

# WIRELESS ROBOT FOR COAL MINES BASED ON MIXED SIGNAL PROCESSOR (MSP430)

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**Abstract**— *Coal mining has various fatal factors which menace the people. After a coal mine disaster the situation inside the tunnel is very dangerous as well as situation inside the tunnel is not known to the rescuers. Entering into a mine without knowing the exact situation is dangerous as the chances of second explosion is high as well as the disaster results in increased level of harmful gases like CO, CO<sub>2</sub>, decreased oxygen level and high temperature. Many rescuers are killed by this increased level of harmful gases and second explosion. Detecting this situation inside the tunnel is main objective of this paper. The robot can go into the explosive environment with autonomous obstacle avoidance system. The sensors sense the harmful gases such as CO, CO<sub>2</sub>, Methane, temperature and transmits the data through wireless module. A coal mine robot can move into the mine and detect the level of different toxic gases and temperature level and send the result to the control room. At present, rescue robot using 8052 microcontroller senses the harmful gases & temperature condition in the mine and transmit the data via zigbee wireless technology. In the proposed method, the data can be transmitted through MSP430 based long range wireless module (CC1120) and the controller used for this project is MSP430. The coal mining rescue robot having ultralow power consumption and compact in size.*

**Keywords**— *Mixed Signal Processor 430, Sensors, Wireless Module.*

## I. INTRODUCTION

Coal mine accidents mostly happen due to the presence of toxic and combustible gases inside the tunnel. As earlier the miners used safety lamp and pellistor for detecting toxic gases in the tunnel. Nowadays due to the technological advancement the sensors such as MQ2, MQ4 are used to detect the toxic gases. Thousands of miners die from mining accidents each year, so it is necessary to avoid the tunnel accidents and also detect the toxic gases in the tunnel. Robotics is one of the parts of today's communication. The autonomous obstacle avoidance robot can perform desired task in any kind of environment by using IR sensors in their way without human guidance. The proposed method uses obstacle avoidance system, sensor unit, communication unit.

S.Tejaran, [1] developed a mobile robot which is based on microcontroller (ARM processor) and zigbee wireless technology which consist of gas and temperature sensors. This robot can send into the mine and it will detect the gas content and the data send to the control room by using zigbee wireless technology. The robot movement is controlled by the computer keyboard in the control room and we could able to know the tunnel situation in the control room monitor through wireless camera.

P.Raghuram, [2] designed a robot for enhancing mine safety with zigbee wireless technology. Explosion occurs in the tunnel, the robot can have the capable of detecting the explosion location and it enter into that location before the arrival of resources. This robot gives first aid to miners and sends the environmental condition to the rescue team. This robot has its own automatic obstacle avoidance system and it is implemented with PIC 16 Microcontroller and zigbee wireless technology

T.S.Kumar Reddy, [3] proposed a rescue robot for detecting hazardous gas in coal mines. This robot is based on microcontroller ATMEGA328-PIC and zigbee wireless technology with 2.4GHZ RF band width, It is a type of mobile robot and composed with mechanical, communication, control system. It uses two sensors (LM35, MQ3) for measuring temperature and toxic gases. The data can be transmitted via zigbee wireless technology and the wireless camera also used to transmit the live environment about the tunnel.

PratimaBhagat, [4] presented a robot for hazardous coal mines, It uses proximity sensor to sense the toxic gases present inside the tunnel and it has automatic obstacle avoidance system. The sensor provides the environmental data to the microcontroller and the controller process this data then the environmental condition can be transferred to the control room via serial communication (RS-232).

Chika yinka.Banjo, [5] presented a study of autonomous multi-robot behavior for safety in the underground mines. This paper describes the different kind of safety mechanism in underground mines. The proposed paper focused on two real-time scenarios, a) Inspection about rock falls b) toxic gas

detection in mines. This paper provides better understanding about mine safety.

A.Sivasoundari, [6] developed a surveillance robot for motion detection. This robot is implemented by using microcontroller (PIC 16F877). The aim of this robot is to detect motion automatically around its environment and the robot has the features of live video transmission using CCTV. This method uses USB communication mechanism or transmitting the data to the computer. It has the additional features such as metal sensor for find out the metal and fire sensor for detecting flames.

Nadar Mohamed, [7] surveyed and presented a middleware for robotics. It describes the solution for middleware challenges.

Sabarish Chakkath et al, [8] developed a mobile robot with wireless camera for transmitting the status of the mine. Robot is like a conveyor belt type, so it climb up the obstacle. Gas level is sensed by MQ2&MQ4 sensor and transmitted by RF transceivers works on zigbee technology.

Ibrahim Al-Adwan et al [9] describes zigbee technology to monitor greenhouse climate.

Pradeep Kumar Gubbala et al, [10] presented a hybrid wireless communication system for coal mines. This paper describes a wireless monitoring system for mines. The robot is based on the zigbee and Wi-Fi technology with sensors. This robot uses ARM7 and ARM9 processor and it provides improved safety system for miners.

This proposed paper described about the mining robot with autonomous obstacle avoidance system. This robot uses MQ2 and MQ4 sensor for detecting toxic gas content in the tunnel. Heart of the robot is microcontroller (MSP 430) and the level of different toxic gas content can be transmitted through MSP430 based long range wireless module (CC1120). This proposed robot has the features of I) ultra-low power consumption II) long range data transmission III) Easy data transmission compared to other wireless technology. This is an alternative method for zigbee wireless robot. This robot has an additional feature of temperature sensor itself.

**II. METHODOLOGY**

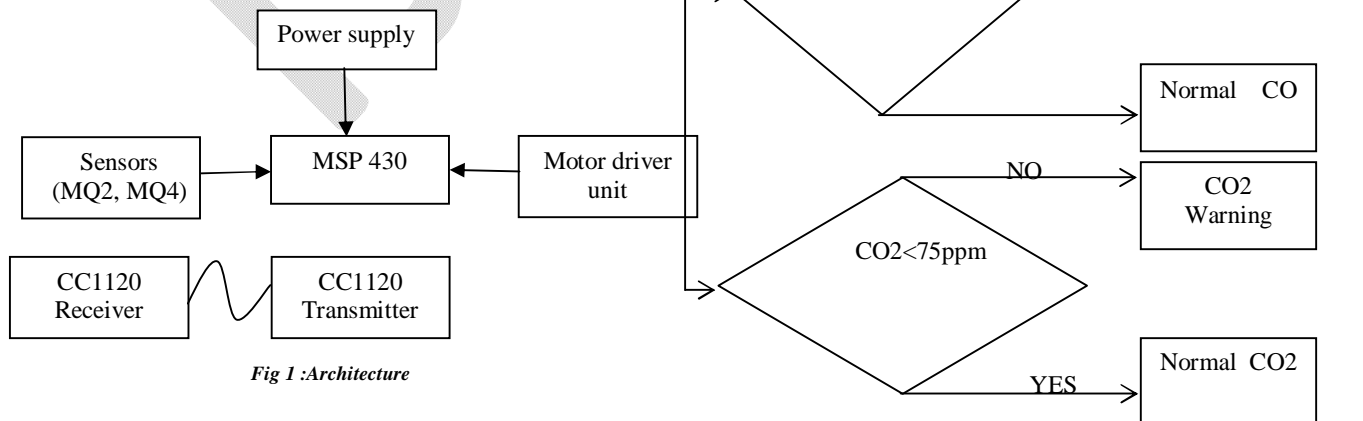


Fig 1 :Architecture

### 2.1 Sensors

A sensor is a device which is used to measure the physical quantity and convert it into the signal. The signal can be read by an observer or by an instrument. The sensor senses the gas content and transmits to the control room through wireless module. This proposed system uses four sensors. It uses two IR sensors for robotic obstacle avoidance system and two gas sensors for detecting toxic gas content. There is no temperature sensor used in this system because the wireless module (CC1120) has the temperature sensor.

Sensor:

- 1) IR Sensor
- 2) Gas sensor (MQ2, MQ4)

IR Sensors:

The IR sensors are used to detect the obstacles on its way. As per the response of IR sensors, the Microcontroller decides the motor rotation. IR sensor helps a robot to sense its environment similar to the sense organs of human being.

MQ4 gas sensor:

It is a semiconductor type analog gas sensor. The MQ4 sensor can detect natural gas, methane, coal gas, co etc. this MQ4 gas sensor has high sensitivity to toxic gases and NO<sub>2</sub> is a sensitive material for this sensor. Normally the conductivity of this sensor is very low in clean air and if any combustible gas exist in the air, the conductivity of this MQ4 sensor is increased along with increase in gas concentration. The concentration range for butane, LPG is 300-10000 ppm

Features:

- 1) Wide detection range
- 2) Stable performance and long life
- 3) Response is very fast

MQ2 gas sensor:

It is also a semiconductor type analog gas sensor. This MQ2 sensor can detect the toxic gases such as Methane, Butane, LPG, Smoke, Propane and Hydrogen. This sensor has high sensitivity and fast response time, so it is highly efficient

Features:

- 1) Simple driver circuit
- 2) Wide range detection
- 3) Stable

### 2.2 . Smart RF transceiver (cc1120)

Smart RF transceiver is a long range wireless module which is under MAP430 and CC1120 is fully integrated with single chip radio transceiver. It is a short range device and the frequency band lies between 16HZ-192MHZ, 410-480 MHZ and 820-960 MHZ.SPI is interfaced with CC1120 to control the operating parameter like voltage and current. This smart RF transceiver is designed for attaining high performance at low voltage and power consumption. This CC1120 transmitter transmits the environmental data and the CC1120 receiver receives the

transmitted data which is located in the control room. The CC1120 display the result via LCD display.

Features:

- 1) High performance transceiver
- 2) Blocking performance 90db at 10 MHZ
- 3) Excellent receiver sensitivity
- 4) 123 dbm at 1.2 Kbps
- 5) 108 dbm at 50Kbps
- 6) 127 dbm using built-in coding gain
- 7) Low phase noise -111 dbe/HZ at 10 KHZ
- 8) Temperature Sensor

### 2.3. Mixed signal processor430

The Texas Instruments MSP430 is an ultra-low power device. This microcontroller is a heart of the robot. The sensor senses the gas level and it is given to the controller. The controller process the data and it converts analog input into digital output for transmission over long distance.

Features of MSP430 are,

1. Operating voltage is very low (from 1.8v to 3.6v).
2. Ultra low power consumption.
  - 0.1μA for RAM data retention.
  - 0.8μA for real time clock mode operation.
  - 250μA/MIPS at active operation.
3. <1μs clock startup.
4. <50nA port leakage.
5. 16 bit RISC CPU.

## III. RESULT AND DISCUSSION

The proposed robot movement is controlled by microcontroller (MSP430) and it uses IR sensor for detecting obstacles.

Table I. Robot Movement Mechanism

Left sensor	Right sensor	Robot movement
NO	NO	Forward
O	NO	Right
NO	O	Left
O	O	Reverse

O- Obstacle present, NO- No obstacle

The robot uses two IR sensors both the left as well as right Sensor does not detect any object then the robot can move forward. The left sensor detect any obstacle and the right sensor does not detect any obstacle, then the robot can move right direction and it is opposite for left direction. Both the sensor detect any obstacle, the robot can move reverse direction.

The sensors MQ2 and MQ4 sensed the CO, CO<sub>2</sub>, smoke at the experimentation time. The sensed data's analog are send to the



microcontroller (MSP430).The processor processed the data and it produced the digital output to RF transmitter (CC1120). This RF transmitter transmits the digital data to the RF receiver in the control room. The control room RF transmitter displayed the gas content normal level (or) warning level.

In this proposed system there is no external temperature sensor for measuring temperature content, because the RF transmitter has the temperature sensor itself. The temperature sensor in the RF transmitter sensed the temperature level and it is transmitted to the receiver. In this system the temperature range is set as 45 degree Celsius as a reference value. The temperature level in the tunnel exceeds above 45 degree Celsius, the receiver displayed the temperature warning. The temperature level exceeds 45 degree c below 45 degree c the receiver displayed as normal temperature.

The reference level for various gases as shown below:

- 1) CO > 15ppm- indicates gas warning.  
     < 15ppm- indicates normal gas level.
- 2) CO<sub>2</sub> > 75ppm- indicates gas warning.  
     < 75ppm- indicates normal gas level.
- 3) Temp > 45 C- indicates temperature warning.  
     < 45 C- indicates normal temperature.

Table II. Operating parameters of controller

Controller	8051	PIC	MSP-430
Voltage	5V	5V	1.8V-3.6V
Frequency range	1MHz-16MHz	20MHz	16MHz

Table III. Comparison of Communication Result with Proposed Method

Technology	Bluetooth (802.15.1)	Zigbee (802.15.4)	Wi-Fi (802.11)	CC1120
Voltage	3.3DC	2.8DC	3.3DC	1.8V-3.6V
Current	50mA	40mA	50mA	22mA
Frequency	2.4GHz	2.4GHz	2.4GHz	3.0GHz
Range (meter)	20-30m	30m+	30m+	1Km
Rate of data transfer	160Kbps	250Kbps	1Mbps	>2Mbps

This proposed robot provides better result compared to other wireless robot. The table 3 shows the comparisons between

different wireless data transmission of proposed system. This clearly indicates the performance of this proposed robot. Table2 indicates the comparison of different controllers with this mixed signal processor (MSP430). The main aim of this robot is ultra-low power consumption and long range data transmission has been achieved.

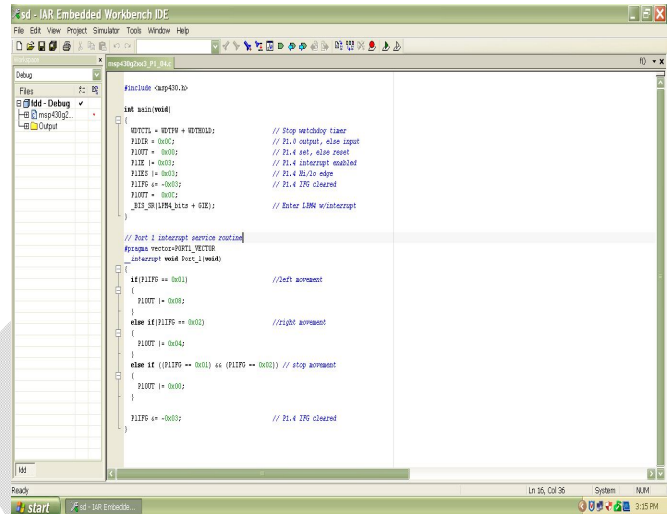


Fig 3: Software Overview (IAR Embedded Workbench)



Fig 4 :Implementation Of Robot

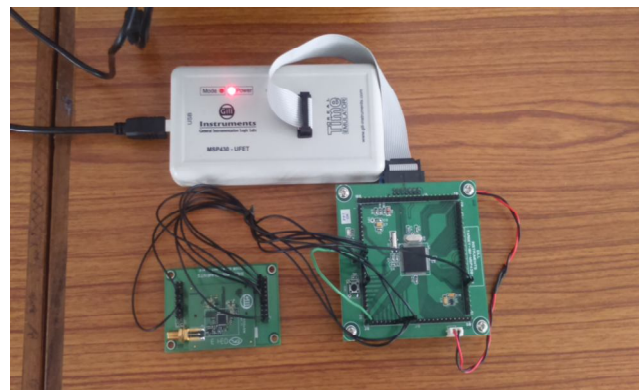


Fig 5 : CC1120 Transmitter section

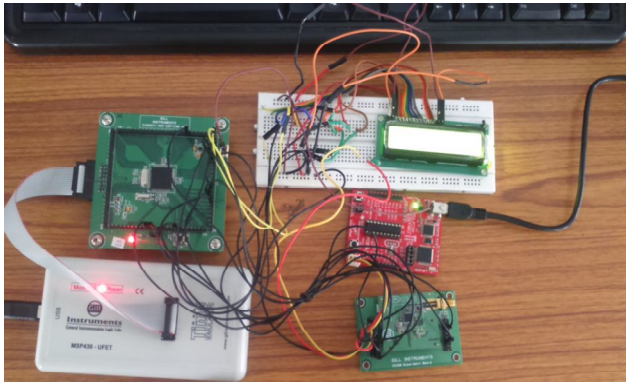


Fig 6 : CC1120 Receiver section

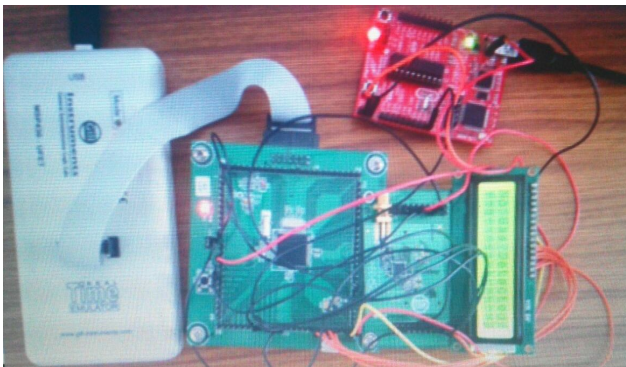


Fig 7 : CC1120 receiver output

#### IV. CONCLUSION

The presence of toxic gases inside the tunnel causes serious problem to the miners and detection of this toxic gases is very difficult for rescue team. The rescue robot provides suitable solution for this problem. This robot enter into the mine and its detect the various combustible gases such as CO, CO<sub>2</sub>, smoke etc. It sends the gas level and temperature level to the control room by using smart RF transmitter (CC1120) with higher performance. The performance were analyzed in terms of operating frequency, voltage of operation, current, rate of data transfer and the range of data transmission by using CC1120 and MSP430. Based on the results obtained this proposed system is concluded that, the robot has ultralow power consumption and long range of data transmission with high efficiency and the Robert will overcome the difficulties in zigbee and Wi-Fi wireless mining Robot.

#### V. FUTURE WORK

This proposed robot transmits only the data such as temperature and various gas levels in the tunnel by using CC1120 transceiver. In future, the robot can be implemented with camera for capturing the environment of the tunnel and live video transmission.

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