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Home Automation Using ZigBee Protocol

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Abstract: In coming years, the home environment will see a proliferation of network enabled digital connectivity among different appliances. Even though the use of home automation technology is low. This paper highlights the potential of ZigBee [1] through the design and implementation of home automation system. ZigBee based home automation system provides remote access to the user for the monitoring and controlling purpose. To explain the effectiveness and working of the proposed system, four appliances viz. bulb, fan, refrigerator and alarm along with the ZigBee and touch screen enabled remote controller are developed. ZigBee wireless devices are most preferable because of its low power consumption. Previously mentioned advantages of ZigBee take advantage of short-range wireless protocol and provide complete interoperability. This makes the complete home automation wireless which add to its benefits. User can control home switches with ZigBee enabled touch screen.

Keywords: Touch Screen, ZigBee, ARM Controller, Home Automation.

I. INTRODUCTION

This paper presents a novel, low-cost and flexible ZigBee based home automation system. The architecture is designed to reduce the system's complexity and lower fiscal costs. The system allows home owners to monitor and control connected home devices, through touch screen over ZigBee wireless connectivity. Additionally, users can remotely monitor the current power status of appliances.All communications are encrypted for security purpose before being transmitted.

This home automation includes centralized control from a touch screen which can be operate over a given range(~100m) of home lighting, centralize heating and cooling of home, security locking of home and controlling other systems.We are using ZigBee for the wireless communication which provide enhanced range, less power consumption and better security. Home automation for the older and disabled people which will help them to improve their quality of life,who might otherwise require caretakers or care from old age homes.A home automation system integrates electrical and electronic devices in a house. With the integration of innovation and technology with the home environment, appliances can communicate in an incorporated way which results in efficiency and vitality effectiveness.

II. OVERVIEW

A.Existing Systems
There are various wireless technologies, like Bluetooth, Radio Frequency (RF), ZigBee, Infrared (IR)[2] etc. Radio frequency (RF) communicates at the frequency of 413 MHz or 315 MHz.To communicate over RF there is no any fixed protocol signal are just broadcasted over the given range with no security.

Infrared (IR) works only when transmitter and receiver are in one line and in front of each other. Range for IR communication is up to 1 meter. Bluetooth technology is developed to be used in near range communication such as Personal Area Network (PAN). The range for Bluetooth wireless device is up to 20 meters with 2.5mW (4dBm) power consumption.

Comparison between currently popular three different wireless technologies is given in Table.1 [3].

B. Implemented System
ZigBee is a protocol is developed using Open System Interconnection (OSI) layer model. IEEE standard 802.15.4 defines the physical and Medium Access Control (MAC) layers of the ZigBee protocol.

TABLE I
COMPARISON OF SPECIFICATION OF WIRELESS TECHNOLOGIES

Feature(s)	Wi-Fi	Bluetooth	ZigBee
Power Consumption	High	Medium	Low
Complexity	Very Complex	Complex	Simple
Nodes/Master	32	7	64000
Latency	3 Seconds	10 Seconds	30 ms – 1s
Range	100m	10m	70-300m
Extendibility	Yes	No	Yes
Data Rate	11 Mbps	1 Mbps	250 Kbps
Security	128/64 bit	128/64 bit	128 bit AES and Application Layer

ZigBee supports three types of communication topologies [4]; i.e. Star topology, Tree topology and Meshtopology. ZigBee also provides advantages [5] such as low range data integrity, low power consumption, advance networking and security, ADC and I/O support, 64000

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nodes etc. ZigBee module on the hardware prototype act as transreceiver.

1) Touch screen sensor:
A touch screen we are using here is a resistive touch screen, it is a device which has two sheets separated by a nonconductive material. Its construction consists of hard glass bottom layer for support and flexible Polyethylene layer on top.The position of this meeting (a touch) can be read by change in resistance.Notice that some pins switch functions depending on if the controller is looking for X-touch or a Y-touch position. The controller reads the X and Y position many times per second so the user may move his stylus (or finger) rapidly across the touch screen and the data will be captured. This provides smooth operation and allows drag-and-drop or signature capture [6].

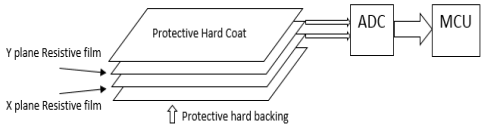

Fig.1. Connection of touch screen to ADC

2) MAX232 (Serial communication):
Serial communication is used between data received over ZigBee and ARM controller. The MAX232 from Maxim contains the two drivers and two receivers to match the RS-232 signal voltage levels to TTL logic voltage levels. It input voltage is +5V and with the help of this it generates the necessary RS-232 voltage levels (approx. -10V and +10V) internally. This simplifiesthe design of circuitry. Circuit designers no longer need to design and build a power supply with three voltages (e.g. -12V, +5V, and +12V), but could just provide one +5V power supply, e.g. with the help of a simple 78x05 voltage regulator.The MAX232 has two receivers which actually converts RS-232 voltages to TTL voltages and two drivers which converts TTL logic voltages to RS-232 voltages. This means only two of the RS-232 signals can be converted in each direction [7].

3) Block Diagram:
Fig.2 shows the block diagram of connection of ZigBee with Serial communication port. The microcontroller contains the software components written in embedded C through which home appliances are controlled. Microcontroller being the main module all control logic required for the circuitry in written in it. A 16x4 Character LCD is standard liquid crystaldisplay (LCD) device designed for interfacing with embedded systems.

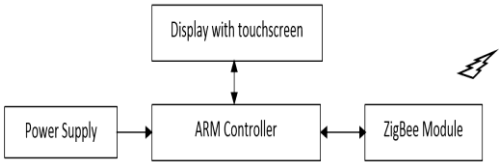

Fig.2. Detailed structure of the transmitter

This LCD is used to display the messages and current status of appliances received from other block in Fig.4.

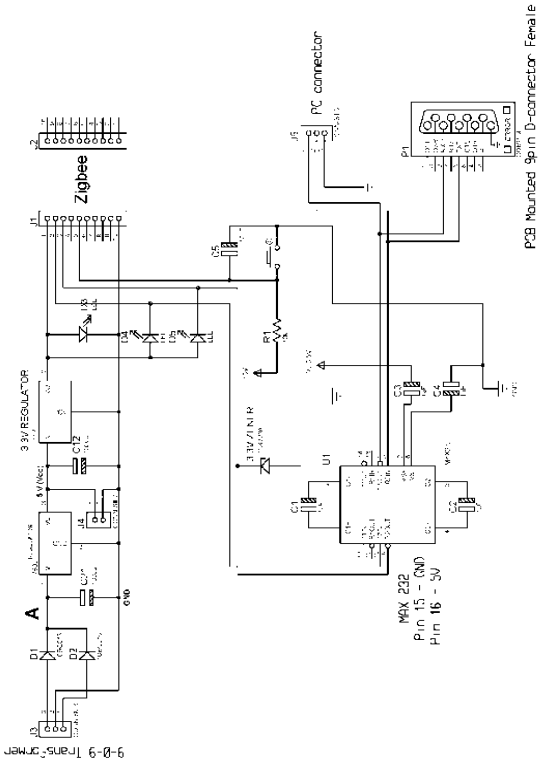

Fig.3. ZigBee module connection with serial communication port

ZigBee module on user's side sends data to the other circuit to switch ON or OFF the device according to users request over touch screen.Fig.4 shows the block diagram of control unit havingZigBee connected to the home appliances to be controlled.
Control unit in Fig.4 works as follows: The ARM microcontroller on transmitter side interprets the touch over touch screen and decides which massage need to send over ZigBee to receiver. Then both ZigBee modules communicate with each other. The ZigBee module in Fig.4 receives the messages and ARM microcontroller interprets the messages. Based on the message receive from the user, appliances and controlled i.e. Turn the device ON or OFF. Four appliances connected to relays are monitored and controlled. Once the status is changed ZigBee will send the status back to the user.

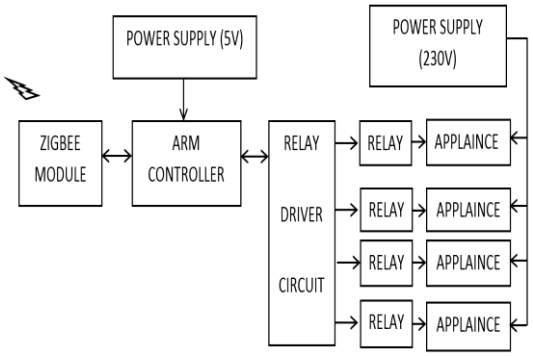

Fig.4. Detailed structure of the receiver

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III.METHODOLOGY

The methodology of this paper is explained in two sections; hardware and software implementation.The hardware implementation consists of the development of the touch screen sensor, ZigBee, LCD with ARM controller at one side and other circuit will consists of LCD, ZigBee, Relays connected to appliances and ARM controller.

Software implementation focuses on programming ARM controller in embedded C using Keil compiler. Circuit simulations are performed using Proteus and ZigBee is configured using X-CTU.

A. Hardware Implementation
Microcontroller LPC2138 is the interface between theuser and the system. The LPC2138 microcontroller is based on 16/32 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support that combines the microcontroller with embedded high speed Flash memory ranging from 32 kB to 512 kB.

Due to their tiny size and low power consumption, these microcontrollers are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale [8].In-System Programming/In-Application Programming (ISP/IAP) via on-chip boot loader software adds to its advantages because we don't need any special burner to burn program on chip.

The device that will be available at user side will have display which will give status of connected devices. On this display touch screen is mounted so by touching over device name user can change the status of device i.e. ON or OFF.

The circuit that is mounted near switch board will also have display to show status of device, controller to drive the relay and to send the updated status of devices to user over ZigBee. Along with these major implementations we have used IC7805 for voltage regulation, MAX232 for serial communication, ULN2003 Relay driver IC etc.

B. Software Implementation
The software part consists of programming the LPC2138 using Keil compiler. Programming language used is embedded C.

The scope of the programming includes USART communication with ZigBee module, ADC conversion of signals from touch screen, configuration of displays to send different messages over it, controlling relays as per the signals received over ZigBee and send the changed status of relays back to user over ZigBee.

Flash Magic developed by NXP semiconductors is user for burning program on ARM. In Proteus we have virtually created the transmitter and receiver section for testing purpose.

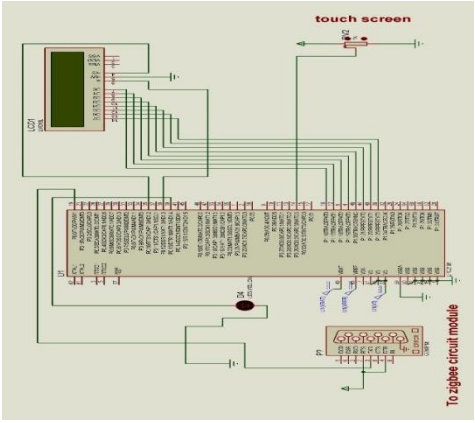

Fig.5. Overall LCD and ZigBee interfacing to LPC 2138 at user's side

IV. RESULT AND OBSERVATIONS

As per the block diagram that explained previously in section III, with respect to the message receive via ZigBee on receiver side that has been send to the Controller via ZigBee on user side module from touch screen, get interpreted by controller and then switch the state of required relay to control the electrical/electronic item. The proposed model can control all electrical/electronic appliances from anywhere within the range of ~80 m. Fig.7 shows the LCD status at user controller when device is initialized. Number displayed on left hand side of LCD screen shows the resistance value of the touch screen. On the basis of these resistance values, touch screen is divided into four horizontal sections. Fig.8 shows the waveform at port pin where device 1 is connected. Resolution of CRO is set to 2V/DIV. Fig.9 shows the LCD status when we turn ON device 1. This status is displayed on LCD mounted on circuit near switch board as well, Fig.10 shows this status. Fig.11 shows the updated voltage waveform at device 1 port pin. Resolution of CRO is set to 2V/DIV.

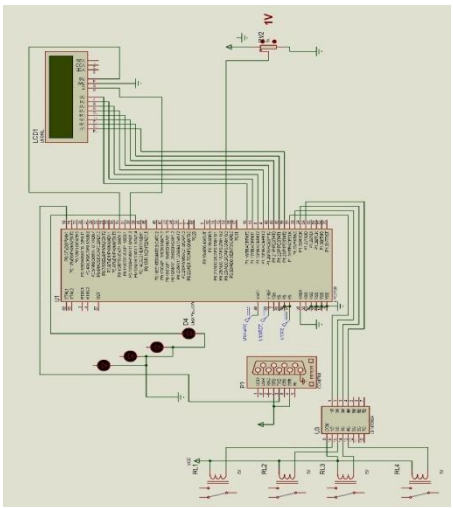

Fig.6. Overall LCD and Relay interfacing to LPC2138 at switch board

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Fig.7. Controller LCD status when system is initialized

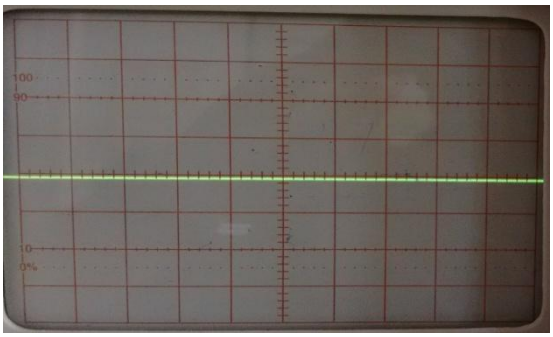
Fig.8. Device 1 port pin voltage

Fig.9. Transmitter LCD status when device 1 in ON

Fig.10. Receiver LCD status when device 1 in ON

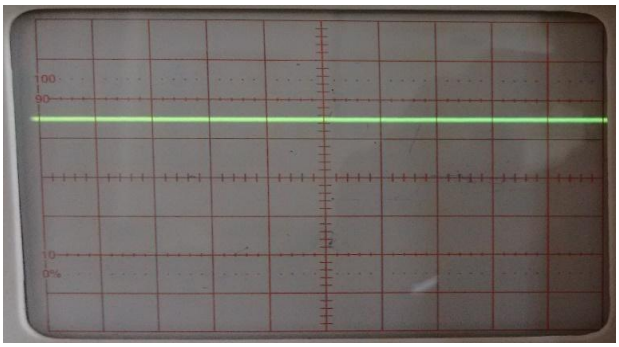
Fig.11. Device 1 port pin voltage

V. CONCLUSION

This paper represents the design and implementation of easy to interacthome automation system using ZigBee technology, ARM controller and Touch screen. As the mobility in the world increases, need to control home from remote locations also increases. The ZigBee isbest choice for this due to its medium range coverage of around 80m. The touch screen makes the system user friendly for the interactive interface. The whole system and communication between two ZigBee modules is secured through encryption. The design is completely wireless and integrated with the ARM controller to form a robust, easily operable and low-costsystem. Wireless communication makes the system easy to install.

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