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HETEROGENEOUS NETWORK FOR COAL MINE SAFETY SYSTEM

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ABSTRACT

A wireless sensor network is composed of a large number of sensor nodes that communicate with each other possibly through multi-hop wireless links despite the absence of any fixed administration or established infrastructure. To design a heterogeneous wireless sensor networks for harsh industrial environments, considering the location accuracy, the communication performance, the intrinsic safety and other requirements. Here in this project we automate the coal mine unit and ensure the safety of the unit. The main reason being that given the intricacies in the physical structure of a coal mine, only low power WSN nodes can produce accurate surveillance and accident detection data.

Keywords: Communication protocol, Radio Frequency (RF), Wireless Sensor Networks (WSNs).

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1. INTRODUCTION

Embedded systems has deployed in many areas. Implementation of embedded system can avoid a hazard in many areas. It can avoid human made errors. It can sense an accurate data and can execute an approximate response regarding to that collected data. It can work on the place where even a human entry is risky. So we can easily interface an embedded system in a highly risky areas like coal mines, gold mines, oil resources etc. Our project is mainly focused in the area of coal mines to protect the human beings from a hazard. In our project, we are going to sense the methane level, temperature data and moisture level. These three data are very important in terms of the coal mine areas. Our project is related to an embedded system. So the total control of the project can be controlled by a microcontroller.

A microcontroller used here in our project is PIC16F877A. Three parts available in this system. They are monitoring unit, sensing unit and person availability checking unit. The block diagram of each unit is as shown in the following figure. Each unit has one

microcontroller. Monitoring unit will receive a data from the sensing unit whereas sensing unit is continuously monitoring the above mentioned data. The methane concentration, temperature level and the moisture level has been sensed and send to the monitoring unit simultaneously. Another unit is a person availability checking unit. Every employee has this unit to check their presence. It is also will send to the monitoring unit. So the monitoring unit will monitor the sensing data as well as the availability of the employees. The description of each blocks have described in the upcoming sections.

2. LITERATURE REVIEW

- The existing monitoring system underground of coal mine mostly use as ZigBee. This kind of network has poor performance of expansion. The ZigBee have high incidence of failure.
- A comprehensive review of existing approaches for mine monitoring has been presented. For the base protocol, most works have relied on Zigbee for its ease of deployment, low data rate (250 kb/s), substantial range and most importantly low power consumption when compared to other technologies such as Wi-Fi, bluetooth and ultra wideband communication. So this paper targets an even lower data rate and lower frequency protocol. Due to the simple direct energy-bandwidth relationship; lower data rate projects better energy efficiency and lower frequency promises higher range.
- ZigBee is a general purpose protocol. Although nodes can be configured to some extent, the nodes are randomly deployed and the network is formed and operates dynamically. This means that it does not benefit from known characteristics such as signal attenuation, network topology, and routing.
- As we know safety is one of the main aspects of industry specially mining industry as coal is the ultimate natural fuel of the world. To avoid any types of unwanted phenomena, all mining industry must follow some basic precaution.
- Communication is the main key factor for any industry today to monitor different parameters and take necessary action accordingly to avoid many 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.
- Accordingly, development of mine monitoring system to accurately detect temperature, pressure, flammable and poisonous gas and to track underground miners and vehicles on real-time has significant meaning to safety protection and rescue of coal mine disaster.

Drawbacks

- Underground mining is inherently dangerous and its safety monitoring is a complex activity.
- The existing systems lack of monitoring in the most hazard working area
- Due to homogeneity, some nodes are getting over burdened.
- Highly efficient nodes are wasted in low level application.
- The existing monitoring system underground of coal mine mostly use as ZigBee.
- This kind of network has poor performance of expansion. The ZigBee have high incidence of failure.

3. PROPOSED SYSTEM

- Embedded systems has deployed in many areas. Implementation of embedded system can avoid a hazard in many areas. It can avoid human made errors. . It can sense an accurate data and can execute an approximate response regarding to that collected data. It can work on the place where even a human entry is risky.
- So we can easily interface an embedded system in a highly risky areas like coal mines, gold mines, oil resources etc., our project is mainly focused in the area of coal mines to protect the human beings from a hazard. In our project, we are going to sense the methane level, temperature data and moisture level.
- These three data are very important in terms of the coal mine areas. Our project is related to an embedded system. So the total control of the project can be controlled by a microcontroller. A microcontroller used here in our project is PIC16F877A.
- Three parts available in this system. Those are, monitoring unit, sensing unit and person availability checking unit. The block diagram of each unit is as shown in the following figure. Each unit has one microcontroller. Monitoring unit will receive a data from the sensing unit whereas sensing unit is continuously monitoring the above mentioned data.
- The methane concentration, temperature level and the moisture level has been sensed and send to the monitoring unit simultaneously. Another unit is a person availability checking unit. Every employee has this unit to check their presence. It is also will send to the monitoring unit. So the monitoring unit will monitor the sensing data as well as the availability of the employees.
- Every data will be entered and saved in the PC using the PC interface-RS 232 port. The description of each blocks have described in the upcoming sections.

4. BLOCK DIAGRAM

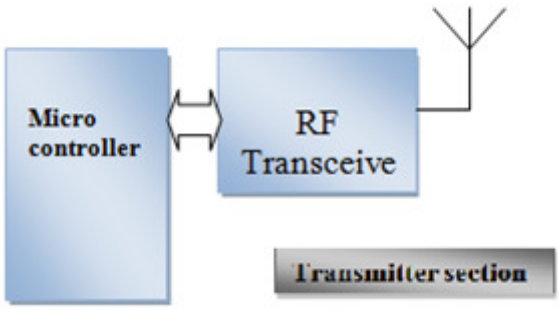


Figure 1 TRANSMITTER SECTION

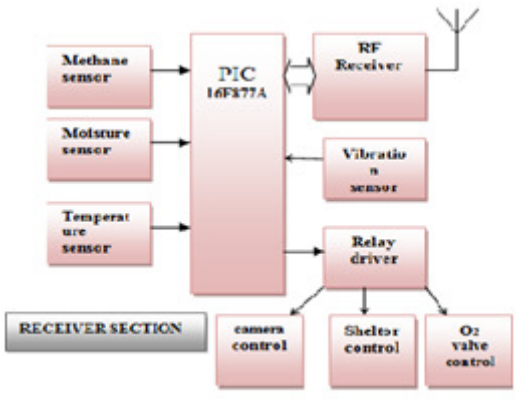


Figure 2 RECEIVER SECTION WITH CONTROL SIGNALS

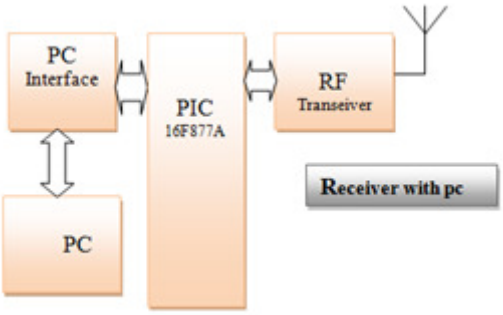


Figure 3 RECEIVER SECTION WITH PC SECTION.

ADVANTAGES

- The proposed system meets the requirements of low-latency, high data fidelity, fully and reliable coverage on the underground mining tunnels.
- Provides the system with a higher ability to recover from errors and a better flexibility to change their behavior at execution time.
- The networks are highly efficient, with highest Quality of service.

5. HARDWARE MODULE

A). POWER SUPPLY UNIT

Every circuit needs a source to give energy to that circuit. The sources will a particular voltage and load current ratings. The following is a circuit diagram of a power supply. We need a constant low voltage regulated power supply of +5V, providing input voltages to the microcontroller RS232, LM311 and LCD display which requires 5 volts supply.

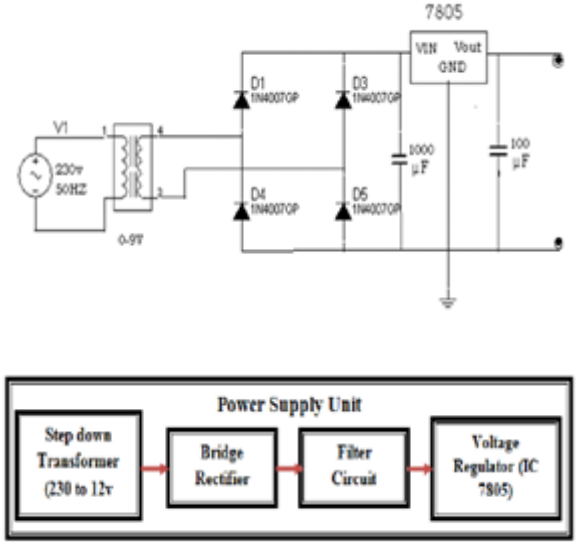


Figure 4 POWER SUPPLY DESIGN

Every power supply has the following parts:

1. Transformer, 2.Capacitor, 3.Resistor, 4.Rectifier, 5.Regulator.

B) PIC16F877A MICROCONTROLLER

PIC microcontroller is the smallest microcontrollers that can be programmed to carry out a huge range of tasks. These microcontrollers are found in many electronic devices such as phones, computer control systems, alarm systems, systems. Every PIC microcontroller architecture consists of some registers and stack where registers function as Random Access Memory (RAM) and stack saves the return addresses. The main features of PIC microcontrollers are RAM, flash memory, Timers/Counters, EEPROM, I/O Ports, USART, CCP(Capture/Compare/PWM module), SSP, Comparator, ADC (analog to digital converter), PSP (parallel slave port), LCD and ICSP. The 8-bit PIC microcontroller is classified into four types on the basis of internal architecture such as Base Line PIC, Mid Range PIC, Enhanced Mid Range PIC and PIC18.

PIC microcontrollers appeal in the fields of electronics and robotics. Key features include wide availability, low cost, ease of reprogramming with built-in EEPROM an extensive collection of free application notes, abundant development tools, and a great deal of information available on the Internet. Every PIC microcontroller has a set of registers that also function as RAM (random access memory). Special purpose control registers for on-chip hardware resources are also mapped into the data space. Every PIC has a stack that saves return addresses. The stack was not software-accessible on the earlier versions of the PIC, but this limitation was removed in later devices.

ARCHITECTURE OF PIC

The PIC architecture is characterized by its multiple attributes:

- Separate code and data spaces (Harvard architecture) for devices other than PIC32, which has Von Neumann architecture.
- A small number of fixed length instructions
- Most instructions are single cycle execution (2 clock cycles, or 4 clock cycles in 8-bit models), with one delay cycle on branches and skips
- One accumulator (W0), the use of which (as source operand) is implied (i.e. is not encoded in the opcode)
- All RAM locations function as registers as both source and/or destination of math and other functions.[3].

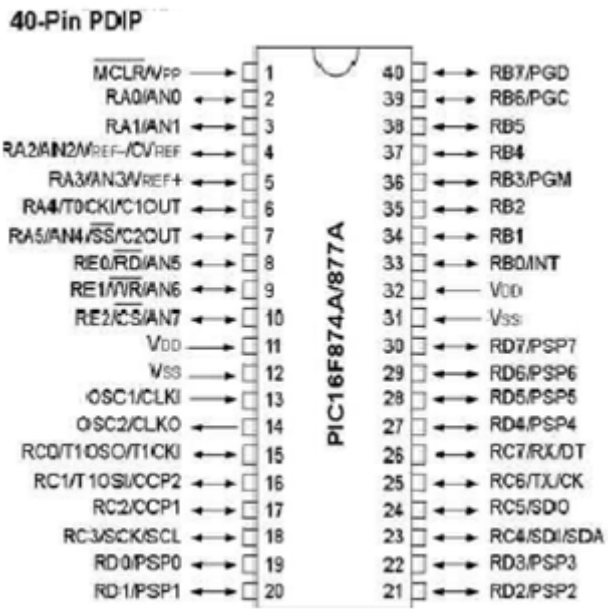


Figure 4B 16F877A PIC MICROCONTROLLER PIN DIAGRAM

- A hardware stack for storing return addresses
- A fairly small amount of addressable data space (typically 256 bytes), extended through banking
- Data space mapped CPU, port and peripheral registers
- The program counter is also mapped into the data space and writable (this is used to implement indirect jumps). There is no distinction between memory space and register space because the RAM serves the job of both memory and registers and the RAM is usually just referred to as the register file or simply as the registers.

C) RF TRANSMITTER & RECEIVER

The RF module, as the name suggests, operates at Radio Frequency. The corresponding frequency range varies between 30 kHz & 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as Amplitude Shift Keying (ASK).

Transmission through RF is better than IR (infrared) because of many reasons. Firstly, signals through RF can travel through larger distances making it suitable for long range applications. Also, while IR mostly operates in line-of-sight mode, RF signals can travel even when there is an obstruction between transmitter & receiver. Next, RF transmission is more strong and reliable than IR transmission. RF communication uses a specific frequency unlike IR signals which are affected by other IR emitting sources. This RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.

The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter. The RF module is often used along with a pair of encoder/decoder. The encoder is used for encoding parallel data for transmission feed while reception is decoded by a decoder. HT12E-HT12D, HT640-HT648, etc. are some commonly used encoder/decoder pair ICs.

This encoder-decoder pair supports 4 bit parallel data. The circuit has two parts transmitter and receiver. In the transmitter part we are using HT12E for encoding data from parallel to serial. The serial output from the encoder is fed to the data IN of the RF transmitter. Four switches namely SW0, SW1, SW2, SW3 are used to input data to the decoder. These switches are pushbutton switches with active low states. (i.e. when you press it, the data input will be '0' and in the released state data input will be '1'. The default state is '1'). At the receiver section we are having RF receiver and HT12D decoder IC. The serial data from the receiver is fed into to serial input of the decoder. The parallel data is displayed with the help of LED's.

D). RELAY DRIVER

A relay is an electromechanical switch operated by a relatively small electric current that can turn on or off a much larger electric current. The heart of a relay is an electromagnet (a coil of wire that becomes a temporary magnet when electricity flows through it). You can think of a relay as a kind of electric lever switch it on with a tiny current and it switches on ("leverages") another appliance using a much bigger current. Why is that useful? As the name suggests, many sensors are incredibly sensitive pieces of electronic equipment and produce only small electric currents. But often we need them to drive bigger pieces of apparatus that use bigger currents. Relays bridge the gap, making it possible for small currents to activate larger ones. That means relays can work either as switches (turning things on and off) or as amplifiers (converting small currents into larger ones).

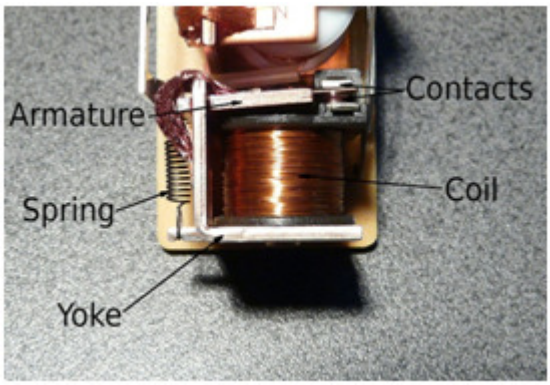
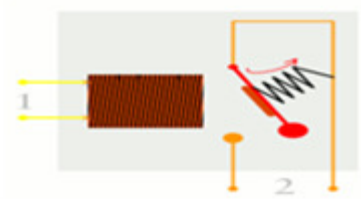


Figure 4D SIMPLE ELECTROMECHANICAL RELAY

HOW RELAY WORKS

Here are two simple animations illustrating how relays use one circuit to switch on a second circuit.



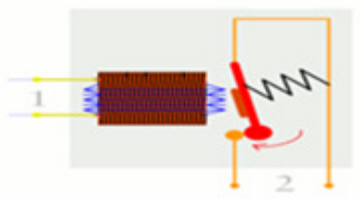


Figure 4E(a) RELAY OFF

Figure 4E(b) RELAY ON

When power flows through the first circuit (1), it activates the electromagnet (brown), generating a magnetic field (blue) that attracts a contact (red) and activates the second circuit

(2). When the power is switched off, a spring pulls the contact back up to its original position, switching the second circuit off again.

E) SENSORS

- 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. Cheaper sensors -often for home use- are based on two electrodes measuring the resistance of the soil.
- Vibration sensors are sensors for measuring, displaying, and analyzing linear velocity, displacement and proximity, or acceleration. Vibration sensor is used to Abnormal vibration indicative of problems with an industrial machine can be detected early and repaired before the event of machine failure.
- A gas detector is a device that detects the presence of gases an area, often as part of a safety system. This type of equipment is used to detect a gas leak and interface with a control system so a process can be automatically shut down.
- LM35 is a IC temperature sensor. The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self heating and does not cause more than 0.1 ^{o}C temperature rise in precision still air.

6. SOFTWARE MODULE EMBEDDED C

Embedded C is a set of language extensions for the C programming Language by the C standard committee to address commonality issues that exist between C extensions for different embedded systems. Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as Fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.

In 2008, the C Standards Committee extended the C language to address these issues by providing a common standard for all implementations to adhere to. It includes a number of features not available in normal C, such as, fixed-point arithmetic, named address spaces, and basic I/O hardware addressing.

Embedded C uses most of the syntax and semantics of standard C, e.g., main() function, variable definition, data type declaration, conditional statements (if, switch case), loops (while, for), functions, arrays and strings, structures and union, bit operations, macros, etc. Embedded C has several keywords that are not present in C. These keywords are associated with operations needed by microprocessors. You will need to be familiar with all of them to be able to write Embedded C programs.

7. CONCLUSION

The project has been checked with both software and hardware testing tools. In this work "Methane Sensor, Moisture Sensor, Temperature Sensor, Micro controller, RF transceiver" are chosen are proved to be more appropriate for the intended application. The project is having enough avenues for future enhancement. The project is a prototype model that fulfills all the logical requirements. The project with minimal improvements can be directly applicable for real time applications. Thus the project contributes a significant step forward in the field of "**Industrial security system**" and further paves a road path towards faster development s in the same field. The project is further adaptive towards continuous

performance and peripheral up gradations. This work can be applied to variety of industrial and commercial applications.

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