Acta Technica 62 (2017), No. 4A, 529–536

The application of radio frequency identification technology in drilling communication

Lin DeShu[1], Cheng CaiFeng[2,3]

Abstract. Aiming at the shortage of drilling fluid and electromagnetic wave communication technology in petroleum drilling and production, this paper studies the application of RFID technology. Electromagnetic signal transmission efficiency of kinds of frequency band RFIDs are analyzed in the low resistivity liquid. The reading distance and the reading time of kinds of RFIDs are measured in the low resistivity liquid. The theoretical analysis and the experimental results prove that the reading effect of 125KHz and 134KHz low frequency RFID are best and satisfy with the requirement of the down hole Radio Frequency Receiver. According to the theoretical analysis and the experimental results, the Down hole Radio Frequency Receiver is designed. Coupling efficiency is improved by using long distance antenna matching circuit.

Key words. Radio Frequency, dense tag environments, drilling communication, mutual coupling between antennas.

1. Introduction

In order to control the down hole tools in the process of drilling, completion and fracturing, at present, the most effective way is to use the ball, that is, through the ball to plug the drill string inside the mud, plus pump pressure to push the ball and the executive body. In this way, it is lack of flexibility, can only achieve one-way control, can not achieve reciprocating action, but also can not achieve complex mufti-level control. Take the eye opener as an example, it can only be realized by pitching. It is difficult to achieve the retraction of the eye, and it is difficult to achieve the size of the size of the opening of the eye opener.In order to improve the intelligent level of all kinds of down hole tools, to achieve a variety of complex actions, to meet the requirements of various underground construction, it is urgent to study a more efficient tool and technology of down hole control.

[1]Workshop 1 - College of Computer Science, Yangtze University, Jingzhou Hubei, 434023, China
[2]Workshop 2 - Department of Information, Yangtze University College of engineering and technology, Jingzhou Hubei, 434020, China
[3]Corresponding author:Cheng CaiFeng; e-mail: ccf_cheng@126.com

In recent years, Radio Frequency Identification(RFID) technology has been developed rapidly. It has been widely used in many fields, such as industrial production, commerce and transportation. Some progress has been made in the application of oil field, which is mainly applied to the marking of drill rod, the tracking of special vehicles and instruments[1-6]. The application of RFID in down hole tools is also in the early stage of research and development, and it has achieved good application effect[7-8].

2. RFID principle and standard agreement

The typical RFID system consists of three parts: a programmable electronic tag, a reader, and a remote computer that processes data, as shown in figure 1. Electronic tag is a radio frequency card, with the ability to read and write encrypted communications. The electronic tag comprises an antenna, a matching network, a continuation module, a central controller, a communication algorithm module, a memory. The reader is composed of an antenna, a wireless control module and an interface circuit. The signal is sent to the label by the modulated radio frequency signal, and the label answers the identification information. Coupling is based on the demand and cost of electromagnetic and magnetic induction can be achieved. The inductance reading range is small and the amount of information is small. The principle of electromagnetic coupling back scattering; the reading range can be set according to the demand, the amount of information is large.The difference between electromagnetic coupling and inductance coupling is that the reader can transmit the RF energy in the form of electromagnetic wave. In the inductive coupling mode, the reader tied the RF energy to the induct coil of the reader. The magnetic field of the coil between the reader coil and the radio frequency label coil is communicated through the closed coil magnetic field, schematic as shown in Figure 2.

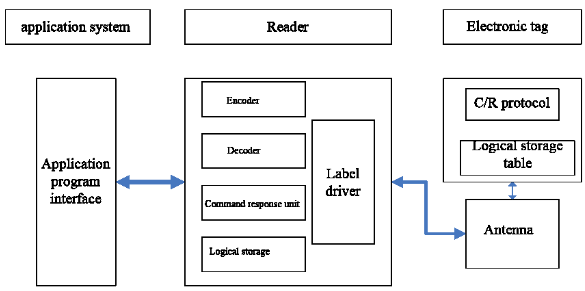

Fig. 1. The working process of RFID System

According to the frequency band of RFID tags, RFID tags can be divided into low frequency, high frequency and ultra high frequency, the typical operating frequency are: 125KHz, 134KHz, 13.56MHz, 433MHz, 915MHz, 2.4GHz, 5.8GHz, etc. According to the RFID label whether the battery is divided into active and passive.Taking into account the RFID tag storage cycle, working temperature, volume and other factors, the active RFID tag is not suitable for high temperature and high pressure

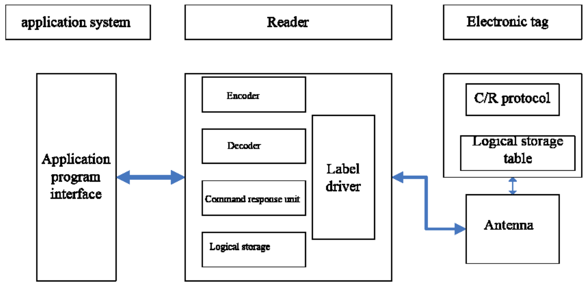

Fig. 2. Electromagnetic coupling and inductance coupling

environment due to the battery. And it's too big.Therefore, this paper focuses on the passive RFID system in each frequency band.

3. Research on RFID technology of underground communication

Existing RFID systems are working in the air environment. RFID tags are in the reader to read and write the antenna to stay within a second or so, the completion of the identification number and the transfer of command code. In view of the special environment of underground, not only the existing RFID card can not be used directly, but also the reading and writing device can not be directly transplanted to the down hole tool. The underground is a liquid environment, and the resistivity of liquid is lower than that of air. In particular, water-based mud, in the low resistivity environment, high frequency electromagnetic wave attenuation is very fast.This is due to the electromagnetic field in the electric field in the water, will arouse a certain intensity of conduction current. It will cause Joule loss, so that most of the electromagnetic energy into heat, resulting in a sharp reduction in electromagnetic energy. At the same time, with the increase of frequency, attenuation will increase rapidly. Take electric field strength as an example , as shown in formula 1.

$$E = E_0 \exp^{(-17.3\sqrt{f\sigma})} \tag{1}$$

In the E0 field emission electric field, f is the frequency of electromagnetic wave, the conductivity is ??.It can be seen in the lower resistivity, that is, the higher conductivity of the body under the condition of exponential decline.The conductivity of fresh water is about 0.06, and the seawater is 4. From this we can calculate the attenuation distance of 120dB as shown in Figure 3 . The attenuation of the 120dB is considerably reduced to one million parts, which is generally believed to have disappeared completely. Unable to receive the extract, that is, does not have the communication function. This is also the reason why the high frequency electromagnetic wave is not suitable for the submarine communication and the data transmission while drilling.Therefore, although the existing UHF radio frequency identification system can achieve an effective reading and writing distance of more than 3m, but once placed in a low resistivity liquid environment, the reading and writing distance into a geometric decline. By theoretical calculation, it can be concluded that the read-write distance is decreased to several millimeters.

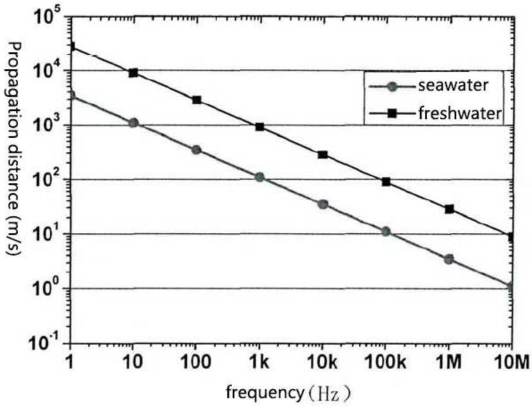

Fig. 3. Propagation distance for 120dB attenuation of different frequencies in seawater

Table 1 and table 2 are the effective reading and writing distances of the different frequency standard RFID, which is obtained by theoretical calculation and experiment, in the salt water with a resistivity of 10/m. The calculation and test conditions are: transmit power 100mW, room temperature. It can be seen from the data in Table 1 and table 2 that with the increase of frequency, the reading and writing distance is decreased obviously. According to the theoretical calculation, the higher the frequency, the faster the reading and writing speed. Due to the serious attenuation of high frequency signal, it is necessary to extend the read and write delay of RFID tags, so as to effectively read and write information.Therefore, in order to meet the environmental requirements of the tool work, select 125KH and 134KHz two low frequency RFID tags as the first choice for the trigger sliding sleeve.

Table 1. Reading distance comparison

RFID standard frequency	Theoretical reading and writing distance	Actual test read and write distance
125KHz	30cm	28cm
134KHz	25cm	24cm
13.56MHz	10cm	8cm
433MHz	2cm	1.5cm
915MHz	1cm	0.7cm
2.45GHz	0.2cm	0.1cm
5.8GHz	0.1cm	0.1cm

Table 2. Reading time comparison

RFID standard frequency	Theoretical reading and writing time	Actual test read and write time
125KHz	<1ms	<1ms
134KHz	<1ms	<1ms
13.56MHz	<0.1ms	<0.2ms
433MHz	<0.02ms	<0.1ms
915MHz	<0.01ms	<0.05ms
2.45GHz	<0.005ms	<0.01ms
5.8GHz	<0.005ms	<0.01ms

4. anti-collision algorithm and analysis

For a large number of dense label, to ensure high reading rate conditions under the RFID system, the tag to the reader the inventory time with the label increase non-linearly. The main reason for this phenomenon is that the tag signal intensity varies in the course of the collision, as well as some tags are read repeatedly. In this paper, we propose an anti-collision algorithm which can keep the stability of reading efficiency in the presence of a large number of dense tags.The algorithm is based on the minimum read power packet anti-collision algorithm.

When a large number of tags are densely stacked, to ensure that the system's label read rate, there will be a considerable part of the label is read repeatedly. The tags are read repeatedly, that is, the most easily read that part of the label, often a strong signal tags. It will repeat the use of time slots, resulting in a weak signal label can not be recognized in the specified reading time. Moreover, with the increase in the number of redundant tags, it will further affect the efficiency of RFID system.

The minimum reading power grouping anti-collision algorithm based on the idea is: in the scenario of dense label, label due to mutual coupling, minimum read power will vary according to the minimum, the label read power is divided into several groups, each group has independent disk label. Because the signal intensity of each label is similar, it is not easy to appear when the signal is submerged by the large signal in response to the reader. At the same time, due to the number of tags in each group is less than the total number of tags, the label will not be stressed due to the excessive number of tags. So, inventory time increases linearly with the number of tags, the efficiency of the system will not be because of tag number variation. This algorithm is based entirely on the ISO/IEC 18000-6C protocol without any additional hardware overhead.

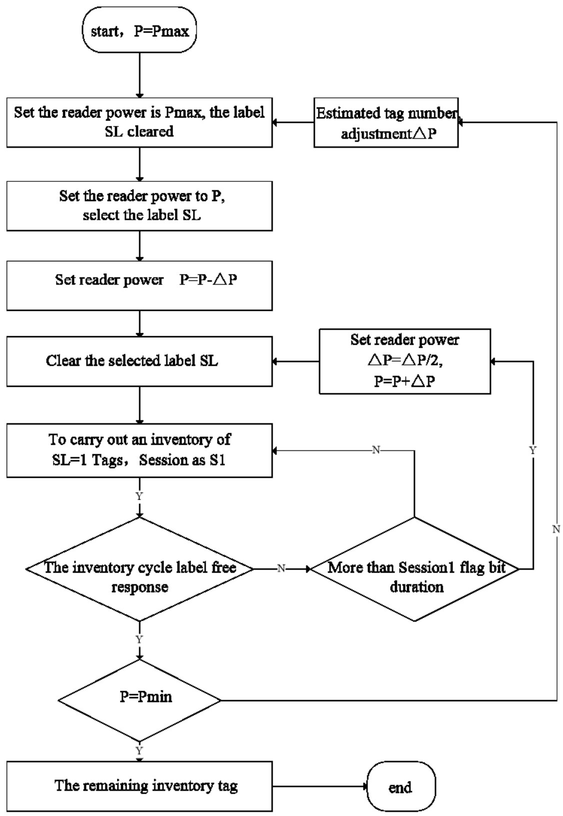

Fig. 4. Flow chart of anti-collision algorithm based on minimum read power grouping

The algorithm flow is shown in Figure 4, each reader selected inventory tag in a power range of the minimum reading. To read the minimum power range inventory [P-P,P] label, first of all to the maximum power through the Action parameter Select directive will all label SL flag is cleared. Then the reader to the output power of the size of the P will position mark label SL to power P-??P label SL flag is cleared. The minimum reading power in [P-??P,P] tag SL is 1, while the other 0 label. The Sel parameter of Query instruction in inventory on the label only make SL a response for the 1 labels. In the inventory process, in order to ensure the minimum reading power within the scope of the labels are identified, in a period of no longer have inventory tag response, only to a range of power under the label inventory. If more than S1 flag duration, indicating that the label number decreased P. In the power range of smaller re inventory tag. Because there is a certain correlation between adjacent minimum read power range label, ??P can be roughly predicted according to the number of previous labels. For example, the initial value of Q is 4, you can adjust the number of tags for each group of about 16, the label can make the most efficient. Each packet label number should not be too much, otherwise the packet in the inventory time may exceed the S1 flag duration, resulting in a label a serious impact on the efficiency of the system.

5. Conclusion

When the tag is densely stacked, the electromagnetic coupling between the tag antennas will lead to the decline of the parameters of the label. This leads to a reduction in the power of the tag and reader in the RFID system link, which affects the efficiency of the RFID tag read rate and tag identification. In this paper, we mainly study the characteristics of the RFID tag system based on the electromagnetic coupling of tag antenna. The label mutual coupling model is established. On the basis of the theoretical analysis of the mutual coupling effect on the tag performance, the different shape tags are calculated. The influence of the mutual impedance and the mutual coupling on the antenna parameters are obtained, and the differences of different tag antennas are found. Based on the simulation results of the tag antenna parameters, and the actual test of the minimum read power, and the influence of the mutual coupling on the minimum read power of the tag, the paper provides the basis for analyzing the limited link when the label is coupled.

References

[1] C. Morris: *The challenges and benefits of implementing RFID and mobile computing in upstream environments.* SPE (2008).

[2] O. Vincke, D. Averbuch: *Anew drillstring fatigue supervision system.* SPE (2007).

[3] R. H. Gutierrez, P. A. A. Laura: *Using radio frequency identification electronic chips to effectively control the elements of the drillstring.* SPE (1998).

[4] R. P. Singh, S. K. Jain: *Adding the human factor to rig anti-collusion system:a new technology explored.* SPE (2003).

[5] M. N. Gaikwad: *Research and Application of Whole Dynamic Monitoring Early Warning Management System of Oil Drilling Tools.* Internet of Things Technologies*4* (2011), No. 12, 56–58.

[6] S. Chakraverty, R. Jindal, V. K. Agarwal: *Radio frequency identification of remotely operated horizontal frac.* SPE (2011).

[7] N. L. Khobragade, K. C. Deshmukh: *RFID actuation of self-powered downhole tools.* Sadhana (2008).

[8] Y. F. Zhou, Z. M. Wang: *Vibrations of axially moving viscoelastic plate with parabolically varying thickness.* J Sound and Vibration *316* (2008), Nos. 1–5, 198–210.

Received November 16, 2016