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Research on Well Site H_2S Detection System

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Abstract: A kind of well site hydrogen sulfide detection system is designed because toxic gas-H_2S may present in the developing process of high sulphur gas field in the east of Sichuan Basin. The design elaborates the developing process of software and hardware of H2S detection system. In hardware part, 51 MCU is the core chip, hardware circuit is composed of signal conditioning circuit, data acquisition circuit and communication circuit; in software part, MCU software and computer software can be developed by C language and LabVIEW respectively. Tests on the H_2S detection system show that system measurement error is less than 0.2% so it can satisfy the need of high-accuracy measurement of H_2S in well site.

Key words: H_2S, Detection system, well site, data acquisition

INTRODUCTION

In recent years, China has successively found many large gas fields in SiChuan, XinJiang, ChongQing and South China Sea. Among them, much of gas reserve in Sichuan Basin contains H_2S,about 78.6% of gas fields that PetroChina Southwest Oil and Gas field Company has developed contain H2S. Exploration and development continue to be expanded which increases the difficulty of the development and the risk and the leakage will lead to serious consequences and bad social influence.

Data research shows that the current well site H2S detection has a lot of problems. For example, the phenomenon that H_2S sensor did not alarm but field workers smelled something ripe once occurred on the offshore oil platform in the Bohai Bay (Abe and Kimura, 1996); the platforms in Texas, the United States once failed to detect the H_2S because of the low sensitivity of detection system. These cases show that the lack of highly sensitive H_2S detection system and the corresponding emergency prevention system is one of the major bottlenecks restricting the safe development of high-sulfur gas wells. Given the current situation of China's gas field exploration, establishing prevention and emergency rescue system by researching well site H_2S detection system is an urgent requirement of oil and gas development (Smith *et al*., 2008).

SYSTEM MODEL

Technical specification: The goal of the plan is to develop a set of well site H_2S detection system, field workers get the information of H_2S content in well site through H_2S detection system.

Once the concentration exceeds alarm threshold value, field worker will get timely warning on environment risk degree. Well site detection system is mainly responsible for signal detection, data acquisition, data storage and data processing analysis task in the process of H_2S detection (Ge *et al*., 2011). The system works in well site ,so technical indicators should be as follows: system operating temperature -40~50°C, maximum allowable vibration value 2 g; The H_2S measurement range 0-100 ppm; maximum utilization 2000 pm; measure precision value is 0.05 pm.

System design framework: Well site detection system can be seen as a data acquisition intelligent system of high precision and reliability. According to the characteristics of H_2S monitoring, the designer comes up with a real-time H_2S concentration detecting and processing system based on virtual instrument technology (Ge *et al*., 2013). The system is mainly composed of detecting system and processing system, the detection system can achieve H_2S signal detection, signal conditioning, data acquisition and communication (Lou *et al*., 2007); the processing system mainly completes data processing, data analysis and alarm. Only the two parts work coordinately can the system achieve the whole well site H_2S detection function. The overall design of H_2S detection system in well site is shown in Fig. 1.

The function of each in the block diagram is as follows:

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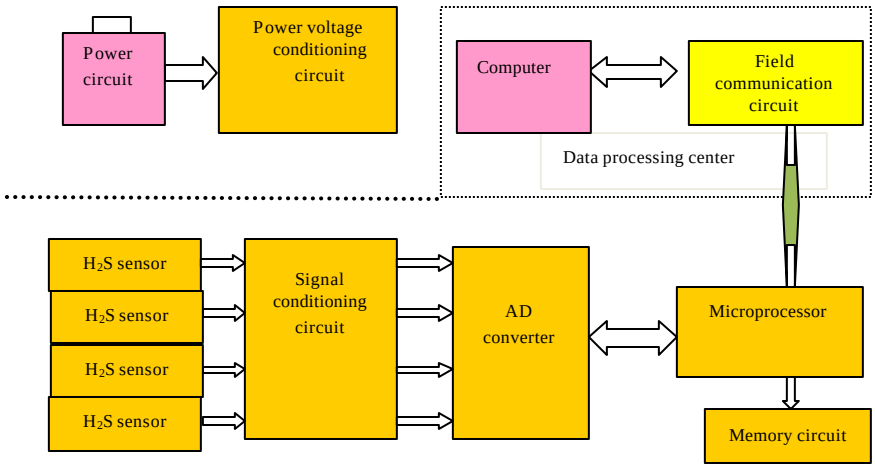

Fig. 1: Block diagram of system

- **Sensor circuit:** Complete well site H_2S signal detection
- **Signal conditioning circuit:** Complete the amplification and filtering of the weak signal outputted by the sensor
- **Microprocessor and AD converter:** Complete system data acquisition and control
- **Memory circuit:** Complete the storage of the collected H_2S data
- **Power circuit:** Power system circuit and H_2S sensor;
- Field communication circuit: complete the communication between H_2S detection system and computer
- **Computer:** H_2S data processing, display, analysis and alarm

SYSTEM DESIGN

Sensor selection: The sensors in this design are used in well site, so the H_2S sensor used in the design need to go through strict selection, the precision, sensitivity, linear range, anti-jamming ability, repeatability and stability should be taken into consideration besides its range, volume, way of measurement and information outputting (Finger *et al*., 2003). The fact that it is sometimes windy in well site should be taken into account in the actual selection of sensor, so the sensor would better be the one whose diaphragm has breathable film or air holes to guarantee the measurement reliability when it is windy. The sensor used in this design is electrochemical H_2S sensor H_2S/C-200.sensor H_2S/C-200 is based on electrochemical principle, the concentration of H_2S can be obtained by measuring the magnitude of the current outputted by the sensor. In order to test H_2S effectively and precisely, the H_2S sensor should be placed at some sensitive places, such as Bell Nipple, under beneath of buffer tank, the corner of circulating pool and pump layer (Geng *et al*., 2004).

Signal conditioning circuit design: Judging from the characteristics of H_2S output signal of the sensor, the key to the design is high gain and low. Signal conditioning consists of operation circuit, amplifying circuit and standard current signal generation circuit. Among them, operation circuit can amplify the weak current signal of H_2S sensor into millivolt level voltage signal; amplifying circuit can amplify millivolt level voltage to better gather the data, it should also have zero adjustment function and gain adjustment function; the introduction of standard current signal generation circuit is suggested to avoid output signal distortion in the transmission in the field.

Data Acquisition Interference Circuit Design

The interface circuit of AD574 and 51MCU which is shown in Fig. 2 is designed to collect H_2S signal outputted by the sensor.

Communication circuit design: To realize data communication, well site H_2S system transmits H_2S data to computer through serial communication circuit (Hu, 2001). Communication RS485 is adopted for signal transmission distance is rather long. The connection between MCU and the hardware of computer serial communication is shown as Fig. 3.The asynchronous communication mode RS485 is adopted between MCU and computer. Because common computer's serial port

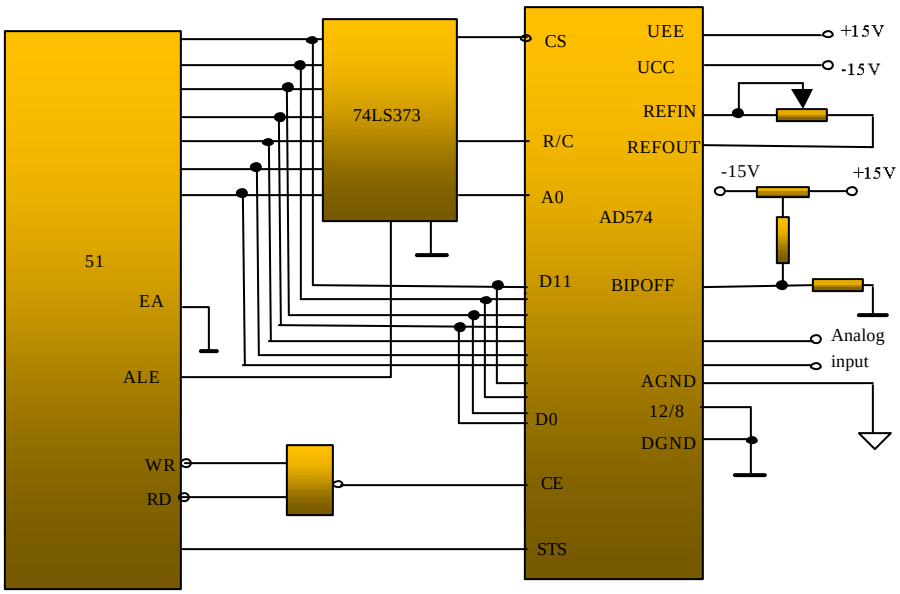

Fig. 2: Data acquisition interface circuit

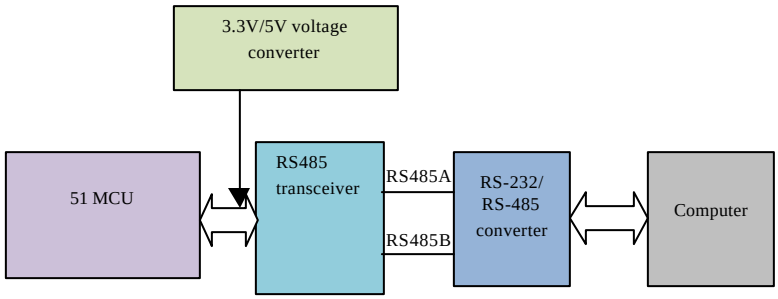

Fig. 3: Communication system hardware connection diagram

Table 1: H_2S concentration test data

Reference concentration/ppm	Time	Measure concentration/ppm	Error/ppm	Relative error/(%)
5.0	1	4.98	0.02	0.4
	2	4.98	0.02	0.4
	3	4.99	0.01	0.2
20.0	1	20.02	0.02	0.1
	2	20.01	0.01	0.05
	3	20.02	0.02	0.1
40.0	1	39.96	0.04	0.1
	2	39.98	0.02	0.05
	3	39.97	0.03	0.075

adopts RS232 level signal, a RS-232/RS-485 should be converted between MCU and computer (Heising, 1999). The RS485 chip in the design is MAX485.MAX 485 is a low-power consumption transceiver with a driver and a transceiver and the driver is not slew-rate limited, its transmission rate can be as high as 2.5 Mbps (Lv *et al*., 2009).

Software design: Well site H_2S detection system consists of MCU software and computer software, MCU software is written in the C language realizing H_2S data acquisition and data transmission function; computer software is written in the virtual instrument development language to set menu bar, communication serial port, alarm and display the concentration of H_2S (Sarma and Tao, 2007), grading alarm, warning and real-time curve.

SYSTEM TEST

After the test is completed, the first thing to do is carry out simulation test on well site H_2S detection system using sine wave signal to simulate the output signal of H_2S sensor (Kim *et al*., 2006). Contrast system output with analog input to guarantee the accuracy the system function.

Laboratory test should be carried out after simulation test is completed. In libratory test, the concentration of standard H_2S is 5.0, 20.0 and 40.0 ppm, respectively, the whole test is carried out in fume cupboard and the gas flow rate is 400 mL/s. Get H_2S whose flow rate is 400 mL/s to aim at H_2S sensor after the well site H_2S detection system runs, then take notes of data after its display is stable. Every time a measurement is completed, remove all H_2S gas and measure again in 10 min. The standard gas of 3 kinds of concentration is measured three times; data record is shown as Fig. 1.The result shows that the relative measurement error is not more than 0.5%.

CONCLUSION AND SUGGESTION

- This article comes up with a design approach to well site H_2S detection system describing the design process of hardware design and software design of the well site H_2S detection system
- System measurement error is verified to be less than 0.5% by testing on the well site H_2S detection system, so it can meet the need of high-precision measurement of well site H_2S detection system
- Modern virtual instrument technology is used to achieve the design of well site H_2S detection system. Users can modify computer software to meet different practical needs

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