MEASUREMENT AND WIRELESS TRANSMISSION OF VITAL HEALTH PARAMETER

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***Abstract*- This paper addresses the design, implementation and testing of a low cost human health monitoring system which will measure and transmit human pulse rate and body temperature.**
Pulse rateforms the basisof any normality and abnormality of a patient's health condition. Body temperature gives us additional information to support our results after pulse measurement. Our system aims at not only sensing these parameters but also sending them to the doctor or a main system where a disorder can be identified. System will take certain input data such as patient's identity, age and gender, process the sensed pulse rate and body temperature, display it on the LCD and transmit the output. Timely measurements and saving of data is also one of the features of the system. Zigbee is used for the wireless transmission in this project for cost effectiveness but we can opt for other techniques such as GSM too.

***Keywords:*body temperature, Photoplethysmography, pulse-rate, Zigbee**

I. INTRODUCTION

As of today various types of health monitoring systems are available. They include systems that can measure blood pressure, body temperature, blood sugar level as well as heart beat. However the present systems are not exactly affordable to common man. Their expense is one of the major hindrances to its widespread utility. Hence it is of utmost importance to develop a system that can do the above mentioned tasks and make it available to common man at the most affordable price. This is one of the major objectives of our proposed system.Also very few of the present health monitoring systems available in the market have the ability to transmit the measured data to the nearest expert. These predictions can help a common man to avoid potential emergencies.

The proposed system helps a person measure his pulse rate and body temperature at any viable time with the help of the handheld device. It can transmit immediately measured data or data averaged over hourly or daily readings. RTC helps in taking automatic hourly and daily measurements if the sensors are in touch with patient's body. The system basically makes use of two sensor:TCRT1000 (PPG) for measuring pulse rate andLM 335 for measuring body temperature. A keypad enables the user to enter his personal data which includes his identity, gender and age. Mode of operation is to be selected: instantaneous, hourly or daily. Then sensors measure the heart rate for 60 seconds and body temperature and the measured data is processed by the micrcontroller : Atmega32. This microcontroller controls the entire functioning of the circuit and provides memory for storing user information and measured data to be retrieved later. The output is displayed on the LCD and at the same time transmitted to the remote computer via Zigbee. Making such a system available to common man at an affordable price, will help avoid extreme emergencies due to continuous check on health status by a professional even from home. It can also be used in hospitals in more sophisticated form.

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II. LITERATURE SURVEY

Before we started with the design and implementation of the system, a detailed survey on various phenomenon of heart ra te and body temperature along with their sensing technique will have to be carried out which is as follows.

The pulse wave signal is generated by the expansion of the a rteries as the blood circulates during the heart beats [10]. Th is signal is really information rich and can be detected using PPG method. The signals of PPG are related to pulsating art erial blood, which is synchronous with the heart cycle, so it can be used to assess the cardiovascular conditions [5]. This signal have an initial peak that is rounded and descends sm oothly until a hollow called “dicrotic notch” or “insures” wh ich results from aortic valve that suddenly closed, and beco me descents until diastole occurs[10]. A time varying dynam ic blood volume change, caused by the pulse wave can be de tected by placing a stationary photoelectric probe on the ski n. [2].

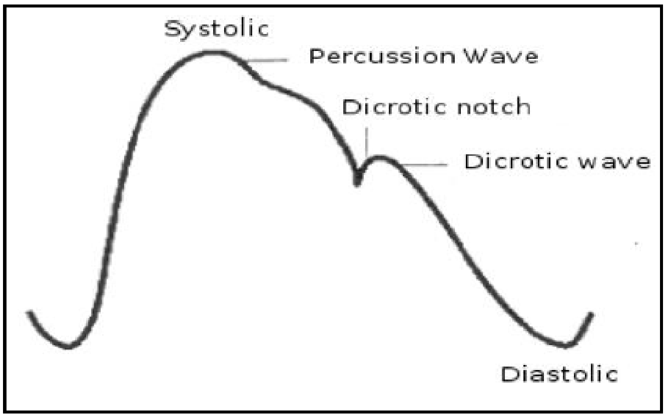

Fig 1: Characteristic of pulse wave signal

Photoplethysmography (PPG): Plethysmograph is a combination of the Greek word. Plethysmos means increase and Graph refesr to write. It is an instrument used mainly to determine and register the variation in blood volume or blood flow in the body. There are several different types of Plethysmography (PG), which vary according to the type of transducers used. The common types include air, impedance, photoelectric and strain gauge. Each type of PG measures the changes in blood volume in a different technique and use different types of applications [9]. We used photoelectric type plethysmograph. Hence is known as Photoplethysmograph. First reported in 1937, Photoplethsmography (PPG) is a non-invasive, electro-optic method of detecting the cardiovascular pulse wave [2]. It is one of biomedical instruments that will become information rich when combined with pulse wave analysis. PPG is a non-invasive method to measure relative changes of blood volume in the blood vessels close to the skin. Electro-optic technique of measuring cardiovascular pulse wave is by measuring the changes in optical absorption [2]. PPG is an ideal ambulatory device because it uses inexpensive optical sensors, rugged, needs little maintenance, less power consumption and can be powered by a battery pack. PPG signal contains much information related to cardio pulmonary system[7]

Hardware of PPG Sensor

Photoplethysmograph (PPG) is a low cost and simp le optical technique that can be used to detect blood volume changes in the micro vascular bed of tissue [3]. A PPG consi sts of an emitter receiver pair to determine blood flow. An in frared light emitting diode (IRLED) will act as an emitter an d a phototransistor as a receiver. IR LED will transmit light t hrough the skin and the detector which is positioned on the s urface of the skin, can detect the reflection or transmission o f waves from various depths and from highly absorbing or w eakly absorbing tissues. However, the PPG signals can vary widely, based on a number of factors, including transducer l ocation, ambient temperature, respiration, and subject differ ences.

The output of the phototransistor is a current in proportion t o the amount of radiation received. Hence, the increase in bl ood flow in capillaries will increase the output current. Then , current to voltage converter is used to inverts current to vol tage. This signal contains a DC offset proportional to ambie nt light and must be removed otherwise it would cause ampl ifier saturation. This is done by applying the voltage equal t o DC offset to non-inverting terminals of Operational Ampli fier current to voltage converter this voltage is obtained by c onnecting a potential difference between the two supply ter minals and giving output to non-inverting terminal. The out put of current to voltage converter is fed to active low pass f ilter of cut off frequency to eliminate supply noise [7]. Whe n Photoplethysmography (PPG) connected to an oscilloscop e it will display pulsation of blood in the vascular system. T hese pulsation results from the action of the heart and PPG will show their amplitude, frequency and waveform.

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Types of PPG Sensors

PPG sensor is used to detect cardiovascular pulse wave signal and it consists an IR LED (940nm) and a Phototransistor (photocell). The detection of PPG signals fall into two main categories:

a) Reflectance PPG Sensor

The light source (IR LED) and the light detector (Phototransistor) are placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the light detector. This sensor can be applied to any part of human body. The reflectance detection technique saves more power than the transmittance one, since it does not require as much light intensity as the transmittance one in order to get a readable data.

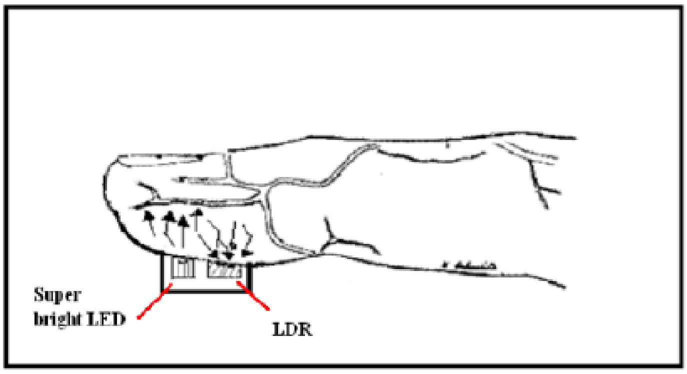

Fig 2: Reflectance PPG Sensor.

b) Transmission PPG Sensor

A light source is emitted into the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. This sensor is applied to certain part of body such as fingertip, toe or the ear lobe.

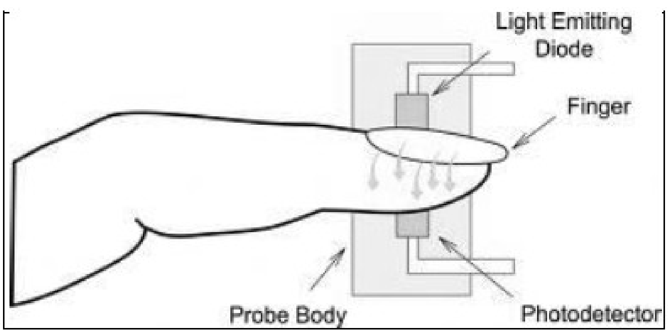

Fig 3: Transmission PPG Sensor

Based on the above explanations, both types of PPG sensor use different methods to detect the light. However, in both cases, light will reach the detector after multiple scattering by the red blood cells

Temperature Sensors

Temperature sensors are devices that are used to gather information or data about temperature from specific sources and, convert the data into understandable forms for an observer or for other devices. They come in different forms and, therefore, their applicability is not limited. They are used in simple matters like taking body temperature to more complex scientific use. The most common type of temperature sensor is the mercury-in-glass thermometer. This thermometer is always used for purposes that are non-scientific because of they are not very accurate. Computerization is necessary to achieve results that are more accurate from temperature sensors.

The basic types of sensors form two groups: non-contact and contact temperature sensors. Contact temperature sensors are used when thermal equilibrium is presumed to exist between the temperature sensor and the object in question. Non-contact temperature sensors are used for commercial purposes. They are used to measure optical radiation or infrared's thermal radiant power. They are able to do this by relying on measurements received from a known point on the surface in question. The LM135, LM235, LM335 are precision temperature sensors which can be easily calibrated. They operate as a 2-terminal Zener and the breakdown voltage is directly proportional to the absolute temperature at 10mV/oK. The circuit has a dynamic impedance of less than 1Ωand operates within a range of current from 450µA to 5mA without alteration of its characteristics. Calibrated at +25 degree. The LM135, LM235, LM335 have a typical error of less than 1degree C over a 100 degree C temperature range. Unlike other sensors, the LM135, LM235, LM335 have a linear output.

In the proposed system we have used LM 335 as the temperature sensor.

The LM335 temperature sensor is an easy to use, cost-effective sensor with decent accuracy (around +/- 3 degrees C calibrated). The sensor is essentially a zener diode whose reverse breakdown voltage is proportional to absolute temperature.

Since the sensor is a zener diode, a bias current must be established in order to use the device. The spec sheet states that the diode should be biased between 400 uA and 5 mA. It is important to note that self-heating can be a significant factor. The bias circuit is as follows:

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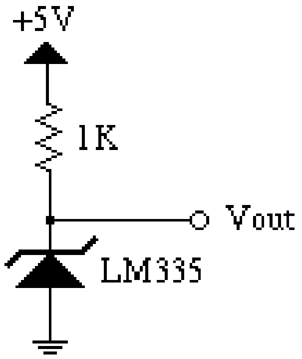

Fig 4: Bias circuit for LM335

The temperature sensor's voltage output is related to absolute temperature by the following equation: Vout = VoutT0 * T / T0, where T0 is the known reference temperature where VoutT0 was measured. The nominal VoutT0 is equal to T0 * 10 mV/K. So, at 25 C, VoutT0 is nominally 298 K * 10 mV/K = 2.98. Thus, the voltage dropped between +5 and the diode is 5V - 2.98V = 2.02V. In order to get 2 mA bias current, we need a 1 K resistor for R1.

Wireless Transmission

To implement the wireless communication between the hand held device and the base station, different technologies were compared.The choice is between the following 6 wireless technologies:Wi-Fi (IEEE 802.11),Bluetooth (IEEE 802.15.1), WiMAX (IEEE 802.16), GSM, UHF radio and ZigBee (IEEE 802.15.4).

The usage of Bluetooth and Wi-Fi modules is set aside because of the shortage of products for a range higher than 200 meters, although the transmission rates are high (11 or 54 Mbit/s with Wi-Fi and 1 or 3 Mbit/s with Bluetooth).

Both WiMAX and GSM are eliminated based on the cost of the solutions found, the first due to the very high price of modules (although the transmission rate is high - 75 Mbit/s) and the second due to the pricing over the communications themselves since it uses frequency channels allocated to mobile communications.

The UHF radio devices have much lower transmission rates (115.2 kb/s) although prices and ranges available are very competitive. The ZigBee radios found on the market present higher transmission rates (250 kbit/s) but have a lower range when compared to the UHF radios.

The ZigBee modules taken in consideration have the best transmission rate/price ratio and a range than comfortably meets specifications.

III. SYSTEM DEFINITION

The proposed system can be divided into different blocks, each having specific function to perform. Below is a block diagram of the overall health monitoring system and functions that each block perform.

Block Diagram

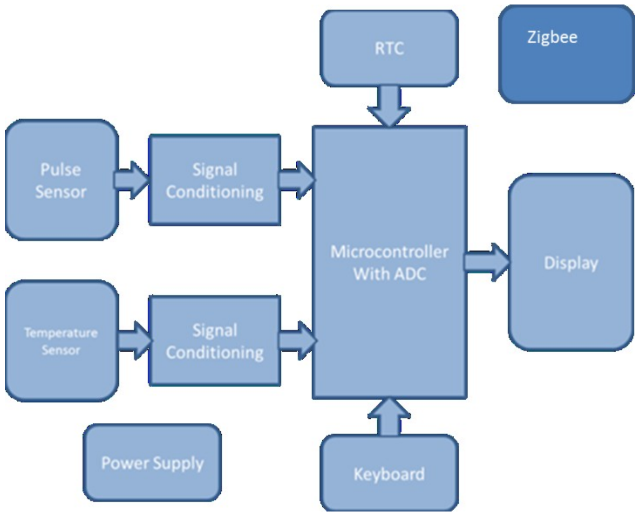

Fig. 5: Block Diagram

Description

Microcontroller

We are using Atmega32 microcontroller. It is the brain behind all the working. It controls all the actions of sub-blocks such as keyboard, sensors, LCD,Zigbee etc. Atmega32 is chosen over other microcontrollers because of the availability of inbuilt 10bits 8channel ADC that makes it easier to process raw pulse and temperature signals. Also it has suitable memory required for storing look up tables, hourly/daily readings along with individual patient's information.

Pulse sensor

Optical reflectance principle is used for pulse measurement. The TCRT1000 reflective optical sensor is used for photoplethysmography. We have also designed a printed circuit board for it, which carries both sensor and signal conditioning unit using MCP604 and its output is a digital pulse which is synchronous with the heart beat. The output pulse can be fed to either an ADC channel or a digital input pin of a microcontroller for further processing and retrieving the heart rate in beats per minute (BPM).

Temperature Sensor

LM335 which is a precision temperature sensor is used for human body temperature measurement. Its output is conditioned using an LM324 amplifier which gives a wider output range and hence sensitive measurement of temperature. Output of this signal conditioning circuit is given to ADC port of microcontroller.

RTC

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As our system can measure pulse and temperature in three modes viz., instantaneous, hourly and daily, we require a real time clock to keep track of these measurements. Also it helps in keeping one minute time to measure pulse and suitable time to obtain stabilized temperature output.

LCD

To make the system user friendly a set of instructions are displayed on the LCD. Also the results are to be displayed after every measurement. For this purpose we use a 20*4 LCD.

Xbee

In order to transmit the vital health parameters a wireless transmission module is required. This will enable the concerned person(doctor) to receive exact information.For this purpose we have used Xbeetransreceiver.

Keypad

System accepts information about user identity, age and gender through keypad as they influence the disease predictions. Also the mode of operation is to be selected with the help of keyboard. For this purpose we use 4*3 numeric keypad.

Power supply

Microcontroller, pulse measurement circuit, temperature measurement circuit and LCD all operate on 5V DC. Hence an adapter converts AC to DC and gives 12 V to our board where 7805 down converts it to 5V. Also Zigbee Pro works on 3.3V and hence a LM1117 voltage regulator is used.

IV. PULSE SENSOR MODULE

Circuit Diagram

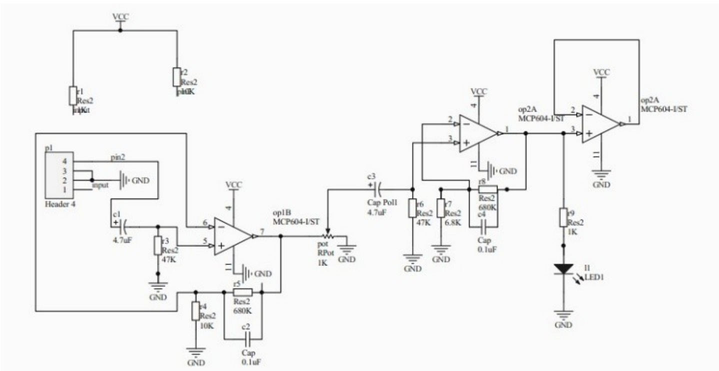

Fig. 6: Pulse Sensor Module

Working

The sensor used in this project is TCRT1000, which is a reflective optical sensor with both the infrared light emitter and phototransistor placed side by side and are enclosed inside a leaded package so that there is minimum effect of surrounding visible light. The circuit diagram below shows the external biasing circuit for the TCRT1000 sensor. Pulling the Enable pin high will turn the IR emitter LED on and activate the sensor. A fingertip placed over the sensor will act as a reflector of the incident light. The amount of light reflected back from the fingertip is monitored by the phototransistor.

The sensor output is first passed through a RC high-pass filter (HPF) to get rid of the DC component. The cut-off frequency of the HPF is set to 0.7 Hz. Next stage is an active low-pass filter (LPF) that is made of an Op-Amp circuit. The gain and the cut-off frequency of the LPF are set to 101 and 2.34 Hz, respectively. Thus the combination of the HPF and LPF helps to remove unwanted DC signal and high frequency noise including 60 Hz (50 Hz in some countries) mains interference, while amplifying the low amplitude pulse signal (AC component) 101 times.

The output from the first signal conditioning stage goes to a similar HPF/LPF combination for further filtering and amplification (shown below). So, the total voltage gain achieved from the two cascaded stages is 101*101 = 10201. The two stages of filtering and amplification converts the input PPG signals to near TTL pulses and they are synchronous with the heart beat. The frequency (f) of these pulses is related to the heart rate (BPM) as,

Beats per minute (BPM) = 60*f

A 5K potentiometer is placed at the output of the first signal conditioning stage in case the total gain of the two stages is required to be less than 10201. An LED connected to the output of the second stage of signal conditioning will blink when a heart beat is detected. The final stage of the instrumentation constitutes a simple non-inverting buffer to lower the output impedance. This is helpful if an ADC channel of a microcontroller is used to read the amplified PPG signal.

V. TEMPERATURE SENSOR MODULE

Circuit Diagram

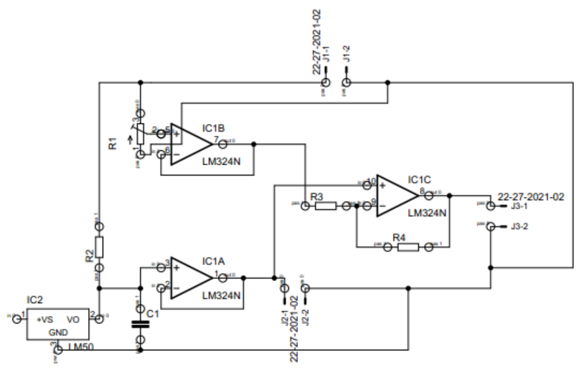

Fig. 7: Temperature Sensor Module

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Working

The temperature sensor LM335 gives a precise temperature measurement corresponding to the body temperature in degree Kelvin. The voltage variation is 0.01V per every degree Kelvinat the output of the sensor. This temperature change is too minute to be observable and taken further for processing. Hence, we use LM324 operational amplifier to provide conditioning to the temperature sensor output.

LM335 acts like a zener diode connected to the positive terminal of LM324 which acts as a buffer. A capacitor is used to filter out any transients in sensor output. 10k potentiometer R1 at the input of other LM324 is used to adjust the input to the differential amplifier. Gain of LM324 acting as differential amplifier is adjusted by the feedback resistor R4 in the diagram given below. For our design it is 100k. It is observed that sensor outputs,

At room temperature 304°K	3.04V
After touching 309°K	3.09V

And circuit output is observed as,

At room temperature	0.05V
After touching	3.22V

Hence, a change of 0.05V at sensor output is mapped to a change of 2.17V at the output of LM324 differential amplifier. This output is given to the ADC pin of the microcontroller.

VI. REAL TIME CLOCK

The DS1307 serial real-time clock (RTC) is a low power, full binary-coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM. Address and data are transferred serially through an I2C, bidirectional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with AM/PM indicator. The DS1307 has a built-in power-sense circuit that detects power failures and automatically switches to the backup supply. Timekeeping operation continues while the part operates from the backup supply.

Owing to these features RTC enables user for timely measurements of the parameters. These timely records can be used by the physician for the analysis. In the system we have provided three working modes namely hourly, daily and instantaneous mode. Also, RTC is responsible for providing start and stop signal for keeping a track of one minute while pulse counting.

VII. RADIO TRANSRECEIVER

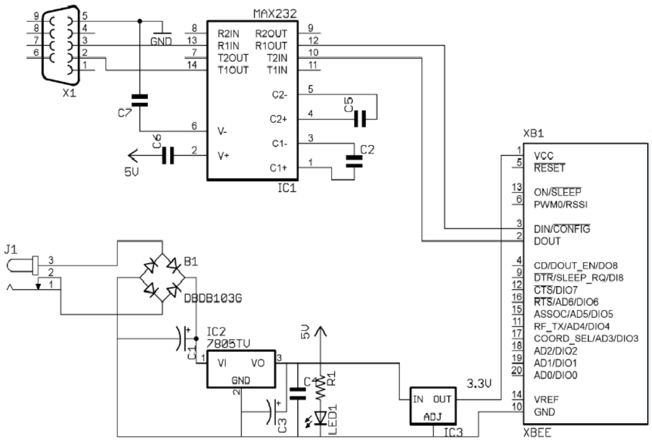

Fig 8 : Radio Transreceiver

The above figure is a schematic of aXbee trans-receiver interfaced with a DB9 connector.Max232 level shifter is used for voltage compatibility.LM7805 and LM1117 are used as voltage regulators for 5v and 3.3v outputs respectively.This circuit interfaces the Xbee Pro S1 to the laptop through the DB9 connector. By interfacing, we can configure Xbee and set it Mode, Baud rate, Destination Address, etc using XCTU software. After configuration the Xbee is capable of wirelessly sending and receiving data to the other Xbee on the mobile station.With the help of this module we are able to monitor important health parameters like heart rate and body temperature. Using puTTY software installed on the laptop we can observe the above mentioned parameters in real time.

VIII. SOFTWARE IMPLEMENTATION

BASCOM –AVR

BASCOM-AVRis the original Windows BASIC COMPILER for the AVR family**.** It is designed to run on W95/W98/NT/W2000/XP and Vista

PuTTY Software

PuTTY is a free and open-sourceterminal emulator,serial co nsole and network file transfer application. It supports sever al network protocols, including SCP, SSH, Telnet, rlogin, an d raw socket connection. It can also connect to a serial port (since version 0.59). The name "PuTTY" has no definitive m eaning, though "tty" is the name for a terminal in the Unix tradition, usually held to be short for Teletype.

PuTTY supports many variations on the secure remote termi nal, and provides user control over the SSH encryption key and protocol version, alternate ciphers such as 3DES, Arcfo ur, Blowfish, and DES, and Public-key authentication. It als

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o can emulate control sequences from xterm, VT102 or ECMA-48terminal emulation, and allows local, remote, or dynamic port forwarding with SSH (including X11 forwarding). The network communication layer supports IPv6, and the SSH protocol supports the zlib@openssh.com delayed compression scheme. It can also be used with local serial port connections.

IX. RESULTS AND DISCUSSION

We have obtained the following results:

Pulse sensor counts number of pulses per minute i.e; BPM-beats per minute: The TCRT1000 circuit senses the heart beats and the RTC keeps the accurate one minute timing for counting pulses on the ADC.

Temperature sensor gives an output in accordance with the human body temperature in degree Celsius: The LM335 measures the temperature and gives an output voltage corresponding to temperature in degree Kelvin (degree Celsius + 273). This output voltage is amplified and output of signal conditioning circuit gives resolution equivalent to 0.0088 degree Fahrenheit (subtract 32 and multiply by 5 and divide by 9 for degree Celsius).

Keypad takes input from users such as: Mode of operation : hourly checking, daily checking or instant results, User identity, Age and Gender. Depending on the selected mode, controller checks for RTC signal to measure the pulse and temperature on an hourly, daily or immediate basis. Every user's data is stored in different memory locations assigned to them. Transmision of patient's identity, age, gender, BPM and body temperature through Zigbee to the base station takes place.

The system comprise of a pulse measuring section, a temperature measuring section, microcontroller and display unit, Real time clock unit and a power supply. We have made separate modules for each pulse and the temperature sections. Also entire system consist all the section on one board.
SOFTWARE PLATFORM used for PCB Layouts: Altium(Build 9.4.0.20159)

X. CONCLUSION AND FUTURE SCOPE

We are designing and developing a system that measures pulse rate and body temperature of a person(s) and further it will transmit the vital information using a transreceiver module. An exhaustive literature survey is carried out on various pulse sensors, temperature sensors, microcontrollers, RF transreceivers and displays.
According to the present proposed system, it is possible to develop a device which will be handheld and portable which facilitates the user to measure his/her pulse count and temperature. The parameters thus measured can be transmitted to the concerned doctor thus enabling the patient to get immediate advice and help from him. As a part of future scope of the system, with further additions, we will also be able to determine the other important health parameters of a person such as oxygen levels, blood-pressure, etc. Also by interfacing the device with a computer, we can maintain a complete database of all the patients with respect to different health parameters corresponding to time scale, which will be of vital use for the hospital records, thus determining the overall history and health tendency of the patient.

XI. ACKNOWLEDGMENT

Any accomplishment requires the efforts of many people and this work is no different. We find great pleasure in expressing our deep sense of gratitude towards all those who have made it possible for us to complete this project with success.
We would like to express our true and sincere gratitude to **Mr. TanayManjrekar,** our mentor, for his dynamic and valuable guidance and keen interest in our project work. This project has been a result of combined efforts of our guide and us. He has been a strong and reassuring support to us throughout this project.
We would also like to express appreciation and thanks to all our friends who assisted us with their valuable suggestions and inputs, and we are very grateful for their assistance. We would also like to thank everyone else who has knowingly or unknowingly guided us.

XII. REFERENCES

[1]RuhaizanBinti Ismail "HANDHELD NIBP AND HEART BEAT MONITORING SYSTEM FOR HOME USE"

[2]Crabtree, V. P. and P. R. Smith (2003). "Physiological models of the human vasculature and photoplethysmography." Electronic Systems and Control Division Research: 60-63.

[3]Christian Nordqvist. (2012, 18th September 2012). "What Is Heart Rate? What Is A Healthy Heart Rate?" Retrieved 8th October 2011, from http://www.medicalnewstoday.com/articles/235710.php.

[4]International, M .L. (2004-2012)."Medical dictionary." from http://www.medilexicon.com/medicaldictionary.php.

[5] Wong, K. I. (2010). Rapid prototyping of a low-power, wireless, reflectance photoplethysmography system.Body S

ISSN: 2278 – 7798

ensor Networks (BSN), 2010 International Conference on, IEEE.

[6] World, D. (2011-0-09). "What Should My Pulse Be - How to Check Your Pulse Rate - BPM Chart." from http://www.disabled-world.com/calculators-charts/bpm-chart.php.

[7] Sundararajan, M. (2010).CHAPTER 3: PHOTOPLETHYSMOGRAPHY: 23-41.

[8] Nguyen, W. and R. Horjus (2011). Heart-Rate Monitoring Control System Using Photoplethysmography (PPG).

[9] Ramli, N. I., M. Youseffi, et al. "Design and Fabrication of a Low Cost Heart Monitor using Reflectance Photoplethysmogram." 44

[10] Cifuentes, J., F. Prieto, et al. (2011). "Simulation of a neonatal monitor for medical training purposes."Revista EIA (16): 9-27.

[11] IEEE. Standard 802.15.4™-2006 - Wireless Personal Area Networks.Technical report, IEEE, 2006.

Web References:

- www.pulsesensor.com
- www.embedded-lab.com
- www.alldatasheets.com
- www.avrfreaks.com

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