Design of an intelligent Methane gas alarm

Jingjing Yang[a], Xiaogang Mu

Xi'an Research Institute of High Technology, Xi'an Shaanxi, 710025,China

[a]yangjingjing8405@sina.com

Keywords: ADuC812, Methane gas Monitoring System, Voice Broadcast.

Abstract. Monitoring of methane gas concentration in the mine is directly related to the safety of coal mine production and lives of the vast majority of miners. Based on the requirement of methane gas monitoring in the mine, an intelligent methane gas alarm based on ADuC812 microcontroller of Analog Device is designed. Besides the traditional functions of concentration display and sound and light alarm, this methane gas alarm has new characteristics of data filter and voice broadcast. It could start up sound and light alarm and voice alarm within 8 seconds when methane concentration in the air is higher than alarm point(1.92V). It insures the high precision of system and functional reliability. By testing at laboratory and running at workshop ,this methane gas alarm has good result in practical implements.

1. Introduction

Methane gas is harmful in the process of underground coal mining from the coal rock body emission。 Methane gas explosion is one of the most serious disasters in the coal mine production. Methane gas explosion may not only cause casualties, but alsodestroy the mine production and safety facilities, bring enormous loss to national economy, bring disaster to the casualties families. So methane gas concentration alarm has important practical significance[1]。

All countries in the world have coal mine methane gas monitoring system,such as DAN6400 of Poland, TF200 of France and so on. The representative products of mine comprehensive monitoring control system are MSN system produced by USA Inc, the PROMOS system from BEBRO company of Germany.Methane gas monitoring technology applied latly in China. A number of safety monitoring system were introduced from Poland,France,Germany,Britain and USA in early 80's. At the same time,through digestion,absorpsion and combined with the actual situation of our country, coal science research institute in Fushun and Chongqing and other well-known domestic coal science research institute had developed a series of coal mine methane gas monitoring system. But the transmission of data of big part of the instrument is analog. So it is susceptible to interference from electromagnetic equipment under mine and caused the inaccurate and false alarm phenomenon[2].

This paper designed a kind of intelligent methane gas alarm system based on ADuC812 MCU. Besides the concentration display, alarm and other traditional functions, it also can upload data to the PC, complete the data processing and voice broadcast. In a dangerous situation, it can report directlyt to the emergency stations. It has the vital significance to enhance safety awareness and avoid casualties.

2. Working Principle

The hardware part of intelligent methane gas alarm mainly includes ADuC812 MCU,methane gas detection module,LCD module,alarm module,RS232 converter module and voice broadcast module. The system uses 128×64 dot matrix LCD to display the methane gas volume fraction(0.00-4.00%) of the current air. And through the serial communication port of the MCU, the measuring and sampling data is uploaded to PC for data storage,the query or analysis. When the methane gas concentration is within a limit, the system starts 5 minutes broadcast timing.When the broadcast time is over,MCU converts the latest methane gas concentration into code to control voice synthesis uint for voice broadcast.When the methane gas beyond the limit, system starts sound and light alarm circuit

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alarming.At the same time,MCU immediately enters into a state of emergency.During this period,MCU broadcasts the methane gas density and corresponding precautions every minute.

3. Hardware design

3.1 Hardware design based on ADuC812 microcontroller

Circuit diagram is shown in Fig3.1.

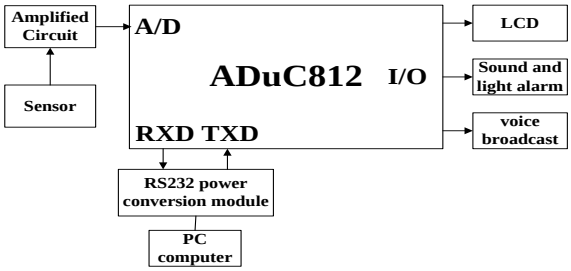

Fig3.1 Hardware circuit diagram

3.2 Choosing single chip microcomputer

MCU is the core of the methane gas alarm.It is mainly completed the function of data acquisition,processing,outputing and controlling.Though comparing,ADuC812 microcontroller that is designed by Analog Devices company is used.It is a 12 bit data acquisition system that is fully integrated and highly performed.A single chip integrates two 12 bit ADC and the high performance programmable 8-bit MCU.It has a low power operating mode,relatively simple to achieve power-down protection.It reduces the complexity of the hardware circuit and improves the reliability of microcomputer[3].

3.3 Display and alarm module

Display and alarm module is used to achieve the function of concentration display and exceeded alarm.Display module uses a graphic dot matrix LCD display module OCM4X8C that contains Chinese character.The control driver of this module uses ST7920 that is designed by Taiwan Silicon Electronics Company.It has control and display functions that are stronger.OCM4X8C's LCD screen is 128×64 dot matrix.It could display four lines and eight characters per line.Alarm module directly uses common I/O port to control alarm sound/light circuit.It provides a clear warning signal to underground staff[4].

3.4 RS232 power conversion module

Alarm needs to return methane gas concentration that is measured and sampled back to the PC for data preservation.RS232 is selected as the communication protocol of the meauring device.RS232 standard level uses negative logic,which provides that any level between +3V to +15V for logic level 0 and any level between -3V to -15V for logic level 1.It is different from TTL and CMOS levels.It is mostly used TTL and CMOS levels in the interface circuit and computer interface chips.So level conversion is necessary when conmmunication to match the level of the standard RS-232C.

3.5 Voice Broadcast module

Voice broadcast function is one of the characteristics of the alarm.To achieve this, a high-quality speech synthesis system is needed to design. Traditional voice synthesis design is a very complex project. It has not only heavy workload, long design cycles ,but also high cost, large size, good sound quality and other shortcomings.Especially applied in the coal mine,it is difficult to deal with explosion due to their circuit complexity and power consumption.

4. Software design

This system's software uses modular design methods.The system is divided into several subroutline to achieve various funtions.Thus during the debugging process of software,each

subroutline debugs indepently to help identifying and soling problems.Subroutline includes:A/D convention,data procession,LCD display program,voice broadcast program.The overall flow chart shown in Fig4.1.

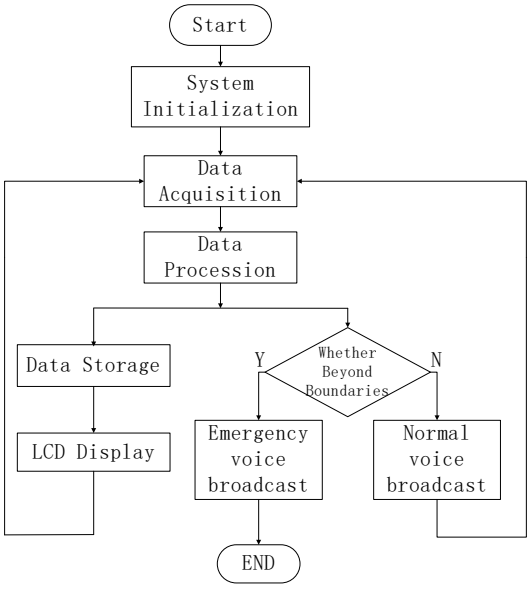

Fig 4.1 Software flow chart

4.1 Data Acquisition

Data acquisition uses ADuC812 microcontroller's internal A / D converter module. It contains a 5μs conversion time, 8-channel 12-bit single-power A / D converter. A / D converter's all features are controled by ADCCON1, ADCCON2, ADCCON3 three special function registers.Using software to put the convert signal to the external pin25(CONVST) to start the continuous conversion mode. In addition ADuC812 equippes engineering program calibration coefficients.It could automatically download to the ADC to ensure optimum ADC performance when it has the power[5].

4.2 Data Procession

Data were processed using the arithmetic mean method for filtering. It overcomes the effect of random errors in the final reading, to ensure reliability in the practical application of the alarm function. In the testing process N samples are required continuouslly to make arithmetic average calculation.When N takes larger could obtain a higer signal smoothness,but the sensitivity reduces; When N takes smaller could obtain a lower signal smoothness,but the sensitivity increases.Typically,the gas concentration is not large,so it could set N equal to 8 during the test,i.e.,calculating the average of eight times.Thus it plays a very good role in filtering. In voltage - concentration conversion,it could use curve fitting methods to ensure the accuracy of the concentration display.

4.3 Voice Broadcast

Voice broadcast design module has the following contents:Setting the serial communication mode,the baud rate,the timing and determining the speech code to broadcast based on the current value of the gas sensor.Generally,in order to facilitate program,a buffer zone could be set.Putting the broadcast's statement code into the buffer zone sequentlly.The guide and end codes are filled in the buffer's head and tail.When broadcasting,the statement codes are sent to the ISD components sequentlly through serial port to complete voice broadcast.

5. Experiment

5.1 Alarm point acquisition

Acquicision methods:Passing into the 1% CH4 gas(volume fraction),when the gas sensor is stable,observe the displayed readings and record the values.Sensor tests more than eight

times,calculates the average values as the alarm point.The measurement data are shown in Tab5.1(data table shows is the hexadcimal).

Tab5.1 Alarm points collection

Num	Data records				
1	0c7bh	0c68h	0c80h	0c85h	0c68h
2	0c62h	0c72h	0c5fh	0c5eh	0c90h
3	0bffh	0c20h	0c5eh	0c38h	0c65h
4	0c70h	0c75h	0c8eh	0c86h	0c65h
5	0c81h	0c8fh	0c79h	0c68h	0c32h
6	0bf9h	0bd9h	0beeh	0c10h	0c05h
7	0c15h	0c24h	0c36h	0c3fh	0c2eh
8	0c71h	0c58h	0c48h	0c80h	0c84h

Calculating the average value: X=0c51h,and convert it to the voltage:

$$\mathbf{u_o = \frac{X}{2^{12}} \times 2.5 = 1.92V}$$

Set the alarm point of 1.92V,thus takes the alarm point alarm test.Five experiments are done,the results are shown in Tab5.2.

Tab5.2 Alarm points test

Num	Alarm concentration（%volume fraction）
1	0.93
2	1.02
3	0.98
4	1.08
5	1.05

Experimental results show that the absolute error of the alarm using the alarm concentration of ± 0.1% is meeting the design requirements. So the alarm point sets reasonable.

5.2 Response time

To pass into the glass the gas that above its alarm point value of 15%,the time between the end of the ventilation and the alarm is the response time.Just using the stopwatch for timing immediately when pass the gas into,both the response time is within 8 seconds.It is meeting the international requirements of less than 20 seconds.

6. Conclusion

An intelligent methane gas alarm based on ADuc812 MCU is developed in this article.It makes the methane gas detection instruments digital and intelligent.The alarm could start sound and light alarm and voice alarm when the concentration of the methane in the air is above the alarm point(1.92V).After the actual trial,the accuracy of the systemmeets the requirement and the instrument works reliable.

References

[1] Chen tiejun,Wang zhiyong.An intelligent mine gas sensor based on PIC microcontroller, Microcomputer Information(Control and automation),Vol.24(2008),p.127

[2] Liu xiqing.The present situation and the development of domestic coal mine gas monitor system,Shanxi Coking Coal Technology,Vol.03(2006),p.37

[3] Liu shuming,Feng xiaoping,The Priciples and Application of data acquisition system chip ADuC812,China,Xi’an,2000.

[4] Kuang xiaocai,Wang daohui,Microcontroller and LCD display interface and drive technology, China Measurement Technology,Vol.2(2004),p.61

[5] Xie weihua,8-channel 12 A_D converter with embedded MCU of ADuC812 and its application, Application of Electronic Technique,Vol.04(2003),p.51