HT32F65C32F_Driver Board Hardware Description

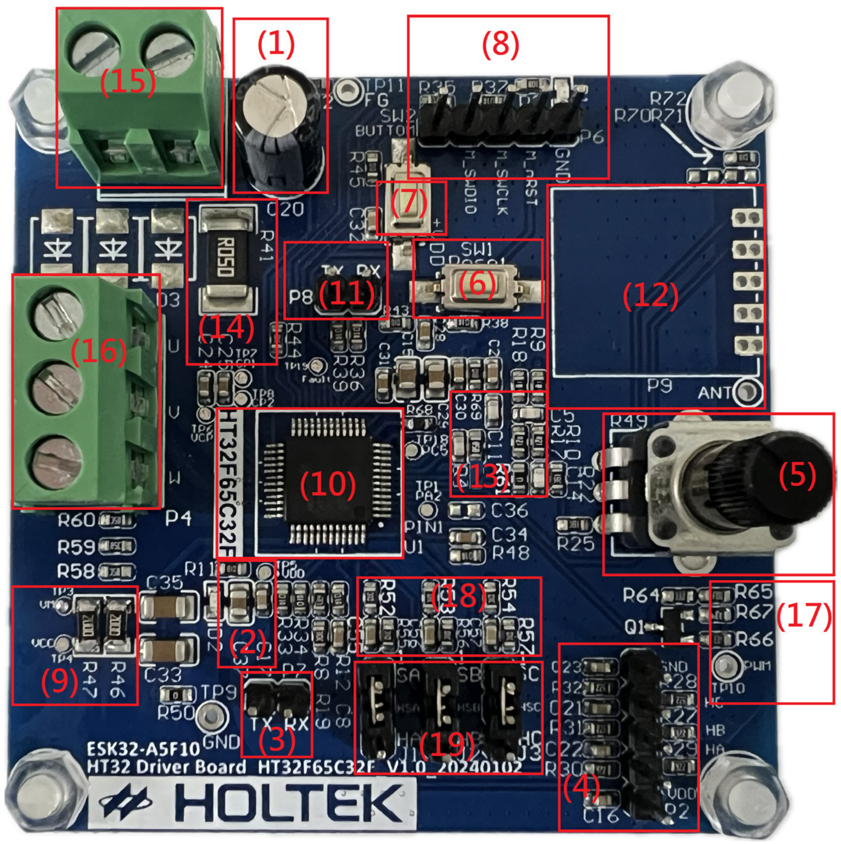
Revision: V1.01 Date: November 22, 2024

www.holtek.com

Table of Contents

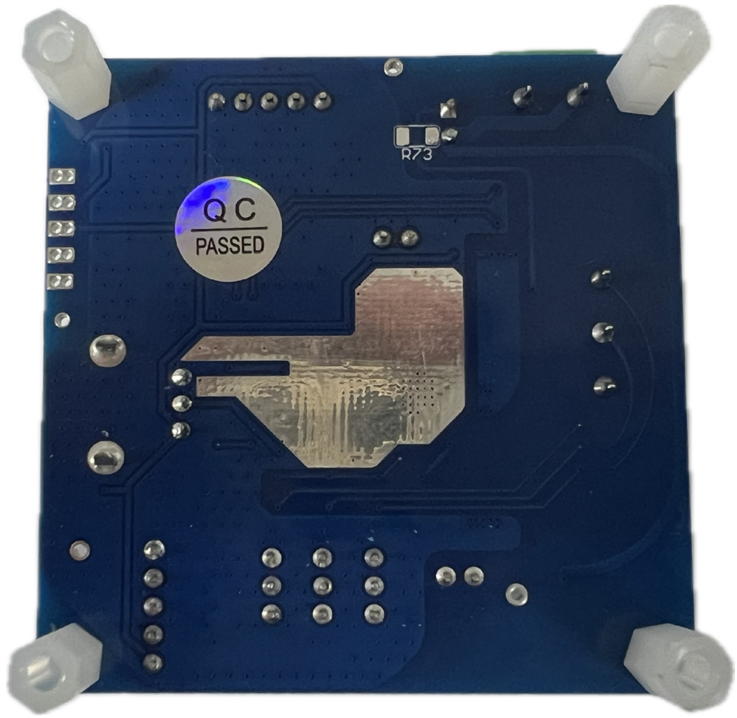
1. General Description

The HT32F65C32F_Driver Board front view is shown below. The component parts are: (1) Input electrolytic capacitor. (2) 5V LDO output capacitor. (3) Communication pin header interface. (4) Hall sensor connection ports. (5) VR variable resistor. (6) Reset button. (7) SW2 button. (8) SWD programming interface. (9) VCC buck resistors. (10) HT32F65C32F MCU. (11) Motor workshop communication interface. (12) RF receiver module. By default, this hardware board does not include this module. (13) Differential OPA current amplifier external components. (14) Current sampling resistors. (15) Input DC voltage terminal. (16) Motor coil terminal. (17) PWM command input signal. (18) Back EMF detection resistors. (19) Jumper to select Hall sensor or sensorless. The default situation is sensorless.



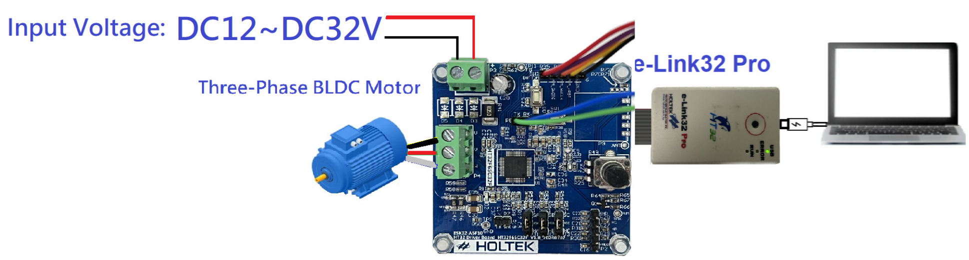
BLDC Motor Workshop HT32F65C32F_Driver Board Front View

The HT32F65C32F_Driver Board back view is shown below. Bare copper and PCB through-holes are added below the MCU, which can effectively and quickly dissipate heat to the surrounding air to improve heat dissipation.



BLDC Motor Workshop HT32F65C32F_Driver Board Back View

The figure below shows the HT32F65C32F_Driver Board development environment. Connect the PC USB port to the e-Link32 Pro using a Mini USB cable and then connect the e-Link32 Pro to the HT32F65C32F_Driver Board to communicate with the BLDC motor workshop. The input voltage range is DC 12V~32V.



HT32F65C32F_Driver Board Development Environment

Features

- Input voltage: DC 12V~32V
- Max. DC Bus current: 1A
- Max. motor phase current: ±3.5A
- R_Shunt (Phase): 0.05Ω/2512/1%/2W
- DC Bus voltage divider ratio: 1/10
- Gate-Driver Polarity:

  (1) Low side active low

  (2) High side active high

As the above feature shows, the HT32F65C32F_Driver Board maximum motor phase current is ±3.5A. The following figure shows the phase current sampling OPA circuit. The default hardware parameters are shown as follows:

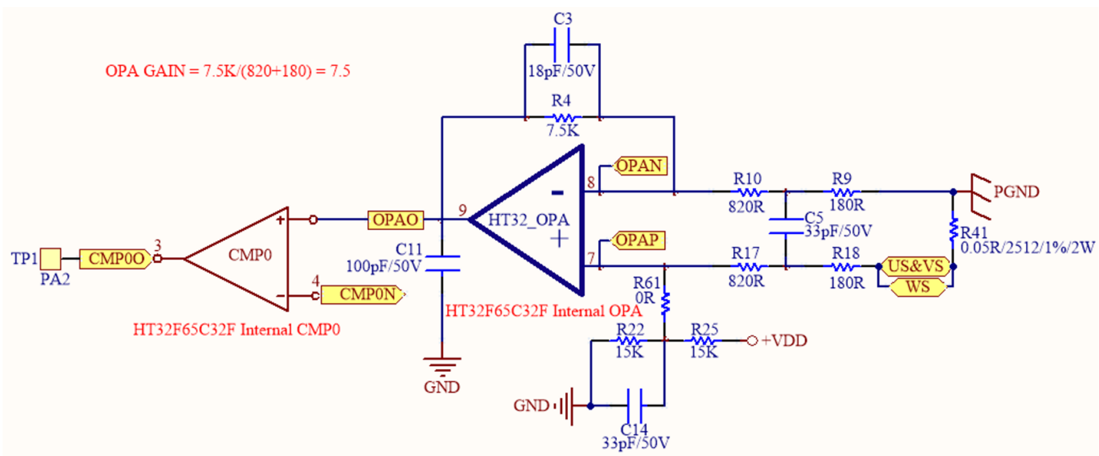
(1) HT32F65C32F_Driver Board R41 specification is 0.05Ω/2512/±1%/2W.

(2) HT32F65C32F_Driver Board R9 and R18 specifications are both 180Ω.

(3) HT32F65C32F_Driver Board R10 and R17 specifications are both 820Ω.

(4) HT32F65C32F_Driver Board R4 specification is 7.5KΩ.

(5) HT32F65C32F_Driver Board R22 and R25 specifications are both 15KΩ.



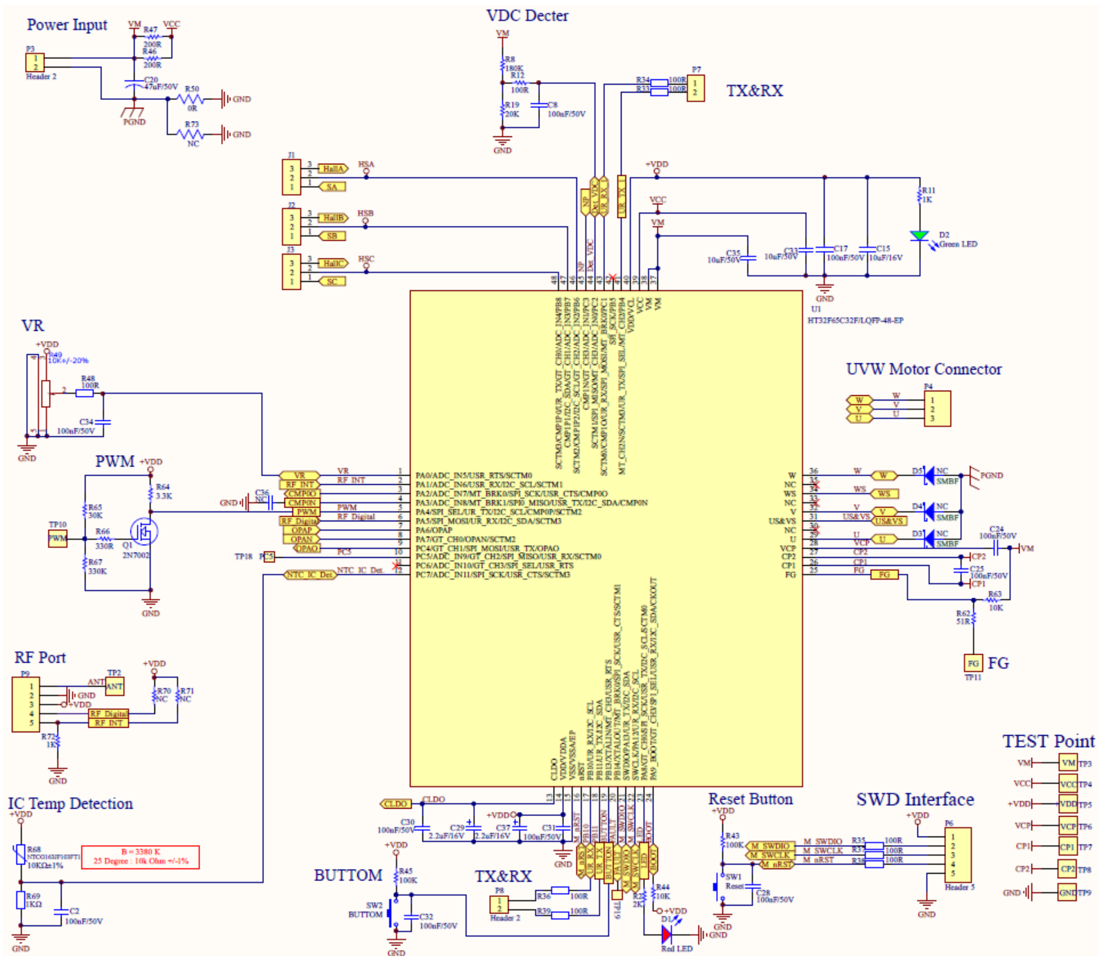
Phase Current Sampling OPA Circuit

2. Schematics

This chapter will present the schematics and explain the HT32F65C32F_Driver Board hardware circuit as shown in sections 2.1 to 2.12.

2.1 HT32F65C32F Peripheral Component Reference Circuit

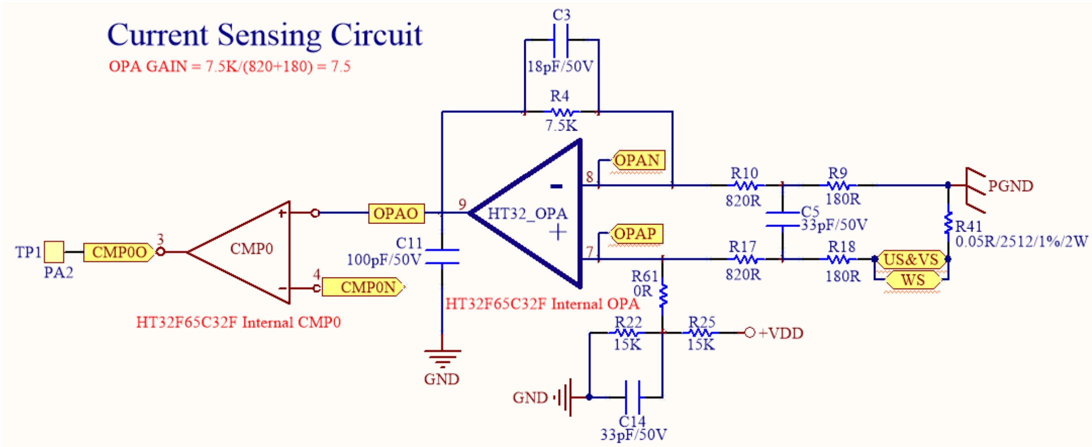
The following figure shows the HT32F65C32F_Driver Board peripheral component reference circuit which uses a charge pump driving structure with an integrated 32V half-bridge N-channel MOSFET. The total internal resistance of the high-side and low-side MOSFETs is 450mΩ. The driver includes an integrated dead time function. The integrated 5V LDO can supply power for the MCU circuit. The device contains both over temperature protection and output short-circuit protection.



HT32F65C32F Peripheral Component Reference Circuit

2.2 Over Current Protection Circuit and Current Sensing Circuit

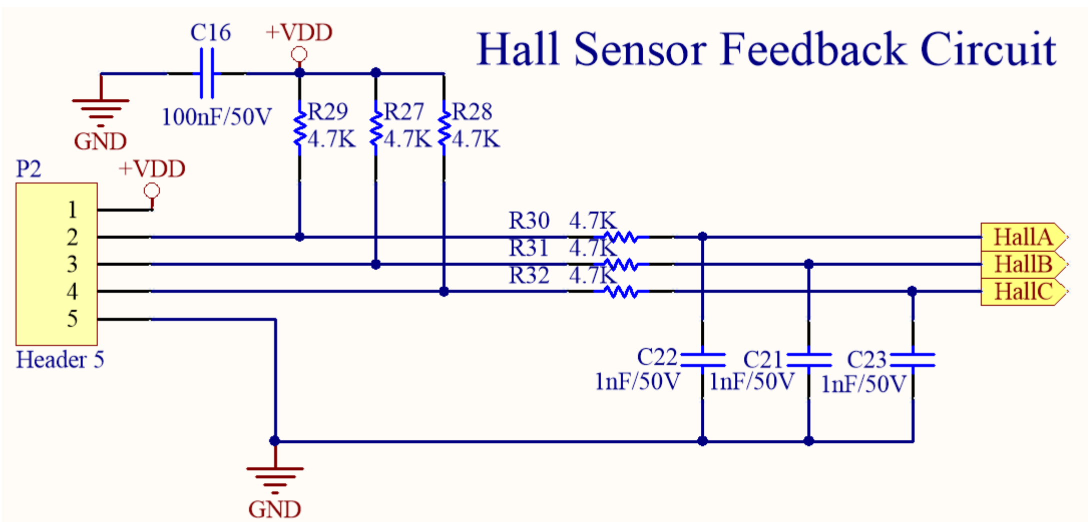
The figure below shows the over current protection circuit and the current sensing circuit. The R-Shunt voltage passes through a low-pass filter before reaching the internal amplifier. The internal DAC over current threshold is compared with the OPA output to implement the over current protection function. The output short-circuit protection current is 3.5A. It is recommended to set the over current threshold for the HT32F65C32F_Driver Board to be 3A to trigger the over current protection.



Over Current Protection Circuit and Current Sensing Circuit

2.3 Hall Sensor Feedback Circuit

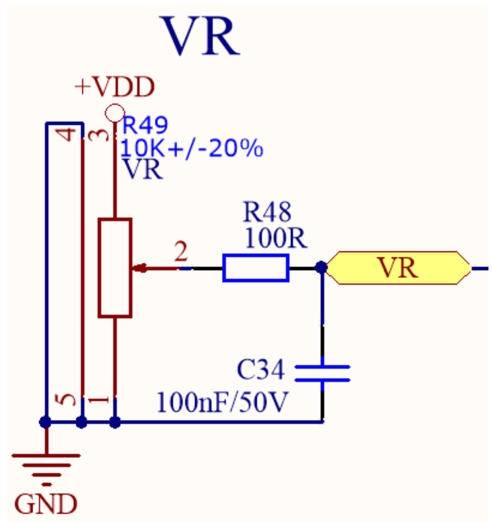
The figure below shows the Hall sensor feedback circuit. Connect the three Hall signals to pin2~pin4 on the P2 pin header if the motor has three Hall sensors. The input Hall sensor signals will be pulled high to +VDD by pull-high resistors and then connect to the low-pass filter. After this, the filtered signals are input to the MCU for phase change signal processing.



Hall Sensor Feedback Circuit

2.4 VR Variable Resistor Circuit

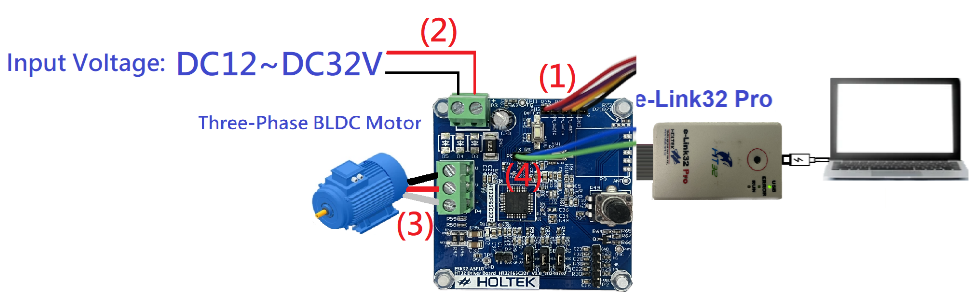
The figure below shows the VR variable resistor circuit. The VR divided voltage enters the MCU ADC after passing through a low-pass filter. In practical applications, the VR can be used as a human interface motor speed control function.



VR Variable Resistor Circuit

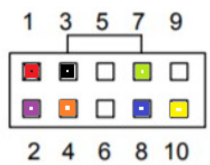
2.5 Programming Interface and Motor Workshop Communication

Check whether the hardware pre-setting wiring on the HT32F65C32F_Driver Board is setup normally. As shown in the figures below, there are 4 places to be checked: (1) e-Link32 Pro programming wiring; (2) Input power wiring; (3) Motor wiring; (4) The communication line between the e-Link32 Pro and the workshop.



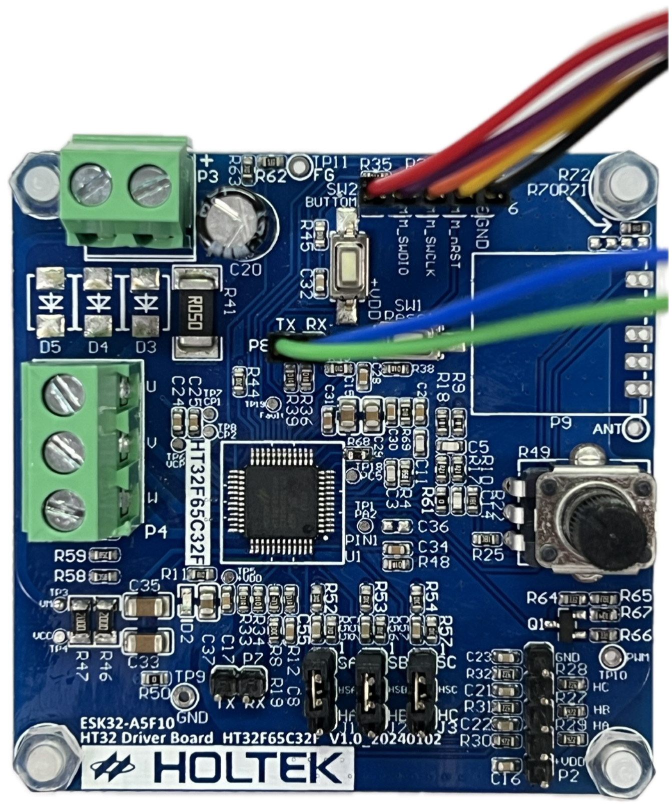
Check the HT32F65C32F_Driver Board Hardware Pre-setting Wiring

As shown in the figure above, connect the three-phase motor lines, black, red and white, to the HT32F65C32F_Driver Board terminals, U, V and W. Connect the e-Link32 Pro to the PC USB port using a Mini USB cable. Then, connect the e-Link32 Pro output port to the P6 pin header on the HT32F65C32F_Driver Board using Dupont lines, as shown in the following figures. The P6 pin header pins from left to right are 5V (red), SWDIO (purple), SWCLK (orange), nRST (yellow) and GND (black). The e-Link32 Pro output pin7 and pin8, the VCOM_RXD and VCOM_TXD pins, are connected to the TX (green) and RX (blue) pins of the P8 pin header on the HT32F65C32F_Driver Board respectively. Finally, connect the 24V power lines to the P3 screw terminal.

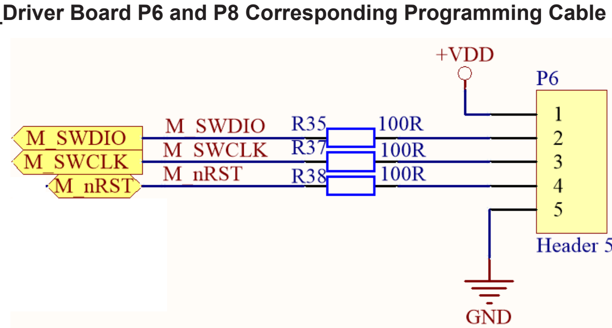


Pin#	Description	Pin#	Description
1	5V	2	SWDIO
3	GND	4	SWCLK
5	GND	6	Reserved
7	NC (VCOM_RXD[Note])	8	NC (VCOM_TXD[Note])
9	GND	10	Reset

e-Link32 Pro Output Port Definition



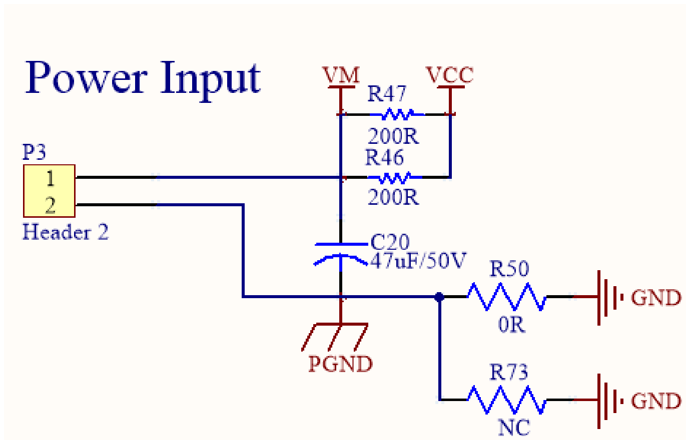
HT32F65C32F_Driver Board P6 and P8 Corresponding Programming Cable Color Reference



P6 Pin Definition

2.6 VCC Buck Resistors

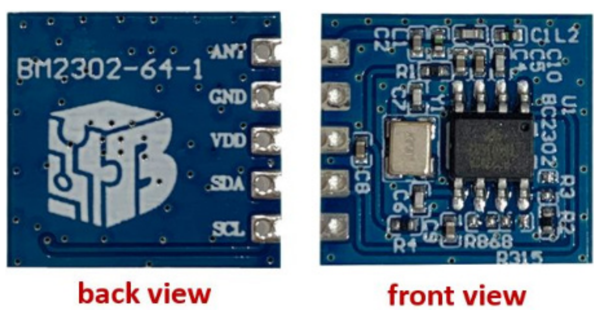
As shown in the figure below, R46 and R47 are 200Ω by default and have a resistor footprint of 1206. When the input voltage exceeds 12V, it is recommended to modify the R46 and R47 resistors to more appropriate values to reduce the 5V LDO input voltage. The VCC current consumption is about 35mA under normal operation. The resistor voltage can be calculated using Ohm's law. It is recommended that VCC is kept within a range of 8V~12V to keep the device temperature within a reasonable range.



R46 and R47 VCC Buck Resistors

2.7 RF Receiver Module

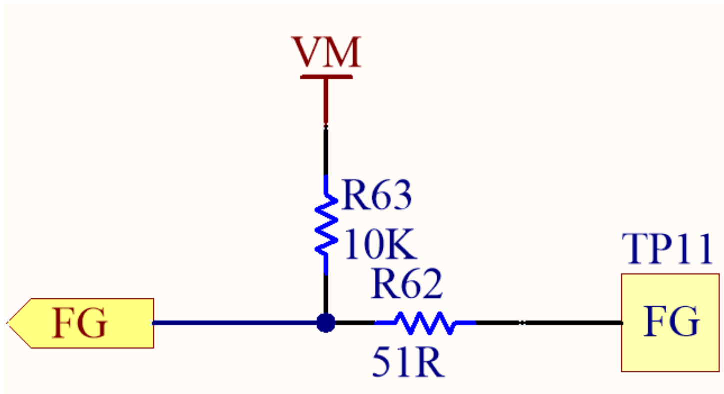
The figure below shows the Low-IF OOK receiver module with a 433MHz frequency band, the BM2302-64-1. If there are long-distance remote control requirements, users can purchase this module on the Best Modules official website. By default, the hardware board does not include this module.



RF Receiver Module

2.8 FG Speed Function

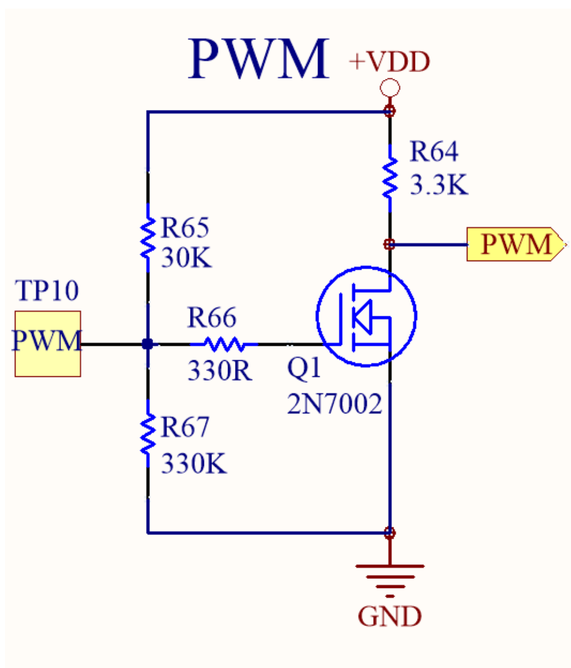
The figure below shows the FG speed function. This uses the integrated FG function in the HT32F65C32F MCU which requires no external components. Since the internal MOSFET is open-drain, a 10KΩ pull-high resistor is used to pull the FG output voltage to the VM voltage level. Add a 51Ω resistor to the FG output to enhance the ESD capability.



FG Speed Function

2.9 PWM Command Function

The figure below shows the PWM command function. By connecting the external PWM command signal to the TP10 pin header and using the Q1 MOSFET to invert the PWM signal, a reverse PWM command signal can be obtained.

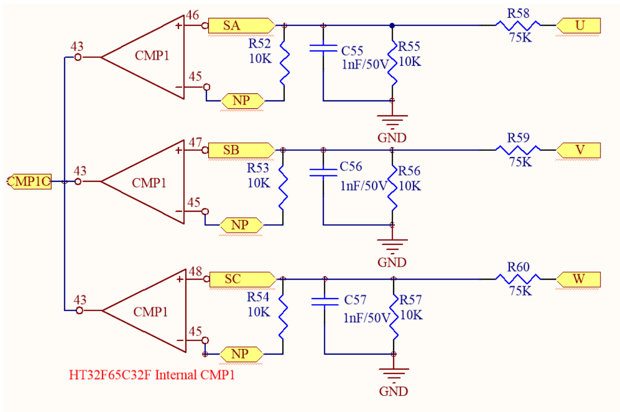


PWM Command Function

2.10 Back EMF Detection Circuit

The figure below shows 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. The resistance values of the voltage divider resistors connected to ground, R55, R56 and R57, are fixed at 10KΩ. Assuming that the highest input voltage is 32V and that the resistance value of the voltage divider resistors to the phase voltage are 75KΩ, the divided voltage can be calculated as:

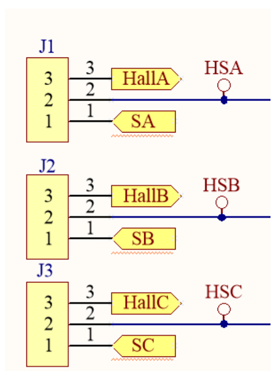
$$32V\times(\frac{10K\Omega}{10K\Omega+75K\Omega})=3.76V$$



Back EMF Detection Circuit

2.11 Sensorless and Hall Sensor Jumper Settings

The figure below shows the sensorless and Hall sensor jumper settings. When the HallA, HallB and HallC signals are selected, short pin2 to pin3 on the external J1, J2 and J3 jumpers. When the SA, SB and SC signals are selected, short pin1 to pin2 on the external J1, J2 and J3 jumpers. The hardware is sensorless by default.

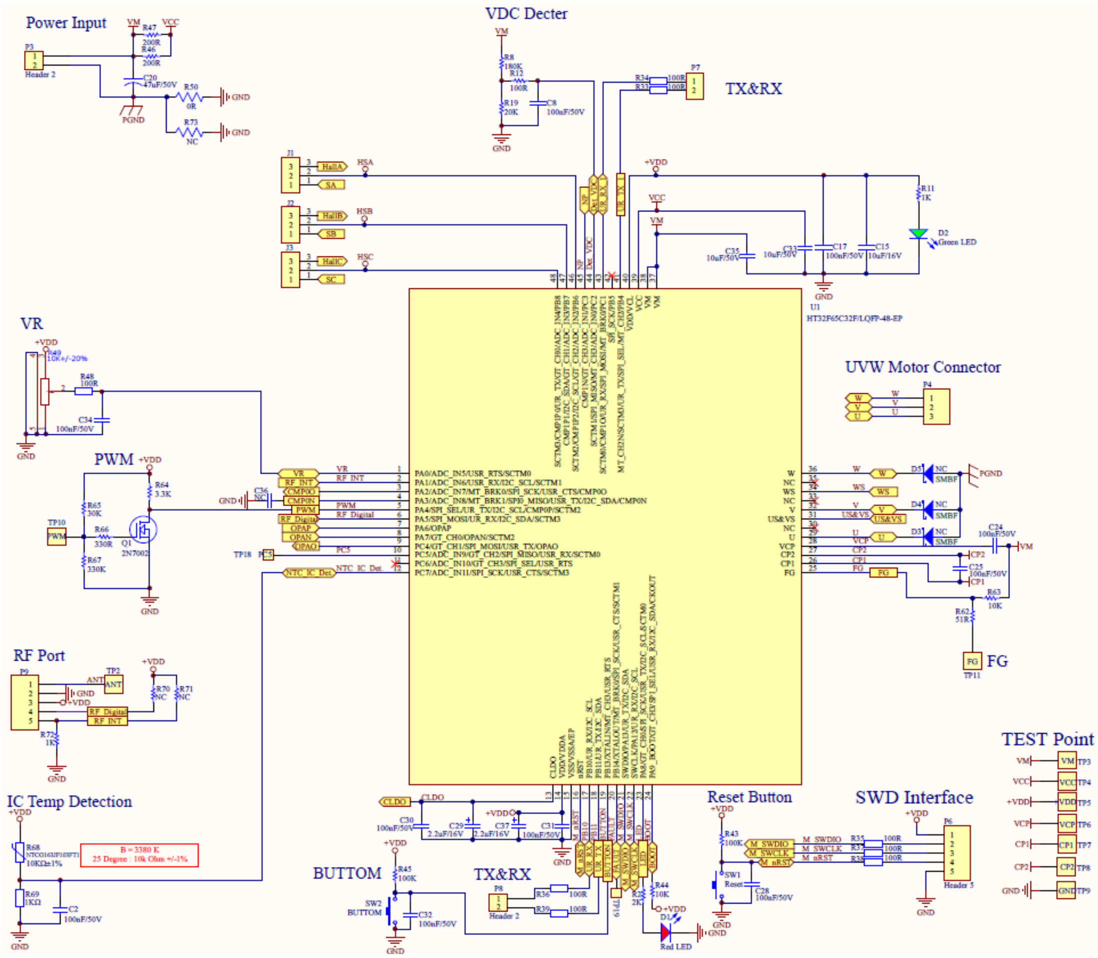


Sensorless and Hall Sensor Jumper Settings

Sensorless by Default

2.12 MCU Pin Function Definition

The figure below shows the HT32F65C32F pin circuit. Refer to the following table for the MCU pin function definitions.



HT32F65C32F Pin Circuit Diagram

PA0 (VR)	PA1 (RF_INT)	PA4 (PWM)
PA5 (RF Digital)	PC5 (Test Point)	PC7 (NTC IC Det.)
PB10 (UR_RX)	PB11 (UR_TX)	PB13 (Button)
PB14 (Fault)	PA8 (LED)	PB4 (UR_TX)
PC1 (UR_RX)	PC2 (Det VDC)	PC3 (NP)
PB6 (HSA)	PB7 (HSB)	PB8 (HSC)

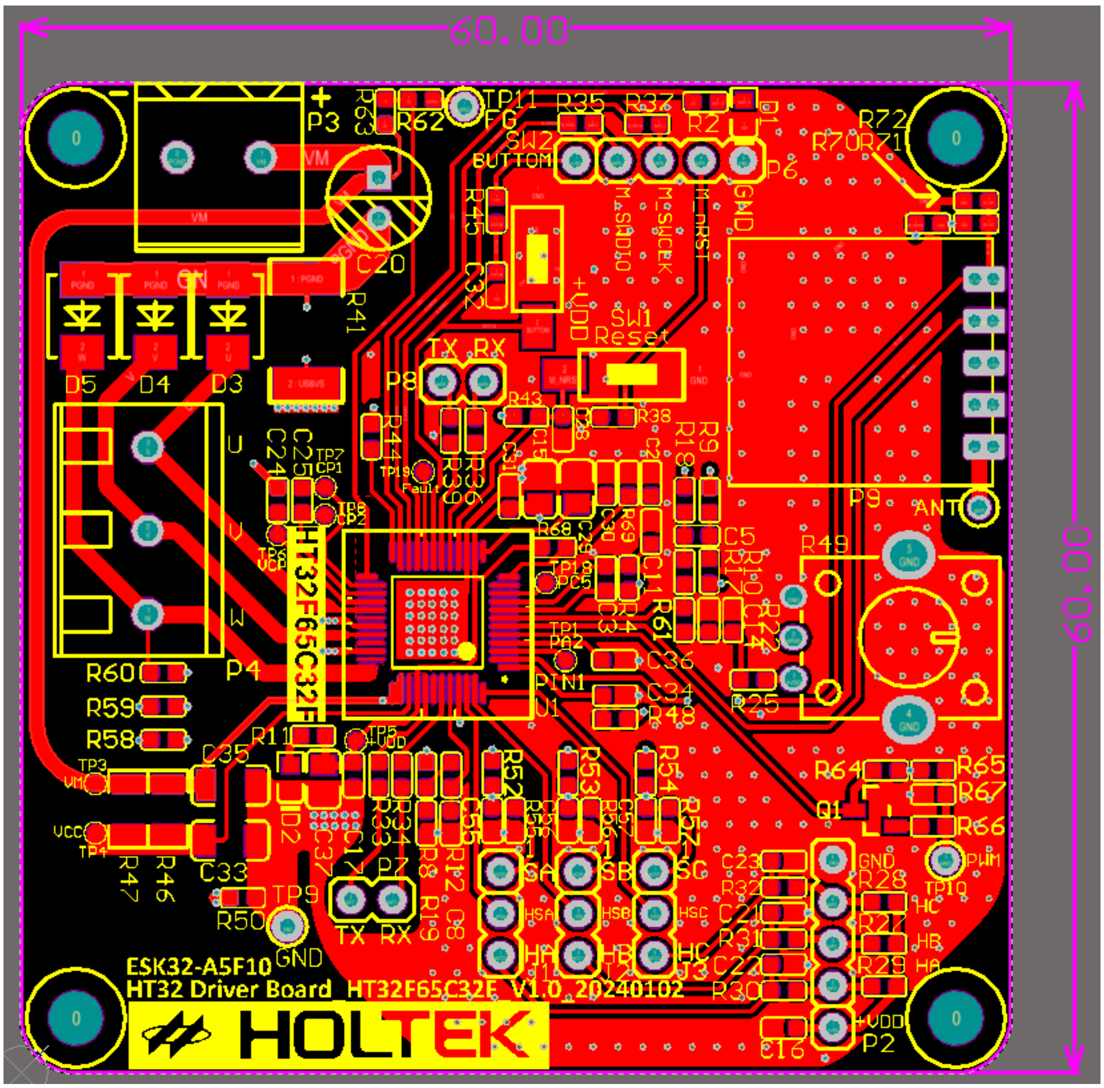
MCU Pin Function Definition

3. PCB Layout

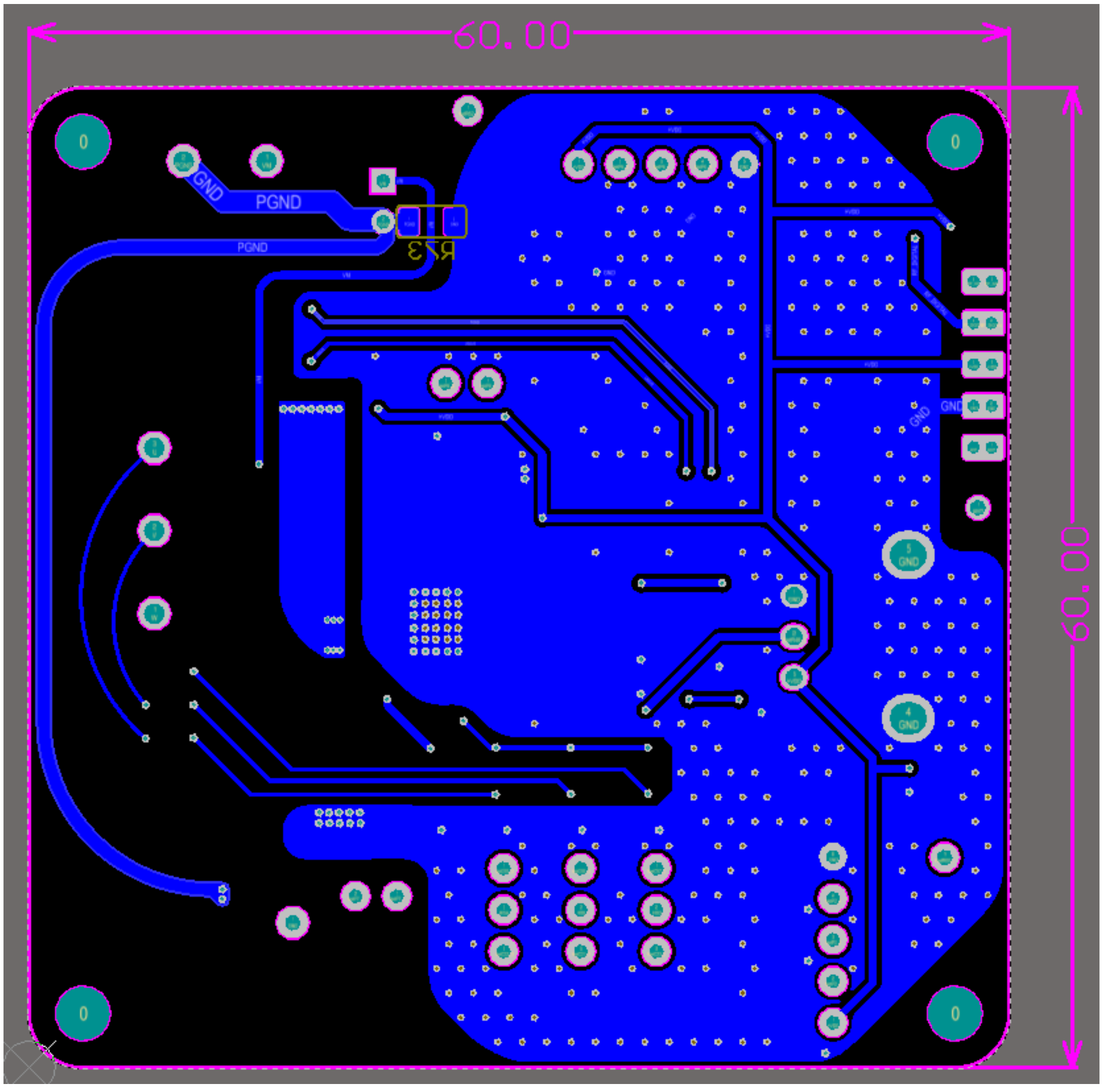
The figures below show the HT32F65C32F_Driver Board PCB Layout. The detailed specifications are shown in the table below.

Length × Width	60×60 (mm)
Thickness	1.6 (mm)
Number of Layers	2
Copper Foil Thickness	1 (Oz)
Material	FR-4
Solder Mask Layer Color	Blue

HT32F65C32F_Driver Board Specifications



HT32F65C32F_Driver Board_Top Layer



HT32F65C32F_Driver Board_Bottom Layer

4. BOM List

The following table shows the HT32F65C32F_Driver Board BOM List, which lists all the required circuit board components.

Comment	Description	Designator	Quantity	Footprint
HT32F65C32F	Motor Driver MCU	U1	1	LQFP48_EP
18pF±5% 50V NP0	MLCC	C3	1	0603
33pF±5% 50V NP0	MLCC	C5, C14	2	0603
100nF±10% 50V X7R	MLCC	C2, C8, C16, C17, C24, C25, C28, C30, C31, C32, C34	11	0603
1nF±10% 50V X7R	MLCC	C21, C22, C23, C55, C56, C57	6	0603
100pF±10% 50V NP0	MLCC	C11	1	0603
2.2μF±10% 16V X7R	MLCC	C29, C37	2	0805
10μF±10% 16V X7R	MLCC	C15	1	0805
10μF±10% 50V X7R	MLCC	C33, C35	2	1206
Tact switch, TS-1101-C-W	SMD button	SW1, SW2	2	SMD
SMD red LED, plain bright	SMD LED	D1	1	0603
SMD green LED, plain bright	SMD LED	D2	1	0603
100KΩ ±1%	SMD resistor	R43, R45	2	0603
100Ω ±1%	SMD resistor	R12, R33, R34, R35, R36, R37, R38, R39, R48	9	0603
10KΩ ±1%	SMD resistor	R44, R52, R53, R54, R55, R56, R57, R63	8	0603
1KΩ ±1%	SMD resistor	R11, R69, R72	3	0603
50mΩ ±1 % 2W	SMD resistor	R41	1	2512
180KΩ ±1%	SMD resistor	R8	1	0603
15KΩ ±1%	SMD resistor	R22, R25	2	0603
4.7KΩ ±1%	SMD resistor	R27, R28, R29, R30, R31, R32	6	0603
0Ω	SMD resistor	R50, R61	2	0603
20KΩ ±1%	SMD resistor	R19	1	0603
51Ω ±1%	SMD resistor	R62	1	0603
7.5KΩ ±1%	SMD resistor	R4	1	0603
180Ω ±1%	SMD resistor	R9, R18	2	0603
820Ω ±1%	SMD resistor	R10, R17	2	0603
75KΩ ±1%	SMD resistor	R58, R59, R60	3	0603
2KΩ ±1%	SMD resistor	R2	1	0603
330KΩ ±1%	SMD resistor	R67	1	0603
330Ω ±1%	SMD resistor	R66	1	0603
30KΩ ±1%	SMD resistor	R65	1	0603
3.3KΩ ±1%	SMD resistor	R64	1	0603
10KΩ ±1%	SMD NTC negative resistor	R68	1	0603
200Ω ±1%	SMD resistor	R46, R47	2	1206
2N7002	SMD N-ch MOSFET	Q1	1	SOT-23
(P=2.54mm, 2Pin, 180 degrees)	Single row	P7, P8	2	HEADER_1X2P
(P=2.54mm, 3Pin, 180 degrees)	Single row	J1, J2, J3	3	HEADER_1X3P
(P=2.54mm, 5Pin, 180 degrees)	Single row	P2, P6	2	HEADER_1X5P
47μF ±20% 50V	DIP aluminum electrolytic capacitor	C8	1	CEC 6.3X11.2H_P2.5
(P=5.08mm, 3Pin, 180 degrees)	Screw type terminal	P4	1	DIP3W-5.08

Comment	Description	Designator	Quantity	Footprint
(P=5.08mm, 2Pin, 180 degrees)	Screw type terminal	P3	1	DIP2W-5.08
10KΩ ±20%, RK09K1130A5R	DIP variable resistor	R49	1	Through-hole
NC	MLCC	C36	1	0603
NC	SMD resistor	R70, R71	2	0603
NC	SMD resistor	R73	1	1206
NC	SMD diode	D3, D4, D5	3	SMBF
NC	SMD RF module	P9	1	RF Module
NC	TEST PAD	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP18, TP19	13	

HT32F65C32F_Driver Board_BOM List