DEVELOPMENT OF COAL MINE SAFETY SYSTEM USING WIRELESS SENSOR NETWORK USING NRF TECHNOLOGY

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Abstract

Today, safety of miners is a major challenge. Miner’s health and life is vulnerable to several critical issues, which includes not only the working environment, but also the after effect of it. To increase the productivity and reduce the cost of mining along with consideration of the safety of workers, an innovative approach is required. Coal mine safety system based on wireless sensor network using NRF technology can timely and accurately reflect dynamic situation of staff in the underground regions to ground system. The air pollution from coal mines is mainly due to emissions of particulate matter and gases include sulphur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO) etc. To monitor the concentration level of harmful gases, semiconductor gas sensors are used. Due to any reason miner’s falls down and lose consciousness also proper treatment is not provided them at that time, so number of miners are died. To overcome this problem the system provide emergency alert to the supervisor if person fall down by any reason. Some workers are not aware for safety and they are not wear helmet. A emergency switch was then used to successfully determine whether a miner has removed his helmet or not. This system also provides an early warning, which will be helpful to all miners present inside the mine to save their life before any casualty occurs. The system uses NRF technology for transmission of data. There is emergency switch and GSM at receiver and transmitter side for emergency purpose.

Keywords: NRF, GSM, Miner Safety, Emergency Switch.
1. Introduction

The safety issues of coal mines have been gradually turned into a major concern for the nation. Since 1900, over 200,000 workers have been killed in coal mines in the U.S. (Alford, 1985) and many more have been injured and disabled [1]. Underground coal miners are exposed to a wide range of hazards including gas explosions, water leakage, shifting rock, falls, and machinery and electricity equipment accidents [1]. Coal as an important source of energy in industrial production, it plays a crucial role in the national economy. So the miner safety is very important factor to be considered. In this system we will find the concentration level of harmful gases and hazardous event of coal mines and transmit the data to the base station using Nrf Technology. To monitor the concentration level of harmful gases present in coal mine like SO2, NO2, CO etc. and temperature, humidity sensor are used. In this project there are two sections. The first section is underground section and another section is ground section. In underground section the sensors will sense the environment conditions such as temperature, humidity, gas, moisture etc., and this information is send to ADC. ADC will convert this information and send to the micro controller. Micro controller sends the information through NRF transmitter. In ground section NRF receiver take that information and display it on the LCD and if any parameters crosses the threshold level it will switch on an alarm so that people can be alert.

2. Literature Survey

Yongping Wu and Guo Feng implement coal mine monitoring using the Bluetooth wireless transmission system. As a standard of unified global short-range wireless communication, Bluetooth technology is to establish a common low-power, low-cost wireless air interface and controlling software opening system. This paper describes the development background, technical features and the structure of the protocol stack of Bluetooth technology, and proposed the solutions of the Bluetooth host controller interface (HCI) wireless communication for the complexity of its development At the same time, the system uses CAN bus technology maturely, has realized the combination of wired and wireless data transmission system. The main difficulty of this system is that the Bluetooth is short distance wireless technology and use of cabling is difficult. When a natural calamity or a roof fall occurred, the cabling is damage. So the reliability and long life of conventional communication system is poor. Due to the harsh environment inside the mine, the installation and maintenance of the wired communication is very difficult.

Zhenzhen Sun proposed DCS Coal Mine Monitoring System Based on RS485 Bus, RS485 bus structure supports multi-point and two-way communication. So, this type of monitoring system can be developed using common 8-bit microcontrollers.
It has the advantages of simple circuit structure and low costs. However, due to the adoption of master-slave structure network, it is difficult to guarantee the reliability of the network with urban/indoor communication, in order to enhance the system even further, multiple identical sensor nodes could be introduced. This would turn the master/slave (2 node star) topology into a mesh network. By using the proprietary technology from the manufacturer of the Zigbee module known as DigiMesh a smart mesh network can be configured. This would allow for a sensor node to be out of range with the collection node, but as long as that sensor node can communicate to another sensor node, the data can be passed along from the end sensor node to the collection node through intermediary sensor nodes. This would increase the communication range inside the mine.

Tanmoy Maity and Partha Sarathi Das implement a wireless surveillance and safety system for mine workers based on Zigbee. This system addresses a cost-effective, flexible solution of underground mine workers’ safety. A module of MEMS based sensors are used for underground environment monitoring and automating progression of measurement data through digital wireless communication technique is proposed with high accuracy, smooth control and reliability. A microcontroller is used for collecting data and making decision, based on which the mine worker is informed through alarm as well as voice system. The voice system with both microphone and speaker transforms into digital signal and effectively communicate wirelessly with the ground control center computer.

Valdo Henriques and Reza Malekian developed Mine Safety System Using Wireless Sensor Network. This system describe the design and construction of a mine safety system prototype using a wireless sensor network with the objective of building a safety system to monitor the ambient characteristics of the mining environment. The hardware consisted of electronic circuitry where a microcontroller is the principal processing unit. A graphical user interface is also implemented. While the wireless communication implemented in this design shows success
ZigBee, based on IEEE 802.15.4 standard is used for this short distance transmission between the hardware fitted with the mine worker and the ground control center. Zigbee is a short distance wireless communication network so it is not possible to intimate to responsible authorities who are at long distance.

3. Proposed System

The key to controlling coal mine accidents the prediction of outburst by implementing sensors and microcontrollers and to generate an alarm system before critical atmospheric level. A continuous monitoring is very necessary which is again requires some effective and accurate sensing system. Many technique are adopted to sense the presence of these gas, among them use of semiconductor type gas sensor is very much effective. These sensors can be mounted in the coal mine area but some time these create some problems in mining too. Accidental damage of the sensor device often took place. Another technique is the use of robot. These robots are effective but cost of robot is very high. However, there is another way of getting effective and low cost solution of sensor implantation

So these sensors works in the coal mine like we used the gas sensors, soil moisture sensors, firesensors all these are transmitted through the Nrf technology and at receiver side the data receives and we use a GSM so that in case of any emergencies, its sends a text message to the Higher Authorities and the nearest hospital.

**Fig-1:** Block diagram of transmitter side of Underground Section

This system has a sensor module consisting of some sensors that measures real-time underground hazardous condition like harmful gas concentration, water leakage and Fire accident. The semiconductor type sensor detects and send real time data to the base station. When threshold values of gases exceed then the alarm raises and send emergency message using the GSM module.

All sensor output is amplifying using amplifier before transmission of controller. The Arduino have inbuilt ADC and fast transmission speed. In system also provide emergency alert switch. If miner press emergency switch for any emergency the emergency message transmit through NRF to base station.
Fig-2: Block diagram of Receiver side of base station

All real time data are received from Underground section to the base station through NRF and display on LCD and also it plots the graphs of temperature. NRF is a short distance wireless communication network so it is not possible to intimate to responsible authorities who are at long distance. Meanwhile GSM based wireless sensor network are investigated due to their remote environmental monitoring capabilities. By using GSM based technology.

This system provide an alert button so that miners can directly convey the emergency message to the control room and also control room convey the alert message to the miners.

4.1 Gas Sensor

A sensor is a technological device that detects / senses a signal, physical condition and chemical compounds. It is also defined as any device that converts a signal from one form to another. Sensors are mostly electrical or electronic.

Gas sensor is a subclass of chemical sensors. Gas sensor measures the concentration of gas in its vicinity. Gas sensor interacts with a gas to measure its concentration. Each gas has a unique breakdown voltage i.e. the electric field at which it is ionized. Sensor identifies gases by measuring these voltages. The concentration of the gas can be determined by measuring the current discharge in the device.

4.2 Soil Moisture Sensor

This sensor can be used to test the moisture of soil, when the soil is having water shortage, the module output is at high level, else the output is at low level. By using sensor one can automatically water the flower plant, or any other plants requiring automatic watering technique. Module triple output mode, digital output is simple, analog output more accurate, serial output with exact readings.

Soil moisture sensors measure the water content in soil. A soil moisture probe is made up of multiple soil moisture sensors. One common type of soil moisture sensors in commercial use is a Frequency domain sensor such as a capacitance.
sensor. Another sensor, the neutron moisture gauge, utilize the moderator properties of water for neutrons. Soil moisture content may be determined via its effect on dielectric constant by measuring the capacitance between two electrodes implanted in the soil. Where soil moisture is predominantly in the form of free water (e.g., in sandy soils)

4.3 Fire Sensor

fire detector works by detecting smoke and/or heat. These devices respond to the presence of smoke or extremely high temperatures that are present with a fire. After the device has been activated, it will send a signal to the alarm system to perform the programmed response for that zone.

Since a fire detector usually works by detecting smoke and/or heat, and not actual fire, these devices are not usually called "fire detectors". Instead, these devices are more appropriately called "smoke detectors" and "heat detectors". Some of these devices are single-function devices that will only detect either smoke or high temperatures. However, other sensors are multi-function, and they will detect the presence of both smoke and high temperatures.

Multi-function devices are usually the most effective when it comes to detecting a fire. However, single-function devices are typically less expensive. Additionally, multi-function devices might not be appropriate for every area. For example, there may be a room inside the home where smoke is commonly present. This could include a kitchen or a designated room for smoking herbs. For these areas, a single-function heat sensor may be more appropriate than a dual-function smoke and heat detector.

4.4 NRF Module

This module uses the 2.4GHz transceiver from Nordic Semiconductor, the nRF24L01+. This transceiver IC operates in the 2.4GHz band and has many new features! Take all the coolness of the nRF2401A and add some extra pipelines, buffers, and an auto-retransmit feature - very nice!

Note: We now populate these boards with the nRF24L01+. The '+' version of the IC has improved range, sensitivity, and data rates. The command set is backward compatible with the original nRF24L01.
4.5. DHT SENSOR

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). Its fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using our library, sensor readings can be up to 2 seconds old.

4.6. GSM

GSM is a mobile communication modem; it is stands for global system for mobile communication (GSM). The idea of GSM was developed at Bell Laboratories in 1970. It is widely used mobile communication system in the world.

GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands.

GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates.

RESULT
Where we can observe the temperature conditions inside the coal mines in the form of Graphical Representation. So we can know the temperature levels at different timings.

5. Conclusion

A real-time monitoring system is developed to provide clearer and more point-to-point perspective of the underground mine. This system is displaying the parameters on the monitoring unit and also in the form of Graphical Representation; it will be helpful to all miners present inside the mine to save their life before any casualty occurs. Alarm triggers when sensor values cross the threshold level. This system also stores all the data in the computer for future inspection.

6. References


[8] Tanmoy Maity and Partha Sarathi, “A wireless surveillance and safety system for mine workers based on Zigbee”, 1st Int’l Conf. on Recent Advances in