Research and Design of Torque Measurement Wireless Transmission System for Gas Drilling

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Abstract

To obtain the real working condition of the downhole in real time and timely solve the downhole safety risk, downhole near-bit torque is need to be real-time monitored while gas drilling. The author of the paper research and design a torque measurement wireless transmission system which based on the resistance strain sensor and microwave drilling data transmission technology. The system adopted C8051F3XX series chip as main controller, the hardware circuit and software program design of data acquisition, data storage and data transmission are completed, the microwave communication distance was greatly enhanced by using signal relay transmission method, measured depth reach 3000m, and the monitoring software of the host computer is developed, the monitoring of the downhole torque while drilling is realized. The experimental result suggests that the system meet the demand of the downhole torque measurement while gas drilling. Wireless transmission delay is short, and torque can be collected, transmitted and displayed in real-time.

Keywords

Torque measurement, microwave communication, Measurement While Drilling, Relay Transmission, gas drilling, wireless transmission.

1. Introduction

Gas drilling is a kind of unbalanced drilling method developed in recent years. Compared with conventional mud drilling, gas drilling has the advantages of improving mechanical drilling rate, reducing drilling cost, protecting oil and gas production, increasing oil gas production and so on[1]. In the gas drilling process, in order to prevent such accidents as sticking, lost cone, broken tool, one of preventive measures is real-time monitoring the change of downhole near-bit torque.The current way of measuring the torque mainly are MWD and ground measurements. In the domestic and foreign markets, the signal transmission of the drilling tool is based on mud pulse and electromagnetic wave. Mud pulse measuring instrument is relatively mature, it cannot be used in the drilling of no continuous liquid phase like gas drilling, because of it using drilling fluid pulse transmission way; Electromagnetic wave measuring instrument is tool is the use of low frequency electromagnetic wave propagation in formation for signal transmission, low resistivity formation can make the signal attenuated greatly, and the measuring depth is limited by the formation characteristics[2]. In the

measurement of torque on the ground, it cannot accurately reflect the movement of the drill string in the downhole, which is affected by the formation, lithology, etc[3].

This paper designed a wireless transmission system which is suitable for gas drilling torque measurement, the measurement depth exceeds 3000m and the signal transmission rate is greater than 100Kbps.The near-bit downhole tests can accurately measure the torque in the shaft of the instantaneous value and record the whole process of drilling torque curve, and it make on-site technical personnel can real-time monitor downhole torque and predict abnormal situation in the underground.

2. System key technology principle

2.1 Strain testing method to test the torque

This design uses the transmission method to measure the torque, the direct measurement of the torque method is convenience and high precision. By the material mechanics, the elastic shaft will produce deformation under the influence of torque, on the inclined plane of the shaft and the shaft to45 °and 135 °subjected to normal stress, and the normal stress is primary stress, which value is equal to the maximum shear stress on the cross section [4]. The strain gauge can be pasted on the surface of the shaft at 45 degrees and 135 degrees along the axis of the elastic axis, and the maximum tensile stress and the compressive stress will be formed, and put them into differential full bridge. Because of the space limitation of measuring short section in this design, the monolithic full bridge strain gauge is used. By using the deformation of drill collar in the loading process to drive the change of resistance strain gauge bridge output, in the ideal case, torque variation - resistance variation - voltage variation is linear relationship[5], the downhole drill string torque can be accurately measured by measuring the voltage changes.

2.2 Microwave transmission principle in drilling string

Waveguide technology is mainly used in the process of microwave transmission of the drill string, which is generally use cylindrical hollow metallic tubes to conduct electromagnetic wave [6]. For gas drilling, the medium of the drill string is gas, its contribution to the attenuation of the microwave power is very small and can be neglected, so the drill string is considered as an ideal circular waveguide.

According to the theoretical calculation of the waveguide microwave frequency, the frequency band of 2.4 GHz can be used, the medium and high power transceiver module is small in size, which is suitable for installation to mine narrow space, the 2.4 GHz spectrum is adopted for microwave communication in the drill string [7].

Actual microwave transmission test results show that only use single stage point-to-point transmission cannot achieve 3000m transmission distance, this design use wireless relay transmission technology to solve this problem, the basic principle is the use of wireless relay function of AP (Access Point), which can transfer the wireless signal from one relay points to the next relay points. Signal relay method is introduced to increase the effective transmission distance of microwave signal and reduce the transmit power, which can reduce the volume of the battery downhole instrument inside and extend the downhole working time of microwave communication module.

3. Design of torque measurement wireless transmission system

According to the overall design scheme of gas drilling measurement system, the system's design framework is shown in Figure 1. Torque sensor measure the short section subjected to torque

variables which should be converted into voltage signal, and the voltage signal is amplified and filtered into suitable for C8051F35X MCU by conditioning circuit amplifier[8], And then through the 24 bit precision A/D conversion function to complete the analog-digital conversion, MCU will signal processing to the microwave communication module for the transmission of encoding modulation, MCU send the processed signal to be coded and modulated by the Microwave communication module. Through the relay module in the drill string, the microwave communication module receives the received signal and then makes it demodulated and decoded, the signal is transmitted to the host computer by RS232 level conversion transfer for analysis and processing, and the real-time monitoring of torque is realized. And a backup data storage module can be taken out from the measuring short section in the underground, the data stored in the data storage module is read by the serial communication module, which is convenient to analyze the accuracy of the wireless transmission.

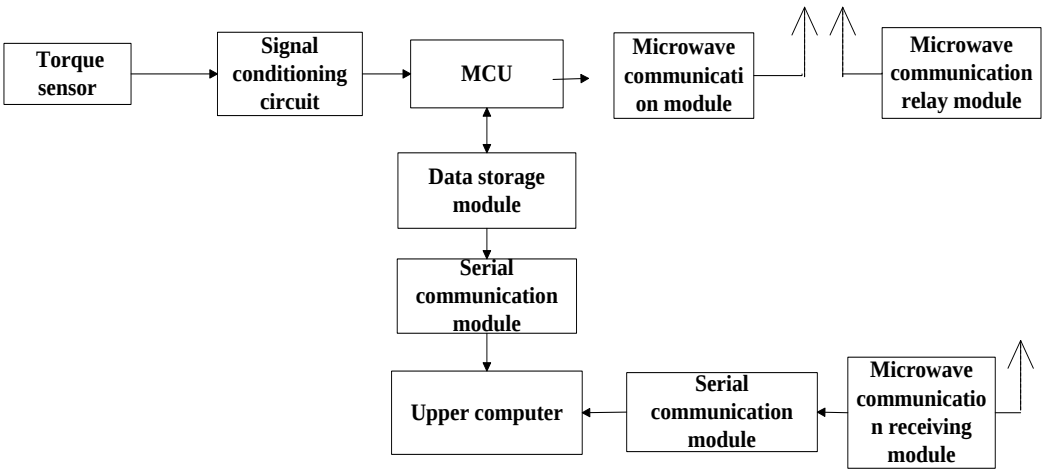

Fig. 1 Hardware block diagram of the torque measurement system

3.1 Signal conditioning module

The strain capacity generated by the torque is very weak, so the voltage signal of the torque sensor measured is very weak and the fluctuation range is relatively large, there is a great component of common mode interference. Therefore, it is necessary to carry on the signal amplifying circuit in the back of the sensor, and the signal is amplified and filtered out of the common mode interference component [9], so as to collect the more accurate data. The system uses the amplifier AD623 and OP196 to form the two stage amplifier to improve the common mode rejection ratio and stability, and take the limit voltage protection function to prevent the output voltage is too high to damage chip. Experiments show that the signal conditioning module is stable and reliable, and meets the design requirements.

3.2 Data acquisition module

The C8051F35X chip built-in A/D conversion function is adopted to save hardware, the A/D conversion has 24 bit resolution rate, the ADC has a calibration function, it can use the internal 2.5V voltage reference, and it can also be used to measure the difference between the external benchmark. The ADC can be programmed for offset correction and full correction, the correction results will be automatically saved in the SFR of the microcontroller.

3.3 Data storage module

The system the non-lost W25Q128FVFI flash memory produced by Winbond company as the data memory to store data, it can prevent the signal is not transmitted to the host computer caused by the failure of the microwave communication module, and the data transmission accuracy can be verified by the W25Q128FVFI flash memory . The chip capacity is 128M-bit, with advanced write protection mechanism, SPI compatible bus access operation speed up to104MHz, it communications with the

C8051F35X microcontroller through the SPI serial interface, its working voltage range 2.7V to 3.6V, which can satisfy the design requirements of low power consumption in underground.

3.4 Microwave transmission module

The development of microwave communication module follows the following principles. It can be transmitted by microwave and the module can be loaded into the drilling tool, the communication microwave power can guarantee a certain transmission distance with a low cost. Microwave communication module mainly includes the main control chip, wireless RF chip, general module and signal transmitting module. The module connected with data acquisition by the UART interface. The data is collected by interface protocol and uploaded by the ZigBee transmission mode.

3.5 Serial communication module

Serial port level of C8051F35X is TTL level standard, however, the level of PC serial port is RS-232C standard, level conversion can be achieved by the MAX3266E chip produced by MAXIM company. Serial communication module only needs to be connected with serial port reserved in the PCB when the measuring short section removed from the underground, then the data stored in the memory of W25Q128FVFI can be send to the host computer through the serial port of RS-232C.

3.6 Power Module

Limited by the working environment of gas drilling, it is can not pass cable from the ground into the downhole to the equipment for power supply, finally, downhole special lithium battery with high capacity suitable for high temperature is used, the voltage of single section is 3.7V, and the LP2985LV is used as the power conditioning chip to provide a stable 3.3V voltage.

4. System matching processing software design

The design requirements of torque measurement wireless transmission system in the gas drilling are as follows. Electrical signal data are obtained by the data acquisition system of Lower machine, then these electrical signals are processed and calibrated by the monitoring software to real time curve and the value, which can monitor the communication of whole system in real-time. Acquisition for each relay short section, such as temperature, power and received signal strength information, to facilitate the operators know the downhole acquisition parameters and microwave communication situation in the first time, at the same time, the information of each module can upload data and save as separate files which facilitating access to data analysis in the future.

According to the functional requirements of the above analysis, the development of the PC monitoring system of each module is completed by SQL Server 2008 database and Visual Studio 2010 and C # language. The overall block diagram of the upper computer system is shown in figure 2.

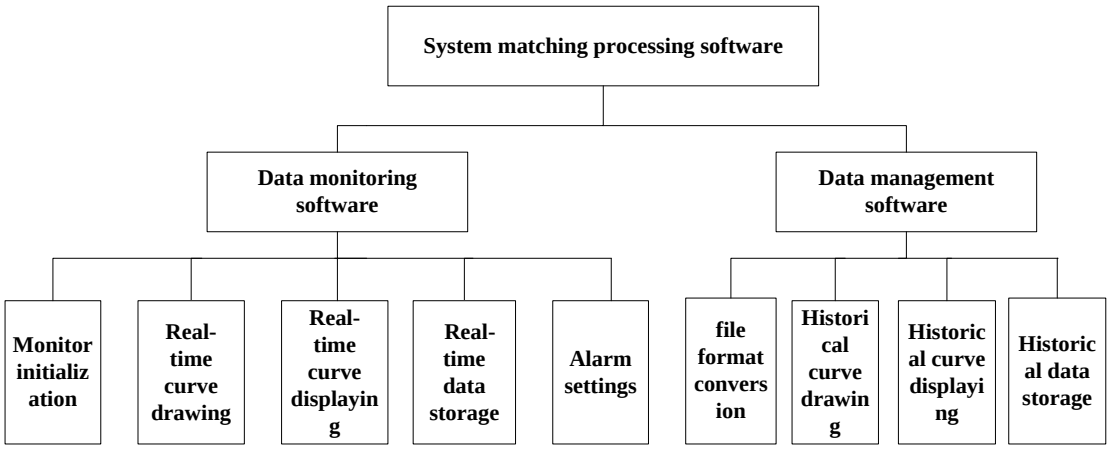

Fig. 2 Overall block diagram of the upper computer system

Supporting processing software is mainly divided into two parts, which are data monitoring software and data management software. Monitoring software is based on real time data and historical data is the core of data management software. The set of processing software can realize the torque processed and displayed in the real-time, each module working status monitoring, and historical data analysis. It also can be expanded into centralized monitoring of multi-source data to monitor various underground engineering parameters in gas drilling in real-time.

5. Conclusions

Aiming at the problem that the electromagnetic wave measurement is influenced by the formation characteristics and mud pulse can not be used for gas drilling, this design uses the microwave transmission in the drill string and relay transmission mode to greatly improve the microwave communication distance. The monitoring software of the host computer is developed, which can realize the monitoring of the downhole torque of the gas drilling, and provide technical support for the real-time understanding of the real working conditions and to deal with the underground safety risk.

The experimental results show that wireless transmission delay is short, the system can accurate quantitative measurement data collection, transmission and display of torque in real-time, and it can work stable and reliable more than160h, the measurement accuracy is less than 2.5% and the measuring depth of more than 3000m. The system meets the actual requirements of downhole torque measurement in gas drilling.

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