

## Smart Patient Monitoring System Using WSN & Android

Rima D. Nandurkar

M.E. Student  
Government College of Engineering  
Jalgaon, India  
rima.nandurkar@gmail.com

Sanjay O. Dahad

Associate Professor in Electronics  
Government College of Engineering  
Jalgaon, India  
dahad.sanjay@gmail.com

**Abstract**— Body area network (BAN) is an affirming technology for real-time monitoring of physiological parameters of the patients. Tele medical system is provided when wireless technology is combined with body area network. When the Wireless Body Area Network comes in contact with the Android based smart phones gives a latest technology and is easy to use. The telemedical systems measures and evaluate the parameters such as, e.g. heart rate, blood pressure, temperature, vibration and level. (W)BAN along with the use of the sensors, localization of patient, stores the data, analysis and representation on the smartphone, transmission of the data and emergency communication with the one who enrolled his phone number and email address at the setting activity and a clinical server can perform the operation using this system. The Bluetooth based sensor nodes takes the parameters of patients then perform signal processing and data analysis, data recording and send results to the coordinator node.

**Keywords**- Android Smartphone, Bluetooth, Heart rate, Microcontroller, Sensors, Wireless Body Area Network (WBAN).

\*\*\*\*\*

### I. INTRODUCTION

The increasing elderly population in many countries brings a need for more healthcare options. Increased life expectancy has led to the median age being pushed higher, which results in an increased proportion of senior citizens. In communal, not only the senior citizens are leading to the chronic diseases, but also the young and the elder all require medical care. Medical crisis due to lack of medical doctors and nurses, and excessive expenditure of medical treatment tends to more serious according to population ageing in a world. In order to solve this serious social problem, a scientist and an engineer contributed in it. Networking technologies are bringing great change into communications or connections between people to people, people to services and so on. Wireless communications technologies enable omnipresent networking for anyone, at any time, and at anywhere. IEEE 802 is an international standardization committee which has been working on the standardization of various wireless technologies including wireless metropolitan area networks (wman), wireless local area networks (wlan), wireless personal area networks (wpan).

Telemedicine is the field of on-line monitoring and analysis of vital parameters of the patients and in the emergency situation it helps to provide medical care as early as possible, so that the life of patient can be saved. Different kinds of wireless technologies promise to ensure patient compliance. Especially body area networks (BAN) combined with these wireless technologies such as Bluetooth, zigbee allows the setup of a comprehensive telemedical infrastructure. Monitoring and recording of physiological parameters of patients in the environment is becoming increasingly important in research as well in applied physiology and medicine in general. Depending on the environment two different subsystems are base to the BAN: An embedded system as a sensor platform and a wireless sensor network (WSN) tailored to the specific task. In this case the BAN is usually called a wireless BAN or

WBAN. ZigBee/IEEE 802.15.4 is widely used in WSN. The IEEE 802.15 is developing the communication standard optimized for low power devices and operation on, in or near the human body.



Fig.1 BAN Architecture

Figure.1 shows the BAN architecture in which different sensor nodes performed the primary data processing, which include the physiological data processing in the microcontroller. The android smartphone performs secondary data processing and shows the resulting output on the Graphical User Interface (GUI) and finally the last data processing is done with database management in the server. The main idea for the current project is to develop an Android OS based data collection platform that can collect physiological data from multiple sensors, perform signal processing and analyses, store data in an internal memory and transmit data via a UMTS connection to a clinical server and after that the current data is been recorded and compared with the previous history record to obtain the best result.

### II. LITERATURE REVIEW

This section describes the general information about body area network and gives the information about related work and summary of the work that have been performed in past year.

In 1967 [1] proposed the wearable computer which was attached to the patient's wrist. In this off-the-shelf wireless sensors are used to design a prototype such as remote sky platform. It forms an ad hoc network with portable tablet PC. Sensors used in this project are wireless two-lead ECG, a wireless pulse oximeter sensor & a wireless electromyogram. In 2008 [2] P.Khanja, S.Wattanasirichaigoon, J.Natwichai, L.Ramingwongl, S.Noimanee proposed a paper on Web based system for ECG data transferred using zigbee/ieee technology in which they describes the development of a remote monitoring system for ECG signals. The system provides remote monitoring of several patients wearing a portable device equipped with zigbee/IEEE RF module connective based on wireless sensor networks. Again in 2008 Ryuji Kohno, Kiyoshi Hamaguchi, Huan-Bang Li Kenichi Takizawa [3] proposed a paper on R&D and Standardization of Body Area Network (BAN) for Medical Healthcare. Body area network (BAN) is expected to be much attractive application of UWB technology. BAN will play an important role in supporting a wide range of applications with BAN devices being operated in the vicinity, on, or inside body. In this paper, R&D and standardization activities of BAN were overviewed. A prototype BAN using UWB is described. Formal proposal process in 15.6 will be started within 2008. In 2012 Matthias Wagner, Benjamin Kuch, Carlos Cabrera, Peter Enoksson, Arne Sieber [6] proposed a paper on Android Based Body Area Network for the Evaluation of Medical Parameters in which they evaluated several parameters using zigbee/IEEE 802.15.4. But there are some drawbacks with the data transmission such as a data transfer at slower rate, operating frequency and bandwidth is less and also critical issue is regarding the data failure during transmission. In 2013 Jana Púchyová and Michal Kochlá'n, Michal Hod'ň proposed an article on Development of Special Smartphone-Based Body Area Network: Energy Requirements [7] in which energy requirements necessary for the data transmission among the network is analysed in detail. For this purpose, communication solution based on 2.4 GHz proprietary RF transceiver is implemented.

We conclude from the above history that the wireless technologies are the next step for improving the mobile health applications and hence it is also referred as mHealth and electronics health is referred as eHealth. A Wireless Body Area Network contains small and intelligent systems or devices attached to the body of the patient which is to be continuously monitored by the mobile health application over a wireless communication device which can be Zigbee or Bluetooth. WBAN gives the continuous data and monitoring and real time graphs and feedback to the user, patient or to the doctor allocated for that patient. Next the values taken are used for analyzing purpose. The analyzed values are used to check that any kind of disease will occur. The data is recorded for the long period of time. [2] Describes the development of a remote monitoring system for ECG signals. The system provides remote monitoring of several patients wearing a portable device equipped with zigbee/IEEE RF module connective based on wireless sensor networks, but some drawbacks arise by using zigbee regarding corruption of data via transmitting from one end to the other. [3] Gives an idea that BAN plays an important role in supporting a wide range of applications with

BAN devices being operated in the vicinity, on, or inside body. In this paper, R&D and standardization activities of BAN were overviewed. A prototype BAN using UWB is described. Formal proposal process in 15.6 will be started within 2008. From [6] the conclusion comes is about the data transmission such as a data transfer, which performs at slower rate, along with this operating frequency and bandwidth is less and also critical issue is regarding the data failure during transmission of the data. In [7] energy requirement for the data transmission is necessary among the network and is analysed in detail. For this purpose, communication solution based on 2.4 GHz proprietary RF transceiver is implemented.

### III. PROPOSED SYSTEM

#### A. Basic System

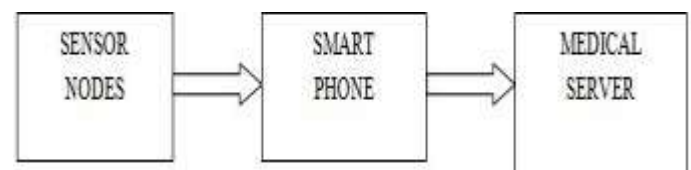


Fig.2 Basic System

The basic system consists of the following three parts:-

- Sensor nodes
- Smart phone
- Medical server

Figure 2 shows the structure of the basic system. It consists of three steps which include sensor nodes which will sense the various physiological parameters and performs the operation of primary data processing along with physiological signal processing in microcontroller. Data representation, data filtering, graphical user interface, data synchronization will be done in smart phone whereas the data processing along with data base management and data storage will be followed at the medical server. The above figure shows the three most important steps that are involved in the whole system; no system will get completed if any of the above steps is missed from the system. Hence all of the above steps play a crucial part in the whole system.

#### B. General Proposed System

There are two different designs of a (Wireless) Body Area Network connected to an Android smart phone with the Real-Time system features several capabilities: Data acquisition in the (W)BAN plus the use of the smart phone sensors, patient localization, data storage, analysis and visualization on the smart phone, data transmission and emergency communication with first responders and a clinical server. In the based approach smart and energy efficient sensor nodes acquire physiological parameters, perform signal processing and data analysis and transmit measurement values to a coordinator node. In the second design sensors are connected via cable to an embedded system.

In figure 3 the block diagram consists of the sensors that are applied to the patient's body which are then given to the A to D Converter since the data acquired are in the analog form which is applied to the microcontroller. From microcontroller

the data is sent to the android smart phone via Bluetooth which is then transmitted to the server via Wifi. If the patient's condition leads to the critical state an alert alarm is also provided in the system. Basically the various physiological parameters of the patient are measured using various parameters. Here instead of Zigbee / IEEE 802.15.4 the communication between the primary node and smart phone will be done using Bluetooth also the communication between the smart phone and the server computer will be done using WI-FI. Along with this the project will be extended with data mining i.e. the last history records of the patients will be stored in the server computer so that it will be easy for the doctor to treat the present patient by using the last data.

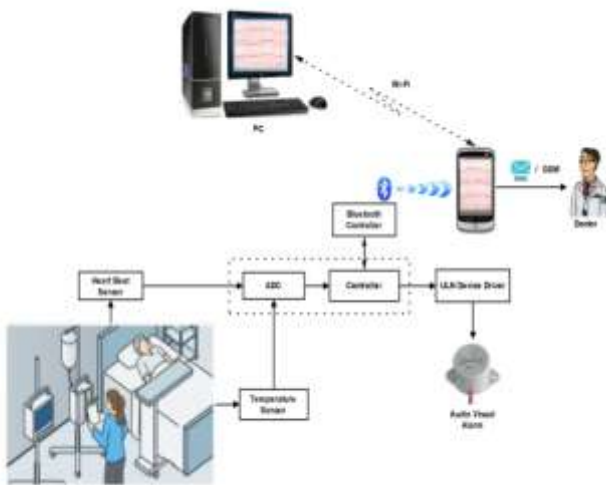


Fig.3 General Block Diagram

### C. General Flowchart of the System

Figure 4 shows the flowchart of the system operation. It describes about the operation that takes place during whole process. Initially all the required software is installed in the personal computer. Micro C AVR software is used to embed the program into microcontroller memory. The code is initially edited in the software followed by a process of selection of the target device. Micro C AVR has a provision to visualize the results. When the status of the input port is assigned to a particular sensor, the output can be visualized as a step by step execution of program. After successful debugging the HEX file is generated using the software. This HEX file is then burned by the flash programmer named as AVR Flash.

The coding of whole project except the microcontroller is performed using java language. Along with this android development kit (ADT) is also used. In eclipse software initial window gets open under which by taking a new project and by saving it a new project is been saved. By using this software various windows have been created such as main window or it is also called as main activity, a window for entering the IP address, mobile number and email id, a window for connecting Bluetooth and lastly a window for visualizing the parameters on android smart phone. These all windows are assembled on one package and that package is called as an android

application. This android application now can be installed in any of the android smart phone just by sending it through Bluetooth to the phone and then just by clicking on to the installed button. Lastly, for development of the GUI and also for connecting the server PC with the mobile phone Net Beans software is used. Net Beans is open source software for the development. For coding the program in the Net Beans java language is used. Here in Net Beans various frames have been designed these designs are used by the server PC.

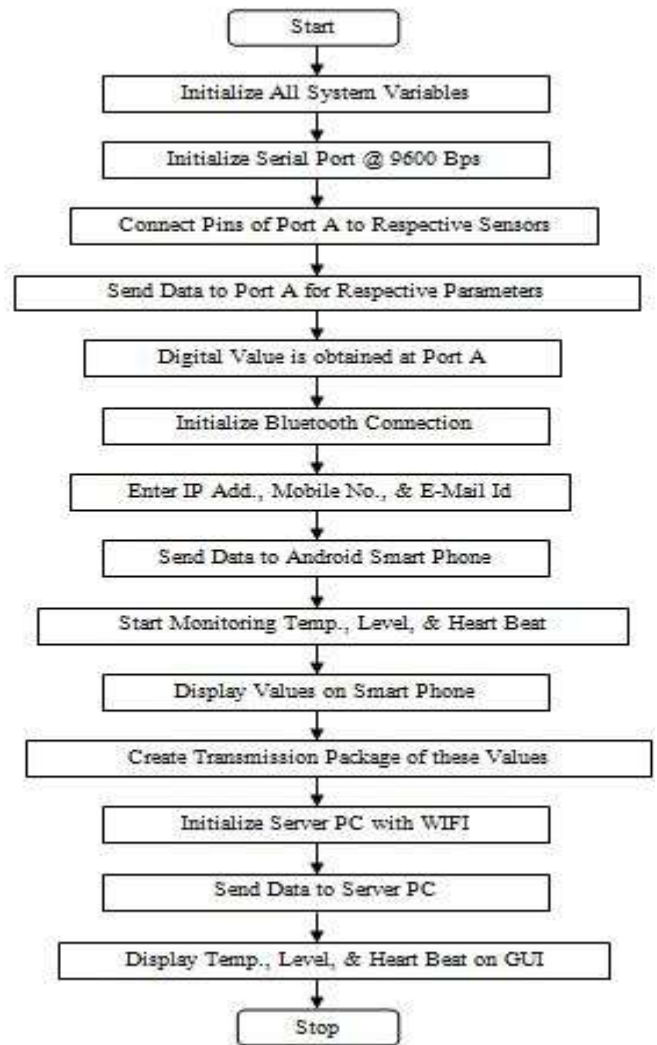


Fig.4 General Flowchart of System

The frames involved are the welcome frame, login frame and main frame. These frames are designed by using different pallets, swing controls and swing containers. These frames are called as "jframes" as its coding is been written in java. When the server PC starts, the first window opened is a welcome window and then a login window. Login window requests for login id and password which is accessible to the one who is continuously monitoring the patients and then after entering the password the window of GUI gets opened where a continues monitoring of the patient's parameters can be visualised. The coding for connecting the server PC with the mobile phone is done in different frame under public class by using hyper text transfer protocol (HTTP). This protocol is

been initialised first under the public class and then by using input and output function the files in the form of packages is been transferred to the server PC. To run the program or to transfer the files from mobile phone to server PC firstly connect the PC & mobile phone with wifi and then right click on the frame of HTTP coding and then deploy it. After deploying the files gets transferred to the server PC and hence the output is been visualised on the GUI at the server PC.

#### D. Android Software

Android is the most popular operating system in the smart phone. It is software stack made for mobile devices which consist of an operating system, applications and middleware. Android operating system is based on a Linux kernel designed primarily for touch screen mobile devices such as smart phones and tablets. Android is open source operating system for touch screen devices. The Android Open Source Project (AOSP) is led by Google, and is tasked with the maintenance and development of Android. According to the project "The goal of the Android Open Source Project is to create a successful real-world product that improves the mobile experience for end users." AOSP also maintains the Android Compatibility Program, defining an "Android compatible" device "as one that can run any application written by third-party developers using the Android SDK and NDK", to prevent incompatible Android implementations.

There are some advantages of android OS which are listed below:

- It is simple and powerful
- Java-based development kit
- Android development tools
- It's excellent documentation and library including classes like Bluetooth Health.
- It is useful to develop on many platforms, like Windows, Linux and Mac operating system.

Nowadays, android is the very popular operating system in the smartphones. It's popularity increasing day by day. It has simple and powerful java based development kit and ability to develop on any platform such as Windows, Linux or Mac. So the user can develop an android application according to its requirements. Android software development kit (ADK) is used to developed android applications. The officially supported integrated development environment (IDE) is Eclipse using the Android Development Tools (ADT) plug-in. As shown in the BAN Architecture the smartphone should acquire data from wireless BAN and provide a Graphical User Interface (GUI), on which different physiological parameters are displayed. So to do this an Android application is required, this application should feature several functions such as data acquisition from wireless BAN using Bluetooth communication, data analysis and representing this data using GUI and transfer of data to a medical server via WiFi or cellular network. Also for future work internal smartphone sensors can be used, e.g. GPS, accelerometer etc., provide additional opportunities, i.e. location of patient and possible detection of alert.

1) *Eclipse software*:- Eclipse is a multi-language software development environment comprising an integrated development environment (IDE) and an extensible plug-in system. It is written mostly in Java. It can be used to develop applications in Java and, by means of various plug-ins, other

programming languages including Ada, C, C++, COBOL, Haskell, Perl, PHP, Python, R, Ruby (including Ruby on Rails framework), Scala, Clojure, Groovy, Android and Scheme.

The initial codebase originated from IBM VisualAge. The Eclipse SDK (which includes the Java development tools) is meant for Java developers. Users can extend its abilities by installing plug-ins written for the Eclipse Platform, such as development toolkits for other programming languages, and can write and contribute their own plug-in modules. Eclipse SDK is free and open source software. It was one of the first IDEs to run under GNU Classpath and it runs without issues under IcedTea.

The Eclipse Platform uses plug-ins to provide all functionality within and on top of the runtime system, in contrast to some other applications, in which functionality is hard coded. The plug-in mechanism is a lightweight software component framework. This plug-in architecture supports writing any desired extension to the environment, such as for configuration management. Java and CVS support is provided in the Eclipse SDK, with support for other version control systems provided by third-party plug-ins.

The Eclipse SDK includes the Eclipse Java development tools (JDT), offering an IDE with a built-in incremental java compiler and a full model of the Java source files. This allows for advanced refactoring techniques and code analysis. The IDE also makes use of a workspace, in this case a set of metadata over a flat filespace allowing external file modifications as long as the corresponding workspace "resource" is refreshed afterwards.

Eclipse implements widgets through a widget toolkit for Java called SWT, unlike most Java applications, which use the Java standard Abstract Window Toolkit (AWT) or Swing. Eclipse's user interface also uses an intermediate graphical user interface layer called JFace, which simplifies the construction of applications based on SWT. Starting with the Eclipse 4.x series, Eclipse XWT (XML Window Toolkit) replaces SWT as the preferred way to create user interfaces for Eclipse.

2) *Net Beans software*:- The NetBeans IDE is written in Java and can run anywhere a JVM is installed, including Windows, Mac OS, Linux, and Solaris. A JDK is required for Java development functionality, but is not required for development in other programming languages. The NetBeans platform allows applications to be developed from a set of modular software components called modules. The NetBeans IDE is an open-source integrated development environment. NetBeans IDE supports development of all Java application types (Java SE including JavaFX, (Java ME, web, EJB and mobile applications) out of the box. Among other features are an Ant-based project system, Maven support, refactorings, and version control (supporting CVS, Subversion, Mercurial and Clearcase). All the functions of the IDE are provided by modules. Each module provides a well defined function, such as support for the Java language, editing, or support for the CVS versioning system, and SVN. NetBeans contains all the modules needed for Java development in a single download, allowing the user to start working immediately. Modules also allow NetBeans to be extended. New features, such as support for other programming languages, can be added by installing additional modules.

The platform offers reusable services common to desktop applications, allowing developers to focus on the logic specific to their application. Among the features of the platform are:

- User interface management (e.g. menus and toolbars)
- User settings management
- Storage management (saving and loading any kind of data)
- Window management
- Wizard framework (supports step-by-step dialogs)
- NetBeans Visual Library
- Integrated Development Tools

#### E. Alert System

The alert system is been formed here for handling the emergency situation. A threshold value is been set in the setting of the system. Whenever the sensors readings are above the threshold value, the system automatically starts the alert system in order to provide the proper medical care to the patients. The alert system consists of the two types of alerts such as SMS alert and email alert. If no response obtains from the patient's is recorded then automatically the alert propagation starts.

1) *SMS Alert:-* Whenever any abnormalities is detected the APP will initiate an alert SMS (message) to primary contact save in the settings activity. The primary number is been entered at the window of the android application.

2) *Email Alert:-* The alert email is been send immediately after the alert SMS send by the system. For sending the email alert an internet connection is necessary to the android smart phone. The email is sent to the primary contact person whose email id is filled in the setting activity of android application.

#### IV. RESULT

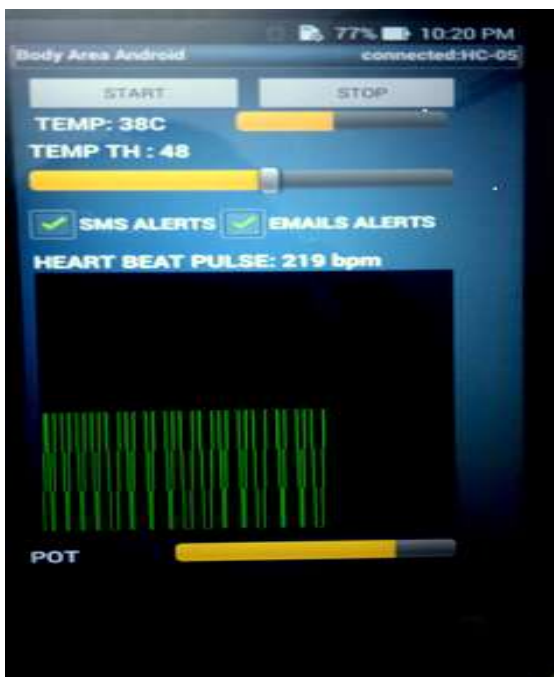


Fig.5 Android Prototype Application

Initially the reliability test is been performed that runs with wireless BAN prototype with the various sensor connected to

it. Three sensors are connected to the co-ordinator node i.e heart rate, body temperature and level sensor. All these sensors work properly and obtain the following readings of the patient's physiological condition. These sensors correctly monitor the patient's physiological condition and send the respective data to an android smartphone via Bluetooth connection. The android prototype application is shown in figure 5.

As we open the application in android smart phone, the setting activity log opens as shown in the figure 6. It consists of three parameters IP address, mobile number and email ID. The IP address is the address of computer of the medical professional, who monitors the physiological parameters of the patients. The mobile number and email ID is required to send the alert messages to the concern person. When the initial setting activity parameters are filled, it opens the main screen of the android application. On this main screen of the android application, three physiological parameters can be monitored such as temperature sensor, heart rate sensor and level sensor. All the physiological parameters can be continuously monitored by the medical professionals.



Fig.6 Android Application Setting Activity Screen

#### V. CONCLUSION & FUTURE SCOPE

Body area network (BAN) plays an important role in supporting a wide range of medical applications with BAN devices that operates in the whole vicinity. Reliability,

functionality and range are enough to obtain the best results. The combination of the WBAN with an Android smartphone offers a large functionality. Vital parameters can be stored, analyzed and visualized with GUIs designed for the end-user. Due to fears with respect to transmission power of wireless systems the upcoming standard IEEE 802.15.6 will be considered for future designs. In future a special application can be designed especially for the medical representative so that if he is out of hospital he can receive the latest updates of the patients and he can provide first aid from anywhere. Certification according to medical safety standards is currently impossible due to the different components used, e.g. the Android operating system.

#### REFERENCES

- [1] Mayuri C. Navale Rameshwari T.Chavan 'A Survey Paper on Body Area Network in Healthcare System' Multidisciplinary Journal of Research in Engineering and Technology, Volume 1, Issue 2, Pg.143-151 143.
- [2] P.Khanja, S.Wattanasirichaigoon, J.Natwichai, L.Ramingwong1, S.Noimanee (ISBME 2008)'A web base system for ECG data transferred using Zigbee/ieee technology' The 3rd International Symposium on Biomedical Engineering.
- [3] Ryuji Kohno, Kiyoshi Hamaguchi, Huan-Bang Li Kenichi Takizawa ICUWB 2008 'R&D and Standardization of Body Area Network (BAN) for Medical Healthcare', IEEE International conference on UWB, vol. 3.
- [4] Ying-Wen Bai, Wen-Tai Li, You-Wei Chen on 2/10/2010 'Design and Implementation of an Embedded Monitor System for Detection of a Patient's Breath by Double Webcams' IEEE 978-1-4244-6290.
- [5] Wojciech M. Zabołotny and Radosław Wielgórska and Marcin Nowika 2011 'J2ME Implementation of System for Storing and Accessing of Sensitive Data on Patient's Mobile Device' aInstitute of Electronic Systems, Warsaw University of Technology, ul. Nowowiejska 15/19, 00-665 Warszawa, Poland Proc. SPIE Vol. 8008,800811.
- [6] Matthias Wagner, Benjamin Kuch, Carlos Cabrera, Peter Enoksson, Arne Sieber 2012 'Android Based Body Area Network for the Evaluation of Medical parameters'.10th International Workshop on Intelligent Solutions in Embedded Systems IEEE.
- [7] Jana Púchyová and Michal Kochláň, Michal Hodoň 2013 'Development of Special Smartphone-Based Body Area Network: Energy Requirements' Federated Conference on Computer Science and Information Systems.
- [8] Baviskar Rahul Nandkishor, Aprna Shinde 6th Oct 2013 a review paper on android based body area network for medical healthcare Proceedings of Sixth IRAJ International Conference.
- [9] Dale Cigoy' June 2007 'How to Select the Right Temperature Sensor' Senior Applications Engineer Keithley Instruments, Inc. Cleveland, OH.