Design of Motor Condition Monitoring System for Belt Conveyor in Coal Mine

Tongzhe Li [1, 2, 3], Hongkui Zhang [1, 2, 3, *]

[1] Fushun CCTEG Inspection Center Co. Ltd, Fushun Liaoning, China

[2] CCTEG Shenyang Research Institute, Fushun Liaoning, China

[3] State Key Laboratory of Coal Mine Safety Technology, Fushun Liaoning, China

* Corresponding Author Email: 18940021505@126.com

Abstract. With the increase of the number of mines and the depth of mining coal in China, it is more and more important for the safety performance of underground equipment. On the basis of analyzing the coal mine safety production and transportation system, we design the motor condition monitoring system of coal mine belt conveyor, choose high-precision sensors to collect the signals of voltage, current, temperature, torque and speed of the coal mine belt conveyor motor, and use the CAN communication circuit to transfer the collected data to the computer, so as to realize the condition monitoring of the coal mine belt conveyor motor.

Keywords: coal mine; transportation system; motor; monitor.

1. Introduction

Coal accounts for more than ninety per cent of China's fossil energy resources, and is the most stable, economical and self-securing energy source. The rapid development of natural gas, nuclear energy and renewable energy is more capable of replacing traditional energy sources such as coal. This will gradually reduce the proportion of coal in primary energy consumption, but the status of coal as the main energy source will remain unchanged for a long period of time. In recent years, it has been improving the production safety situation in coal mines year by year, but there are still many weak links in the production safety work, such as complex and changeable geological hazards, chaotic on-site management, and lack of disaster management, etc., and the production safety work is still the focus of the work in the field of coal mines.

Transportation system is an important part of coal mine safety production work, and transportation equipment also occupies a large proportion of all kinds of equipment in coal mine underground. Coal mine safety production and the development of intelligent mine technology have higher and higher requirements for the safety, reliability and energy-saving effect of coal mine transportation system. As the pace of intelligent construction of large and medium-sized coal mines in China continues to advance, the coal mine transportation system is facing the primary task of technological innovation and product upgrading. Belt conveyor is the main mode of coal mine transportation system. The motor is the power source of the belt conveyor, whose stability and safety are directly related to whether the coal mine safety work can be carried out smoothly and the construction process of intelligent coal mine. Therefore, it is of great significance to carry out the research on the condition monitoring technology of motor for belt conveyor to ensure the smooth implementation of coal mine safety and the construction of intelligent coal mine.

2. Belt Conveyor for Coal Mine

A belt conveyor for coal mine is a common equipment for mining, which is applied to convey coal and other materials from the mine or stockpile yard to the processing equipment or warehouse. The belt conveyor for coal mine is shown in Figure 1. The belt conveyor for coal mine consists of driving device, pulley, supporting device, tensioning device, deceleration device, cleaning device, protection device, transmission device and so on. Generally, the belt conveyor for coal mine consists of several

sections of belts connected together, and the drive device (usually an electric motor) drives the pulley to rotate, so as to make the belt move and convey the materials from one end to the other end. Belt conveyor for coal mine can realize horizontal, inclined, large inclination angle and vertical conveying. The belt conveyor for coal mine adopts fully enclosed structure, which can effectively prevent coal dust and environmental pollution. Meanwhile, the conveyor is equipped with multiple speed reducer and tensioning mechanism, which ensures the stable operation and reliability of the conveyor. As an important part of mining equipment, belt conveyor for coal mine is characterized by high efficiency and energy saving, large conveying capacity, simple structure, stable and reliable operation and strong adaptability. In coal mine production, the application of belt conveyor can improve working efficiency, reduce labor intensity, and provide a reliable guarantee for coal production and processing.



Fig 1. Coal mine belt conveyor

3. Design of Motor Monitoring System

The motor is the core of the whole coal mine belt conveyor and adopts digital signal processor (DSP) and CAN bus technology as the core to design the motor condition monitoring system for coal mine belt conveyor, as shown in Figure 2. The motor condition monitoring system for coal mine belt conveyor includes DSP minimum system, signal conversion circuit, high-precision sensor, CAN communication circuit, and computer, in which the DSP minimum system is used for receiving and processing the signals and feeding the signals back to the upper computer through CAN communication circuit. The high-precision sensors are applied to collect the operating parameters of the coal mine belt conveyor motor, which mainly include voltage sensor, current sensor, temperature sensor, torque sensor and speed sensor. Signal conversion circuit is used to isolate and amplitude reduction of the original signal output from the sensor into a signal that can be received by the DSP, and CAN communication circuit is used for the signal transmission. The working process of coal mine belt conveyor motor monitoring system: the output signal of the sensor is converted into a signal that can be received by the processor through the signal conversion circuit and sent to the DSP, which analyzes and processes the signal and then transmits it to the host computer through the CAN communication circuit.

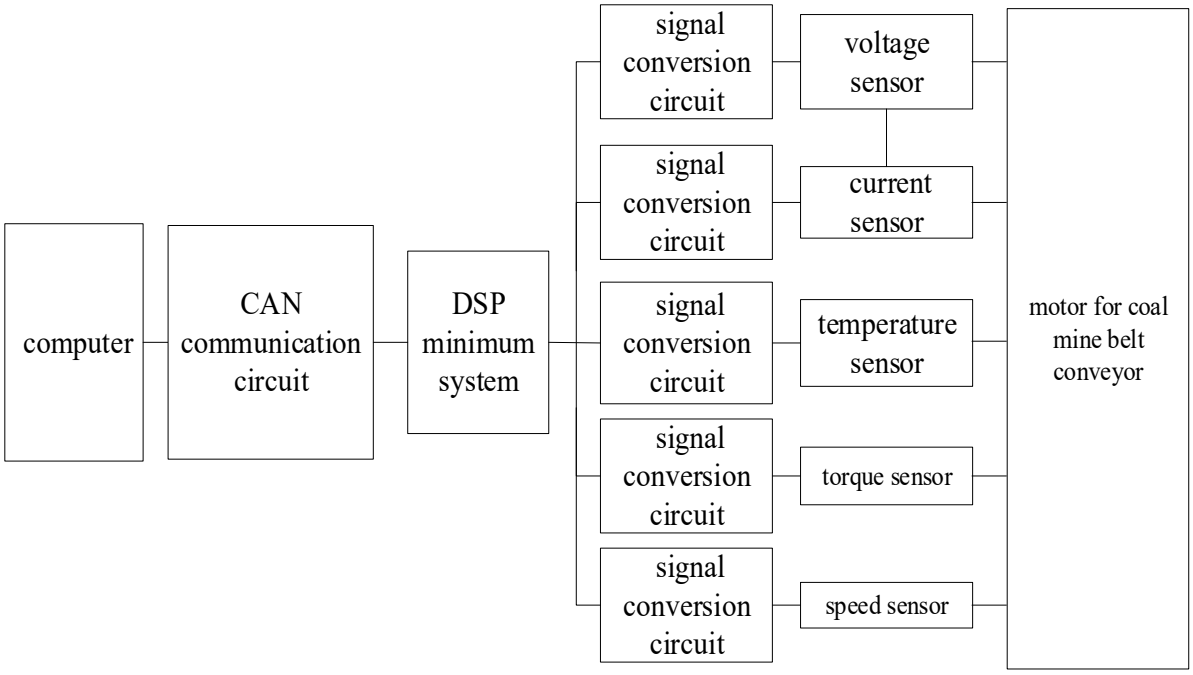


Fig. 2 Structure block diagram of motor condition monitoring system for coal mine belt conveyor

3.1. Signal Conversion Circuit

DSP chip input signal pin can directly accept voltage signals in the range of 0-3.3V, the sensor's output signal amplitude is higher than the DSP received voltage range. Sensor output signals need to be converted into signals that can be received by the DSP through signal isolation circuits and resistor-voltage divider circuits composed of high linearity analog photocoupler HCNR201 as the core, and then be transmitted to the input pin of the DSP. HCNR201 consists of three photoelectric components, with low linearity error, high bandwidth and high voltage resistance, and so on, and it is widely used in the data communication, variable detection and industrial control and other occasions. A voltage regulator circuit is set at the input of the DSP to limit the input voltage of the chip pins and ensure that the input voltage of the DSP does not exceed 3.3 volts.

3.2. CAN communication circuit

Fieldbus technology is one of the hotspots in the field of automation, providing strong technical support for real-time and reliable communication between nodes of a distributed control system. CAN is the abbreviation of Control Area Network, which is a kind of serial communication bus that supports distributed control or real-time communication.DSP has already integrated a CAN communication module that supports the CAN2.0 communication protocol. The communication circuit is designed to realize the data transmission between DSP and CAN communication network by only one CAN transceiver. CAN bus adopts a "carrier monitoring, multi-master control/conflict avoidance" communication mode in data transmission. This arbitration method allows any device on the bus to have the opportunity to gain control of the bus and send data out. Assuming that two or more devices are requesting data at the same time, a bus conflict occurs, and the CAN bus detects these conflicts in real time and arbitrates them so that higher priority data can be transmitted in real time without damage.

When designing the circuit, it is to avoid designing a separate level conversion circuit and simplify the hardware circuit of the monitoring system, the 3.3V series CAN transceiver SN65HVD230 is selected to realize the reliable bidirectional transmission of data between the DSP and the host computer, and the interface circuit between the DSP and the CAN bus is shown in Figure 3. SN65HVD230 supports differential signaling with a transmission rate of up to 1 Mbit / s, but also compatible with the existing signaling system, and its output conversion time can be programmed to control, which helps to improve the ability to resist electromagnetic interference.

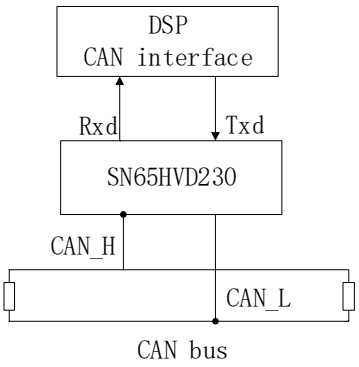


Fig 3. DSP and CAN bus interface

4. Conclusion

The motor condition monitoring system of coal mine belt conveyor designed based on DSP and CAN communication technology realizes the real-time acquisition of motor temperature, voltage, current, speed and other signals and the monitoring of operating condition, which improves the reliability and stability of the operation of the coal mine belt conveyor and provides data support for the intelligent development of the coal mine transportation system at the same time.

Acknowledgements

The authors gratefully acknowledge the financial support from Technical Support Project of the State Administration for Market Regulation (2023YJ12) and Technology Project of the Liaoning Market Supervision Administration (2023JS007) funds.

References

[1] Ju Xu, Lin Sun. Test and temperature field of finite element simulation about the effect of scanning speed on 304 stainless layer's properties by laser cladding [J]. Materials Research Innovations,2015,19(sup8): S8-9-S8-13.

[2] Seong-Kyung Back. A Study on the Lighting plan for the Tunnel of a Radioactive Waste Disposal Facility using Fluorescent Induction Lamps and the Design Feasibility Investigation using Simulation [J]. Journal of the Korean Institute of Illuminating and Electrical Installation Engineers,2010,24(5)：8-15..

[3] Claudiu Ionel Nicola,Marcel Nicola,Dumitru Sacerdotianu,Marian Duta,Iulian Hurezeanu. Automatic System for Temperature Rise Test in Power Transformers[J]. International Journal on Engineering Applications (IREA),2019,7(2):40-51.

[4] Chen Wencheng,Huang Zheng,Guo Liping,Lin Yandan,Chen Dahua. Performance of induction lamps and HPS lamps in road tunnel lighting [J]. Tunnelling and Underground Space Technology incorporating Trenchless Technology Research,2007,23(2)：139-144.

[5] Wang Zezhong, Li Mingyang, Xuan Mengzhen, Huang Tianchao, Li Bing. Temperature Rise Test and Simulation of Single-Phase Four-Column Transformer under DC-Bias. Transactions of China Electrotechnical Society, 2021, 36(5): 1006-1013.

[6] Shaodi Zhao,Yan Yin,Jiusheng Bao,Xingming Xiao,Zengsong Li,Guoan Chen. Analysis and correction on frictional temperature rise testing of brake based on preset thermometry method [J]. Industrial Lubrication and Tribology,2019,71(7):907-914.

[7] Cheng-bo LIANG,Jie YAN,Bei-bei XU. The Test Methods for Temperature Rises and Low-power Circuit [C]//. Proceedings of 2017 2nd International Conference on Applied Mechanics, Electronics and Mechatronics Engineering.2017:27-31.