

Design and Development of Mine Monitoring System using Embedded System

Aayesha Ali, Ritesh Bohra

Abstract: Coal mine is the area which is very sensitive and prone to accident. Toppling of the roof in coal mine tunnel, hazardous gases, flooding are the main reason of accidents in the coal mines. The life of the mine workers are always in danger due to these threats. It is very important to assess the situation inside the coal mine in term of safety and security of the mine workers. This paper present the monitoring system design for the coal miner which can detect the hazardous gas, humidity and temperature and with the built in wireless module can send these information to the receiver section.

Keywords: Robot, coal-mines, SAR, sensors, Wireless.

I. INTRODUCTION

Coal mine is a special kind of mine which has underground tunnel system. Sometime in case of any mishap, workers trapped in this underground tunnel and are not able to escape from the tunnel. The environment inside the tunnel some time become very toxic by release of hazardous gas like CO, CO₂, Methane etc [1][2]. Lack of oxygen, smokes and fire are also some other reason responsible for the mishap in the coal mine. In a coal mine when coal is mined, gas is released which is pushed up by the forced ventilate system. In case this forced ventilate system become faulty, gas explosion from coal layer occur and the whole gas is filled in the tunnel. This may cause the death due to suffocation to all the workers in the tunnel. If there is any fire point in the way of the gas then it will cause big gas explosion. Mining tunnel, being in the shape of tube can be dangerous point for the worker in such circumstances. This gas explosion can destroy all the thing inside the tunnel. All the devices and people may be destroyed after the release of the toxic gases. These gases causes a second level of the explosion and fire may broke out inside the tunnel. Under such circumstances, it is very difficult for rescuer to go inside the tunnel. Since it is very difficult to assess the condition inside the tunnel the rescuer may be in danger. So detecting the situation inside the tunnel is the first problem faced by the rescuer. Robot designed for coal mine has many properties which are different from the design of the robot used in the ground[3][4].

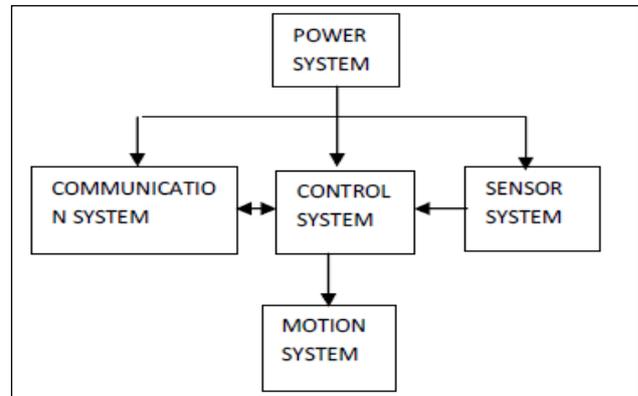


Figure 1 Block Diagram of Robot System

Environment of the coal mine is different from the environment of the ground and therefore it require different designed and character. Since in almost all the coal mine tunnel, explosion of the gas is the main problem which causes the fire to break out in the tunnel. Therefore it is important to design a robot which must be made up of fire-proof device. Since, generally the coal mine tunnel is very narrow and rugged therefore the robot must be designed so as to walk in such condition. Basically Robot consist of some mechanical parts, control system, motion system, communication system, power system and sensor system. Block diagram of a typical robot system is shown in the figure given above. Some of the common reason which lead to the serious accident in the coal mine are flooding, subsidence, collapsing of the roof and explosion. These serious can cause many death cases in the mines. Abandoned underground mine are the serious threat to the operation of the efficient operation of the mine. Many death toll cases in India and abroad under a coal mine reveal that this area require special attention in order to save and protect the life of the miner[5].

This paper present various effort, suggestion and report to fight this menace of coal mine. Some of the noteworthy contribution in this regard is given in the next section. In the past various types of robot rescue system has been developed by various researcher erkman [6] proposed snake robot for rescue, Casper[7] presented Human robot interaction robot during the WTC attack at Newyork, matsuno [8] presented a review on rescue robot in japan,wang[9]presented a design of mobile mechanism for searching the miner, Weixin [10], Gabriely [11], Junyao [12],Murphy [13],Baca[14], Zhigang [15], heng [16], Kuntze [17],mishra [18], Ashwini [19], Bharathi [20] are some other noyeworthy contribution in this field.

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II. PROPOSED MONITORING SYSTEM

In this project, a Monitoring system has been designed which is capable of sensing and assessing the prevailing condition inside the coal mine, take decision or send the information to the operator sitting outside the mine area so that he can take right decision about the prevailing situation inside the mine area. As it has been described in the previous chapter, most of the toll recorded inside the coal mines are due to various reason such as

- i. Sudden leakage of some very harmful and hazardous gases inside the coal mine.
- ii. Sudden explosion of the gases inside the coal mines.
- iii. A very high and unbearable temperature inside the coal mine.
- iv. Unsuitable humidity inside the coal mines.

The above mentioned conditions are always prevail inside the coal mines and it can not be eliminated. But with the help of automatic Robot , we can assess the inside environment of the coal mines for taking remedial action and avoid the mishap. In this work, a coal mine detection robot is designed and developed to fight the above mentioned threats. This robot is capable of sensing the temperature, humidity and hazardous gases inside the coal mine. The heart of this robot is microcontroller which control the various operation of the robot. The system is designed under the VLSI environment.

A. Transmitter Section

The functional block diagram of the transmitter part of the proposed robot for coal mine area is shown in the figure 4.1.

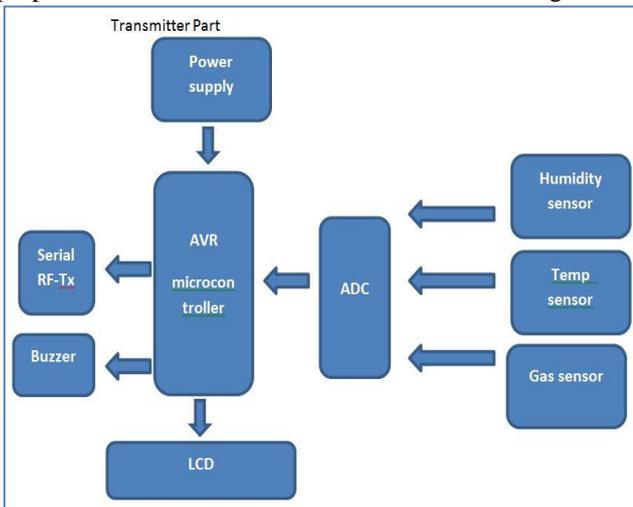


Figure 2 Transmitter part of the proposed system

The transmitter part consist of different block which is described in the next part

- i. Microcontroller- Microcontroller is the part of the proposed system. Microcontroller is basically a kind of device which has some inbuilt memory to keep the data or information, has the capability to take the decision with the help of program stored in its memory. Unlike the microprocessor, microcontroller does not have a processing power i.e. it is not made to perform a very heavy processing task but it was made to perform the controlling function i.e. to control something. For controlling something we need not require the very high end processing devices.

Microcontroller is the heart of this project because it take all the decision with the help of program stored in the memory. Microcontroller comes in different flavors and varieties.

- ii. Power supply- In any electronics system, power supply play a very crucial role because it provide the power for proper functioning of the whole system. Most of the electronics devices are run on +5 volt dc(Direct current). This direct voltage or current can be obtained by either converting the alternating voltage(AC) to direct voltage(DC) with the help of rectifier or battery can directly be used for DC. Since the proposed system is basically a mobile unit, therefore we can not use the AC to Dc conversion process but instead, a battery is used to provide the necessary power to the whole system.
- iii. Humidity Sensor- Sensors are the devices which convert the physical quantity to the electrical quantity. Once the physical quantity is converted in to a electrical quantity then the electrical signal can be used for taking any action. Humidity sensors are the electronics devices which are used to sense the humidity of the environment. Humidity sensor basically convert or map the physical quantity to the electrical quantity. Different kind of humidity sensors are avialbe in the market.
- iv. Temperature Sensor- temperature sensor is used in this project to sense the temperature of the environment. Basically, temperature sensor convert or map the physical quantity to the electrical quantity. Thermo couple is one of the most widely used temperature sensor.
- v. Gas sensor- Gas sensor is used to detect or sense the gases. Again these gas sensor basically establish the relationship between gases and the electrical signal.
- vi. Analog to digital Converter- Output of the sensor is in the form of analog voltage and current (a voltage or current which is changing continuously) which is not suitable as an input to the microcontroller unit of the proposed system. Microcontroller work on digital signal (A signal which has either 1 or zero). Therefore it is important to convert the analog voltage or current to the digital signal. This done by the analog to digital converter (ADC).
- vii. LCD(Liquid Crystal Display)- LCD is used to show the temperature, humidity and the presence of the gases in the visual form. One of the advantage of the LCD is that it take less power than the CRT display.
- viii. Serial R_F-Tx module- Main function of this block is to send and receive the important instruction to and from the operator.
- ix. Buzzer- a buzzer is a device which come to live when some important thing occur. This buzzer is used to indicate the particular condition by giving the beep sound.

B. Receiver Section

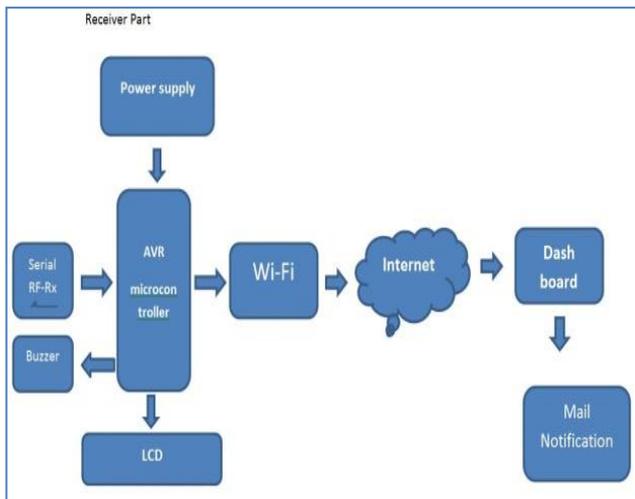


Figure 3 Receiver part of the Proposed system

Just like the transmitter part, receiver part also contain the AVR microcontroller for controlling the different events in this system. AVR micro controller is the heart of this alert system which take the RF signal sent by the transmitter part, and on the basis of this signal it decide the action to be implemented. If temperature of mine area is sending by the transmitter, the receiver part take the signal and send it to the LCD panel which display it. So any one can see any time what is the temperature inside the mines. Same is true for humidity information. The transmitter part also send if there is any harmful gases or not if yes it at once send the signal to the receiver which after taking this signal, display the name of the gases in the LCD panel. In case of detecting the harmful gas or higher temperature than the normal temperature or dangerous humidity condition it will hoot up the buzzer or send the mail to all the recipients or through wireless communication.

Receiver part of the proposed system is shown in the figure 3. the receiver part consist of the following part

- i. RF receiver Port- This port is used to take the RF signal sent from the transmitter part to the microcontroller. Microcontroller receives the RF signal from this port and processes it.
- ii. AVR Microcontroller- In this project AVR microcontroller have been used for Controlling the various activity in the receiver part. This micro controller is a 8 bit microcontroller. It take the input signal from the serial port and according to the signal, generate various control signal.
- iii. LCD- In this system , LCD panel is used for displaying the various condition like temperature value, humidity values and the detected gas name.
- iv. Wi-Fi Module- This module is also incorporated in this project for sending the important information to the Wi-fi campus. All the important Information like temperature, humidity and gas detected can also be transmitted to wireless communication with this wi-fi module. This is essential because if the campus is wi-fi then any one inside the campus is able to receive the environment of the mines easily in his mobile and laptop and take action accordingly. Wi-fi module can also be linked with the internet so that any one inside

the mines, outside the mines or any other places in the world can have the environment condition of the mines by just one click.

- v. Mail Notification Module- This module is designed separately for sending the important information to the miners as well as the person outside the mines. This module work in conjunction with the wi-fi module.
- vi. Dashboard- This is basically system of different types of push button which is sued for carrying out various work like sending the information to the mail, for turning on the buzzer etc. This dashboard is visible and is kept at the upper part of the system so that operator can perform specific task.
- vii. Buzzer- This is an indicator of some crucial events in the mines. If any kind of emergency occur then, microcontroller after receiving the signal from its RF port, activate the buzzer which after activating at once start hooting which alert the other miners.

III. EXPERIMENTAL RESULTS

In order to design and develop the monitoring system using Embedded system, AVR microcontroller has been selected for it being the versatile microcontroller easy to design and has all the in-built capability which is required for making small control system. For detecting and measuring the humidity, and temperature, sensors has been used which sense the the physical quantity and convert it in to the electrical signal.LCD panel is used for displaying the reading of the temperature and the humidity along with the name of the hazardous gas. Gas sensor is used for sensing and detecting the gas. Figure 4 shows the control and wi-fi module for this system. There different number of pins in the module which is used to take out the signal from the board to the other devices. The proposed system is calibrated in such a way so that it produces linear characteristics. The first phase of the system performance checking is the testing which is described in the next section



Figure 4 Control and Wi-Fi Module of the proposed system

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Figure 5 shows the sensor module of the implemented system. These modules are made separately for different sensors and the input and output pins are provided for the convenience of the connection.



Figure 5 Sensor Module of the system

Figure 6 shows the complete monitoring system with sensor, LCD panel, Transformer, rectifier circuit and control module.



Figure 6 Complete monitoring system

Figure 6 shows the module during the implementation steps as can be seen that, transformer is being soldered in the system for step down the AC supply voltage. Transformer here is used to step down the supply line i.e. 230v ac to around 10-15 volt. It is very essential because we cant give the AC supply directly to the control circuit as it contain electronic devices like transistor, Microcontroller IC's LED's and rectifier diode. AC supply voltage of 230 volt is first converted in to a 10-15 volt AC with the help of the transformer. This low voltage ac is then given to the rectifier unit which contain the rectifier diodes. In this project full wave rectifier diode has been designed and used for converting the AC voltage to DC voltage. A full wave rectifier, convert the full AC cycle of the supply line and it is made by using two diode in opposite fashion. Even after converting the AC to DC by the rectifier, some component of the AC still left in the DC voltage produced by the diode. These noisy AC voltage is called pulsating DC as it has a shape of pulse. So it is necessary to filter out the remaining AC component of the pulsating DC before applying it to the

electronics devices. Capacitor offer very high resistance to the AC while negligible resistance to the DC voltage so due to this property it is used for filtering out the AC from the noisy DC. The function of the electrolytic capacitor in this project is therefore to filter out the AC component of the Noisy voltage and make a pure DC. Microcontroller, LCD panel and other digital electronics devices work on +5V DC.



Figure 7 LCD display Module

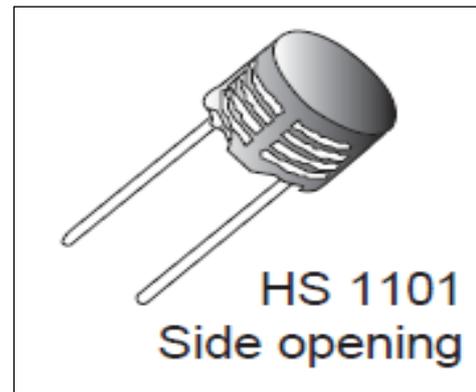


Figure 8 Humidity sensor used in this project

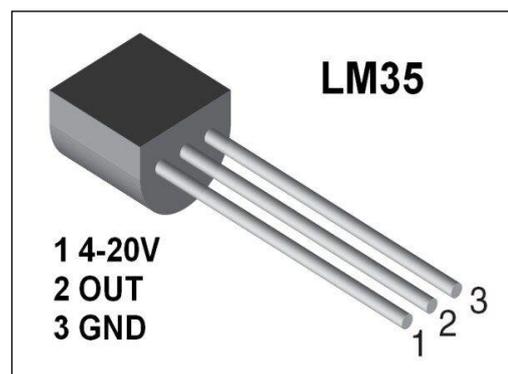


Figure 9 Temperature Sensor LM35



Figure 10 MQ 135 Gas sensor

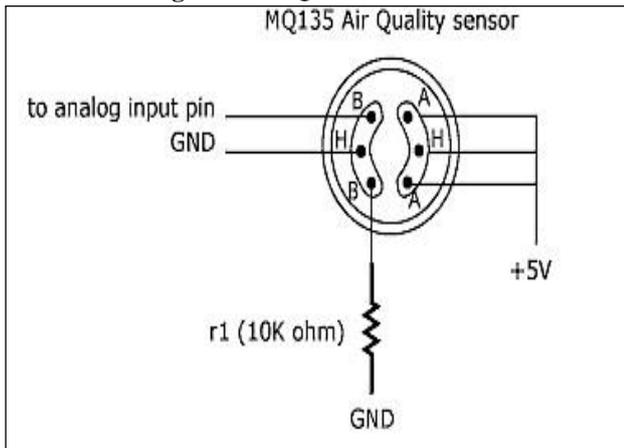


Figure 11 Internal Circuit diagram of MQ 135 Gas Sensor

IV. CONCLUSION

Accident and mishap in coal mine can happen any time. In most of the time, it is important to extend the help to the trapped the miners as early as possible. The situation under the mines is very dangerous after any kind of mishap. It is very important for the rescuer to assess the situation under the mines after such mishap which helps them to plan their rescue operation along with the safety of the recuer time also. Robot being a non living body play very important role under such condition. A tactfully and efficiently designed Monitoring system can perform or help the rescue operation very precisely. In this paper a very efficient monitoring system is proposed which can detect the harmful gases, temperature and humidity inside the mine area and can send these information to the receiver so that one can get the timely rescue operation in case of any mishap. The testing of the system proved that it can detect the harmful gases, temperature and humidity successfully.

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