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COAL MINE MONITORING AND ALERT SYSTEM WITH DATA ACQUISITION

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Abstract—The communication network in coal mine underground is the foundation of colliery distributed monitoring system and plays an important role in transferring information when the production is in gear and events happens in coal mine underground, which is the key to keep the safety information expedite. A wireless sensor network (WSN) consists of an array of diverse micro-sensors, which is interconnected by a wireless communication network to provide plenty of sensing and monitoring services. It has the advantages of simple structure, flexible network, good efficiency and trustiness. Firstly, the paper brings forward a new project of the distributed monitoring system in coal mine underground based on WSN according to the analysis of special communication circumstance of coal mine underground. The WSN nodes do not need to communicate directly with the nearest high-power control tower or base station as other traditional wireless devices do, but only with their local peers. In a word, WSN forms a new kind of wireless networks with a new set of characteristics and challenges. Then the safety theories of communication of WSN in coal mine underground are dissertated and the key techniques are discussed, on the basis of which a distributed monitoring system in coal mine underground based on WSN is designed. Finally, the layout and functions of WSN of coal mine underground in the whole distributed monitoring system are mainly researched, including the peacetime datum collection and emergent application when events happens.
Index Terms: Coal Mine Monitoring: Data acquisition: Wireless Technology: ATMEGA 2560 etc:

I. INTRODUCTION

A. Coal Mines

India produces 89 minerals by operating 569 coal mines, 67 oil and gas mines, 1770 non-coal mines, and several more small mines, running into over a lakh, all of them translates into the direct employment of about millions of people on a daily average basis and overall sector contribution is about 5 percent of the India's gross domestic product [13]. Even after such a huge profit from this sector, there are very less preventive steps taken against mining accidents. The open cast mines can be considered safe as compared to the underground coal mine. As the workers in open cast mines do not face any problem of humidity, heat, suffocation etc. Whereas, in the underground coal mine, there is a major risk to the health of the worker due to factors like suffocation, high temperature, harmful gases, humidity & chances of fire which creates a great threat to their life compared to the open cast mine workers. The inappropriate conditions in underground coal mines include improper lighting, insufficient ventilation & underground slippery areas.

The uncontrolled temperature in presence of highly inflammable gases like methane can cause fire anytime. With the increase in depth of coal mine a number of harmful gases like sulphur dioxide, methane increases. Excess exposure to them is harmful & fatal for human health. So to reduce these risks, we developed an embedded system that helps to monitor the physical conditions in underground coal mine. This System uses wireless communication technology to transmit the data collected by the underground station to the base station for further processing.

B. Vehicular Ad-hoc Networks

With the ever growing technology, human efforts are reduced to great extent but even now some industries do exist, where we cannot neglect the importance of manpower. Some of these industries that help us extract the natural resources; need a lot of human effort. One such a large scale industry is coal mines. Coal mines are the places where extraction of coal takes place. This extracted coal is then supplied to various other industries, where it is used for the production of electricity and heat through combustion or for some other secondary uses. Vehicular Ad Hoc Networks (VANETs) have cultivated out of the have to support the growing quantity of wireless items that very easily employed in the vehicles. These products include remote keyless entry devices, personal digital assistants (PDAs), laptops and mobile telephones. As mobile wireless devices and networks become increasingly important, the need for Vehicle-to- Vehicle (V2V) and Vehicle to-Roadside (VRC) or Vehicle-to- Infrastructure (V2I) Communication will continue to develop. VANETs can be utilized to get a broad range of safety and non- safety applications, leave useful services like vehicle safety, automated toll payment, traffic management, enhanced navigation, location-based services for example choosing the closest fuel station, restaurant or travel lodge and infotainment applications including providing access to the online world.

II. LITERATURE REVIEW

Overage, coal mine monitoring was done using traditional method of using wired network systems i.e. by laying underground cables or parallel lines, which proved to be inconvenient for safety purposes. An integrated system of traditional method and modern method was also developed. Jian Wang and Peng Wang developed a system that combines optical fibre cable with wireless gas sensor network [6]. They proposed an advanced and intelligent gas inspecting network. The system composes of underground substation, information transmission system and surface centre. The former is structured as tree system so as to reduce the branches of the system and later for data collection. The wireless sensors here communicate with the control centre through the optical fibre cable. Here, the optical fibre cable is the important part of the tree-structured system. Their paper combines the existing optical fibre communication with the wireless gas sensor network. The system also has special feature or functions like acception handling, controlling of inspecting system switch and transmitter. The MID04 sensor is infra-red methane sensor and it has high advantages.

Chen Hui developed a more advanced modern system with many advantages by using single chip micro-controller for gas detection in underground mines. The hardware design of the system consists of AT89S52 by ATMEL as the main controller unit, sensors, signal amplifier circuit & analog to digital converter, a digital display module, keyboard input module, serial communications, sound-light alarming units etc [2]. The software part of the system uses assembly language programming to initiate the system, setting the threshold value, data collection & serial communication etc. The system has an operating interface for data collection, enter, reset, power, ad-just value and a numeric keypad. The system collects data from the sensors and gives for analog to digital conversion. The data from ADC is transmitted to the host computer through serial communication unit i.e. RS-485. The host computer then compares collected data with the threshold value to generate the alarm signal accordingly. Later on, monitoring system based on MEMS (Micro Electro Mechanical Systems) sensor and ARM7 was developed by G. Prabhakar Reddy, M.Vijaya Lakshmi.

Communication protocols developed should be based on location-addresses as opposed to some global node identifier. The main focus of this report is to communicate various ideas about what is required to provide guarantees that messages in the network are delivered according to their real-time deadlines The system uses MEMS (Micro Electro Mechanical Systems) based sensor network for collecting the coal mine data. The transmission of the sensed data is carried out to the ARM7 micro-controller. When severe conditions are detected by data processing in ARM7, workers are alerted. Wi-Fi, IEEE 802.11 wireless protocol was used for communication of the system instead of radio communication [10].T.Asesh Kumar, K.Sambasiva Rao proposed a system which includes hardware circuit to be carried by the workers, termed sensor node. The second section is the base station. The sensor module consists of MEMS sensors that are very small in size between 1μm to 100μm micrometres. The system uses PIC16F877A microcontroller for signal processing of the data provided by sensors installed underground sensing the underground coal mine parameters. The author has integrated the CAN bus communication technology, used for the communication of sink node and the base station and Wi-Fi module [11].

This coal mine monitoring system using wireless sensor network proved to be advantageous for the safety of mine workers over traditional methods. From above references, it can be concluded that the system can be more advantageous if we use fast communication technology and advanced sensors are utilised. The new technologies that were brought up so as to improve the existing technologies used wireless transceiver antenna. The technology promises to revolutionize the way we live, work, and interact with the physical environment. A quick comparison between these communications is done in Table I. In reference to these studies, we choose wireless transceiver antenna communication technology for the communication between the underground station and base station.

III. SYSTEM DESCRIPTION

The developed system is basically divided into two parts; first is the underground or mine station and second is the ground or base station.

A. Underground Station

The sensor value extraction is done by the underground station. As shown in figure 1 underground station has sensors connected to the micro-controller. For this system, we are only dealing with three sensors namely temperature, humidity & gas sensor those sensing the underground coal mine conditions and giving the analog input to the controller [8].

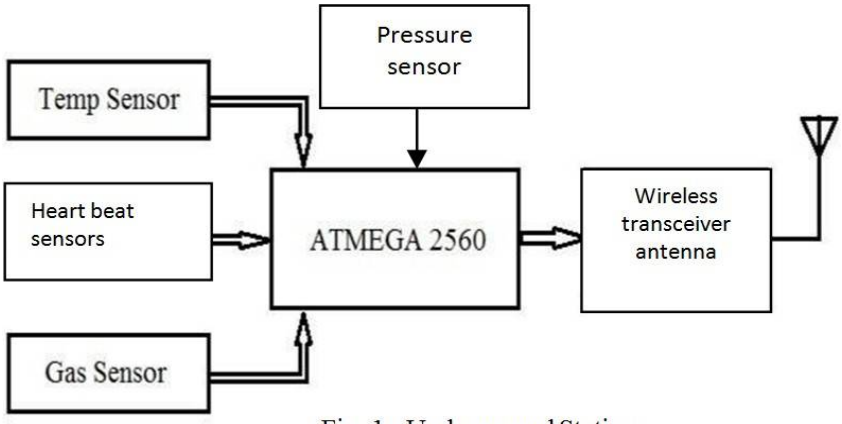

Fig. 1. Underground Station

The controller at underground station transforms the analog sensor values into four-bit digital data. This data is further transmitted by the Wi-Fi transmitter to Wi-Fi receiver of the base station.

B. Base Station

The base station plays a major role of monitoring the underground conditions, refer Figure 2. The Wi-Fi receiver of base station receives the signals from Wi-Fi transmitter from underground station, which further fed to the controller. The base station controller converts the digital data into Lab VIEW understandable variables with the help LIFA base programmed, ref Section V-A.

C. SMA Wireless transceiver Antenna

The 2.4GHz NRF24L01+PA+LNA SMA Wireless Transceiver Antenna has voltage of 3-3.6V and maximum output power:+20dBm.Its Power down mode current is 4.2uA Operating Range of 1Km and its Antenna Gain(peak): 2Dbi. 2MB rate (open area): 520m and 1MB rate (open area):750m. And 250KB rate (open rate):1100m.

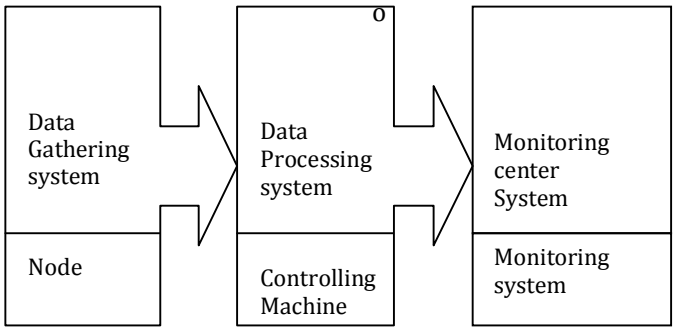

Fig.2.Monitoring System

D. Pressure sensor

Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude. Pressure sensors can alternatively be called pressure transducers, pressure transmitters, pressure senders, pressure indicators, piezometers and manometers, among other names.

E. Temperature sensor

The temperature sensor used for the system is LM35. As it gives the simplicity of connection and required a range of temperature measurement. The problems like oxidation do not occur due to proper packaging. Compared with thermistor, LM35 is giving more accurate and linear in measuring tem. The operating temperature range is from −55 C. It also has the property of low self-heating and do the system is consisted by three sub-systems: the data collecting sub-system, the data processing sub-system and the monitoring sub-system. The data collecting system contains the sensor nodes and the wireless communication parts, using not cause a change of more than 0.1 still air [5]. G. Heartbeat sensor C temperature rise in for real-time gas concentration underground monitoring. The collecting nodes are divided into two parts, movable nodes and static nodes.

IV. SYSTEM HARDWARE

The system hardware consists of the following components; micro-controller ATMEGA 2560, Wi-Fi module, temperature sensor, humidity sensor, gas sensor & GSM module etc.

A. Micro-controller ATMEGA 2560

The microcontroller used in the system is ATMEGA 2560. The motivation behind the selection of ATMEGA 2560 is its simplicity in interfacing with the Lab VIEW 2015 in integration with Wi-Fi module and availability of more number of analog inputs and digital outputs. It has 54 digital I/O pins and 16 analog pins, which are sufficient to monitor the parameters. The micro-controller ATMEGA 2560 basically converts the analog sensor values of coal mine conditions into digital ones through its inbuilt ADC (Analog to Digital converter). So that these digital values can be transmitted through the Wi-Fi transmitter to the Wi-Fi receiver connected to the other ATMEGA 2560 at the base station. It also activates the alert and gives the command to GSM module to call and/or send SMS message. When the heart beat detector is working, the beat LED flashes in unison with each heart beat. This digital output can be connected to microcontroller directly to measure the Beats Per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse.

B. Gas sensor

The mine gases are highly concentrated and toxic, become a threat to both miner's health and the environment and also limit visibility. The main component of the flammable gases that leak from coal seams is methane. The sensor uses MID04 infra-red methane sensor. The concentration sensing range of 300 ppm to 10,000 ppm is suitable for leak detection. The temperature range of the sensor is from − 10o C to 50o C and it consumes power less than 150 mA at 5 V. The MG-811 is the carbon dioxide sensor. It is highly sensitive to C O2 and less sensitive to alcohol and CO. It could be used in air quality control, ferment process, indoor air monitoring application. The output voltage of the module falls as the concentration of the CO2 increases [7].

V. OVERALL STRUCTURE OF SYSTEM

A. System Main Control Software Modular Structure

The main control software part of the overall system installs on the main terminal computer as well as the subordinate substation various labor controls machine. The real-time data acquisition display module has implemented the acquisition and display of all changed data of the entire mining area. The history data inquiry and the maintenance module can be used to manage and maintain all the collected data; The statistical history data graph module can be used to analyze and compare the historical data; The display and printing data report module is used to in print the mine data form. The expert decision-making module can complete the gas forecast, mechanical device breakdown diagnosis, accident decision-making; The warning and ceasing engine module can give the alarm timely when the data changed abnormally, disconnect the power source automatically to ensure the safety of equipment when the data surpass the predetermined value.

B. Intelligent Decision-Making Module Design

According to expert knowledge base, it can provide the suggestion and hints for variety parameter of abnormal parameter to forecast the shaft gas; can provide the best environment parameter and reasonable production instruction; indicate the best disaster relief and evades the disaster route and provide the decision-making for rescuing and dispersing personnel and equipment when disaster appearance.

C. Human- Machine Interface

Human-machine interface is the interface for watch to provide information to system, bring forward the task requirement and for system to provide solution and various assistant decision- making information to user.

D. Client/Server mode

Based on the Client/Server mode, coal mine safety monitor system connects each ache of coal mine closely through the network, enables the coal mine superintendent to control entire enterprise's production management in real-time. This mode applies Windows Socket which is core technology of network programming. The main station group network connected together through the net cable. As server and the subordinate station network are the work master station has implemented seamless integration for the data and service with the subordinate substation client. It has openness and easy to expand and so on the merits. It divides into the forestage client and the backstage server; to saves mine information parameters and management information decision-making separately. The system is consisted by three sub-systems: the data collecting sub-system, the data processing sub-system and the monitoring sub-system. Coal Mine Security System totally based on wireless sensor network which consist of transmitter circuit and receiver circuit. In transmitter circuit sensor sense the given parameter and send this to analog to digital converter, then send this signal to 89S52 processor. Processor performs three functions.

a) Transmit data
b) Display data on monitor
c) Store data permanently

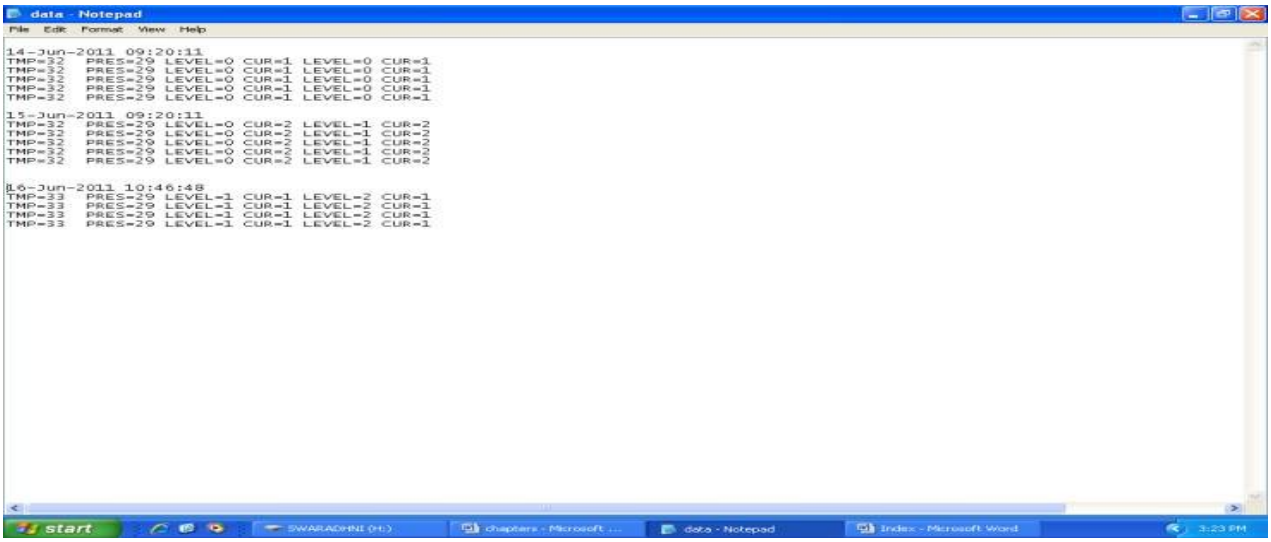

Fig. 3. Database result.

VI. RESULT

The Figure 3 shows the HMI (Human Machine Interface) or the front panel of monitoring system developed in the Arduino software, which monitors all the sensor parameters and gives indication on the panel and alert signal by operating the GSM module through the micro-controller. The front panel shows the sensors values for the sensed parameters.

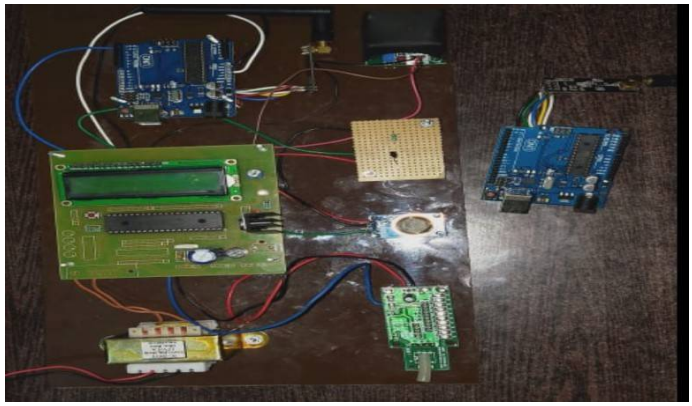

Fig. 4. System hardware connection

It also provides the flexibility of adjusting threshold values as per the mine conditions. The interfacing of ATMEGA 2560 with the temperature and humidity sensor is shown in figure 4. When sensor values exceed the predefined threshold values in the Arduino software front panel it gives an indication by turning LED on giving buzzer alert.

At the same time, GSM is also operated for call or SMS alert. The data acquisition part gives the control over the saving of sensor data from the underground mine. Master control facilitates the stop control over the entire monitoring system.

VII. CONLUSION

Utilizing sensor technology, automatic detection Technology, communication technology and microcomputer technology, to realize the operational parameter intelligent monitored management of entire mining area, this system occupies following characteristic:

(1) The real-time data warning. The warning displays with kinds of representation. Using industry camera, it carries on image gathering and the remote control.

(2) Establish the real-time monitor security information data platform, Using the Matlab, making the system safety, convenient processing each kind data.

VIII. FUTURE SCOPE

With the growing innovations future work of this experimentation may include, more development of the system by using other advanced sensors for monitoring the underground. Threats. Also, all the underground operations can be carried out from the ground surface. New developing communication technologies can be used for high-speed data transfer in integration with smart sensors for sensing the mine conditions. Also, more IOT enabled systems can be developed for more advanced functionality [9] [10].

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