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ZigBee and Wi-Fi based Safety System for Mine Workers

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Abstract: The paper addresses a cost-efficient, flexible solution for underground mine workers' safety. A module of sensors and webcam are used for underground environment monitoring and analysing measurement data through digital wireless communication technique is proposed with high accuracy, smooth control and reliability. A microcontroller is used here for gathering data and making decision, based on which the mine worker is informed through alarm as well as voice system. 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 centre. Also the wireless camera is used for visual distant monitoring purpose.

Keywords: ARM Microcontroller, Zig Bee, Methane Sensor, Humidity Sensor, Temperature Sensor, Video Camera and Audio Processor, Wi-Fi connectivity

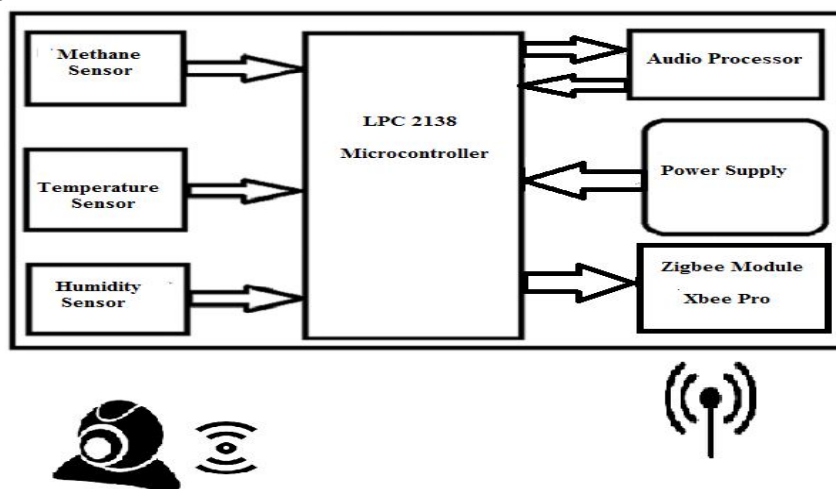
I. INTRODUCTION

Workers safety is one of the main aspects of industry specially in mining industry. In the mining industry safety is a very vital factor. To avoid any unwanted phenomena all mining industry follows some basic precaution and phenomena. Communication is the key factor for any industry today to monitor different parameters and take necessary actions accordingly to avoid any types of hazards. To avoid loss of material and damaging of human health, protection system as well as faithful communication system is necessary inside the underground mines. To increase both safety and productivity in mines, a reliable communication must be established between workers, moving in the mine, and a fixed command center. The wired communication system inside mines is not that much effective. The reliability and long life of conventional communications systems in critical mining environments has always been a problem. Inside mines due to harsh conditional situation the installation cost as well as maintenance cost is high for wired communication networks. It is very difficult to reinstall the wired communication system inside mines after a landslide or damage due to any reasons. If by any means some workers trapped inside mines due to the roof fall, to maintain the continuity of the communication system is very much important to know the actual position and condition of the trapped workers.

II. SYSTEM ARCHITECTUR

The following figure1 shows the block diagram of the system. The entire system is implemented using LPC2138 ARM Controller, Methane sensor, Humidity Sensor, Temperature Sensor, Web Cam, ZigBee, Audio Processor and Wi-Fi.

A. Under Ground Mining Side



B. Ground Control Unit Side

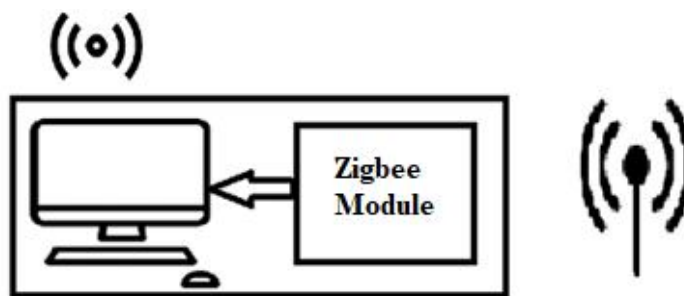


Figure 1: Block diagram of Wireless Surveillance and Safety System

In this proposed system, Methane sensor, temperature sensor and humidity sensor will continuously sense the data and sends to ARM microcontroller. The reading of sensors received by the microcontroller on which data is processed by microcontroller. This processed data is continuously monitored by Ground control unit on the screen. The data is received by the ground control unit with the help of ZigBee, For each sensor data received by microcontroller there is threshold level set. When data received from individual sensors surpasses there corresponding threshold level then an emergency alert get activate automatically on both sides i.e. on miners and Ground Control unit side. Aside of this the more important part of the project is Ground control unit can surveillance the present situation inside mine live with the help of Camera. After examining the previous papers, we introduce visual surveillance which sends live video directly to the Ground Control Unit. For sending live video wirelessly ZigBee is not capable of doing this so we used Wi-Fi technology to send live video status of inside mines.

On the side of Ground Control Unit monitoring people can see both sensors data and live visual status of the underground mines.

C. Power Supply

This project uses two power supplies, one is regulated 5V for web cam and other one is 3.3V for LPC2138. The LM317 three terminal voltage regulator is used for voltage regulation. The LM317 device is an adjustable three-terminal positive-voltage regulator capable of supplying more than 1.5 A over an output-voltage range of 1.25 V to 37 V. It requires only two external resistors to set the output voltage.

D. Temperature Sensor

The temperature sensor is used to measure the temperature inside mines is LM 35. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade). The LM35 does not require any external calibration. The range of temperature sensor is -55°C to 150°C .

E. Methane Sensor

Sensitive material of MQ-4 gas sensor is SnO₂, which with lower conductivity in clean air. When the target combustible gas exist, The sensor's conductivity is more higher along with the gas concentration rising. Please use simple electro circuit, Convert change of conductivity to correspond output signal of gas concentration. MQ-4 gas sensor has high sensitivity to methane, also to Propane and Butane. The sensor could be used to detect different combustible gas, especially methane(CH₄), it is with low cost and suitable for different applications.

F. SY-HS220 Humidity Sensor

This sensor module converts relative humidity(30-90%RH) to voltage and can be used in weather monitoring application.

G. Arm Microcontroller

The ARM Controller (LPC2138) board is the central unit of the system. All the components are interfaced to the board and programmed as per their functionality to operate in synchronization. LPC2138 is the widely used IC from ARM-7 family. The LPC2138 microcontrollers are based on a 32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace high speed flash memory upto 512 kB. It has 128-bit wide memory interface and unique accelerator architecture which enable 32-bit code execution

at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. \

H. Web Cam

The web cam used here is for the purpose of visual monitoring, to monitor internal conditions of underground mines. The web cam used here is running on wifi to send video data wirelessly to the control unit. The specification of web cam are it has 300K pixels (Interpolated 20M pixels still image resolution & 2M pixels video resolution) also have high quality 5G wide angle lens for sharp and clear picture.

I. Apr33a3 audio processor

The APR33a3 is a powerful audio processor with high performance audio analog-to-digital converters (ADCs) and digital-to-analog converters (DACs). The APR33A series are a fully integrated solution offering high performance and unparalleled integration with analog input, digital processing and analog output functionality. The APR33A incorporates all the functionality required to perform demanding audio/voice applications. High quality audio/voice systems with lower bill-of-material costs can be implemented with the APR33A series because of its integrated analog data converters and full suite of quality-enhancing features such as sample-rate convertor.

The APR33A processor is designed very simply such that, user can record their voice and playback the audio message averagely for 1, 2, 4 or 8 voice message(s) by switch, It is suitable in simple interface and need to limit the length of single message, e.g. toys, leave messages system, answering machine etc. Meanwhile, this mode provides the power-management system. Users can let the chip enter power-down mode when unused. It can reduce electric current consumption to 15uA and increase the using time in any projects powered by batteries.

J. Flow Chart Description

Flowchart in the Figure.2 explains how the system works actually, after initializing the system all sensors and web cam start to send respective data from the work place to the ground control unit. The data from web cam is continuously feeded to the ground control unit directly with the help of Wi-Fi technology as shown in flowchart, while sensors data is first processed by ARM controller 2138 where there is a threshold set. If the sensors data is less than threshold set, data is received any how by ground control unit via ZigBee, If data is greater than threshold set then data is received by both ground control unit also it is received by voice codec on work place in which workers are informed quickly about dangerous levels of gases, temperature and humidity so that they can guard themselves from further consequences.

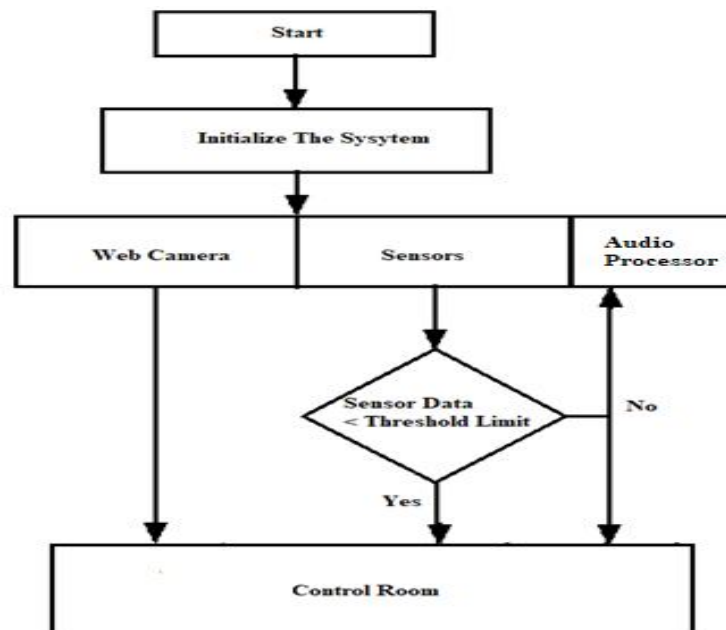


Figure 2: flow chart

III. SOFTWARE DESCRIPTION

We need software for programming the device and make it run according to our needs

A. Matlab (Graphical User Interface)

The main application of GUIs are to make it things simple for the end-users of the program. If GUIs were not used, people would have to work from the command line interface, which can be extremely difficult and frustrating. Imagine if you had to input text commands to operate your web browser (your web browser is a GUI too!). It wouldn't be very practical would it?, Here we have used matlab software as a sophisticated GUI in which we can see sensors data as well as video simultaneously.

B. Keil μ vision3

Keilvision is a freely available software on internet which is mainly used for Embedded Systems. KeilMicro Vision is a free software which solves many of the pain points for an embedded program developer. This software is an integrated development environment (IDE), which integrated a text editor to write programs, a compiler and it will convert your source code to hex files too.

C. Flash Utility

To load the program into the controller, we are using Philips Flash Utility Tool to load the hex codes to the ARM controller through UART port so that we cannot compile the code every time when we are running.

D. Proteus8

Proteus is one of the most famous simulators. It can be used to simulate almost every circuit of electrical fields. It is easy to use because of the GUI interface that is very similar to the real Prototype board. Moreover, it can be used to design Print Circuit Board (PCB). Proteus has features that can generate both analogue and digital result.

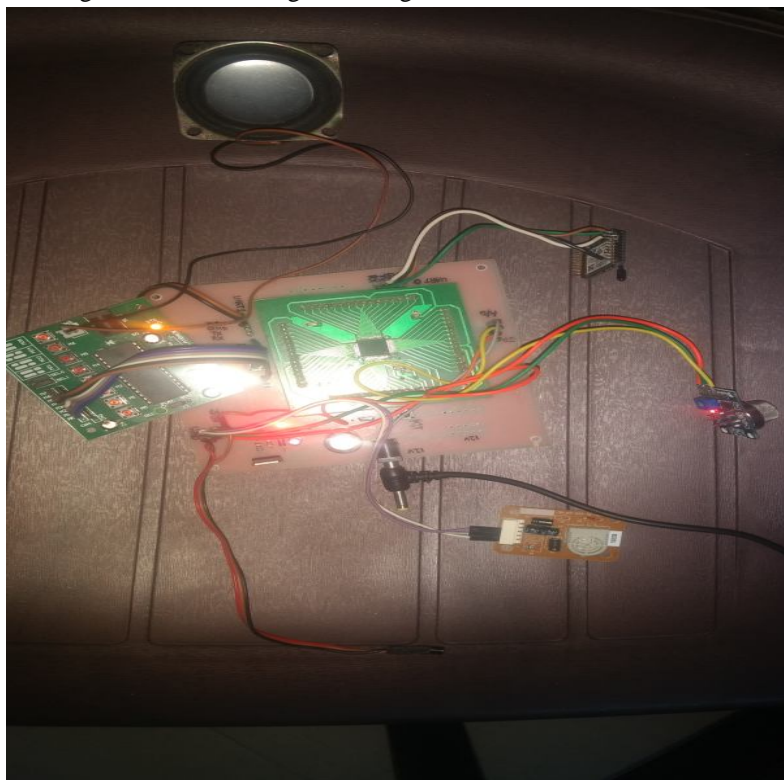


Figure 3 :Snapshot of Proposed system Hardware.

IV. RESULTS

This section describes about final results of a proposed system. In this we can monitor all sensor values obtained by the sensors inside mines on purposefully created GUI. In the below snapshot we can observe humidity, methane and temperature values with their respective graphs.

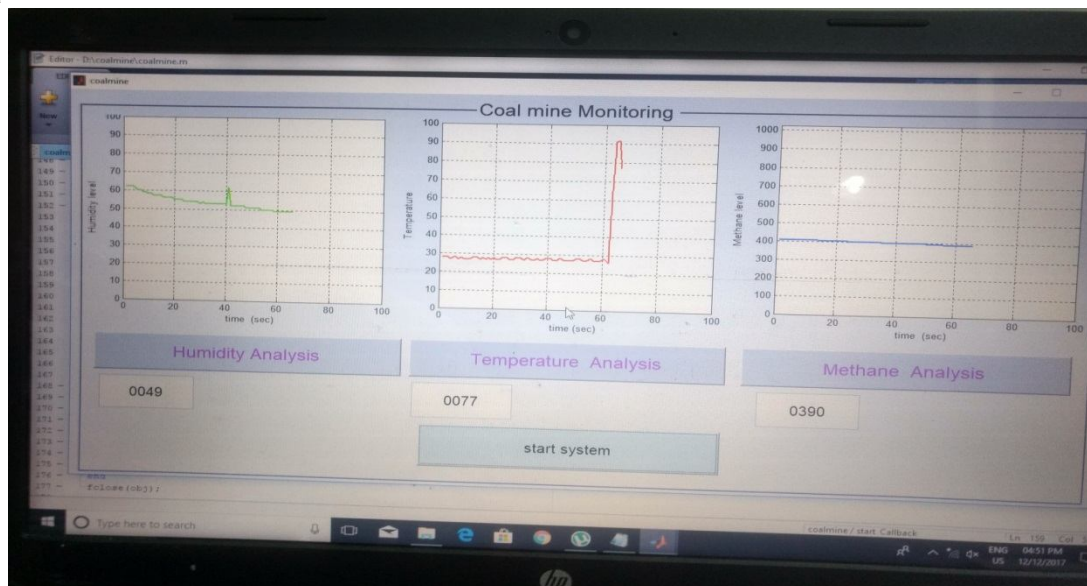


Figure 4: Snapshot of Matlab GUI.



Figure :Snapshot of IP CAM.

V. ADVANTAGES

- A. This is safest and cost efficient system
- B. Works on wireless technology
- C. Very helpful for rescue missions.
- D. Quick alert to mine workers against fatal hazards.
- E. Less power consumption
- F. The safety of mine workers inside mine increases.

VI. CONCLUSION

The project is thus carried out using ARM7 with the help of zigbee and wifi technologies. The system used to alert mine workers inside mines from the hazardous poisonous gaseous concentration also from unbearable temperature and humidity conditions. This system also have one important advantage with it, it can be very helpful for rescue mission in case of any fatal incident as it consist of wireless video monitoring.

VII. FUTURE SCOPE

The project scope involves the add-on of inbuilt full duplex voice transmission in between ground control and miners also improvement on signal strengthening and reachability of wireless signal.

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