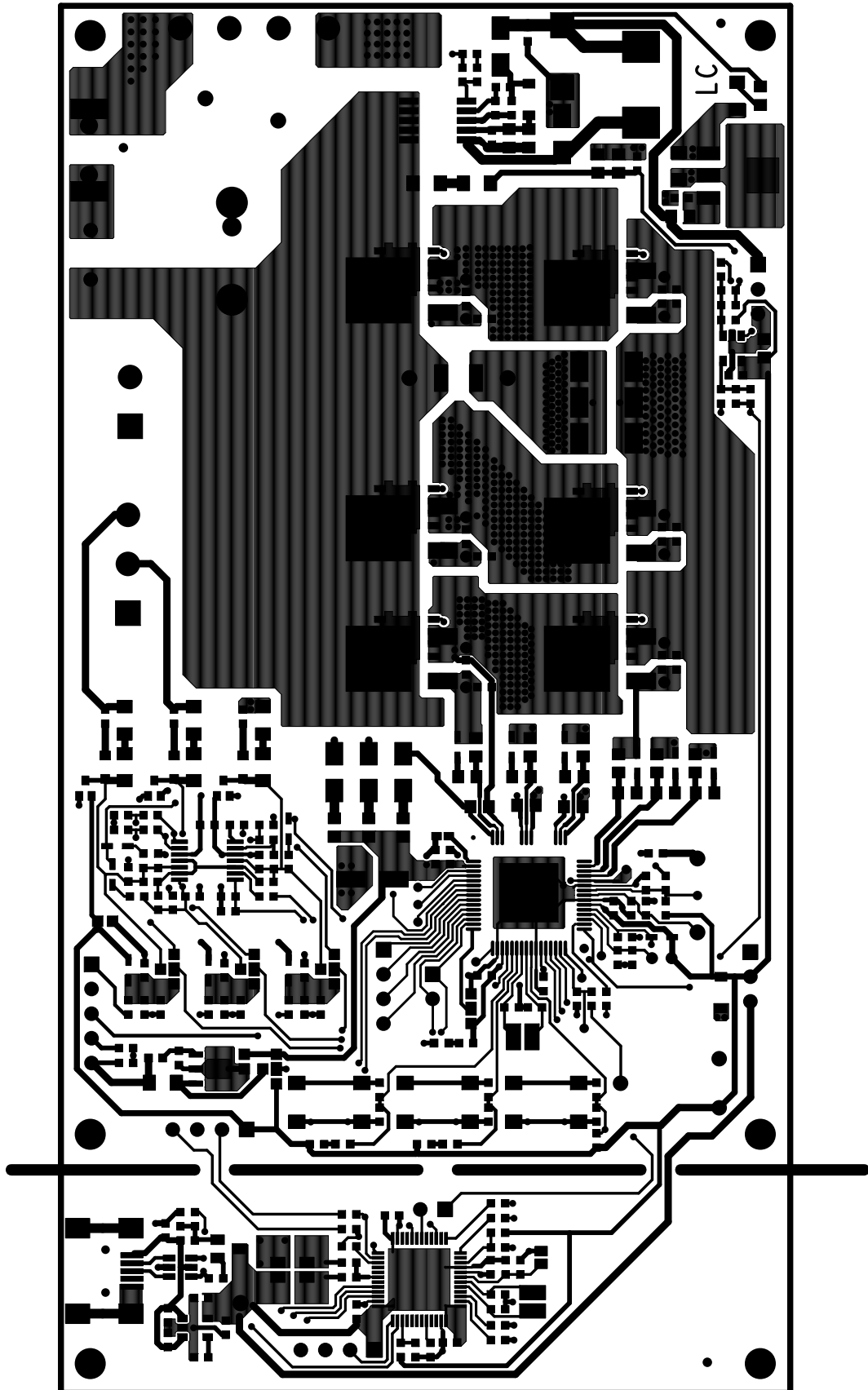
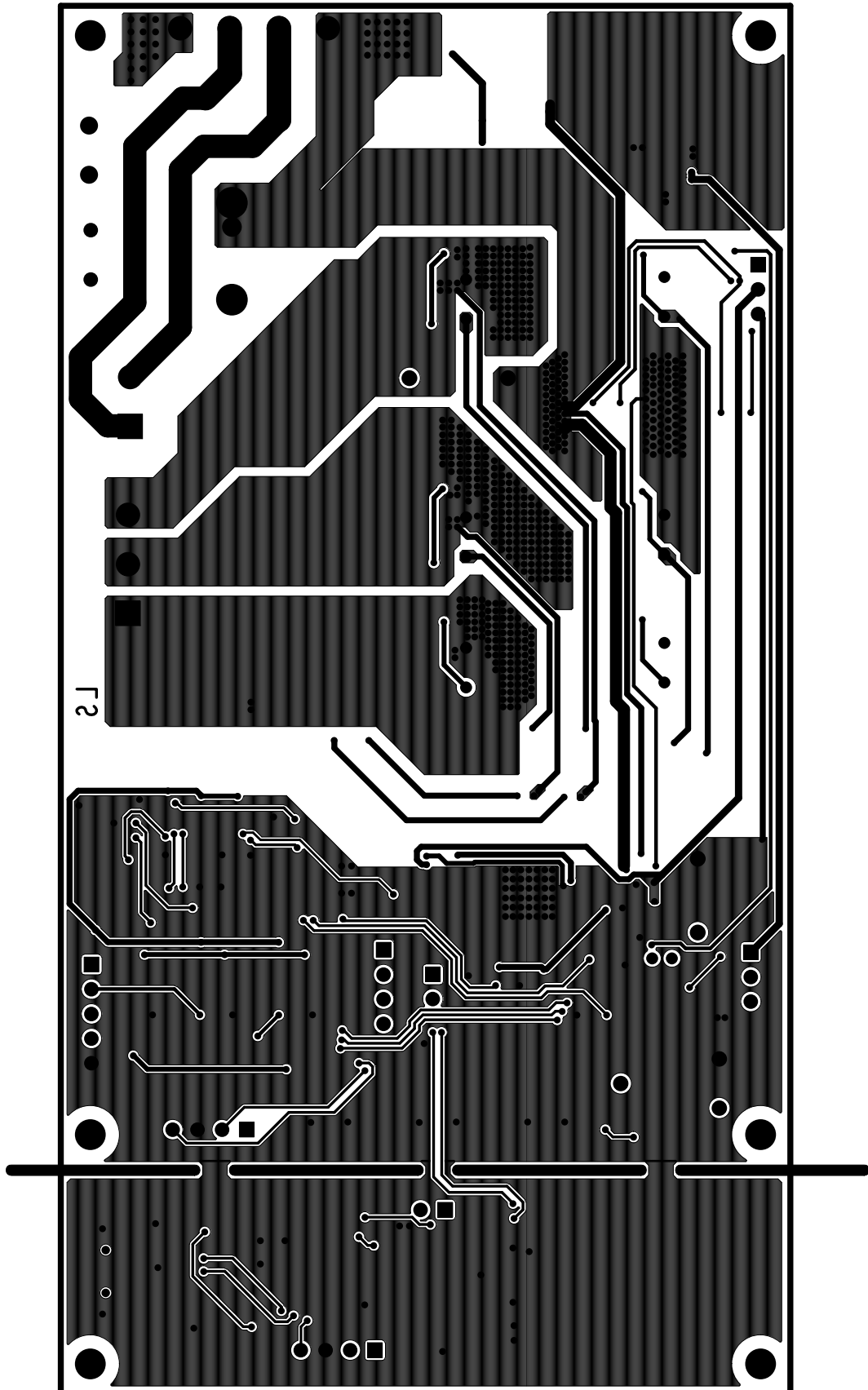


Figure 8. EVSPIN32F0251s – Layout (bottom layer)



Revision history

Table 2. Document revision history

| Date | Version | Changes |
|-------------|---------|------------------|
| 28-Oct-2019 | 1 | Initial release. |

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