

Monitoring and Controlling of Air Pollution Using Intelligent Control System

¹Anil.H.Sonune, ²S.M.Hambarde

¹ JSPM's Jayawantrao Sawant College of Engineering, E&TC Dept., Pune-28

²E&TC Dept., JSPM, Pune, MH-India,

anil.h.sonune@gmail.com, shaileshhambarde@gmail.com

Abstract: *This paper focuses on implementation of Environmental air pollution monitoring and controlling system. First, the air pollution monitoring system contains sensors to monitor the interested pollution parameter in environment. Second, wireless communication modules for monitoring system were developed using wireless sensor networks technologies based on ZigBee network. And then a performance of modules was estimated in the real-fields. Finally, integrated wireless sensor board which employs dust, CO₂, temperature, humidity sensor and a ZigBee module was developed. The board is embedded device based on Arm processor LPC2148. This paper accelerates the digital convergence age through continual research and development of technologies related the smart-City.*

Keyword– ZigBee protocol, Sensor Node, Air Pollution, CO₂, temperature.

I. Introduction

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one sensor. Each such sensor node has typically several parts: radio transceiver with an internal antenna or connection to an external antenna, a Microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. There are many opportunities for using wireless sensor networks within the industries.

The system is based on a smart sensor micro converter equipped with a network capable application processor that downloads the pollutants level to a personal computer for further processing. A wearable and wireless sensor system for Real-time monitoring of toxic environmental volatile organic Compound was developed. A wireless mesh network based on embedded microprocessors consisting of multiple sensors and multihop wireless communication is designed to cover a geographic area. The system monitors and transmits parameters atmospheric environment to a command center. An outdoor air pollution monitoring system using ZigBee networks for smart-cities. The system integrates wireless sensor board which employs dust, CO₂, temperature and humidity sensors. An abstract model of a system based on long-range wireless communication was proposed. Most of the above air pollution and quality monitoring system are based on sensors that report the pollutants levels to a server via wired modem, router, or short-range wireless access points. In this paper, we propose a system that integrates a single-chip microcontroller, several air pollution sensors, and a wireless data acquisition unit.

II. Literature Review

Due to recent technological advances, the construction material for small and low cost sensors became technically and economically feasible. Even though, Industrialization increase the degree of automation and at the same time it increases the air pollution by releasing the unwanted gases in environment especially in industrial areas like Pune. To detect percentage of pollution, we used the array of sensor to measure gas quantity in the physical environment in surrounding the sensor and convert them into electrical signals for processing. Such a signal reveals some properties about interested gas molecule. A huge number of these sensors nodes can be networked in many applications that require unattended operations create a wireless sensor network. Wireless Sensors are devices that range in size from a piece of glitter to a deck of cards. Integration of various components creates the air pollution monitoring system. They are functionally composed of: Some common examples of properties or parameters that are monitored are light, temperature, humidity, pressure, etc. a converter that transforms the sensed signal from an analog to a digital signal; A Processing Unit in the Microcontroller, process the signals sensed from sensor with help of embedded memory, operating system and associated circuitry. A radio component that can communicate the sink node or zigbee router which collects the sensed pollution gas level from sensor node and forwards to pollution server.

In an external environment where the power source is batteries, wireless sensors are placed in an area of interest that is to be monitored, either in a random or known fashion. The sensors self-organize themselves in a radio network using a routing algorithm, monitor the area for measure the gas levels in air, and transmit the data to a central node, sometimes called a pollution server or base station (interfaced with coordinator), or sink node(interfaced with router), that collects the data from all of the sensors. This node may be the same as the other detection nodes, or because of its increased requirements, may be a more sophisticated sensor node with increased power. The most advantage of wireless sensors is that they may be implemented in an environment for extended over a time period, continuously detecting the environment, without the need for human interaction or operation.

III. Material And Methodology

A. Hardware Architecture

The following diagram shows the hardware block diagram of proposed system.

To satisfy the system's functional and nonfunctional requirements, two major building blocks are needed, namely: a

Data Acquisition unit and a Pollution Monitoring Server. The data acquisition unit is designed by integrating microcontroller with a sensor array using analog ports. Data Acquisition Unit is also connected to ZigBee modem using RS-232 interface.

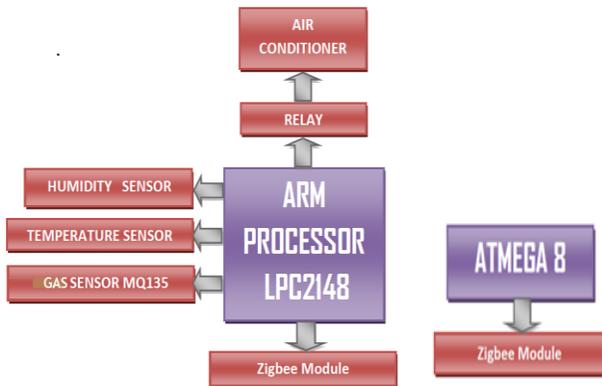


Fig.1. Node Block Diagram

The sensor array consists of three air pollutions sensors including Carbon Dioxide (CO₂), temperature, and gas.

1) 32-Bit Chip Microcontrollers

ARM is a family of instruction set architectures for computer processors based on a reduced instruction set computing (RISC) architecture developed by British company ARM Holdings. A RISC-based computer design approach means ARM processors require significantly fewer transistors than typical processors in average computers. This approach reduces costs, heat and power use.

The features of LPC214x series controllers: 8 to 40 kB of on-chip static RAM and 32 to 512 kB of on-chip flash Program memory. 128 bit wide interface/accelerator enables high speed 60 MHz operation. (ISP/IAP) via on-chip boot-loader software. Single flash sector or full chip erase in 400 ms and programming of 256 bytes in 1ms. USB 2.0 Full Speed compliant Device Controller with 2 kB of endpoint RAM. In addition, the LPC2146/8 provides 8 kB of on-chip RAM accessible to USB by DMA. 10-bit A/D converters provide a total of 6/14analog inputs; with conversion times as low as 2.44 us per channel. Single 10-bit D/A converter provide variable analog output.

2) First Step- Hardware Requirement

Now let us start with the hardware requirement of LPC2148. LPC2148 need minimum below listed hardware to work properly.

- a. Power Supply
- b. Reset Circuit
- c. Crystal Oscillator
- d. RTC crystal oscillator (This is not necessary if you are not using RTC. However this is considered as necessary requirement)
- e. UART

B. Sensors For Air Pollution Monitoring

1) Gas sensor

MQ-135 is a solid electrolyte type gas sensor adopted planar technologies to improve the reliability, the sensing property. Components of heater, electrodes and electrolyte were made by

thin film technology. This sensor exhibits a non-linear relation between voltage of output and density of gas. It also displays long term stability and shows excellent durability against the effect of high humidity.

2) Humidity & temperature sensor

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 32-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

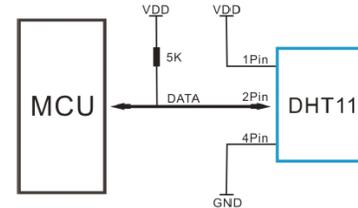


Fig.2. Interface between DHT11 and LPC2148

C. Zigbee Technology

The Digi Xbee 802.15.4 modules are the easiest to use, most reliable and cost-effective RF devices we've experienced. The 802.15.4 Xbee modules provide two friendly modes of communication - a simple serial method of transmit/receive or a framed mode providing advanced features. These modules can communicate point to point, from one point to a PC, or in a mesh network.

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks.

It is present at the bottom three layers i.e. physical, data link, and network layer. This is the recently published IEEE 802.15.4 standards for personal area networks. It is present at the bottom three layers i.e. physical, data link, and network layer. This is the recently published 802.15.4 standards for personal area networks. ZigBee network layer supports star, mesh and tree topologies.

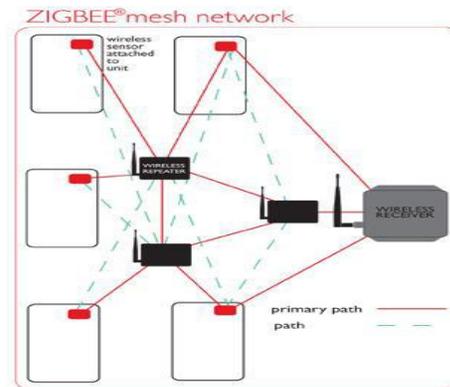


Fig.3. Block diagram of Zigbee

The ZigBee coordinator is responsible for initiating and maintaining the devices present in the network and other end devices directly communicate with the ZigBee coordinator. The Xbee modules work at the 2.4 GHz frequency which means smaller board and antenna size. Xbee modules have the ability to transmit Digital, PWM, Analog or Serial RS232 signals wirelessly.

To communicate over UART or USART, we just need three basic signals which are namely, RXD (receive), TXD (transmit), GND (common ground). So to interface UART with LPC2148, we just need the basic signals.

We now want to interface the ZigBee module with LPC2148 Primer Board for accessing the sensor devices without wires through UART0. The data communication is done in internet by using the ZigBee module through MAX232 into the SBUF register of LPC2148 microcontroller (refer serial interfacing with LPC2148).

The serial data from the Zigbee receiver is taken by using the Serial Interrupt of the controller. +5V and ground is connected to provide power to the module. While TX and RX pin is connected for communication.

IV. Software Design

Fig. 5 shows how to interface the Zigbee with microcontroller. The Xbee modules work at the 2.4 GHz frequency which means smaller board and antenna size. Xbee modules have the ability to transmit Digital, PWM, Analog or Serial RS232 signals wirelessly. To communicate over UART or USART, we just need three basic signals which are namely, RXD (receive), TXD (transmit), GND (common ground).

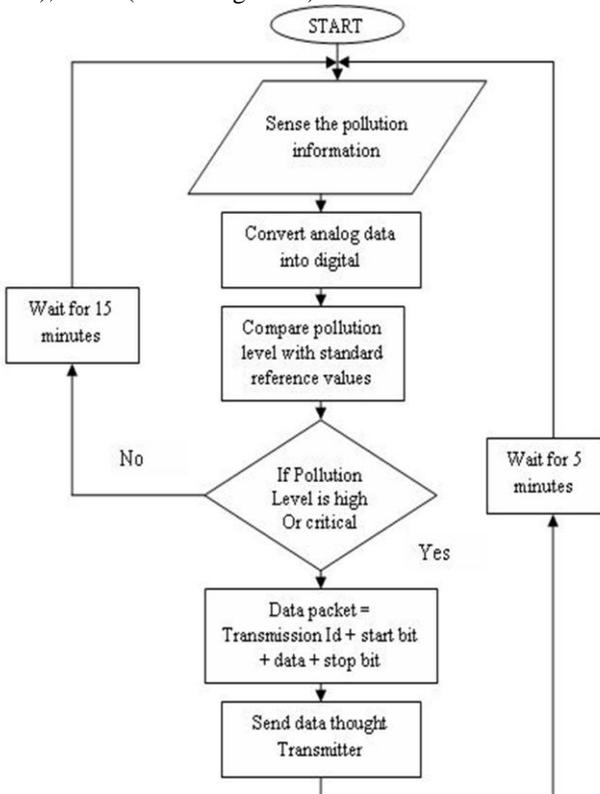


Fig.4. Flow Chart

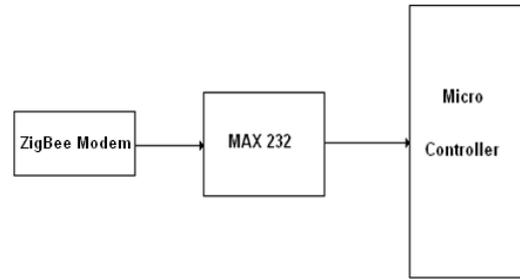


Fig. 5. Interfacing Zigbee to Microcontroller

A) Interfacing Zigbee with LPC2148

We now want to interface the ZigBee module with LPC2148 Primer Board for accessing the mobiles without wires through UART0. The data communication is done in internet by using the ZigBee module through MAX232 into the SBUF register of LPC2148 microcontroller (refer serial interfacing with LPC2148).

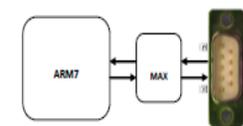
	UART DB-9 Connector	LPC2148 Processor Lines	Serial Port Section
UART0(P1) ISP PGM	TXD-0	P0.0	
	RXD-0	P0.1	
UART1 (P2)	TXD-1	P0.8	
	RXD-1	P0.9	

Fig.6. Pin Assignment with LPC2148

The serial data from the Zigbee receiver is taken by using the Serial Interrupt of the controller. +5V and ground is connected to provide power to the module. While TX and RX pin is connected for communication.

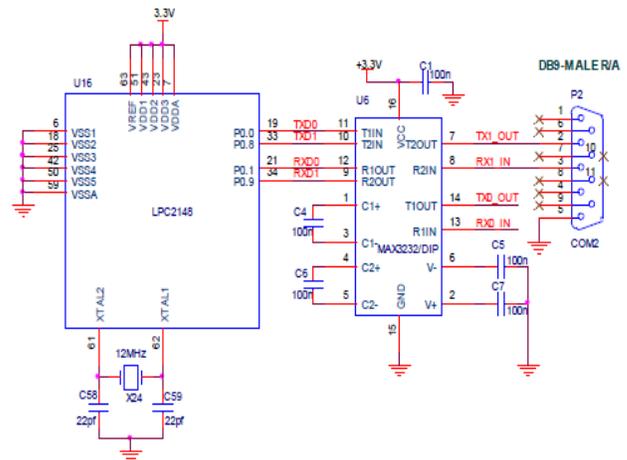


Fig.7. Circuit Diagram to Interface Zigbee with LPC2148

V. Results Of Experiment

As shown in above fig. 1 implementation of A part of the system is done. In order to check if the hardware is working as per the requirement, an experimental setup is done. In this,

system is continuously monitored on the display unit which is on LCD module.

Below images shows the results of hardware implementation. Reduce the possibility of unplanned power off of system and thus reducing the downtime cost. Presented study, describe the way of continuously automatically monitoring of system. In this paper we present the system with ARM and ZigBee protocol to monitor and diagnose. The ZigBee protocol is used for serial communication which provides high data transmission rate and reliability.

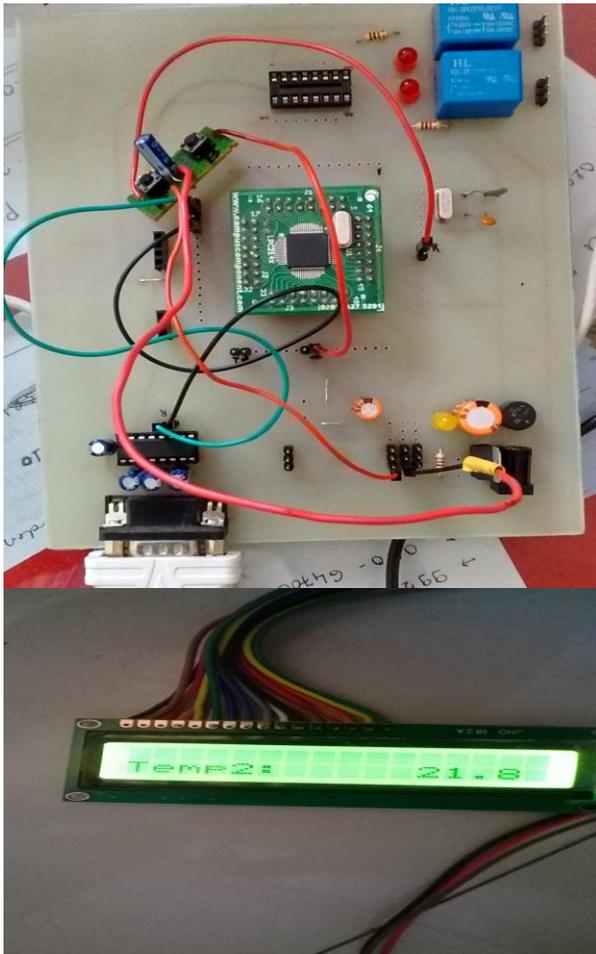


Fig.8. Experimental setup

This system has an advantage such as low power consumption, in order monitor quantity in different site future work can be focused on establishing a system with more sensor node and more base station connection between node and base station are via WSN, while connection among different base station are via Ethernet (LAN), Ethernet can also be connected to internet so that users can login to the system and get real time data far away.

VI. Conclusion

This paper describes implementation of the air pollution monitoring and controlling system using ZigBee technologies

and embedded system. The system is constituted by a base station and several sensor nodes. As the ZigBee was applied to communication for monitoring system, available feasibilities are confirmed. The system possesses low cost, wide coverage using ZigBee protocol, especially mobility on wiring to remove the limitation of traditional wired network systems for Smart-City.

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