A Design for Medium Voltage Inverter DC Bus Sampling Circuit

Shufang Ma1,2*, Bin Xue1,2

1Engineering and Technology R&D center of Mechanical and Electrical in Colleges of Shandong, Qingdao Binhai University, Qingdao, Shandong, 266555, PR China;
2School of Mechanical and Electrical Engineering, Qingdao Binhai University, Qingdao, Shandong, 266555, PR China;
*Corresponding author’s e-mail: kkmsf@163.com

Abstract. This design is aimed at a 1140V medium voltage converter for mining industry, which can sample the high voltage DC bus voltage of the frequency converter by voltage reduction and A / D conversion optical fiber transmission. Because the DC bus voltage of frequency converter is high, which brings great danger to detection and maintenance, the DC sampling scheme greatly solves this problem, and highlights photoelectric isolation through appropriate circuit design. The problem of isolation between high voltage area and low voltage area of frequency converter is solved, and the accuracy of sampling and the safety of maintenance personnel are guaranteed.

1. Introduction
The converter works according to the principle of AC-DC-AC. AC is changed into DC by rectifier, and then inversely into the required frequency of AC. DC bus is the bus that carries the rectified DC. The output AC voltage of frequency converter is based on DC bus voltage. If the bus voltage detection is not accurate, it will affect the output voltage of the frequency converter (the bus voltage is on the high side, the AC output voltage is on the low side). In addition, the undervoltage and overvoltage protection functions in the frequency converter are judged by DC bus voltage.

On the high voltage DC bus side of frequency converter, the high voltage DC signal is step by using the characteristic of high voltage resistance partial voltage, and the DC bus voltage signal after voltage reduction is sent to the emitter output of operational amplifier circuit. The analog signal is transmitted to the A / D conversion module through the emitter output. The A / D conversion module converts the analog signal into a digital signal, passes the gate circuit to the optical fiber transmitter, and transmits it to the CPU by using the optical fiber as the communication medium.

2. Circuit design

2.1. Voltage division circuit
The DC bus side voltage of 1140V frequency converter is too high, so the voltage dividing measure must be adopted. The design of voltage divider circuit is shown in figure 1 below. Two high voltage resistances R1, R2 series and partial voltage are used to reduce the voltage to the suitable value of the subsequent circuit. Then paralleling two sampling resistances R3 and R4, then through the current
limiting resistance $R_5$, and finally through the voltage regulator to stabilize the voltage into the voltage follower pin No. 3.

The voltage follower adopts TL0521 integrated module, which is an electronic device whose output voltage varies with the input voltage. The voltage magnification of the voltage follower is infinitely close to 1, and less than 1. The voltage follower is characterized by high impedance at the input end, which is usually thousands or even tens thousands of $\Omega$, which greatly reduces the size of the input capacitor and ensures the application of high-quality capacitors[1]. However, the output impedance is very low, which can provide stable voltage for the follow-up circuit and achieve good isolation effect.

Figure 1. Partial voltage circuit

2.2. ADC

After the voltage signal is buffered and isolated by the voltage follower, the voltage signal is sent to the analog-to-digital conversion module MAX186 through the current limiting resistance and filter capacitance, which realizes the purpose of converting the analog quantity into the digital quantity[2].

Integrated with large pulse width tracking / holding circuit, serial port and 8-channel multi-channel switch. It is suitable for instruments with high conversion rate, low power consumption and high precision. It converts analog signal into digital signal, and realizes the conversion and processing of sampling signal by subsequent circuit.

2.3. Electric light conversion circuit

The digital signal sent by the A / D conversion circuit is converted into an optical signal sent to the main control board CPU, circuit through the optical fiber as shown in figure 2. The electrical isolation between the two circuits can be realized by the conversion between the optical fiber seats T-1521 and R-2521.

In order to improve the load capacity of the circuit, it is necessary to add a gate circuit SN75452BP. A/D converter converts the analog signal into a digital signal after the A / D conversion, and then send the signal into the optical fiber transmitter through the SDO port. In order to improve the load capacity of the circuit, the gate circuit SN75453BP is added as the intermediate stage.

SN75453BP processes the signal and sends it into the T-1521 optical fiber transmitter, which converts the digital electrical signal into a flashing optical signal and transmits it outward.
2.4. Optical switching circuit

The optical signal feedbacks from the main control board CPU needs to be converted into a digital signal and sent back to the A/D converter MAX186. T-1521 optical fiber transmitter transmits the signal through the optical fiber to the transmitter on the main control board after processing the signal through the optical fiber, and then converts the optical signal into the electrical signal through the optical fiber to convert the optical signal into the electrical signal through the R-2521. R-2521 of the signal reverse mining template. The serial clock SCLK, serial digital interface DIN, fed back to MAX186 analog-to-digital conversion chip realizes the photoelectric conversion of communication signal, the circuit is shown in figure 3.

The photoelectric conversion of communication signal is realized by transmitting signal and receiving signal by T-1521 and R-2521. And full duplex communication is achieved[3].

2.5. Isolated power supply circuit

In order to isolate the power supply ground wire between parts, install the isolation power supply to supply power to the voltage follower and A/D conversion module[4]. The power supply circuit is shown in Figure 4. Input 24V DC current at the VH socket, pass through fuse, connect 220uF electrolytic capacitance in parallel and non-polar capacitor, and connect 68uH inductance in series, and the composed dual filter circuit enters the isolated power supply (WRA 2405CS2W). The isolated power supply outputs +12V,-12V voltage and a neutral line. Finally, after two 220uF electrolytic capacitance and four non-polar capacitance filter network, external power supply is achieved[5].
3. Loading test

(1) Add two power supply U+ and U- to the rear of high voltage resistance, and simulate the signal after voltage division, then connect to the neutral line and 24V DC power supply, as shown in figure 5. The isolated power supply is working properly if the indicator light is on.

(2) Plug in the communication fiber, with one for transmitting and two for feedback. Use optical fiber as medium to transmit the sampling signal to the main control board, and connect the main control board with measuring instrument after processing the signal, so that the sampling signal can be displayed on the instrument ABB ACS800.

(3) When operating the loading test, a DC test voltage 4600V is added between U+ and U-. As shown in figure 6, the figure displayed in the instrument is 921.9V, and the actual voltage is 4609.5V after multiplying by an amplification factor of 5, the error is 9.5V, 0.2% < 1%. Therefore, the actual measurement result is in the allowable range, and the electrical circuit is stable and reliable.

4. Conclusion

In this article, the high voltage distribution characteristics of high voltage resistance series are used to solve the problem of high voltage on the DC bus side of frequency converter. The upper and lower
circuits are buffered and isolated by using the characteristics of high input impedance and low output impedance of the voltage follower. The isolated power supply is used to power the voltage follower and A/D conversion module to prevent interference. The optical fiber is used as transmission medium, not only because the interference is small, but also the high voltage side is isolated from the low voltage side.

The accuracy and security of the sampling circuit are verified by the physical tests.

Project information
Qingdao Binhai University scientific and technological planning research projects. Project number: 2018KY02.

References
[1] Gu B G, Nam K. A DC-link capacitor minimization method through direct capacitor current control[J]. IEEE Transactions on Industry Applications, 2006, 42(2): 573-581.
[2] Xabier Larrucea, Izaskun Santamaria. Correlations study and clustering from SPI experiences in small settings[J]. Journal of Software: Evolution and Process, 2019, 31(1).
[3] João Vitor Munari Benetti, Jessica Thais do Prado Silva, Vânia Regina Nicoletti. SPI microgels applied to Pickering stabilization of O/W emulsions by ultrasound and high-pressure homogenization: rheology and spray drying[J]. Food Research International, 2019, 122.
[4] Sakda Somkun, Panarit Sethakul, Viboon Chunkag. Novel control technique of single-phase PWM rectifier by compensating output ripple voltage[C]. Industrial Technology, DEC, 2005: 966-978.
[5] Wang Lixin, Zhang Ning, Jin Gang. Calculation and simulation of the filter capacitor at the DC side of the VSR[J]. Journal of Harbin Institute of Technology, 2006, 38(1): 63-66.