

BODY AREA SENSOR NETWORK FOR HEALTH MONITORING

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ABSTRACT-- There has been an exponential increase in the health problem of the human life. Elders habitually visit to their doctor for the treatment of their disease. So the objective of this research is to design a device which is wireless, low-cost, portable, non-intrusive and reliable to use. This device will provide the information about the four parameters on Electrocardiogram, Body Temperature, Heart Rate and Oxygen Concentration in real time and then will be sent wirelessly from remote to base station. This will help the doctor to understand the situation of the patient from a distance and then take required action against the disease. This project deals with signal conditioning and data acquisition of the four parameters. Behavior of the heart is measured through an Electrocardiogram (ECG) that is achieved by attaching a skin surface electrodes on patient's chest. Body Temperature is measured through thermistor. Heart Rate and Oxygen Concentration are measured through same technique that is Photo-plethysmograph (PPG). Thus, doctors can monitor and diagnose the patient's condition continuously and could suggest an early precaution for the patient's health.

which uses Light Depended Resistor (LDR) and Light Emitting Diode (LED). Body Temperature is measured from Resistance Temperature Detector (RTD) using the technique of Wheatstone Bridge. After detecting all four parameters, signal conditioning and data acquisition is made from E-Health Sensor Shield for Arduino, where the signal is amplified, filtered, converted from analog to digital (ADC). When the signals of different parameters are identified and cleared, they are transmitted from the remote station to base station through ZigBee, where the doctor can view the patient's results. LabVIEW will be used for displaying results of all four parameters that are ECG, Pulse Rate, Body Temperature and Oxygen Saturation and with this LabVIEW software, all data will be transmitted to the Web Portal at run time. This can help doctors to consult the patients result with another doctor who is whether in state or out of state. This is also beneficial in terms of cost, no complicated settings, and saves time and even very helpful for patients who lives alone. Even it is useful for those patients who need to check their health on a daily basis. Such type of work is useful in hospitals, military services, rural areas and many other places. Moreover, it provides important status or information on the reliability level, which characterizes the result of the diagnosis.

I. INTRODUCTION

With the aging of human and advancement of the era, diseases related to the heart is increasing like coronary heart disease, heart attack, congenital heart disease and congestive heart failure which leads elderly people to death. Now a days youngsters are also suffering from heart diseases. In the present era everyone is deeply engaged in their duties and social activity due to which they are not willing to monitor their health. So the purpose of writing the research paper is to develop such a device that anyone can monitor their health at anywhere and provide the data to their personal doctor through wireless in their computer and mobile at run time. Different techniques are used in acquiring the data from the human body. To measure the behavior of the heart (ECG), three adhesive Ag+/Ag+Cl electrode sensor is used, placing them right, left and left abdomen of the chest, which sense the beats (systole and diastole functioning) of the heart and transduces it to electrical form. Pulse rate and Oxygen Saturation are measured from the same technique called Photo-plethysmograph (PPG),

II. SYSTEM ARCHITECTURE OVERVIEW

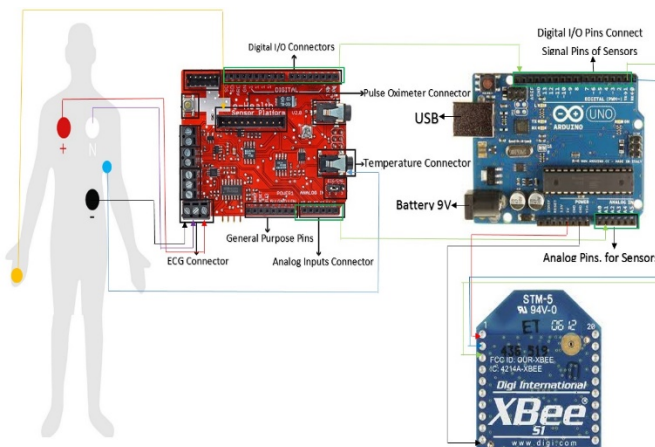


Figure 1: Remote Station of four Parameters

Above figure 1 shows the system architecture overview of remote station, it is clear from the figure that the analog signal is captured by the sensor and from that signal the required signal is filtered out which is then finally converted into digital form done in E-Health Sensor Shield Arduino. After that Arduino sets an AT command to ZigBee to transmit the array of digital string data to the receiver side which base station [1].

Let's first focus on the signal conditioning section. The figure below shows the signal conditioning of ECG,

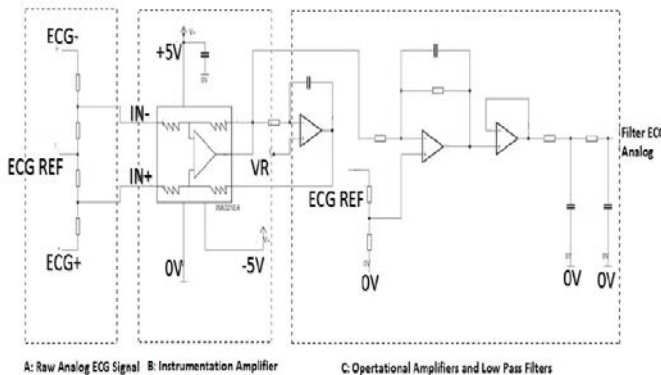


Figure 2: Signal Conditioning of Raw Analog ECG Signal

Figure 2 is divided into three sections. In the section A the raw ECG signal is captured from sensors denoted as ECG+, ECG- and ECG REF. In section B INA321 instrumentation amplifier is used from TEXAS INSTRUMENTS, which is built it by using two differential amplifiers. This INA321 is used because it is low cost, low-noise amplification of differential signals with 40 μ A power current, high gain accuracy $G = 5$, low offset voltage and high CMRR = 94db. Finally, in section C operational amplifier and low pass filters are used, in this section the left ECG REF sensor is used to reduce interference from the instrumentation amplifier. However, it is possible to amplify an ECG signal that forms a DC common mode (CM) biasing electrically of the inputs of the amplifier. The left ECG REF drive inverts and amplifies the average common mode signal, this technique cancels 60 Hz noise and forms much cleaner ECG signal at the output. So canceling the noise relaxes the attenuation required from the common mode rejection (CMR) of the instrumentation amplifier [2].

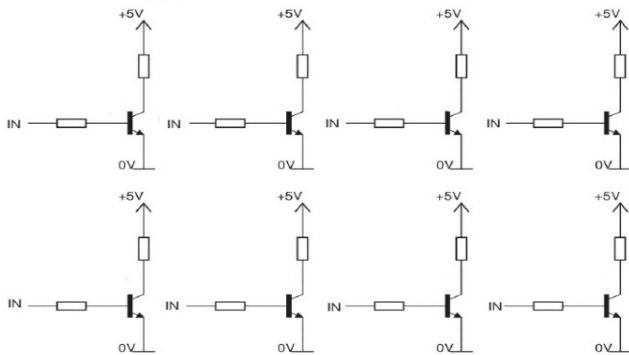


Figure 3: Pulse Oximeter Circuit

In figure 3 Pulse Oximeter circuit is shown. Pulse Rate and Oxygen Saturation are obtained from the same technique of Photo-plethysmography (PPG) allocated in the sensor model CMS50DL, so after extracting and dividing both the signals, the signals moves toward the transistors. As we know, the battery supply of 5V (collector) has a larger electrical supply and the receiving part (emitter) is the outlet for that supply. So when signals of varying levels of current is sent from the PPG sensor to the gate (base), the amount of current of it and the battery side may be regulated according the threshold and firing angle. In this way, large amount of current is controlled by very small amount current, which act as an amplifier and in the same way, binary codes are generated for the digital processors [3] and [4].

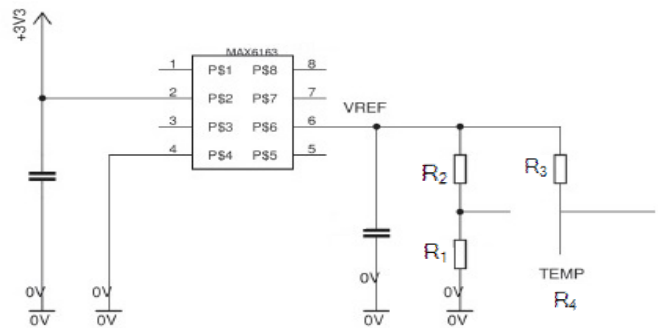


Figure 4: Body Temperature Sensor

Figure 4 shows Body Temperature sensor. Body Temperature is measured with a simple technique that is Wheatstone bridge and using Resistance Temperature Detector (RTD) [6]. In Wheatstone bridge, its construction is made up of four resistors, connected in H shape or diamond, two of them are parallel connected to each other in such a way that resistor R1 gets parallel to R4 and resistor R2 gets parallel to R3. So this forms two terminal for input and other two terminals for output. In place of resistor R4, RTD sensor is placed which will assimilate body temperature and resultant of this temperature is passed at the points C and D. This resultant output cannot be zero because resistance R1 cannot be equivalent to the resistance of temperature sensor, hence resulting same voltages at nodes C and D. And, now finally this incoming voltages are amplified from instrumentation amplifier INA321 [5].

Now, after achieving all the results of the four parameters, they are then converted from analog to digital form within the analog to digital converter (ADC) of Arduino. Now digital results are simulated and calculated by the coding software (E Health libraries) which is burned in ATMEGA328P of ATMEL. Figure 5 shows the coding of Arduino software, which manipulates the simulated and calculated results and sends the result data to the ZigBee within an array form. This array consists of all data strings of the four parameters assembled according to the code burned in Arduino. Now the Arduino sets an AT command to the ZigBee on the remote side to send the same array data continuously to the ZigBee at the receiving side within the preferred protocols, where the results are displayed. The ZigBee protocol also allows other kind of network configurations, like mesh networks [11] and [7].

```

#include <PinChangeInt.h>
#include <eHealth.h>

int cont = 0;

void setup() {
    Serial.begin(9600);
    eHealth.initPulsioximeter();
    PCIntPort::attachInterrupt(6, readPulsioximeter, RISING);
}

void loop() {

    Serial.print(" PRBpm: ");
    Serial.print(eHealth.getBPM());

    Serial.print(" SPo2: ");
    Serial.print(eHealth.getOxygenSaturation());

    float temperature = eHealth.getTemperature();
    Serial.print(" Temp: ");
    Serial.print(temperature, 2);

    float ECG = eHealth.getECG();
    Serial.print(" ECG: ");
    Serial.print(ECG, 2);
    Serial.print(" V");
    Serial.println("");

    void readPulsioximeter(){

        cont ++;

        if (cont == 50) {
            eHealth.readPulsioximeter();
            cont = 0;
        }
    }
}
    
```

Figure 5: Arduino Code

At the base station side, it is composed of a receiver ZigBee module which is attached with an FTDI cable. This FTDI cable consists of a USB232M which is directly inserted into the PC through UART transceiver. This connection helps to have a serial communication with the LabVIEW software supported by the PC. LabVIEW software reads the data stream receiving from USB port, and starts to display the results of the four parameters in the graphical view, as shown in figure 6. Before connecting all the modules, the relationship or the settings of the sampling rate, buffer size and baud rate must be relevant, such that the consumption of power can be reduced and to maintain the continuous data stream [8].

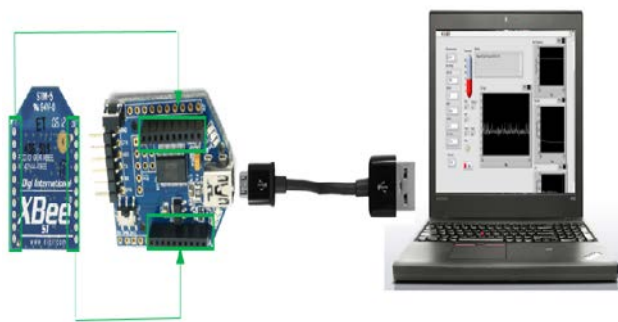


Figure 6: Receiving End of Four Parameters (Base Station)

The algorithm used for the continuous data stream in LabVIEW is shown in figure 7. In this LabVIEW code Virtual Instrument Software Architecture (VISA) is used, which is used for programming, troubleshooting and configuring instrumentation system serial or USB interfaces. Which basically which means that the VISA is a program which interfaces between the hardware function and the windows software like LabVIEW and many others. Now, since arrays of strings are received from the VISA serial communication, the define bits must be divided or separated from the array. This is done, because when the LabVIEW receives the data from receiver ZigBee, it cannot decide which data is for ECG or which one is for body temperature, so the interpretation came out with a palette called as a String Subset Function. This palette is used to select the positions of the bits which consists of a specific body parameter as shown in figure 7. This will help to display the graphical view for different parameters [9].

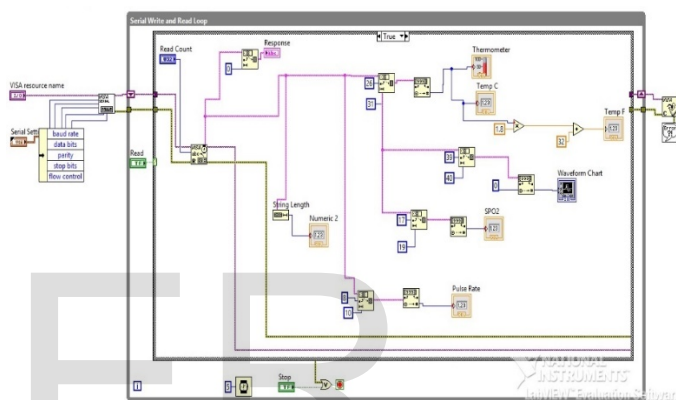


Figure 7: LabVIEW Algorithm of Receiving Data

III. DATA FLOW CHAIN

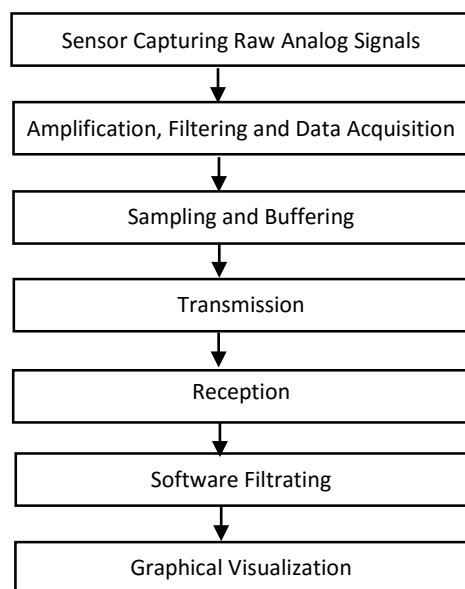


Figure 8: Data Flow Chain from Remote to Base Station

IV. EXPERIMENTATIONS AND RESULTS

To check the device, some experiments and observations were being made regarding ECG signal. Some of the measurements of different patients are as follows,

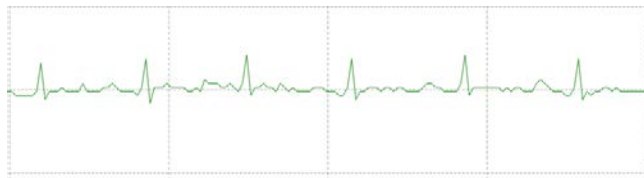


Figure 9: ECG Measurement of First Patient

Age: 30
 ECG: Sinus Bradycardia
 Body Temperature: 96°F
 Pulse Rate: 76 bpm
 Oxygen Saturation: 99%

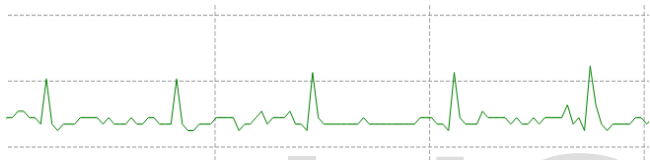


Figure 10: ECG Measurement of Second Patient

Age: 51
 ECG: Ischaemia
 Body Temperature: 97°F
 Pulse Rate: 83 bpm
 Oxygen Saturation: 97%



Figure 11: ECG Measurement of Third Patient

Age: 23
 ECG: Sinus Bradycardia
 Body Temperature: 97°F
 Pulse Rate: 73 bpm
 Oxygen Saturation: 99%

According to the experiments and observations, the results of three parameters like Body Temperature, Pulse Rate and Oxygen Saturation were exactly the same, when compared with the hospital testing machines. A little problem occurred in ECG, which can be easily worked out is that muscle movement harmonics were also captured as the patient age is getting smaller, while the rest of the P, Q, R, S and T wave of the heart was also same as compared to the hospital testing machines [10] and [12].

So, the coordinator receives the measured data sent by the remote station through the operating system COM port, which makes FTDI module accessible. Then the measured data are then processed by the LabVIEW software that performs real-time visualization. Which also can send this real-time visualization through the Web Portal.

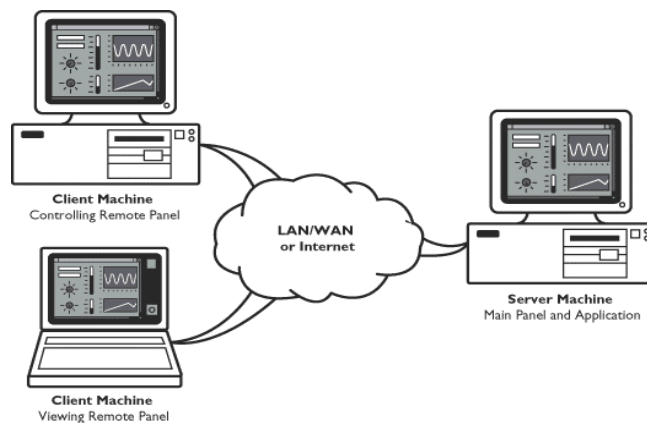


Figure 11: Distributed Application Configured Web Server

Figure 11 shows the wireless transfer of measured data through internet at run time. For this, web server must be configured and enabled on the server machine. So, three configuration areas are required which are File directories and network settings, Visible and permitted clients. Then in the next step, it is to specify a client IP addresses which are generated by the Web Server. After generating an IP address enabled for Web Server, Web Page is to be created and furnished to show the synchronized result data. Now select the Web Publishing Tool, this will show three options regarding publishing, embedded the client and control front panel remotely is the first one, then the snapshot which displays static image in the internet browser this is the second one and the last one is the monitor option which displays clients static image continuously. Since the data acquired signal is live, select the third option. Finally, an IP address is generated, this IP address is sent to the doctor to view the data result in his personal smart phone or computer. Below, figure 12 represents the final display at doctor's desk [7].

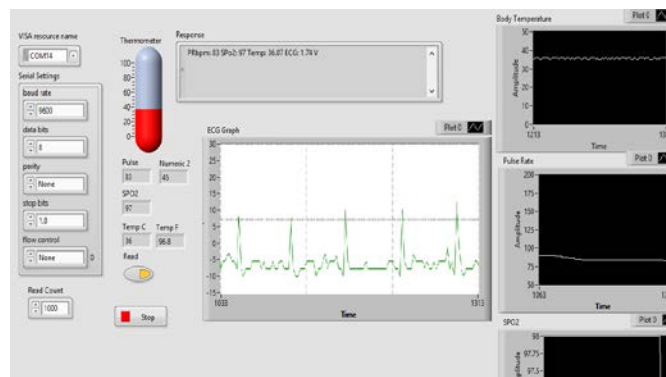


Figure 12: Final Data Result at Doctors Desk

V. CONCLUSIONS AND FUTURE SCOPE

Both Arduino and LabVIEW have immense impact in the result data of four parameters. This research is useful because one can monitor his or her heart conditions by just simply utilizing the power of Arduino and LabVIEW, instead of visiting to hospital for checkup and diagnosis. Furthermore, the planning, problem solving, implementation, reporting, technical design and presentation skills acquired by the authors of this research during the project are also worthwhile.

The future advancement can be done by making the desired signal more effective and cleared. This can be done by using different filters to remove noises. Another advancement can be done by adding other parameters like Electromyography (EMG), Blood Pressure (BP) and many more. Even sound can be added if it detects any abnormalities. And Final but not least Global System for Mobile Communications (GSM) can be used for tracking the patients in emergency situations.

VI. REFERENCES

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