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A Robust Oilwell Sensor System Using RFID Antenna

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Abstract— Most oil pumping units have been using manual control in the oilfield. To achieve reliable data collection and transmission between downhole and ground RFID based sensor system is presented. The fatal effects of extreme downhole environment are studied. Radio frequency identification device (RFID) technology is an automatic identification which is used to communicate with radio wave. RFID has certain advantages such as rapid identification, large data storage capacity, updating data and so on. Recently RFID has a great role in oil well for improving the operating efficiency effectively and to reduce the cost of well drilling.

Index Terms— Data collection, data transmission, RFID, Microprocessor, Analog to digital conversion, Sensor network

INTRODUCTION

To optimize the production process in oilwell management system it collects the data of downhole and ground drilling platform using sensors, and transmit it to the ground control center. An intelligent oilwell control system can reduce the production risk and cost [4]. Based on various technologies such as acoustic wave, electromagnetic radiation, fiber optic cable and with a sensor system data transmission become more easier. Optic fiber usage may cause damage and increases the repair cost. One of the core element of this system is Radio Frequency Identification Device (RFID) [10]. Many types of RFIDs are existing. It can be divided into two classes as active RFID and passive RFID. Active tag uses a power source as a battery pack [18]. The life time depends upon the stored energy and its usage [6]. Passive RFID tags don't require batteries or maintenance. An antenna, a semi- conductor chip attached to the antenna, and some form of encapsulation are three main parts of a passive tag. As a non-contact automatic identification technology, RFID (Radio Frequency Identification) system can achieve data exchange between the reader and the electronic tag using radio frequency signals [20]. RFID has been widely used for many applications in the past two decades, such as surface crack detecting, small animals tracking, mobile robot navigating and intelligent traffic scheduling [13]. RFID technique is beginning to be recognized to transmit the data between the downhole tools and ground system in the oil production field [2]. Now a days wireless Sensor Network Monitoring Platform for Oil and Gas Pipelines is popularly implementing. Health monitoring and leakage detection is also necessary for an efficient oilwell system [7]. Many intelligent oilwell systems can be used in any environmental conditions such as marine and desert areas. Oilwell monitoring system can also be implemented with the help of microprocessor, microcontroller, etc…as the core element. In this proposed system, RFID is also a core element, it can be divided into low frequency (125KHz), high frequency (13.56 MHz), ultra high frequency (860-960 MHz), and microwave (2.45 GHz or 5.8 GHz) [1]. In many oilwell systems antenna tuning unit is used for monitoring of data and its transmission. Actually antenna should be of high gain and there is no loss in signal reception [5]. Antenna tuning unit should provide wideband signal reception capability. Multi range frequency detection is also possible with antenna tuning unit. A combination of antenna tuning unit with RFID technology is also efficient one. Another application is the use of RFID tag Antenna based sensing for pervasive surface crack detection. It is the concept of using an RFID tag's antenna to sense surface cracks [8]. RFID is often presented as replacement for barcode, but the technology has much greater potential such as individual serial numbers for each item and possibility to read these numbers at some distance. RFID is a technology being adopted in various fields such as security field, medical field, business field [17].

The proposed system uses contactless smart card to limit the entries of unwanted persons. Automatic monitoring of downhole system in an oilwell platform reduces the risk occurring and the human presence. Recently, harsh Environment Silicon Carbide Sensors for health and performance monitoring of aerospace systems is also used [11]. Health monitoring technologies for the development of a distributed sensor network can be utilized to improve engine efficiencies and reduce emissions while maintaining safety. Usage of wi-fi, wireless technologies, GPS, etc…is also helpful for the transmission purposes [19]. In this a customized RFID based sensor system for an efficient oilwell is proposed to achieve data collection and transmission between downhole and ground. With the help of this, fatal effects of extreme downhole environments can be studied.

II. LITERATURE SURVEY

A. Control of oil pumping units

Donglin Wang et.al. [2] says about a sensor network based intelligent control. Most oil pumping units (OPUs) have been using manual control in the oilfield. Structural health monitoring is difficult in existing systems due to its high power consumption. In this, a sensor network based intelligent control is proposed for the reduction of power consumption and for efficient oilwell health monitoring. The proposed sensor network consists of three-level sensors: several types of basic sensors, such as load sensor, angular

sensor, voltage sensor, current sensor and oil pressure sensor.

B. Wireless sensor network for oil and gas pipelines

Salman Ali, Adnan Ashraf et.al. [10] proposed a wireless sensor network monitoring platform for oil and gas pipelines. Issues such as recovering from holes where a node cannot reach another node in either side or policies to establish a route for data dissemination need to be intelligently solved for linear sensor networks. To solve such issues, it propose a linear sensor network deployment application for oil and gas pipeline using a custom sensor board accompanied with algorithms to solve the problems such as, leak interrupt detection, and routing of high-priority messages with reliability while keeping network alive at all times.

C. Design a system for aircraft structural health monitoring

Thomas Becker et.al. [41] explains about an autonomous nodes for aircraft structural health monitoring. Nowadays the design of aircraft structures using various materials helps structural health monitoring in future. Wireless sensor network usage will reduce the damage and stress of various parts of the system. Autonomous sensor nodes (ASNs) are key elements for a WSN, it is to allow a self-sufficient and maintenance free operation, without any complex wiring for power supply or communication purposes.

D. Downhole to surface communication in an oilwell system

F. N. Trofimenkoff [50] proposed a downhole-to-surface communication channel consisting of a long vertical cylinder and an isolated downhole in-line cylinder embedded in a homogeneous earth is considered in this work. In between electrode and stem a signal voltage is applied and the received voltage is picked up at the surface between the stem and a ground point or between two ground points.

E. Design of a smart RFID antenna system for indoor tracking

Luca Catarinucci et.al. [10] proposed a smart RFID Antenna System for behavior analysis of small animals and indoor tracking purposes. Radio Frequency Identification (RFID) technology is more and more adopted in a wide range of applicative scenarios. In many applications, commercial and general-purpose solutions can be unsuitable. Some examples for that is as the tracking of small-size living animals for the behavior analysis.

III. PROPOSED METHOD

The whole system contains a downhole and a ground system. Ground system contains RFID reader and it is used to program the tag with specific commands from control center. Downhole system uses sensor system which monitor the condition of underground system,receiving the tag commands and transferring the sensor data. When a coded tag is released into the well from the ground, the flow of liquid would drive it down until it passes through the reader antenna, which powers up the tag by the RF field. Then the coded data in the tag and the sensor data in the reader are exchanged. After that, the tag returns back to the ground through a circulation loop opened by a circulating valve. Finally, the ground reader picks up the sensor data and transfers them to the control center. If a series of tags are released into the oilwell, the control center can obtain large amounts of sensor data and optimize the production process for the oilwell. RFID tag is too small and is flexible. For an oilwell, two or more RFID-based sensor systems can be installed at different depths. A basic model of proposed system is shown in figure 1. This figure 1 shows an architecture which is used in big oil refineries and oil mining areas. Implementation of this is costly and also difficult one.

The whole system is divided into downhole and ground system. Downhole RFID based sensor system consist of three functions. They are RFID system (RFID reader, RFID antenna and RFID tag), sensor system and battery pack. The sensor system has a motor which is actuated by the command data and collects the condition of downhole environment. A battery pack is used to supply energy needed for the whole system.

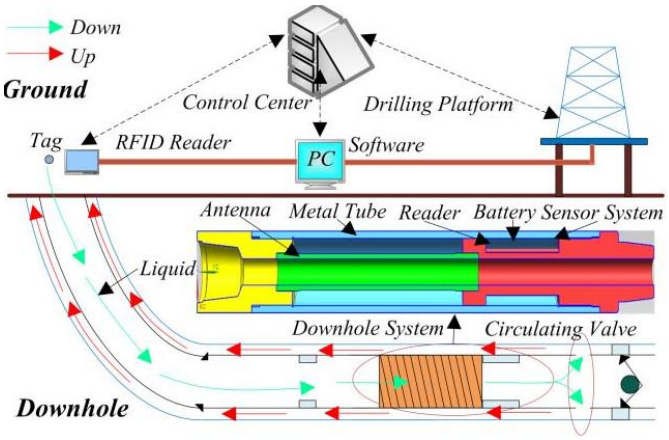

Fig. 1 Architecture of RFID based sensor system

IV. WORKING MECHANISM

The downhole RFID based sensor system block diagram is shown in Fig 2. The commercial RFID reader and tag cannot bear the high temperature in the downhole. In the designed system, the RFID tag works less than 2 hours for a circulation loop, whereas the reader should be capable of long time working. So the commercial RFID tags encapsulated with the insulating material are adopted. Through investigation, the tag featuring a long read range from the HITAG which is a well-established brand in the low frequency RFID market is employed. But for the reader, a customized design has to be implemented.

The reader circuit also has two parts: the hardware of RF interface and the software of logic control. The transmitter and receiver of the RF interface realize the signal modulation and demodulation. The MCU (Micro Control Unit) of the logic control realizes the sequential control, signal encoding and decoding. To bear the high temperature, the military grade circuit chips are used. Reliable thermal analysis and design are adopted to improve the reliability of the circuit.

The sensor system mainly consists of two parts: motor driving and data acquisition. By a two-stage amplification of 500 times, the voltage of 0-5 V is sent to the control chip for AD sampling, then the sensor data can be obtained.

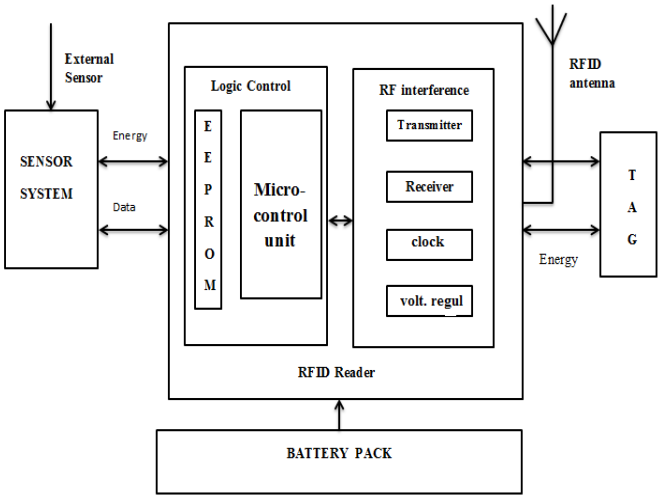

Fig. 2 Block diagram of downhole system

ARM LPC2148 is used as the core element. Sensors such as temperature sensor, humidity sensor, pressure sensor and gas sensor also included for monitoring of underground condition of oilwell. LM35 is the temperature sensor, MPL115A1 is the barometric pressure sensor, DHT11 is the humidity sensor used. A dc motor with 100rpm is also used to drive the sensor system. Two voltage regulators such as LM7805, L117 is also used as 5v and 3.3V regulators. ARM processor have several features. The core features of an ARM processor is it has a 32 bit internal bus, registers, etc…, 32kb data memory and 512kb program memory. Maximum 60MHz clock speed is used. The peripheral features of ARM processor is 32 bit timers, 10 bit analog to digital convertor, Universal synchronous asynchronous receiver transmitter. ARM uses a 3.3V for its working and a 5V is used by all sensors.

A. RFID System Design

Commercial RFID tag cannot bear high temperature in the downhole, and reader should be worked long time. To compensate with high temperature, RFID tags are encapsulated with ceramic material. The reader consists two parts: reader circuit and antenna. To bear high temperature, military grade circuit chip can also be used. Reader antenna is nothing but a solenoid coil which is wrapped around a Teflon frame work. To collect the monitored data from sensor system, we have to know the different positions of tag inside the downhole and the efficiency of RFID tag. This is shown by the figure 3.

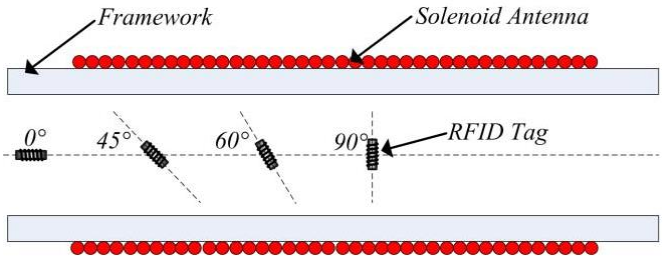

Fig 3 Reader Antenna with different tag positions

The RFID tag is powered by the induced voltage generated in its coil, which is a function of the angle of tag position to the magnetic field of the reader antenna. The induced voltage is maximized when the tag coil is placed in parallel with the magnetic field, and decreases gradually until zero when the angle changes from 0° to 90°. A long rod shape of RFID tag with a ceramic package is used to reduce communication failure.

B. Sensor System Design

It have two parts. They are motor driving and data acquisition. An instrumentation amplifier is used to eliminate weak sensor signals in a sensor system. Sensor system provides an analog output and it is sampled by Analog to digital convertor. Inter integrated circuit is used for serial communication between sensor system and RFID system.

V. SIMULATION RESULT

Data acquisition part completed by using temperature sensor. The atmospheric temperature is measured and is sampled by using analog to digital convertor. It is programmed using Keil software.

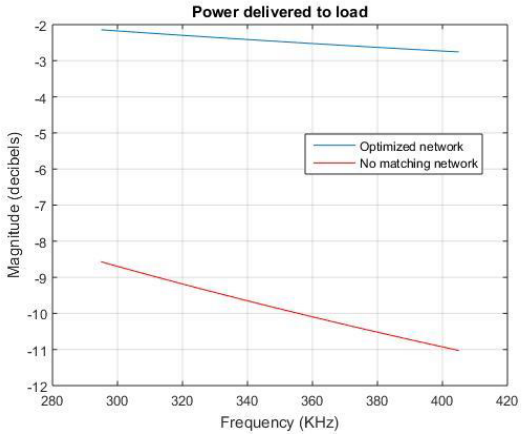

Fig. 4 Plot of frequency Vs magnitude

Figure 4 shows the relationship between frequency response and magnitude for a nonmatching network. When frequency increases the attenuation also increases. During the increase of frequency gain or magnitude becomes negative value. And it is in decibel rate. In optimized or in matching network the frequency change does not affect gain obtaining.

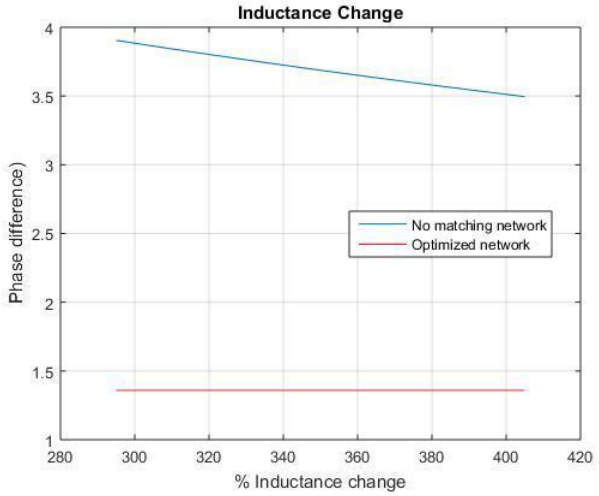

Fig. 5 Plot of inductance change Vs phase difference

Figure 5 shows the relationship between inductance change occurring in percentage and the phase difference. For matched network an ideal condition is considering which shows a straight line graph. But it is not possible in real condition. In optimized network there is no phase difference. But for nonmatching network with the increase of inductance change phase difference occurring also increases gradually.

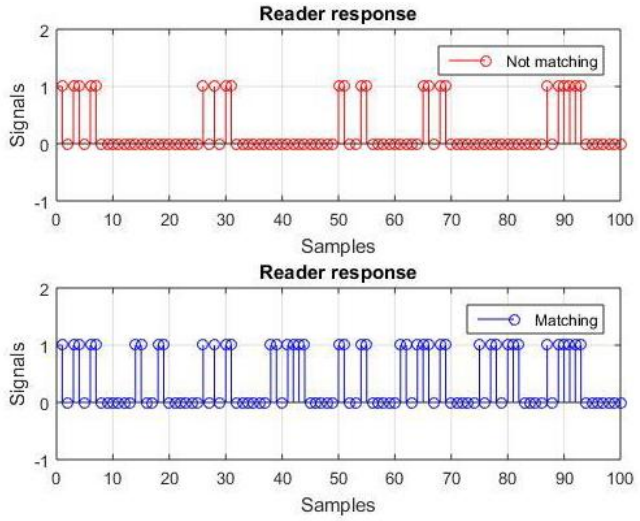

Fig 6 Plot of Reader Response

Figure 6 shows the reader response. According to the received data such as sensor read, motor control data the graph is plotted for matching and nonmatching networks. For nonmatching network there is no read response. And for matched network response will be shown.

The relationship between pressure sensor response with time and the relationship between temperature sensor response with time is plotted in the figure 7. A 5 minute interval is chosen for sensing action. Here analog signal is sampled and plotted and certain samples of data is using.

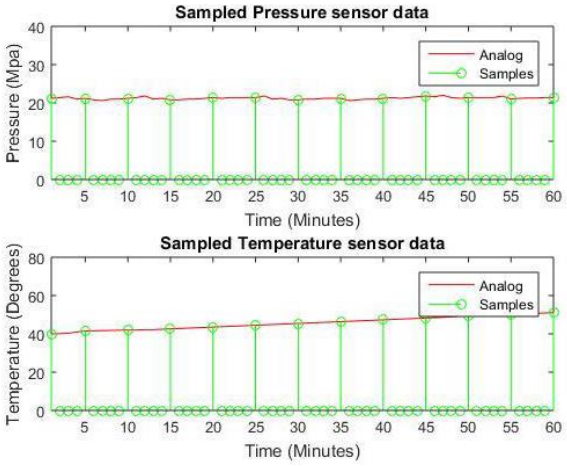

Fig. 7 Response of pressure sensor and temperature sensor

VI. CONCLUSION

The proposed system shows the RFID communication with sensor system. It helps for the monitoring of extreme conditions of downhole environment of an oilwell system. The monitored data will be stored in internal memory of microprocessor unit. According to the need it restores the monitored data and can collect it by number of RFID tags. Thus the present condition of downhole can be monitored easily. This reduces occurance of dangerous effects to the environment.

REFERENCES

[1] Salman Ali," SimpliMote: A Wireless Sensor Network Monitoring Platform for Oil and Gas Pipelines", IEEE SYSTEMS JOURNAL, 2016.

[2] Pawel Kopyt, "Graphene based Dipole Antenna for a UHF RFID Tag", IEEE transactions on antennas and propagation, July 2016.

[3] Bo Zhao, "An Inductive-Coupling Blocker Rejection Technique for Miniature RFID Tag", IEEE Transactions on Circuits and Systems August 2016.

[4] Dahmane Allane, "Harmonic Power Harvesting System for Passive RFID Sensor Tags", IEEE Transactions on Microwave Theory And Techniques, July 2016.

[5] Yan Yu, "Design of Wireless Logging Instrument System for Monitoring Oil Drilling Platform", IEEE SENSORS JOURNAL, June 2015.

[6] K.Sivaprakash, "Monitoring and Control of Oil Well Using Arm Processor", International Journal of Innovative Research in Computer and Communication Engineering, May 2015.

[7] Rajeshwari Sundar, "Implementing Intelligent Traffic Control System for Congestion Control, Ambulance Clearance, and Stolen Vehicle Detection", IEEE SENSORS JOURNAL, Feb 2015.

[8] Riccardo Colella, "SPARTACUS: Self-Powered Augmented RFID Tag for Autonomous Computing and Ubiquitous Sensing", IEEE Transactions On Antennas And Propagation, May 2015.
[9] Mahima Arrawatia, "Differential Microstrip Antenna for RF Energy Harvesting", IEEE Transactions On Antennas And Propagation, April 2015.
[10] Luca Catarinucci, "Smart RFID Antenna System for Indoor Tracking and Behavior Analysis of Small Animals in Colony Cages", IEEE SENSORS JOURNAL, April 2014.
[11] Sukhraj Singh, "Design And` Development Of Rfid Based Intelligent Security System", International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), January 2014.
[12] Husnain Saeed, "Reliable Monitoring of Oil and Gas Pipelines using Wireless Sensor Network (WSN) – REMONG", International Conference on system of systems Emgineering, June 2014.
[13] Anupama K R, A Wireless Sensor Network based Pipeline Monitoring System", International Conference on Signal Processing and Integrated Networks (SPIN), 2014.
[14] Qiang Luo, "Design of Wireless Monitoring System for Gas Emergency Repairing", 2014.
[15] Alvin Valera, "Underground Wireless Communications for Monitoring of Drag Anchor Embedment Parameters: A Feasibility Study", IEEE International Conference on Advanced Information Networking and Applications, 2014.
[16] Michele Magno, "Extended Wireless Monitoring Through Intelligent Hybrid Energy Supply", IEEE Transactions on Industrial Electronics, APRIL 2014.
[17] Shang Gao, "A Wireless Piezoelectric Sensor Network for Distributed Structural Health Monitoring", IEEE Transaction, 2014
[18] Talha J. Ahmad, "Performance Analysis of Downhole Acoustic Communication in Multiphase Flow", IEEE Transaction, 2014.
[19] Yichen Li, "Single Photon Avalanche Diode (SPAD) VLC System and Application to Downhole Monitoring", Optical network and system, 2014.
[20] Zhang Wei, "Design of Acoustic Wireless Remote Transmission System for Logging-While-Drilling Data", IEEE International Conference on Electronic Measurement & Instruments,2013