Design and Research of Oilfield Underground Data Acquisition and Monitoring System

Shengyu Cao, Jing Zhang, Can Zhang

School of Civil Engineering and Architecture, Southwest Petroleum University, Chengdu, 610500, China

Abstract

The petroleum gas industry makes efforts to achieve the goal of remote monitoring of oil and gas wells in the field of well completion, and in order to achieve this goal, the use of intelligent well technology is required. The matched oilfield underground data acquisition monitoring plan design is of great significance for building the intelligent underground and ground measurement and control system. The oilfield underground data acquisition monitoring system designed in this thesis consists of a complete set of underground data acquisition and remote monitoring system, including data acquisition part, ground data remote transmission part, cloud platform data backup part and WEB data development viewing part, and it can timely send underground and ground key data to the administrator in real time and through the network, and ensure that the high-level leadership can view the data in real time data, so that it can improve the monitoring efficiency of the oilfield and promote the intellectualization of the production.

Keywords

Petroleum gas industry, Data acquisition, Monitoring, Cloud platform.

1. Research background

In recent years, intelligent well completion technology has developed rapidly, and some achievements have been achieved in terms of improving oil recovery and accelerating oilfield development. Intelligent well completion saved the workover cost, and there was a better return on investment especially in terms of multi-branch wells, offshore wells and unmanned management platform wells. Intelligent well completion is a well completion system with permanent underground sensor, which can collect, transmit and analyze underground production state, oil deposit state and data information of whole well production chain in real time, and conduct a remote distribution and production of oil layers and improve oil well output according to the production situation of the oil wells [1]. The systematic research designed a set of electronic implanted data acquisition unit and corresponding ground remote monitoring scheme which can resist a high temperature of 100 ℃ underground to realize the real-time remote monitoring of reservoir fluid pressure, temperature, sliding sleeve opening degree as well as surface equipment data.

Intelligent well system needs sensor groups of temperature, pressure, flow, displacement and so on which are permanently installed underground and distributed in the whole shaft, as well the communication circuit which can transmit the data of oil production layers to the ground through the transmission device, thus acquiring underground production information, so as to provide parameters basis for the optimization of the production process and scientific management of oil wells [2]. The oilfield underground data acquisition and monitoring system researched and designed in this thesis includes a complete set of underground data acquisition and remote monitoring system, including data acquisition part, ground data remote transmission part, cloud platform data backup part and WEB data development viewing part. The underground data acquisition part is used to complete the signal acquisition of underground temperature, pressure as well as the opening degree of underground sliding sleeve. Ground data remote transmission part plays a role in transmitting power supply downward and uploading signal, and the collected data the ground is backuped in the cloud server

database through the client PC. Meanwhile, WEB data development viewing part implements data acquiring, screening and independent display, and finally achieves the purpose that the administrator can examine the oilfield operation condition in every place across the country with network in real time.

2. Hardware circuit design of underground data acquisition terminal

2.1 Circuit design of A/D acquisition

A/D acquisition circuit consists of a microprocessor, 12-bit parallel A/D and analog multiplexer. The circuit is shown in Figure 1:

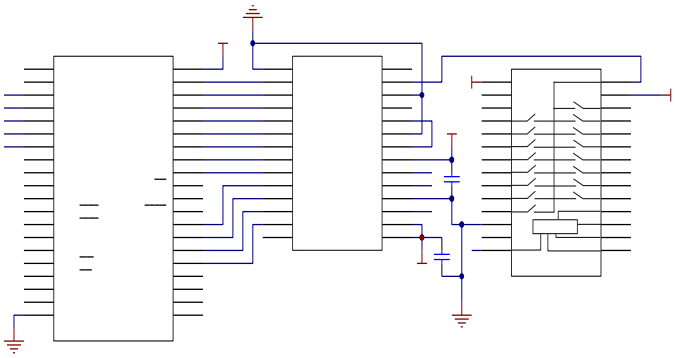

Fig. 1 A/D acquisition circuit diagram

After conditioning, the signal of underground sensor group will be converted into 0~5V voltage signal. The analog multiplexer will selectively collect the multi-channel conditioning signal under the control of single-chip microcomputer, which will carry out A/D conversion of the analog signal selected by control A/D, and then transmit the converted value to the single-chip microcomputer through parallel port for subsequent processing [3]. This thesis selected the high temperature electronic components in Honeywell HTMOS™ family series to conduct the hardware design, for example, the microprocessor was HT83C51, 12-bit A/D converter was HT574, analog multiplexer was HT506, clock generator was HTCCG, etc.

2.2 Sensor selection design

In underground data acquisition hardware device part of the system design, considering the influence of high temperature environment on the stability and service life of the electronic components, various electronic components of the monitoring system adopt military device or functional block circuit made of through special process, so as to guarantee the stability and reliability of the circuit. Platinum resistance temperature sensor, sapphire pressure gauge and differential transformer type linear displacement sensor are selected to detect the fluid temperature, pressure as well as the opening degree of underground gliding sleeve. The collected data will be encoded and encapsulated by protocol and then transmitted to the ground through cables. When selecting cables, because the whole system adopts a working mode of real-time transmission, the underground machine supplies the power supply required by the work of the underground machine through 3000m single-core armoured cable. At the same time, it sends the ground control signal to underground machine, and the underground data and status is sent to the ground through this cable, and data processing and real-time display are conducted by the computer.

3. Hardware circuit design of ground data acquisition terminal

3.1 MCU main hardware circuit design

The main chip of the hardware circuit is STM32 single-chip microcomputer produced by STM semiconductor company, and its model is STM32F103RCT6. Ground data acquisition is divided into wellhead data acquisition terminal and control room data acquisition terminal. In order to simplify the design of hardware circuit and improve the application range of the hardware circuit, a hardware circuit board which can be used to both terminal is designed, as shown in Figure 2 below.

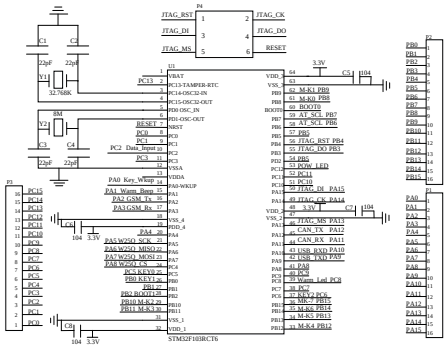

Fig. 2 Main hardware circuit at both terminals of the ground

3.2 CAN voltage transfer circuit design

The communication from underground to wellhead, and from wellhead to control room acquisition terminal will be achieved by CAN bus technology. Completing CAN bus communication needs corresponding hardware circuit, and here, we choose CAN transceiver chip TJA1050, which is the interface between control area network (CAN) protocol controller and physical bus and a standard high-speed CAN transceiver [4]. TJA1050 can provide differential send performance for the bus and differential receive performance for the CAN controller. The schematic diagram of its level switching application is shown in Figure 3 below:

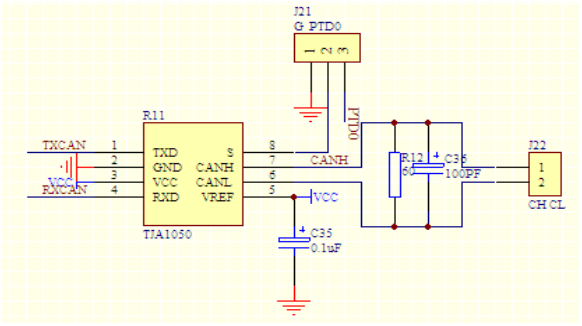

Fig. 3 CAN communication TJA1050 level switching circuit

4. Remote monitoring software design

4.1 PC terminal product development

PC terminal includes four functions: data real-time collection, data dynamic display, data local storage and monitoring forewarning management.

The administrator account was set up before logging in to view, and only the designated person could view it. After logging in, the administrator could change the warning value of abnormal situation corresponding to the monitoring object at any time to realize multi-channel monitoring. In terms of monitoring and early-warning, a monitoring and early-warning module was established between the cloud server database and WEB server. The administrator could conduct the user-defined input of alarm threshold and alarm interval after turning on the alarm switch, and acquire SMS and email reminder service support through the server interface.

4.2 Mobile terminal product development

The design of mobile terminal was based on the product prototype design drawing. Under the LNMP environment, PHP and MySQL were used for the background development of the mobile terminal of the intelligent underground data acquisition and remote monitoring system. Meanwhile, static file distribution cache was adopted to realize the dynamic refresh and real-time display of data through Ajax, which improved the user experience. In terms of security and availability, the server adopted kernel-level cloud protection and load balancing to guarantee the normal development of the business[5].

The administrator account was established in the mobile terminal, and it could only be viewed by designated personnel. When using the mobile terminal, the problems could be reminded by email according to the server response, page loading, HTTP status and other indicators. Through the production of WEB page, page design of module display terminal, and the configuration of Application Insights, the alarm service could be used to achieve early warning function, so as to guarantee real-time update of the data and enable the administrator to view the operation of oilfields in real time wherever there was a network across the country. When users open the background management system, input the user name and password and login in successfully, they can enter the backstage management page, namely, they can detect 10 items of data, including wellhead pressure, wellhead temperature, oil tank liquid level, running speed of the drill stem, derrick hook tension, generator's three-phase winding temperature, temperature of water faucet, temperature of hydraulic oil, rotary speed and temperature of top drive motor.

5. Conclusion

This set of system combined the data acquisition function of the hardware with the information transmission function of the software to realize the system function integrating data acquisition, transmission, early-warning and prediction. It had a stronger innovation and practicality, as well as a good market prospect. The system covered in this work could be applied to a variety of fields requiring early warning, and at the same time, it could be disassembled and removed at any time, and it had an extensive applicability. It could not only realize commingling production of oil reservoir and monitor and control multi-branch wells, but also achieve infusion, observation, production and other functions on one well simultaneously, and make one well play the role of multiple wells. Therefore, it effectively improved the intelligence of oilfield data monitoring and reduced the development costs of oilfields.

Acknowledgements

National Innovation and Entrepreneurship Training Program for College Students（201710615039）.

This paper is funded by the National Innovation and Entrepreneurship Training Program for College Students (201710615039).

References

[1] Ni Jie, Li Haitao, Long Xueyuan. New Technology of Intelligent Well Completion[J]. Offshore Oil, 2006,(2):84-87,92.

[2] Zhang Kai, Yao Jun, Liu Junrong, etc. The Reservoir Dynamic Real-Time Monitoring and Control [J]. Oil Field Euipment, 2010, (4) : 4-8.

[3] Xu Sheng, He Dongsheng. Design of intelligent underground data acquisition system based on high temperature single chip microcomputer [J]. Instrument Technology and Sensor, 2011 (02):51-53.

[4] Guo Changdong, Yao Shucai. Design of CAN Bus System Based on C8051F040 Single Chip Microcomputer [J]. Shanxi Electronics Technology, 2011,(1):3-4.

[5] Cao Shengyu, Zhang Jing, Zhang Can. Design of Intelligent Underground Data Acquisition and Remote Monitoring System [J]. Digital User, 2018,(6):39-40.