A Simulation Study of Power Line Carrier Technology for Oil Field Data Transmission

WEI GuoHui [1], GE Liang [2, 4*], HU Ze [3*], WU Beng [2, 1], Wang ZhengYin [2]

1 School of Sciences
Southwest Petroleum University
Chengdu 610500, China
2 School of Mechatronic Engineering
Southwest Petroleum University
Chengdu 610500, China
3 School of Electrical Engineering and Information
Southwest Petroleum University
Chengdu 610500, China
4 Oil Gas Fire Protection Key Laboratory of Sichuan Province
Chengdu 610500, China

***Abstract* — Due to the characteristics of the oil industry, oil is always distributed in remote areas, with much land and few people, which has brought some problems to the oil-field's data transmission. A data transmission scheme based on power line carrier communication technology is proposed in this paper, to realise data transmission from well RTU to central station. Through simulation and debugging in the power line carrier communication module we verify the design performance indicators in terms of the quality of communication. It is shown to meet the requirements of data transmission in oil fields, is applicable to data transmission between the wells and the central station, and the central station can receive data from wells in time. Through simulation debugging module of the power line carrier, we verify the performance of the design in communication quality that can satisfy the requirement of data transmission between wells and extend it to the central station it enable it to get oil well data in a timely manner.**

Keywords - Power line carrier communication; Digital oil fields; Oil field data transmission

I. INTRODUCTION

Petroleum and natural gas are regarded as a clean energy, because of the importance of their limited resource and strategy, has become an indispensable strategic material and special commodity. In order to cope with these challenges, the different countries urgently need the support of digital technology to oil and gas exploration and development while they are developing oil and gas exploration and technology. Thus, among the major oil companies set off a wave of construction of digital oil field all over the world. Digital oil field provides a scientific and effective method and means to meet the oilfield enterprise data application. In order to meet the requirement of oil field enterprise application data provides a scientific and effective ways and means, it is the use of integration and visualization technology to realize data of fast acquisition, information fast transmission and accurate expression and visual display, provided a new way for the application of oil and gas data. And the important component of digital oilfield is the timely and accurate transmission of all kinds of data in the oil field. And the power line carrier due to its use of existing power line without additional network, investment is small, the power line itself more reliable, not The need to provide services with better data security and other features is in line with the needs of the oil field.

Chinese in power line carrier technology compared to the United States and the European Union in some developed countries started relatively late, Chinese Electric Power Research Institute started the research of power line carrier communication technology since 1997. The application of low voltage power line carrier communication technology of China before the late 1990s is limited in the AM or FM carrier telephone to achieve close voice calls, including using a dedicated power line carrier chip to realize the short distance data transmission. It was not until 2000 that the power line carrier technology was developed for the first time in China. At present, the power line network is oil field is the most mature, coverage area is the largest, the most widely used of the existing network, if it can be slightly modified to transmit data by using the existing power line network, is undoubtedly an effect is better, the higher the price Therefore, it is very important to study the oil field data transmission based on power line carrier technology

Until 2000, China launched the first large-scale application of power line carrier technology in the user distribution network. At present, the power line network is the most mature oil field, the largest area of coverage, the most widely used existing network Collaterals, if slightly

modified to transmit data by using the existing power line network, it is undoubtedly a better, higher price scheme. Therefore, conducts research on the oil field data transmission based on power line carrier technology has very important function and meaning

II. BASED ON THE POWER LINE CARRIER OIL FIELD DATA TRANSMISSION SYSTEM FRAMEWORK DESIGN

A case study of an oil production plant in Karamay oilfield of Xinjiang, In Karamay oilfield oil production plant as an example, at present, the factory(similar to the other oil production plant in Xinjiang oil field) has built many central station in the oil field operation area. Each central station has jurisdiction over a certain area of oil wells and collecting wells data and transmits them to the rear of the center is one of its major role. Central station has wired broadband network access so data is collected from each oil well through a variety of ways (such as the manual meter reading, wireless bridge etc) and back to the rear center via the network. As shown in figure 1.

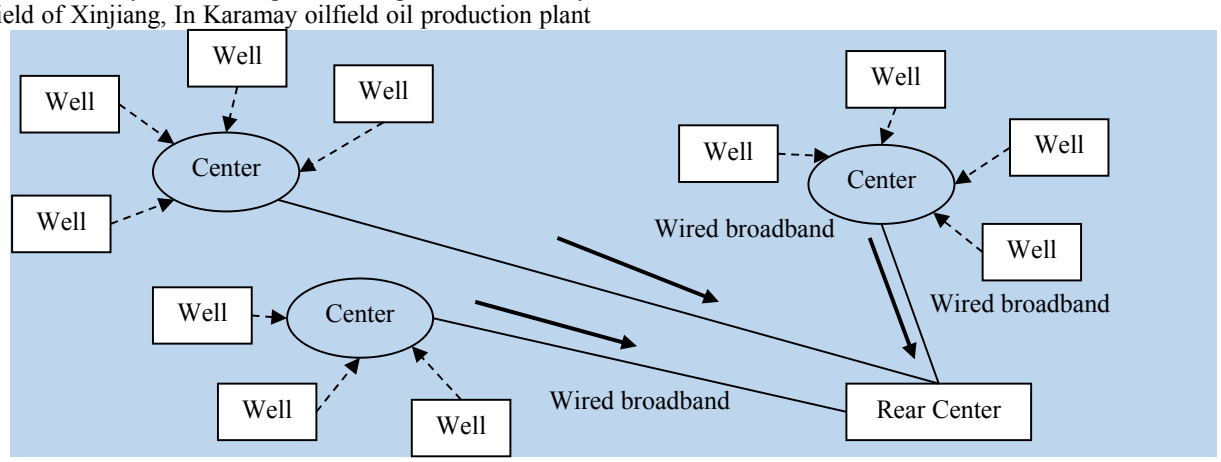

Figure 1. Oil well data transmission in an oil production plant

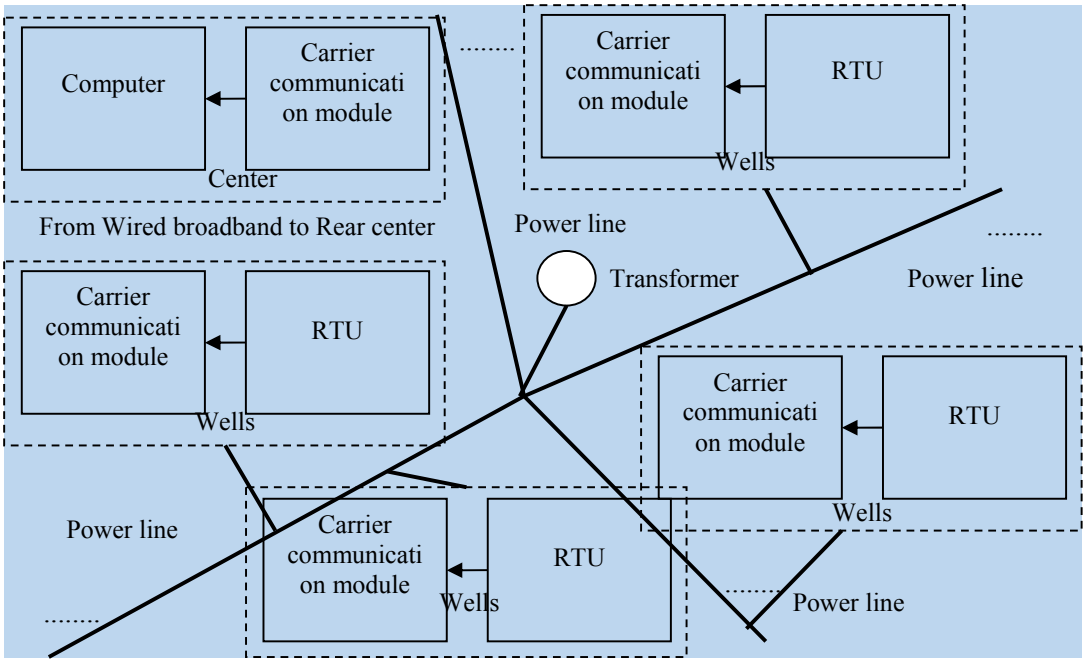

Figure 2. Transmission sketch map

As shown in figure 2, in order to realize the data transmission from the wells to the central station, in each well, it should has the installation of a power line carrier communication module and data transmission module, the wells RTU through the serial port connected to the central station; the central station and the computer through the

serial port connected, with the installation of a data transmission module. Using polling mode, central station sends commands to each well and the module of the corresponding oil well transmits the data after receiving the command. Oil well data of each well Communicate with single chip microcomputer system by its own RTU through the communication interface protocol of the corresponding (Usually RS-485 or RS-232). Then, according to SPI bus protocol, SCM system sends these data to power line carrier modem chip. The signal is coupled to the power line through the coupling circuit after the modulation and amplification of the modem chip. Module located in central station receives signal and sends it to SCM system by SPI bus protocol after modem chip demodulating signal.SCM uploads signal to the computer of central station through the corresponding communication interface and finishes the oil well data transmission from the RTU to the central station. For oil wells near the center of the station, data can be transmitted directly to the central station via the process. But, for the central station near to the well, the data can be directly through this process transmitted to the central station; and for the far away from the center well can be in between wells module used as a relay, to receive data from the remote oil wells and the resending data, from the center of the receiving station, the relay method reduce single transmission distance.

III. HARDWARE DESIGN OF OIL FIELD DATA TRANSMISSIONMODULE

A. Hardware block diagram of oil field data transmission module

The overall block diagram is shown in figure 3.The carrier board comprises a transmitting / receiving circuit, a carrier chip working circuit, a coupling circuit and a zero crossing detection circuit.

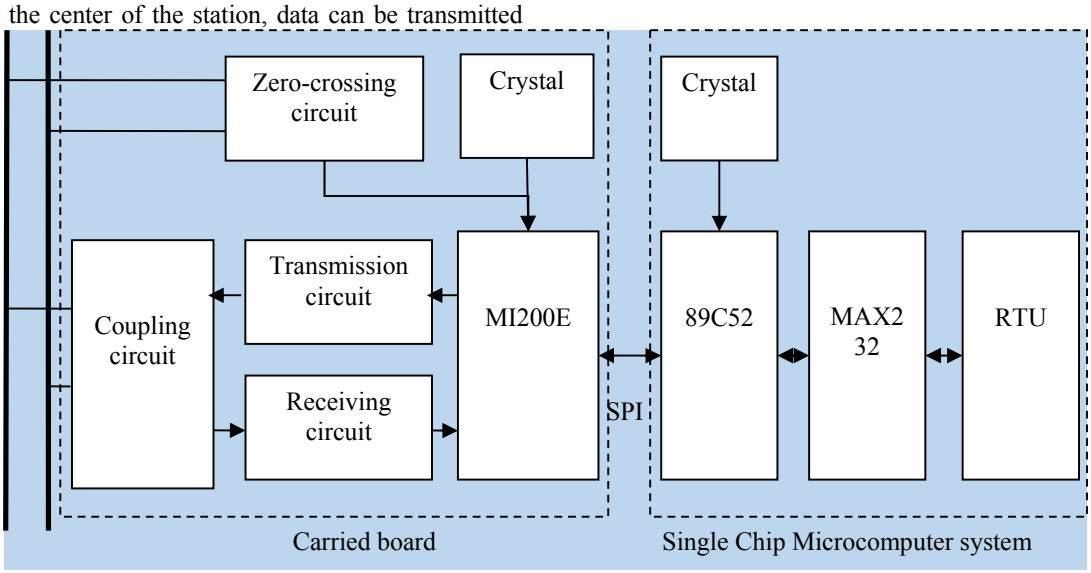

Figure 3. Hardware circuit diagram

MCU sends the data to the MI200E, and via the carrier chip, the data transmits through the power line; the receiving end carrier chip receives the carrier signal and sends it to the MCU to send it to the computer through the serial port. The core of the power line carrier communication control module circuit as shown in figure 4.

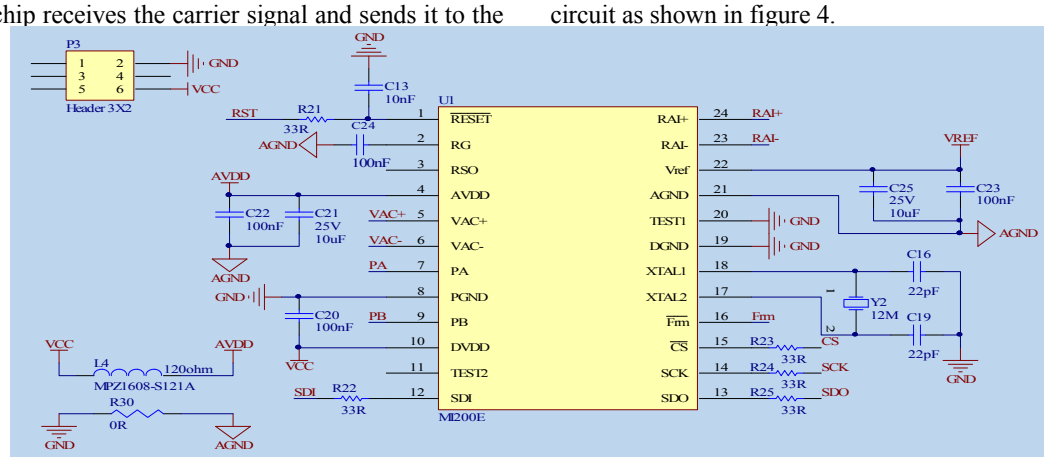

Figure 4. Chip circuit

B. Power line coupling circuit

Coupled circuit is the carrier signal input and output path, you need to be able to isolate the power line voltage protection circuit on the power frequency security, so that communication is normal. The coupling circuit is shown in figure 5.

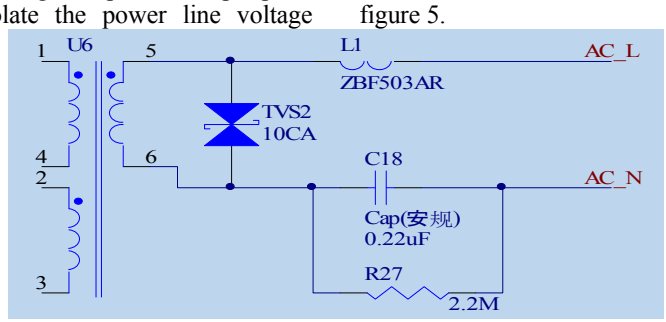

Figure 5. coupling circuit

C. Send / Receive circuit

Because of MI200E internal integration of the signal amplification circuit so it requires less transmission circuit device, just a simple LC band pass filter can do. Also in order to protect the element, a bidirectional transient voltage suppressor is connected to the diode, as shown in figure 6.

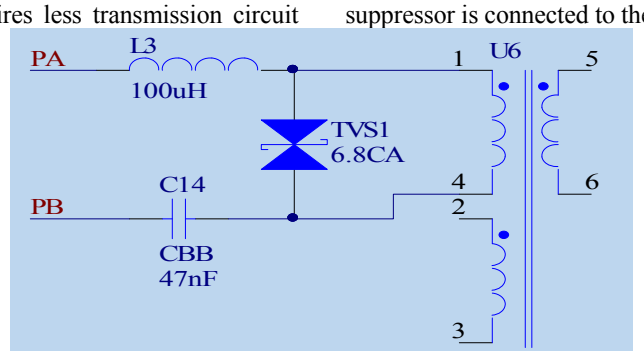

Figure 6. transmission filter circuit

The MI200E signal is received in a differential manner, the differential reception of the reference voltage provided by the 22 pin Vref, the level of the AVDD half. The receiving circuit uses a combination of a LC band pass filter, as shown in figure 7.

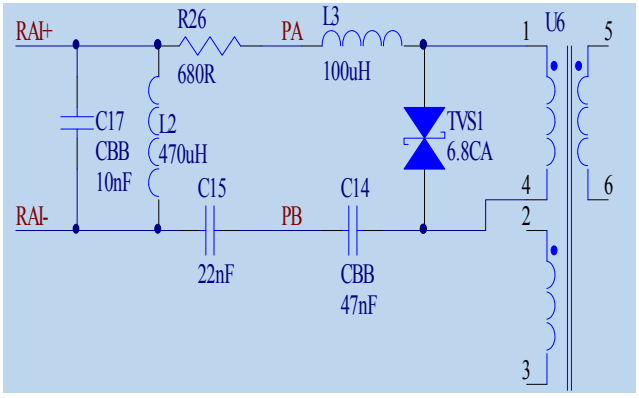

Figure 7. Receiving filter circuit

D. Zero crossing protection circuit

MI200E 5, 6 feet used as zero input. For safety reasons, use photo coupler, as shown in Figure 8

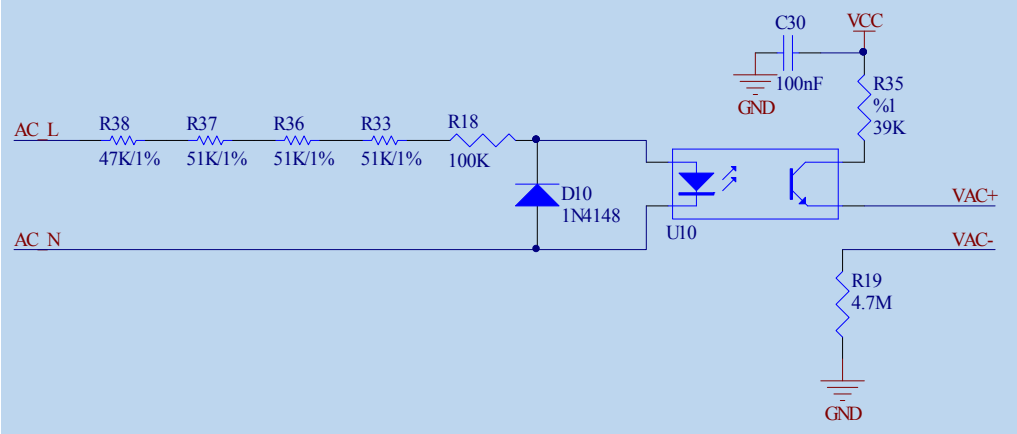

Figure 8. Zero crossing circuit

IV. SOFTWARE DESIGN OF OIL FIELD DATA TRANSMISSION MODULE

MI200E using interrupt mode to send and receive data. Through the serial port, module exchange data to external. Thus, Module to read data and save while Interrupt appearing. Over zero synchronous transmission technology is adopted in MI200E, When the city power over the zero time to send data, there will be produced two zero crossing in the 50Hz city of a cycle. So MI200E is sent every 1/(50*2) seconds which is10msin the transmission of data. For receiving, we need to use internal register that checks the internal registers of the MI200E every 2ms whether the carrier signal is received. If carrier signal has been received, MI200E should compare to the local address. If it is different from the machine address, the carrier signal isn`t native command and we can ignore it. If not, MI200E enters the sending program. The design flow chart of the main program is shown in Figure 4-12. The design flow chart of the main program is shown in Figure 9.

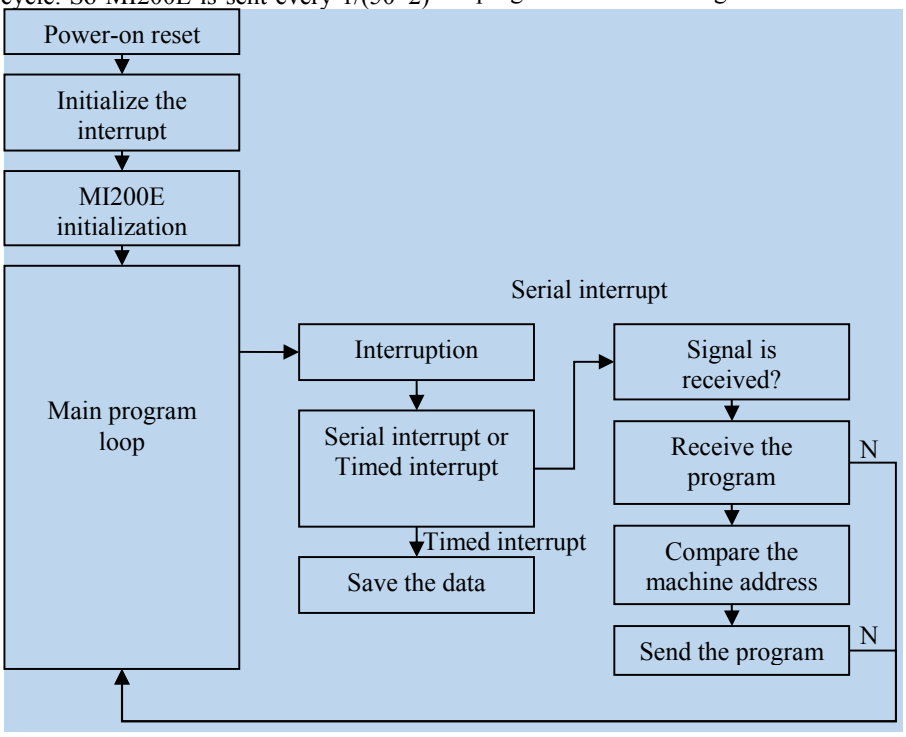

Figure 9. The main program block diagram

V. BASED ON THE POWER LINE CARRIER OIL FIELD DATA TRANSMISSION SYSTEM SIMULATION TEST

In order to verify the accuracy of the design, we conducted simulation tests which were in the same building. Its environment is as follows:

Power line access load electric appliances: fluorescent lamp, computer, projector, printer, water dispenser, etc.

Load interference: the line has a large number of electrical appliances and The situation will happen that is the electrical appliances accessing / cutting out of the situation any time. A variety of electrical appliances in use will cause a certain degree of interference. But, the main effect of the power line carrier is the non synchronous pulse noise generated when the access / cut out of the electrical equipment is used. So the channel environment of power line carrier is more changeable and worse.

A. Close range test

Firstly, we took close test on different socket in the same room and estimated transmission distance within 10 meters. Test results are shown in table 1.

TABLE I CLOSE RANGE TEST IN THE SAME ROOM

Transmission speed	Send times	The number of received	The number of lost	Success ratio
1600bps	1000	1000	0	100%
800bps	1000	1000	0	100%
400bps	1000	1000	0	100%
200bps	1000	1000	0	100%

All the data have been received, we can see that the communication quality is good in the near distance.

B. Long distance test

Increasing the test distance, we selected the same layer of different rooms for communication test and the estimated distance is about 50 meters. The test results are shown in Table 2.

TABLE Ⅱ TEST OF DIFFERENT ROOMS ON THE SAME FLOOR

Transmission speed	Send times	The number of received	The number of lost	Success ratio
1600bps	1000	999	1	99.9%
800bps	1000	1000	0	100%
400bps	1000	1000	0	100%
200bps	1000	1000	0	100%

Communication quality is still good in the case of 50 meters. All the data in the 200, 400, and 800bps are received, but the transmission rate at 1600bps is missing. The low voltage distribution network of the teaching building is made of three-phase four wire system. Then we take out one of the phase as the firing line, and the zero line to form a single phase power supply line with the zero line to the general use of electrical appliances. In order to balance the load between the lines, we will use the power of each phase. Thus, the lines on different floors may be different.

During the test, it is found that the first and two layers, the two layer and the three layer, and the three layer and the four layer are unable to communicate with each layer. This situation is due to the line between the adjacent layers of the room is different. But, communication between the four layer and one layer can be realized, so the communication test of the distance between the two layers is selected.

When the test length increases to about 150 meters, the test results are shown in Table 3.

TABLE Ⅲ. TEST BETWEEN DIFFERENT FLOORS

Transmission speed	Send times	The number of received	The number of lost	Success ratio
1600bps	1000	967	33	96.7%
800bps	1000	968	32	96.8%
400bps	1000	968	32	96.8%
200bps	1000	976	24	97.6%

VI. CONCLUSION

Based on the specific situation of power line and network in the field of oil field, the oil field data transmission scheme based on power line carrier communication technology is proposed, which can realize the transmission of data from oil well RTU to central station. As the oil field has good operating conditions of the power line network can be used directly, so there is no need to transform the physical lines of input, we can greatly save costs.

This design meets the requirements of the oil well data transmission, but there are still some deficiencies, but also need to be further modified and improved in the future. The performance of power line communication is deeply influenced by the specific environment of power line network, weather, load level, power line length, and so on would have a great influence on the quality of communication, including data transmission circuit PCB design will also have certain influence on the quality of communication, so in these areas can also further research in order to improve the level of performance

ACKNOWLEDGMENT

This work is supported by scientific research starting project of SWPU (No.2014QHZ029), national natural science foundation of China (No.51504211) , the State administration of national security (No.sichuan-0011-2016AQ), Oil Gas Fire Protection Key Laboratory of Sichuan Province (No.YQXF201602),the Sichuan educational committee (No.15ZB0060, 16ZB0082),and the University student innovation industry project (No.201610615013).

REFERENCES

[1] Shi Chongdong and Zhang Shaohuai, The design and implementation of intelligent drill string , Petroleum Drilling Techniques, 32(6) (2005) 7-10.

[2] Zhang Shaohuai. Theory and technology of intelligent drilling and its development, Natural gas industry. 28(11) (2008) 3-7.

[3] GE Liang, HU Ze, CHENG Ping. Design of down-hole engineering parameters measurement while drilling system,Transducer and Micro-system Technologies, 08(2013)105-107.

[4] ZhengXue, Le Jian, Cai Wei, Jin Chao, Huang Chuhong. Overview of the component impedance modeling research of power line communication, Power System Protection and Control. 40(6) (2012) 135-141.

[5] Zhang Shaohuai, He Huacan, Li Qi, GuoJianming. Study on intellectualization of petroleum drilling information technology, ACTA PETROLEI SINICA,17(4)(1996)114-119.

[6] Liang Ge, Hu Ze, Yang Qing, Li Junlan and Lai Xin. Research on Distributed Optical Fiber in Oil Well Temperature Field Measurement System, Information Technology Journal, 12(18)(2013)4651-4654.

[7] XieDonglei, Liu Zongxing, Chen Xiansheng, Test on model parameters of average transformation, Journal of Chongqing University (Natural Science Edition). 29(5) (2006) 24-28.

[8] Zhou Xiaoquan, Wang Zhiyong, Analysis on main detection parameters of precise conductive slip ring, Papers Album of Academic Exchanges about Measurement and Quality. 27 (Supplement) (2007) 72-73.

[9] Cataliotti A, Daidone A, Tinè G. Power line communication in medium voltagesystems, characterization of MV cables, Power Delivery,IEEE Transactions on. 23(4) (2008) 1896-1902.

[10] Liang Ge, Ze Hu, Chen Ping et al. Research on Overflow Monitoring Mechanism Based on DownholeMicroflow Detection, Mathematical Problems in Engineering, (2014)1-6.

[11] Xiaoxian Y, Tao Z, BaohuiZ,etal. Research of impedance characteristics for medium-voltage power networks, Power Delivery, IEEE Transactions on. 22(2) (2007) 870-878.

[12] Chen J, He L. Transmission line modeling and synthesis for multi-channel communication, Behavioral Modeling and Simulation Workshop, 2005. BMAS 2005.Proceedings of the 2005 IEEE International. IEEE.(2005) 94-99.

[13] Yu R, Yuan P B. Development of intelligent drilling and intelligent drill tools, Nano/Micro Engineered and Molecular Systems (NEMS), 2011 IEEE International Conference on. IEEE. (2011) 760-763.

[14] G. E. Liang, S. U. Fu, H. U. Ze, L. I. Qiang, and C. Rong. Research on power line carrier technology for the intelligent drill pipe, Advances in Information Sciences and Service Sciences, 5(6)(2013)892–900.

[15] J. Lee, J. Kim, S. Yu, J. Kim. Picosecond time-domain characterization of CPW bends using a photoconductive near-field mapping probe, IEEE Microwave and Wireless Components Letters. 11(11) (2001) 453-455.

[16] Cui Yijie, XuJinfeng. Communication channel modeling and Simulation, Shanxi electronic technology. (3) (2012) 41-44.

[17] RongJiguang, XiongJiyou, Yu Ronghua. The finite element analysis of the structure of the intelligent drill rod conductive ring, Journal of Southwest Petroleum University: Natural Science Edition. 35(1) (2013) 168-172.

[18] L. GE, Z. Y. WANG, K. DENG, Q. ZENG, X. WANG, X. S. CHEN, J.B. J. B. LIAO.Research on the oil life estimation and detection method,J Balkan Tribological Association, 21(4) (2015) 897-911.

[19] L. GE, Q. ZENG, Z.Y. WANG, X. H. XIE, J. B. LIAO, J. L. LI.Research on moisture content measuring device of edible oil based on capacitance detection mechanism, OxidCommun, 39(1) (2016) 240-248.

[20] L. GE, P. HU, X. H. XIE, Z. HU, Q. ZENG, J. B. LIAO.Study on high precision swill-cooked dirty oil detection system based on date fusion technology,OxidCommun, 39(1) (2016)317-330