Implementation of Real time Detection of Gas leakage in Industries using ARM7 &ZigBee

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Abstract

In this Paper hardware for gas leakage detection and accurate location identification system for the production safety in any risky Industries is proposed. The detection and location are implemented based on Wireless Sensor Networks (WSN). However, formerly the system was developed using Virtual Instrumentation. Based on ZIGBEE and ARM7, the system is easy to be deployed and overcomes the shortcomings on current systems. Using number of nodes at different places of risky areas, this system can detect the leakage of gas and immediately sends the details of that location to the observer. It is used to improve the rescue quality and shorten the time for rescue. Therefore it can compensate for the weaknesses of existing systems.

Index terms: Leakage detection, ARM7, Wireless Sensor Networks; ZIGBEE, Gas sensor.

1. Introduction

Leakage detection and location is one of the paramount concerns of pipeline operators all over the world. A timely evaluation and response to a leakage, allows proper management of the consequences and an effective risk minimization [2]. With the continuing growth of the forces of social production and the gradual awakening of the people's consciousness of the importance of production safety, a series of measures have been put forth to ensure worker's safety. In high-risk industries such as chemical, electricity and cement industries, small negligence may cause heavy economic losses and serious environmental pollution. Therefore, many large companies, including Petro China and Sinopec, are pumping large amounts of funds to upgrade existing equipment in order to remove the hidden danger.

However, there are still some shortcomings on real-time monitoring and on data transmission and accurate location of a leakage point when an accident happens. Mainly because: most of the current equipments are based on wired networks, it is backward in technology and hard to be deployed; the technology of data acquisition in accidents is also backward and so it is hard to locate the leakage point. These problems can be solved with the help of Wireless Sensor Networks.

2. Model of the System

The gas leak detection and location system consists of three parts: PC, coordinator and terminal nodes. There are number of terminal nodes. Each node is placed at different locations of the risk areas in the industries or at the gas pipe lines. The coordinator always collects the data from monitoring sites. This information will send to the PC to update the values of monitoring sites in the PC, it displays the location and the status messages of all the monitoring sites, and it is a graphical description of the geographical information of the entire potential risk area.

This system can be used in two application modes. We considered WSNs which combine mobile and static sensors [3]. They are Static monitoring and Dynamic deployment.

Static monitoring is to fix some terminal nodes near the potential risk areas, such as: joins of containers, reaction kettles and pipelines and places that are easy to be eroded or broken [1]. In this way, the system can track the monitoring data for these areas round-the-clock or in one time period. Leakage is the main problem when conveying gases through pipelines. Trace leakage is mainly caused by erosion, bad connection and external forces and so on; it is a hidden fire danger or causes of other serious accidents. But it is hard to find out. By means of this method, it is easy to warn ruinous accidents caused by leakage.

Dynamic deployment is one of the main topics that directly affect the performance of the wireless sensor networks [3]. Throw some terminal nodes through ejection of a robot or at some height, and then all the information of the distribution of temperature and gas thickness can be collected. The location of the leakage point can be known from the analysis of the information. In the past, rescuers cannot approach the accident spot in a long time because of the toxic gas, high temperature or heavy fog. It is hard to rescue and deal with the problems in time. However, the system provides reference for an

effective rescue plan and can help to shorten salvage time.

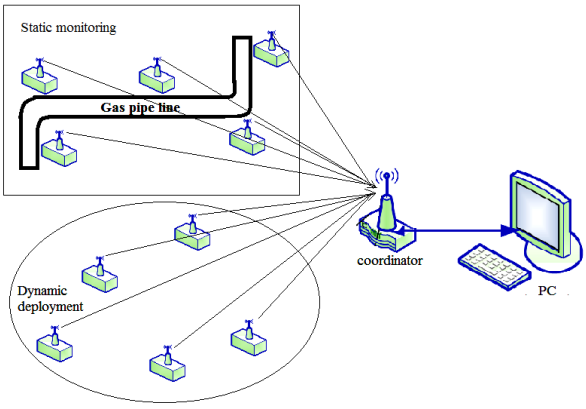

Fig.1.Model of the system

In both Static monitoring and Dynamic deployment all the nodes are directly in contact with the coordinator to transmit the information.

3. System Design

A. Hardware Approach

The entire system consists of number of terminal nodes, coordinator and PC.

I. Terminal Node as a Transmitting section: Each terminal node consists of Gas sensor [4] with power supply to it. Our design consists of number of Gas sensor modules at different areas in industries. All of these terminal nodes are connected to a board consisting of ARM based micro controller, LCD, Buzzer and a ZigBee module. The description of these components is given below:

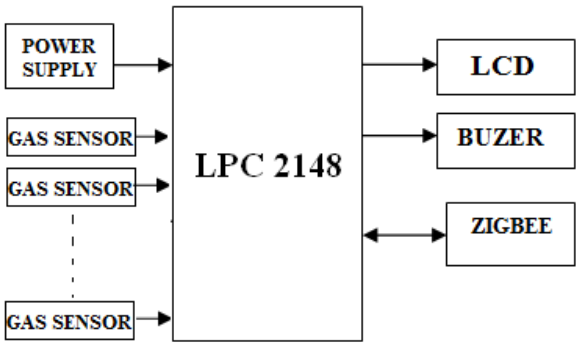

Fig.2 Block diagram of transmitter

ARM LPC2148: The LPC 2148 microcontroller is based on a 16-bit/32-bit ARM7TDMI-S CPU with flash memory ranging from 32 kB to 512 kB. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. Due to their tiny size and low power consumption, LPC2148 is ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale.

Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make this microcontroller suitable for industrial control and medical systems.

ZigBee: ZIGBEE is new wireless technology guided by IEEE 802.15.4 Personal Area Network standard [5]. It is primarily designed for the wide range controlling applications and to replace the existing non-standard technologies. It currently operates in 868 MHz band at a data rate of 20Kbps in Europe, 914MHz band at 40kbps in USA, and the 2.4GHz ISM bands Worldwide at a maximum data-rate of 250kbps. It is used to verify whether user's truncation is possible or not. One of the main advantages of this ZIGBEE communication is that it provides a noise free communication, the amount of noise added in this type of communication is very less compared to the other wireless communications.

Gas Sensor: Gas sensor is used to detect the gas leakage. The electrical properties of the sensor would change with variations in gas concentration [4]. Sensitive material of MQ-6 gas sensor is SnO2, which with lower conductivity in clean air. When the target combustible gas exist, the sensor's conductivity is higher along with the gas concentration rising.

MQ-6 gas sensor has high sensitivity to Propane, Butane and LPG, also response to Natural gas. The sensor could be used to detect different combustible gas, especially Methane; it is with low cost and suitable for different applications.

Buzzer: A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical,

or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke.

16x2 LCD Display: A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs does not emit light directly.

They are used in a wide range of applications, including computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc.

Working of terminal node: Whenever there is a gas leakage in the surrounding areas of this node, this will be detected by the sensor. The sensor consists of Tin dioxide chemical material which has the property that when a gas is detected the resistance of that material will fall from 50kΩ to 3.5kΩ [4]. Then a large current flow occurs through this to the microcontroller. Then the Microcontroller activates the Buzzer and displayed the leakage location on LCD. At the same time the ZigBee sends the location details to the coordinator through an antenna.

II. Receiving section: The receiving section consists of a Coordinator and PC. The Coordinator has ZigBee module to receive the information from the terminal nodes through an antenna. This collected data will send to the PC using a serial communication called RS-232.

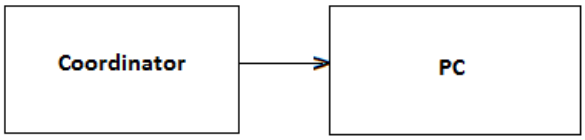

Fig.3. Receiving section with PC

The observer at the PC will take the data of monitoring sites and can take the necessary actions. As a gateway, the coordinator has to communicate with the PC, which is different from the terminal nodes [1]. So we need another communication port in hardware design. This port should be widely used because this system is not specially designed for some computer, SCM or PLC. Therefore, RS-232 is qualified for this. The RS-232 communication circuit is shown in the fig.4

The power required to operate the controller is of 3.3V. The same voltage is connected to the ZigBee, buzzer and Gas sensor.

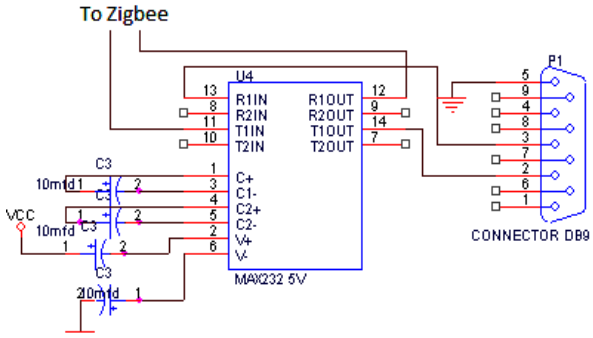

Fig.4. The RS-232 schematic

The power management uses a transformer, rectifier with filter and a voltage regulator. The power management module schematic is shown in Fig. 5

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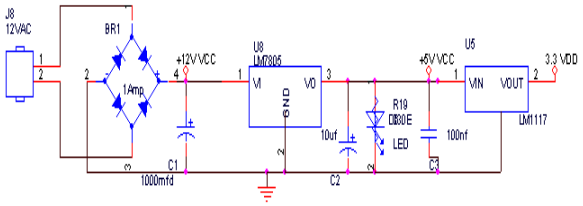

Fig.5 Power management module schematic

B. Software Approach

ZigBee Wireless Sensor Networks has two kinds of nodes: the coordinator and the terminal nodes. There is no marked qualitative difference between them on hardware design [1]. The main difference is on communication software design. As the gateway of the ZigBee WSN, coordinator automatically initiates the formation of the network. After that, it will wait on until all the nodes nearby finished joining in the net. Then the coordinator will send instructions or collect information such as the connection status, sensor data and location data, and then send them to the PC to update value in the location software. The algorithm of system is shown below.

Step1: Initialize all the hardware components.
Step2: Build network between coordinator and all the terminal nodes.
Step3: Check how many terminal nodes are connected in the network.
Step4: If there are more than 8 terminal nodes then we need to use another coordinator because a coordinator

can communicate with a maximum of eight terminal nodes.
Step5: Depending on the number of nodes and coordinators update the information in the PC.
Step6: The terminal nodes always searches for the gas leakage.
Step7: If gas is detected go to step 8 otherwise go to step6
Step8: When the gas at the terminal node crossed the threshold of the sensor it detects and sends information to the controller
Step9: The controller enables the buzzer, LCD and ZigBee.
Step10: The ZigBee sends details of this node to the coordinator
Ste11: The coordinator will send to the PC to update the details and to alert the observer.

The main difference between the terminal node and coordinator whether it provides multi-hoping for messages, and this difference comes from program design. The ZigBee module at the terminal node acts as transmitter and ZigBee module at the coordinator acts as receiver. Using a single coordinator a network with eight terminal nodes can be developed. The terminal nodes will search a present network and apply for joining in, and then they will search for the neighbor nodes and update the banding table, acquisite information of sensor data and location, and then send them to the coordinator. Suppose the third pin of ZigBee at the terminal node acts as transmitter then the third pin of ZigBee at the coordinator acts as receiver.

4. Results

Using this proposed system the response from the leakage point can be obtained immediately. Response time and recovery time are two parameters which determine the alertness of the sensor module. It is done in two levels. For most of the resistive type gas sensors when the system is switched on the output voltage would be very close to supply voltage and slowly it stabilizes to threshold level.

In case of MQ6 gas sensor, the initial stabilization time/Setup time is about 4 minutes. The second level of response time is how fast the sensor module responds to change in gas concentration.

For determining this response time of the sensor module, the gas is allowed to pass to the sensor then it was stabilized within 5s. The recovery time is calculated as, once the infused gas level removed from the gas sensor, it would take some time to revert back to its gas free voltage level. The infused gas level flushed out of the area of the sensor module and recovery time is determined as 15s.

Conclusion

The Gas leakage detection and accurate location identification system for the production safety in any risky Industries is developed. The detection and location are implemented based on ARM and Wireless Sensor Networks (WSN) like ZigBee which is smart, low-cost, low-power and low-maintenance.

The Proposed system can immediately respond for the leakage of any type of Gas in the surrounding areas of the nodes and alerts the observer. In two modes, this system can monitor the gas leakage sensitively, get the data from a scene of the accident and locate the leakage point and display it in the PC. As we are using Wireless Sensor Networks and ARM controller the system is easy to be deployed and overcomes the Shortcomings on current systems. It is used to improve the rescue quality and shorten the time for rescue. Therefore it can compensate for the weaknesses of current systems.

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