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Research Article

A Real Time Wireless Multi –Parameter monitoring System with ZigBee and LabVIEW

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Abstract

Wireless communication technologies become popular in real-time industrial environments. The availability of products and solutions based on the IEEE 802.11 standards make such kind of communication technology more cost effective in distributed control systems and process parameter measurement systems. This paper describes fundamental work of real time multi parameter monitoring system with ZigBee, micro controller and Graphical Programming language (LabVIEW). Data acquisition system of two parameter temperature and distance reported in this paper. After acquiring the analog data from the sensor with suitable signal conditional and amplification is fed to micro controller then it is connected to the ZigBee- transmitter module, which transmits the data and at the other end the ZigBee receiver. There is arrangement of LCD for local data measurement and data received in computer via RS232 and ZigBee hence its provide redundancy which is one of the important parameter in a real time industrial data measurement. The methodology describe in the proposed work will be very useful for designing wireless data acquisition system in the industrial application likes to measure liquid level and temperature at gas station, For measurement of process parameters in batch process and to measure various biomedical signals for patient monitoring system.

Keywords: *Microcontroller, Power supply, Temperature sensor, Ultrasonic proximity sensor, ZigBee protocol, Personal computer*

1. Introduction

The Wireless Sensor Networks is a wide area of research in recent years. Wireless sensor network consists of spatially distributed autonomous sensors to monitor physical or environmental conditions like temperature, sound, pressure, distance and to cooperatively pass their data through the network to a main location (Nidhi Patel *et al*, 2013). The wireless sensor network can be used with ease in the environment where wired system cannot be used or if used, are to be treated with caution, for example, in medical treatment. One advantage is in home patient monitoring system for measuring Blood pressure and heart rate. The patient wear a ZigBee device that interfaces with the sensor and data can be wirelessly transmitted in computer and it will be sent to the doctor via internet (Karandeep Malhi *et al*, 2012). WSN is built of nodes- it may vary from few to several thousands. The sensor node has different parts radio transceiver with internal or external antenna, a microcontroller for interfacing with the sensors and energy source or battery. Bluetooth, Smart transducers, PAN, Wi-Fi and ZigBee are different types of Wireless Sensor Network. ZigBee operates in the scientific, industrial, and medical (ISM) radio bands. In this 868 MHz in Europe, 915 MHz in the USA and 2.4 GHz use in worldwide. The IEEE helped the production of ZigBee protocol and devices that support this protocol (Nidhi Patel *et al*, 2013, T. C. Manjunath *et al*, 2008). The disadvantage of using traditional systems is that it increases the cost whereas digital systems reduce the cost of system. ZigBee is low cost, wireless network standard and Low power usage. It allows longer life with smaller battery (Jim Torresen *et al*, 2010). ZigBee supports mesh, star, hybrid and tree topologies (T. C. Manjunath *et al*, 2008, Jing Sun *et al*, 2007). ZigBee has been developed to meet the demand for capable wireless networking between the low power devices. It is widely used for controlling and monitoring application. The LR- WPAN technology and ZigBee standard is appearing because of its potential for low power, low cost, fast response, and simple implementation compare to traditional new wired network. It's simple installation used for industrial and process automation (H.VijayaLaxmi *et al*).

The basic structure of ZigBee based parameter monitoring and controlling system consists of microcontroller 89v51, ADC and ZigBee device. These

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are connected with temperature sensor and ultrasonic sensor and acts as transmitter for the other end ZigBee device which is near the computer where the parameters are displayed on computer using software application and LCD is also connect with microcontroller for display the same output which can be shown in PC. In addition to ZigBee Device various other sensors are used for measuring different parameters. Wireless sensor network (WSN) system are autonomous and operate unattended also adaptive to the environment (Leijun Xiang , 2013).

The main aim of this paper is to design a cost effective multi parameter wireless data acquisition system with microcontroller and ZigBee transceiver Tarang F4 (Ankita Gupta *et al*). Main functions of the system is

- To monitor and control distance and temperature continuously
- To incorporate automatic and manual control
- To Transmit and receive the real time data serially on the PC in the form of ASCII character and numerical form

2. ZIGBEE technology and overview

Wireless sensor network

Wireless sensor network system are autonomous and operate unattended also adaptive to the environment. The wireless system for monitoring purpose will not only reduce the overall monitoring system cost in term of facilities setup and labor cost, but always provide flexibility in system in term of distance or location. So these systems are widely used in military, hospitals, home and other commercial areas (Nidhi Patel *et al*, 2013). ZigBee standard performs well at industrial environments the fundamental design and implementation of WSN featuring a high power transmission ZigBee based technology. The developed platform is cost-effective and allows easily in WSN systems as well as the effect on reducing energy consumption approx 33µW. WSN has sub system: Computing system, Communication system, Supply system.

Computing system consists of a microcontroller unit. This controls the sensor data and executes communication protocols. MCU's are operated under various operating modes of power management, for long battery life purpose. Communication system consist of 2.4 GHz range radio frequency transceiver, which is used to communicate with neighboring nodes within cluster and the outside the cluster. The transceiver can operate under the different modes which are Transmit, receive, idle and sleep modes. Power supply system consists of Lithium battery that supplies power 9 to 30V DC to the node.

Zigbee architecture and functionality

ZigBee is built on top of the physical layer and medium access control (MAC layer) defined in the IEEE standard 802.15.4 for low-rate WPAN's (Ramya, C.M. *et al*, 2011). The ZigBee specification then adds to the standard four main components: Network Layer, Application Layer, ZigBee device Object and User-defined application objects which allows for customization and flexibility within the standard (Ken Masica, 2007).

In addition to integrating two high-level network layers to the underlying structure, the most significant addition is the introduction of ZigBee Device Objects (ZDO's). ZigBee device objects are responsible for device roles, management of requests to join a network, device discovery and security. In this we use Tarang F4 module net functionality.

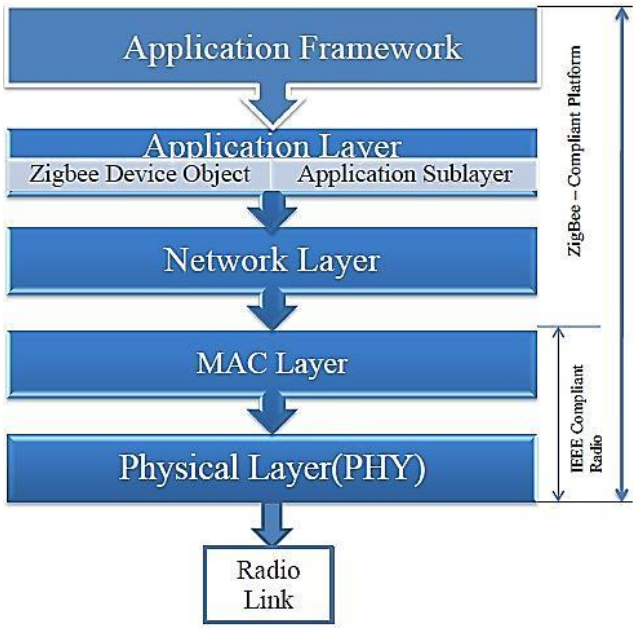

Fig.1 Adaption ISO/OSI to ZigBee standard

The ZigBee network layer allows three device types:

- ZigBee Coordinator (ZC)
- ZigBee Router (ZR)
- ZigBee End Device (ZED).

ZigBee Coordinator: In network topologies only one ZigBee coordinator is there. The main function of ZC is to initiate the network formation by configuring the channel and Personal Area Network ID.

ZigBee Router: The ZR is an optional network component. The main function of ZR is to participate in multi-hop or mesh routing of network messages. It maintains the routing table and manages address allocation or de-allocation for its assigned ZED's (H.VijayaLaxmi *et al*).

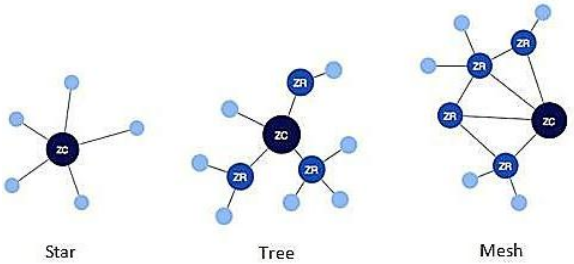

Fig.2 Network topologies

ZigBee End Device: The ZED is also an optional network component and not participates in routing. It can be optimized for low power operation by taking advantages of sniff and sleep techniques.
Routing: When a request is send through a router then router will issue a route request but it does not have an entry in routing table, which is broadcast throughout the network. When the destination path receives the route request it will then reply with the path how many hops it took to reach the destination and cost gives how to count cost during maintenance (Jing Sunet *et al*, 2007).

3. Block Diagram of WSN and Subsystem

The block diagram of multi parameter monitoring system is shown in fig.3.In the system ultrasonic proximity sensor is connected to SPI of a controller 89v51 through buffer IC74LS125.The ZigBee module – 1 (Tarang F4) is also connected to SPI via buffer. They are communicating alternatively via buffer IC. The temperature sensor LM35D (TO-92 plastic package) is connected to port – 1 via ADC-0804. The LCD is connected to port -2 of MCU. ZigBee module -1 is communicating to ZigBee module-2 (Tarang F4) via wireless radio link. The ZigBee module -2 is connected to PC via RS -232 cables. The sensing data is displayed on the LCD then to TMFT hyper terminal on PC (Singh, R. *et al*, 2010).LM35 temperature sensor is used with 89v51 microcontroller, Ultrasonic sensor, LCD and Tarang F4 ZigBee module connected. The ultrasonic proximity sensor is used to measure the distance of stationary object. The sensor model no.1166 and it is product of Sunrom technologies. Its compact size, higher range and easily usability make it handy sensor for mapping. The sensor can measure distance up to maximum 400cm.The sensor can operate 5V dc supply voltage and its accuracy of +- 1cm. The sensor data is captured at serial port of an MCU. This data is stored in MCU memory as well as displayed on LCD. If distance is less then 10cm the message is displayed on LCD that minimum distance reached xxx.xx cm. The data pin no.2 TX of ultrasonic proximity sensor is connected to RXD pin of MCU through buffer (Nidhi Patel *et al*, 2013).

The data received on RXD pin by the MCU is in ASCII format at data rate of 9600 baud rate. The received data format is XXX.XX cm<CR>, where X is '0' to '9' ASCII character and <CR> is carriage return where the string terminates.

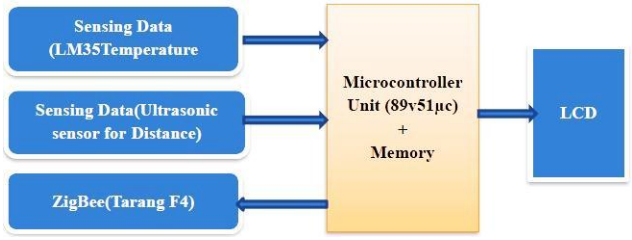

Fig.4 Block diagram of receiving section

The temperature sensor LM35 is used to sense the environmental temperature. The Vout pin no.2 of LM35D is connected to Vin pin no.6 of ADC for analog to digital conversion.

The 8 bit digital output DB0 to DB7 is connected to port1 of MCU. The temperature reading of 8 bit stored inside MCU. The LM35 is precision integrated-circuit temperature sensor. It gives output in voltage which is linearly proportional to the Celsius (Centigrade) temperature. This will require a voltmeter to sense the temperature. Vout can be measured by voltmeter. The output voltage is converted to temperature by a simple conversion factor. The sensor has a sensitivity of 10mV/°C. Hence conversion factor is the reciprocal, and that is 100°C/V. The general equation used to convert output voltage temperature is:

$$\text{Temperature (°C)} = \text{Vout} * (100°C / V) \quad (1)$$

So if V_{out} is 1V, them, Temperature =100°C. The output voltage varies linearly with temperature. Temperature reading is also displayed on LCD with the distance reading.

ZigBee module is connected to MCU via. The Vout pin of ZigBee module is connected to RXD pin of MCU via buffer IC and Din pin of ZigBee module is connected to TXD pin of MCU. Both the sensor data can be transfer to ZigBee module through wired connection. This sensor data is transferred to ZigBee module to via radio link. ZigBee module2 is connected to COM port of PC via RS232 cable (MALIKA *et al*, 2013). In figure 4 there is output can be displayed in PC. In PC we use Tarang multi functioning tool. For data acquition we had used LabVIEW (Laboratory Virtual Instrument Engineering Workbench) software by National Instrument which provide cost effective and reliable solution for the system (Manish Thakker *et al*, 2013, M.Thakker *et al*, 2011).
The same sensor reading displayed on the LCD can be displayed hyper terminal on PC (MALIKA *et al*, 2013). Here the network formed by both the ZigBee module is unicast network and communication between two nodes. For unicast network it needs to assign source address and destination address for both of the ZigBee module. The ZigBee module is used in this project is Tarang-F4 module, which works on 3.3v to 3.6v operating voltage and ISM 2.4 GHz band of frequency.

4. Experimental Setup

Multi-parameter monitoring system is tested with two parameters as shown in Fig. 5. Temperature and Distance are taken here as test parameters.

- To measure Temperature LM35 Integrated chip were selected which is having temperature range 0° to 100° C with accuracy of ±1.5°C
- To measure distance ultrasonic sensor from Sunrom Technologies Company, model no.1166 is used. It requires 5V supply voltage, 15mA current and gives output at 9600 bps serial data.

Here, LM35 is connected to Port1 of Microcontroller via ADC0804. The variation in temperature is sensed by LM35 and converted in variation in voltage at the output

of sensor, which is given as input to ADC0804. The ADC0804 converts voltage into Digital data, which is calibrated using experiments and manufactures specification given in data sheet. The calibration is done with the help of hot water bowl with thermometer, and LM35 placed over the water bowl. The temperature measured at different level on thermometer and reading of online data acquisition system with ZigBee is compared and calibration is done.

The ultrasonic sensor data output is received serially by microcontroller with serial port 3. The distance calibration is done by experimental setup and manufacture specification given in data sheet. The wooden box is place in front of the sensor at different known location and result measured on the online data acquisition system with ZigBee is compared and calibration is done.

The LCD is also interfaced with port 2 of microcontroller for locally monitoring the data.

The data transferred with Microcontroller using ZigBee Transmitter is received by ZigBee receiver connected with the Personal Computer. The PC is installed with LabVIEW, which is ready to receive the serial data. The data acquired can be utilized for data plotting, on-off indication, report generation, alarming etc by the inbuilt tools of LabVIEW interactive VI.

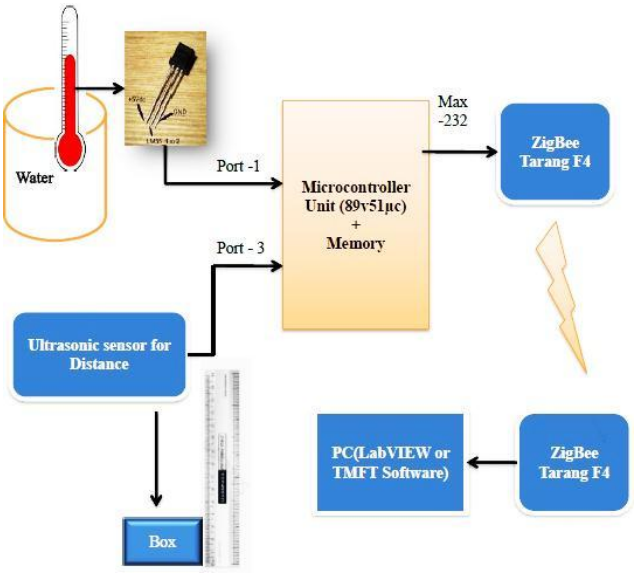

Fig. 7 Front Panel of basic serial writes and read VI

Procedure for data acquisition from sensor to ZigBee to PC (LabVIEW or TMFT): The microcontroller initiates the process, by sending the SOC (Start of Conversion) to the ADC0804. The ADC0804 converts the input signal voltage to equivalent digital data, which is eventually the temperature information. ADC0804 when completes the conversion, it sends the EOC (End of Conversion) to the Microcontroller. In response to EOC, Microcontroller read the data from ADC0804 and stores it temporary for further process later. Microcontroller again initiates communication with Ultrasonic sensors and receives the information regarding distance. Once Microcontroller receives both data, Microcontroller calibrates this data with the help of lookup reference tables. The calibrated data of temperature and distance are displaced on LCD connected for local visualization.

Microcontroller also sends this information serially to the ZigBee module connected to it. ZigBee module transmits these data to the ZigBee receiver, which is connected with PC using RS-232 to USB cable. PC installed with the LabVIEW and programmed to receive the serial data, stores the data for further future use.

The ZigBee Trans-receiver pair is initially connected with PC to setup the ZigBee Module on same transmitter and receiver address, baud rate, stop bit, data bit etc. In figure 6 overall transmitting and receiving section is shown. In figure 7 front panel of LabVIEW VI is shown.

Fig. 6 Hardware Connection

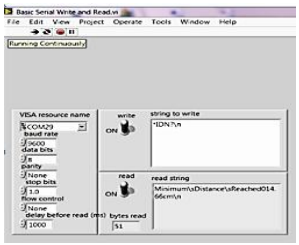

Fig. 7 Front Panel of basic serial writes and basic read VI

5. Results & Conclusion

In Fig.8 comparative graph shows measurement from scale and measurement data acquired in computer. We have demonstrated lab scale setup to measure two parameters using ZigBee and acquired data into computer successfully. In future this system may be scale up to measure Industrial parameter like level, temperature etc.

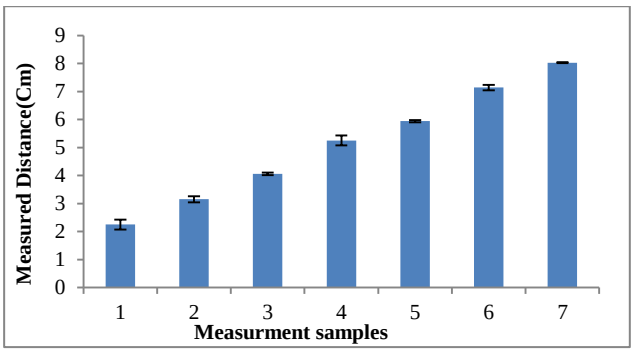

Fig.8 Actual distance measurement Vs distance measurement from wireless sensor.

In this work we had proposed multi parameter monitoring system by measuring simultaneously two parameters with wireless communication using ZigBee and Virtual Instrument LabVIEW software. Its application was demonstrated by measuring two parameter simultaneously features likes report generation, plotting, alarming was incorporated in the software. The data receive through Zigbee in Personal computer. The data acquired in to

computer Tarang Multi Functioning Tool software and temperature and distance was displayed in that terminal.
The proposed approach can be useful in the small process like level, temperature, Measurement at Gas station, Load Measurement with load cell at Way Bridge, automatic counting system etc.

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