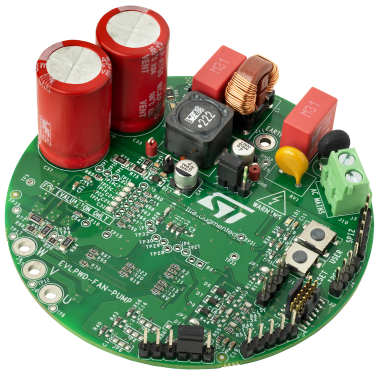
EVLPWD-FAN-PUMP

Data brief

PWD5T60 circular reference design for 100 W inverter optimized for fan and pump applications



Product status link	
100 W 3-phase inverter	EVLPWD-FAN-PUMP
Compact high-voltage three-phase power stage with integrated gate driver	PWD5T60
Mainstream Arm Cortex-M0+ MCU	STM32G071RB
STM32 Motor Control Software Development Kit	X-CUBE-MCSDK
VIPerPlus: Low voltage energy saving fixed frequency high voltage converter	VIPER01

Features

- Input voltage from 15 V_{AC} (20 V_{DC}) to 280 V_{AC} (400 V_{DC})
- Suitable for applications up to 100 W
- Output current up to 0.7 A_{rms}
- Adjustable overcurrent protection threshold set to 1.8 A_{peak}
- PWD5T60 system-in-packaging featuring:
  - High-voltage 3-phase gate driver
  - Integrated power MOSFETs with $R_{DS(on)}$ 1.38 Ω and BV_{DSS} = 500 V
- STM32G071RBT6 Arm® Cortex®-M0+ 32-bit MCU featuring:
  - 128 KB Flash
  - 36 KB RAM
  - 4x USART, timers, ADC, DAC, standard communication interfaces
- Selectable single or three-shunt current sensing topology suitable for:
  - Sensored or sensorless 6-step algorithm
  - Sensored or sensorless space vector (FOC) algorithm
- Digital Hall effect sensor and encoder input
- Plug-and-play due to available 6-step/FOC firmware
- Speed regulation through an external potentiometer
- Fully protected:
  - Thermal shutdown
  - Overvoltage/undervoltage lockout
  - Overcurrent protection
- Bus voltage sensing
- 12 V VCC and 3.3 V VDD supplies are internally generated
- Serial wire debug (SWD) port for debugging/programming
- Compact footprint (80 mm diameter)

Description

The EVLPWD-FAN-PUMP board is a 3-phase complete inverter based on the STM32G071RBT6 Cortex®-M0+ microcontroller and PWD5T60 3-phase motor driver.

The evaluation board has been designed, in terms of characteristics and form factor, to address some of the main product applications of the PWD5T60, such as fans and pumps.

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

A current comparator allows the cycle-by-cycle current limiter feature to implement a current mode control.

The presence of on-board bus voltage sensing can be exploited for overvoltage or undervoltage protection. The driver, in addition, has an undervoltage lockout mechanism to protect against VCC supply voltage drop.

The driver built-in overcurrent circuitry allows almost immediate hardware protection, without the intervention of the microcontroller.

The possibility to use a temperature sensor completes the set of protection features.

The demonstration board is compatible with a wide range of input voltages and includes a power supply stage with the VIPER011LS in buck configuration to generate the +12 V and +3.3 V supply voltages required by the application. The input stage of the board is equipped with a complete AC mains line filter.

Programming and debugging of firmware can be performed with standard STM32 tools through an external STLINK debugger (such as STLINK/V3).

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 a 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.*

Attention: *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.

Important: *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 board must be protected against excessive strain. In particular, components should not be bent nor should isolating distances be 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 properly operate 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 the power supply from the board and electrical loads before taking any electrical measurements.
   - 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 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, included PCB, may still be very hot.
The kit is not electrically isolated from AC/DC input.

3. Personal safety
   - Always wear suitable personal protective equipment such as 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 an insulating box with interlocks if necessary.

2 Schematic diagrams

Figure 1. **EVLPWD-FAN-PUMP schematic - driver output stages**

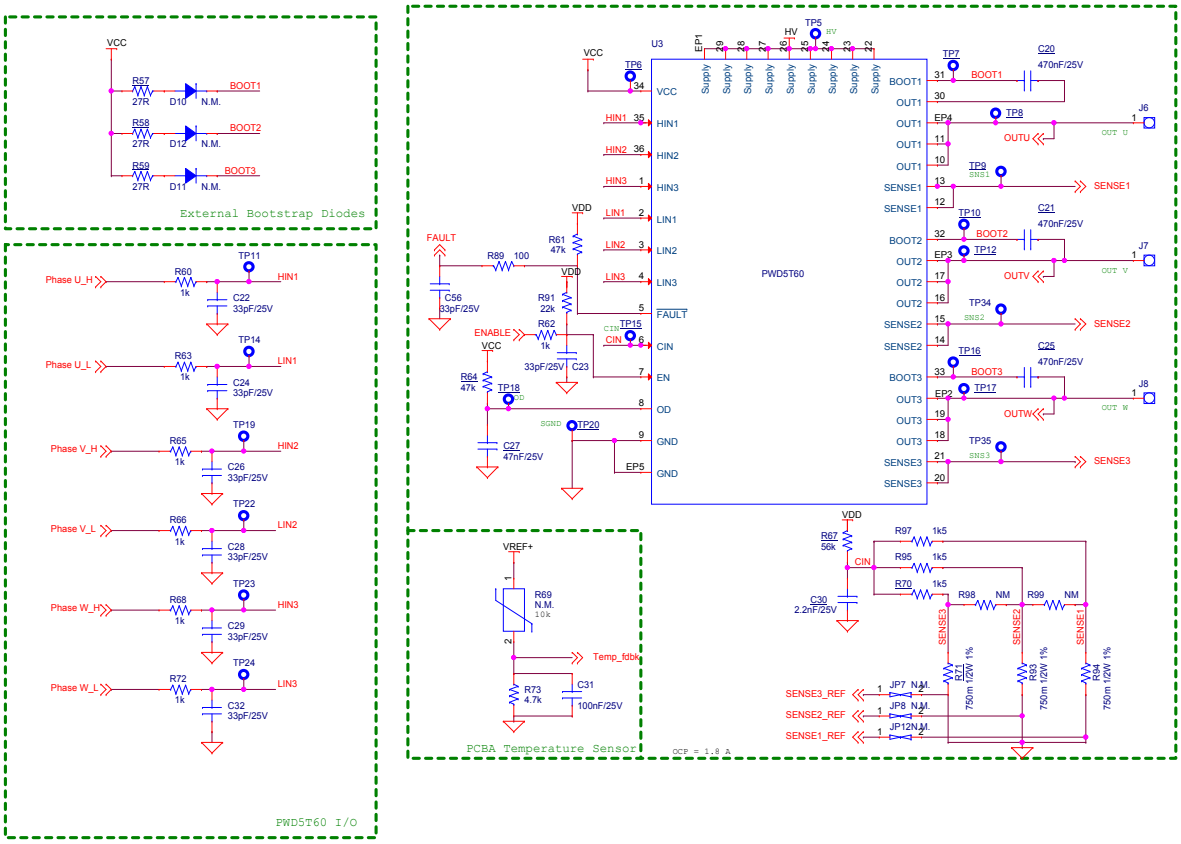


Figure 2. EVLPWD-FAN-PUMP schematic - MCU section

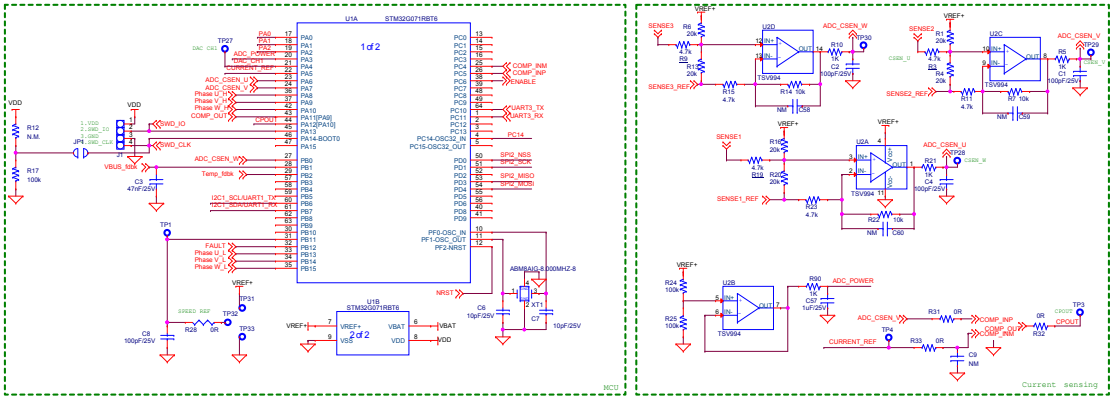
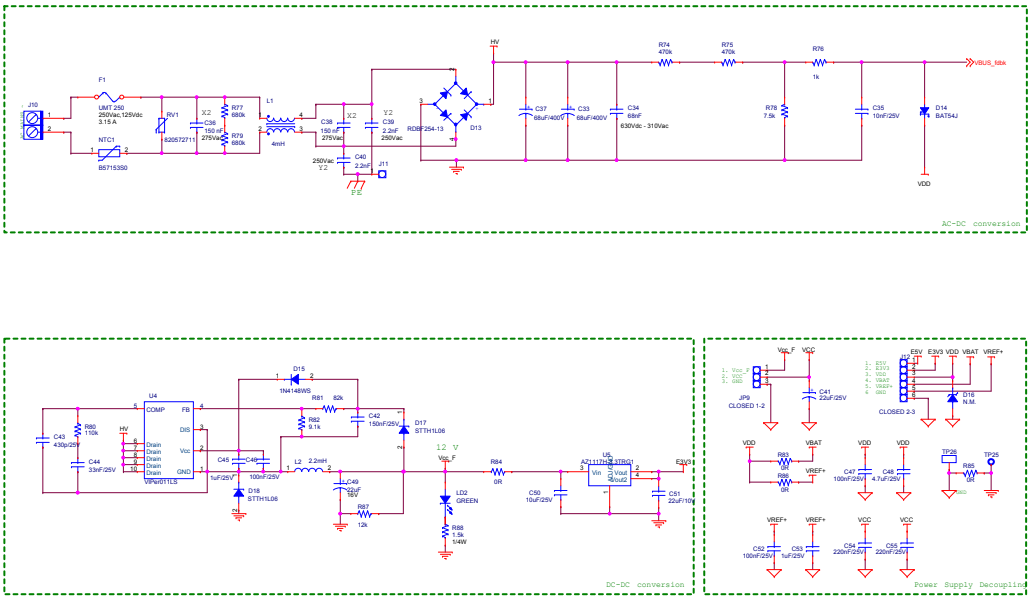


Figure 3. EVLPWD-FAN-PUMP - power supply



3 Bill of materials

Table 1. **EVLPWD-FAN-PUMP bill of materials**

Part reference	Part description	Part value	Package/manufacturer's code
C1, C2, C4, C8	SMT ceramic capacitor	100 pF/25 V	Size 0603
C3, C27	SMT ceramic capacitor	47 nF/25 V	Size 0603
C6, C7, C14, C15, C17	SMT ceramic capacitor	10 pF/25 V	Size 0603
C9, C12, C13, C16, C58, C59, C60	SMT ceramic capacitor	N.M.	Size 0603
C10, C18, C19, C31, C47, C52	SMT ceramic capacitor	100 nF/25 V	Size 0603
C11	SMT ceramic capacitor	1 nF/25 V	Size 0603
C20, C21, C25	SMT ceramic capacitor	470 nF/25 V	Size 0603
C22, C23, C24, C26, C28, C29, C32, C56	SMT ceramic capacitor	33 pF/25 V	Size 0603
C30	SMT ceramic capacitor	2.2 nF/25 V	Size 0603
C33, C37	THT electrolytic capacitor	68 µF/400 V	Diam. 16 mm, pitch 7.5 mm Würth Elektronik - 860021000000
C34	SMT ceramic capacitor	68 nF	Size 1210 Würth Elektronik 885342209005 or equivalent
C35	SMT ceramic capacitor	10 nF/25 V	Size 0603
C36, C38	WCAP-FTX2 film capacitors	150 nF	7 x 13 mm, pitch 10 mm Würth Elektronik 890324023025CS or equivalent
C39, C40	WCAP-CSSA ceramic capacitors	2.2 nF	Size 2211 Würth Elektronik 8853522130151 or equivalent
C41	SMD aluminum electrolytic capacitor	22 µF/25 V	5 x 5.4 mm Panasonic EEE1EA220WR or equivalent
C42	SMT ceramic capacitor	150 nF/25 V	Size 0603
C43	SMT ceramic capacitor	430 pF/25 V	Size 0603
C44	SMT ceramic capacitor	33 nF/25 V	Size 0603
C45	SMT ceramic capacitor	1 µF/25 V	Size 0805
C46	SMT ceramic capacitor	100 nF/25 V	Size 0805
C48	SMT ceramic capacitor	4.7 µF/25 V	Size 0603
C49	THT electrolytic capacitor	22 µF	Diam. 5 mm, pitch 2 mm
C50	SMT ceramic capacitor	10 µF/25 V	Size 0603
C51	SMT ceramic capacitor	22 µF/10 V	Size 1206
C53, C57	SMT ceramic capacitor	1 µF/25 V	Size 0603
C54, C55	SMT ceramic capacitor	220 nF/25 V	Size 0603
D4, D5, D8	Low current voltage regulator diodes	BZX38450-C3V3X	SOD-323 Nexperia BZX38450-C3V3X or equivalent

Part reference	Part description	Part value	Package/manufacturer's code
D6, D7, D9, D14	40 V, 300 mA small signal Schottky SMT diode	BAT54J	SOD-323 STMicroelectronics BAT54JFILM
D10, D11, D12	Turbo 2 ultrafast high-voltage rectifier	N.M.	SMA STMicroelectronics STTH1L06A
D13	2.5 A surface mount fast bridge rectifier	-	DBF Diodes Incorporated RDBF254-13 or equivalent
D15	Small signal fast switching diode	1N4148WS	SOD-323F Vishay 1N4148WS-E3-08/-E3-18 or equivalent
D16	3.3 V Zener diode	N.M.	SOD-123
D17, D18	Turbo 2 ultrafast high-voltage rectifier	STTH1L06	DO 41 STMicroelectronics STTH1L06RL or equivalent
F1	Surface Mount Fuse, time-lag T	5 A / 277 V slow	UMT250 Schurter 3403.0171.11
JP1	SMT jumper	Open	Soldering pad
JP2	SMT jumper	Closed	Soldering pad
JP3, JP4, JP6	SMT jumper	Open	Soldering pad
JP5	SMT jumper	Closed 2-4	Soldering pad
JP9	Strip connector	1x3 pins, 2.54 mm, closed 1-2	Amphenol FCI 68000-403HLF or equivalent
J1, J4	Strip connector	1x4 pins, 2.54 mm	Amphenol FCI 68000-404HLF or equivalent
J2	SMT Micro header	FTSH-107-01-L-DV-K-A	Pitch 1.27 Samtec
J3	Strip connector	1x5 pins, 2.54 mm	Würth Elektronik 68000-404HLF or equivalent
J5	Strip connector	1x5 pins, 2.54 mm	Amphenol FCI 68000-405HLF or equivalent
J6, J7, J8, J11	Soldering pad		Diam. 4.7 mm, hole diam. 2.4 mm
J10	Connector terminal block T.H.	MORSV-508-2P_screw	2 poles, pitch 5.08 mm Phoenix Contact 1715721 or equivalent
J12	Strip connector	1x6 pins, 2.54 mm, closed 2-3	Würth Elektronik 61300611121 or equivalent
LD1	Yellow LED	Yellow	Size 0603 Würth Elektronik 150060YS75000 or equivalent
LD2	Green LED	Green	Size 0603
L1	WE-CMB common-mode power line choke	4 mH	XS Würth Elektronik 744821240 or equivalent
L2	WE-PD HV SMT power inductor (high voltage)	2.2 mH	Size 1210 Würth Elektronik 7687709222 or equivalent

Part reference	Part description	Part value	Package/manufacturer's code
NTC1	NTC thermistor for inrush current limiting	10 Ω	Diam. 8.5 x L6 x H13 mm TDK B57153S0100M0 or equivalent
RV1	Disk varistor standard	275 V_{RMS}	Diam. 9 mm, pitch 5 mm Würth Elektronik 820572711 or equivalent
R1, R4, R6, R13, R16, R20	SMT resistor	20 kΩ	Size 0603
R3, R9, R11, R15, R19, R23,	SMT resistor	4.7 kΩ	Size 0603
R5, R10, R21, R60, R62, R63, R65, R66, R68, R72, R76, R90	SMT resistor	1 kΩ	Size 0603
R7, R14, R22, R44, R45, R46, R67	SMT resistor	10 kΩ	Size 0603
R12, R52, R53, R55	SMT resistor	N.M.	Size 0603
R17, R24, R25	SMT resistor	100 kΩ	Size 0603
R28, R31, R32, R33, R54, R83, R85, R86	SMT resistor	0 Ω	Size 0603
R34	SMT resistor	39 kΩ	Size 0603
R35	SMT resistor	330 Ω	Size 0603
R36, R37, R41, R42	SMT resistor	200 kΩ	Size 1206
R38, R39	SMT resistor	100 Ω	Size 0603
R40, R43, R56	SMT resistor	3.3 kΩ	Size 0603
R47, R48, R51	SMT resistor	1.8 kΩ	Size 0603
R49, R50	SMT resistor	180 kΩ	Size 1206
R57, R58, R59	SMT resistor	27 Ω	Size 0805
R61, R64	SMT resistor	47 kΩ	Size 0603
R69	NTC resistor	N.M.	Hole 0.8 mm
R70, R95, R97	SMT resistor	1.5 kΩ	Size 0603
R71, R93, R94	SMT resistor	750 mΩ/½ W/1%	Size 1206 TT Electronics LRC-LR1206LF-01-R500-F or equivalent
R73	SMT resistor	4.7 kΩ	Size 0603
R74, R75	SMT resistor	470 kΩ	Size 1206
R77, R79	SMT resistor	680 kΩ	Size 0805
R78	SMT resistor	7.5 kΩ	Size 0805
R80	SMT resistor	110 kΩ	Size 0603
R81	SMT resistor	82 kΩ	Size 0603
R82	SMT resistor	9.1 kΩ	Size 0603
R84	SMT resistor	0 Ω	Size 0805
R87	SMT resistor	12 kΩ	Size 0603
R88	SMT resistor	1.5 kΩ	Size 0805
R89	SMT resistor	100 Ω	Size 0603

Part reference	Part description	Part value	Package/manufacturer's code
R91	SMT resistor	22 kΩ	Size 0603
R98, R99	SMT resistor	N. M.	Size 0805
SW1, SW2	CMS tactile switches - 6x6 J-bend		Würth Elektronik 430483025816 or equivalent
TP1, TP3, TP4, TP5, TP7, TP8, TP9, TP10, TP11, TP12, TP14, TP15, TP16, TP17, TP18, TP19, TP22, TP23, TP24, TP25, TP27, TP28, TP29, TP30, TP34, TP35	Test point for probe	N.M.	Diam 1.27 mm, metallized hole, 0.8 mm
TP6	Ring test point, red	-	Diam. 2.54, hole 1 mm Vero Technologies 20-313137 or equivalent
TP20	Ring test point, black	-	Diam. 2.54, hole 1 mm Vero Technologies 20-2137 or equivalent
TP26	Ring test point, red	-	Diam. 2.54 mm, hole 1 mm Keystone 5003 or equivalent
TP31, TP32, TP33	Test point for probe	N.M.	Diam. 1.27 mm, metallized hole, 0.8 mm
U1	Arm Cortex®-M0+ 32-bit MCU, up to 128 KB Flash, 36 KB RAM, 4x USART, timers, ADC, DAC, comm. I/Fs, 1.7-3.6 V	STM32G071RBT6	LQFP64 STMicroelectronics
U2	Rail-to-rail input/output 20 MHz GBP op amp	TSV994	SO-14 STMicroelectronics TSV994IPT/IYDT or equivalent
U3	Compact high voltage 3-phase power stage with integrated gate driver	PWD5T60	VFQFPN 12 x 12 x 0.95 mm, 36 L STMicroelectronics PWD5T60/TR
U4	Low voltage energy-saving fixed frequency high voltage converter	VIPER011LS	SSOP10 STMicroelectronics VIPER011LSTR
U5	Low dropout linear regulator	AZ1117I	SOT223 Diodes Incorporated AZ1117H-3.3TRG1 or equivalent
XT1	Automotive & industrial grade ceramic base SMD crystal	8 MHz crystal	3.2 x 2.5 x 0.8 mm Abracon ABM8AIG-8.000 MHZ-8 or equivalent

4 Layout and component placements

Figure 4. **EVLPWD-FAN-PUMP layout - component placement (top view)**

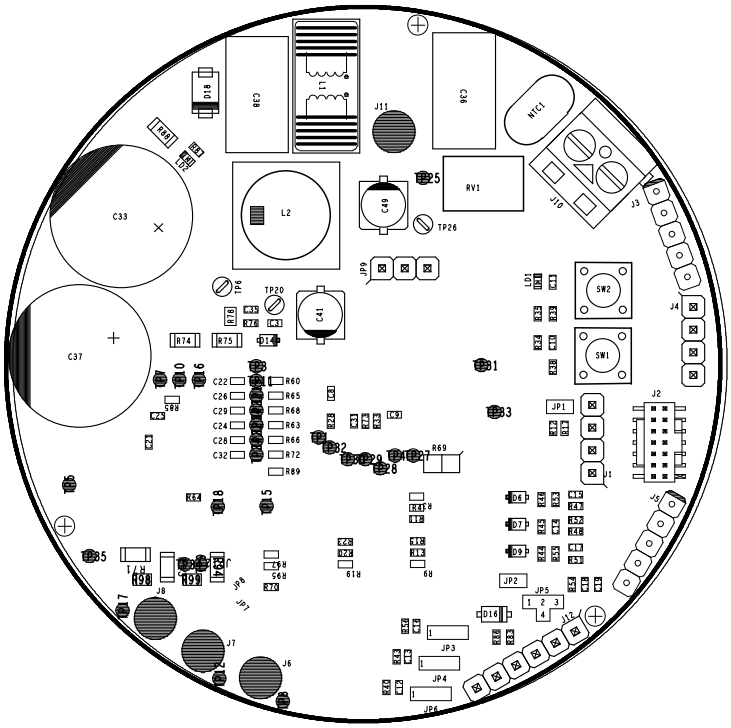


Figure 5. **EVLPWD-FAN-PUMP layout - component placement (bottom view)**

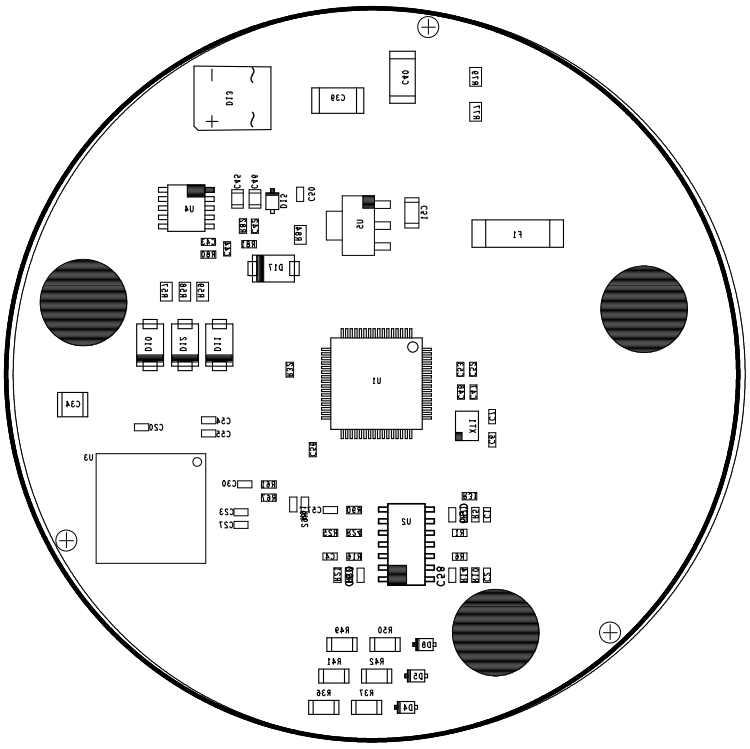


Figure 6. **EVLPWD-FAN-PUMP layout - top layer**

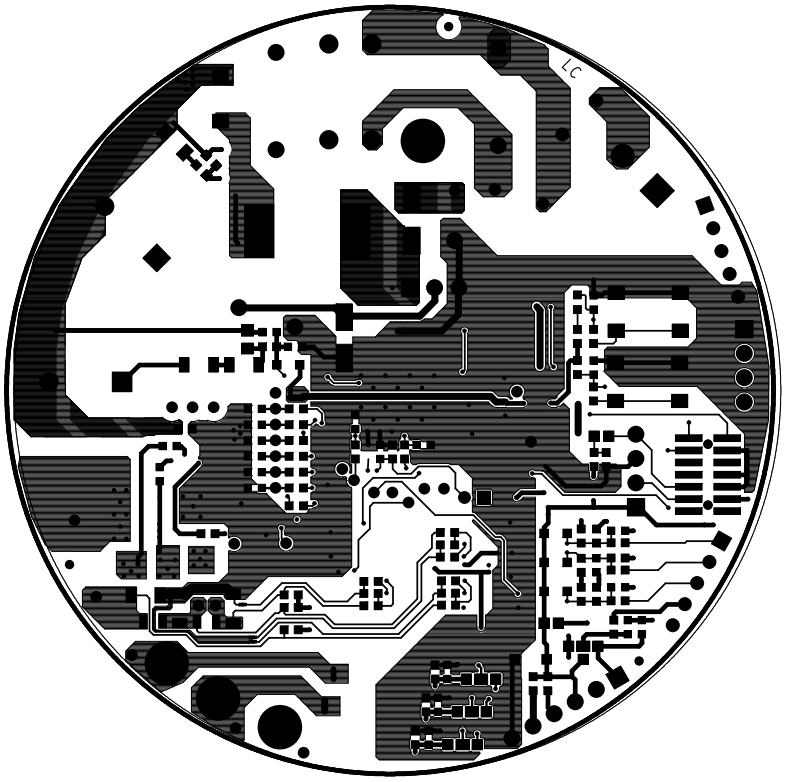
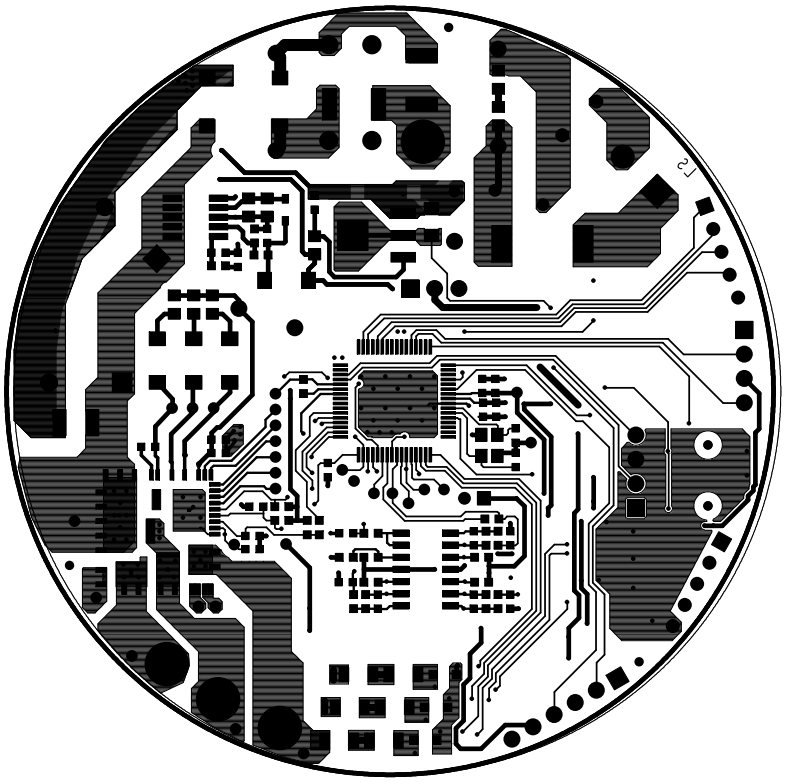


Figure 7. **EVLPWD-FAN-PUMP layout - bottom layer**



Revision history

Table 2. **Document revision history**

Date	Version	Changes
06-Jun-2024	1	Initial release.

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