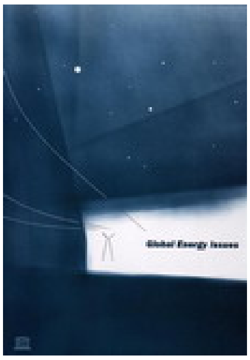

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Design of remote data quantum system for geological oil extraction based on ARM and GPRS

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Abstract: With the rapid development of industrial automation, the control accuracy in industrial production has gradually improved and the control process has become more and more complex. Since then, the requirements for the security and real-time performance of the data collected on site have also been continuously improved, and high-quality, strong real-time data has played an important role in the entire control process. This article aims to study the design of a remote data quantum system for geological oil extraction based on ARM and GPRS, and put forward some related methods about quantum information and GPRS technology. In addition, experiments were conducted on a quantum system based on ARM and GPRS for remote data extraction of geological oil. The experimental results of this paper show that the remote data quantum system for geological oil extraction based on ARM and GPRS can detect the flow information of oil and water in the process of oil production in real time. Moreover, it has played a great protective role in the remote transmission of data, and the security protection of data has been improved by 10%.

Keywords: GPRS mobile communication; Modbus protocol; geological oil extraction; quantum information; quantum system design; remote data collection.

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1 Introduction

With the advancement of science and technology and the continuous development of industry, the demand for energy in social production, especially the demand for petroleum resources, has increased, which puts forward the requirements for more reliable and accurate data collection and transmission in petroleum production. So far, data collection usually uses manual reading methods, however, this method has low accuracy, slow speed, high-work intensity and prone to improper behaviour, so it cannot meet the data collection requirements required by the latest industrial production. At the same time, the traditional data transmission method is easily damaged by bad network elements, and it is easy to cause data leakage and damage during data transmission.

The emergence of GPRS and quantum communication technology provides strong technical support for realising the rapid transmission of data information and ensuring the safety of data information (Han et al., 2012). GPRS communication technology can ensure that industrial production enterprises can realise low-cost, high-efficiency and high-capacity data transmission in different regions, and can also realise the direction control of instruments and equipment. Quantum information technology can provide protection for the transmission and storage of remote data, protect the information produced by enterprises from interference from the external network environment and improve data security (Kitouni et al., 2018).

With the continuous development of network transmission technology, people are more and more widely used in the transmission and reception of remote data. Straub A found in the study of small sewage treatment plants in Germany that some companies have developed remote data transmission modules for equipment maintenance, and by using these modules, the maintenance frequency can be reduced to once a year (Straub, 2019). With the rapid development of cloud computing, more and more customers want to store their data on a Public Cloud Server (PCS) (Li et al., 2018). New security issues must be resolved to help more customers process their data in the public cloud. To this end, from the perspective of security, Wang et al. (2016) proposed a new agent-oriented data upload and remote data integrity check model in identity-based public key cryptography: identity-based agent-oriented data upload and public cloud remote data integrity check. Similarly, to protect the security of data, Shen et al. proposed a new paradigm called remote data ownership check, which includes a privacy protection authenticator for cloud storage. In this new paradigm, neither cloud service providers nor public verifiers can access real authenticators for cloud data. At the same time, it can still effectively check the integrity of cloud data (Shen et al., 2017). In order to confirm whether the outsourced file is intact and does not need to be downloaded completely, the researchers invented the Remote Data Integrity Check (RDIC) mechanism. But this mechanism requires a lot of Public Key Infrastructure (PKI), so Peng et al. (2019) proposed a new identity-based RDIC scheme. That is, efficient, dynamic and identity-based multiple replication can prove data ownership without the burden of PKI (Peng et al., 2019). Quantum information security has played a very important role in protecting the security of data and information. Xie (2020) stated in his research that quantum secure direct communication is a branch of quantum communication, which transmits messages directly in quantum form instead of using encryption keys. As communication security becomes more and more important today, the early use of quantum proof cryptography is believed to minimise future risks (Xie, 2020). In the field of applied research on quantum communication, Ferrara R aims to point out and clearly describe how quantum communication networks go beyond the inherent limitations of classical technologies, enhance distributed computing within the network and reduce overall end-to-end latency. In addition, Ferrara et al. (2021) also explained how entanglement can reduce the communication complexity that classic virtualised networks will experience in the future. Although these researchers have done a lot of research on information and data security, their research results have rarely been applied in real life, only in certain specific fields.

As a very popular wireless data transmission protocol in the world, the application field of GPRS communication protocol is becoming wider and wider. The innovation of this article lies in the combination of GPRS technology and ARM technology to achieve wireless transmission of data collection in industrial production sites. Through the combination with quantum information technology, a remote data quantum system for geological oil extraction based on ARM and GPRS was created to ensure the data security of the petroleum industry to the greatest extent.

2 GPRS technology and quantum information method

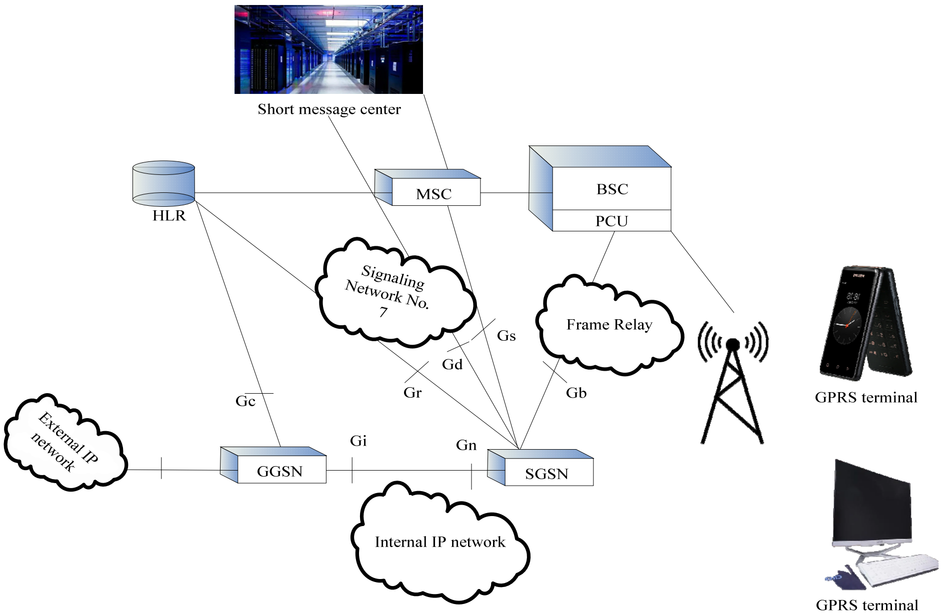
2.1 GPRS technology

GPRS is a 2.5-generation wireless data transmission technology based on GSM technology, which is an important link in the development of 3G services and an important milestone in the development of mobile communications. GPRS is compatible with the GSM network, not only inherits the original technical functions, but also optimises some functions of the GSM system, making data transmission and signalling more effective (Kianinia et al., 2017). As the fusion of wireless and network, the GPRS system includes both wireless technology and data technology in its implementation technology, so it has a relatively large change compared to GSM. In terms of network structure, the GPRS system adds a data processing unit and processes data information through some core network equipment; in terms of interface types, it adds SS7 signalling interface and data interface; in terms of protocol types, GPRS network involves frame relay protocol, IP protocol, etc.; in terms of business support, GPRS supports WAP and TCP/IP-based internet access, multimedia messaging, video services, Email services and wireless remote control. GPRS is more advantageous in high-speed data processing, which supports the TCP/IP protocol and replaces the time billing method with business billing, and the main function of GPRS is data packet switching technology (Algarni et al., 2018).

The main advantages of GPRS wireless network technology are low cost, small terrain restrictions, long-lasting online, high-transmission speed, strong anti-interference, etc. (Qamar and Cong, 2019). Of course, GPRS wireless network technology also has certain shortcomings. For example, the quality of GPRS communication is greatly affected by the strength of the signal, and the communication effect is poor in places with no signal coverage or weak, which may affect the completion of the service.

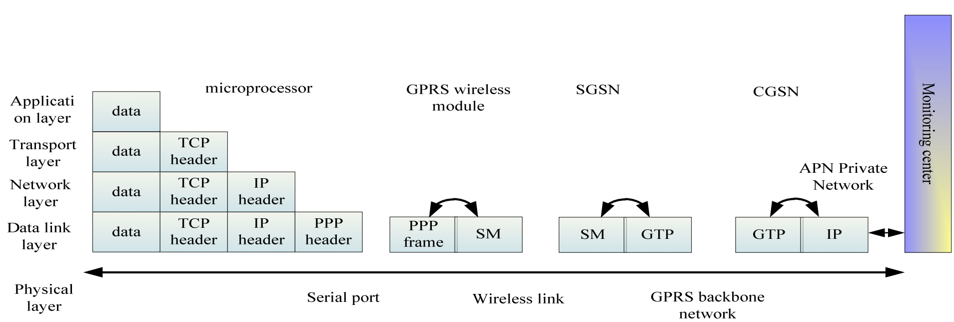
1 *Network components*: The newly introduced network elements in the GPRS system can be divided into two categories: wireless part and data part. Among them, the PCU belongs to the wireless management part, the SGSN belongs to the common part of wireless management and data management and the GGSN completely belongs to the data management part. PCU and BSC jointly provide wireless data processing functions, such as logical link and physical link mapping, data packet decompression and confirmation, wireless data channel allocation, etc. (Bi et al., 2021). The PCU can be inserted into the BSC as a module, or it can exist as a unit independent of the BSC. The SGSN provides a connection with the wireless data packet controller PCU through the Gb interface, and manages mobile data such as user ID, encryption and compression. GGSN plays the role of a router, unites with relevant network elements such as PIX, DNS, DHSP, etc., to realise the function of accessing and sending data services (Gohar et al., 2016). The interface between the GGSN and the SGSN is a Gn interface using the GTP protocol type, and the interface between the GGSN and the external data network is a Gi interface using the IP protocol type. Figure 1 shows the structure of the GPRS system.

Figure 1 GPRS system structure diagram



2 *GPRS data conversion protocol*: The GPRS wireless module decompresses the received PPP frame, repackages it into an SM message and sends it to the SGSN via a wireless link. SGSN performs protocol conversion on data and encapsulates it according to GTP (GPRS tunnel protocol, GPRS tunnel protocol). GTP packets are sent to the corresponding GGSN through the GPRS backbone network, and the GGSN also needs to perform protocol conversion and data encapsulation according to the corresponding external network (Rodrigues et al., 2019). Here, the route must be selected according to the fixed IP address of the monitoring centre, and the final data will be sent to the monitoring centre (Kianinia et al., 2017). The GPRS wireless module communicates with the monitoring centre according to the assigned internal IP address. Figure 2 is a flow chart of GPRS data protocol conversion.

Figure 2 GPRS data protocol conversion flow chart



3 *Modbus protocol*: The Modbus protocol is a general industrial communication standard developed by MODICON. It is a general transmission protocol for PLC, various industrial equipment, man-machine interfaces, drives and other electronic equipment communications (Volovich and Kozyrev, 2016). By standardising the format of communication data and defining an identifiable information structure, real-time communication and remote operation can be realised between controllers or between remote devices via a network (Wang et al., 2019).

The Modbus protocol works in the network application layer, using the ‘master-slave’ mode to send data frames. The slave device can only respond when it receives the query command issued by the master device, and cannot actively send data (Ghamisi et al., 2016). The master device can establish a connection only with the slave device, or use broadcast signals to communicate with multiple slave devices without specifying a specific communication network.

The Modbus protocol has two different transmission modes, ASCII mode and RTU mode and the communication transmission characteristics of the two modes are shown in Table 1.

Table 1 ASCII and RTU mode characteristics

Agreement	*Transmission efficiency*	*Program processing*	*Start tag*	*End tag*	*check*	*Data interval*
ASCII	Low	Easier	:	CR, LF	LRC	<1S
RTU	high	complex	without	without	CRC	<24bit
Is the difference obvious	Yes	Yes	Yes	Yes	No	Yes

There are special characters in the ASCII protocol data frame to identify the beginning and the end. DATA domains are all ASCII characters that are easy to process and analyse, so the storage and analysis of data packets is more convenient and easy to debug.

4 *The overall architecture of wireless terminals*: In order to meet the characteristics of low-cost, miniaturisation and GPRS terminals suitable for industrial environment applications, the design of wireless terminals adopts an embedded system based on the AR core (Wan et al., 2019). The embedded system can realise the control, monitoring, management and other functions of other equipment. The wireless terminal is mainly composed of a microprocessor unit, a GPRS communication module unit, a memory unit, a serial communication unit (including UART0, UART1), a power supply unit and a JTAG interface unit. The GPRS hardware block diagram is shown as in Figure 3.

2.2 Oil extraction data collection

With the continuous advancement of science and technology, the degree of industrial automation is getting higher and higher and some instruments that are traditionally mainly controlled by manual on-site control are gradually replaced by instruments with a high degree of automation. In the rapidly changing industrial automation development, the flow measurement system has also undergone major changes and the production site data acquisition system with the computer monitoring system as the core has emerged (Zhao et al., 2017).

There are many different measurement methods for flow measurement in oil extraction, and there are countless types of flowmeters. Figure 4 shows the currently widely recognised types of flowmeters.

Figure 3 GPRS module connection diagram

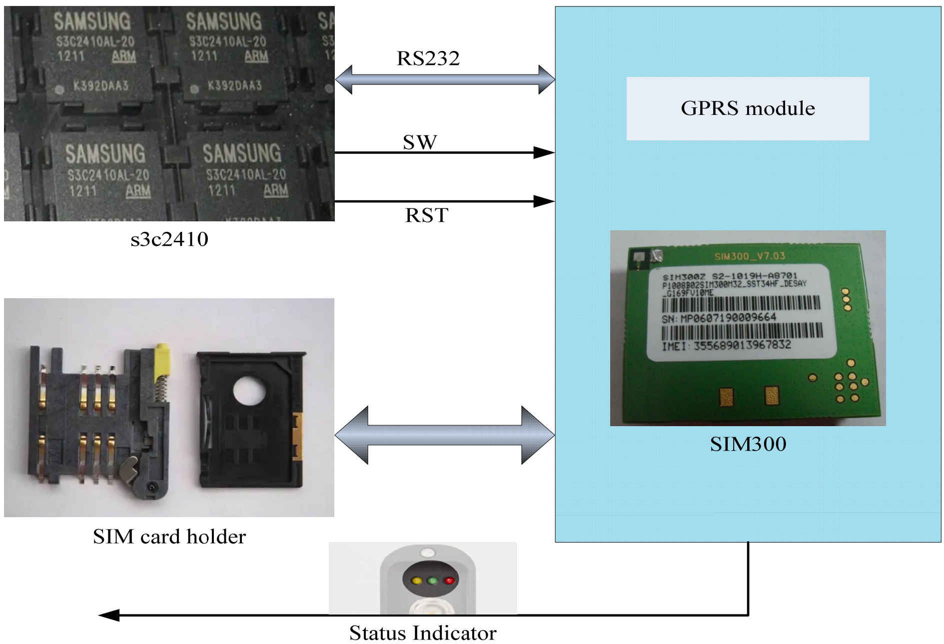
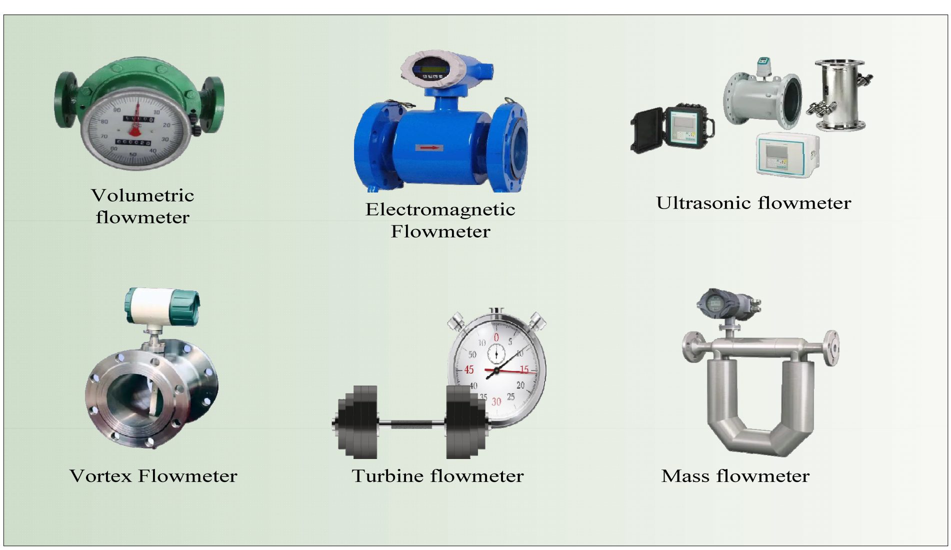


Figure 4 Types of flowmeters



Different types of flowmeters have their strengths and shortcomings, and this is an important reason why there are so many types of flowmeters. However, with the progress of the times, in this era of the explosion of science and technology, a brand-new flowmeter-mass flowmeter was produced (Fakher and Imqam, 2020).

Because crude oil has poor fluidity at room temperature and relatively high viscosity, the requirements for flowmeters are relatively high. Among the more widely used types of flowmeters, the high-precision turbine flowmeters, positive displacement flowmeters and electromagnetic flowmeters are not suitable for petroleum product fluids with high viscosity. The accuracy of other flowmeters is relatively large compared with these three types of flowmeters, and cannot meet the required accuracy requirements of the petroleum production site. Therefore, in the oil pipeline, because the mass flowmeter has the advantages of high-measurement accuracy and many types of measurable fluids, the mass flowmeter is usually used as the flowmeter of the oil pipeline (Ebrahim et al., 2019).

In several commonly used oil flowmeters, each has its own advantages and disadvantages. The advantage of the electromagnetic flowmeter is that the measurement range is wide and the accuracy is relatively good, which can reach 0.5% and the requirement for fluency is not very high (Leung et al., 2016). However, the shortcomings of the electromagnetic flowmeter are also very obvious. The fluid with low conductivity cannot get accurate data in the electromagnetic flowmeter, and it is not suitable for the occasions where the temperature is too high or too low; turbine flowmeters are known as the most repeatable and accurate flow measurement equipment. Its advantages mainly include good accuracy, the most accurate equipment of all types, good repeatability, no zero drift, strong anti-interference ability and large measurement range. But the main disadvantage of turbine flowmeters and Coriolis mass flowmeters is that the equipment must be calibrated frequently. Positive displacement flowmeters have good accuracy, low requirements for measuring pipeline conditions and a wide measurement range. However, positive displacement flowmeters are not suitable for occasions with complex structures, large volumes and high or low temperatures.

2.3 Basic principles of quantum information

(1) *Quantum state:*

a) *State vector in Hilbert space*: In quantum mechanics, quantum systems are represented by Hilbert space. The Hilbert space is a multi-dimensional linear complex space, and the quantum state is represented by a unit vector in a space called a state vector. The Hilbert space is composed of a set of vertical independent basic vectors (Zampieri et al., 2020), and the quantum state φ is often described by $|\phi\rangle$, or it can be described by a column matrix, such as:

$$|\phi\rangle = a_1|1\rangle + a_2|2\rangle + \ldots + a_n|n\rangle = \begin{pmatrix} a_1 \\ a_2 \\ \ldots \\ a_n \end{pmatrix} \tag{1}$$

Among them, a_1, a_2, a_n are the coefficients of $|\phi\rangle$ on basis vector 1, basis vector 2, basis vector *n*, which are usually called probability amplitudes and conform to:

$$|a_1|^2 + |a_2|^2 + \ldots + |a_n|^2 = 1 \tag{2}$$

Formula 2 shows that all the coefficients of the state vector in the space on its basic vector, that is, all the probability amplitudes meet the normalisation condition.

b) *Qubit*: Quantum algorithms and quantum information are based on queue bits. Qubit, also called qubit, is a single quantum system and the basic unit of quantum information. Qubit is different from classic bits, and Qubit's state may be $|0\rangle$ or $|1\rangle$, or it may not be between $|0\rangle$ and $|1\rangle$, but a linear combination of states, which is a superposition state.

A double Qubit has four ground states, namely $|00\rangle$, $|01\rangle$, $|10\rangle$, $|11\rangle$. A pair of Qubits can also be the superposition of these four ground states, so that the state vector of the double qubit is:

$$|\phi\rangle = \partial_{00}|00\rangle + \partial_{01}|01\rangle + \partial_{10}|10\rangle + \partial_{11}|11\rangle \tag{3}$$

(2) *Quantum evolution*: The state evolution of quantum mechanics obeys the Schrodinger equation:

$$\left(-\frac{x^2}{2d}\nabla^2 + P\right)\varphi(a,b) = lh\frac{\alpha\varphi(a,b)}{\alpha b} \tag{4}$$

In Schrodinger's equation, wave function $\varphi(a,b)$ is used to represent the state of an object, and the wave function is related to the probability of the object being discovered. That is, assuming that m is a continuous variable, the probability density of particles in the dm interval at time *b* is:

$$\beta(m,b) = \varphi^*\varphi dm \tag{5}$$

And it meets the normalisation conditions:

$$G = \int_{-\infty}^{\infty} \varphi^*\varphi dm = 1 \tag{6}$$

(3) *Quantum operator:*

a) *Linear operator*: In quantum computing, all operations and calculations of state vectors are called operators. The linear operator is a more important operator, and the linear operator *X* satisfies the following relationship:

$$X(|m\rangle + |n\rangle) = X|m\rangle + X|n\rangle \tag{7}$$

$$X(a|m\rangle) = aX|m\rangle \tag{8}$$

Among them, $|m\rangle$ and $|n\rangle$ are two different vectors in Hilbert space, and *a* is a complex number.

The equivalent operator D and the zero operator 0 are two special operators, and their definitions are as follows:

$$D|m\rangle = |m\rangle \tag{9}$$

$$0|m\rangle = 0 \tag{10}$$

The linear Hilbert space can be composed of a set of orthogonal normalised basis $|n\rangle = (n = 1, 2, ..., n)$, and the state vector can be described by a single column matrix. Therefore, matrices can be used to represent operators. Operators operating on a single qubit can be described by a 2*2 matrix, such as the Pauli matrix, which is very important in quantum computing:

$$\alpha_0 \equiv d \equiv \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \tag{11}$$

$$\alpha_1 \equiv \alpha_p \equiv P \equiv \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \tag{12}$$

$$\alpha_2 \equiv \alpha_t \equiv T \equiv \begin{bmatrix} 0 & -n \\ n & 0 \end{bmatrix} \tag{13}$$

$$\alpha_3 \equiv \alpha_o \equiv O \equiv \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \tag{14}$$

Among them, α_p is a single-qubit NOT gate and α_t is a single-qubit phase gate with a phase angle of π.

b) *Hermite operator and unitary operator*: It can be seen from the foregoing that after determining a set of orthogonal normalised bases of the space, the operators are the same as the corresponding matrices and they can be replaced with each other. Assuming that the operator is S, its conjugate transpose is S^+, if:

$$S = S^+ \tag{15}$$

Then, S is called the Hermite operator, if it satisfies:

$$SS^+ = E \tag{16}$$

S is called a unitary operator, or a reversible operator.

(4) *Quantum unclonable theorem*: Quantum cannot be cloned, that is, an arbitrary quantum state cannot be copied with 100% accuracy. It should be noted that the quantum state mentioned here refers to any quantum state. The linear nature of quantum mechanics shows that it is impossible to accurately copy an uncertain quantum state, and it also shows that two different non-orthogonal quantum states cannot be copied, and they cannot be measured without interfering with these states (Jiang et al., 2019).

The ground states $|0\rangle$ and $|1\rangle$ that are orthogonal to each other in a quantum computer can be copied like a classical Boolean state, that is, quantum states that are orthogonal to each other can be copied. For example, there is such a unitary transformation 3:

$$|0\rangle_1 |0\rangle_2 \xrightarrow{S_1} |0\rangle_1 |0\rangle_2 \tag{17}$$

$$|1\rangle_1 |0\rangle_2 \xrightarrow{S_1} |1\rangle_1 |1\rangle_2 \tag{18}$$

Regardless of whether the first Qubit is $|0\rangle$ or $|1\rangle$, S_1 can copy the state of this Qubit to the second Qubit. But if the first Qubit is the superposition state $|\varphi\rangle = \partial |0\rangle + \delta |1\rangle$ of $|0\rangle$ and $|1\rangle$, under the action, S_1 will become:

$$\left(\partial |0\rangle_1 + \delta |1\rangle_1\right)|0\rangle_2 \xrightarrow{S_1} \partial |0\rangle_1 |0\rangle_2 + \delta |1\rangle_1 |1\rangle_2 \tag{19}$$

Obviously, the state obtained after the transformation is not $|\varphi\rangle_1 |\varphi\rangle_2$, which means that the state of the first Qubit is not copied to the second Qubit. This shows that quantum cloning cannot accurately copy an unknown quantum state.

$|\varphi\rangle$ and $|\gamma\rangle$ are two different and non-orthogonal quantum states, and if there is a copy machine, its input is quantum state $|\varphi\rangle$ and its initial state is $|C\rangle$. Its output consists of two parts, the first is the original quantum state $|\varphi\rangle$ and the second is the $|\varphi\rangle$ obtained by copying the initial state $|C\rangle$, so the function of this copy machine can be written as:

$$|\varphi\rangle_1 |C\rangle_2 \xrightarrow{S_1} |\varphi\rangle_1 |\varphi\rangle_2 \tag{20}$$

Similarly, when the input is quantum state $|\gamma\rangle$, there are:

$$|\gamma\rangle_1 |C\rangle_2 \xrightarrow{S_1} |\gamma\rangle_1 |\gamma\rangle_2 \tag{21}$$

Owing the unity of evolution operator S_1: $S_1^+ S_1 = S_1 S_1^+ = E$. Taking the inner product of formulas 20 and 21, plus the normalised property $|C\rangle$ of $\langle C | C\rangle = 1$, it is easy to get:

$$_1\langle\gamma|\varphi\rangle_1 = {}_1\langle\gamma|\varphi\rangle_1 \, {}_2\langle\gamma|\varphi\rangle_2 \tag{22}$$

$|\varphi\rangle$ and $|\gamma\rangle$ are not orthogonal, so only equation $\langle\gamma|\varphi\rangle = 1$ is true, that is, $|\varphi\rangle$ and $|\gamma\rangle$ are in the same state. Therefore, there is no copying machine that can replicate two different and non-orthogonal states $|\varphi\rangle$ and $|\gamma\rangle$. This is the quantum unclonability theorem, which is another difference between quantum information and classics.

2.4 Quantum system design

(1) *System design*: When developing a quantum system based on ARM and GPRS, the production of software plays an important role in the efficiency and reliability of the system. An embedded system is composed of hardware and software, and is a device

that can operate independently. In embedded systems with low functional complexity, the system software usually adopts the front and back structural design. In the front-end system, the software consists of a cyclic program running in the background and an interrupt handler in the front field, while the background program executes operations that do not depend on time. The main field interrupt handler is mainly responsible for processing operations that require relatively strict time, such as the response to externally triggered asynchronous events (Guo and Aryana, 2016) and the lower computer system software also adopts the structure of the front and rear systems.

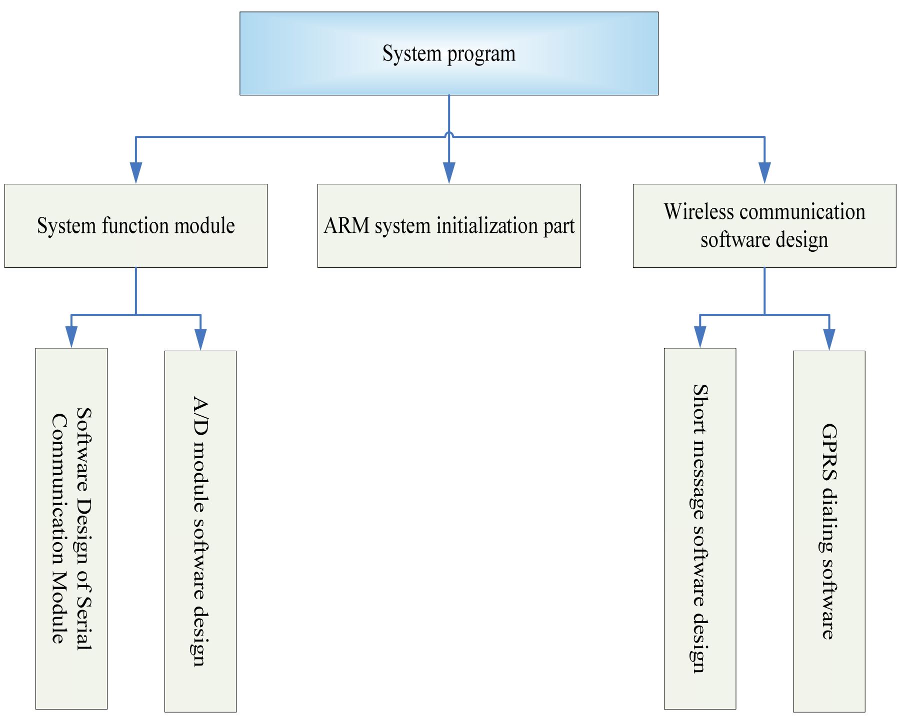
The system software of the lower computer can be divided into three software modules, including ARM system initialisation module, system function module and GPRS communication software module.

After the system is powered on, the initialisation of each part is performed first, including the allocation of the hardware resources of the microcontroller, register configuration, timer start, variable initialisation and analogue multiplex switch closing. After the initialisation is completed, it enters the infinitely repeated background main loop process.

In the background main loop, driven by the timer, the sampling channel is switched at a certain time interval, and after the corresponding calculation is completed, the result data is written into SRAM and at the same time, it is sent through the RS-232 serial port or wireless communication module for debugging (Morzhin and Pechen, 2019).

The overall functional block diagram of the lower computer system software is shown in Figure 5.

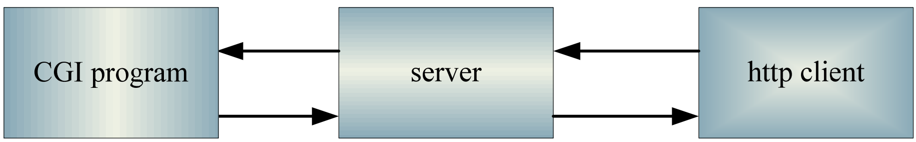
Figure 5 System software block diagram



(2) *Common gateway interface CGI*: The CGI universal gateway interface is a tool for the HTTP server to communicate with users or programs on other machines, and its programs must be executed on the web server. Almost all CGI programs are used to interpret and process the input information from the form, generate corresponding processing on the server or feed the corresponding information back to the browser.

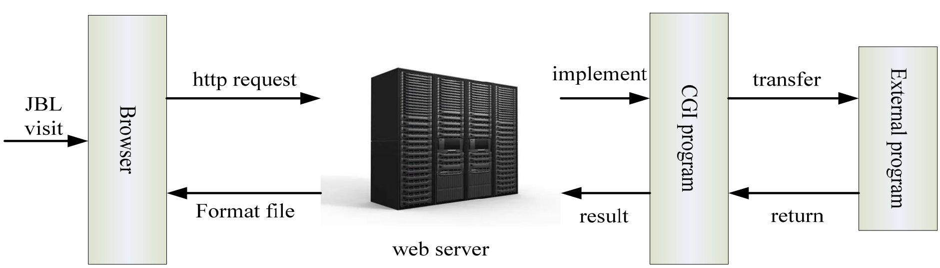
The CGI program enables the web page to have interactive functions, and the CGI program and the server can send information to each other through the public gateway. CGI programs can be written in various executable languages such as C and C++. Figure 6 shows the relationship between CGI, client and server.

Figure 6 The relationship between the CGI program and the client and server



The working principle of CGI is very simple, and the user accesses the web server through a browser on the client side and sends an http request. When the submitted request requires CGI to be executed in the webserver, such as submitting a form, CGI will call an external program to return the request result and the webserver will return the result to the user in the form of a format document. Figure 7 shows the working principle of CGI.

Figure 7 The working principle of CGI



2.5 Remote data collection

'Remote data collection' refers to the conversion of collected analogue humidity, temperature, pressure, displacement and other remote signal values into digital quantities. These values are saved, calculated and output by the computer and can also be used to detect faults, and the corresponding hardware and software systems are called data acquisition systems.

3 Debug and experiment of remote data quantum system based on ARM and GPRS

3.1 Data collection stability experiment based on quantum system

In this experiment, all equipment was calibrated and the system data collection experiment was started after the frequency was calibrated. During the experiment, the flow collection is mainly divided into two parts to test the stability and accuracy of the data collection system.

Regarding stability, the experimental method of this experiment is to adjust the frequency of the inverter to a certain fixed value, keep it unchanged, and observe the changes in the flow rate in the pipeline. In this experiment, the frequency was fixed at 20 Hz for stability testing, and the set acquisition time interval was 5 s. The flow data of the two phases of water and oil are shown in Tables 2 and 3.

Table 2 Fixed frequency water flow

Time (s)	*Flow rate (m3/h)*	*Frequency (Hz)*
1	0	20 Hz
6	0.12	20 Hz
11	0.632	20 Hz
16	0.982	20 Hz
21	1.069	20 Hz
26	1.198	20 Hz
31	1.285	20 Hz
36	1.396	20 Hz
41	1.402	20 Hz
46	1.410	20 Hz
51	1.413	20 Hz
56	1.411	20 Hz

Table 3 Fixed frequency oil flow

Time (s)	*Flow rate (t/h)*	*Frequency (Hz)*
1	0	20 Hz
6	0	20 Hz
11	0	20 Hz
16	0.269	20 Hz
21	0.541	20 Hz
26	0.895	20 Hz
31	0.996	20 Hz
36	1.136	20 Hz
41	1.259	20 Hz
46	1.351	20 Hz
51	1.384	20 Hz
56	1.361	20 Hz

Finally, the experiment observes the data obtained by the host computer and the field data of the flowmeter at different frequencies, and analyses and compares the two types of data obtained. As for the accuracy of the analysis data acquisition system, whether the data is collected accurately, the control system can also be improved by adjusting and revising the control program. Fluctuation occurs when the flow rate in the system changes, and in the flow accuracy test, every time the frequency is changed, observe and compare the display data in the host computer and the field data of the flowmeter within a certain period of time to determine the accuracy of the data acquisition system. In the experiment, the upper computer data and the oil and water two-phase data calculated by the on-site flowmeter are shown in Tables 4 and 5.

Table 4 Water flow data relationship

Frequency (Hz)	*Display flow (m3/h)*	*Actual flow rate (m3/h)*	*Error*
3	0.162	0.165	1.8%
4	0.198	0.203	2.5%
5	0.216	0.226	4.4%
6	0.358	0.366	2.2%
7	0.462	0.468	1.3%
8	0.587	0.591	0.6%
9	0.697	0.705	1.1%
10	0.746	0.753	0.9%

Table 5 Oil flow data relationship

Frequency (Hz)	*Display flow (t/h)*	*Actual flow rate (t/h)*	*Error*
3	0.158	0.158	0%
4	0.193	0.195	2.6%
5	0.199	0.203	2.0%
6	0.239	0.248	3.6%
7	0.369	0.374	1.3%
8	0.498	0.506	1.6%
9	0.587	0.596	1.5%
10	0.634	0.636	0.3%

3.2 Data fidelity and other related experiments of the remote data quantum system for geological oil extraction based on ARM and GPRS

At present, GPRS is a brand-new technology that can quickly and easily connect at any time and at any place, and at the same time, the cost is very reasonable. In short, GPRS data transmission speed has increased, applications have increased and costs have become more reasonable. It can meet the ideal needs of industrial sites, can transmit large-capacity data information stably and the real-time performance is better guaranteed. In this experiment, the remote data quantum system for geological oil extraction based on ARM and GPRS will be tested for data transmission speed, data fidelity and data security. In the experiment, the time step is set to $\Delta t = 0.01$ and the control time is t=80. Table 6 shows some statistical data of the fidelity experiment.

Table 6 Fidelity experimental statistics

1	Fidelity	0	10	20	30	40	50	60
	Time	0.72	0.80	0.91	0.94	0.97	1	1
2	Fidelity	0	10	20	30	40	50	60
	Time	0	0.73	0.85	0.94	0.98	0.99	1
3	Fidelity	0	10	20	30	40	50	60
	Time	0	0.71	0.92	0.97	1	1	1
4	Fidelity	0	10	20	30	40	50	60
	Time	0.71	0.78	0.86	0.94	0.98	0.99	1

During the experiment, the data security of the quantum system was also tested. Table 7 shows the statistical table of the experimental data for this experiment.

Table 7 Data security experiment data table of quantum system

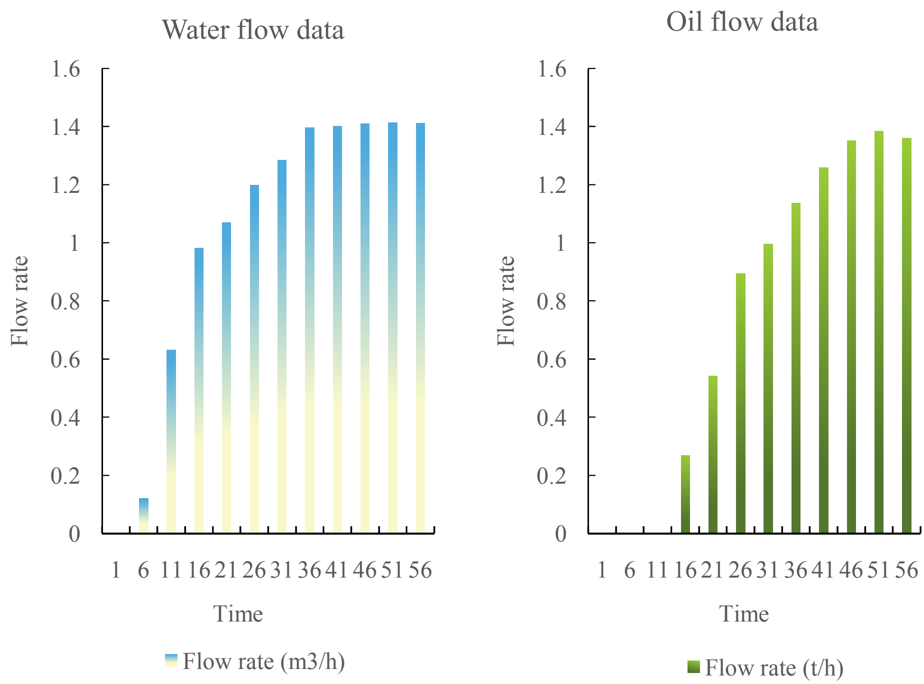
	Data security	*Data security*
1	88.60%	99.3
2	86.50%	99.8
3	85.30%	99.8
4	84.70%	99.5
5	91.20%	99
6	91.40%	99.4
7	87.40%	98.5
8	83.80%	98.4
9	89%	99.3
10	92.60%	99.2

4 Experimental analysis of remote data quantum system based on ARM and GPRS

4.1 Experimental results of data collection stability based on quantum systems

In the experiment of this article, statistics are made on the change data of water flow and oil flow at a fixed frequency. According to the data in Tables 2 and 3, a graph of the changes in water flow and oil flow at a fixed frequency can be obtained, as shown in Figure 8.

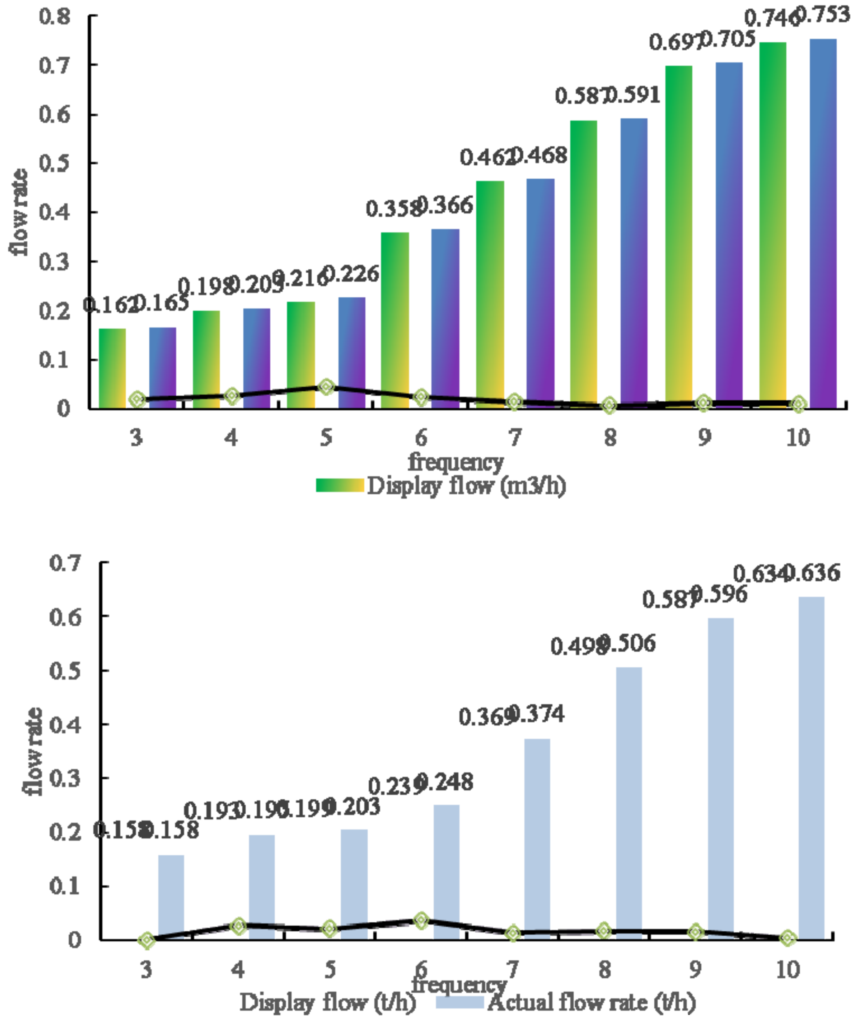
Figure 8 The change of water flow and oil flow at a fixed frequency



It can be seen from Figure 8 that the adjustment and stabilisation time of the flow in the water pipeline is about 36 s, while the flow stabilisation time of the oil pipeline is longer, about 46 s. After a period of time, the flow rate of the fluid in the oil pipeline and the water pipeline will gradually tend to a stable state and the fluctuation of the flow rate is relatively small. In this experiment, the data obtained by the host computer and the field data of the flowmeter under different frequencies were observed, and the data of the host computer in the experiment and the oil and water two-phase data obtained by the field flowmeter were recorded. According to Tables 4 and 5, we can get.

By observing the two sets of data, it can be seen that there is still a certain error between the data collected in the host computer and the data collected on the spot. This error is inevitable due to pressure changes in the pipeline, the accuracy of the metering equipment and the interval of data collection. By comparing the data obtained from the host computer and the field data of the flowmeter under different frequencies, the error of the two-phase data of water and oil is calculated. Because the system requires that the error should be less than 5% to meet the requirements of the data acquisition system at the oil production site. Through Figure 9, it can be clearly observed that the error does not reach 5%. Therefore, although the experimental results of the system have certain errors, they meet the requirements of system design and the experimental results have achieved the expected results.

Figure 9 Comparison of oil and water two-phase data



4.2 The results of related experiments such as the fidelity of the remote data quantum system based on ARM and GPRS

In this experiment, four different types of data were transmitted and their data was also recorded during the transmission. According to the data in Table 6, the fidelity change diagrams of different target states can be obtained, as shown in Figure 10.

According to Figure 10, it can be seen that the fidelity of the four sets of different data has reached 1. Although the time spent is different, they all achieved the same effect, which further illustrates the feasibility of the remote data quantum system based on ARM and GPRS in the geological oil extraction industry. Of course, in order to verify the data security of the quantum system, related experiments were also carried out during the experiment. Figure 11 shows the data security of the quantum system.

Figure 10 Fidelity change curve of different target states

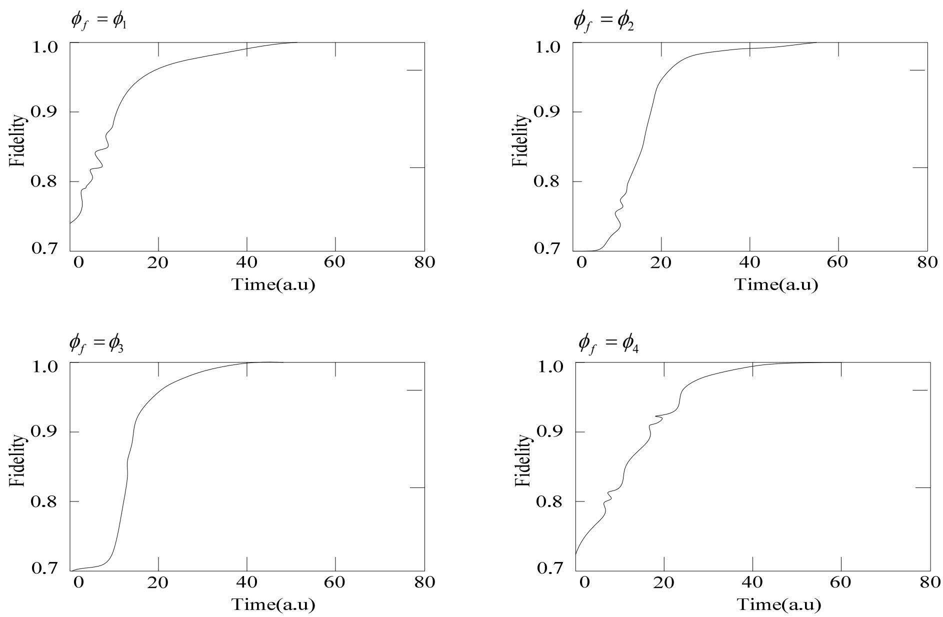
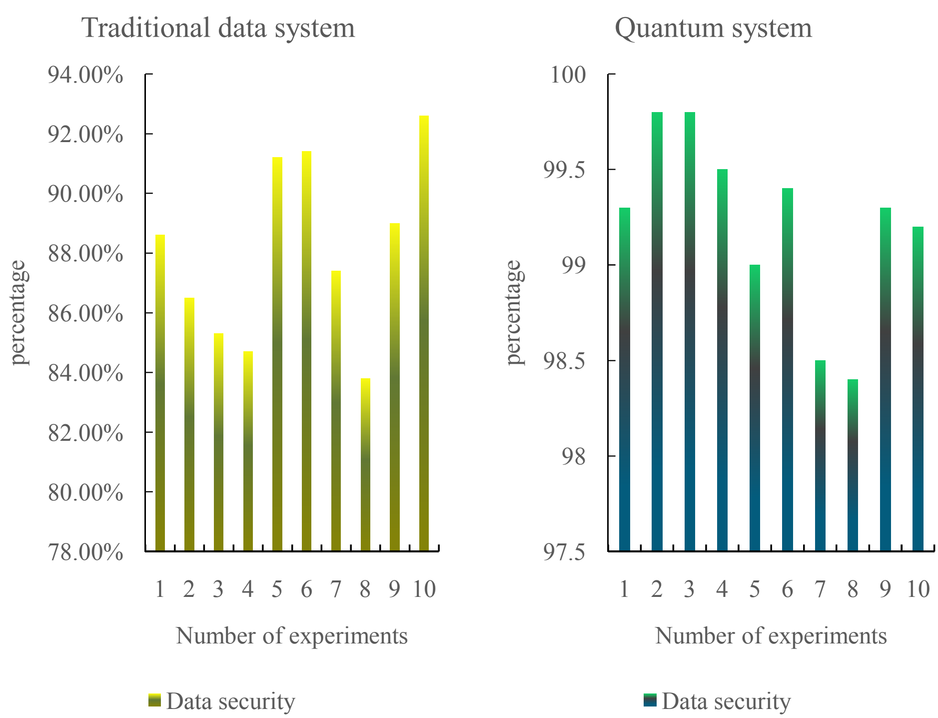


Figure 11 Comparison of data security of quantum systems



According to Figure 11, it can be concluded that the security of traditional data systems is generally below 90%. The security of remote data quantum systems based on ARM and GPRS is much higher, basically reaching 98%, which is more than 8% more secure than traditional data systems. Such a high-security remote data system is more conducive to protecting domestic oil exploration data and maintaining the country's energy security.

5 Conclusion

Through the experiments in this article, the following conclusions can be drawn: the remote data quantum system based on ARM and GPRS has made great progress in security and fidelity. The application in large-scale industries can not only speed up the data transmission speed while ensuring data security, but also keep the transmitted data without errors to the greatest extent. The experiment in this paper shows that the data security of the remote data quantum system based on ARM and GPRS has been improved by more than 8% compared with the previous data system.

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