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Health Monitoring Device For Underground Coal Miners

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Abstract: the underground coal mine environment is harsh. It is difficult to work in such conditions and the environment also effect the miners' health. Researchers found long term effects on underground coal miners' health. Mines are more prone to accidents and natural disasters; for example Roof fall occurrence is a major problem in Coal Mines. It causes revenue loss and casualty in underground coal mines; sometimes miners who are alive get trapped by roof fall occurrence and lost their lives due to lack off or delay in rescuing operation. Researches are being carried out to provide technological advancement for the safety and health improvement precautions of underground miners. We have designed a prototype of such device cum system which can continuously monitor the heart rate pulse of an underground coal miner. We get to know through this device during the accidents that how many miners are alive under the mine. Our aim is to design a low-cost, wearable wireless device which can continuously monitor the human heart rate pulse and send the information to the receiver/base station, either directly from sensor node or through intermediate nodes. Sensor node is integrated with a pulse sensor while intermediate node is just a kind of repeater. We present the major requirements to develop a small device that can operate on a tiny event-driven operating system, and also it provides support for efficient modularity and concurrency-intensive operation.

Key Terms: IR light, pulse sensor, sensor nodes.

I. INTRODUCTION

Frequently happened underground coal mine accidents is a big problem for mining industries. Mining industries are most dynamic in nature in compare with others due the bad environment of the underground mines. Mine accidents causes thousands of causalities of human lives and wealth as well. Not only accidents but also the environment condition is difficult for underground minors. The underground environmental conditions causes a long term negative effects on human health's. The crucial parameters for coal mine include Dust Density, Temperature, Gas Density, Carbonic Oxide Density and Wind Speed. So it is important to continuously monitor the mine environment condition and minors health [1]. The environment under underground coal mine is bad and complex, so it is more prone to accidents and natural disasters. Tunnels in underground mines are generally long and narrow, with lengths in kilometers and several meter width. With the increase of coal mine mechanization it is important to monitor the underground mining activities and mines physical conditions. The interactive communication between different types of systems is difficult; the wired equipment interconnection and power supply are more susceptible that it may damage on accidents, hence the entire system becomes vulnerable. Traditional systems are performed with poor flexibility and expansibility [2]. Wireless sensor networks have characteristics of self-organization, wireless communication, distributed autonomous and simple maintenance; these characteristics draw the attention of researchers in home, commercial, defense and medical application of Wireless sensor networks. Wireless sensor networks are more flexible and have better perceptive function than wired network, but it is inferior to wired communication in transmission capacity, rate and reliability. A sub branch of Wireless Sensor Networks (WSN), often referred to as Body Area Networks or Body Area Sensor Networks deals with wearable, small devices having computing technology to sense human body's vital signs. Such as accelerometer can be used to detect movement of the body, likewise Electrocardiogram (ECG) for heart functionality test and Electromyogram (EMG) for muscular problem. By wearing these devices one can continuously monitored and the vital signs of human body we get through this type of devices is the real-time data [3]. In this paper we discussed the design of our system which can monitor the human pulse and transmit it wirelessly. The pulse detection system is based on Infrared (IR) light reflection and refraction approach. Pulse sensor is based on *Lambert-Beer Law*. While the transmission of the pulse data is done by the microcontroller board. Microcontroller board is integrated with a Radio Frequency (RF) transceiver. This paper is organized as follows. The following section discusses system overview. In section 3, working and operation is discussed. In section 4, result is presented and section is the conclusion of this article.

II. SYSTEM OVERVIEW

This paper describes the prototype design of our system which is very low in cost. And it can be easily affordable to everyone. The pulse sensor design is such that, it can be easily wearable on hand. Because our main aim is to focus on underground coal miners health and safety.

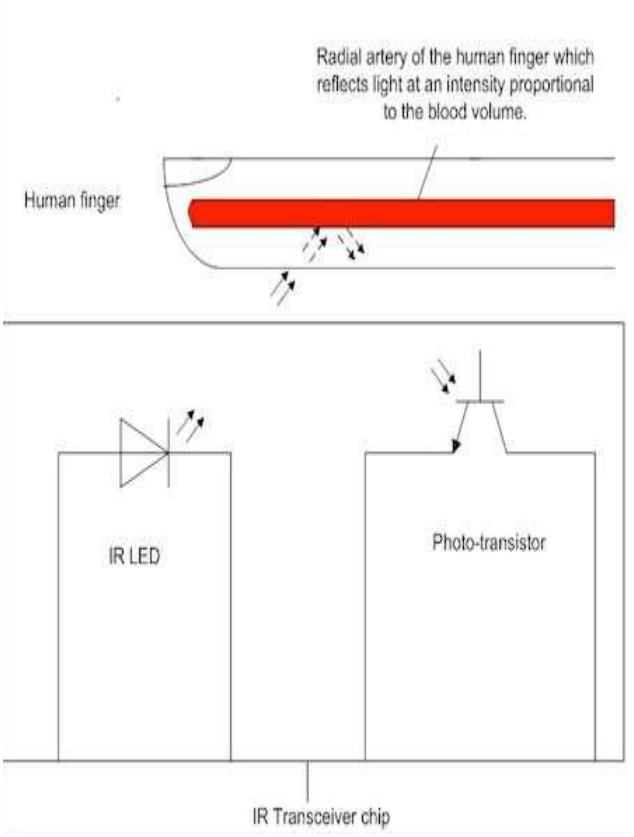

Fig.1. *Reflection of IR light from radial artery*

The fig. 1 depicts the behavior of IR light towards the human blood. This figure shows the IR sensor module of our design for the detection of human pulse [4]. The IR LED is used to transmit IR light which is then reflected by the radial artery of the human finger and the reflected IR light will be detected by Photo-transistor. The amount of light absorbed by oxygenated blood can be determined by a *Lambert-Beer Law*. According to this Beer's law, a linear relationship exist between absorbance of the light and concentration of the absorbing species and is usually written as:

A= a(λ)*b*c

Where ***A*** is amount of absorbance, a(λ) is the wavelength of the dependent absorptivity-coefficient, ***b*** and ***c*** are path length and analyte concentration [5].

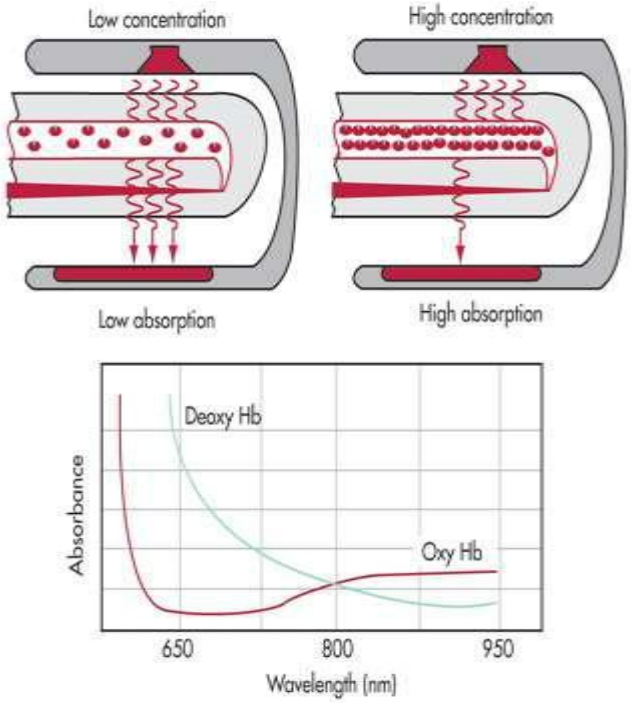

Fig. 2. *Oxygenated and deoxygenated blood characteristics*

The fig. 2 is showing the pulse-oximetry phenomennon. Here the IR light absorption and reflection is pictured for the oxygenated and deoxygenated human blood. It is human blood characteristics that it absorbs more IR light when oxygenated while less when it is de-oxygenated. Such technique is also called the *Pulse-oximetry*. Next the plot between Absorbance and Wavelength is shown which clearly indicate the amount of IR light absorbance for oxygenated (red curve) and deoxygenated (blue curve) blood [4].

III. SYSTEM DESIGN & OPRERATION

The overall system design can be divided into two main category:

i. Pulse Detection Sensor
ii. Wireless Transceiver

A. Pulse Detection Sensor

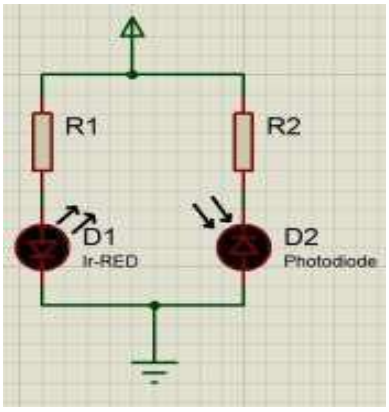

Fig. 3. *IR sensors*

The major functionality of this module is dependent on the IR sensor module. Output from the photo-detector diode is given to the op-amp through tantalum capacitor. Tantalum capacitor differs from other capacitor as it has more noise immunity to signals. And is popularly used in wireless communications systems to provide better insulation from noise in the transmission medium. The op-amp is used to identify the desired range signal and improve the circuit gain. Generally it can be assumed that its function is intended to improve circuit gain for driving the wireless transceiver efficiently. At the laboratory level test to check the pulse sensor functionality, an ultra-bright LED is placed at output terminal of pulse sensor and it glow with heart beat pulse detected.

B. Wireless Transceiver

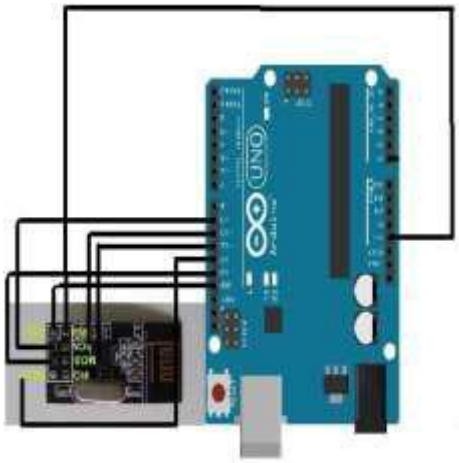

Fig. 4. *Transceiver module*

Fig. 4 is the complete RF transceiver module. For this module we select the Arduino board which is interfaced with nrf24L01. It is an open-source platform. Arduino board is based on the ATmega328 microcontroller and has 6 pins for analog input, 14 pins for digital input/output, 16MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The advantage over selecting Arduino board is, it does not require the FTDI USB-to-Serial driver chip. In spite of that it features the ATmega16U2 programmed as a USB-to-Serial converter.The nrf24L01 is highly integrated, ultra-low power (ULP) 2Mbps RF transceiver IC for the 2.4GHz ISM (Industrial, Scientific and Medical) band. The interfacing of Arduino and nrf24L01 is done through SPI (Serial Peripheral Interface) protocol. There are number of nodes possible between the sensor node and the receiver/base station.

IV. RESULTS

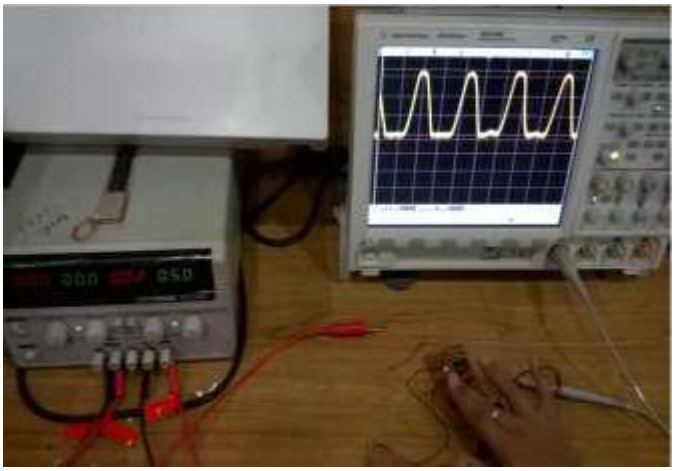

Fig. 5. *Pulse sensor output waveform on MSO*

In the fig. 5 the lab results is shown for the pulse sensor module. The output waveform is obtained on Multiple Signal Oscilloscope (MSO) manufactured by Agilent Technologies. The peaks in the waveform represent the *systolic blood pressure* of the person.

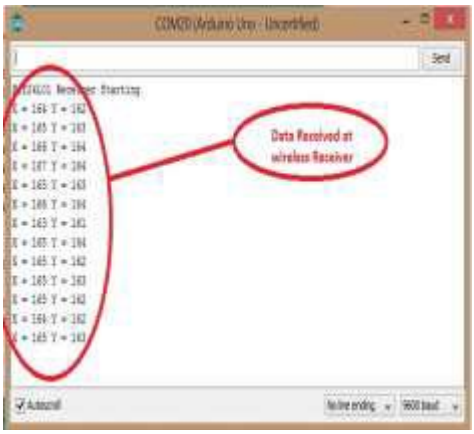

Fig. 6. *nrf24L01 receiver data*

In fig. 6, received data on receiver is figured out. This is viewed on Arduino serial monitor interface. The prototype of wireless pulse monitoring system is tested at the laboratory stage and is found to be working correctly. At lab we use two intermediate nodes between sensor and the receiver node/base station. All the nodes architecture is same; sensor nodes, receiver node and intermediate nodes.

V. CONCLUSIONS

The prototype of wireless monitoring of pulse sensor is designed and tested at the laboratory stage. At this stage it is found to be working according to our need for coal miners. Although the prototype design needs to be tested in the real conditions. The range and operations of the design may wary in harsh conditions of underground coal mine environment. Doing so we get the operating temperature range for the designed system because as testing is done near about at the room temperature only.

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