BLDC Motor Workshop Hardware Description – HT32F65232 BLDC-EVB

Revision: V1.00 Date: September 22, 2022

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1. Introduction

The Brushless DC (BLDC) Motor Workshop HT32F65232 BLDC-EVB is shown in Figure 1-1. The EV board utilises the BLDC motor driver dedicated MCU, the HT32F65232, which is a Holtek 32-bit Arm® Cortex®-M0+ high performance, low power microcontroller designed for Cortex®-M0+ entry level. The BLDC-EVB aims to provide users with a low cost platform and the convenience of rapid application development, thereby realising a complete solution for evaluation, development and production. The EV board includes an integrated e-Link32 Lite, which can be directly connected to the Keil μVision program development environment through a USB cable and is used together with standard C language for development or online emulation testing. In addition, the EV board can be simultaneously connected to the BLDC Motor Workshop for online real-time control parameter adjustment and dynamic response monitoring. Users can also select a suitable companion power board according to the voltage/current range of the actual applications. There are three power boards provided for selection, namely the high voltage AC power board, the medium voltage DC power board and the low voltage DC power board.

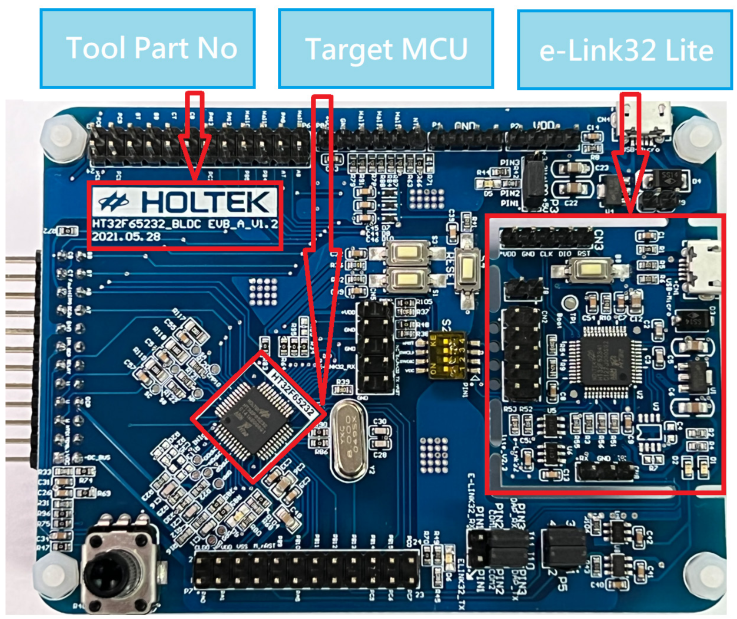


Figure 1-1 BLDC Motor Workshop HT32F65232 BLDC-EVB

Features

- Operating frequency up to 60MHz
- 32KB Flash, 4KB SRAM
- Uses an HT32 high performance microcontroller, which has integrated a wide range of peripherals including Timers, I²C, SPI, USART, UART, PDMA, Hardware Divider, 12-bit A/D converters, OPAs and CMPs, etc.
- Composed of a target board and e-Link32 Lite USB debug adapter
- Powered by the target board external power supply or through the e-Link32 Lite USB, the power can be selected to be either 5V or 3.3V

2. Hardware Settings

Figure 2-1 shows the BLDC Motor Workshop BLDC-EVB component placement. In this section, the details of the circuit board, such as external I/O ports, the switch condition and jumper resistors will be described in the tables of the following chapters.

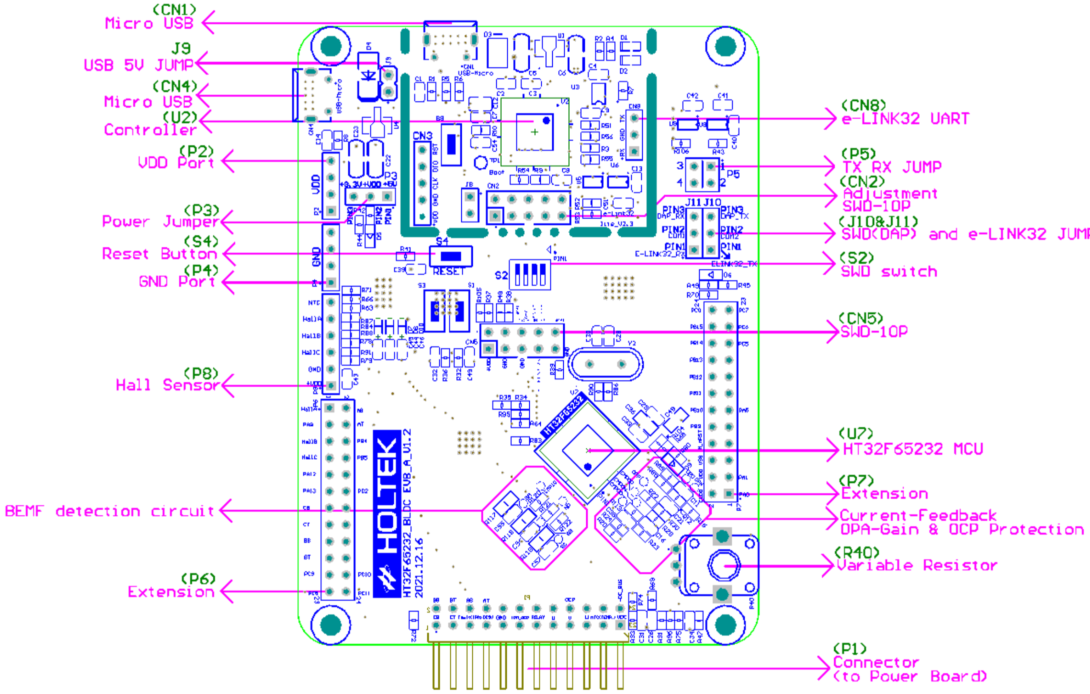


Figure 2-1 HT32F65232 BLDC-EVB Component Placement

2-1 Serial Wire Debug Interface Switch

The DIP switch, S2, is used to connect or disconnect the connection between the e-Link32 and the target MCU code programing port. The switch states are shown in Table 2-1.

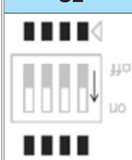
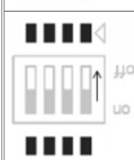
S2	Setting
	When the DIP switch S2 is switched to ON, the target MCU SWD interface port will be connected with the e-Link Lite. Users can connect the EV board to the PC by plugging a Micro USB cable into CN1 for target MCU code programing or online emulation testing.
	When the DIP switch S2 is switched to OFF, the SWD interface connection between the target MCU and the e-Link32 Lite will be disconnected. In this case, users should connect the EV board and external programmer through CN5 for target MCU code programing or online emulation testing – default state.

Table 2-1 Serial Wire Debug Interface Switch Setting – S2

2-2 SWD-10P Ports

The CN2 and CN5 components are SWD-10P Ports used to connect the BLDC-EVB to an external programmer, the pin definitions are shown in Figure 2-2 and Table 2-2.

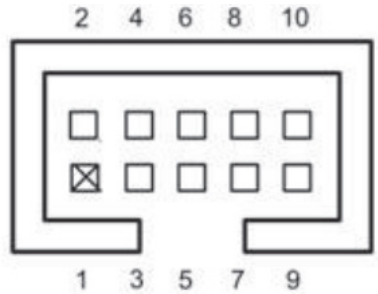


Figure 2-2 SWD-10P Port Component Schematic – CN2, CN5

Pin No.	Definition	Pin No.	Definition
1	+VDD	2	SWDIO
3	GND	4	SWCLK
5	GND	6	NC
7	RX	8	TX
9	GND	10	Reset

Table 2-2 SWD-10P Port Pin Definitions – CN2, CN5

2-3 Type B Micro USB Ports

When S2 is switched to ON, users can carry out code programming or online emulation testing through the Micro USB CN1.

The Micro USB CN4 is only used for converting the 5V power supply to 3.3V. It does not support the same function with the Micro USB CN1. The Type B Micro USB port pin definitions are shown in Figure 2-3 and Table 2-3.

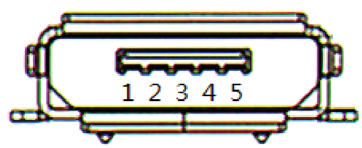


Figure 2-3 Type B Micro USB Port Component Schematic – CN1, CN4

Pin No.	Definition	Pin No.	Definition
1	DC+5V	2	D-
3	D+	4	NC
5	GND	—	—

Table 2-3 Type B Micro USB Port Pin Definitions – CN1, CN4

2-4 Target MCU +VDD Power Supply Setting

The target MCU power source can be selected to be either 5V or 3.3V using the P3 port. The details are shown in Table 2-4.

P3	Setting
	Short the +VDD on the P3 port with the 5V power, the target MCU power source is selected to be 5V – default state.
	Short the +VDD on the P3 port with the 3.3V power, the target MCU power source is selected to be 3.3V, which is sourced from the Micro USB CN4 and output by the 3.3V LDO (U4).

Table 2-4 Target MCU Power Source +VDD Setting – P3

2-5 Power Ports

P2 and P4 are the power ports representing +VDD and GND respectively, the details are shown in Table 2-5.

Port No.	Definition
P2	The +VDD selection of P3 for either 5V or 3.3V will affect the voltage value on P2 port.
P4	P4 is the GND port.

Table 2-5 Power Port Definitions – P2, P4

2-6 Boot Option Setting (located on the board reverse side)

It is recommended that users should carry out FOC project development in the default environment. The jumper resistors R34 and R35 conditions are shown in Table 2-6.

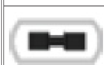
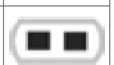
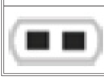
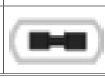
R34	R35	Setting
		Open R35, the target MCU boots from the main flash – default state.
		
		Short R35, the target MCU boots from the bootloader – ISP.

Table 2-6 Boot Option Setting (located on the board reverse side) – R34, R35

2-7 High Speed External Crystal Oscillator (HSE) Option Setting

It is recommended that users should carry out FOC project development in the default environment. Short R86 and R90, after which the XTALIN and XTALOUT pins of the target MCU will be connected to an external oscillator Y2, the jumper resistors R86 and R90 conditions are shown in Table 2-7.

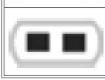
R86, R90	Setting
	Short R86 and R90, the HSE I/O pins are connected to Y2, switch on HSE – default state.
	Open R86 and R90, the HSE I/O pins are disconnected with Y2, switch on HIS.

Table 2-7 High Speed External Crystal Oscillator (HSE) Option Setting – R86, R90

2-8 USART TX and RX Pins Connection Setting

It is recommended that users should carry out FOC project development in the default environment. By shorting Pin1 to Pin2 and Pin3 to Pin4 on the P5 port, users can connect the target MCU to the BLDC Motor Workshop through the Micro USB CN1. CN1 can also connect to Keil for online emulation testing simultaneously.

If the pins are not shorted, users should connect the PB9 and PB12 pins on port P7 to the external UART-to-USB converter to implement the desired connection between the target MCU and the BLDC Motor Workshop. The shorted pin conditions are shown in Table 2-9.

P5 (Pin1-to-Pin2, Pin3-to-Pin4)	Setting
	If Pin1-to-Pin2 of P5 and Pin3-to-Pin4 of P5 are shorted, the target MCU USART-TX pin and USART-RX pin will be connected to the USART Level Shift IC, and users can transmit or receive data through CN1.
	If these pins are opened, the target MCU USART-TX pin and USART-RX pin will not be connected to the USART Level Shift IC, users can only transmit or receive data through P7.

Table 2-8 Shorted Pin Setting Between USART TX, RX and UART Level Shift Chip – P5

2-9 3.3V LDO U4 Input 5V Power Supply Setting

Users can select the U4_3.3V LDO to input a 5V power through the jumper pin J9, the details are shown in Table 2-9.

J9 (Pin1-to-Pin2)	Setting
	The J9 jump short represents the CN1 USB_5V can supply power to 3.3V LDO U4.
	The J9 jump open represents the CN4 USB_5V can supply power to 3.3V LDO U4.

Table 2-9 3.3V LDO U4 Input 5V Power Setting – J9

2-10 Extension Connector P6 Definition

The BLDC-EVB has bounded parts of the target MCU pins to the P6 port, providing users with a convenient means for signal measurement and testing. Details are shown in Figure 2-4 and Table 2-10.

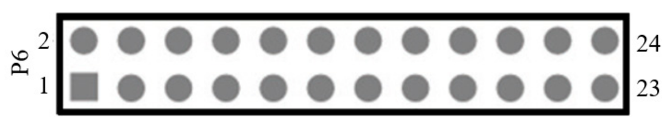


Figure 2-4 Extension Connector P6 Component Schematic

Pin No.	Definition	Pin No.	Definition
1	Hall Sensor A	2	PWM AB
3	GPIO (PA9)	4	PWM AT
5	Hall Sensor B	6	GPIO (PB4)
7	Hall Sensor C	8	GPIO (PB5)
9	GPIO (PA12)	10	NC
11	GPIO (PA13)	12	GPIO (PC2)
13	PWM CB	14	NC
15	PWM CT	16	NC
17	PWM BB	18	NC

Pin No.	Definition	Pin No.	Definition
19	PWM BT	20	NC
21	GPIO (PC9)	22	GPIO (PC10)
23	GPIO (PC8)	24	GPIO (PC11)

Table 2-10 Extension Connector P6 Pin Definitions

2-11 Extension Connector P7 Definition

The BLDC-EVB has bounded parts of the target MCU pins to the P7 port, providing users with a convenient means for signal measurement and testing. Details are shown in Figure 2-5 and Table 2-11.

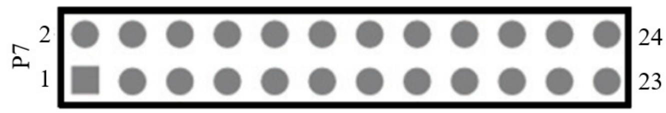


Figure 2-5 Extension Connector P7 Component Schematic

Pin No.	Definition	Pin No.	Definition
1	GPIO (PA0)	2	CLDO
3	GPIO (PA1)	4	VDD
5	NC	6	VSS
7	NC	8	M_nRST
9	NC	10	GPIO (PB9)
11	GPIO (PA5)	12	GPIO (PB10)
13	NC	14	GPIO (PB11)
15	NC	16	GPIO (PB12)
17	NC	18	GPIO (PB13)
19	GPIO (PC5)	20	GPIO (PB14)
21	GPIO (PC6)	22	GPIO (PB15)
23	GPIO (PC7)	24	GPIO (PC0)

Table 2-11 Extension Connector P7 Pin Definitions

2-12 Power Board Connector P1 Definition

The BLDC-EVB is connected to the power board through the P1 port. Details are shown in Figure 2-6 and Table 2-12.

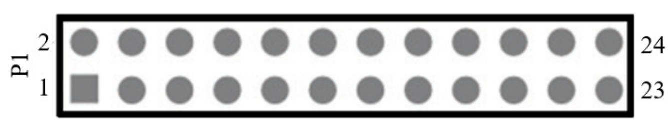


Figure 2-6 Power Board Connector Component Schematic – P1

Pin No.	Definition	Pin No.	Definition
1	PWM CB	2	PWM BB
3	PWM CT	4	PWM BT
5	IPM Fault Signal	6	PWM AB
7	+5V	8	PWM AT
9	GND	10	NC
11	IPM OCP Signal	12	NC
13	RELAY Signal	14	NC
15	U Phase BEMF Signal	16	NC
17	V Phase BEMF Signal	18	OCP
19	W Phase BEMF Signal	20	NC
21	TEMP Feedback Signal of Power Board	22	-Idc Bus Current Feedback Signal
23	Vdc Feedback Signal	24	Power GND

Table 2-12 Power Board Connector Pin Definitions – P1

2-13 e-Link32 Lite and SWD USART TX, RX Ports

By shorting Pin1-to-Pin2 and Pin3-to-Pin4 on the P5 port, users can connect the USART interface to the BLDC Motor Workshop through the the jumper pins J10 and J11. Details are shown in Table 2-13.

J10	Setting
Pin3 DAP_TX Pin2 COM2 Pin1 e-Link32 TX	Jump short Pin1-Pin2: Using e-Link32 USART_TX Jump short Pin2-Pin3: Using SWD(DAP) USART_TX
J11	**Setting**
Pin3 DAP_RX Pin2 COM1 Pin1 e-Link32_RX	Jump short Pin1-Pin2: Using e-Link32 USART_RX Jump short Pin2-Pin3: Using SWD(DAP) USART_RX

Table 2-13 e-Link32 Lite USART Port and SWD USART Port Setting – J10 and J11

3. Schematics

This section will present the schematics and explain the BLDC-EVB hardware circuit. The details are described in the the following chapters.

3-1 Target MCU Pin Configurations and Peripheral Circuit Schematics

Figure 3-1 shows the target MCU pin configurations and its peripheral circuits. For the target MCU pin configurations, the required pins for FOC control have been fixed with certain definitions as shown in Table 3-1. Other peripheral functions can be enabled for use according to specific application requirements. For hardware, the target MCU pins and the BLDC-EVB peripheral circuit should be connected through 0Ω resistors as shown in Table 3-2.

Target MCU Pin No.	0Ω Resistor	Function Definition	Comment
3		CMP0O	CMP0 output
4		CMP0N	CMP0 negative input
5		CMP0P	CMP0 positive input
7		OPAP	OPA positive input
8	R85	OPAN	OPA negative input
9	R89	OPAO	OPA output
25		Hall A Signal Input	Connected to the motor Hall Sensor A

Target MCU Pin No.	0Ω Resistor	Function Definition	Comment
27		Hall B Signal Input	Connected to the motor Hall Sensor B
28		Hall C Signal Input	Connected to the motor Hall Sensor C
31		PWM CB	PWM CB is connected to the power board through P1 port
32		PWM CT	PWM CT is connected to the power board through P1 port
33		PWM BB	PWM BB is connected to the power board through P1 port
34		PWM BT	PWM BT is connected to the power board through P1 port
37		PWM AB	PWM AB is connected to the power board through P1 port
38		PWM AT	PWM AT is connected to the power board through P1 port
41		CMP1O	CMP1 comparator output
43		NP	Virtual neutrality
44		SA	U phase BEMF signal
45		SB	V phase BEMF signal
46		SC	W phase BEMF signal

Table 3-1 BLDC-EVB Target MCU Fixed Function Pins

Target MCU Pin No.	0Ω Resistor	Function Definition	Comment
1	R66	Motor NTC Feedback	ADC-IN5 reads the motor temperature
2	R74	Vdc Feedback	ADC-IN6 reads the VDC voltage
10	R75	IPM OCP Signal Feedback	GPIO PC5 receives the high voltage power board IPM overcurrent feedback signal
11	R47	VR Feedback	ADC-IN10 reads the R40 variable resistor divided voltage value
12	R104	LED2	GPIO PC7 output to LED D9
17		USART RX Pin	USART is used to communicate with PC (Connected to the BLDC Motor Workshop)
20		USART TX Pin	USART is used to communicate with PC (Connected to the BLDC Motor Workshop)
21	R86	XTALIN	HSE Pin
22	R90	XTALOUT	HSE Pin
23	R96	RELAY Signal	GPIO PB15 output the signal to the relay of the high voltage power board
24	R70	LED1	GPIO PC0 output to LED D6
26	R95	Boot Pin	Boot Pin
29	R48	M SWCLK	SWD Interface Pin
30	R105	M SWDIO	SWD Interface Pin
35	R64	Button1	GPIO PC8 receives the signal of button S1
36	R83	Button2	GPIO PC9 receives the signal of button S2
39	R72	IPM Fault Signal Feedback	GPIO PB4 receives the high voltage power board IPM fault signal
42	R69	Power Board NTC Feedback	ADC-IN0 reads the power board temperature

Table 3-2 BLDC-EVB Target MCU Peripheral Function Pins

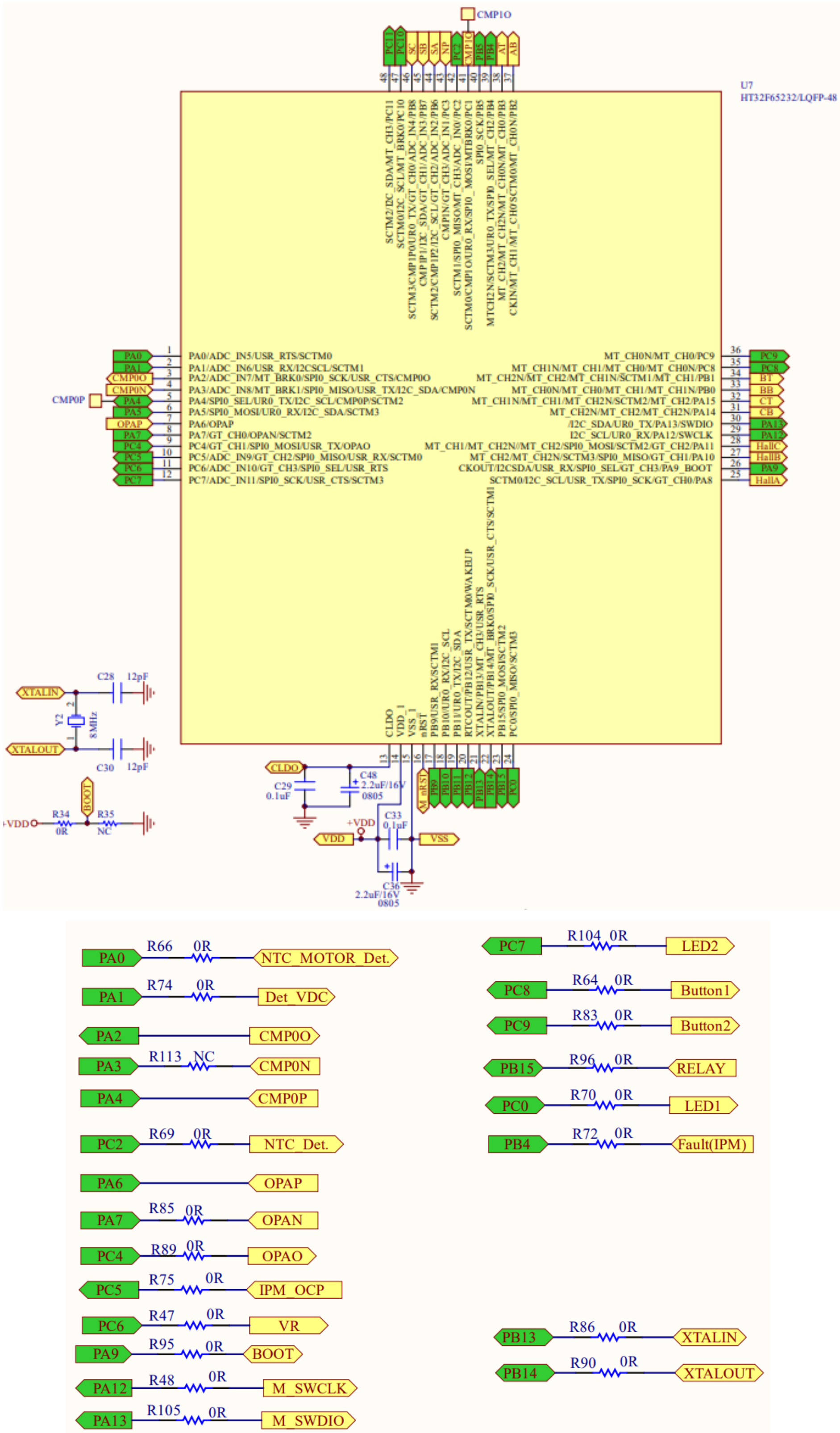


Figure 3-1 Target MCU Pin Configurations and Peripheral Circuits

3-2 Target MCU Test Pin Port

Figure 3-2 shows the target MCU signal test ports, namely P6 and P7. Users can use these two ports to measure the feedback signals such as Vdc, VR, NTC of the Motor, NTC of the Power Board, etc., or the input/output digital signals, such as PWM AT~CB, Hall A~C, OCP signal, high voltage power board IPM signal, etc. Users can also use the un-configured GPIOs for testing during program development.

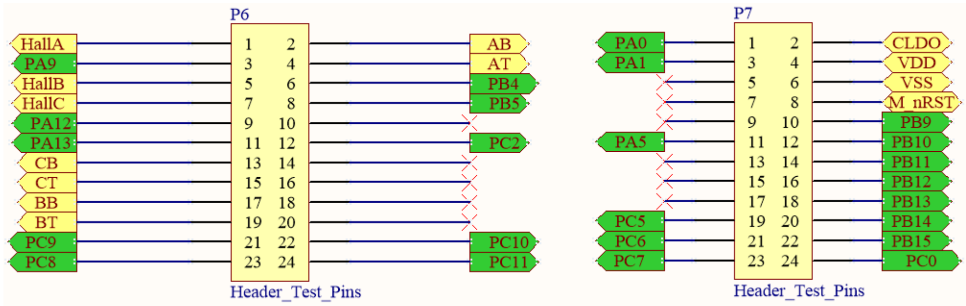


Figure 3-2 Target MCU Test Pin Port

3-3 Motor Hall Sensor and Temp. Sensor Signal Feedback Circuit

Figure 3-3 shows the motor hall sensor feedback and temperature sensor feedback circuit. Initially, the input hall sensor signals are pulled to +VDD by 4.7kΩ pull-high resistors and then be passed to the low frequency filter. After that, the filtered signals are finally input to the target MCU digital pins. The Motor NTC feedback signal is pulled to +VDD by the R63 resistor, and the motor temperature signal is fed back to the target MCU ADC-IN5 analog/digital pin using the divided voltage of +VDD between R63 and NTC. The D7, D8, D10 are used to set as clamping voltage to protect the MCU I/Os.

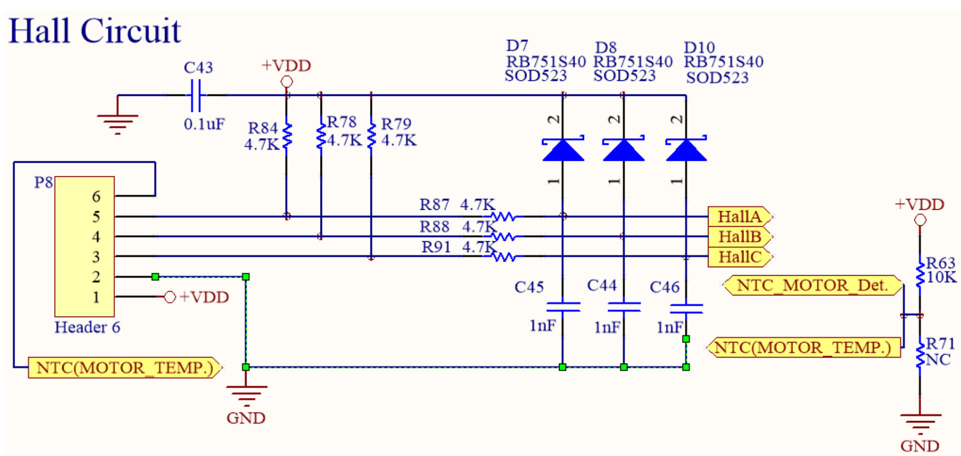


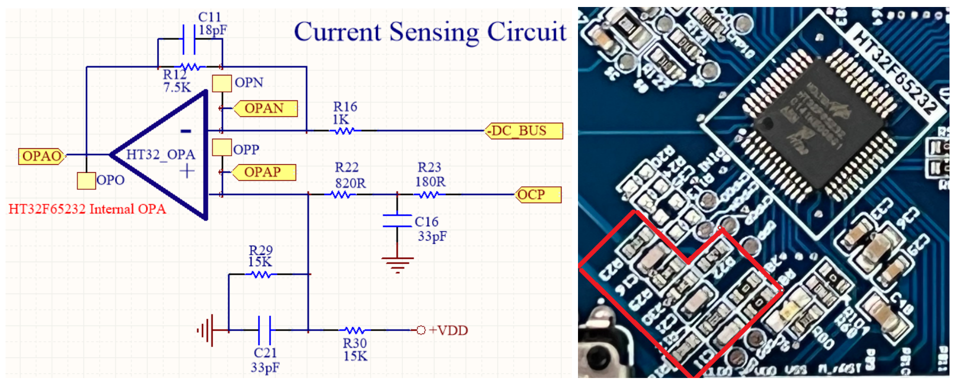
Figure 3-3 Motor Hall Sensor and Temperature Sensor Signal Feedback Circuit (Ha, Hb, Hc, Temp.)

3-4 Single Resistor Current Detection Circuit

Figure 3-4 shows the single resistor current detection circuit. The current flows through the shunt resistor and then is input to the target MCU internal OPA for differential amplification. The gain is calculated and listed in Table 3-3.

Single Resistor Current Detection – OPA Amplifier Design
R16=R22+R23; R29=R30=2×R12; OPA Gain=R12/R16.
BLDC-EVB OPA default magnification: R16=1kΩ; R22=820Ω; R23=180Ω; R12=7.5kΩ; R29=R30=15kΩ; OPA Gain=7.5.

Table 3-3 BLDC-EVB Current Feedback Gain Design



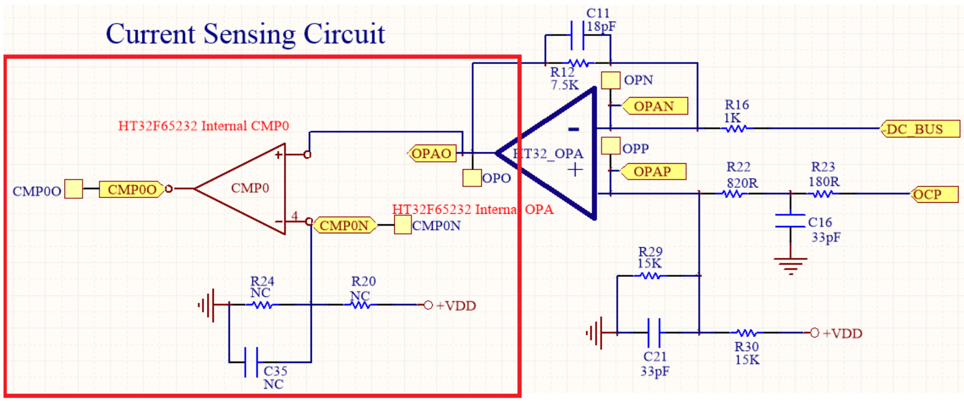
(a) **(b)**

Figure 3-4 Single Resistor Current Detection Circuit

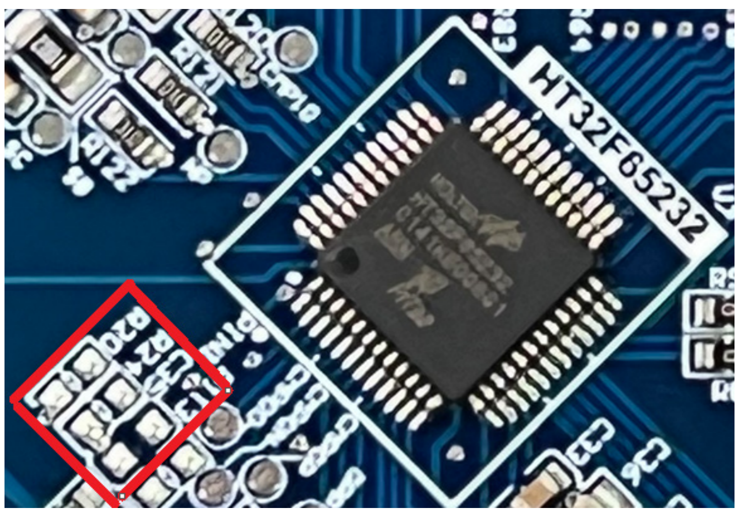
(a) Single Resistor Current Detection Circuit; (b) Component Position

3-5 Over Current Protection Circuit

Figure 3-5 shows the over current protection circuit. The target MCU internal CMP0 is used for bus over current protection. In addition, for the program register configuration, voltage on the comparator CMP0 inverting input end can be setup to refer to the target MCU external hardware pin CMP0N, the OCP current value can be determined by the divided voltage on R20 and R40. It can also be implemented by being setup to refer to the internal 8-bit resolution digital DAC value. Here the comparator minimum scale is 5V/255=0.091V. After the over current protection points are set, it can be used to realise an over current protection function for the motor bus current.



(a)



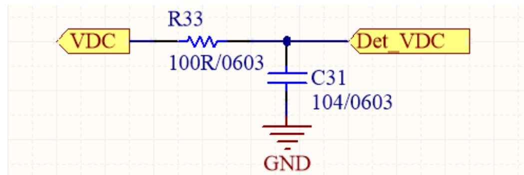
(b)

Figure 3-5 Over Current Protection Circuit

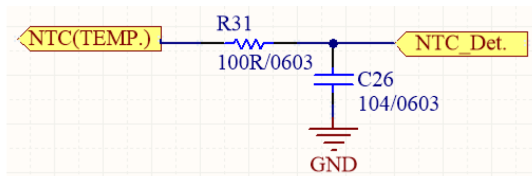
(a) Over Current Protection Circuit; (b) Component Position

3-6 Low-pass Filter Circuits for Feedback Signals

Figure 3-6 shows the low-pass filters for the feedback signals. R33 and C31 are used as the filter components for the VDC voltage feedback signal while the R31 and C26 are filter components for the power board temperature feedback signal.



(a)



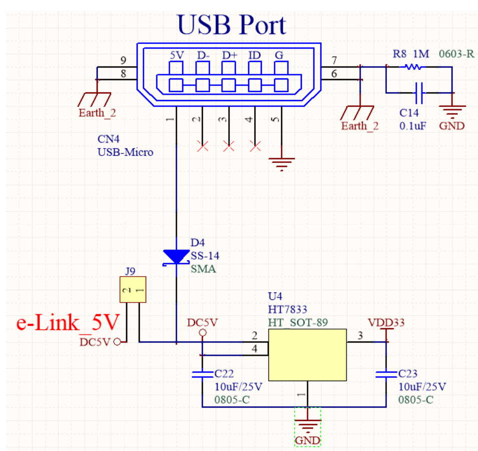
(b)

Figure 3-6 Low-pass Filter Circuits for Feedback Signals

(a) VDC Feedback Signal; (b) Power Board Temperature Feedback Signal

3-7 USB Port 5V-to-3.3V LDO Circuit

As Figure 3-7 shows, the 5V voltage input through the USB port CN4 can be converted to 3.3V by the 3.3V LDO (U4). Users can select the target MCU +VDD to be 5V or 3.3V through the P3 port.



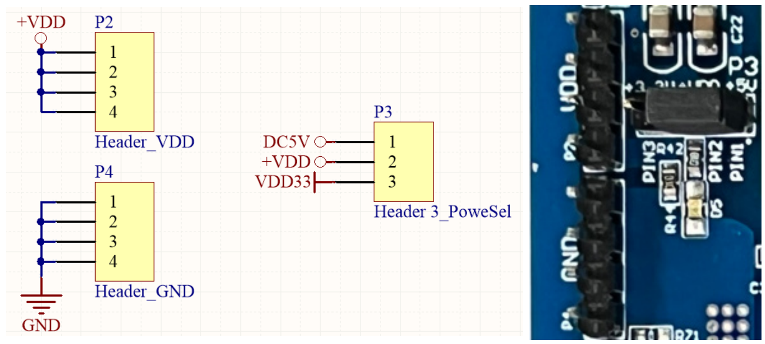
(a) (b)

Figure 3-7 USB Port 5V-to-3.3V LDO Circuit

(a) USB Port 5V-to-3.3V LDO Circuit; (b) Component Position

3-8 Power Port and Target MCU Power Selection Port

Figure 3-8 shows the BLDC-EVB power port. The P3 port can be used to select the target MCU +VDD to be 5V or 3.3V using a pin shorting method. The +VDD hardware default setting is 5V.



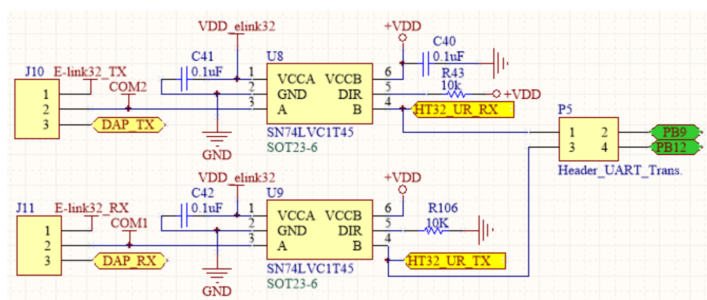
(a) (b)

Figure 3-8 Power Port and Target MCU Power Selection Port

(a) Power Port and Target MCU Power Selection Port; (b) Component Position

3-9 UART Level Shift Circuit

Figure 3-9 shows the UART level shift circuit. Data direction of U8 is from A to B while data direction of U9 is from B to A. The voltage level on A is VCCA, namely the voltage of VDD_elink32, which is the e-Link32 Lite 3.3V LDO(U1) output voltage. The voltage level on B is VCCB, namely the +VDD voltage. Finally, the communication interface can use e-Link32 Lite interface or SWD(DAP) interface which selected by J10 and J11.



(a)

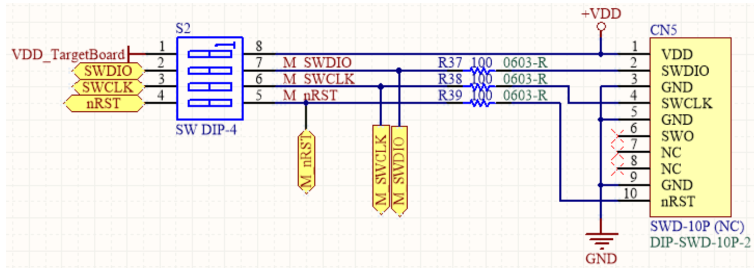
(b)

Figure 3-9 UART Level Shift Circuit

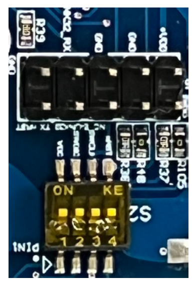
(a) UART Level Shift Circuit; (b) Component Position

3-10 Programming Pin DIP Switch Circuit

Figure 3-10 shows the target MCU programming pin DIP switch circuit, refer to chapter 2-1 for more detailed information.



(a)



(b)

Figure 3-10 Programming Pin DIP Switch Circuit

(a) Programming Pin DIP Switch Circuit; (b) Component Position

3-11 Reset Button and Test Buttons

Figure 3-11 shows the BLDC-EVB buttons. S1 and S3 are the switch components provided for testing. S4 is used to reset the target MCU. When button S4 is pressed, the nRST pin is pulled to GND to reset the target MCU.

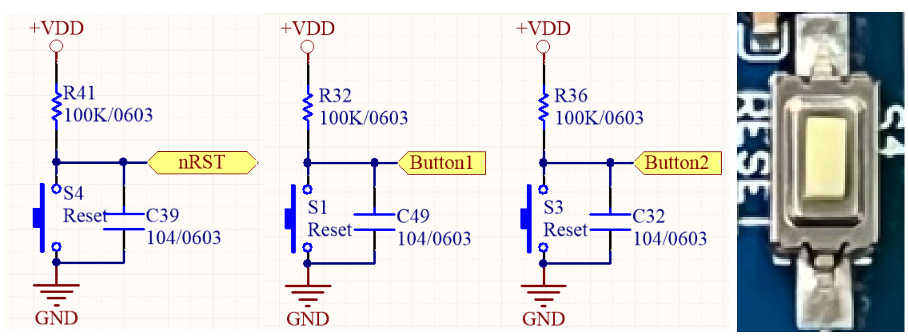


Figure 3-11 Reset Button and Test Buttons

3-12 Variable Resistor Test Circuit

Figure 3-12 shows the variable resistor test circuit. The output analog voltage signal, VR, is connected to the target MCU internal A/D converter pin ADC1-IN5.

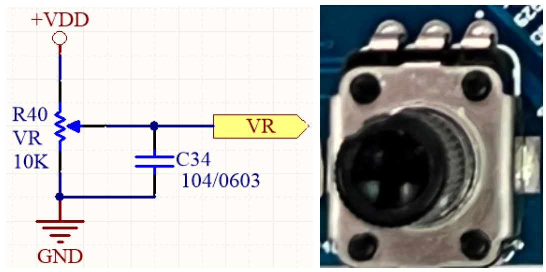


Figure 3-12 Variable Resistor Test Circuit

3-13 Power Indicator LED and Test LED Circuits

Figure 3-13 shows the power indicator LED and test LED circuits. D5 is used for BLDC-EVB power indication while D6 and D9 are provided for testing during development.

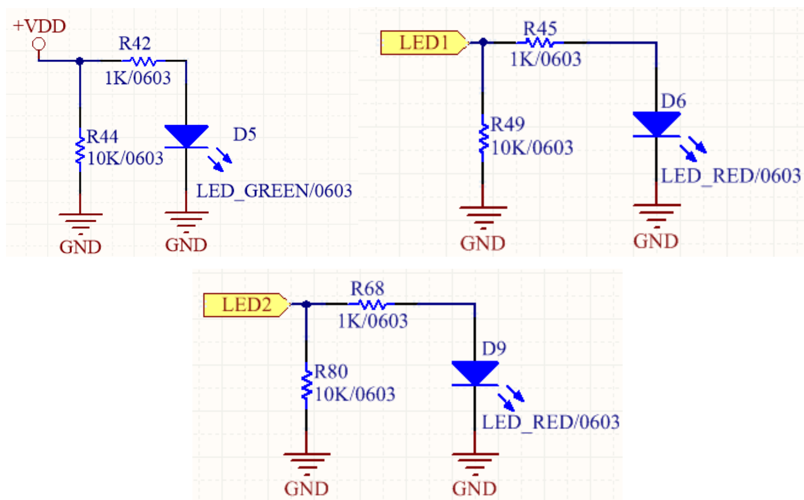
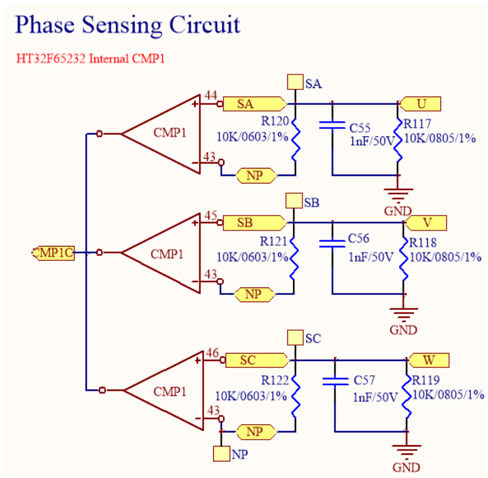


Figure 3-13 Power Indicator LED and Test LED Circuits

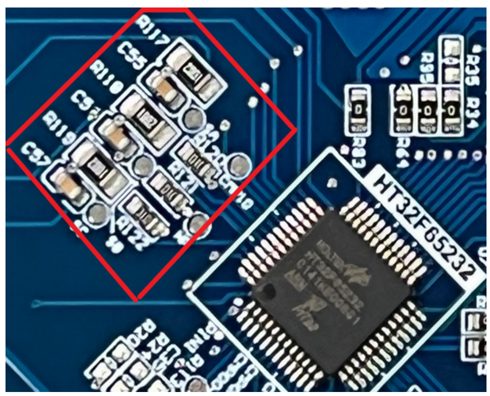
3-14 Back EMF Detection Circuit

Figure 3-14 shows the Back EMF detection circuit, which is used to detect the phase voltage of the motor. It is recommended that the voltage after divided should not exceed 4V. The resistance of the divided voltage point to the ground of R117, R118 and R119 are 10kΩ. Assuming that the highest input voltage of the power board is 60V and the resistance of the divided voltage point to the phase voltage of the power board is 154kΩ, the divided voltage can be calculated as:

$$60V\times\left(\frac{10k\Omega}{10k\Omega+154k\Omega}\right)=3.65V$$



(a)



(b)

Figure 3-14 Back EMF Detection Circuit

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

4. PCB Layout

Figure 4-1 shows the BLDC-EVB PCB layout, the detailed specifications of which are shown in Table 4-1.

Length×Width	70×94 (mm)
Thickness	1.6 (mm)
Number of Layers	2 (layers)
Copper Foil Thickness	1 (Oz)
Material	FR-4
Solder Mask Layer Color	Blue

Table 4-1 BLDC-EVB Circuit Board Specifications

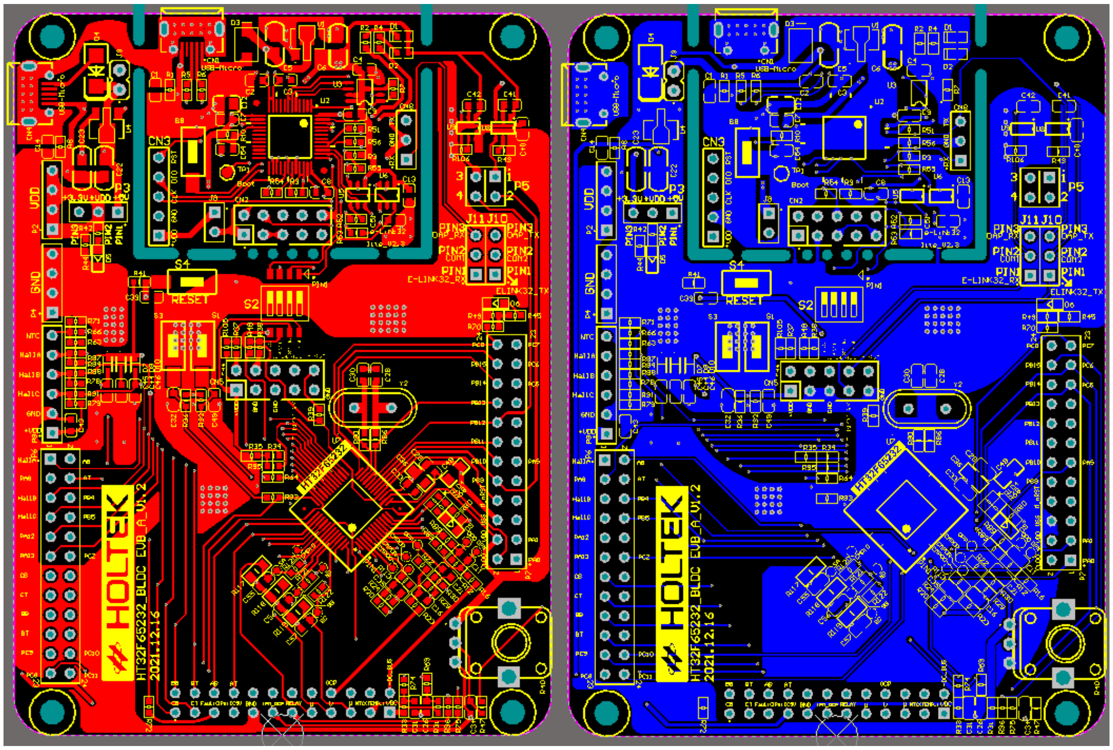


Figure 4-1 BLDC Motor Workshop BLDC-EVB PCB Layout: Upper Layer (Red); Lower Layer (Blue)

5. BOM List

Table 5-1 shows the BLDC-EVB BOM list, which lists all the required components for the circuit boards.

No.	Comment	Designator	Quantity
1	Multilayer Ceramic Capacitors, 10μF, 25V, ±10%, (0805)	C5, C6, C22, C23	4
2	Multilayer Ceramic Capacitors, 2.2μF, 16V, ±10%, (0805)	C12, C36, C48	3
3	Multilayer Ceramic Capacitors, 0.1μF, 50V, ±5%, (0603)	C1, C7, C8, C9, C13, C14, C26, C29, C31, C32, C33, C34, C39, C40, C41, C42,C43, C49, C51	19
4	Multilayer Ceramic Capacitors, 10nF, 50V, ±5%, (0603)	C54	1
5	Multilayer Ceramic Capacitors, 1nF, 50V, ±5%, (0603)	C44, C45, C46, C55, C56, C57	6
6	Multilayer Ceramic Capacitors, 47pF, 50V, ±5%, (0603)	C2, C3	2
7	Multilayer Ceramic Capacitors, 33pF, 50V, ±5%, (0603)	C16, C21	2
8	Multilayer Ceramic Capacitors, 18pF, 50V, ±5%, (0603)	C11	1
9	Multilayer Ceramic Capacitors, 12pF, 50V, ±5%, (0603)	C28, C30	2
10	Multilayer Ceramic Capacitors, NC, (0603)	C4, C35	2
11	Multilayer Ceramic Capacitors, 0Ω, (0603)	R34, R47, R48,R64, R66, R69, R70, R72, R74, R75, R83, R85, R86, R89, R90, R95, R96, R104, R105	19
12	Chip Fixed Resistor, 100Ω, (0603, accuracy=5%)	R31, R33, R37, R38, R39, R51, R52, R53, R54, R55, R56	11
13	Chip Fixed Resistor, 1kΩ, (0603, accuracy=1%)	R16, R42, R45, R68	4
14	Chip Fixed Resistor, 10kΩ, (0603, accuracy=1%)	R3, R43, R44, R49, R63, R80, R106, R120, R121, R122	10
15	Chip Fixed Resistor, 100kΩ, (0603, accuracy=5%)	R10, R32, R36, R41	4

No.	Comment	Designator	Quantity
16	Chip Fixed Resistor, 1MΩ, (0603, accuracy=5%)	R1, R8	2
17	Chip Fixed Resistor, 27Ω, (0603, accuracy=5%)	R5, R6	2
18	Chip Fixed Resistor, 330Ω, (0603, accuracy=5%)	R2, R4	2
19	Chip Fixed Resistor, 470Ω, (0603, accuracy=5%)	R9	1
20	Chip Fixed Resistor, 4.7kΩ, (0603, accuracy=5%)	R78, R79, R84, R87, R88, R91	6
21	Chip Fixed Resistor, 180Ω, (0603, accuracy=1%)	R23	1
22	Chip Fixed Resistor, 820Ω, (0603, accuracy=1%)	R22	1
23	Chip Fixed Resistor, 7.5kΩ, (0603, accuracy=1%)	R12	1
24	Chip Fixed Resistor, 15kΩ, (0603, accuracy=1%)	R29, R30	2
25	Chip Fixed Resistor, 10kΩ, (0805, accuracy=1%)	R117, R118, R119	3
26	Chip Fixed Resistor, NC, (0603)	R7, R20, R24, R35, R71, R113	6
27	Schottky Barrier Diode, SS-14, (DO-214AC)	D3, D4	2
28	Schottky Barrier Diode, RB751S40, (SOD523)	D7, D8, D10	3
29	Surface Mounted LED, (green, 0603)	D1, D5	2
30	Surface Mounted LED, (red, 0603)	D2, D6, D9	3
31	Surface Mounted Push-button Switch, SW (2Pin)	B8, S1, S3, S4	4
32	Surface Mounted Dip switch, SW (4Pin)	S2	1
33	Level Shift Chip, SN74LVC1T45, (SOT23-6)	U5, U6, U8, U9	4
34	3.3V LDO, HT7833, (SOT-89)	U1, U4	2
35	MCU, HT32F52341, (LQFP48)	U2	1
36	MCU, HT32F65232, (LQFP-48)	U7	1
37	USB-Micro, (DIP)	CN1, CN4	2
38	MX25L8006E, (NC)	U3	1
39	Plug-in Rheostat, 10kΩ, (RK09K1130A5R)	R40	1
40	Plug-in Oscillator, 8MHz, (HC-49S)	Y2	1
41	Dual rows (2×5Pin, Pitch2.54mm, 180 degree)	CN2, CN5	2
42	Single row (1×5Pin, Pitch2.54mm, 180 degree)	CN3	1
43	Single row (1×3Pin, Pitch2.54mm, 180 degree)	P3, J10, J11, CN8	4
44	Single row (1×2Pin, Pitch2.54mm, 180 degree)	J8, J9	2
45	Dual rows (2×2Pin, Pitch2.54mm, 180 degree)	P5	1
46	Single row (1×6Pin, Pitch2.54mm, 180 degree)	P8	1
47	Single row (1×4Pin, Pitch2.54mm, 180 degree)	P2, P4	2
48	Dual rows (2×12Pin, Pitch2.54mm, 180 degree)	P6, P7	2
49	Dual rows (2×12Pin, Pitch2.54mm, 90 degree)	P1	1
50	PCB board four sides of plastic column (15mm)		4
51	PCB board four side plastic nut		4
52	Black jump hat _2.54mm		5

Table 5-1 BLDC Motor Workshop BLDC-EVB BOM List