# Design and implementation of the nuclear logging instrument controlling and monitoring system based on MSComm

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**Abstract**

The author used MSComm to achieve the control of the uranium neutron logging instrument, and the real-time communication between the ground software system and the downhole detecting instrument through serial communication technology. Two problems were resolved intensively. Firstly, the real-time parameter control and feedback monitoring are implemented mainly through controlling the high voltage power supply and ion source to control the neutron flux, and utilizing the instrument feedback information to monitor the neutron source state. Secondly, the real-time data acquisition and display are achieved through the data acquisition module which monitors the instrument indirectly and ensures the instrument to work safely and stably. The reliability and practicability of the software system is verified by experiments.

*Keywords*: MSComm, nuclear logging instrument, controlling, monitoring

## 1 Introduction

At present, uranium quantification using computer technology is the research hotspot in the research of academic field based on the principle of the uranium fission causing by the neutron hitting [1-3]. In the communicating process between the computer and the instrument, the data acquisition and management are usually needed, and are often connected with external via RS-485 interface such as the data exchange between the host computer and the lower computer of the hierarchical control system, the communication between the computer and the digital instrument of the data acquisition system etc [4]. In the uranium logging instrument control system [5-7], control of the instrument determines its safety and reliability. Firstly, nowadays, the main research of uranium logging is uranium content detection and interpretation using the way of the controllable neutron source. The injury of neutrons to human bodies can be deadly. If the neutron source is controlled in error or out of control, the environment and the experimenter bodies will be damaged irreparably. Thus, it is very crucial to control and monitor the logging instrument. In addition, whether the instrument is stable or not mainly determines the interpretation accuracy of uranium content [8-10]. Therefore, the instrument stability monitoring is also an important indicator to measure the practicality of the software system. Based on the above needs, the author designed and developed this nuclear logging instrument controlling and monitoring system. Finally, the system were tested and applied successfully. The anticipated results have been achieved, and the controlling and monitoring system is stable and reliable.

## 2 MSComm application

There are two working modes of the communication component [11]. One is inquiry mode, in which the programmers read the CommEvent value and handle the event. The other is event-driven mode of which the working principle is like the interrupt mode. In the case of communication event occurs (such as sending data, receiving data etc.), the OnComm event of the component will be triggered. Generally, various applications and functions can be processed in the handler of the OnComm event. In this paper, the software system adopts the second way to achieve the communication of the ground system and the downhole instrument.

The frequent used attributes of MSComm:

CommPort: select the serial number.

Settings: set the serial communication parameters. The type is CString of which the value is followed by the baud rate, the parity check, the effective number of data bits and the stop bit.

InBufferSize: set the size of receiving buffer.

OutBufferSize: set the size of sending buffer.

InputMode: set the type of the received data. Zero indicates the text type. One indicates the binary type.

Rthreshold: set after how many characters received, the OnComm event will be triggered.

InputLen: set the number of bytes read from the receiving buffer.

SThreshold: set the minimum number of characters in the sending buffer before the OnComm event triggered.

The event-driven mode is mainly applied in this article. The instrument is regulated through sending control parameters and triggering the OnComm event in real time. Meanwhile, the monitoring of the instrument, the real-time data acquisition and display functions are implemented through receiving feedback information and detecting data information.

## 3 System module design and multi-thread control

In this paper the system module is designed based on the principle of safety, reliability and practicability, both covering the hardware communication protocol.

The main module division is shown in Figure 1. This system is mainly divided into a control module, a feedback monitoring module and a data acquisition module. Thereinto, the control module contains the downhole instrument power supply control, the winch lifting control and the neutron generator control.

The above control units are designed and controlled according to the industry standard protocol MODBUS. The detailed agreements will be introduced later. The feedback monitoring module supervises whether the instrument working state is normal or not, mainly through the feedback information which including the downhole high pressure, the ion current and the instrument temperature. The high pressure and the ion current are used to control the neutron occurrence quantity (In uranium logging, the neutron occurrence quantity influences the neutron detection time spectrum directly, furthermore the interpretation of the uranium content). Temperature monitoring can avoid the instrument burned by high temperature after abnormality. Data acquisition module mainly includes the neutron time spectrum, the natural $\gamma$ -ray time spectrum and the neutron $\gamma$ -ray time spectrum. These spectrum data can both monitor whether the instrument is normal or not indirectly and be used for the explanation and calculation of the uranium content directly.

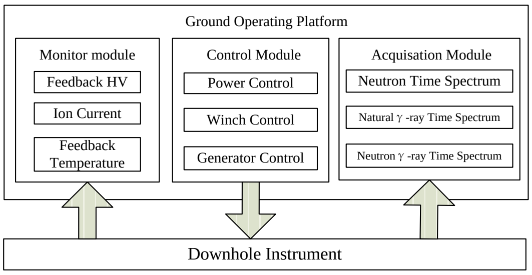


FIGURE 1 System framework

The ground operating platform communicates with the downhole instrument through transforming RS-485 to USB, and using the MSComm component to program. The main communication mode is single-thread communication. In order to improve the communication efficiency, and ensure the synchronization and the real-time performance of the control information, the monitoring information and the data acquisition information, the data acquisition clock (generally every five seconds or every ten centimeters which is the lifting distance of the downhole instrument each time ) and the data feedback delay (it takes some time for the feedback of downhole data acquisition module) are considered to program the multi-data cross-transmission, which is the multi-thread control actually.

The communication through multi-thread control is shown in Figure 2. After the basic instrument parameters are calibrated, the control commands, the retrieving state commands and the data acquisition commands will be sent to the downhole instrument through the data interface. Each command will be completed by a separate thread. However, the data acquired can not be transferred up to ground in one time. So they are divided into several data segments. Thus, the command sending (control command, reading state command and data acquisition command) and information retrieving (feedback information by the instrument according to the ground commands including state information and data information) are carrying on alternately in accordance with the collection clock interval and the feedback delay interval.

The feedback information retrieved is split into state information and data information by the ground information splitter, and then displayed onto the system interface. In fact, the actual multi-thread data transfer is achieved eventually, which ensures the detection data can be acquired each time in the shortest time, furthermore, increases the reading frequency of the instrument state, and guarantees the real-time tracking of the instrument state. The repeated experiments showed that this method ensures all the data acquired from the current instrument can be uploaded, displayed and saved within two seconds (generally, the logging instrument is set to acquire data each time within five seconds. So finishing data acquisition within two seconds won't conflict with the subsequent data acquisition. So the reliability of data acquisition is ensured), and the instrument state information can be updated each time within one second. Therefore, the stability of the instrument is guaranteed.

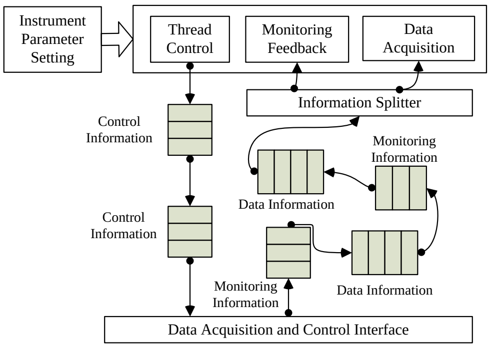


FIGURE 2 Multi-thread control of communication

## 4 System communication protocol

The data mainly acquired through the software system include the neutron time spectrum (divided into thermal neutron and epithermal neutron), the natural $\gamma$ -ray time spectrum, the neutron $\gamma$ -ray time spectrum, the generator control data, the winch depth data etc. Thermal neutron and epithermal neutron data are both 128-track time spectrum. Natural $\gamma$ -ray data are 1024-track time spectrum. Neutron $\gamma$ -ray data are three 512-track time spectrums (background $\gamma$ -ray, capture $\gamma$ -ray and inelastic $\gamma$ -ray). The generator data mainly include generator frequency, duty ratio of the generator frequency, 50V voltage monitoring, feedback voltage and ion flow of the high voltage power etc. Winch control uses BCD code. In order to ensure the reliability and the integrity of the data transfer, each unit communication protocol is designed in accordance with the industry standard protocol MODBUS. The data frame format includes slave address, function code, data bit and CRC verification. The specific structure is shown in Figure 3.

| Slave Address | Function Code | Data | CRC |
|---|---|---|---|
| 1 byte | 1 byte | 0 up to 252 byte(s) | 2 bytes |

FIGURE 3 MODBUS protocol field

According to the above protocol rules, the protocol designed in this paper is as following:

1) Neutron generator control unit protocol.

The slave device address of neutron generator control unit is 03H. The codes for implementing MODBUS function are 03H and 06H. And other bit codes are set as the following meanings:

0002H Generator frequency control register HVFRQ. The unit is Hz.

0003H Duty ratio of generator frequency control HVDTC. The unit is 0.1%.

0004H Storage current control 100KΩ. The range is 0000H~00FFH, 0Ω~100KΩ.

0005H Storage current control 10KΩ .The range is 0000H~00FFH, 0Ω~10KΩ.

000AH 50V voltage detection. The result is ADC sampling value. The unit is mV.

000BH Feedback voltage of high voltage power supply.

000CH Target current.

000DH Generator temperature.

000EH Ion source current.

2) Neutron time spectrum acquisition protocol.

The slave device address of neutron time spectrum is 20H. The codes for implementing MODBUS function are 03H and 06H. The sending and retrieving protocol is as following:

0x20, 0x06, 0x01, 0x00, 0x00, 0x00, CRC1, CRC2 starting measurement

0x20, 0x06, 0x02, 0x00, 0x00, 0x00, CRC1, CRC2 stopping measurement

0x20, 0x06, 0x04, 0x**, 0x00, 0x00, CRC1, CRC2 writing time spectrum track width

0x20, 0x04, 0x00, 0x00, [0x00, 0x00], CRC1, CRC2 reading epithermal neutron time spectrum from RAM, [0x00, 0x00] represents the track number is set to read.

0x20, 0x04, 0x00, 0x80, [0x00, 0x00], CRC1, CRC2 reading thermal neutron time spectrum data from RAM, [0x00, 0x00] represents the track number is set for reading.

Because space is limited, other protocols are omitted here.

## 5 System implementation and application

The system is developed by combining the MSComm with the clock component under the Microsoft Visual Studio 2010. Data acquisition is controlled by a time interval, usually five seconds, or when the winch lifts ten centimeters, the instrument monitoring information reading is set to one second. When the instrument is reading the detection data, the clock generator is needed to control sending the retrieving commands during the interval time of reading data. The OnComm event of MSComm is used for data management at the receiver. The specific parameters of MSComm will be set as following:

CommPort: auto-connecting according to the port number assigned by the hardware.

Settings: baud rate 115200, no check bit, eight data bits, one stop bit.

InBufferSize: setting the different buffer size according to the different data.

OutBufferSize: setting the buffer size to 16 bits to ensure all protocols can be use.

InputMode: one, setting the receiving data type to binary type.

Rthreshold: setting the different trigger bits according to the different data.

InputLen: setting the retrieving bits from receiving buffer.

SThreshold: setting the minimum character number of the sending buffer to three.

According to the above basic settings, experiments were carried out in the standard-model well, using four different model wells with different environment (contained water, increased casing, different sampling frequency, and different track width). The experiments were cycled 20 times in three days. The instrument running was controlled by the software over 24 hours totally, which proved that the software can control the instrument to work accurately and achieve the efficient data acquisition and display functions. The system effect is shown in Figure 4.

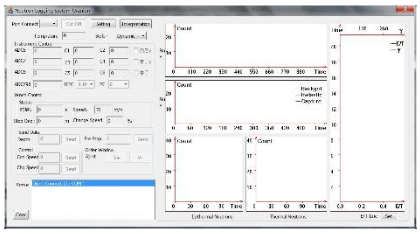

FIGURE 4 System running effect

When the uranium neutron logging instrument worked in the standard-model well stably, the data acquired were shown immediately in Figure 5. The ordinate represents the count of data acquisition. The coordinate represents the channel partitioned according to the time interval. For instance, in the thermal neutrons sub-figure of Figure 5, the coordinate '30' represents 240us which equals 30*8us. In the natural γ (Naγ) sub-figure of Figure 5, the coordinate was divided into 1024 channels. In the neutron γ (Nuγ) sub-figure of Figure 5, the coordinate was divided into 512 channels. In the epithermal neutrons and thermal neutrons sub-figures of Figure 5, the coordinate was divided into 218 channels. From the Figure 5, we can draw the conclusion E/T value and γ total count are stable and the uranium content can be interpreted accurately from experiments in the standard-model well.

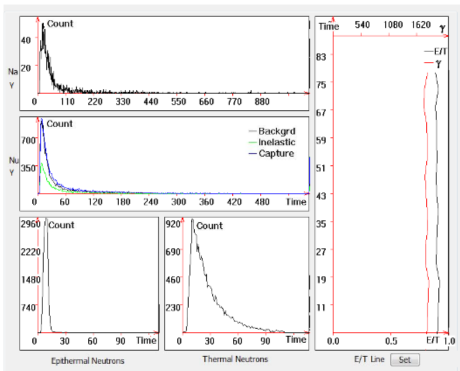


FIGURE 5 Real-time data display

## 6 Conclusion

In this paper, using MSComm technology, the author achieved the controlling, monitoring and real-time display of the uranium neutron logging instrument, and the real-time communication between the ground software system and the downhole detecting instrument through serial communication technology. The experiments showed that this technology can be applied in controlling the uranium neutron logging instrument effectively. Therefore, the instrument can be guaranteed to work safely and stably.

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