Wireless Patient Monitoring System Using Point to Multi Point Zigbee Technology

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ABSTRACT: A ZigBee sensor network for data acquisition and monitoring is presented in this paper. A ZigBee module is connected via a USB interface to a Microsoft Windows PC, which works as a base station in the network. Data collected by sensor devices are sent to the base station PC, which is set as Wireless sensorNetwork (WSN). ZigBee is low power consumption, built-in security method and ratified specifications make it very suitable to be used with medical sensor devices.This application of Zigbee based network consists of two transmitter sections and a receiver section.Each transmitter section consists of heartbeat sensor, body temperature sensor, microcontroller, Zigbee and LCD module.In the proposed system the patient's health is continuously monitored and theacquired data is analyzed at a personal computer using Graphical User Interface(GUI). If a particular patient's health parameter is higher or lower the threshold values, an alarm system is used to alert the doctor**.** The aim of this system is to know the condition of patient's health by the doctor immediately and to reduce the load of the staff taking care of the patient in the hospitals. In this paper, wireless point to multipoint system is used between doctor and patient.

Keywords: Heartbeat Sensor, Microcontroller, Zigbee, Wireless Sensor Network, Temperature Sensor.

I. INTRODUCTION

Patient monitoring system become an important topic and research field today. Research on health monitoring were developed for many applications such as military, homecare unit, hospital, sports training and emergency monitoring system. Patient monitoring systems are gaining their importance as the fast-growing global elderly population increases demands for caretaking. These systems use wireless technologies to transmit vital signs for medical evaluation. This paper describes the wireless sensor network based on ZigBee technology. It is mainly used for collecting and transferring the various monitoring information about thepatients in hospitals. Wireless sensor networks application for physiologicalsignals communication transmission has manytechnologies. Such as the Infrared, Bluetooth and ZigBee,etc. Because the angle limit problem of the infraredtransmission, and the infrared have not be used forPhysiological signal transmission. Although Bluetooth isbetter than ZigBee for transmission rate, but ZigBee haslower power consumption. Hence, ZigBee is generallyused for 24 hours monitor of communication transmissionsystems**.** Compared to Bluetooth, ZigBee provides higher network flexibility and a larger number of nodes, and a better transmission range with low power consumption.Large number of nodes enables the expansion of such systems. Recently, ZigBee-based wireless networks were tested in various applications.

II. HARDWARE DESIGN

In this paper hardware used is Zigbee, LCD, microcontroller 16F887, heartbeat sensor and temperature sensor. Fig. 1 shows the functional block diagram of the system hardware. The system has been designed to take two inputs to measure physiological parameters of human body such as temperature and heartbeat. The inputs from the sensors are integrated and processed. LCD shows the patient's data. In this system, we used three Zigbee modules, two for transmitter and one for receiver. By using Zigbee modules, the data are sent to the doctor's computer. The data can be monitored on the computer usingGUI. By using Zigbee baseboard, it is easy to connect Zigbee module and computer with USB port.

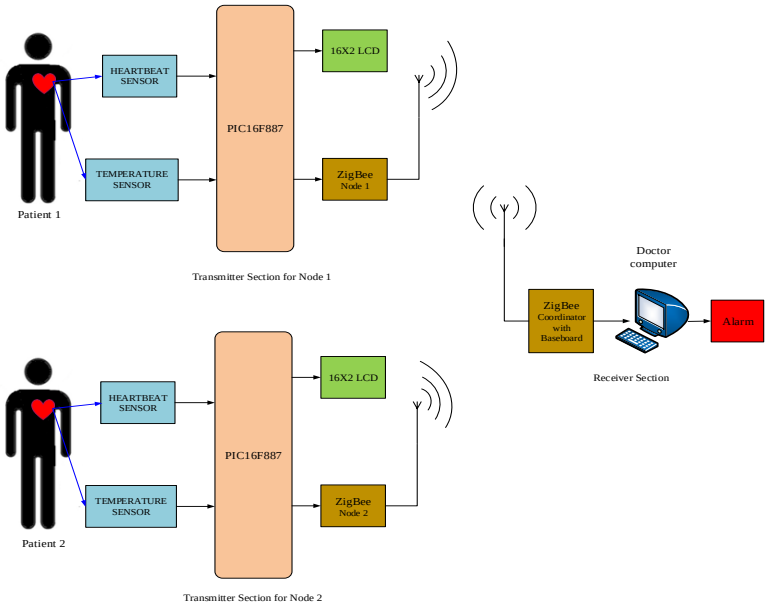

Fig. 1 *Functional Block Diagram of the Overall System*

A. Zig Bee Networking Topologies

The network formation is managed by the ZigBee networking layer. The network must be in one of two networking topologies specified in IEEE 802.15.4: star and peer-to-peer.In the star topology, shown in Fig. 2 every device in the network can communicate only with the PAN coordinator. A typical scenario in a star network formation is that an FFD, programmed to be a PAN coordinator, is activated and starts establishing its network. The first thing this PAN coordinator does is select a unique PAN identifier that is not used by any other network in its radio sphere of influence—the region around the device in which its radio can successfully communicate with other radios. In other words, it ensures that the PAN identifier is not used by any other nearby network.

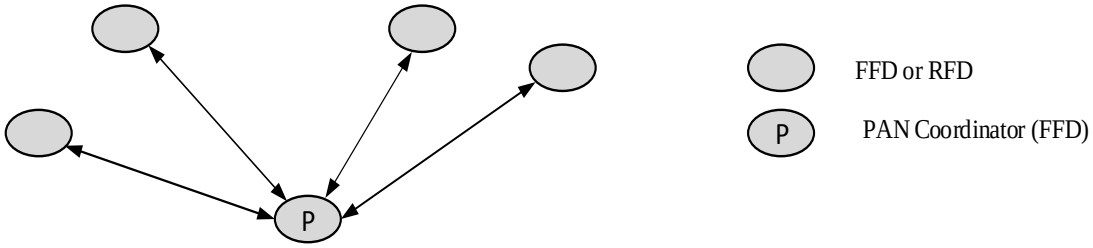

Fig. 2 *A star network topology*

B. Zigbee cc2530 Module

Fig. 3 shows the Zigbee transmitter module that is placed at the patient's room and transmits patient's data to doctor computer.In this system, it used three Zigbee modules, two for transmitter and one for receiver. The difference between transmitter module and receiver module is only firmware and the design is the same. It is a wireless point to multipoint data communication between doctor and patient. Fig. 4 shows Zigbee receiver module with baseboard and it is placed at doctor's computer. The advantage of using Zigbee baseboard is that it can easily interface with Zigbee receiver module and computer.

Fig. 3 *Zigbee Transmitter Module*

Fig. 4 *Zigbee Receiver Module with Baseboard*

C. Zigbee/IEEE 802.15.4 Architecture

Fig.5 shows the architecture of Zigbee which consists of Application, Zigbee alliance, IEEE 802.15.4 MAC and PHY layers.

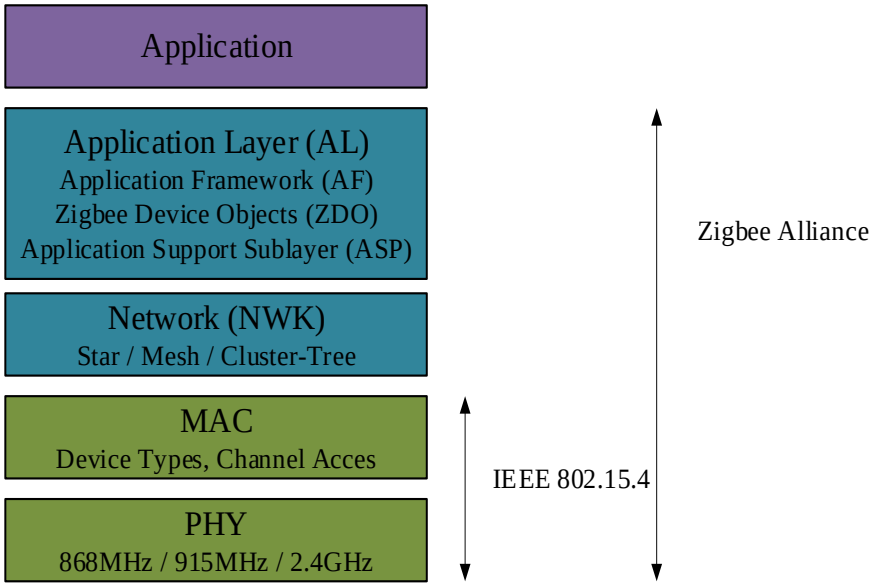

Fig. 5 *Architecture of Zigbee/IEEE 802.15.4*

1. Physical (PHY) Layer

In ZigBee wireless networking as shown in Fig. 5, the lowest protocol layer is the IEEE 802.15.4 Physical layer, or PHY. This layer is the closest layer to hardware and directly controls and communicates with the radio transceiver. The PHY layer is responsible for activating the radio that transmits or receives packets. The PHY also selects the channel frequency and makes sure the channel is not currently used by any other devices on another network.

2. Medium Access Control (MAC) Layer

The medium access control (MAC) enables the transmission of MAC frames through the use of the physical channel. Besides the data service, it offers a management interface and itself manages access to the physical channel and network beaconing. It also controls frame validation, guarantees time slots and handles node associations. Finally, it offers hook points for secure services.

D. PIC Microcontroller

The PIC16F887 features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 14 channels of 10-bit Analog-to-Digital (A/D) converter, 1 capture/compare/PWM and 1 Enhanced capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus and an Enhanced Universal Asynchronous Receiver Transmitter (EUSART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances or consumer applications.

E. Liquid Crystal Display (LCD)

The LCD is used to visualize the output of the application. It isused to check the output of different modules interfaced with the microcontroller. Thus LCD plays a vital role to see the output and to debug the system module wise in case of system failure in order to rectify the problem.

F. Heartbeat Sensor

Heart rate measurement indicates the soundness of the human cardiovascular system. A technique to measure the heart rate by sensing the change in blood volume in a finger artery while the heart is pumping the blood. It consists of an infrared LED that transmits an IR signal through the fingertip of the subject, a part of which is reflected by the blood cells. The reflected signal is detected by a photo diode sensor. The changing blood volume with heartbeat results in a train of pulses at the output of the photo diode, the magnitude of which is too small to be detected directly by a microcontroller. Therefore, a two-stage high gain, active low pass filter is designed using two Operational Amplifiers (OpAmps) to filter and amplify the signal to appropriate voltage level so that the pulses can be counted by a microcontroller. Measuring time for heartbeat is about 15 seconds.

G. Temperature Sensor

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurement. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line for communication with a microcontroller. It has an operating temperature range of -55°C to +125°C and is accurate to ±0.5°C over the range of -10°C to +85°C.Each DS18B20 has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1-Wire bus. Thus, it is simple to use one microcontroller to control many DS18B20s distributed over a large area. Applications that can benefit from this feature include temperature monitoring systems inside buildings, equipment, or machinery, and process monitoring and control systems.

H. Flowchart

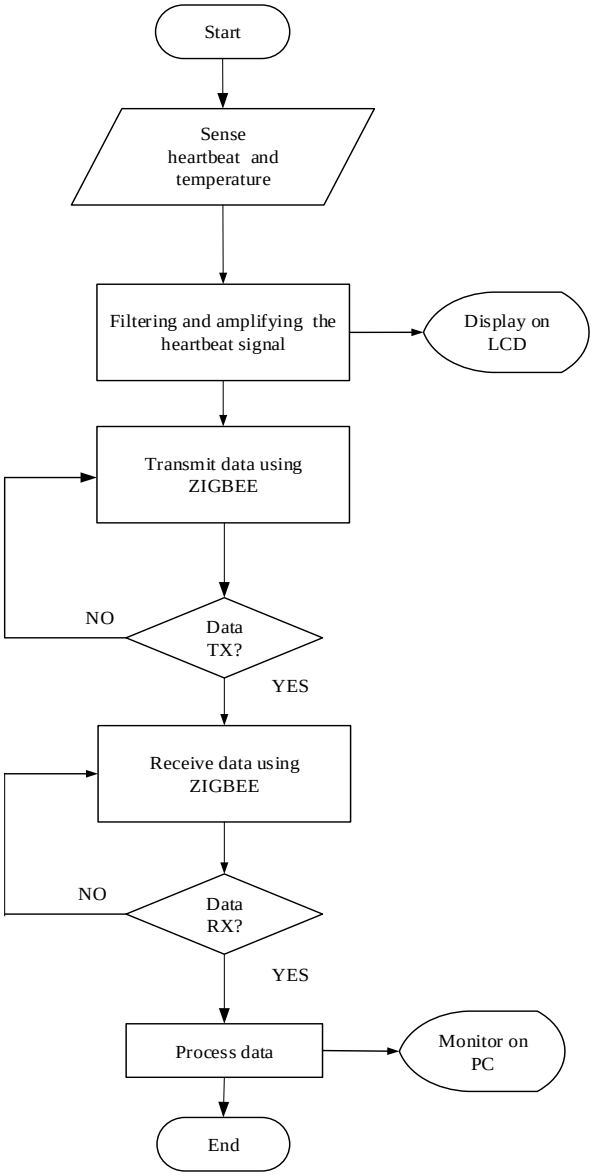

Fig. 6 *System Flowchart*

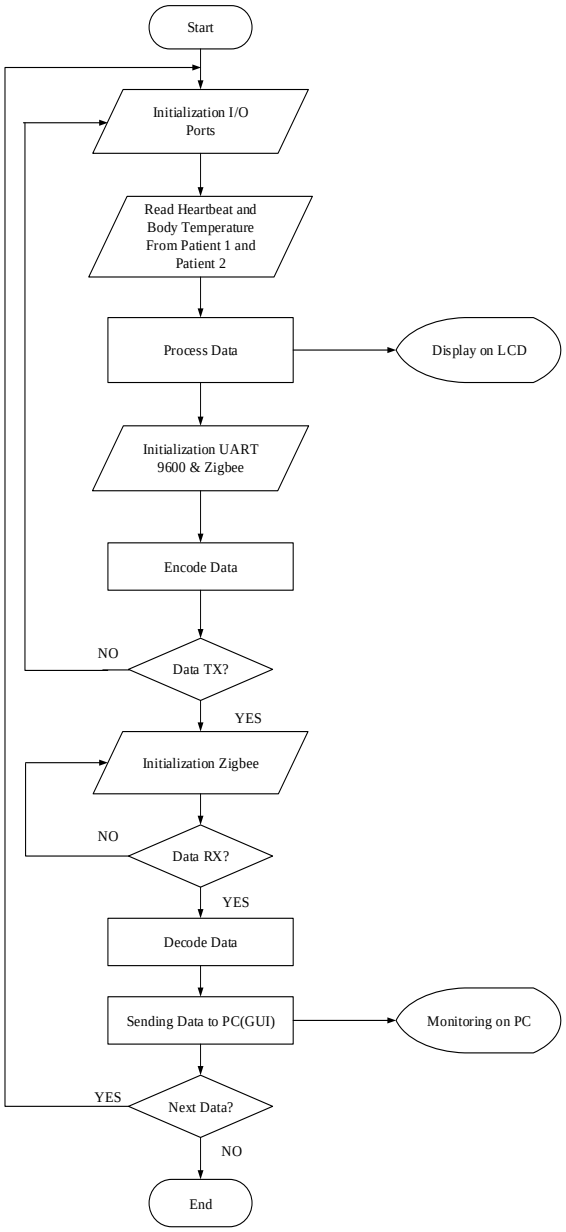

Fig. 7 *Program Flowchart*

III. CIRCUIT DIAGRAM FOR RESEARCH

Fig. 8 shows the transmitter and receiver diagram for wireless patient monitoring system. In this diagram, heartbeat sensor is connected to RA4 pin, temperature sensor is connected to RE2 pin and zigbee is connected to TX pin of the PIC microcontroller.

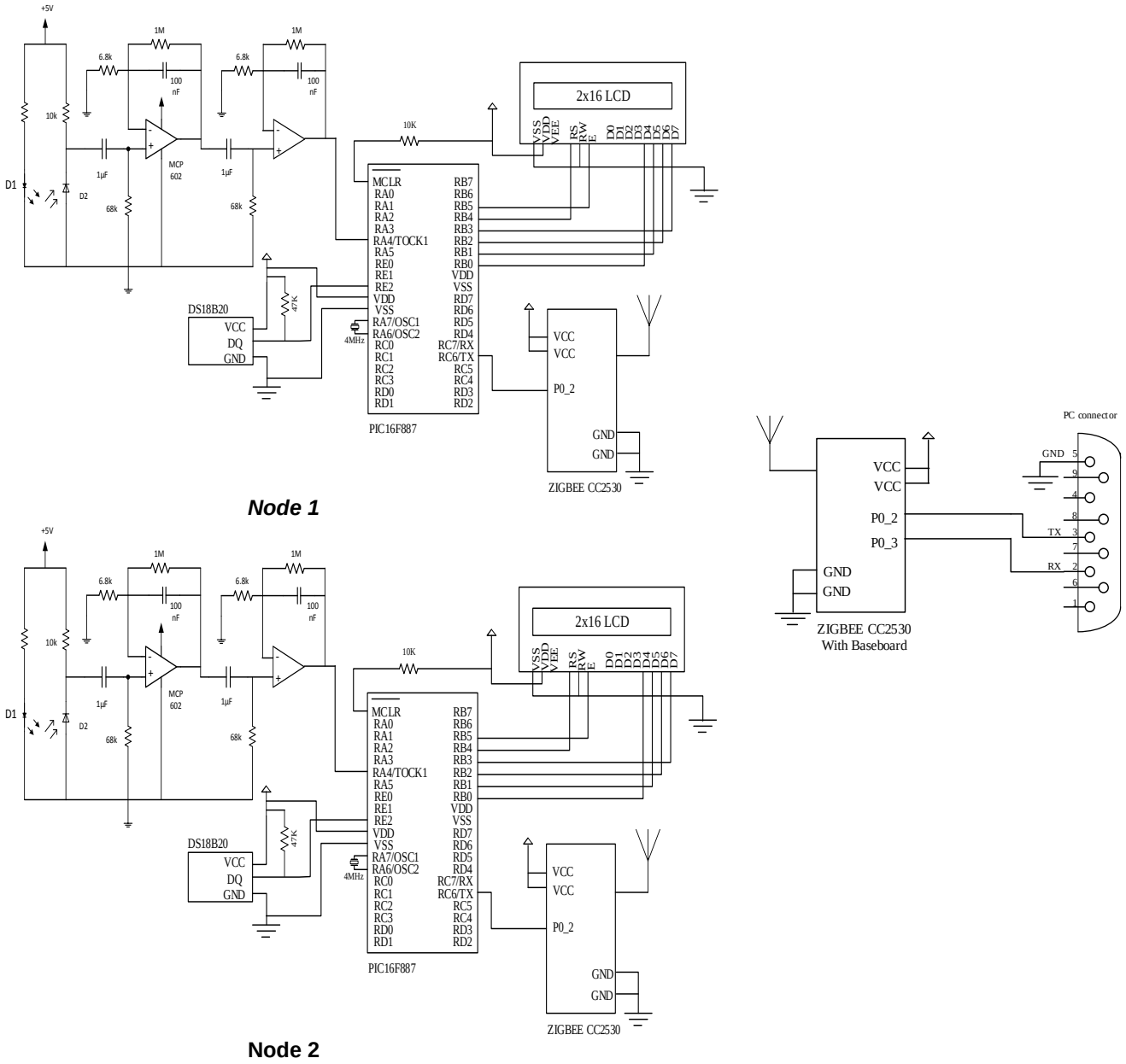

Fig.8 *Overall Circuit Diagram of the System*

IV. GUI RESULTS

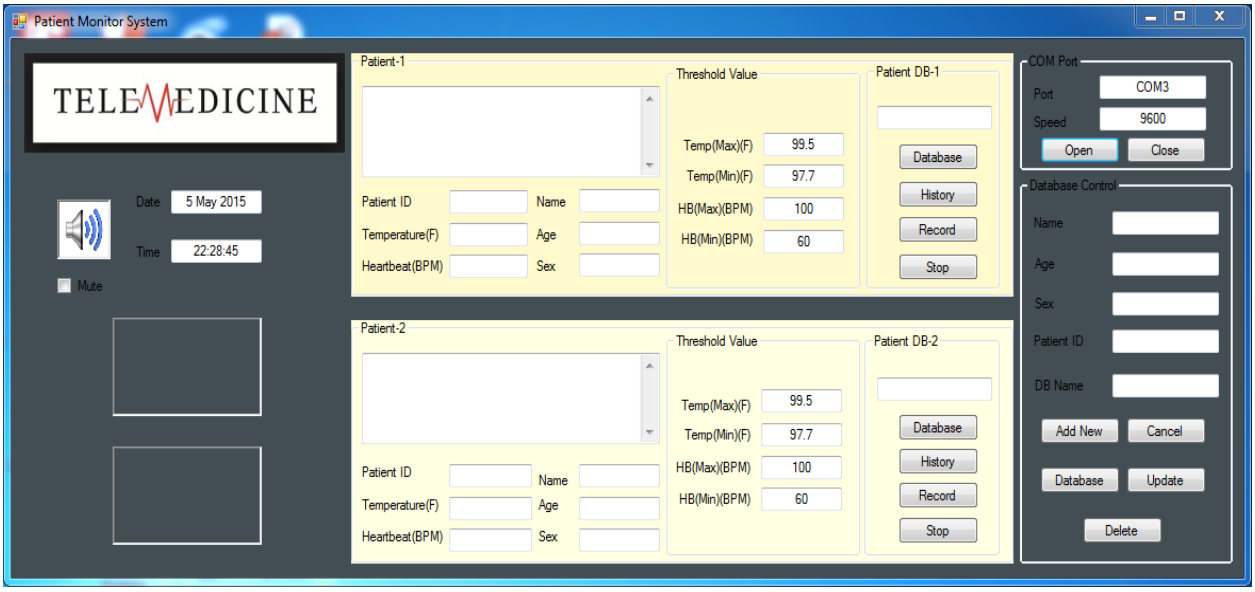

Fig. 9 *GUI Design for Patient Monitoring System*

Fig. 9 shows the GUI results of the system. It consists of two text box for patient to monitor patient 1 information and patient 2 information that include patient ID, name, age, sex, temperature and heartbeat. COM Port is used to connect PC. Database control section is used to add new patient ID and modified patient data. The threshold text box is to set the minimum and maximum values of temperature and heartbeat. The patient DB text box includes database, history, record and stop. Database button is to choose the patient IDfrom database file and history button is to show the patient data. When the record button is click, the data start storing. The stop button is click, the data stop storing. The data will be sent every 20 seconds and store in Microsoft office excel file.

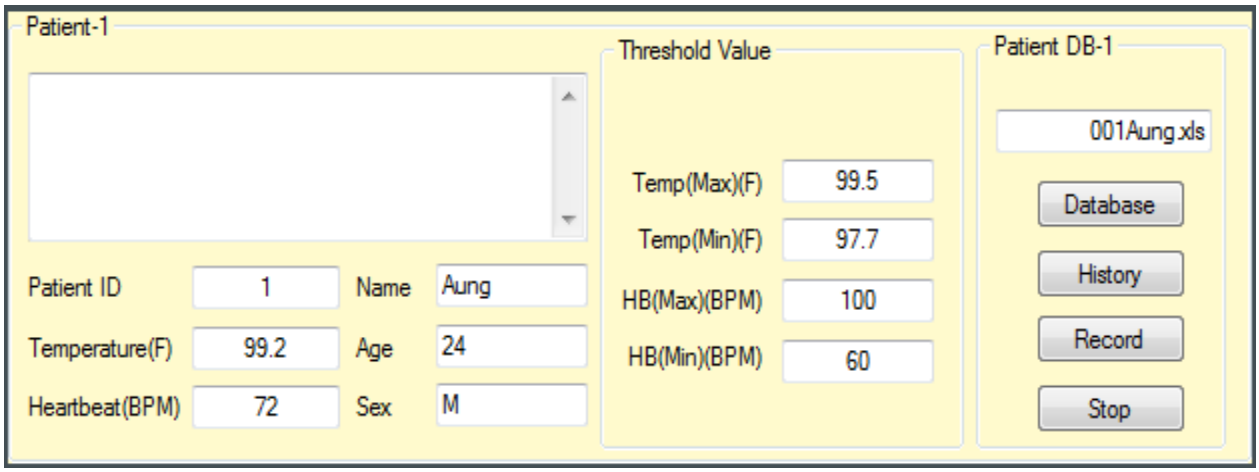

Fig.10 *GUI Result of Patient Monitoring System for Patient 1*

id	name	age	sex	mdate	mtime	temp	hb
1	Aung	24	M				
				27 Apr 2015	10:41:12	97	84
				27 Apr 2015	10:41:34	97.5	88
				27 Apr 2015	10:41:56	97.5	80
				27 Apr 2015	10:42:18	98	76
				27 Apr 2015	10:42:39	98	80
				27 Apr 2015	10:43:01	98.6	84
				27 Apr 2015	10:43:23	98.7	88
				27 Apr 2015	10:43:45	99	84
				27 Apr 2015	10:44:07	99.2	76
				27 Apr 2015	10:44:29	99.2	72

Fig. 11 *Test Result of Saving File in Microsoft Office Excel for Patient 1*

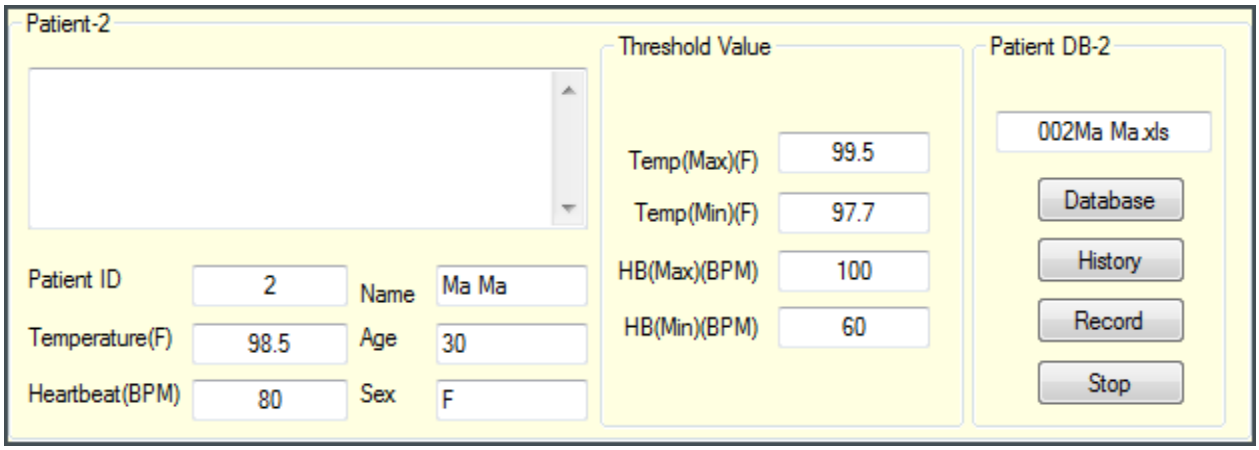

Fig. 12 *GUI Result of Patient Monitoring System for Patient 2*

id	name	age	sex	mdate	mtime	temp	hb
2	Ma Ma	30	F				
				27 Apr 2015	10:41:12	97.2	80
				27 Apr 2015	10:41:34	97.5	88
				27 Apr 2015	10:41:56	97.8	80
				27 Apr 2015	10:42:18	98	76
				27 Apr 2015	10:42:39	98.2	68
				27 Apr 2015	10:43:01	98.2	84
				27 Apr 2015	10:43:23	98.2	72
				27 Apr 2015	10:43:45	98.5	84
				27 Apr 2015	10:44:07	98.5	76
				27 Apr 2015	10:44:29	98.5	80

Fig. 13 *Test Result of Saving File in Microsoft Office Excel for Patient 2*

V. EXPERIMENTAL TESTS

The following figures are shown for design and construction of microcontroller based wireless patient Monitoring system using Zig Bee technology.

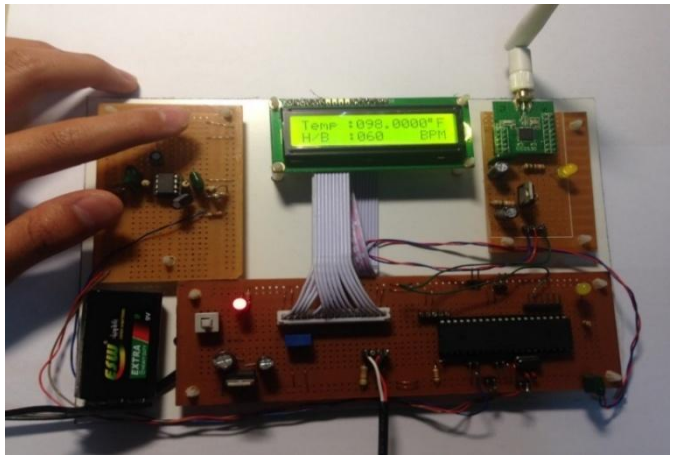

Fig. 14 *Experimental Test of Sensing Heartbeat and Body Temperature*

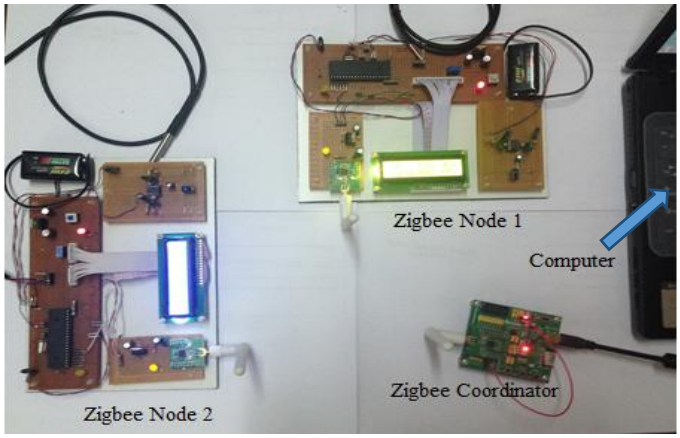

Fig. 15 *Experimental Test of Sensing Data from End Devices by Zigbee Coordinator*

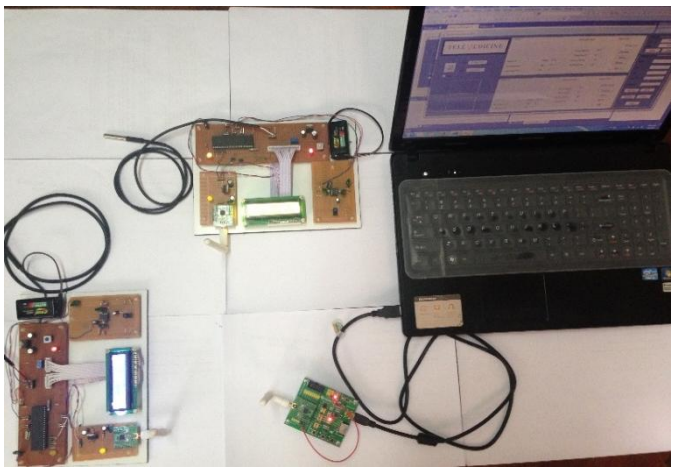

Fig. 16 *Experimental Test of Patient Monitoring System*

VI. CONCLUSION

In this paper, we present a wireless health monitoring system which is able to receive data on receiver side and immediate action will be taken according to the results obtained. This system provides effective solution to upgrade the existing health system by using different kind of sensors mounted on a single system. This system is based upon wireless Zigbee technology IEEE 802.15.4 providing low cost effective solution.Here the cooperative communication also plays an important role to make sure that Zigbee nodesare always in the range of Zigbee Coordinator.The system is convenient and efficient in nature and thus increases interaction between patient and doctor and ultimately avoids unexpected tragedy. This system will widely be used in hospital as point to multipoint network. This Zigbee supports 255 nodes in a single network. The database can be stored more than two patient data in GUI. For further extend, the Zigbee can connect more than 2 nodes in a same network. Moreover, gateway module is needed to interconnect for different network. Adding more sensing device will get a lot of benefit either to the doctor or to the patient. Therefore, the patient monitoring system will be more convenient in hospitals.

REFERENCE

[1] Ms. Amruta Nagarkar, Prof.M.N.Kakatkar**"**ZIGBEE BASED WIRELESS PATIENT MONITORING" International Journal of Science, Engineering and Technology Research (IJSETR) Volume 2, Issue 2, February 2013

[2] Shahin Farahani "Zigbee Wireless Networks and Transceivers"

[3] The Zigbee Alliance "www.zigbee.org"

[4] M.M.A. Hashem, Rushdi Shams, Md. Abdul Kader"Design and Development of a Heart Rate Measuring Device using Fingertip" Khulna University of Engineering & Technology (KUET) Bangladesh

[5] Manisha Shelar, Jaykaran Singh, Mukesh Tiwari "Wireless Patient Health Monitoring System" International Journal of Computer Applications (0975 – 8887) Volume 62– No.6, January 2013