The Design of Gas Monitoring System Based on the Prediction Model

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Abstract. Considering the current situation of the coal mine accident in our country. An intelligent gas monitoring system which has some prediction function is put forward in this paper. In the system, the microcontroller monitoring substation and CAN bus communication system is designed; a prediction method of gas concentration on account of the chaotic model is proposed; moreover, the micro computer processing technology, the simple hardware and software are combined with. The system reduces the complexity of hardware design, improves the reliability of the system and lowers the cost of coal mine gas monitoring system. The experiment results show that the system has the characteristics of detecting accuracy, highly reliability, forecasting exactly, and so on. Fitting the requirements of the small and medium-sized coal mines gas monitoring.

Introduction

Coal mine disaster is the main form of coal mine accidents, which affects the coal mine production and threats the life safety of the miners directly, and it usually brings great economic losses. Considering preventing the happening of the gas disasters, it has been the main research important topic for the Coal science and technology workers to research the coal mine gas monitoring system which is high performance, high reliability and strong practicability. In this paper study above problems, the gas concentration prediction algorithm, forecasting the gas concentration with chaos theory and neural network are researched and put forward. A kind of intelligent monitoring system is designed, that depending on the MCU as the core, and the application of CAN bus communication technology.

The system design

The monitoring system is mainly composed of monitoring host, monitoring substation, the data communication interface, the scene of actuators and sensors. The main equipment is shown in figure 1.The monitoring host can be connected with the other monitoring host through local area network (LAN), and can be accessed to the internet by the server to realize remote detection and data sharing. In the aspects of communication interface, considering long communication distance, security and reliable, RS-485 and RS-232 which is the traditional way of communication can not satisfy the requirements, therefore, the high performance CAN bus is used as the communication connection. The distance between the sensor and monitoring substation is 2 km, between the RACES is 20 km. The maximum load of the Central station is 64 BUS converter.

CPU module design.

First, because the methane gas monitoring sensor in coal mine roadway where the working environment is bad, and the actual running situation is more complex. So we should use the CPU model with better anti-jamming performance because work environment cause greater interference on CPU. The second is to reduce costs while also improving performance. For the tow reasons the paper use TI company launched MSP430 series microcontrollers, which typically MSP430F149 microcontroller products with high performance and low cost.

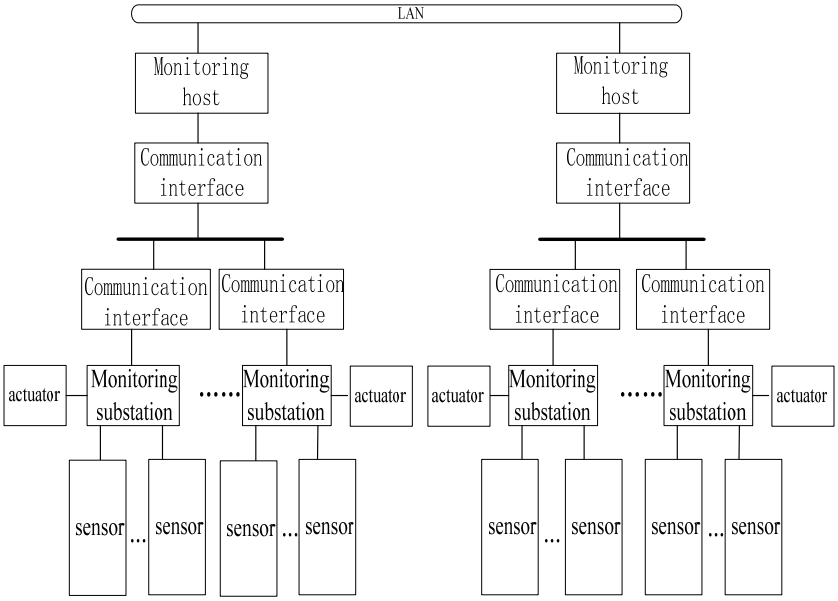

Fig1. The gas monitoring system

The design of the monitoring substation.

Monitoring substation under the mine is the core of the security monitoring system, which is responsible for collecting and processing the safety monitoring data of scene production environment and equipment condition. Monitoring substation mainly consists of gas sensor, microcontroller, LED display, CAN network communication interface and other components. The principle block diagram is shown in figure 2. Substation which is constituted with the single chip microcomputer MSP430 devices is the core part of the coal mine monitoring system, and realizes the recognition of the composition such as CH4, CO and concentration measurement, according to the gas sensor signal. The monitoring and control system password can be changed, the parameters can be set via external command and remote control. Six LED are used to display gas concentration and the number of mine laneway. Using the CAN bus network communicates with the PC.

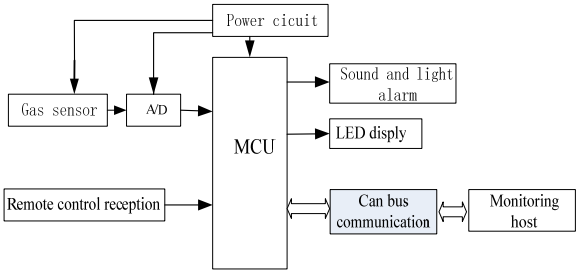

Fig2. The principle diagram of the monitoring substation

CAN bus design.

CAN bus is a spot bus which is kind of digital, bi-directional with multiple field. Compared with the traditional RS485 bus, CAN bus has many main structures, high data transfer rate, communication distance, and high utilization rate etc, strong anti-jamming capability, also. Compared with the optical fiber communication, the CAN bus has higher cost performance. The MSP430 devices doesn't have CAN bus receiver, therefore, the author extended the CAN bus interface chip outside the controller with the Philips SJA1000 CAN bus controller. SJAl000 has two kinds of works, are Basic CAN and PeliCAN, among them, the PeliCAN works supports CAN 2.0 B agreement with many new features. The PCA82C250 is used as CAN bus transceiver. PCA82C250 is the interface between CAN communication controller and physical bus, which provides differential capacity to the CAN controller. The specific circuit is shown in figure 3.

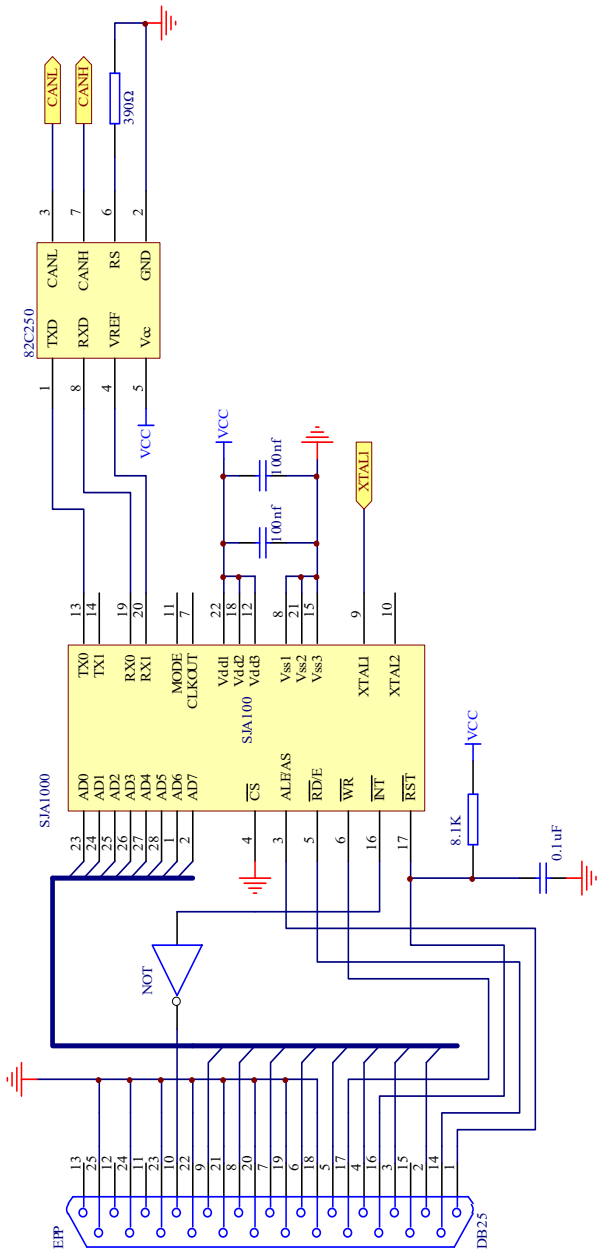

Fig3. CAN bus interface circuit

Prediction model

As the gas is affected by the depth of coal, the permeability of coal seams, surrounding rock and many other factors, meanwhile the interplay of various factors show a great of non-linear. So satisfactory results are difficult to obtained by traditional linear methods such as dynamics and mathematical statistical. But the birth of chaos theory, in order to solve the nonlinear problem, provides a good tool. It makes gas prediction possible by means of chaotic time series. As the time series of gas production is easy to get, coal mine gas concentration signal is used as a prediction object in this paper, we can get the embedding dimension and time delay of the gas concentration sequence based on the chaotic characteristics of the gas concentration signal, and then reconstruct the state space of the time series.

Y（ti）=[x(ti),x(ti+τ), x(ti+2τ),…x(ti+(m-1)τ)] i=1,2,3…[4] .Then use the reconstructed state space to train artificial neural networks, that is to say, using the neural network to approach the relationship between the critical state-point and its follow-up sequence. So it uses the time series value at some times as network input and output will be the neural network forecast value for the next moment. The end, it uses the known gas concentration as the sample and the method proposed in this paper to

study the future gas concentration, and gives their assessment of predictive and analysis. Prediction model which is shown in Figure 4.

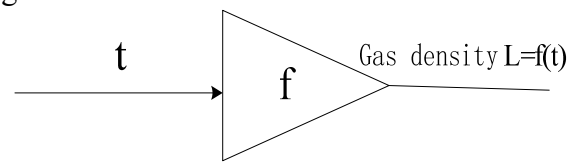

Fig4. Gas concentration predictability model

This paper uses gas concentration data of a mine in January 2012, sampling interval time is 1h, , extracting 360 test samples data from 744 data (shown in Figure 5)， using chaos theory reconstruct phase space of existing sample value, then using RBF neural network forecast the time series reconstructed. Predicted results comparing with the actual concentration (shown in figure 6). Due to the limited length of paper only 24h of data analysis are presented. Though analyses, the maximum absolute forecast error of the mode is 0.0056, and the relative error is between 0 ~ 3%, which could meet the actual needs of the production.

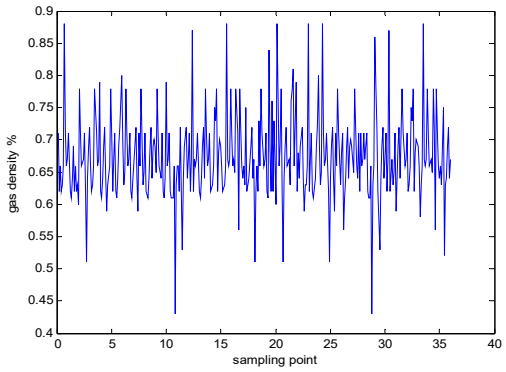

Fig5. The number of sampling points

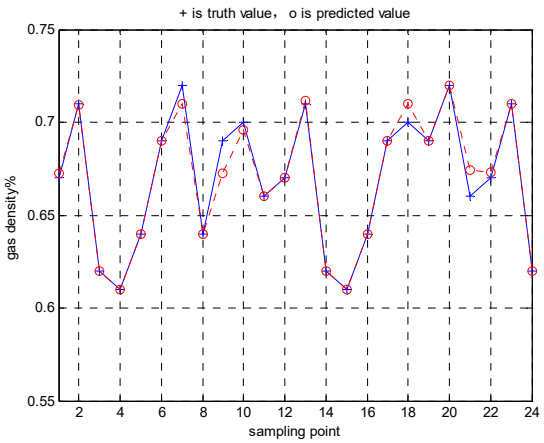

Fig.6 The comparison of actual value and predicted value

System software design

The software design is the main content of the intelligent tester. The system realize real-time monitoring of upper machine and lower machine. Lower machine data through the CAN bus to realize real-time uploaded, under mine can be detected by the LED display. We can improve the ability of prevention of gas accident prevention more effectively. At the same time, the modular programming is used in the system software, which makes software debugging easier.

The main program design.

Some functions such as MCU, some registers, I/0 and others, are initialized firstly in the main program, the power of some IC chips is turned on or off. For example, delay waiting for stable crystals etc. After that, the set parameters are obtained from the flash memory. Then preheating gas

sensors is deferred. Lastly, the program runs the main loop, turning on interrupt, waiting for interrupt wakes up, collecting data, and analyzing forecasting data, etc. Its working process is shown in figure 7.

The design of Prediction model software.

In this system, the gas density index are input of forecasting model, which are collected from monitoring substation, and are transferred to the monitor machine by CAN bus. After that, the gas density index are reconstructed on phase space, judging the embedding dimension is or not equal to the specified value, when it reaches the specified value, input the neural network to predict and judge. If the judgment achieves to forecast value, the alarm monitoring system is turned on, then informing the people on the mine take corresponding preventive measures before the accident happened. At the same time, substations also sound and light alarm, upload real-time gas concentration data. The specific procedures as shown in figure 8.

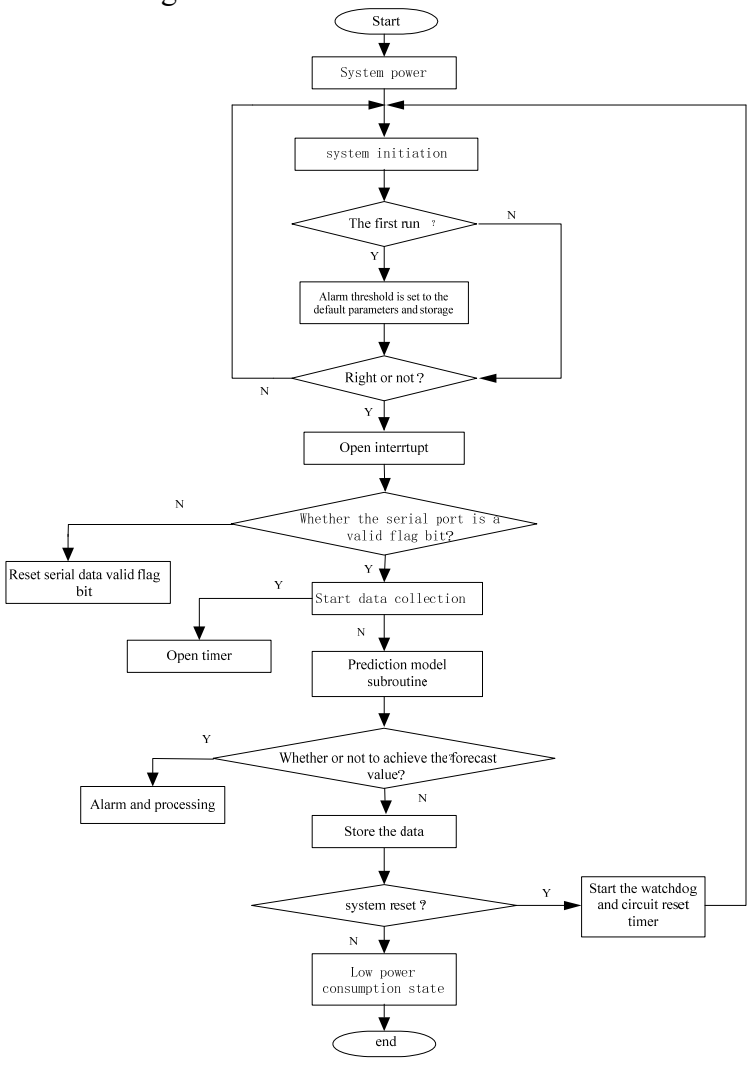

Fig7.The main program flow chart

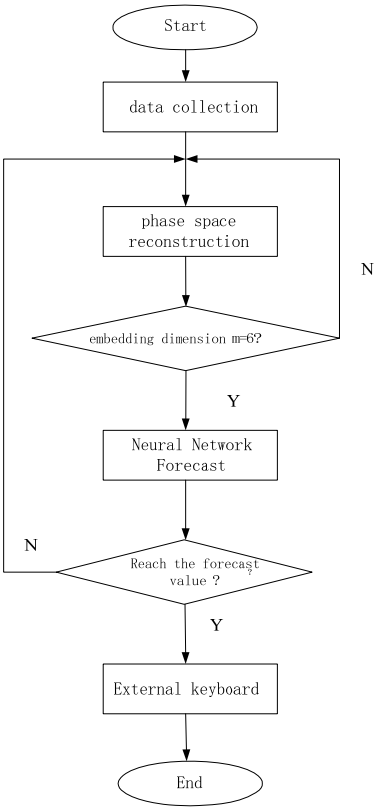

Fig8. Prediction module program flow chart

Conclusions

On the basis of a lot of research on coal mine gas monitoring system, puts forward design scheme which has the function of predicting intelligent monitoring. System be proved that the Lower computer can achieve the correct data collection by test and simulation, the prediction error control between 0 ~ 10%. PC can clearly display the mine data, alarm, and other functions. The experiment proved that the system can timely detect potential safety hazard and reduce the happening of the accident.

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