# Wireless Real Time Universal Interface for the Biomedical System: Design and Realization

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***Abstract*—Utilizing Wireless Sensor Network (WSN) in the real time applications offers a wide area of the remotely system automation. The monitoring of vital sign and biomedical signals covers a wide spectrum of applications in different contexts nowadays and has been a research topic during the last decade. In his work the real time measurement of the temperature using Zigbit module with full optimized Graphical User Interface (GUI) application. A moderate-cost elements and Atmel's IEEE 802.15.4 protocol named Atmel ATZB-24-A2 is used for the wireless communications. The algorithm of the digital temperature measurement is full field by using the PIC18f46k20 microcontroller. The system reading, monitoring and adapting the targeted environmental parameters such as the temperature in our case. This is either locally (on the Coordinator) or remotely (on the Router) of the proposed system by using both the ZigBee module and smart GUI. According the desired Set Point and the measured temperature value of the patient or incubator, the system provides four different states (flags). These flags can be used for driving the adequate actuators. The proposed interactive system provides a simple and an easy deal with patient or the incubators. Smart algorithm is implemented for the system data acquisition.**

***Keywords—Embedded System, Biomedical Application, Real Time, wireless sensor networks, ZigBee protocol, IEEE 802.15.4 recommendation, incubator***

## I. INTRODUCTION

The great potential of WSN is being seen in industrial, consumer and commercial application. The wireless technology is becoming one of the most prominent areas of research. The most widely used transceiver standard in WSNs, a ZigBee technology with the development of network and communication technology, the WSN has solved the inconvenience into people's life. WSN has good functions of data collection, transmission, and processing [1-2]. An ever-growing range of wireless sensors for medical monitoring has shown that there is significant interest in monitoring patients in their everyday surroundings. It however remains a challenge to merge information from several wireless sensors and applications [3]. A simplified block diagram of the proposed system is shown in fig.1.

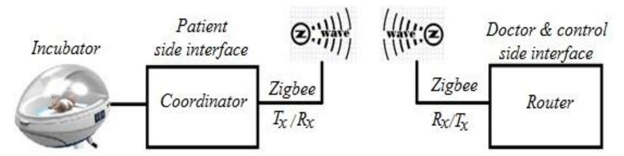


Fig. 1. Proposed biomedical universal interface

Many Diseases cause millions of death worldwide because of the increase in the aging population and the rising of healthcare costs. There is also a demand of remote quality healthcare. Technological advancements in the field of medical electronics and communication offers a competitive and promising alternative for decreasing the cost of healthcare. In this paper a real-time reading, monitoring and reacting to an adequate adaptation of the targeted either patient or incubators. The system also includes a GUI based on desktop application to provide information about the patient status such his temperature and provides new reading every 5 second. The system enables doctors to remotely follow-up the patient status using their computer. The remote monitoring also enables the patient to live his normal live and help decreasing the cost of healthcare. With the recent advance in IC design, the computing power and the memory size of mobile device have increased considerably. This development makes many mobile devices, capable of carrying out complex computing tasks and thus can be used in monitoring patient remotely [4-5].

## II. LITERATURE REVIEW

successfully embedded system capable of monitoring solitary at-home Alzheimer's patient's eating activity and localization [6]. The raw and processed data is viewable by a remote caregiver via a web interface. Two algorithms were developed that detect the patient's eating activities and location throughout the home from the sensor data. A web-based user interface was designed that allows a primary caregiver to remotely viewed the patient's status while away from the home. However, the system functionality has been realized, extra implementation parameters were not available.

The design and development of the insole system are demonstrated to measure the plantar pressure distribution [7]. Plantar pressure distribution is one of the easy and simple ways to detect and analyze the body imbalance in human. The low cost insole system is designed for improving some limitation of the available products. The insole system has very high force range which is suitable for the heavy activities in the daily living such as jumping and running. The graphical user interface on visual C# program displays the level of the color and the number of the plantar pressure. Graphical user interface assists the user for understanding of the pressure distribution in their body.

One kind of embedded system named Biomedical Application of Embedded System for Malnutrition using ARM microcontroller This system can achieve the purpose of long distance real time monitoring of malnutrition. The problems like malnutrition in our society can be well monitored which will help in proper diagnosing [8].

## III. Interactive Embedded Systems Overview

Interactive systems can be defined as the class of systems whose operations involve a significant degree of user interaction. Common media for interaction include the universal I/O ports that can be interfaced the digital and analog (power) systems. The process of formulating the software requirements for such systems must take into account the important issues associated with such systems. Issues to be taken into account for interactive systems such as user interface and user classes. User interface refer to the ability to model and represent user interface requirements. User classes refer to interactive systems often have varied classes of users with varying (potentially conflicting) requirements and expectations. Taking into account the Interactive systems may interface with other systems in their environment.

Interactive system is the term we use to describe the technologies that interactive system designers work with. This term is intended to cover components, devices, products and software systems that are primarily concerned with processing information. Interactive systems are things that deal with the transmission, display, storage or transformation of information that people can perceive. They are devices and systems that respond dynamically to people's actions. The interface to an interactive system is all those parts of the system with which people come into contact, physically, perceptually and conceptually:

- Physically we might interact with a device by pressing buttons or moving levers and the interactive device might respond by providing feedback through the pressure of the button or lever.
- Perceptually the device displays things on a screen which we can see, or makes noises which we can hear.
- Conceptually we interact with a device by trying to work out what it does and what we should be doing. The device provides messages and other displays which are designed to help us do this.

The interface needs to provide some mechanisms so that people can provide instructions and enter data into the system: 'input'. It also needs to provide some mechanisms for the system to tell people what is happening by providing feedback and mechanisms for displaying the content: 'output'. This content might be in the form of information, pictures, movies, animations and so on [9].

## IV. Proposed Biomedical Universal Interface

The main goal of the proposed system is to provide a remote monitoring with real-time information that enables administrator to assess the status of the incubator. The information of greatest interest in this system are the temperature reading of the incubator. These requirements were provided when planning for the project began, primarily because this information is not given in many existing systems.

The development of real-time microcontroller based Data Acquisition System for reading, monitoring the temperature and transmits the acquired information to the remote processing unit. The proposed system is composed of a biomedical hard and soft interfacing system. The hardware interface that is called Temperature Incubation Monitoring (TIM). The software application interface GUI, that is called the Universal Real Time System (URTS). In the next section, the main stages of the hardware will be presented.

## V. Wireless Interface System

A printed circuit board (PCB) was designed to fulfill the requirements of the sensor node. sensor node can support to temperature sensor. Wireless communication on each sensor node is provided by the ZigBit Series 1 RF module from Digi International. These modules are standalone solutions that can function as a drop in wireless replacement for serial communications. The ZigBit Series 1 modules also offer multiple digital I/O and analog inputs, can be reconfigured wirelessly, and have numerous sleep modes with the deepest sleep consuming only 10 μA at 3.3V. The sensor nodes take advantage of the ZigBit module's capability to sample inputs and transmit the statuses periodically [10].

The sensor nodes are responsible for providing the central server with the statuses of the sensors in the system. The sensor node design is a custom embedded system with wireless communication, digital I/O, and analog inputs. It was designed to be physically small in size and battery powered to allow easy concealment. The system is depicted in Fig.2, which includes two main units, the first is the coordinator node, and the second is the router node. The principles of the setting and operation of the two stages will be discussed as follows.

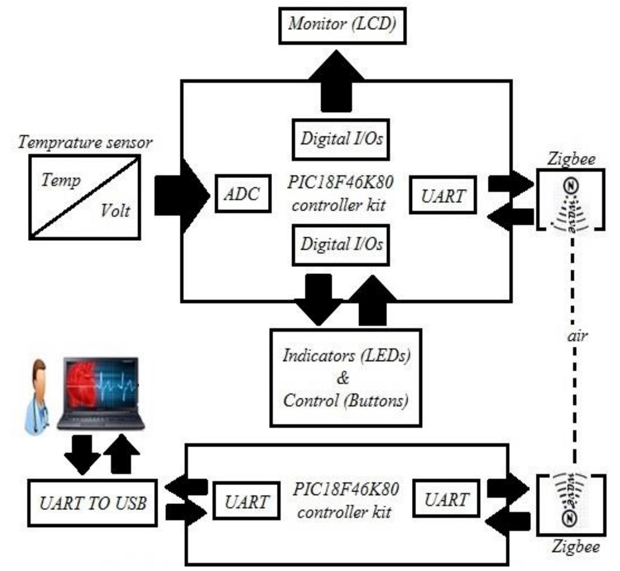


Fig. 2. Block diagram of the proposed biomedical universal interface.

## VI. EXPERIMENTAL WORK

The experimental work is configured by using to different parts. One of them is called a coordinator. The second part is a router. In the next paragraph complete description and functionality.

### A. Coordinator node

The coordinator node is responsible for receiving data from sensor node in the system, formatting the data, and passing it to the central server upon request. It is also responsible for sending remote configuration commands to the sensor node when the central server sends a special instruction to it. To handle the on-board processing requirements a microcontroller is installed. The selected microcontroller is the PIC18F46K80 running at 8MHz via an external crystal oscillator. microcontroller sporting 64KB of onboard flash memory, 2KB RAM, 23 GPIO pins, and numerous hardware peripherals such as a 12-bit ADC, hardware timers, an SPI block, and a UART. The coordinator includes the temperature sensor, LCD Display, actuators triggers and the Microcontroller. The temperature sensor output is connected to coordinator to sense the temperature degree of incubator and send it to the microcontroller and then displayed by a LCD. The coordinator microcontroller is remotely interfaced with the local server (router) by using ZigBee transmitter. Coordinator is considered to be a transmitter. The main components of coordinator are a programmable microcontroller (PIC18F46K80), non-volatile memory (RAM), voltage regulators, Temperature sensor (MCP9700), and LCD as shown in fig.3.

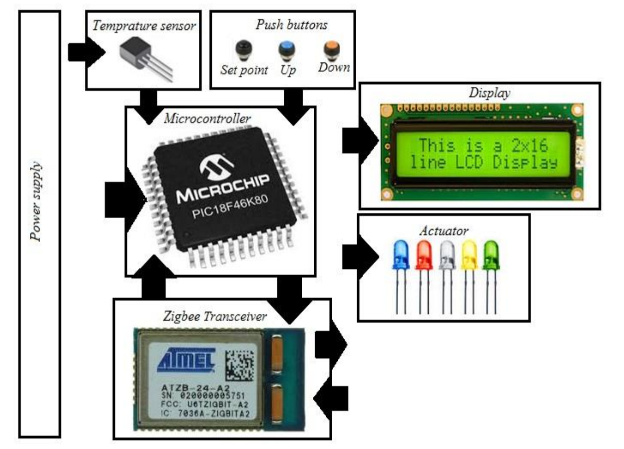


Fig. 3. Block diagram of coordinator unit

Coordinator consists of power supply which provides 5V DC to sensors and MCU. The power supply also produces 3.3V DC for ZigBee module. The recorded data through sensor is send to ZigBee module for transmission using ZigBee protocol at 2.4 GHz. Temperature sensor attached to the In-Built ADC of the microcontroller gives the data in digital frame for the direct transmission. The microcontroller decides the condition of dynamic range according to the threshold value.

### B. Router node

The Router receives these data, send into server's hospital and display data on GUI monitor to monitor from remotely. This whole process is real time control and monitoring for the incubator as shown in fig.4.

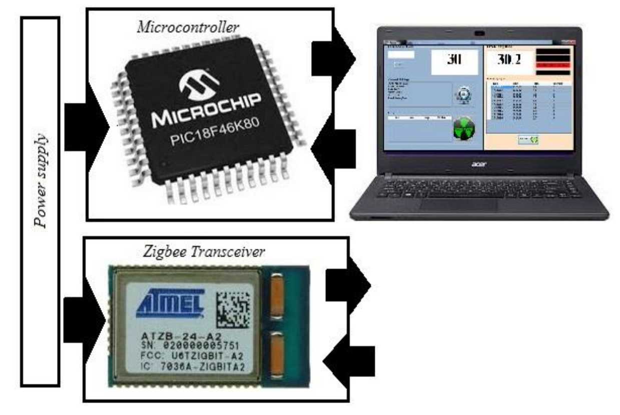


Fig. 4. Block diagram router unit interfacing with server.

The Router also consists of power supply which produces 5V for MCU and 3.3V for ZigBee module. The ZigBee module receives digital data from end device and transfers it to microcontroller serially. Then microcontroller connected with the server. Fig. 5 shows the flow diagram executed by the microcontroller governing the PAN Coordinator. The router procedure of the experimental work is graphically explained through the flow diagram that are executed by the microcontroller as shown in Fig.6

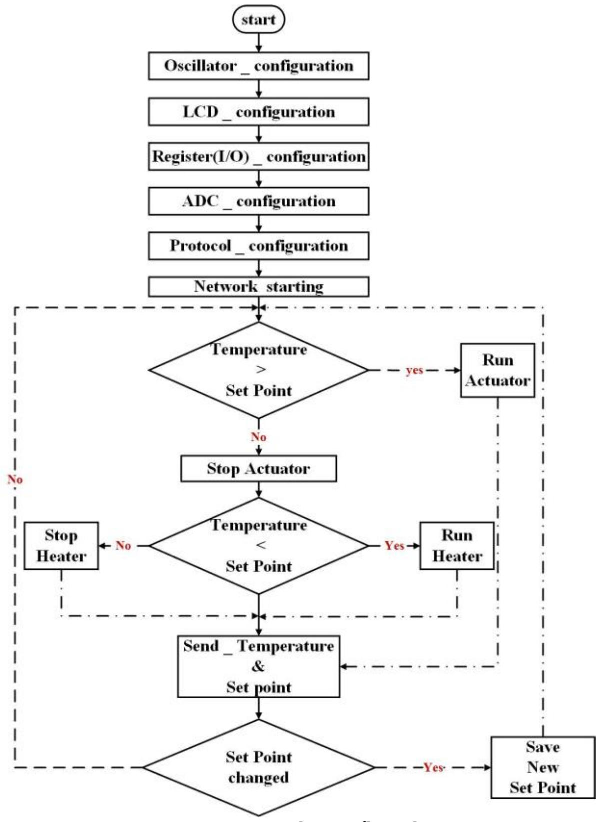


Fig. 5. Coordinator flow chart

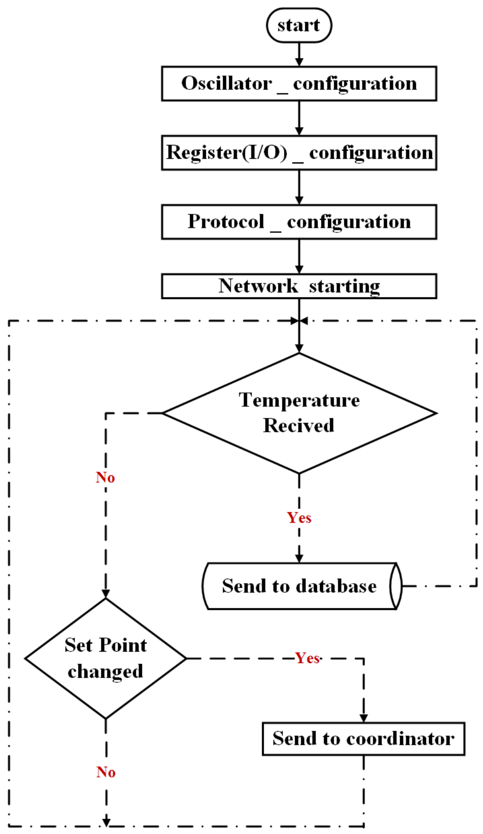


Fig. 6. Router flow chart

## VII. System Operation

### A. Hardware implementation

The parameters are recorded using the built-in 11-channel analog to digital converter (ADC) of the microcontroller. The acquired parameters are processed and recorded in the system memory and transmitted to coordinator unit. On the other hand, the coordinator receives this data and pass to database server. Temperature sensor is used for temperature measurement. Full-bridge circuit is used to convert temperature sensor reading to a compatible signal that can be read by the microcontroller built-in ADCs (0 -5 volts DC). The microcontroller has 8 channels, 12-bit analog-to-digital converter. ADC is used to read the parameters of sensors. A display unit, which may be an LCD display that receives display signals from the microcontroller and displays the parameters. Parameters are also trans/mitted to coordinator unit through ZigBee module. On the other hand, coordinator unit has also a ZigBee module for receiving data from transmitted unit. The MCP9700 low-cost, low-power and tiny temperature sensor family converts temperature to an analog voltage. It provides an accuracy of ±4°C from 0°C to +70°C while consuming 6 μA of operating current. The MCP9700/01 provides a low-cost solution for applications that require measurement of a relative change of temperature [11]. Fig. 7 shows Typical application circuit.

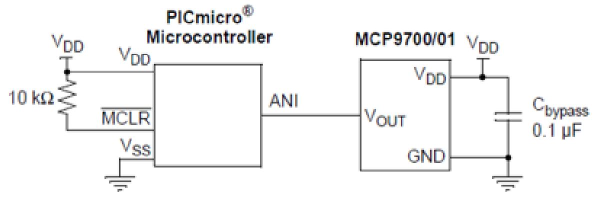


Fig. 7. Typical application circuit

$$V_{out} = V_{zero^0} + T_{C1} * T_A \qquad (1)$$

TABLE I. TABLE I. UNITS FOR EQUATION (1) PROPERTIES

| Symbol | Quantity | Unit & value |
|---|---|---|
| $V_{out}$ | Sensor output voltage | Volt(v) |
| $V_{zero^0}$ | Sensor output voltage at 0°C | 500 mv |
| $T_{C1}$ | Temperature coefficient | 10 mv/c |
| $T_A$ | Ambient temperature | (c) |

The Analog-to-Digital (A/D) Converter module in the PIC18F66K80 family of devices This module allows conversion of an analog input signal to a corresponding 12-bit digital number [12]. The temperature equation is implemented as:

$$T_C = \left(V_{out}/n\right) * T_{max} - T_{offest}$$
$$= \left(V_{out}/8.19\right) - 50^0 C \quad (2)$$

TABLE II. UNITS FOR EQUATION (2) PROPERTIES

| Symbol | Quantity | Unit & value |
|---|---|---|
| $V_{out}$ | Sensor output voltage | Volt(v) |
| $T_{offest}$ | Temperature offset to origin | $50^0$C |
| $n$ | maximum digital value of ADC at $T_{max}$ | 1023 |
| $T_{max}$ | Temperature maximum | $125^0$C |

The proof of concept implementation of the measurement device excluding the coordinator and router part is shown in Fig.8.

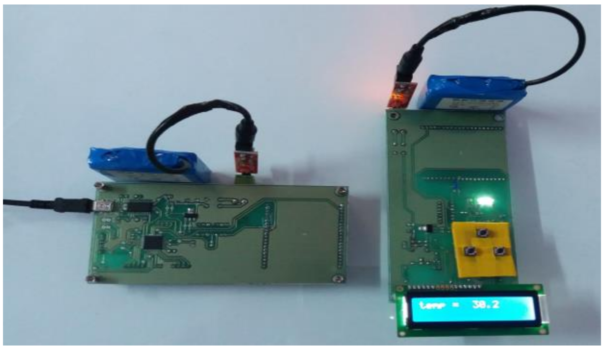

Fig. 8. Proof of concept implementation of the measurement device

### B. System GUI and software development

The software application in this work includes initialization, control and smart operation of the system. The system source code can be classified into several sub modules as in the following sections. The main objective of this work is to create a continuous information obtaining framework. Therefore, URTS software containing the recorded temperature data values is continuously provided to the remote processing unit that enables him to know the real state of the physical environment or process. The software of the URTS is composed of the initialization and data communication. Initialization includes initialization of the input/output ports, data direction flow and reset all related memory locations that are going to be used in the operation. Data communication means transfer of measured data from end device to coordinator unit. fig.9 shows universal real time system GUI (URTS):

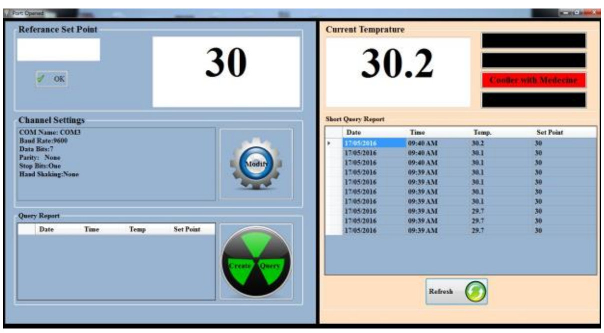


Fig. 9. Universal real time system GUI (URTS)

## VIII. EXPERIMENTAL RESULT

According to the flow chart of fig.10, initially the system starts by setting up the temperature set point.

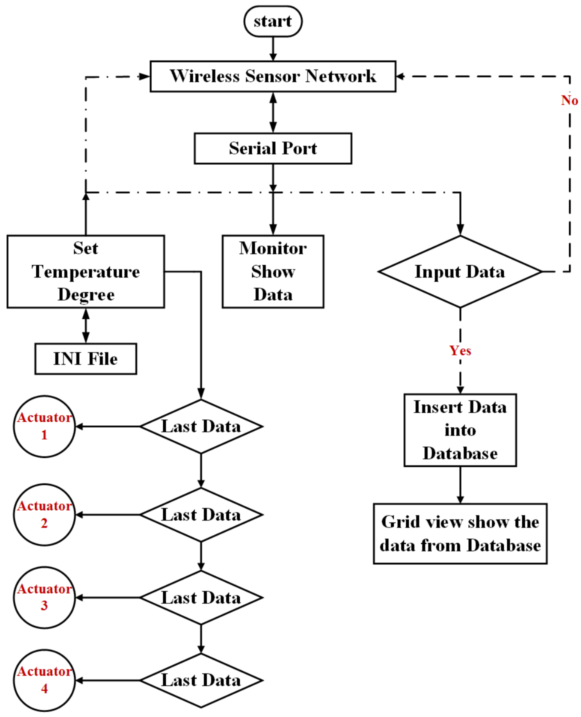


Fig.10.Whole system flow chart

As shown in fig.11 via the monitor part of the system GUI. The system will start to measure, record, display, and calculate the suitable next action such on turn on or off a temperature heater for instance.

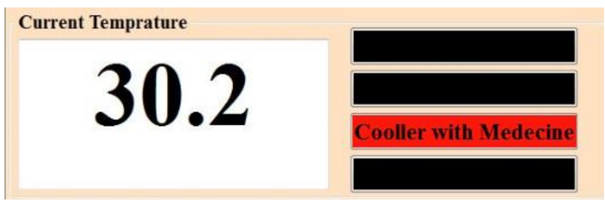


Fig.11. Current temperature monitor part of GUI

The measured temperature of previous fig will be stored in parallel with suitable action (Normal condition or start cooler or cooler with medicine or emergency state). A programmable quarry can be obtained using fig.12 that allows to explore the patient (incubator) data for different periods.

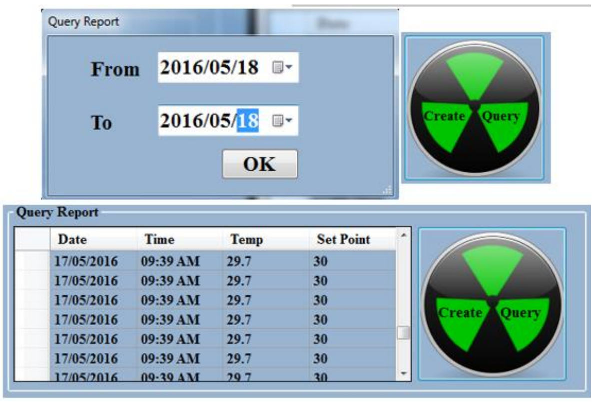


Fig.12. Query report

Prior to deployment on actual condition, it is necessary to test the circuit module by module, to make sure that the complete circuit is working properly. So first the ZigBee module, then the microcontroller circuit and then Sensors were tested and finally the compete circuit were tested. The GUI serves:

1. Browsing the measured patient or incubator temperature.
2. Displaying the reference temperature which allows the system to provide the triggering signal of the adequate actuator.
3. Flexible setting of the set point via either router or coordinator.
4. Smart storing techniques of patient or incubator temperature (system acquired data). The storing action is depending on the change of the measured temperature value. The stored data includes the time and date information of the measured temperature.
5. This is an efficient way of data acquisition with respect to the required storage space as well as the required time to transfer.
6. Data resolution: the measured temperature can be presented as integer or fraction degree that mean the system resolution varies from $(10^0 \rightarrow 10^{-1})$. The system provides a resolution of the measured temperature in the range of $(10^0 \rightarrow 10^{-1})$ C.
7. Recording of data related to the health of people.
8. Analyzing the health issues.
9. Processed report will help for diagnosing.
10. Processed Report can be send to health officer or any authorized person.

## IX. Future Scope

- Health report for multiple can be obtained.
- Health report of multiple persons can be processed and can be sending to multiple persons.
- Multiple diseases can be monitored.

## X. Conclusion

In this paper we presented the design and proof of concept implementation of a biomedical measurement device. This paper will help in exploring and exploiting new opportunities in the emerging interface between computer and healthcare. An effective solution is provided to develop the intelligent system which will monitor various parameters of human being and will send this data to the authorized user is explained in this paper. By using hardware platform PIC18F46K80, Zigbee module. This system can achieve the purpose of long distance real time monitoring.

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