Journal of Computational Science & Engineering
Available at http://www.asocse.org ISSN 1710-4068 57(2022) 27-31

Several common detection circuit design

Qinghui Yuan[1], Bin zhang[1], Lianmeng Shan[2*]
[1]Binzhou Polytechnic, Binzhou, Shandong Province 256603,China
[2]Shandong Mingquan New Material Technology Co. LTD, Jinan, Shandong Province, China

Abstract: **Based on SRM motor under different working conditions, this paper gives the circuit design of detection circuit, position detector, temperature detector and so on. By detecting each signal, it is returned to the controller, and the controller sends out control signals to ensure the safe and stable operation of the power converter and ensure the efficient operation of SRM motor.**

Keywords: **SRM motor; Detection circuit; The controller**

***Corresponding author.** Email: 18615561068@163.com

Received 03 August 2022, Revised 15 August 2022, Accepted 22 August 2022

1.Introduction

The development of switched reluctance motor has been more than 100 years, the last 50 years is its rapid development stage. China's research on switched reluctance motor began in 1984, including switched reluctance motor control system, combined with the advantages of ac and DC motor speed control system, is a new type of electric vehicle speed control system. The application of switched reluctance motor in the field of electric vehicles is also in line with the needs of The Times. Therefore, this paper takes the design of driving motor for golf carts as the background, and designs the controller hardware circuit and the underlying drive based on the switched reluctance motor. This paper introduces the design of detection circuit including bus voltage and current detection circuit, three-phase voltage and current detection circuit, rotor position detection circuit and temperature detection circuit, and the design of current chopper circuit.

2. Bus voltage detection circuit design

This design uses dc voltage power supply, the power supply chooses 60V battery. Corresponding detection methods: sampling resistance method, Hall sensor method. This design uses hall voltage method to complete the detection of bus voltage, hall sensor is produced by Jiangsu Camellia Electric Co., LTD. The module is easy to install, high precision, good electrical isolation, low temperature drift advantages. In addition, the Hall element uses 15V pressure supply. The rated input current of the primary side is 10mA, and the rated output current of the secondary side is 25mA. Turns ratio is 2500:1000, suitable for measuring 10V~500V voltage, the insulation voltage of the primary side and the secondary side is 2.5kV, the precision is 0.6%, the response time is 2 s, and the linearity is less than 0.2%. The circuit diagram of bus voltage detected by Hall voltage sensor is shown in Figure 1.

V+ and V- are connected at both ends of the bus. To prevent RF interference, a capacitor of 100nF is connected in parallel at both ends of V+ and V-. When detecting the voltage, the input resistor R45 is in series on the input road. To ensure accuracy, the input resistance is 6K ohms and the input current is 10mA. The output terminal adjusts the output bus voltage through the variable resistor, and transmits the detected wood dot signal to the analog-to-digital conversion interface of the controller chip F2812. In the circuit, interference often comes from power supply, lightning and other reasons. Electromagnetic waves or spikes affect circuits by magnetic coupling, transmission lines, etc. Therefore, at the output end of signal detection, a capacitor filter of 0.01μF is connected in parallel to ensure that the circuit only retains the DC component.

3. Bus current detection circuit design

Similarly, there are two methods to detect bus current: sampling resistance method and Hall sensor method. Sampling resistance method is more troublesome to adjust the circuit than Hall sensor method is convenient and fast. Therefore, in this design, hall sensor method is used to detect the bus current, the hall voltage detection module is CSM200B, the module is perforated structure, it has good photoelectric isolation performance, a wide range of measurement, turns ratio of 1:2000, power supply voltage is 15V, low temperature shift, accuracy is 0.5%, linearity is not higher than 0.1%. The insulation voltage of the primary side and the secondary side is 5KV, and the output current is 100mA. The response time is less than 1 s. Hall current sensor is used to detect the bus current circuit

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diagram, as shown in Figure 2.

The output end of the Hall detection circuit is connected with the power resistance. When the detection bus current is 200A, the current at the output end of the sensor is 100mA, so the output voltage is 5V. As the controller receives voltage signals, the current is output in the form of voltage. The bus current signals detected on the bus are converted into voltage signals and sent to the analog-to-digital conversion interface ADC of THE chip F2812 to effectively control the bus current, and the capacitor at the output end plays a role of filtering.

4.Three-phase voltage detection circuit design

In order to ensure the normal operation of SRM motor power converter, it is necessary to accurately collect voltage signals of each phase, referring to the empirical data of DMC1500 technical parameters. Three-phase voltage detection, using resistance sampling method. Taking one-phase sampling circuit as an example, voltage sampling circuit is shown in Figure 3.

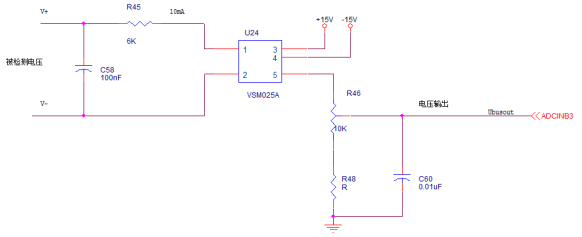

Figure 1 Bus voltage detection circuit

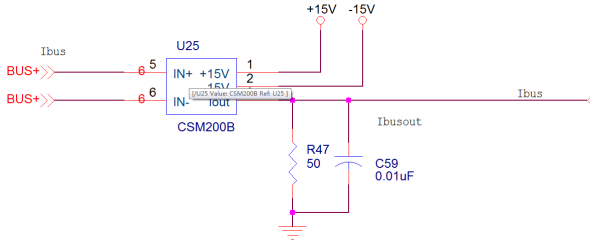

Figure 2 Busbar current detection circuit

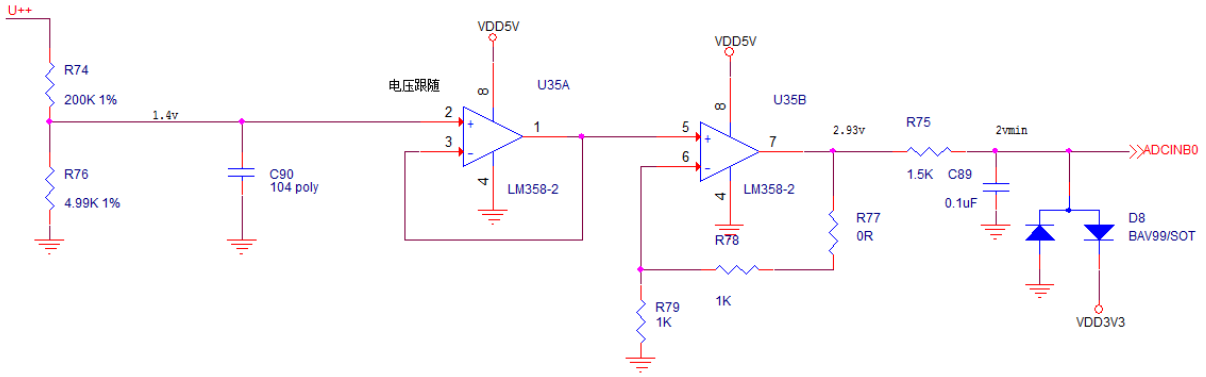

Figure 3 Three-phase voltage detection circuit

A sampling voltage of about 1.5V is obtained at the three-phase voltage monitoring point through the resistor divider, and the capacitor acts as a filter to prevent interference. Sampling voltage through the voltage follower, impedance matching, so that the circuit after the better work. LM358 features: high input impedance characteristics, equivalent to open circuit for the front circuit. Low output impedance, equivalent to a constant voltage source for the rear circuit, so as to isolate the front and rear circuit buffer. At the same time, it also improves the ability to carry loads. In order to satisfy the voltage accepted by the chip F2812 pin, the sampling voltage needs to be amplified. The negative feedback amplifier amplifies the voltage at 2x and the low pass filter filters out the high frequency pulses. Finally, after 3.3V voltage stabilization, the sampling voltage is input to the ADC pin of DSP chip. The detection circuit: good isolation performance, strong anti-interference ability, small temperature drift, low cost.

5. Three-phase current detection circuit design

To complete the electromagnetic torque control and current protection functions of the SRM motor, real-time and accurate phase current signals are required. At the same time, the SRM motor control strategy also needs to detect phase current signals and conduct corresponding control according to the detected phase current signals. In addition, the CHOPPER control of the SRM motor also needs to conduct corresponding chopper according to the detected phase current signals. Three phase current detection of SRM motor includes sampling resistance method and Hall sensor. The hall current module is used for phase current detection. This design uses the perforated Hall

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sensor CSM200B to detect the current in the form of voltage output. Taking c-phase circuit design as an example, the current detection circuit composed of Hall sensors is shown in Figure 4.

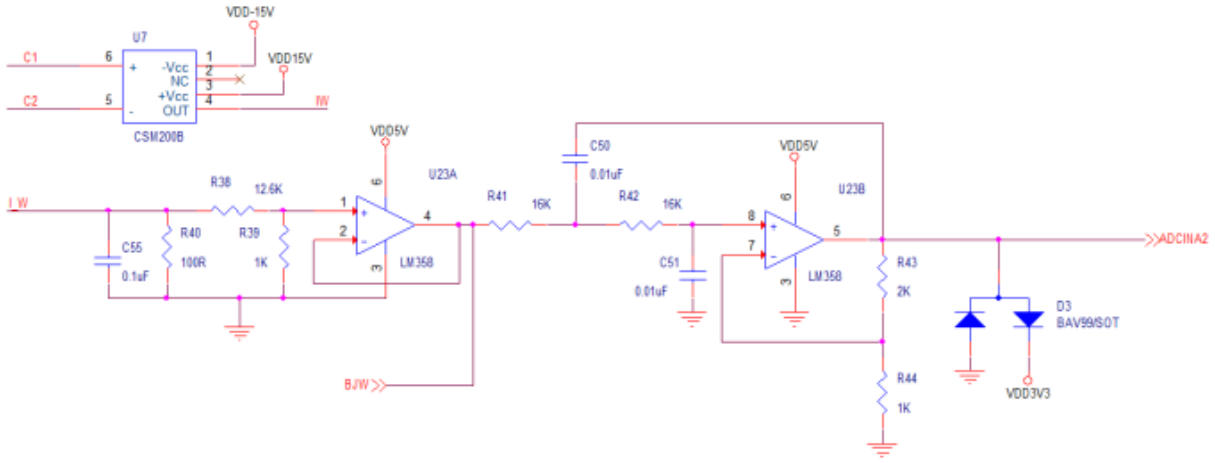

Figure 4 Three-phase current detection circuit

In order to ensure the safety of the circuit, this design isolates the power circuit and control circuit, and the power converter circuit uses a separate PCB board. Therefore, hall detection sensor CSM200B is also on the power converter PCB board. The phase current detected by CSM200B is about 300A, its output current is 150mA, and the output voltage is 15V. The voltage is much higher than the 3.3V voltage of DSP chip, so the voltage is reduced to 1V or so after capacitor filtering and resistor voltage divider, which is composed of operational amplifier voltage follower. Isolate front and rear circuits to eliminate interference signals. The voltage signal output by the voltage follower can be processed in two ways: one is used for signal comparison and chopper control. The other passes through the second order voltage controlled active filter circuit, so that the output voltage can drop at a faster rate in the high frequency band and improve the filtering. RC consists of a low pass filter, which enhances the low

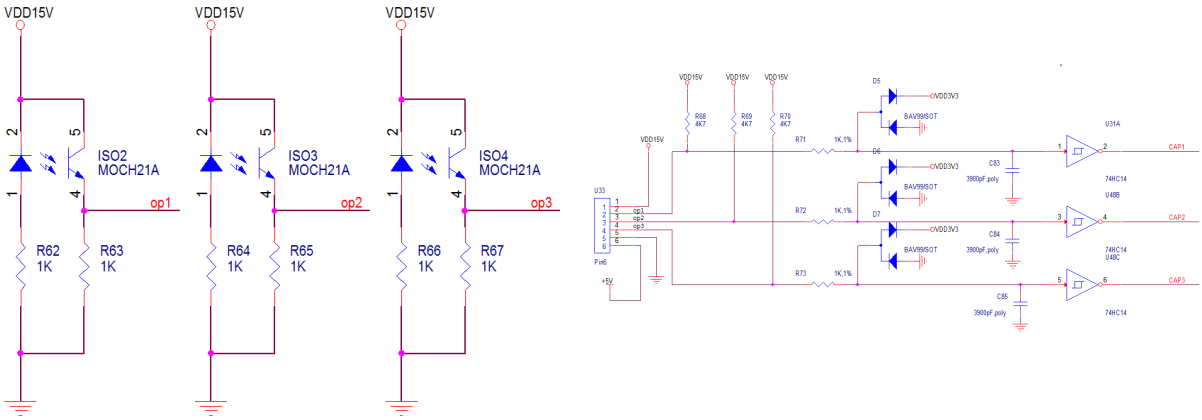

Figure 5 position detection circuit

frequency filtering of the circuit. The passband gain of the circuit is 3, the cut-off frequency is 1KHz, and the output voltage signal of the second-order voltage controlled active power filter is sent to the ADC interface of F2812 after 3.3v voltage stabilization. The controller receives voltage signal and is programmed to control torque and adjust speed.

6.Rotor position detection circuit design

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Position detection is used to detect the position of the rotor relative to the stator and calculate the speed. The controller receives the signal, controls the power converter on and off to ensure the normal and stable operation of SRM motor. The position detector has simple structure and accurate capture. Therefore, the design of direct detection. Photoelectric position detector is selected to form position detection module. The detection scheme uses total detection, that is, three-phase SRM motor to detect the rotor position, and three photoelectric position detectors should be selected.

The position detector selected in this design is MOC H21A. Three U-shaped photocoupler switches are fixed on the stator with an Angle of 60℃ apart from each other. The shading tooth plate is fixed on the rotor, and is coaxial with the rotor with the same structure and distribution, each occupying an Angle of 45 ℃ . The position detection circuit diagram of three-phase SRM motor rotor is shown in Figure 5.

The rotor and disc cover rotate synchronously with the operation of the SRM motor. The teeth of the optical mask pass through the optocoupler MOCH21A, MOCH21A is cut off because the light is blocked, and the output OP is low level; When the slot of the disc cover passes through the MOCH21A, the MOCH21A feels light conduction, and the output OP is high level.

With the rotation of the rotor, the state of the optocoupler MOCH21A changes constantly, and the output phase difference of 15 ℃ and duty cycle of 0.5 square wave signal. After amplitude limiting and filtering, the three-channel square wave signal of MOCH21A is shaped by schmidt trigger, which is divided into two processing :(1) the three-channel square wave detection signal is sent to the CAP1, CAP2 and CAP3 pins of F2812 chip. The controller determines the position of the rotor, the commutation logic of the SRM motor, and the switching state of the MOSFET tube. (2) The three square wave detection signals are different or, and then the square wave signal CAP4, which will jump at 15℃ , is obtained and sent to the CAP4 pin of the chip F2812. The controller calculates the average speed of SRM motor rotor rotation at 15℃ Angle according to the time of two adjacent jumps of rotor position.

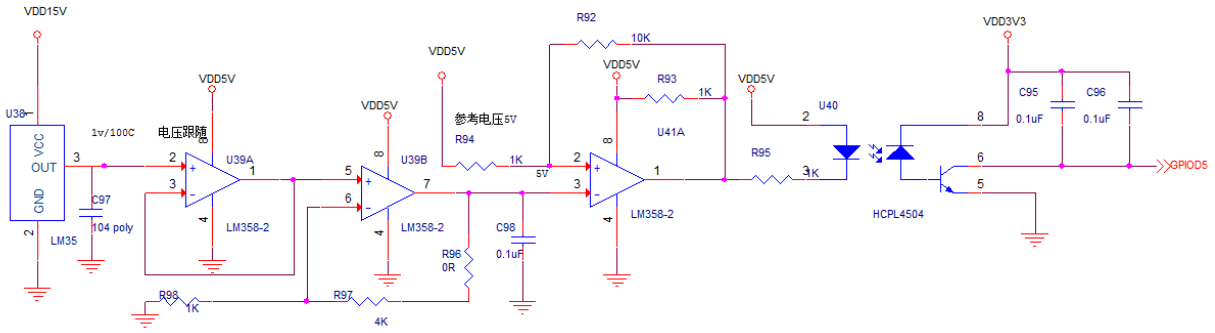
Calculate the average speed of SRM motor at 15 degrees per revolution, and the calculation formula is:

$$\omega = \frac{\text{5}}{360} \cdot \frac{\text{6}}{\Delta t} = \frac{1}{4\Delta t}(rpm) \text{ * MERGEFORMAT}$$

Where, ω is the average rotational speed of the rotor, and is the time of two adjacent jumps of the square wave after three photocouplings.

7.Temperature detection circuit design

When SRM motor is running, MOSFET tube is opened and turned off for a long time at a high frequency, and golf cart is running under high temperature and humidity conditions, so it is necessary to carefully consider the safety of power converter operation. An important reason for power tube damage is that the junction temperature exceeds the allowable value due to long-term high current. For a particular power tube, the most convenient way to reduce junction temperature is to reduce the ambient temperature of the tube. Therefore, in addition to being



installed on the heat sink, the power converter PCB also needs to design an overheating protection circuit to detect the temperature of the MOSFET tube to ensure that the NOSFET tube stops working when it overheats. Therefore, the DESIGN of LM35 temperature detection circuit, real-time and accurate phase chip feedback MOSFET tube temperature, to ensure the normal operation of golf cart. LM35 temperature detection circuit, as shown in Figure 6.

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Figure 6 Temperature detection circuit

The main performance parameters of the LM35 temperature sensor are as follows: the output voltage is linear with the temperature (℃). The power supply voltage of the device is 15V, and the output voltage increment is 10mV/1℃ . At room temperature, the accuracy is 0.25℃ , the accuracy is 0.4℃ ~0.8℃ , and the rated temperature detection range is -55℃ ~+150℃ .

In Figure 5, the temperature sensor detects the temperature in the form of voltage output, the output voltage through capacitive filtering and buffer isolation of the voltage follower, the 1V voltage through the operational amplifier amplification 5 times compared with the reference voltage, after the comparison of signals through high-speed optocoupler isolation and filtering feedback to the CHIP F2812 GPIOD5 pin.

Temperature sensor LM35 is a metal package, installed on the heat sink of the power converter PCB board, MOSFET tube is close to the heat sink, so LM35 indirectly detects the temperature of MOSFET tube, according to the characteristics of the field effect tube set the limit temperature of 100℃ , when the temperature of the field effect tube is higher than 100℃ , The GPIOD5 pin of F2812 chip receives low level signal, the drive signal of MOSFET tube output by the controller presents high resistance state, and MOSFET tube stops working. Until pin GPIOD5 returns to high level.

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