WSN Based Smart Surveillance and Safety System for Coal Mines

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ABSTRACT:

This paper presents a low power, cost-effective, and ZIGBEE protocol based wireless sensor network that provides an intelligent surveillance and safety system for underground coal mines. The system consists of wireless connection of several nodes. Sensor node mainly consists of ZIGBEE protocol based low power CC2530 transceiver integrated with a high performance, low power microcontroller on single chip. This integrated chip connected through RF connector on smartRF05 Battery Board. This small size, low power device is easily interfaced with desired miniature size sensors. Wireless sensor nodes join to other sensor node in specific multi-hop mesh network topology, that creates a Zigbee based wireless sensor network. This network can be easily placed in underground mines and it provides an effectively surveillance and safety system for underground coal miners. Especially, it provides the real-time data communication between miners and surface control room through highly secure, reliable wireless sensor nodes. The proposed system improves the existing miner's safety and early warning surveillance in underground coal mines.

Index Terms: WSN, ZIGBEE, GPRS.
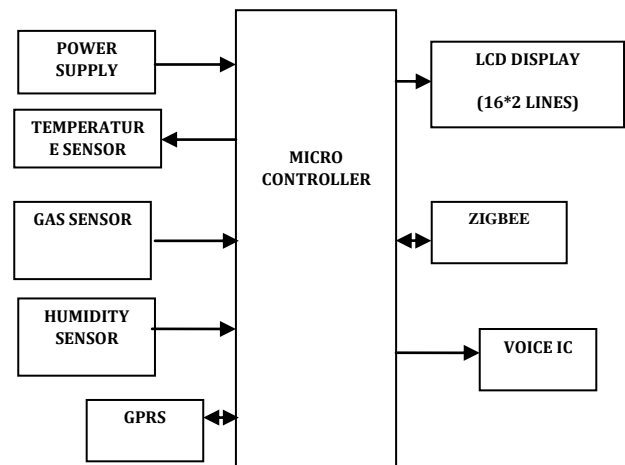
I. INTRODUCTION:

Wireless Sensor networks (WSNs) is an emerging technology that are used in many applications including environment monitoring, home and building automation, lighting control, medical and military applications. A wireless Sensor network consists through joining of several sensor nodes which have included communication and sensing capabilities.

Wireless sensor network consists of large number of sensor nodes in mesh topology. Wireless sensor network performs the data collection from more than one environment parameters by single sensor node. So that, the supervisors can interprets the data or take immediate necessary actions. This network provides the real-time environmental conditions, therefore it will be definitely reduce the frequency of disaster occurs in mines due to sensitive parameters and which improved the performance of surveil1ance and safety system for underground coal mines. A distinct competitive advantage through new revolution in industrial monitoring by wireless is stated in IEEE 802.15.4/Zigbee global standard protocol defined for low-power, low-rate and cost-effective wireless sensor network is developed for automation and wireless environment monitoring.
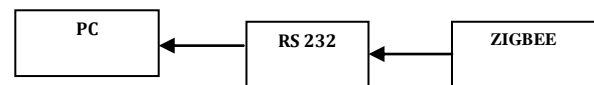
Many applications have been designed based on the Zigbee 2003, ZigBee 2006 version of device such as building automation, security systems, remote control, and smart energy metering. The ZigBee standard utilizes of IEEE 802.15.4 standard and that combinations are made a complete stack. In this paper presented the analysis of wireless data packets and the performance of 802.15.4/ZigBee wireless sensor network for real-time environmental monitoring in underground coal mines. Mining industries in India or other countries, mostly leaky feeder based communication system are used in underground mines. Coaxial cables are the backbone of the whole system and it runs along the underground mines. Coaxial cable emits and receives radio waves for communication purpose, and it behaves as an extended antenna. The radio waves signal is usual1y used by portable transceivers, which are carried by miners.

Leaky feeder based system are more complex and unreliable data communication between underground mine workers and on the surface control room. Industrial safety is one of the main aspects of industry specially mining industry. In the mining industry safety is a very vital factor. To avoid any types of unwanted phenomena all mining industry follows some basic precaution and phenomena. Communication is the main key factor for any industry today to monitor different parameters and take necessary actions accordingly to avoid any types of hazards. In this project the microcontroller continuously collects the sensor values and sends to ground section and also checks the sensor conditions. If the sensors conditions are normal it won't gives the alarm. If any sensor value is abnormal it will give the voice announcement with the help of voice IC (APR9600). In ground section will receive the sensor values and sends to PC. To communicate ground section and underground section we are using the Zigbee communication.

II. HARDWARE SYSTEM:

Micro Controller:

This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, Pull up resistors (if needed) and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

ARM7TDMI:

ARM is the abbreviation of Advanced RISC Machines, it is the name of a class of processors, and is the name of a kind technology too. The RISC instruction set, and related decode mechanism are much simpler than those of Complex Instruction Set Computer (CISC) designs.

Liquid-crystal display (LCD) is a flat panel display, electronic visual display that uses the light modulation properties of liquid crystals.

Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock.

Fig: Underground Mining Section

Fig: Ground control section

III. Board Hardware System Features:

Temperature Sensor:

A Thermistor is a type of resistor whose resistance is dependent on temperature. Thermistors are widely used as inrush current limiter, temperature sensors (NTC type typically), self-resetting over current protectors, and self-regulating heating elements. The TMP103 is a digital output temperature sensor in a four-ball wafer chip-scale package (WCSP). The TMP103 is capable of reading temperatures to a resolution of 1°C.

Fig: Temperature sensor

Humidity Sensor:

Humidity sensor is a device that measures the relative humidity of in a given area. A humidity sensor can be used in both indoors and outdoors. Humidity sensors are available in both analog and digital forms. An analog humidity sensor gauges the humidity of the air relatively using a capacitor-based system. The sensor is made out of a film usually made of either glass or ceramics. The insulator material which absorbs the water is made out of a polymer which takes in and releases water based on the relative humidity of the given area. This changes the level of charge in the capacitor of the on board electrical circuit. A digital humidity sensor works via two micro sensors that are calibrated to the relative humidity of the given area. These are then converted into the digital format via an analog to digital conversion process which is done by a chip located in the same circuit. A machine made electrode based system made out of polymer is what makes up the capacitance for the sensor. This protects the sensor from user front panel (interface).

Fig: Humidity sensor

Gas Sensor:

They are used in gas leakage detecting equipments in family and industry, are suitable for detecting of LPG, i-butane, propane, methane, alcohol, Hydrogen, smoke. The surface resistance of the sensor Rs is obtained through effected voltage signal output of the load resistance RL which series-wound. The relationship between them is described: $Rs\backslash RL = (Vc-VRL) / VRL$

Fig: Gas sensor

GPRS:

GPRS (general packet radio service) is a packet-based data bearer service for wireless communication services that is delivered as a network overlay for GSM, CDMA and TDMA (ANSI-I36) networks. GPRS applies a packet radio principle to transfer user data packets in an efficient way between GSM mobile stations and external packet data networks. Packet switching is where data is split into packets that are transmitted separately and then reassembled at the receiving end. GPRS supports the world's leading packet-based Internet communication protocols, Internet protocol (IP) and X.25, a protocol that is used mainly in Europe. GPRS enables any existing IP or X.25 application to operate over a GSM cellular connection. Cellular networks with GPRS capabilities are wireless extensions of the Internet and X.25 networks.
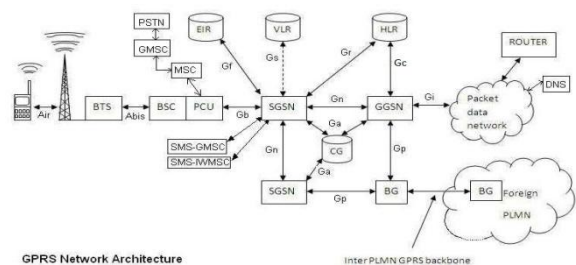
Fig: GPRS Architecture

ZIGBEE:

Zigbee modules feature a UART interface, which allows any microcontroller or microprocessor to immediately use the services of the Zigbee protocol. All a Zigbee hardware designer has to do in this case is ensure that the host's serial port logic levels are compatible with the XBee's 2.8- to 3.4-V logic levels. The logic level conversion can be performed using either a standard RS-232 IC or logic level translators such as the 74LVTH125 when the host is directly connected to the XBee UART. The below table gives the pin description of transceiver. The X- Bee RF Modules interface to a host device through a logic-level asynchronous Serial port.

Through its serial port, the module can communicate with any logic and voltage Compatible UART; or through a level translator to any serial device. Data is presented to the X-Bee module through its DIN pin, and it must be in the asynchronous serial format, which consists of a start bit, 8 data bits, and a stop bit. Because the input data goes directly into the input of a UART within the X-Bee module, no bit inversions are necessary within the asynchronous serial data stream. All of the required timing and parity checking is automatically taken care of by the X-Bee's UART.

VOICE IC:

The APR9600 device offers true single-chip voice recording, non-volatile storage, and playback capability for 40 to 60 seconds. The device supports both random and sequential access of multiple messages. Sample rates are user- selectable, allowing designers to customize their design for unique quality and storage time needs. Integrated output amplifier, microphone amplifier, and AGC circuits greatly simplify system design. The device is ideal for use in portable voice recorders, toys, and many other consumer and industrial applications.

• Single-chip, high-quality voice recording & playback solution
- No external ICs required
- Minimum external components
• Non-volatile Flash memory technology
    - No battery backup required
• User-Selectable messaging options
- Random access of multiple fixed-duration messages
- Sequential access of multiple variable-duration messages
• User-friendly, easy-to-use operation
- Programming & development systems not required
- Level-activated recording & edge-activated play back switches
• Low power consumption
- Operating current: 25 mA typical
- Standby current: 1 uA typical
- Automatic power-down
• Chip Enable pin for simple message expansion

Fig: Voice IC 9600

IV. CONCLUSION:

Through joining of wireless sensor nodes, a wireless sensor network is developed. With the help of this network, data from the different sensors are transmitted from one node to other node and are effectively collected by a PC. It is observed that ZIGBEE based wireless transmission is most suitable for underground coal mines for its low power, low cost intrinsic safe characteristics. Real time environmental data in underground mines are collected through sensor nodes and continuous data transmission to the surface control room is possible through wireless network. This will enhance the safety of the miners working underground with additional reliability and flexibility.

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