Condition Monitoring of Oil using Wireless Sensor Network

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Abstract

Leakage of oil from different oil sections of dumper (CAT773) can lead to fire accident and also machine failure if any considerable change in chemical or physical properties of oil takes place which results in loss of property and also life. The system model proposed by us is divided into transmitter and receiver section. The entire control system is based on microcontroller and ZIGBEE techniques. The main objective of this paper is to propose an efficient wireless sensor network in oil tanks of dumper (CAT773) to collect and monitor the chemical, physical properties in real time by using microcontroller and zigbee technology and generate alarm if any leakage or considerable change in characteristics of oil take place.

Keywords—condition monitoring, wireless sensor network, Wireless Monitoring, ZIGBEE

I. INTRODUCTION

There are numerous cases available from past where there has been considerable industrial loss because attention paid to equipment safety was very less and in some cases negligible. Condition monitoring[19] is the use of advance technologies to determine the condition of equipment and predict the failure. It is a major component of predictive maintenance. The use of condition monitoring allows maintenance to be scheduled, or other actions to be taken to prevent and avoid its consequences.

Wireless sensor network[16] are spatially distributed autonomous sensor to monitor physical or environmental conditions such as temperature, pressure, sound etc. and to completely pass their data through the network to a main location. The most forward application of WSN technology is to monitor remote environment for low frequency data network. Unlike traditional wired system, there is no chance of short circuit or spark taking place which can lead to fire accidents in our case, and also deployment cost would be minimal. WSN is built of nodes from a few to several hundreds or even thousands, where each node is connected to a sensor. Each such sensor network node has typically several parts, a radio transceiver with an internal antenna, a microcontroller, an electronic circuit for interfacing the sensors and an energy source, usually a battery. The topology of the WSN can vary from a simple star network to an advanced multi h-hop wireless mesh network.

With reference to mines the utmost important activity that has to be performed is to avoid mine fire accidents and machine failure which may be caused due to leakage of oil from dumper or considerable occurrence of chemical or physical change (such as temperature, pressure, level etc.) taking place in oil tanks of dumper respectively. Consumption of oil in dumper is more as compared to consumption of fuel. Also the oil used in hydraulic and differential tank such as SA10 oil, C45A13 oil are flammable. So to enhance equipment safety it becomes essential to monitor in real time the different characteristics of oil in the oil tanks of CAT773 dumper. Main objective of this paper is to design a wireless sensor node for real time monitoring of oil tanks of dumper. The wireless Sensor networks are envisioned to be deployed deep inside oil tanks of dumper to collect and report the physical and chemical information in real time. The next important thing is fast transmission of signal using fastest communication network. WSN based on ZIGBEE can be used for data acquisition and transmission, this technology makes transmission and reception of signals very fast which restricts the chances of mine accidents. Also it offers sufficient time to the operator of dumper to carry out rescue operation to prevent loss of life and avoid machine failure.

II. HARDWARE

The system is divided into two main parts: transmitter and receiver section. Transmitter
section mainly consists of: the sensor circuit, the microcontroller unit, the display unit. This unit will be located at the oil tanks of dumper. The sensor circuit contains the temperature sensor, pressure and flow sensor. One sensor provides analog output, which is converted to digital form using ADC in the controller and another sensor provides digital output and which is further processed to get temperature, pressure flow type. The microcontroller PIC16F877A has been used for the measurement of oil tanks environment conditions and transmission of data to the receiver. It has 40-Pin packages. It has a 10-bit A/D converter. The microcontroller uses 20MHz clock. Those measured parameters will be displayed in an LCD display. Block diagram of the overall system is shown in fig 4.1b Receiver section consists of a zigbee unit which is interfaced to laptop or desktop computer. Software collects the data coming from different monitoring devices and presents them in a user interface map. Data is also saved for further analysis.

A. Transmitter section

1. *Atmel 328p* Microcontroller:
   Atmel 328p microcontroller [17] integrates all type of advanced interfacing ports and memory modules. The high-performance Atmel picoPower 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

2. *Temperature and Pressure sensor:*
   The Microcontroller receives voltage input corresponding to the pressure and temperature of the environment from the pressure/temperature sensor [3] BMP180; it already has an inbuilt signal condition circuit, which makes the correct voltage available for analog to digital conversion. The BMP180 consists of a piezo-resistive sensor, an analog to digital converter and a control unit with E2PROM and a serial I2C interface. The BMP180 delivers the uncompensated value of pressure and temperature. The E2PROM has stored 176 bit of individual calibration data. This is used to compensate offset, temperature dependence and other parameters of the sensor. The Microcontroller converts the analog signal to the corresponding digital equivalent and manipulates the data based on pre-programmed code to displays useful result equivalent of Pressure (KPa) on LCD.

3. *Level sensor:
   A level sensor is a device for sensing the level of fluid [15]. Typically a ultrasonic level sensor
HCSR04 is used in level sensing, to record the level of fluids. As is true for all sensors, absolute accuracy of a measurement requires functionality for calibration. The modules includes ultrasonic transmitters, receiver and control circuit. It adopt IO trigger through supplying at least 10us sequence of high level signal which it receives from the controller then the module automatically send eight 40khz square wave and automatically detect whether receive the returning pulse signal. If there is signals returning, throughout putting high level And the time of high level continuing is the time of the ultrasonic transmitting to receiving. Test distance = (high level time * sound velocity (340M/S)/2).

Figure 3. Level sensor- wire connection

4. ZIGBEE

ZigBee is the global Wireless Technology connecting dramatically various devices to work together and enhance everyday life. ZigBee was introduced by IEEE and the ZigBee Alliance provides the standards for various applications. ZigBee is a low power, low cost, low data rate wireless standard for WPAN featured with security, reliability, large network capacity, easily deployed, short delay, long transmission range [14].

Figure 4. Block diagram of ZIGBEE module

It is capable of connecting 255 devices per network. Range of the transceiver module can be 30-70m in urban areas and 11.5km in outdoor (LOS). The transceiver has an on-chip wire antenna and it operates at a frequency of 2.4GHz [16]. The data received from the microcontroller is organized based on the ZIGBEE protocol standards and then modulated. The specification supports data transmission rates of up to 250 Kbps at a range of up to 30 meters.

There are three categories of nodes in a ZigBee system. They are Coordinator which is responsible for initiating the network and selecting the network parameters, Router which act as intermediate nodes, relaying data from other devices. End Devices can be low- power or battery powered devices. ZigBee coordinator node is completely responsible for the initialization, control and maintaining the network. Network may be extended by using ZigBee routers. This reduced functionality allows the device to reduce their cost. Star, Mesh & Tree are the three topologies which support the ZigBee network [16].

Figure 5. ZIGBEE Network

5. Power supply section:

This section is meant for supplying Power to all the sections mentioned above. This system uses batteries as their power supply as they are held with miners. Usually 9V batteries are used for the network and regulators are used to regulate 9V to required voltage (3.3V) as per requirement of microcontroller.

B. RECEIVER SECTION

It is used for continuous monitoring of signal sent from transmitter via ZIGBEE communication network and correspondingly
generating alert signal in case of emergency situations. This receiver section will be located at operator cabin of dumper and hence the operator can take necessary action in emergency conditions. The receiver Section consist of a LCD, Buzzer, and microcontroller interfaced with Zigbee through PC serial port. The microcontroller receives the value from sensor and transmits it to LCD where it is displayed. And if the value of oil is below the threshold or set value then the microcontroller transmits the signal to LCD and buzzer where alarm is generated so that the operator may take necessary action. The measured values are transmitted to the receiver section through Zigbee. ZigBee is a low power, low cost, low data rate wireless standard for WPAN featured with security, reliability, large network capacity, easily deployed, short delay, long transmission range.

Figure 6. Block diagram of proposed system – Receiver section

1) **RS232**
   (Recommended standard-232) is a standard interface approved by the Electronic Industries Association (EIA) for connecting serial devices. In other words, RS-232 is a long established standard that describes the physical interface and protocol for relatively low-speed serial data communication between computers and related devices. An industry trade group, the Electronic Industries Association (EIA), defined it originally for teletypewriter devices. In 1987, the EIA released a new version of the standard and changed the name to EIA-232-D. Many people, however, still refer to the standard as RS-232C, or just RS-232. RS-232 is the interface that your computer uses to talk to and exchange data with your modem and other serial devices. The serial ports on most computers use a subset of the RS-232C standard.

2) **Liquid Crystal Display (LCD):**
   The 20 x 4 LCD display is capable of displaying different characters and symbols. It is used to display the measured parameters such as pressure, temperature, relative humidity and dew point temperature. It is used to display 20 characters in one line and it has foursuch lines.

3) **BUZZER**
   It is used for generating alert signal in case of emergency situations at receiver station after it receives signal sent from transmitter via ZIGBEE communication network.

III. SOFTWARE’S REQUIRED

A) **Keil μVision4**
   μVision is a window-based software development platform that combines a robust and modern editor with a project manager and make facility tool. It integrates all the tools needed to develop embedded applications including a C/C++ compiler, macro assembler, linker/locator, and a HEX file generator. μVision helps expedite the development process of embedded applications by providing the Integrated Development Environment. KEIL can be used to create source files; automatically compile, link and covert using options set with an easy to use user interface and finally simulate or perform debugging on the hardware with access to C variables and memory. Unless you have to use the tools on the command line, the choice is clear. KEIL Greatly simplifies the process of creating and testing an embedded application[4].

B) **Flash Magic**
   Flash Magic is a tool which used to program hex code in EEPROM of micro-controller. It is a freeware tool. It only supports the microcontroller of Philips and NXP. You can burn a hex code into those controllers which supports ISP (in system programming) feature. To check whether your micro-controller supports ISP or not take look at its datasheet. So if your device supports ISP then you can easily burn a hex code into EEPROM of your device.
Manisha and Farmindarsingh at [5] proposed different techniques which can be used to detect the health of oil in different oil well and reservoirs. It depicts the role of wireless sensor network in industry as they play a vital role in condition monitoring process. They discussed how the existing oil pumping units still adopts manual control which have incapability of oil pumping unit structural health monitoring. Also they discussed various advantages of oil well monitoring and control based on wireless sensor network. Its control system is based on Atmega 2560 microcontroller and Xbee techniques. It consists of sensor node which helps in collecting data about multiple oil wells and transmitting the information to the receiver where the information is analysed and corresponding action is taken.

H.S. Lee, S.S. Wang, D.J. Smolenski, M. B. Viola and E.E. Klusendorf at [6] proposed a self contained and micro sized wireless sensor network for oil monitoring. In this they proposed a Zigbee-based oil monitoring system serves as a reliable and efficient system for efficiently monitor the environmental parameters of tank. This paper proposes the design of efficient wireless sensor networks in oil tanks to collect and monitor the physical, chemical properties in real time by using PIC microcontroller and Zigbee technology. It consists of microcontroller based measuring units which collect the value of the temperature, pressure, fluid flow type, etc. from the oil reservoirs. The sensor nodes inside the oil reservoirs contains the temperature, pressure, flows, acoustic sensors, etc. These units send their data to a central station, which collects the Data and stores in an database. An LCD display is also connected to the microcontroller to display the measurements.

Jin-Shyan Lee, Yu-Wei Su, and Chung-Chou Shen at [7] discussed Bluetooth (over IEEE 802.15.1), ultra-wideband (UWB, over IEEE 802.15.3), ZigBee (over IEEE 802.15.4), and Wi-Fi (over IEEE 802.11) four protocol standards for short-range wireless communications with low power consumption. In this paper, they provide a study of these popular wireless communication standards, evaluating their main features and behaviors in terms of various metrics, including the transmission time, data coding efficiency, complexity, and power consumption. It is believed that the comparison presented in this paper would benefit application engineers in selecting an appropriate protocol.

Nisha Ashok Somani and Yask Patel at [16] highlights the effectiveness of ZIGBEE as wireless technology network in solving industrial problems. It elaborates about different types of ZIGBEE physical devices that are available. It also elaborates about ZIGBEE protocol architecture and how different networking layers can be used to carry out different types of applications.

Improper condition monitoring technique in industries not only lead to fire accidents and machine failure but also adds to economic loss, property loss but most important is loss of life and this leads to unending cyclic process because all the above mentioned parameters are connected to each other. This paper provides a condition monitoring system using ZIGBEE which is compatible enough to prevent the occurrence of such hazardous scenario thereby avoiding fire accidents and reducing machine failure.

VI. REFERENCES

properties in biogas engines,


