BLDC Motor Workshop
– FOC-EVB Hardware Description

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1. Introduction

The Brushless DC (BLDC) Motor Workshop FOC-EVB is shown in Figure 1-1. The EV board utilises the BLDC motor driver dedicated MCU, the HT32F65240, which is a Holtek 32-bit Arm® Cortex®-M0+ high performance, low power microcontroller designed for Cortex®-M0+ entry level. The FOC-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.

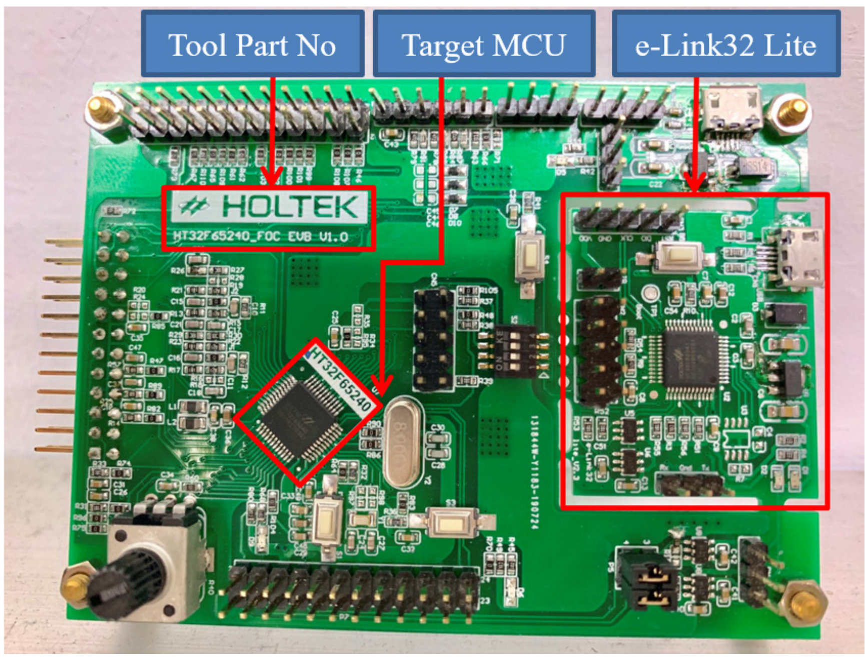


Figure 1-1 BLDC Motor Workshop FOC-EVB

Features

- Operating frequency up to 60MHz
- 64KB Flash, 8KB 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 FOC-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.

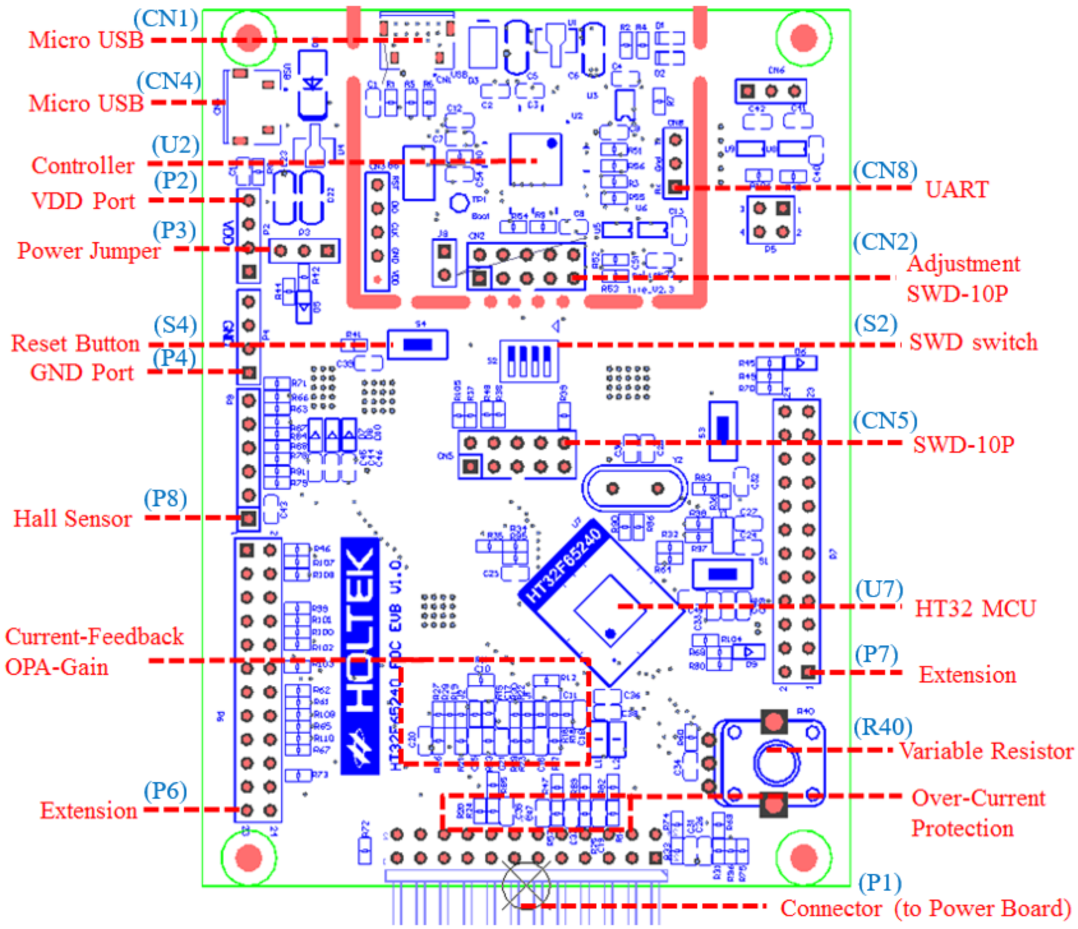


Figure 2-1 BLDC Motor Workshop FOC-EVB Component Placement

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.

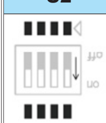
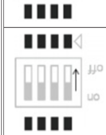
S2	Setting
	When the DIP switch S2 is switched to ON, the target MCU SWD interface port will be connected with the e-Link Lite. Users can connect the EV board to the PC by plugging a Micro USB cable into CN1 for target MCU code programing or online emulation testing.
	When the DIP switch S2 is switched 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 FOC-EVB to an external programmer, the pin definitions are shown in Figure 2-2 and Table 2-2:

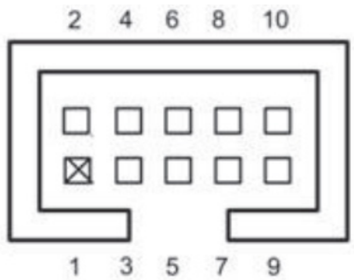


Figure 2-2 SWD-10P Port Component Schematic – CN2, CN5

Pin No.	Definition	Pin No.	Definition
1	+VDD	2	SWDIO
3	GND	4	SWCLK
5	GND	6	NC
7	NC	8	NC
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:

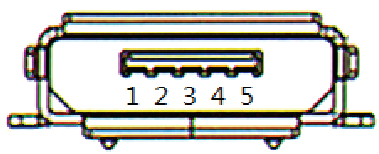


Figure 2-3 Type B Micro USB Port Component Schematic – CN1, CN4

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 Source 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.

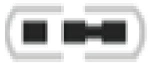
P3	Setting
	Short the +VDD on the P3 port with the 5V power, the target MCU power source is selected to be 5V – default state.
	Short the +VDD on the P3 port with the 3.3V power, the target MCU power source is selected to be 3.3V, which is sourced from the Micro USB CN4 and output by the 3.3V LDO (U4).

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.

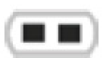
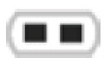
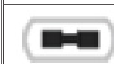
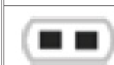
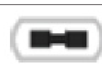
R34	R35	Setting
		Open R35, the target MCU boots from the main flash – default state.
		
		Short R35, the target MCU boots from the bootloader – ISP.

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 HSI.

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

2-8 Low Speed External Crystal Oscillator (LSE) Option Setting

It is recommended that users should carry out FOC project development in the default environment. Open R97 and R98, the X32KIN and X32KOUT pins of the target MCU will be disconnected with external oscillator Y1, the jumper resistors R97 and R98 conditions are shown in Table 2-8.

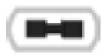
R97, R98	Setting
	Short R97 and R98, the LSE I/O pins are connected to Y1, switch on LSE.
	Open R97 and R98, the LSE I/O pins are disconnected with Y1, switch on LSI – default state.

Table 2-8 Low Speed External Crystal Oscillator (LSE) Option Setting – R97, R98

2-9 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 Pin 4 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 PA1 and PA3 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 2-9 Shorted Pin Setting Between USART TX, RX and UART Level Shift Chip – P5

2-10 e-Link32 Lite USART TX and RX Port

If users short the pins on the P5 port, namely Pin1-to-Pin2 and Pin3-to-Pin4, CN8 will act as the USART interface connected to the BLDC Motor Workshop. Details are shown in Table 2-10.

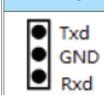
CN8	Setting
	Three USART connector pins: USART-TX, GND and USART-RX. The e-Link32 Lite will send data on the USART-TX pin while data will be received on the USART-RX pin.

Table 2-10 e-Link32 Lite USART Port Setting – CN8

2-11 Extension Connector P6 Definition

The FOC-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 2-11.

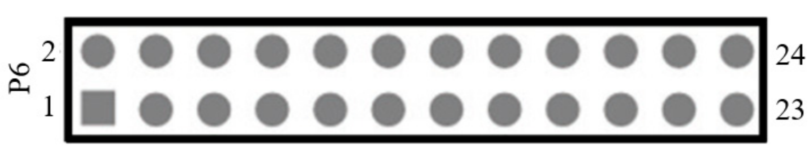


Figure 2-4 Extension Connector P6 Component Schematic

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	OPA1 Output (IA-out)
9	GPIO (PA12)	10	OPA1 Inverting Input (IA-)
11	GPIO (PA13)	12	OPA1 Non-Inverting Input (IA+)
13	PWM CB	14	OPA0 Output (IB-out)
15	PWM CT	16	OPA0 Inverting Input (IB-)
17	PWM BB	18	OPA0 Non-Inverting Input (IB+)
19	PWM BT	20	GPIO (PB8)
21	VDD_2	22	VDDA
23	VSS_2	24	VSSA

Table2-11 Extension Connector P6 Pin Definitions

2-12 Extension Connector P7 Definitions

The FOC-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 2-12.

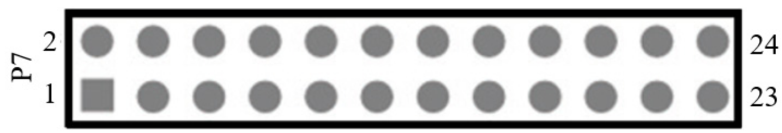


Figure 2-5 Extension Connector P7 Component Schematic

Pin No.	Definition	Pin No.	Definition
1	GPIO (PA0)	2	CLDO
3	GPIO (PA1)	4	VDD_1
5	GPIO (PA2)	6	VSS_1
7	GPIO (PA3)	8	M_nRST
9	GPIO (PA4)	10	GPIO (PB9)
11	GPIO (PA5)	12	GPIO (PB10)
13	GPIO (PA6)	14	GPIO (PB11)
15	GPIO (PA7)	16	GPIO (PB12)
17	GPIO (PC4)	18	GPIO (PB13)
19	GPIO (PC5)	20	GPIO (PB14)
21	GPIO (PC6)	22	GPIO (PB15)
23	GPIO (PC7)	24	GPIO (PC0)

Table2-12 Extension Connector P7 Pin Definitions

2-13 Power Board Connector P1 Definition

The FOC-EVB is connected to the power board through the P1 port. Details are shown in Figure 2-6 and Table 2-13.

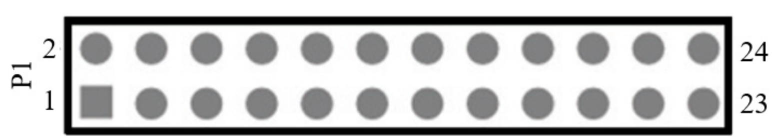


Figure 2-6 Power Board Connector Component Schematic – P1

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	Ready Signal	14	NC
15	NC	16	Ic Feedback Signal
17	NC	18	Ib Feedback Signal
19	NC	20	Ia Feedback Signal
21	TEMP Feedback Signal of Power Board	22	-Idc Bus Current Feedback Signal
23	Vdc Feedback Signal	24	Power GND

Table 2-13 Power Board Connector P1 Pin Definitions

3. Schematics

This section will present the schematics and explain the FOC-EVB hardware circuit.

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 FOC-EVB peripheral circuit should be connected through 0Ω resistors as shown in Table 3-2.

Target MCU Pin No.	Function Definition	Comment
2	USART RX Pin	USART is used for communication with PC (Connected to BLDC Motor Workshop)
4	USART TX Pin	USART is used for communication with PC (Connected to BLDC Motor Workshop)
25	Hall A Signal Input	Connect to motor Hall Sensor A
27	Hall B Signal Input	Connect to motor Hall Sensor B
28	Hall C Signal Input	Connect to motor Hall Sensor C
31	PWM CB	Connect to power board through P1 port
32	PWM CT	Connect to power board through P1 port
33	PWM BB	Connect to power board through P1 port
34	PWM BT	Connect to power board through P1 port
37	PWM AB	Connect to power board through P1 port
38	PWM AT	Connect to power board through P1 port
40	OPA0 Ib_Out	OPA output pin for Ib feedback
41	OPA0 Ib-	OPA inverting input pin for Ib feedback
42	OPA0 Ib+	OPA non-inverting output pin for Ib feedback
43	OPA1 Ia_Out	OPA output pin for Ia feedback
44	OPA1 Ia-	OPA inverting input pin for Ia feedback
45	OPA1 Ia+	OPA non-inverting output pin for Ia feedback

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

No.	Comment	Description	Designator	Quantity
1	10μF, 35V, ±5%, 0805	Capacitor MLCC	C5, C6, C22, C23	4
2	0.1μF, 50V, ±5%, 0603	Capacitor MLCC	C1, C7, C8, C9, C13,C14, C19, C25, C26, C29, C31, C32, C33, C34, C35, C37, C38, C39, C40, C41, C42, C43, C47, C49, C51	25
3	10nF, 50V, ±5%, 0603	Capacitor MLCC	C54	1
4	1nF, 50V, ±5%, 0603	Capacitor MLCC	C44, C45, C46	3
5	100pF, 50V, ±5%, 0603	Capacitor MLCC	C17, C18	2
6	10pF, 50V, ±5%, 0603	Capacitor MLCC	C24, C27	2
7	2.2μF, 35V, ±10%, 0603	Capacitor MLCC	C12, C36, C48	3
8	47pF, 50V, ±5%, 0603	Capacitor MLCC	C2, C3	2
9	33pF, 50V, ±5%, 0603	Capacitor MLCC	C15, C16, C20, C21	4
10	18pF, 50V, ±5%, 0603	Capacitor MLCC	C10, C11	2
11	12pF, 50V, ±5%, 0603	Capacitor MLCC	C28, C30	2
12	USB-Micro, 27USB-05M10B-01G-CQ01	USB-Micro DIP	CN1, CN4	2
13	2×5Pin Connector, Pitch2.54mm, 180degree	Header, 5-Pin, Dual row	CN2, CN5	2
14	1×5Pin Connector, Pitch2.54mm, 180degree	Header, 5-Pin	CN3	1
15	1×3Pin Connector, Pitch2.54mm, 180degree	Header, 3-Pin	CN6, CN8	2
16	1×2Pin Connector, Pitch2.54mm, 180 degree	Header, 2-Pin	J8	1
17	2×2Pin Connector, Pitch2.54mm, 180 degree	Header, 2-Pin, Dual row	P5	1
18	1×3Pin Connector, Pitch2.54mm, 180 degree	Header, 3-Pin	P3	1
19	1×6Pin Connector, Pitch2.54mm, 180 degree	Header, 6-Pin	P8	1
20	1×4Pin Connector, Pitch2.54mm, 180 degree	Header, 4-Pin	P2, P4	2
21	2×12Pin Connector, Pitch2.54mm, 180 degree	Header, 12-Pin, Dual row	P6, P7	2
22	2×12Pin Connector, Pitch2.54mm, 90 degree	Header, 12-Pin, Dual row, Right Angle	P1	1
23	SS-14, DO-214AC	Schottky Diode	D3, D4	2
24	LED, GREEN, 0603	Typical INFRARED GaAs LED	D1, D5	2
25	LED, RED, 0603	Typical INFRARED GaAs LED	D2, D6, D9	3
26	BAT30KFILM, SOD523	Schottky Diode	D7, D8, D10	3
27	PBY201209T-601Y-N, 0805	BEAD/0805	L1, L2	2
28	0Ω, 0603	SMD Resistor	J1, J2, R46, R47, R48, R60, R61, R62, R64, R65, R66, R67, R69, R70, R72, R73, R74, R75, R82, R83, R85, R86, R89, R90, R95, R96, R99, R100, R101, R102, R103, R104, R105, R107, R108, R109, R110	37
29	100Ω, 0603, ±5%	SMD Resistor	R31, R33, R37, R38, R39, R51, R52, R53, R54, R55, R56	11
30	1kΩ, 0603, ±5%	SMD Resistor	R42, R45, R68	3
31	10kΩ, 0603, ±5%	SMD Resistor	R3, R43, R44, R49, R63, R80, R106	7

No.	Comment	Description	Designator	Quantity
32	100kΩ, 0603, ±5%	SMD Resistor	R10, R32, R36, R41	4
33	1MΩ, 0603, ±5%	SMD Resistor	R1, R8	2
34	27Ω, 0603, ±5%	SMD Resistor	R5, R6	2
35	330Ω, 0603, ±5%	SMD Resistor	R2, R4	2
36	470Ω, 0603, ±5%	SMD Resistor	R9	1
37	680Ω, 0603, ±5%	SMD Resistor	R14, R25, R57	3
38	4.7kΩ, 0603, ±5%	SMD Resistor	R78, R79, R84, R87, R88, R91	6
39	180Ω, 0603, ±1%	1% SMD Resistor	R13, R17, R21, R23	4
40	820Ω, 0603, ±1%	1% SMD Resistor	R15, R16, R19, R22	4
41	15kΩ, 0603, ±1%	1% SMD Resistor	R26, R27, R29, R30	4
42	7.5kΩ, 0603, ±1%	1% SMD Resistor	R11, R12	2
43	RV09AF-40-20K-B10K, 10kΩ	DIP Switch-VR	R40	1
44	32768Hz, (3.2×1.5×0.75mm)	Crystal Oscillator	Y1	1
45	XTAL, 8MHz, HC-49S	Crystal Oscillator	Y2	1
46	2-Pin SMD Switch	SMD Switch, 2 Position, 3×6×2.5mm	B8, S1, S3, S4	4
47	4Ports 8-Pin Switch, Pitch1.27mm	SMD Switch, 4 Position, SPST	S2	1
48	SN74LVC1T45, SOT23-6	Level Shift	U5, U6, U8, U9	4
49	HT7833, SOT-89	Holtek HT78xx Series 500mA TinyPower LDO	U1, U4	2
50	HT32F52341, 48LQFP	HT32F52341 LQFP48	U2	1
51	HT32F65240, 48LQFP	Holtek 32-Bits ARM-Based M0 Target MCU	U7	1
52	MX25L8006E (NC)	IC (NC)	U3	1
53	NC	Pad (NC)	R7, R18, R20, R24, R28, R34, R35, R71, R97, R98, C4	11

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

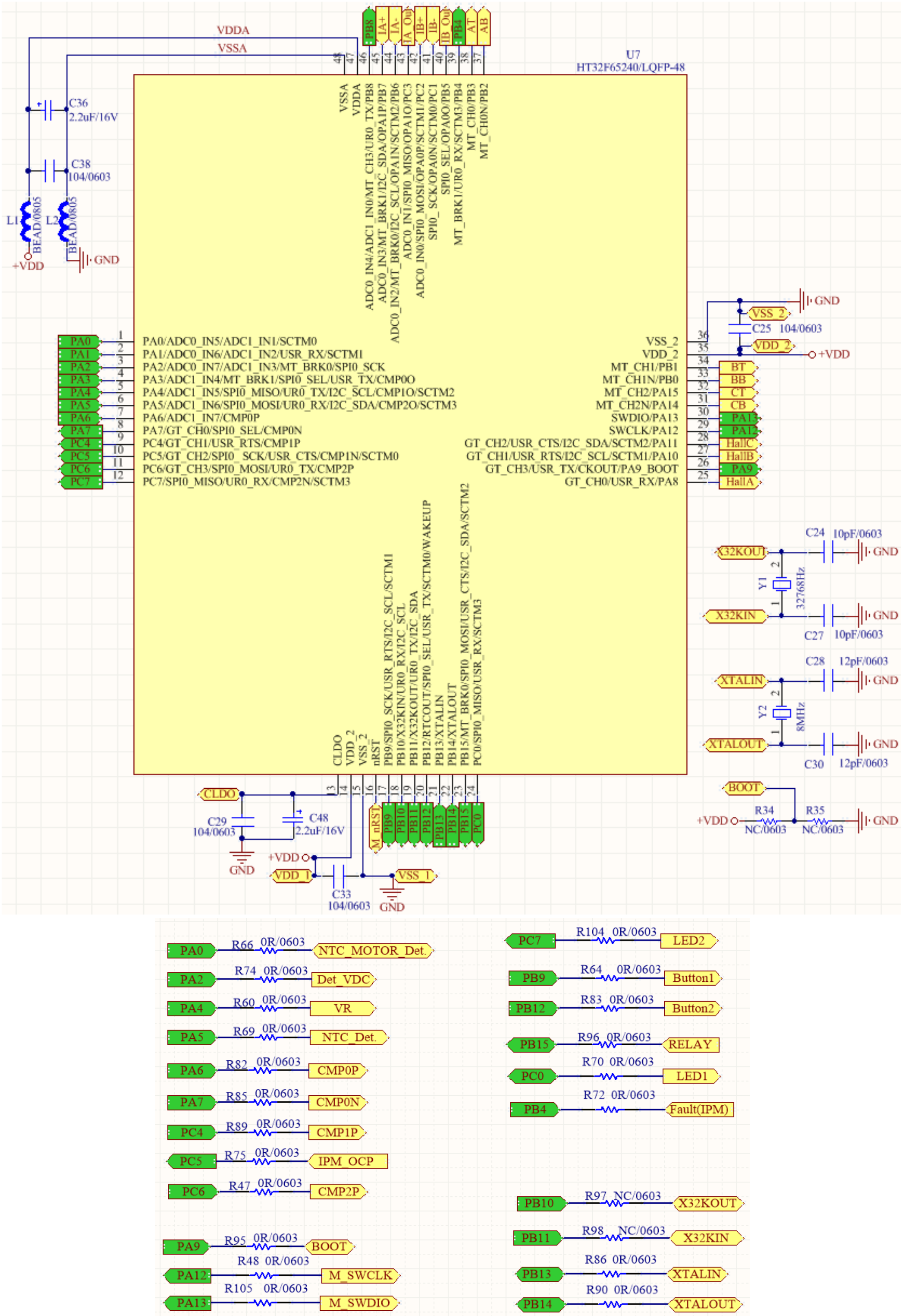


Figure 3-1 Target MCU Pin Configurations and Peripheral Circuits

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 Ia, Ib, 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.

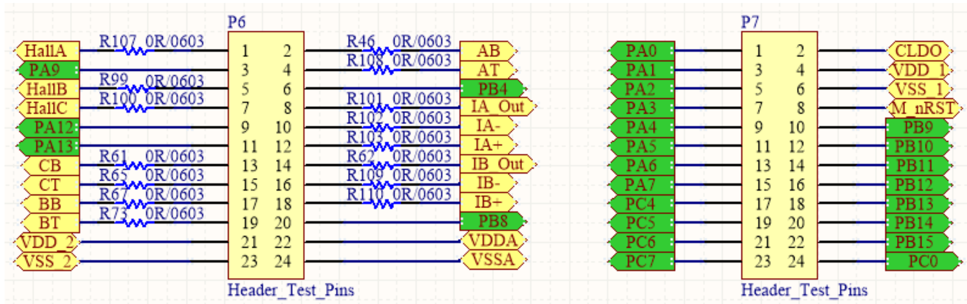


Figure 3-2 Target MCU Test Pin Port

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 ADC1-IN1 analog/digital pin using the divided voltage of +VDD between R63 and NTC.

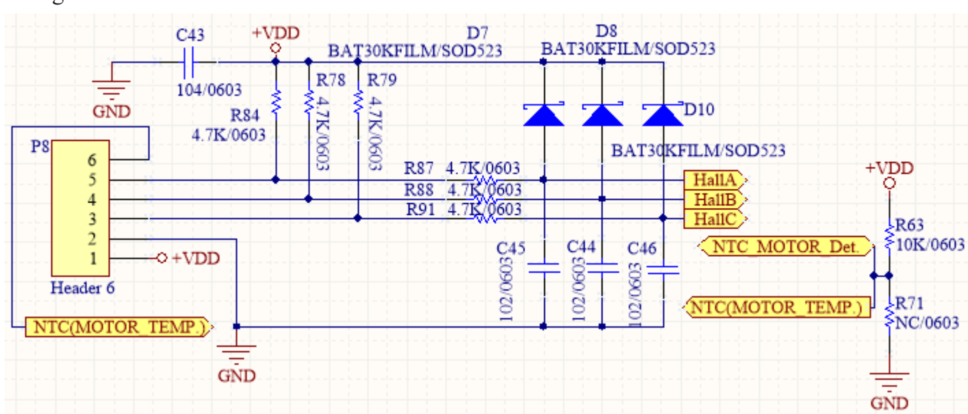


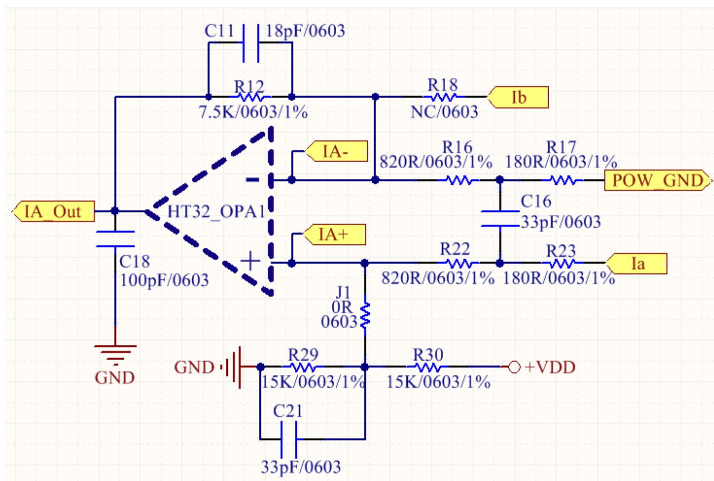
Figure 3-3 Motor Hall Sensor and Tempurature Sensor Signal Feedback Circuit (Ha, Hb, Hc, Temp.)

3-4 Phase Current Feedback Circuits

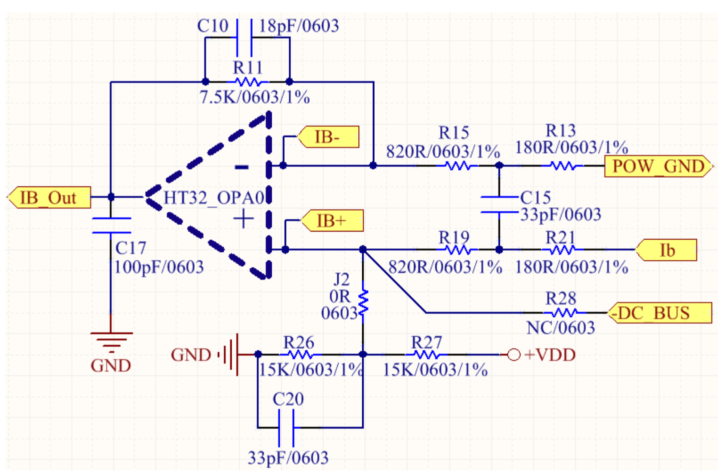
Figure 3-4 shows the motor phase current feedback circuits. Ia is input to the target MCU internal OPA1 for differential amplification, while Ib is input to the target MCU internal OPA0 for differential amplification. The gain is calculated and listed in Table 3-3. For the FOC-EVB hardware setup, R18 and R22 are opened and J1 and J2 are each shorted by a 0Ω resistor.

Ia Feedback – OPA1 Amplifier Design	Ib Feedback – OPA0 Amplifier Design
R16=R22; R17=R23; R29=R30=2×R12; OPA Gain=R12/(R16+R17).	R15=R19; R13=R21; R26=R27=2×R11; OPA Gain=R11/(R15+R13).
FOC-EVB OPA0 and OPA1 default magnification: R16=R22=R15=R19=820Ω; R17=R23=R13=R21=180Ω; R12=R11=7.5kΩ; R29=R26=15kΩ; OPA0 Gain=OPA1 Gain=7.5.	

Table 3-3 FOC-EVB Current Feedback Gain Design



(a)



(b)

Figure 3-4 Motor Phase Current Feedback Circuit: (a) Ia; (b) Ib

3-5 Over Current Protection Circuit

Figure 3-5 shows the over current protection circuit. The target MCU internal CMP0 is used for Ia over current protection while CMP1 is used for Ib and CMP2 is used for Ic. In addition, for the program register configuration, voltage on the comparator CMPx inverting input end can be setup to refer to the target MCU external hardware pin CMPxN, 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 6-bit resolution digital DAC value. Here the comparator minimum scale is 5V/63=0.079V. Finally, the inverting input end of the CMP0~CMP2 comparators can be connected together by configuring the internal compactor registers to realise an over current protection function for the motor three phase current.

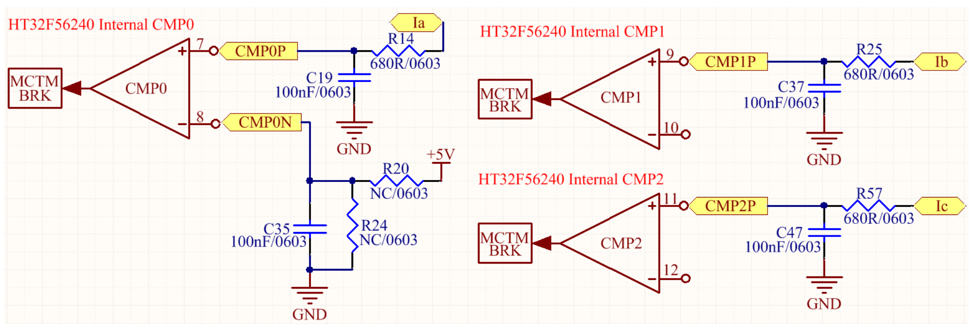
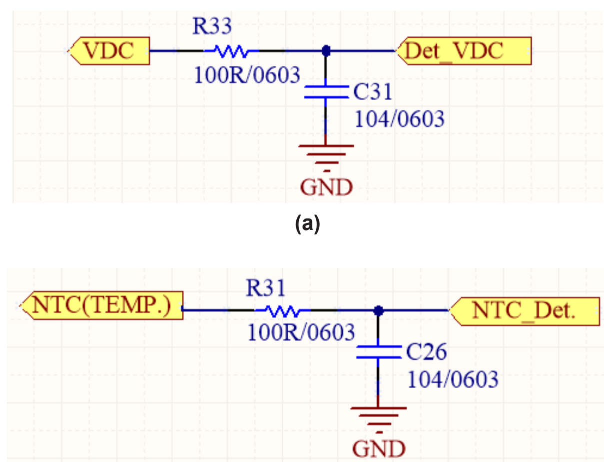


Figure 3-5 Over Current Protection Circuit: (a) Ia; (b) Ib; (c) Ic

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 3V through the P3 port.

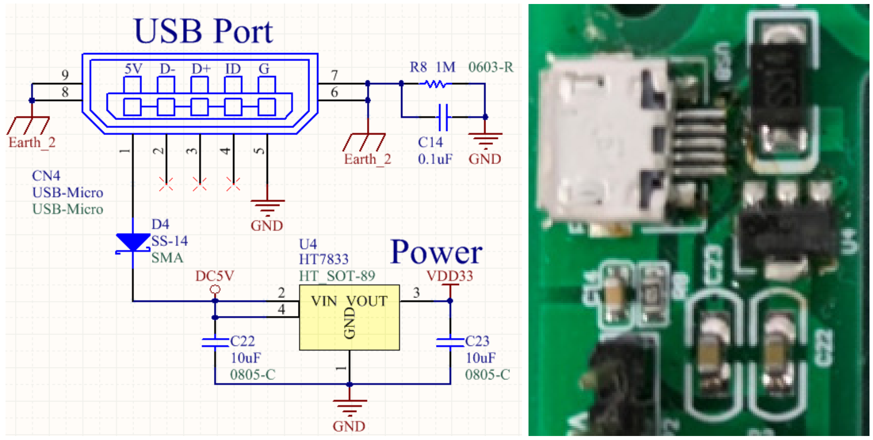


Figure 3-7 USB Port 5V-to-3.3V LDO Circuit

3-8 Power Port and Target MCU Power Selection Port

Figure 3-8 shows the FOC-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.

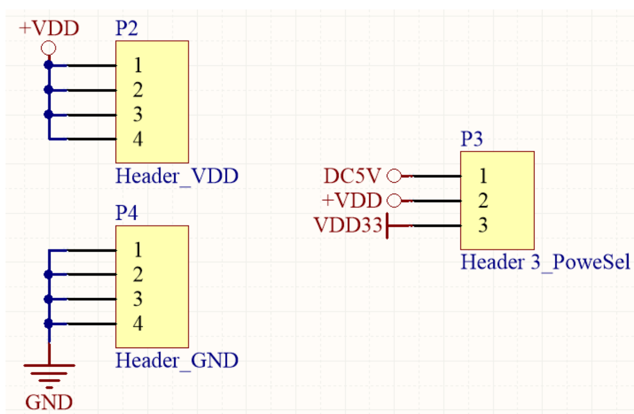


Figure 3-8 Power Port and Target MCU Power Selection Port

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.

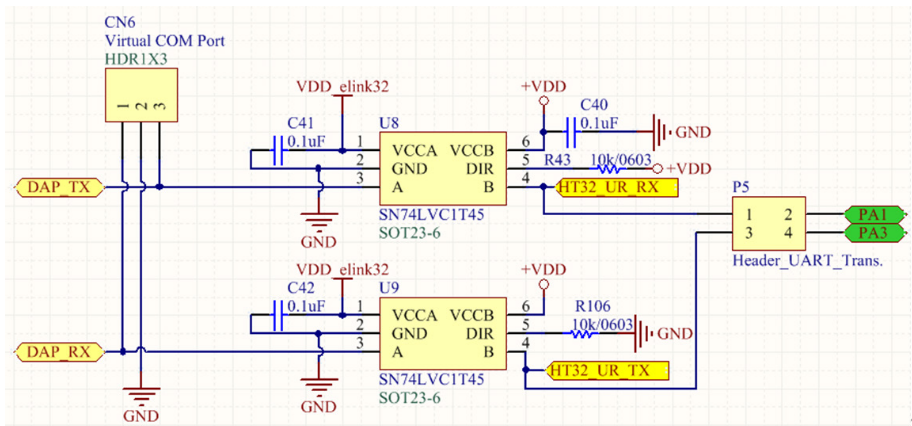


Figure 3-9 UART Level Shift Circuit

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.

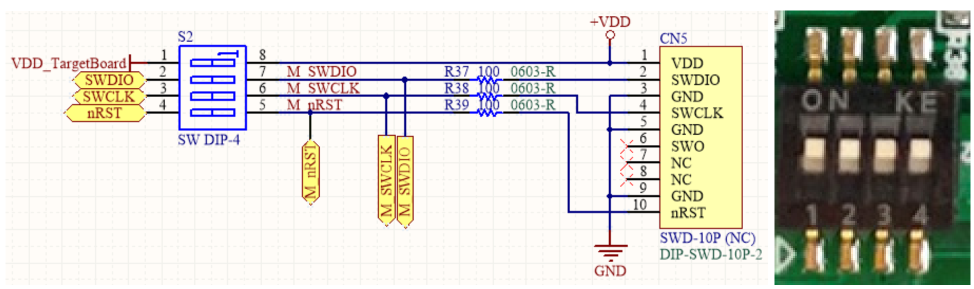


Figure 3-10 Programming Pin DIP Switch Circuit

3-11 Reset Button and Test Buttons

Figure 3-11 shows the FOC-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.

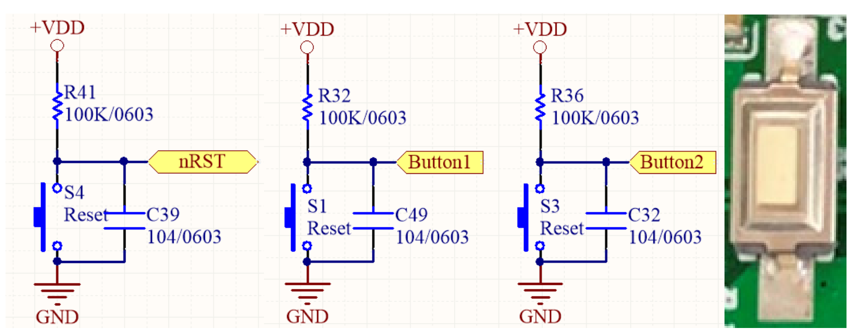


Figure 3-11 Reset Button and Test Buttons

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.

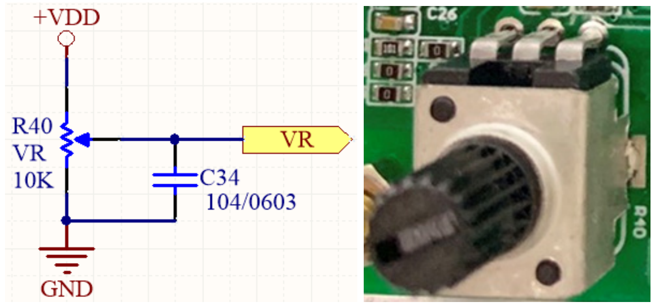


Figure 3-12 Variable Resistor Test Circuit

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 FOC-EVB power indication while D6 and D9 are provided for testing during development.

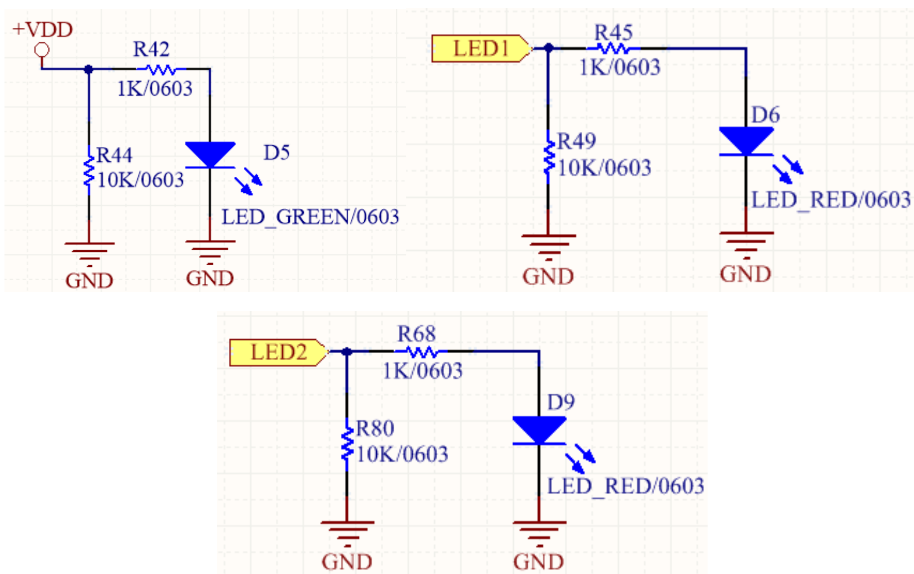


Figure 3-13 Power Indicator LED and Test LED Circuits

4. PCB Layout

Figure 4-1 shows the FOC-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 Colour	Green

Table 4-1 FOC-EVB Circuit Board Specifications

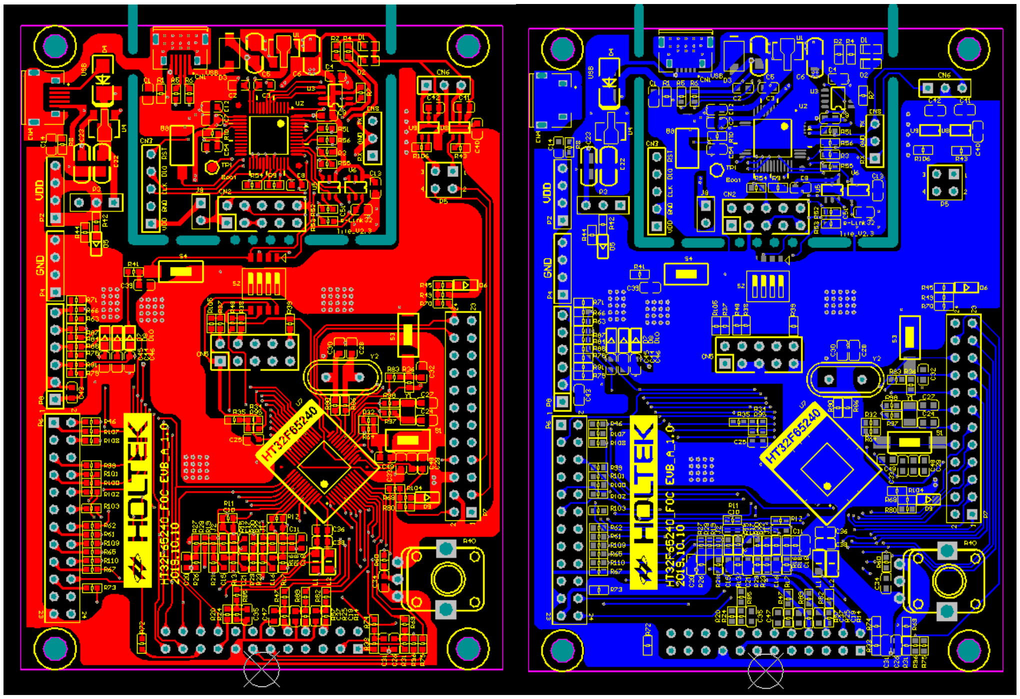


Figure 4-1 BLDC Motor Workshop FOC-EVB PCB Layout: (a) Upper Layer; (b) Lower Layer

5. BOM List

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

No.	Comment	Description	Designator	Quantity	Footprint
1	10μF/0805	Capacitor MLCC	C5, C6, C22, C23	4	0805
2	0.1μF(104)/0603	Capacitor MLCC	C1, C7, C8, C9, C13,C14, C19, C25, C26, C29, C31, C32, C33, C34, C35, C37, C38, C39, C40, C41, C42, C43, C47, C49, C51	25	0603
3	10nF(103)/0603	Capacitor MLCC	C54	1	0603
4	1nF(102)/0603	Capacitor MLCC	C44, C45, C46	3	0603
5	100pF/0603	Capacitor MLCC	C17, C18	2	0603
6	10pF/0603	Capacitor MLCC	C24, C27	2	0603
7	2.2μF/0603	Capacitor MLCC	C12, C36, C48	3	0603
8	47pF/0603	Capacitor MLCC	C2, C3	2	0603
9	33pF/0603	Capacitor MLCC	C15, C16, C20, C21	4	0603
10	18pF/0603	Capacitor MLCC	C10, C11	2	0603
11	12pF/0603	Capacitor MLCC	C28, C30	2	0603
12	NC	Capacitor MLCC	C4	1	0603 (NC)
13	USB-Micro	USB-Micro DIP	CN1, CN4	2	USB-Micro DIP
14	Header-10 (SWD-10P)	Header, 5-Pin, Dual row	CN2, CN5	2	2×5Pin (2.54Pitch) DIP
15	Header-5 (e-Link32 SWD)	Header, 5-Pin	CN3	1	1×5Pin (2.54Pitch) DIP
16	Header-3 (Virtual COM Port)	Header, 3-Pin	CN6, CN8	2	1×3Pin (2.54Pitch) DIP
17	Header-2 (Jumper Pin)	Header, 2-Pin	J8	1	1×2Pin (2.54Pitch) DIP
18	Header-4 (UART_Trans)	Header, 2-Pin, Dual row	P5	1	2×2Pin (2.54Pitch) DIP
19	Header-3 (PoweSel)	Header, 3-Pin	P3	1	1×2Pin (2.54Pitch) DIP
20	Header-6 (Hall_Sensor)	Header, 6-Pin	P8	1	1×6Pin (2.54Pitch) DIP
21	Header-4 (VDD, GND)	Header, 4-Pin	P2, P4	2	1×4Pin (2.54Pitch) DIP

No.	Comment	Description	Designator	Quantity	Footprint
22	Header-24 (Test_Pin)	Header, 12-Pin, Dual row	P6, P7	2	2×12Pin (2.54Pitch) DIP
23	Header-24 (Power Board Connector)	Header, 12-Pin, Dual row, Right Angle	P1	1	2×12Pin (2.54Pitch) DIP
24	SS-14/SMA	Schottky Diode	D3, D4	2	SMA (DO-214AC)
25	LED_GREEN/0603	Typical INFRARED GaAs LED	D1, D5	2	0603
26	LED_RED/0603	Typical INFRARED GaAs LED	D2, D6, D9	3	0603
27	BAT30KFILM/SOD523	Schottky Diode	D7, D8, D10	3	SOD523
28	PBY201209T-601Y-N	BEAD/0805	L1, L2	2	0805
29	0R/0603	SMD Resistor	J1, J2, R46, R47, R48, R60, R61, R62, R64, R65, R66, R67, R69, R70, R72, R73, R74, R75, R82, R83, R85, R86, R89, R90, R95, R96, R99, R100, R101, R102, R103, R104, R105, R107, R108, R109, R110	37	0603
30	100R/0603	SMD Resistor	R31, R33, R37, R38, R39, R51, R52, R53, R54, R55, R56	11	0603
31	1KR/0603	SMD Resistor	R42, R45, R68	3	0603
32	10KR/0603	SMD Resistor	R3, R43, R44, R49, R63, R80, R106	7	0603
33	100KR/0603	SMD Resistor	R10, R32, R36, R41	4	0603
34	1MR/0603	SMD Resistor	R1, R8	2	0603
35	27R/0603	SMD Resistor	R5, R6	2	0603
36	330R/0603	SMD Resistor	R2, R4	2	0603
37	470R/0603	SMD Resistor	R9	1	0603
38	680R/0603	SMD Resistor	R14, R25, R57	3	0603
39	4.7KR/0603	SMD Resistor	R78, R79, R84, R87, R88, R91	6	0603
40	180R/0603/1%	1% SMD Resistor	R13, R17, R21, R23	4	0603
41	820R/0603/1%	1% SMD Resistor	R15, R16, R19, R22	4	0603
42	15KR/0603/1%	1% SMD Resistor	R26, R27, R29, R30	4	0603
43	7.5KR/0603/1%	1% SMD Resistor	R11, R12	2	0603
44	NC	SMD Resistor	R7, R18, R20, R24, R28, R34, R35, R71, R97, R98	10	0603 (NC)
45	10KR	DIP Switch-VR	R40	1	R091L-0BT
46	32768Hz	Crystal Oscillator	Y1	1	HC-49S
47	8MHz	Crystal Oscillator	Y2	1	HC-49/US
48	Reset SW	SMD Switch, 2 Position, 3×6×2.5mm	B8, S1, S3, S4	4	SW_J
49	SW DIP-4	SMD Switch, 4 Position, SPST	S2	1	SW-8P-SMD
50	SN74LVC1T45	Level Shift	U5, U6, U8, U9	4	SOT23-6
51	HT7833	Holtek HT78xx Series 500mA TinyPower LDO	U1, U4	2	SOT-89
52	HT32F52341/48LQFP	HT32F52341 LQFP48	U2	1	48LQFP
53	HT32F65240/48LQFP	Holtek 32-Bits ARM-Based M0 Target MCU	U7	1	48LQFP
54	MX25L8006E (NC)	MX25L8006E	U3	1	USON_4×4 (NC)

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