Global Journal of Engineering and Technology [GJET].
ISSN: 2583-3359 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journal-gjet-home/

Development of a Heart Beat Monitor with Radio Frequency

BY

Okwuchukwu innocent Ani [1] , Innocent Ikechukwu[2] , Eneh S Afam[2*]
[1]Department of mechanical and production Engineering Enugu state university of science and technology
[2]Department of Biomedical Engineering, Enugu State University of Science and Technology

Article History

Received: 10/08/2023
Accepted: 14/08/2023
Published: 16/08/2023

Vol – 2 Issue – 8

PP: - 25-31

Abstract

Heart rate is one of the most important health parameter that is directly related to human cardiovascular system. Heart rate can be described as the number of times the heart beats per minute. heart rate and blood pressure are the basic things that we do in order to keep us healthy. This paper on development of heartbeat monitor with radio frequency RF. that will replace the conventional analog sphygmomanometer mode of measurement. Heart Rate can be monitored in two ways: one way is to manually check the pulse either at wrists or neck and the other way is to use a Heartbeat Sensor. When the heart expands (diastole) the volume of blood inside the fingertip increases and when the heart contracts (systole) the volume of blood inside the fingertip decreases. The resultant pulsing of blood volume inside the fingertip is directly proportional to the heart rate and if you could somehow count the number of pulses in one minute, that's the heart rate in beats per minute (bpm). In this paper an IR transmitter/receiver pair (LED) placed in close contact with the fingertip. When the heart beats, the volume of blood cells under the sensor increases and this reflects more IR waves to sensor and when there is no beat the intensity of the reflected beam decreases. The pulsating reflection is converted to a suitable current or voltage pulse by the sensor. The sensor output is processed by suitable electronic circuits (Microcontroller) to obtain a visible indication. Heart rate is utilized by medical professionals to diagnose and track medical conditions of a person.

KEYWORDS: *Infra-red IR, microcontroller, real-time, heart rate monitoring.*

I. Introduction

A heart rate monitor is a personal monitoring device that allows a person to measure the heart rate in real-time or record for later study. Early models consisted of a monitoring box with a set of electrodes leads attached to the chest. The heart rate of a healthy adult at rest is around 72 beats per minute (bpm) and that of a baby will be at around 120 bpm, while older children have heart rates at around 90 bpm. The heart rate rises gradually during exercises and returns slowly to the rest value after exercise. The rate when the pulse returns to normal is an indication of the fitness of the person. Lower than normal heart rates are usually an indication of a condition known as bradycardia, while higher is known as tachycardia. Recent advancement in wearable technologies, particularly smart watches embedded with powerful processors, memory subsystems with various built-in sensors such as accelerometer, gyroscope, and optical sensor in one single package has opened a whole new application space. One of the main applications of interest is the monitoring of movement patterns, heart rate, ECG, and PPG particularly for longer durations in natural environments. The heart rate acquired from the smartwatch is reasonably accurate with a high degree of correlation. (Phan et al. 2015) [1]. Other devices in the form of wristwatches are also available for the instantaneous measurement of the heart rate. Such devices can give accurate measurements but their cost is usually in excess of several thousand dollars, making them uneconomical. So, the proposed heart rate monitor with a radio frequency is definitely a useful instrument for finding the pulse of a patient. This devices provide an accurate reading of the heart rate using optical technology, Standard infrared Light Emitting Diode (LED), and photo-sensor to measure the heart rate using the index finger. A microcontroller programmed to acquire the signal using its embedded analogue to digital converter, ADC, and use the readings to compute the heart rate; eventually, the reading is digitally displayed on an LCD. Wearable sensors have diagnostic, as well as monitoring applications. Their current capabilities include physiological and biochemical sensing, as well as motion sensing(Teng et al. 2008)[2] (Bonato 2010)[3]. It is hard to overstate the magnitude of the problems that these technologies might help solve. Physiological monitoring could help in both diagnosis and ongoing treatment of a vast number of individuals with neurological, cardiovascular, and pulmonary diseases such as seizures, hypertension, dysrhythmias, and asthma. Home-

*Corresponding Author: Eneh S Afam

based motion sensing might assist in falls prevention and help maximize an individual's independence and community participation. In a clinical environment, the pulse is estimated under controlled conditions like blood measurement, heartbeat estimation, and Electrocardiogram (ECG). In any case, there is a need that patients can measure the heart in the home rate condition also. The pulse rises bit by bit during activities and returns gradually to normal after exercise. This paper presents the design and development of a compact and low-cost microcontroller-based portable system used for monitoring heartbeat on real-time and alerting about patient to a care person in real-time.

II. Related Literature

The author [4] Develop a heart rate monitor and arrhythmia detector. They use a low-powered microcontroller msp430fg4816 manufactured by Texas, it's an ECG monitoring device. The system is law cost and power consumption, portable, reliable capable of interpreting biological signal, however, it is very complex and can only be used by an expert. the use of fingertip which will replace the ECG. Author [5] Develop a heart rate monitor using a low-cost microcontroller AT89C52 from ATMEL CO. It uses an infra-red transmitter and receiver sensor box. The rate is then averaged and displayed on a text base LCD. It uses a low-cost microcontroller and optical technology to detect the blood flow but does not have voice output to aid the visual impaired patients. the use of radio frequency to trigger an alarm signal. [6] Develop an integrated microcontroller-based device for measuring heart rate, it uses fingertips, it uses a three-phase parameter to process its signal, namely pulse, signal extractor, and amplification, It uses an optical methods to develop heart monitor. Low-powered microcontroller and a complex programing algorithm. the design uses three phases to make sure that the data generated is accurate, reliable, and handy but it's a complex device and only the professional can use it. The use of radio frequency signal as a means of sending an alert to a healthcare professional. [7] Develop a wireless heartbeat monitor specifically build for the athlete that undergo an intensive training. It uses a low microcontroller; it also uses radio wave as a means of communication. Very simple, accurate, and mobile but look very fragile and it must be handle with care. The use of radio frequency as a means of sending an alarm signal. [8] Develop a heartbeat monitoring system for the detection of five cardiac condition. It uses signal processing technique and artificial neural networks (ANN) to implement a real-time processing intelligence, It uses a highly embedded systems to implement the device, very accurate, reliable Low powered microcontroller, handy to use, portable, and accurate but highly complex for patience to handle, The use of radio signal as a means of sending an alarm. This paper will develop a device tha has an outstanding advantage that it is easy to handle and access. Heartbeat rate and body temperature monitors are part of the most vital tools needed in first aid kit for saving lives. Unlike the X-ray, the heartbeat and temperature monitor does not impose any hazard to the human health. There devices in the market which can provide raw measurement data of the patients to the doctors, but the patients may not be able to interpret the medical measurement into a meaningful diagnosis due to their limited medical background. On the other hand, if raw medical data is delivered to the doctor, time is wasted and may pose a problem, but in emergencies, waste of time can never be tolerated. It is tough to share data over large area within a short period. Most of the products available in the market have this drawback of limitation in flexibility and portability. If the heat that is produced from metabolism cannot be checkmated on time, it will cause a turbulent body temperature, which could be worse than 40°C and lead to headache, vertigo, low blood pressure, high energy consumption, unconsciousness and crocking up of body temperature regulation function.

III. Methodology

First, a block diagram of a heartbeat monitor mode was critically analyzed and all the components explained, Hardware components used for the design of the prototype and the description was listed. The design analysis and the specification were carried out, Secondly, the circuit diagram of the propose design was developed and simulated using proetus 8 software. The circuit diagram of sensor and the overall heartbeat monitor and radio frequency. The operating principle of the circuit diagrams was discussed. The Arduino and sensor was programmed using the same framework in order to transmit and receive information from the finger. Finally, the overall heartbeat monitor was build considering the design specification and it was validated by testing the performance of the proposed system and conventional system.

1V. Materials Used

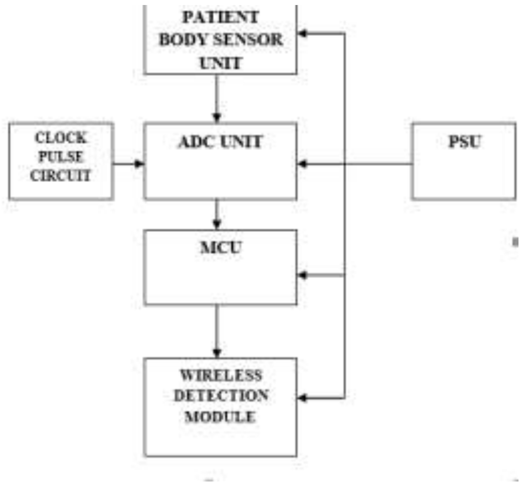
The following components materials used to achieve the newly developed heartbeat monitor

1. The Arduino
2. 9 Capacitors(with different uf and voltages)
3. 12 Resistor (with various watts and sise)
4. NPN/PNP Transistors
5. Jumper wires
6. RF Transmitters
7. 9volts lithium
8. Sensor module
9. Rgulator
10. HT 12E Integrated Circuit
11. LCD display 18*2 lines
12. Buzzer
13. Switch
14. Push button
15. DC port
16. Junction diode
17. Vero board
18. Open source Arduino development software
19. Ice socket
20. LED
21. BOX
22. Tape

*Corresponding Author: Eneh S Afam

23. Soldering Iron and lead
24. Battery cap

V. **Block Diagram of Heartbeat Monitor**



The Control Unit

The control unit is the main board that contains the microcontroller, the MCU unit serves as the brain box of the system, the microcontroller used here is AT89C205 because of its vast in application, flexibility, and programmability. The microcontroller momentarily sends and receive fluctuated heartbeat signal from the sensor module and the collected data is then temporarily stored in the memory location created by microcontroller. according to the arithmetic expression in the firmware, the MCU convert the data to ASCII code and finally displays it on the LCD

The push buttons

These are the three active push buttons connected from ground to the microcontroller. The first button is connected to pin 18 of the microcontroller that enable the minimum data input, the second push button is the center button used to enter the data and its also act as start count button while the third push button is used to input the maximum data.

The power supply

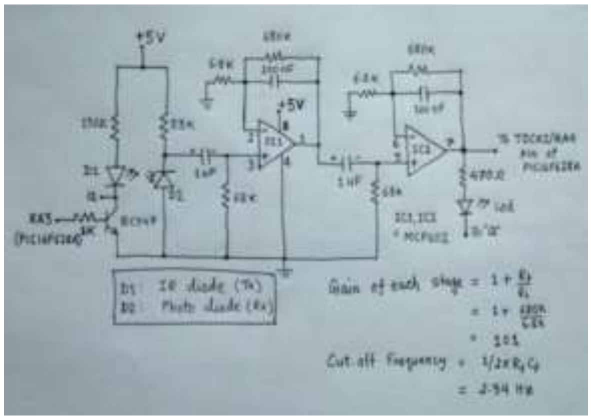
The power section is use to supply the required electrical signal that the device need for optimum performance. The power section perform two stages namely rectification and the supply of pure dc voltage. First, the ac voltage of 240 volts is first rectified through the primary windings and then goes to the secondary winding were a purified 9volts is obtained at the output of the power pack and then fed into the device for the purpose of charging the battery.

The power supply unit is a regulated 5v supply powered from a 9 volts battery. The battery "cycle" is one complete discharge and recharge cycle. It usually discharges from 100% to 20%, and then back to 100%. The battery life is directly related to how deep the battery is cycled each time. If the battery's is discharged to 50% every day, it will last about twice as long as if it is cycled to 80% depth of discharge (DOD). If cycled only 10% DOD, it will last about 5 times as long as one cycled to 50%. The battery powers the project through an LM7805 DC voltage regulator, which keeps the output voltage supply constant.

The Display unit

This unit is responsible for visual purposes, it's a liquid crystal display that display the calculated data performed by the microcontroller through the digital-to-analog converter module for human interpretation

VI. Design Calculations



In the above system design, a signal conditioning circuit consists of two identical active low-pass filters with a cut-off frequency of about 2.5 Hz. This means the maximum measurable heart rate is about 150 bpm.

The value of IC 1 and IC 2 in the above diagram is MCP602.
Inverting bias resistor- 680k (Rf.)
Non-inverting resistor – 68k (RI)

The Inverting Amplifier: the **Open Loop Gain**, (Avo) of the operational amplifier can be very high, as much as 1,000,000 (120dB) or more. However, this very high gain is of no real use to us as it makes the amplifier both unstable and hard to control as the smallest of input signals, just a few micro volts, (μV) would be enough to cause the output voltage to saturate and swing towards one or the other of the voltage supply rails loosing complete control. As the open loop DC gain of an operational amplifier is extremely high, we can therefore afford to lose some of this gain by connecting a suitable resistor across the amplifier from the output terminal back to the inverting input terminal to both reduce and control the overall gain of the amplifier. This then produces and effect known commonly as **Negative**

Feedback, and thus produces a very stable Operational Amplifier based system. **Negative Feedback** is the process of "feeding back" a fraction of the output signal back to the input, but to make the feedback negative, we must feed it back to the negative or "inverting input" terminal of the op-amp using an external **Feedback Resistor** called Rf. This feedback connection between the output and the inverting input terminal forces the differential input voltage towards zero. This effect produces a closed loop circuit to the amplifier resulting in the gain of the amplifier now being called its **Closedloop Gain**. A closed-loop amplifier uses negative feedback to accurately control the overall gain but at a cost in the reduction of the amplifiers bandwidth. This negative

*Corresponding Author: Eneh S Afam

feedback results in the inverting input terminal having a different signal on it than the actual input voltage as it will be the sum of the input voltage plus the negative feedback voltage giving it the label or term of a *Summing Point*. We must therefore separate the real input signal from the inverting input by using an **Input Resistor**, R-in. As we are not using the positive (non-inverting) input, this is connected to a common ground or zero voltage terminal as shown below, but the effect of this closed-loop feedback circuit results in the voltage potential at the inverting input being equal to that at the non-inverting input producing a *Virtual Earth* summing point because it will be at the same potential as the grounded reference input. In other words, the op-amp becomes a "differential amplifier".

Components for the project

These are several important tools that commonly used during the development of this Device

Table 1 List of important components

Arduino	The Arduino is microcontroller board where all the functions are activated
Capacitors	To store charges
Resistores	Limit the current flow
NPN/PNP	Its an active components that produce gain and as well act as switch
JUMPER WIRE	For connection
RF. Transmitter	Means of communication between the device and the wireless unit
Lithium battery	Main power source
Finger sensor module	Used to sense the heartbeat from the fingertip
Regulator	Used to regulate the required voltage needed to power the device
HT 12E integrated circuit	Used to encode the signal. the frequency is around 435mhz
Buzzer	For sound production
Switch	Power on/off nob
Push button	Data input nob
DC port	For charging purposes
Diode	Rectification and for one channel of current
Vero board	Panel that hold the components in a fix point

Table 2 Bill of quantity (BEME)

S/N	ITEMS	QUANTITY	UNIT, PRICE	AMOUNT(N)
1	Resistors	8	10	80
2	Capacitors	4	20	80
3	Battery cap	1	100	100
4	Transistors	1	50	50
5	9V Battery	1	100	100
6	Ardiuno UNO	1	4500	5000
7	Vero board	2	200	400
8	RF module	2	1500	3000
9	Paper Capacitor	2	10	20
10	IC 7805	2	70	140
12	LEDs	3	10	30
13	IC socket	3	100	300
14	Box	1	150	150
15	Button Switch	2	20	40
16	Solo Tape	1	100	100
17	Soldering lead	1 roll	450	150
18	Packaging	1	3400	3400
			Total	

VII Implementation

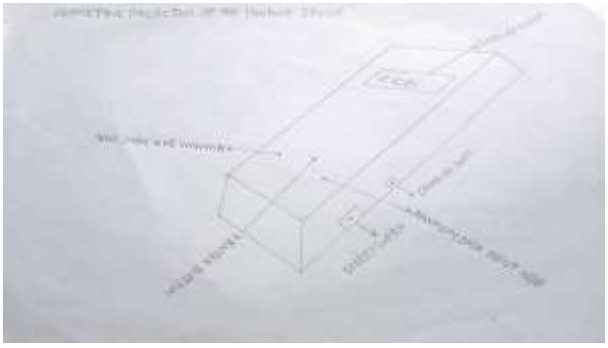


Fig 1 **Isometric Drawing of the Project**

A. Breadboard Implementation

*Corresponding Author: Eneh S Afam

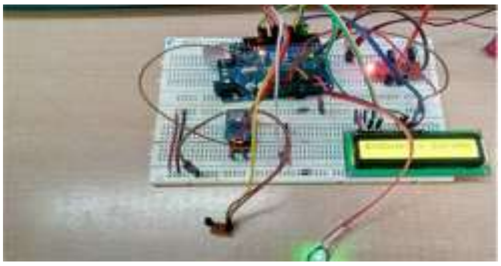


Figure 2 Breadboard Implementation

B. Vero board Implementation

When the design was confirmed working the components were transferred to the Vero board for soldering When the design was confirmed working the components were transferred to the Vero board for soldering

Figure 3 Vero board Implementation

After soldering the circuit was tested and it was working well. Finally, the project packaging. The project was packaged in adoptable box casing of 9 X 4 X 1-inch box. The body was lapped with black emboss card to give it a smooth finishing

C. Circuit diagrams of the proposed device

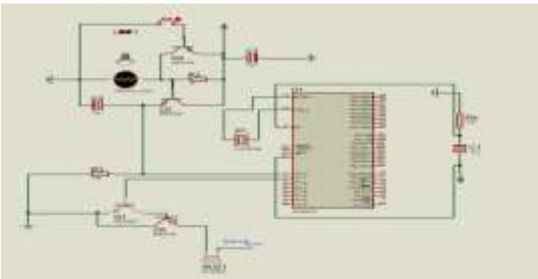


Figure 4 Circuit Diagram of the Sensor

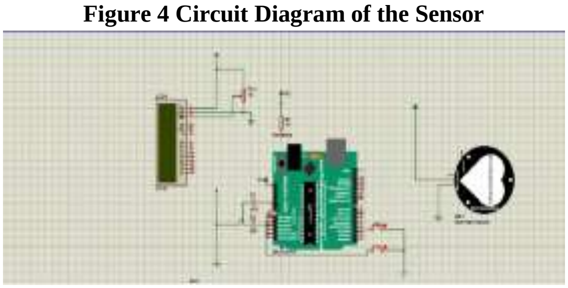


Figure 5 The Circuit Diagram of the RF

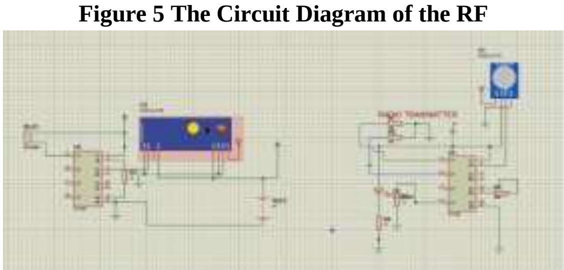


Figure 5 RF circuit simulation

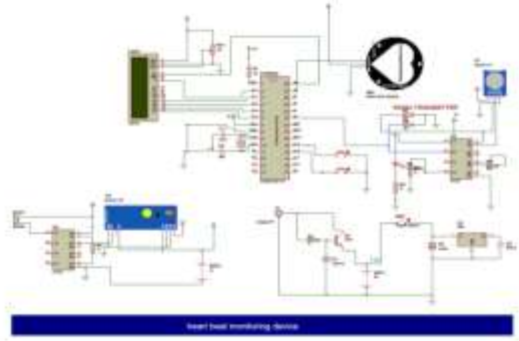


Figure 6 Complete circuit diagram

D. The proposed heartbeat monitor with radio frequency

Sensor Unit

The patient wrist-type body sensor is made of LM35 integrated circuit. The LM35 is used to acquire signal more especially, the body temperature of the patient while a microcontroller processes it. The three common sensors used for this particular task are thermistors, thermocouples, and resistance thermometers but here, an LM35 was used because it can measure temperature more accurately than thermistors and generates a higher output voltage than thermocouples. LM35 sensor may not require that the output voltage be amplified and it is placed on an adjustable bracelet to be worn on the patient's wrist to gather/obtain information about the body's pulse rate, heat flow, and skin temperature. The information gathered is interfaced to the MCU for data transmission. The LM35 is an integrated circuit sensor. Its electrical output signal is proportional to the temperature in oC (degree Celsius temperature).

The scale factor is .01V/oC. The sensor circuitry is sealed and not subject to oxidation. It does not require any external calibration or trimming and maintains an accuracy of +/-0.4 oC at room temperature and +/- 0.8 oC over a range of 0 oC to +100 oC.

VIII. RESULT AND DISCUSSION

The following subsection will be discussed more about the implementation of the heartbeat monitor with radio frequency RF.the programming/simulation of the arduino and using protues 8. The packaging of the overall device components and the comparison of the proposed device and the existing device

Validation of the proposed prototype with the existing device

When testing manually for 1 minute the patient's heart rate reaches 130 bpm while when tested using a patient's heartbeat

*Corresponding Author: Eneh S Afam

it reaches 125 bpm then we do the test for 5 times in a row to get the following results.

Table 3. Heart rate values for five patients

No.	Testing	Manual	Sensor
1	Test1	125	130
2	Test2	130	137
3	Test3	123	129
4	Test4	130	130
5	Test 5	135	137

It can be said that the level of comparison of testing manually and using heartbeat sensors ranging from 3-4 digits in the calculation then the test is considered complete.

Testing for Normal Patients

The results of the examination of the condition of the normal patient's heart rate were carried out randomly by involving 5 people as a sample Examination of the heart rate was done by checking the condition of the heart rate using a manual, heartbeat sensor. Each examination was carried out with a duration of 1 minute. The first test results are performed using a heartbeat sensor to check the condition of the patient's heart rate.

The value of the calculation results is used as the value of the patient's heart rate when examined using a heartbeat sensor. The heart rate of patients who were examined using a heartbeat sensor can be seen in Table 4.

Table 4. Patient Heart Rate Values Using Heartbeat Sensors

No.	Name	Heart Rate With Sensor	Measurement Time
1	Ijeoma	81	1 minute
2	Paul	106	1 minute
3	Okwy	161	1 minute
4	frank	78	1 minute
5	Anthony	89	1 minute

From the results of the examination obtained two test results. The first test only checks the heart rate using a heartbeat sensor. While in the second test, a heart rate examination was performed using a manual with the same duration. Then the results of the heart rate value based on examination of the two devices are made to compare accuracy. Accuracy comparison is done to see the level of accuracy of the heartbeat sensor to check the heart rate, to determine the accuracy value is carried out the division of the value of the heart rate that is checked using a heartbeat sensor with examination using a manual that is used as a reference in examining the patient's heart rate. The formula for determining the accuracy percentage value from the heartbeat sensor check is to divide the heart rate value from the sensor with the heart rate value from the manual, then multiply by 100 to get the accuracy percentage value according to Equation 1.

$$Level\ of\ accuracy\ (\%) = \frac{sensor\ pulse}{mauel} * 100 \qquad eq\ 1$$

The formula for determining the error percentage value (error) from checking the heartbeat sensor is by first reducing the heart rate value of the heartbeat sensor with the heart rate value from the manual with the result in the form of an absolute number. Absolute numbers are numbers that will not have a minus (-) even if the actual result of the reduction is minus. Then the result of the reduction is divided by the value of the heart rate, then the result is multiplied by 100 to get a percentage error value. The formula can be seen clearly in Equation 2.

$$level\ of\ error(\%) = \frac{sensor\ pulse - manual}{manual} * 100 \quad \text{eq 2}$$

From these calculations, it was found the error level of the heartbeat sensor on the examination of the patient's heart rate. The heartbeat sensor error level can be seen in Table 3.

Table 5. Comparison of accuracy of heart rate values from heartbeat sensors with manual

No.	Name	Heart rate with sensor	Manual Measuring Tool	Accuracy Level (%)	Error Level (%)
1	Ijeoma	81	82	98	1
2	Paul	106	100	106	6
3	Okwy	161	101	159	59
4	Frank	78	76	102	2
5	Anthony	89	80	111	11

In Table 3, it can be seen that the heartbeat sensor has a low error rate, this is seen from the range of errors (margin of error) ranging from 0.69% to 1.84%. This can also be seen from the difference in the value of the heart rate in the manual with the heartbeat sensor which ranges between 78. With the low error rate of the heartbeat sensor, it can be concluded that the heartbeat sensor has a fairly high degree of accuracy. The high level of accuracy can be proven by calculating the percentage of the accuracy value of the sensor with the formula.

Discussion of the Study

The proposed device provide a fingertip sensor configured for the detection of patient's heartbeat, the sensor used in this design was connected to the Arduino via port 12cport. The main function was to detect the index finger through the means of infra-red and photodiode. This was achieved by the flash of light produced by the photodiode to the index finger. Hence the electrical pulse cause by the blood flow in the index finger will interrupt the infra-red reception signal of the

*Corresponding Author: Eneh S Afam

sensor. The infra-red signal is sent to the Arduino to calculate the heartbeat signal. And if the calculated heartbeat signal seems abnormal a signal is sent to the wireless RF to trigger an alarm indicating that the heartbeat is abnormal and the doctors, nurses, family members will attend the patient immediately. Comparing the existing pulse oximeter, manual sphygmomanometer, and the microcontroller-based pulse detector proposed by helmy nurbany (2015**).** Indicate that this proposed prototype of heartbeat monitor with radio frequency has advantages over the existing once because they don't have these features.

Conclusion

The planning, design, implementation/execution of this project has been a tough one. The configuration of the various units into one unit to obtain a desired output of detecting the heartbeat rate from the blood vessels on the wrist/thumb took a lot of courage and the application of the technical (and theoretical) initiative of the Engineering practice to execute. Thus, this device (integrated with modern technology) have been initiated to help in regularizing the health condition of most individuals by keeping track of their heartbeat rate condition. Thus, alerting the physician or the family members on the patient's real-time heartbeat condition using RF. as the mode of communication interfaced with LM35 technique.

Reference

1. Dogan, G. and Kadri, B. (2010). Heart Rate Measurement from the Finger using Low
2. Cost Microcontroller. Federal University of Technology, Minna, Niger state: University press
3. Allender, S., Peto, V., Scarborough, P., Boxer, A. and Rayner, M.(2007). Coronary heart
4. disease statistics, British Health Promotion Research Group, Heart Foundation Department of public health. University of Oxford: Oxford Press.
5. Burke, E. (2010): "Precision Heart Rate Training, A self Guide". *International Conference*, University of Toronto Canada. Prentice Hall
6. Enyinnaya, E. (2008) Microcontroller-Based Heart Rate Monitor and Arrhythmia Detector
7. Chime, N. (2009). Design and Construction of a Heart rate Monitor using a low-cost
8. Microcontroller. Minna, Niger state
9. Sara .S. and Bill. Z. (2008): "Photo-plethysmograph". *IEEE International conference extract.* Vol. MTT-32, pp.1230-1242.
10. Péter. C and Balázs .S. (2009): "Development and Applications of A Home Health Monitoring Device", Kuala Lumpur, Kuncicky works
11. Shelley. K. H. and Stout .R. G., (2004): "The Use of Joint Time-Frequency Analysis of the Pulse Oximeter Waveform to Measure The Respiratory Rate of Ventilated Patients." *Anesthesiology* 91(3A): A583.

*Corresponding Author: Eneh S Afam