HOLTEK

BLDC Motor Workshop
HVPB-A_V1.2 Hardware Description

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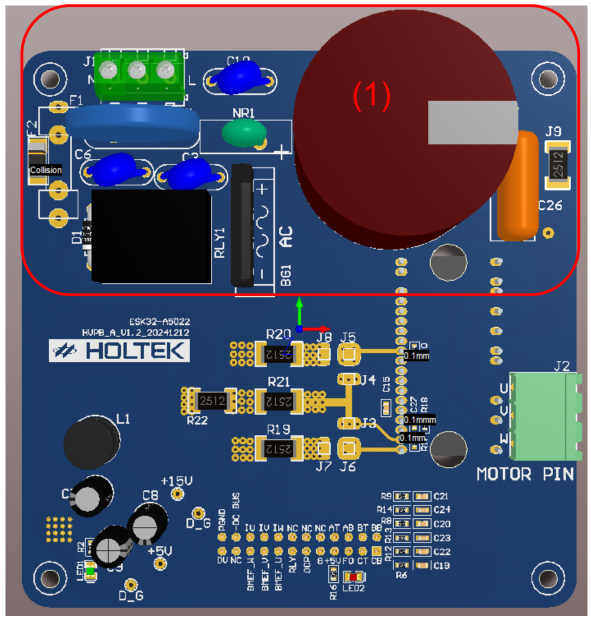
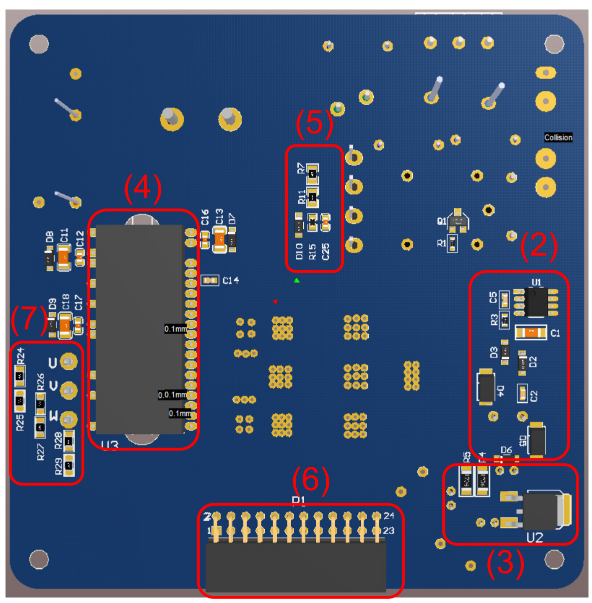
1. General Description

The BLDC Motor Workshop HVPB-A_V1.2 front view and back view are shown below. The component parts are: (1) AC-DC converter circuit. (2) DC-DC power converter circuit. (3) 5V LDO circuit. (4) IPM module. (5) Connector of the HVPB-A_V1.2. (6) DC bus voltage feedback circuit. (7) Back EMF detection circuit. The analog signal generated by the parts (6)~(7) can be read and converted by the MCU A/D converter.



(a)

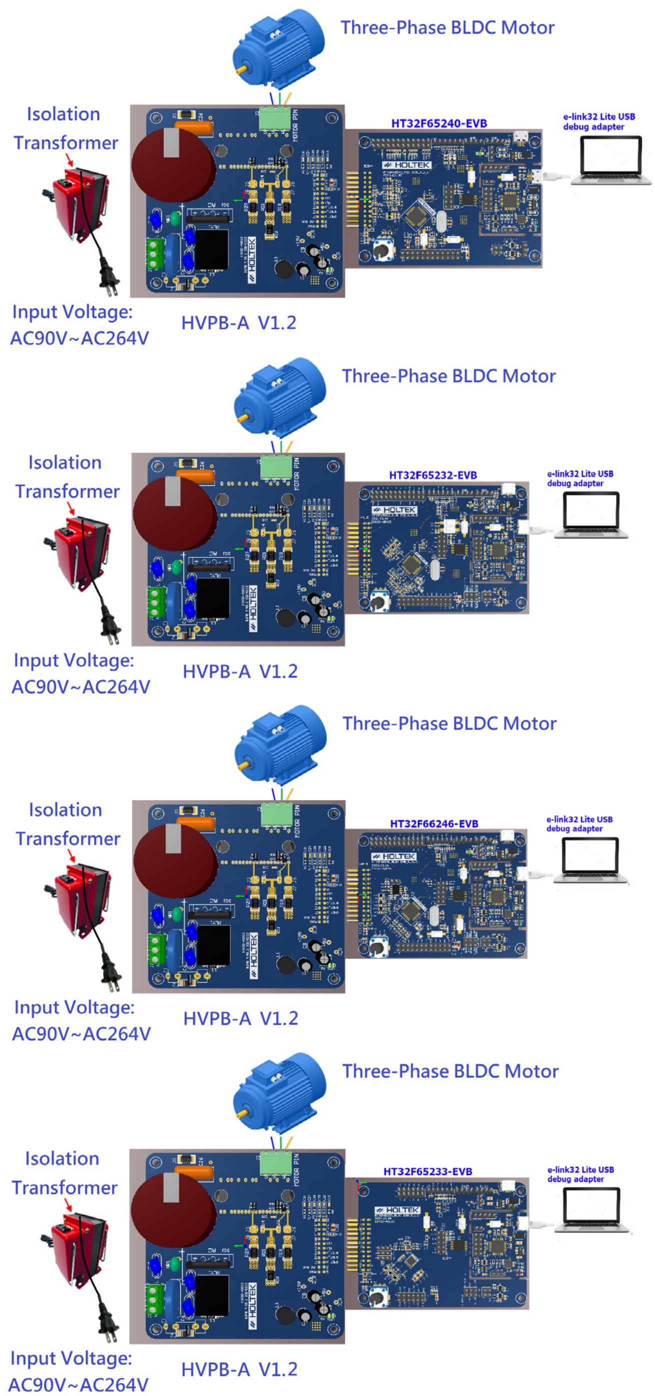


(b)

BLDC Motor Workshop HVPB-A_V1.2

(a) PCBA Front View; (b) PCBA Back View

The figures below show the HVPB-A_V1.2 development environment. If using the 1-shunt resistor sampling, users should connect the HT32F65232-EVB to HVPB-A_V1.2. If using the 2-shunt resistors sampling, users should connect the HT32F65233-EVB or HT32F65240-EVB to HVPB-A_V1.2. If using the 3-shunt resistors sampling, users should connect the HT32F66246-EVB to HVPB-A_V1.2. Then connect the relevant EVB board to PC using an USB cable, allowing the target MCU to communicate with the BLDC motor workshop. The input voltage range is AC 90V~264V. In addition, the HVPB-A_V1.2 power input end must be isolated via an isolation transformer.



HVPB-A_V1.2 Development Environment

Features

- Input voltage: AC 90V~264V
- Max. DC Bus current: 2.5A
- Max. motor phase current: 1.1A
- R_Shunt(Phase): 0.5Ω/2512/1%/2W
- DC Bus voltage divider ratio: 1/102
- Gate-Driver Polarity:
  (1) Low side active high
  (2) High side active high

As the above feature shows, the HVPB-A maximum motor phase current is 1.1A. However, the default hardware parameters are shown as follows:

(1) The HVPB-A R19, R20, R21 and R22 specifications are all 0.5Ω/2512/1%.

(2) The HT32F65240-EVB R13, R17, R21 and R23 specifications are all 180Ω.
The HT32F65240-EVB R15, R16, R19 and R22 specification are all 820Ω.
The HT32F65240-EVB R11 and R12 specifications are both 7.5KΩ.
The HT32F65240-EVB R26, R27, R29 and R30 specifications are all 15KΩ.

(3) The HT32F65232-EVB R23 specification is 180Ω.
The HT32F65232-EVB R22 specification is 820Ω.
The HT32F65232-EVB R12 specification is 7.5KΩ.
The HT32F65232-EVB R29 and R30 specifications are both 15KΩ.

Under these hardware parameters, the maximum motor operating phase current is:

$$I_{max} = \frac{2.5V}{R_{shunt} \times Gain} = \frac{2.5V}{0.5\Omega \times 7.5} = 0.667A$$

(4) The HT32F65233-EVB Gain is set internally, R13, R21, R17 and R23 specifications are all 0Ω.
Adjust the Gain value, the maximum motor operating phase current is:

$$I_{max} = \frac{2.5V}{R_{shunt} \times Gain} = \frac{2.5V}{0.5\Omega \times 8} = 0.63A$$

(5) The HT32F66246-EVB Gain is set internally, R20, R24, R30, R12, R22 and R29 specifications are all 0Ω.
Adjust the Gain value, the maximum motor operating phase current is:

$$I_{max} = \frac{2.5V}{R_{shunt} \times Gain} = \frac{2.5V}{0.5\Omega \times 8} = 0.63A$$

If users want to adjust the maximum motor operating phase current to 1.1A, the following actions are required:

(1) Change the HVPB-A R19, R20 and R21 specifications to 0.1Ω/2512/1%.

(2) Change the HT32F65240-EVB R15, R16, R19 and R22 specifications from 820Ω to 150Ω.

(3) Change the HT32F65232-EVB R16 specification from 1KΩ to 330Ω and change R22 specification from 820Ω to 150Ω.

(4) For the HT32F65233-EVB, there is no need to adjust the resistors, only adjust the internal PGA Gain, as shown below:

$$I_{max} = \frac{2.5V}{R_{shunt} \times Gain} = \frac{2.5V}{0.1\Omega \times 24} = 1.04A$$

(5) For the HT32F66246-EVB, there is no need to adjust the resistors, only adjust the internal PGA Gain, as shown below:

$$I_{max} = \frac{2.5V}{R_{shunt} \times Gain} = \frac{2.5V}{0.1\Omega \times 24} = 1.04A$$

With these configurations, the HVPB-A maximum motor operating phase current can be changed from 0.63A/0.667A to 1.04A/1.1A. In addition, when designing the Gain and R_Shunt, it is necessary to pay attention to the motor operating phase current range, which cannot be larger than its maximum sampling value. If the motor operating phase current range is too wide, the sampling resolution will be affected.

2. Schematics

This chapter will present the schematics and explain the HVPB-A hardware circuit as shown in sections from 2-1 to 2-5.

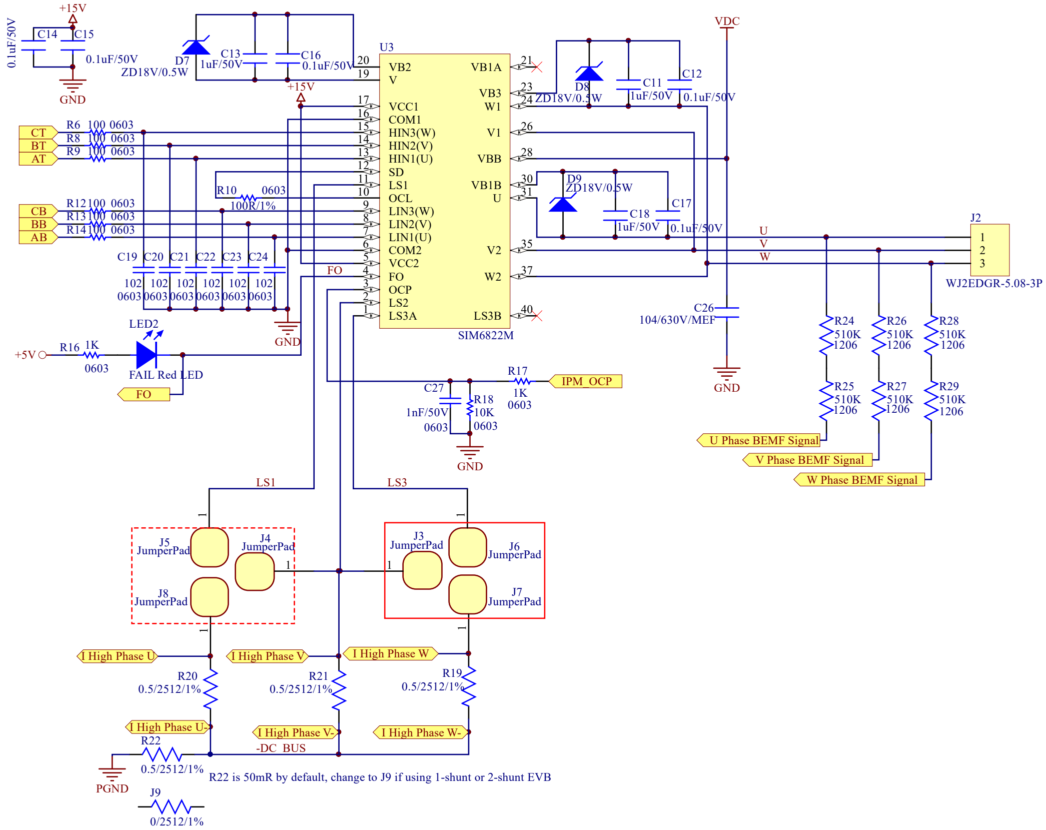
2-1 Driver Circuit

The first figure below shows the driver circuit. The IPM module adopts the SIM6822M, which has integrated the gate-driver and three phase MOSFETs. The PWM signals output by the MCU can be connected to this IPM module for switch driving.

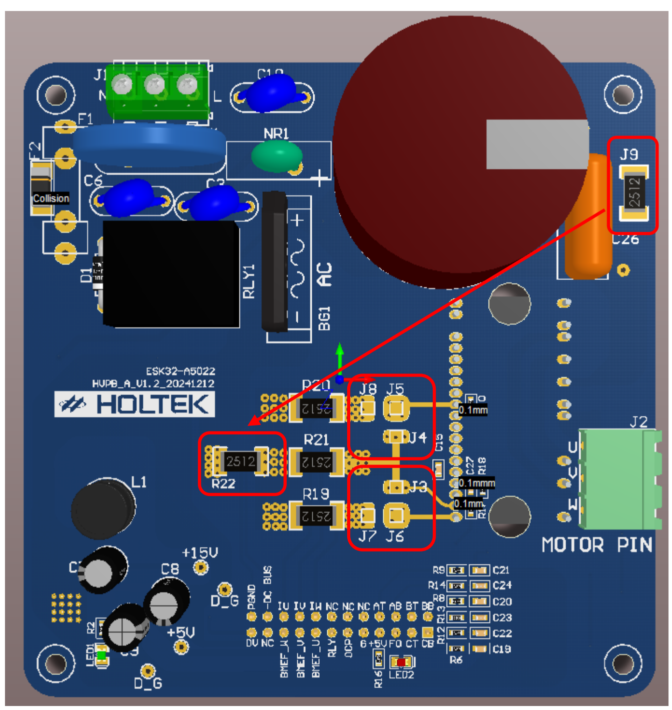
In addition, the circuit includes the over current input signal pin, IPM_OCP. When a motor over current condition is detected, the MCU will output a high level signal to the IPM module OCP pin. This will make the IPM module high side and low side MOSFETs be turned off forcibly, and pull the error return signal pin FO to ground, in which case LED2 will be on to inform users that a system over current error occurs.

For jumper pads, if the HT32F65240-EVB is selected, J5 should be shorted to J8 and J6 should be shorted to J7. R22 should be changed to J9(0R). The shunt resistors are used to feedback motor phase current signals to MCU for FOC closed-loop control, and also feedback them to MCU internal comparators for three-phase over current protection. If the HT32F65232-EVB is selected, J5 should be shorted to J4 and J6 should be shorted to J3. R22 should be changed to J9(0R). If the HT32F65233-EVB or HT32F66246-EVB is selected, the source electrode of the low side MOSFETs should be connected to the shunt resistors, R20 and R19, that is, J5 should be shorted to J8 and J6 should be shorted to J7. The default voltage of R-shunt terminal is advanced to the MCU integrated OPA to amplify the signal, and then enter the internal comparator for over current protection. The hardware default value of these resistors are 0.05Ω/2512. Users should pay attention that the resistance rated power should be more than 2W if want to change the resistance.

IPM



Driver Circuit



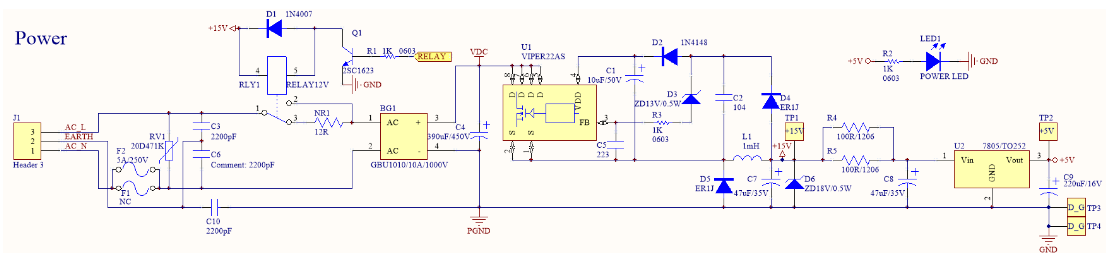
Jumper Pad Location

2-2 System Power Circuit (AC-DC, DC-DC, LDO)

The figure below shows the system power circuit. Firstly, the AC source, either 110VAC or 220VAC, is input to the HVPB-A through the connector J1. At the instant of initial power supplying, the AC source will be sent into the component NR1 for start-up current limitation, and then be converted to DC source via the bridge rectifier circuit GBU1010 and the regulation capacitor C4. After the power supply instant, the MCU sends a RELAY signal to relay, making the AC source bypass the NR1 path and directly input to the bridge rectifier circuit GBU1010 and the regulation capacitor C4 for DC source conversion. If the AC source is 110VAC, the converted DC source will be 155VDC; if the AC source is 220VAC, the converted DC source will be 310VDC.

Then, the DC source will be reduced to 15V by the DC-DC power converter U1, its component model is VIPER22AS. This 15V voltage is mainly used for IPM module power supply.

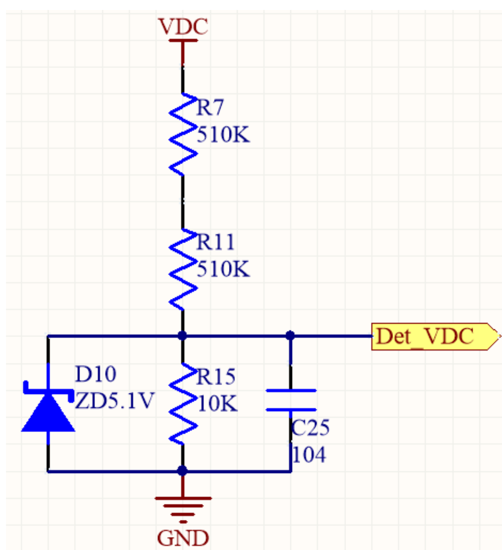
Finally, the 5V LDO, the LM7805 component, outputs a voltage of 5V to supply power for MCU components by being connected to the MCU-EVB through the connector P1. In addition, users can check the LED1 to determine whether the HVPB-A circuit supplies power to the EVB board successfully.



System Power Circuit

2-3 DC Bus Voltage Feedback Circuit

The figure below shows the DC bus voltage feedback circuit. In hardware design, the ratio of the Det_VDC feedback signal and the actual VDC voltage is 1/102 by default. The current VDC voltage can be calculated by the voltage read from MCU ADC together with the hardware reduction ratio.



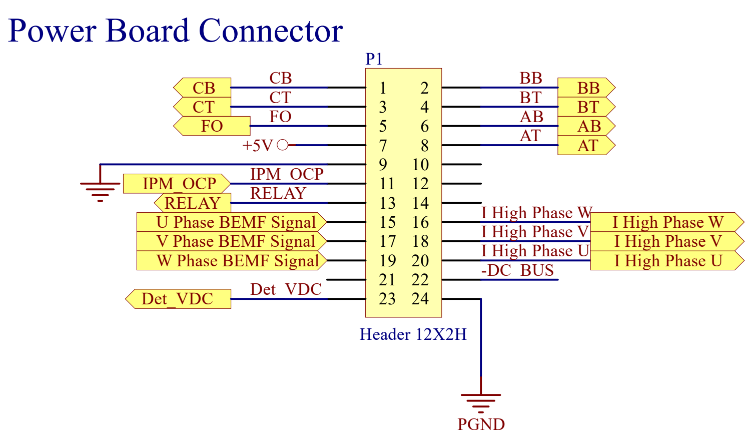
DC Bus Voltage Feedback Circuit

2-4 Connector of HVPB-A

The figure below shows the connector circuit of HVPB-A. The pins include the gate-driver input signals, AT, AB, BT, BB, CT and CB, the DC bus voltage feedback signal Det_VDC, three phase current feedback signals, I High Phase U, I High Phase V and I High Phase W, the 5V LDO output voltage, the MCU output relay control signal RELAY, the MCU output IPM module over current turn-off signal IPM_OCP, the IPM module output error return signal FO, U Phase BEMF Signal, V Phase BEMF Signal and W Phase BEMF Signal. The pin definitions are shown in the following table.

Pin No.	Definition	Pin No.	Definition
1	CB	2	BB
3	CT	4	BT
5	FO	6	AB
7	5V	8	AT
9	GND	10	NC
11	IPM_OCP	12	NC
13	RELAY	14	NC
15	U Phase BEMF Signal	16	I High Phase W
17	V Phase BEMF Signal	18	I High Phase V
19	W Phase BEMF Signal	20	I High Phase U
21	NC	22	-DC_BUS
23	Det_VDC	24	PGND

Pin Definition for the Connector of HVPB-A

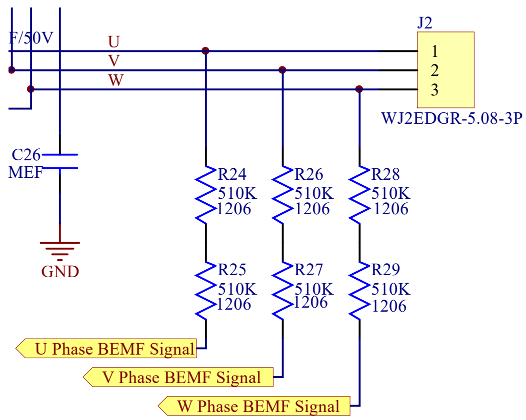


HVPB-A Connector Circuit

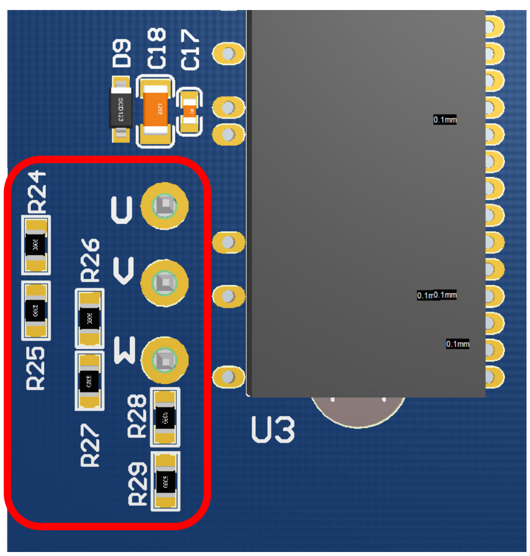
2-5 Back EMF Detection Circuit

The figures below show the Back EMF detection circuit, which is used to detect the motor phase voltage. It is recommended that the divided voltage should not exceed 4V. For the HT32F65232-EVB, the resistance of the divided voltage point to the ground, R117, R118 and R119, are fixed at 10KΩ. Assuming that the highest input voltage of the HVPB-A power board is AC 264V, that is DC 373V, and the resistance of the divided voltage point to the phase voltage of the power board is 1020KΩ. Due to the withstanding voltage, the HT32F65232-EVB should be connected to the power board in series. The divided voltage can be calculated as:

$$373V \times \left(\frac{10K\Omega}{10K\Omega + 1020K\Omega}\right) = 3.62V$$



(a)



(b)

Back EMF Detection Circuit

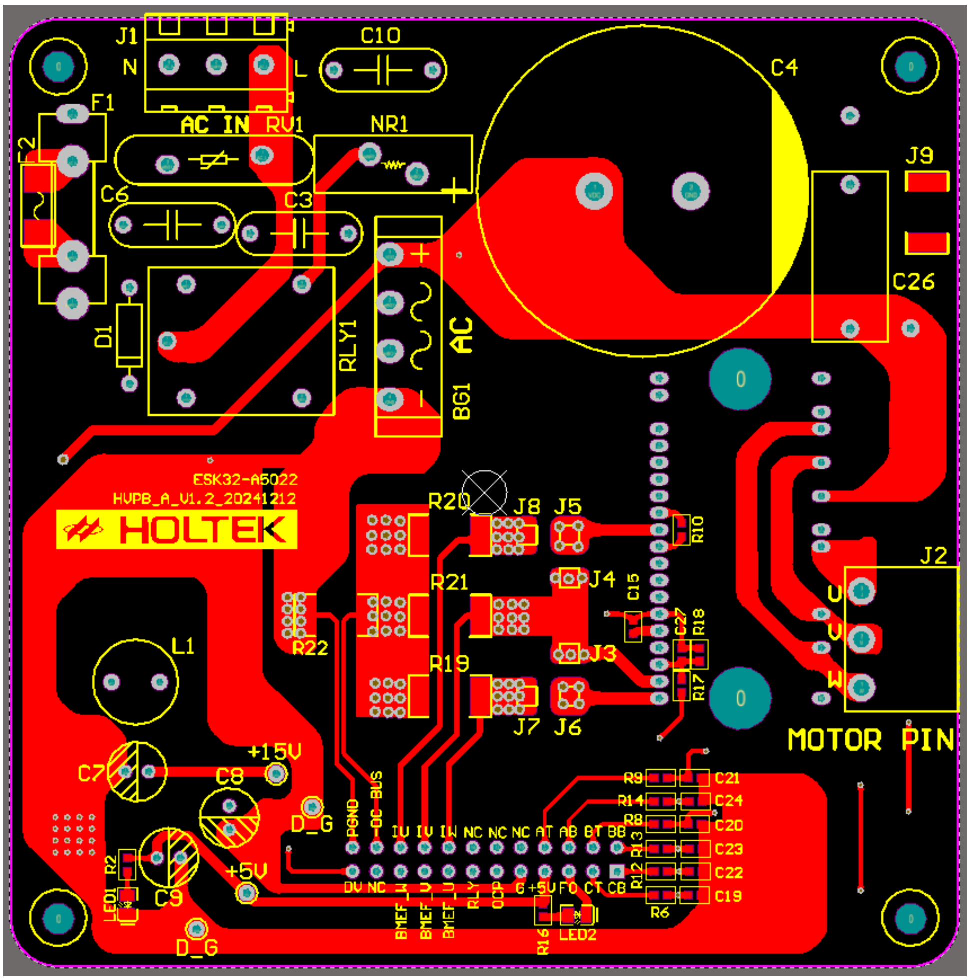
(a) Back EMF Detection Circuit; (b) Component Position (Bottom Layer)

3. PCB Layout

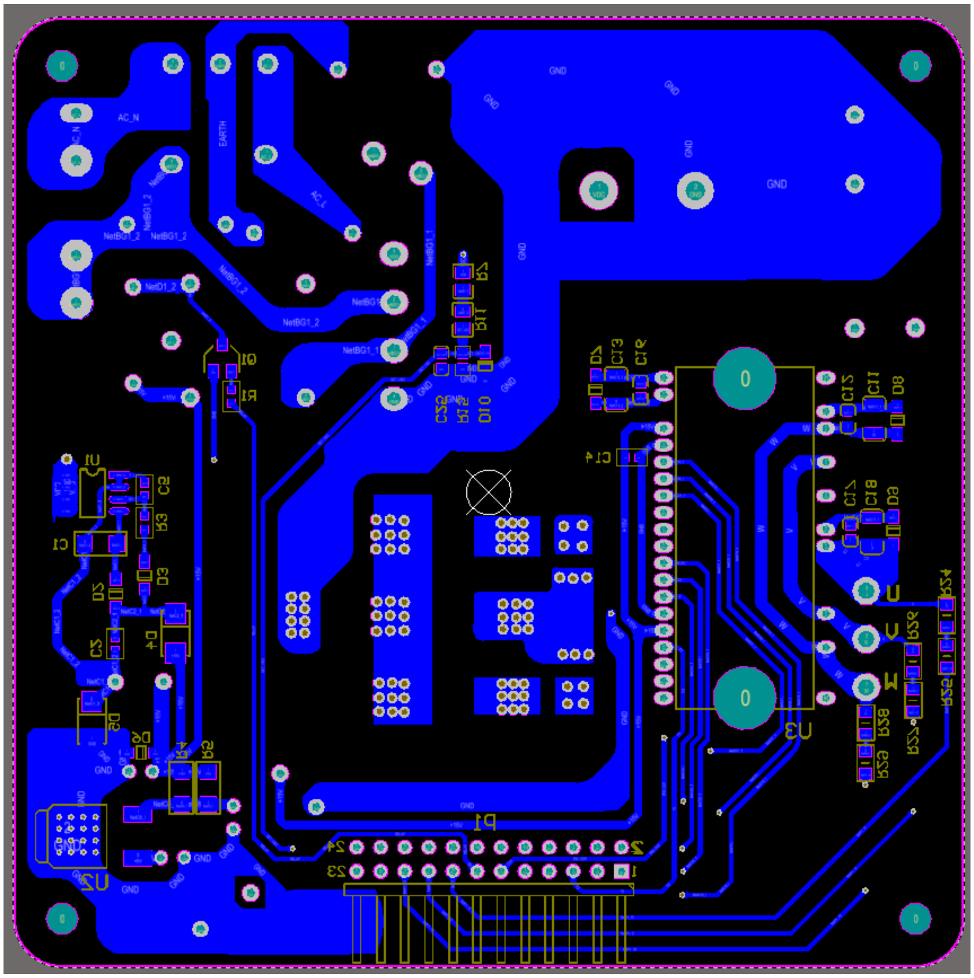
The figures below show the HVPB-A Layout, the detailed specifications are shown in the table below.

Length×Width	100×100 (mm)
Thickness	1.6 (mm)
Number of Layers	2
Copper Foil Thickness	1 (Oz)
Material	FR-4
Solder Mask Layer Color	Blue

HVPB-A Board Specifications



(a)



(b)

BLDC Motor Workshop HVPB-A PCB Layout

(a) Top Layer; (b) Bottom Layer

4. BOM List

The following table shows the HVPB-A BOM List, which lists all the required components for a set of circuit board.

No.	Comment	Footprint	Designator	Quantity
1	MLCC 0.1μF ±10% 50V X7R 0603	0603	C2, C14, C15, C12, C16, C17, C25	7
2	MLCC 1nF ±10% 50V X7R 0603	0603	C19, C20, C21, C22, C23, C24, C27	7
3	MLCC 22nF ±10% 50V X7R 0603	0603	C5	1
4	SMD Resistor 1KΩ ±1% 0603	0603	R1, R2, R3, R16, R17	5
5	SMD Resistor 10KΩ ±1% 0603	0603	R18, R15	2
6	SMD Resistor 100Ω ±1% 0603	0603	R6, R8, R9, R10, R12, R13, R14	7
7	SMD red LED, plain bright	0805_LED	LED2	1
8	SMD green LED, plain bright	0805_LED	LED1	1
9	SMD Resistor 510KΩ ±1%	0805	R7, R11, R24, R25, R26, R27, R28, R29	8
10	MLCC 10μF ±10% 50V X7R 1206	1206	C1	1
11	MLCC 1μF ±10% 50V X7R 1206	1206	C11, C13, C18	3
12	SMD Resistor 100Ω ±1% 1206	1206	R4, R5	2
13	SMD Resistor 2512-2W-500mR-1%	2512	R19, R20, R21, R22	4
14	SMD Resistor 2512-1W-0R-1%	2512	J9	1
15	SMD diode ER1J 600V/1A	DO-214AC	D4, D5	2
16	SMD diode 1N4148 SOD-123	SOD-123	D2	1
17	IC VIPER22AS	SO-8	U1	1
18	SMD zener diode 5.1V/0.5W	SOD-123	D10	1
19	SMD zener diode 18V/0.5W	SOD-123	D6, D7, D8, D9	4
20	SMD voltage regulator diode 13V/0.5W	SOD-123	D3	1
21	SMD transistor NPN 60V 2SC1623	SOT-23	Q1	1
22	SMD LDO L78M05CDT-TR	TO-252AA	U2	1
23	FUSE 5A/250V	FUSE_S6125	F2	1
24	WJ2EDGR-5.08-3P	3EHDR_3P	J2	1
25	Bridge GBU1010/10A/1000V	GBU	BG1	1
26	Electrolytic capacitor, 47μF/35V, (5×11)	CEC6.3_V_P2.5	C7, C8	2
27	Electrolytic capacitor, 220μF/16V, (5×11)	CEC6.3_V_P2.5	C9	1
28	Inductor 1mH PK0810-102KB	COIL2_RC0810	L1	1
29	WJ500V-5.08-3P	P5.00_WJ128V	J1	1
30	Y capacitor 2.2nF ±20% 400V	CY_V_P10.4	C3, C6, C10	3
31	Diode 1N4007 1KV/1A	DO-41	D1	1
32	PM254-2-12-W-8.5, 90 degrees, P=2.54mm	HDR2X12H	P1	1
33	IPM SIM6822M	IPM_SAM68XX	U3	1
34	CBB capacitor 104/630V/MEF	RAD0.6A	C26	1
35	Electrolytic capacitor 390μF/450V	RB_POWER	C4	1
36	NTC NTC12D-7	W6.0-P7.50-D1.0	NR1	1
37	Power relay HF3FF/012-1ZS	RW-12SH-1C-P	RLY1	1
38	MOV 20D471K 470V	MOV_21D_V_P10	RV1	1

BLDC Motor Workshop HVPB-A BOM List