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IoT Based Remote Health Monitoring System and Alert System with Database Features

Ufoaroh S.U[1], Obioma P.C[1], Christopher Ohagwu[1]
[1]Nnamdi Azikiwe University, Awka, Anambra State

Abstract— *Not only is leading a healthy lifestyle critical for existence and longevity, but it is also crucial for producing effective professional results. The practice is now carried out with remarkable sophistication because to advancements in the medical industry. The patient's health parameters are crucial determinants of a correct diagnosis. Bridge-building between engineering and medicine, biomedical engineering (BME) combines engineering design and problem-solving abilities with medical and biological sciences to enhance healthcare diagnosis, monitoring, and therapy. The system described in this work allows for remote monitoring of patient body parameters like temperature, blood pressure, heart rate, and Electrocardiogram (ECG) signal, as well as cloud-based alerts, patient identification, and database inclusion. The wearable pressure and temperature sensors pick up vital signs, sending an SMS to the medical staff's phone with the measured parameters' values and setting off an alarm if the threshold value is surpassed. Unlike prior systems, this one has a database feature and a system for patient identification, which helps to deliver an accurate, continuous real-time diagnosis and monitoring with alerts for early prevention and to handle emergencies.*

I. INTRODUCTION

As long as there are people, the healthcare sector will flourish and expand all over the world, contributing significantly to the economies of all nations [1]. Medical technology must progress while patients continue to pass away from untreated illnesses including fever, high or low blood pressure, heart attacks, etc. It's crucial to keep track of any deviations from any of the key indications of the patient's health that should be functioning normally. Health parameters are typically measured in hospitals and other medical facilities that have the necessary technology as part of conventional health monitoring systems. Patients who are unable to visit these facilities typically have special arrangements made for them. It is crucial that a system that delivers information about the most significant health metrics is made mobile and location-independent due to the complexity and urgency of health issues. Numerous approaches have been developed as a result of research, and these systems can measure a patient's vital health indicators from a distance and transmit the results wirelessly to specialized medical experts. The advancement of telemedicine has been greatly influenced by recent developments in communication technologies. Customers who can access health care more quickly profit from telemedicine, but so do clinicians who can focus their efforts on treating more patients.

IoT-based health monitoring solutions are currently growing in popularity due to the information and technological revolution. These technologies can be used to gather real-time health data and provide patients and medical professionals with feedback [2]. The Internet of Things (IoT) has received much investigation and is now a proven technology standard. Currently, sensors are employed in practically all products, from ordinary items to industrial monitoring systems. IoT and sensor-based solutions for acute healthcare are being used more and more frequently [3].

II. REVIEW OF RELATED LITERATURES

The Global System for Mobile Communications (GSM) technology was used to create a wireless heartbeat and temperature monitoring system in [4] that uses sensors to measure a patient's heartbeat and body temperature and wirelessly transfer the information to the receiving end. [5] describes the design and development of a fingertip and temperature sensor-based microcontroller-based heartbeat and body temperature monitor. The device, which has the benefit of portability over traditional recording devices, uses optical technology to detect the flow of blood via the finger. An IoT-based system for heartbeat monitoring and heart attack detection was implemented in the work by [6].

The research by [7] offered a continuous monitoring aspect of intensive care unit (ICU) patients by allowing the clinicians to use the Hyper Text Transfer protocol to track patients' metrics (such temperature, heartbeat, and Electrocardiograph) in real time. A variety of sensors, an ARM 7 microprocessor, and a GSM/GPRS UART modem are all used by the system. The sensors will feed data to the ARM 7 CPU while continuously sensing the ICU patient's characteristics. These are transformed by the Processor into digital form, and after that, they are sent to the server via a GPRS connection using the Hyper Text Transfer Protocol (HTTP) protocol (General Packet Radio Service). Temperature, ECG, and heartbeat sensors are the sensors that are used. Sensors continuously collect all the parameters, which are subsequently transmitted to the CPU. A VB.Net application downloads all the transmitted data on the server and displays the parameters as waveforms.

The system created by [8] uses wearable sensors to remotely monitor a patient's temperature, systolic and diastolic blood pressure, and heart rate in bits per second. When any parameter's threshold value is surpassed, an alarm sounds. The results were wirelessly transmitted to the doctor at the other end via GSM technology, potentially enabling the delivery of clinical services. The system is made up of an AT89C52 microcontroller for data processing, a GSM module, a buzzer, an LCD, a temperature sensor (LM35) for body temperature reading, and a pulse rate and blood pressure sensor. The temperature sensor is integrated so that both the blood pressure and heart rate readings are taken at the same time. The patient

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has the freedom to go about his or her typical daily routine thanks to this system's re-programmability.
According to a review of prior studies, existing designs still don't have a suitable online database where test results from the past may be preserved and patient body characteristics can be easily accessed and retrieved. The system created in this work incorporates a database feature so that the medical staff can have an organized documentation of client data, which is a significant advantage. The design also has an ECG sensor, which gives the patient's heart rhythmic measurements and is infrequently used in other designs.

III. System Design And Analysis

Similar to its architecture and system design, the key to an effective circuit implementation is to adopt a design methodology that adheres to a set of phases that are often used for such design processes. This project's design and development basically fell into two categories: hardware design and software design. The prototype of the project was produced and the circuit design was created in the hardware architecture, whilst in the software development, the entire complete prototype was run using computer codes.

The various components of the hardware design were described and displayed using a block diagram and a system circuit diagram. Multiple wearable sensors that detect physiological body vitals such as body temperature, heart rate, systolic and diastolic blood pressure were used to collect data. Through the Wi-Fi Module, these sensors are connected to the network. Sunrom blood pressure sensor, LM35 (which measures heart rate, body temperature, and systolic and diastolic blood pressure, respectively), and AD8232 (which is an ECG sensor) were the sensors used. Data from the sensors is sent to the cloud. The Wi-Fi module, power supply, and sensors provide input to the Arduino, which then outputs to the LCD display and sends this output to the web server (ThingSpeak), which the doctor may access using his/her passkey. It should be noted that the NODEMCU has an inbuilt Wi-Fi module. The hardware components used for the project are interconnected as shown in the figure below:

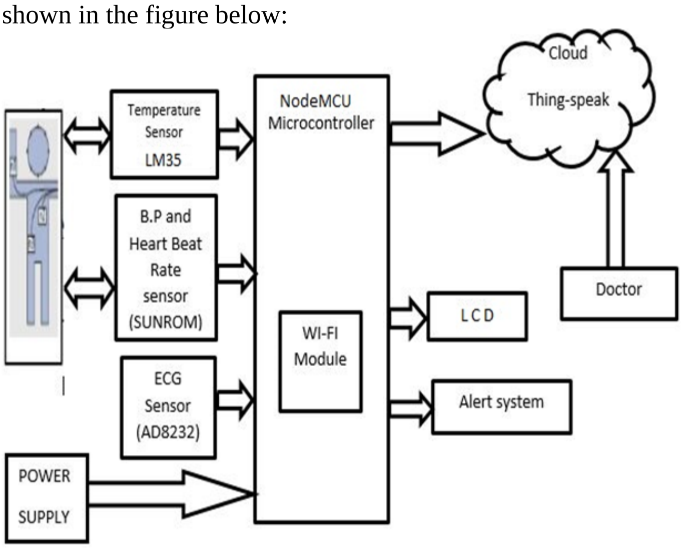

Figure 1: Block diagram of the system

The flowchart of the system is as shown in figure 2.

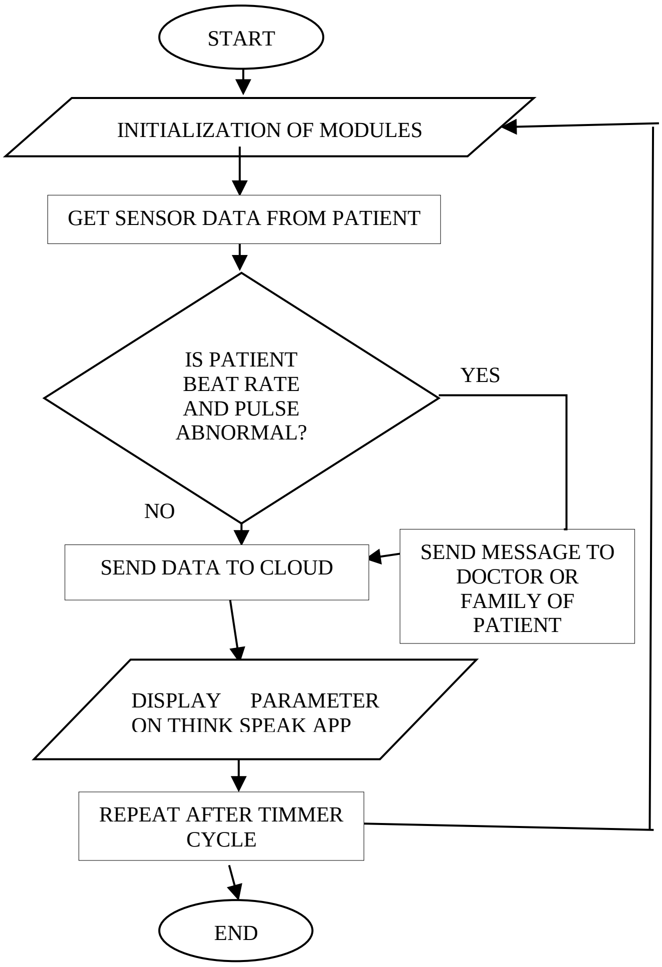

Figure 2: System Flowchart

The circuit diagram is as shown in figure 3:

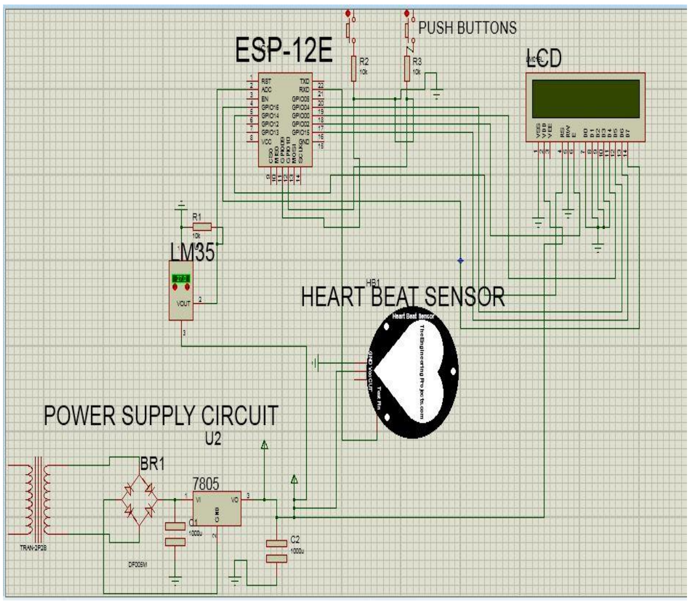

Figure 3: A screenshot of the System Circuit Diagram

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IV. Functional Units Of The System

A. *The wearable Blood pressure sensor unit*

The microprocessor can be easily interfaced with by the wearable blood pressure sensor, and its compact design fits over your wrist like a watch. Pumping is eliminated by the simple wrist design. It simultaneously displays the systolic, diastolic, and pulse readings and retains them in memory for future use [9].

Figure 4: The physical structure of the wearable blood pressure sensor

B. *AD8232 ECG Sensor*

The sensor board used to measure the electrical activity of the heart is reasonably priced. An ECG or electrocardiogram can be used to track this electrical activity and produce an analog reading. The AD8232 Single Lead Heart Rate Monitor functions as an op-amp to help easily obtain a clear signal from the PR and QT Intervals despite the fact that ECGs can be very noisy.

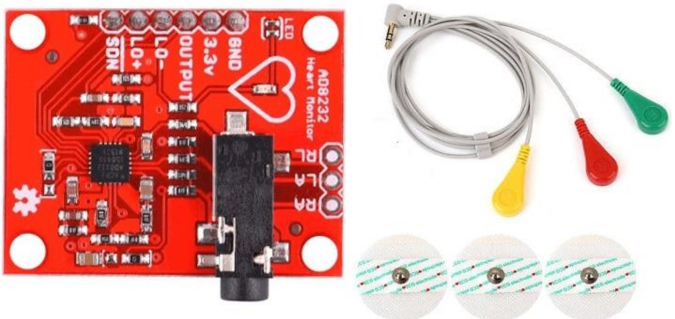

Figure 5: ECG Sensor

Nine connections from the IC are released by the AD8232 module so that you can solder pins, wires, or other connectors to them. The following pins are necessary for using this monitor with an Arduino or other development board: SDN, LO+, LO-, OUTPUT, 3.3V, GND. The RA (Right Arm), LA (Left Arm), and RL (Right Leg) connectors are also included on this board so that you can attach and use your own unique sensors. All leads must be positioned on the chest wall equally spaced from the heart for the best results. The pads can also be applied to the limbs, with the red electrode going on the right arm, the yellow electrode going on the left arm, and the green electrode going on the right leg. An illustration of the positioning is provided in figure 6.

C. *Temperature sensor*

The DS18B20 is a 1-wire programmable Temperature sensor from maxim integrated. In harsh settings like chemical solutions, mines, or soil, it is frequently employed to gauge temperature. The sensor's enclosure is sturdy and has the option to be waterproof, which makes installing it simple. With a respectable accuracy of 5°C, it can measure a wide range of temperatures, from -55° to +125°. As each sensor has a distinct address and only needs one pin of the MCU to transfer data, it is a great option for measuring temperature at various locations without using up many of your microcontroller's digital pins [10].

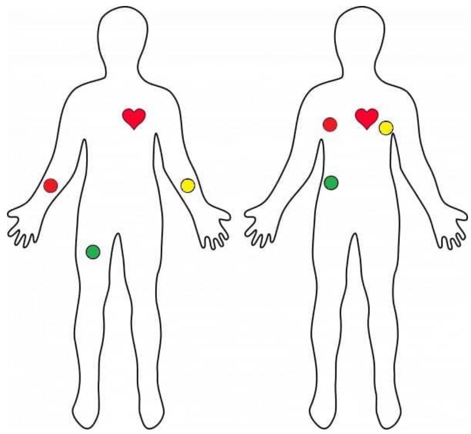

Figure 6: AD8232 ECG Sensor Placement on Body

Figure 7: DS18B20

D. *Node MCU ESP8266*

A low-cost System-on-a-Chip (SoC) called the ESP8266 serves as the foundation of the open-source NodeMCU (Node MicroController Unit).

Figure 8: Node MCU

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The Espressif Systems-designed and -produced ESP8266 has all of the essential components of a computer, including CPU, RAM, networking (WiFi), and even a contemporary operating system and SDK. This makes it a fantastic option for all types of Internet of Things (IoT) projects. The controller features a ROM of 448KB for booting and core functionality, a Wi-Fi module, Bluetooth, and a clock frequency of up to 240MHz.

E. *Power Unit*

The general block diagram of the power unit used for this project is given below. It has the following four main sub-blocks.

1. The Transformer
2. The Rectifier Circuit
3. The Filter
4. The Regulator.

1. Transformer

The needed voltage level was achieved by stepping down the 220V from the ac mains using a step-down transformer (12V). The transformer's turn-ratio is modified in order to get the desired voltage level. The rectifier circuit receives the transformer's output as an input.

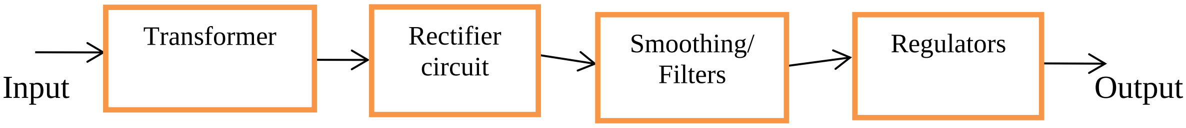

Figure 9: Block diagram of the power circuit

2. Rectification

A full wave rectifier or a bridge rectifier was used to convert the AC input to unidirectional pulsating DC output.

3. Filter

The rectified voltage produced by the rectifier is a pulsating DC voltage with a significant amount of ripple, which is not recommended for powering delicate electronics. So, a filter was applied. As a general rule, for a DC voltage to be completely regulated, the ripples must be less than 10%. Therefore, the capacitor filter is the most cost-effective filter for the basic 5V power supply design in this situation.

4. Voltage Regulator

Voltage sources in a circuit may have fluctuations resulting in not providing fixed voltage outputs. A voltage regulator IC maintains the output voltage at a constant value. The xx in 78xx indicates the output voltage it provides. 7805 IC provides +5 volts regulated power supply with provisions to add a heat sink. The 7805 IC was used to step down the voltage from +12V to 5V which is fed to the ESP8266 -12E. The ESP8266-12E however, consists of an on-chip voltage regulator which finally steps down the +5V to +3.3V required for the operation of the ESP8266-12E Wi-Fi module.

F. *ThingSpeak*

The sensors that are used to track health metrics usually have a localized effect. With IoT integration, devices, websites, and sensors can send data to the cloud for storage in either a private or public channel. This project uses the IoT platform ThingSpeak, which by default saves data in private channels (but public channels can be used to share data with others). Once data has been entered into a ThingSpeak channel, it can be analyzed and visualized, used to generate new data, or used to connect with other devices, web services, and social media. A platform for the Internet of Things (IoT) called ThingSpeak enables you to gather and store sensor data in the cloud as well as create IoT apps. You can use MATLAB apps from the ThingSpeak IoT platform to analyze, visualize, and take action on your data [11]. Additionally, it can be used to store and receive information from objects that use the HTTP protocol and connect to the Internet or a local area network. Application development for location tracking, sensor logging, and a social network of things with status updates are all made possible by ThingSpeak. Hardware like the Arduino, Raspberry Pi, BeagleBone Black, and other devices can send sensor data to ThingSpeak. The open source nature of this integrator, which facilitates simple interfaces and integrated support from MathWorks' MATLAB numerical computing software, gives users of ThingSpeak the opportunity to analyze and visualize uploaded data using Matlab without having to purchase a Matlab license from Mathworks. The illustration below shows how to create a new channel to collect analyzed data.

1. Sign In to ThingSpeak™ using your MathWorks Account, or create a new MathWorks account.
2. Click Channels > MyChannels.

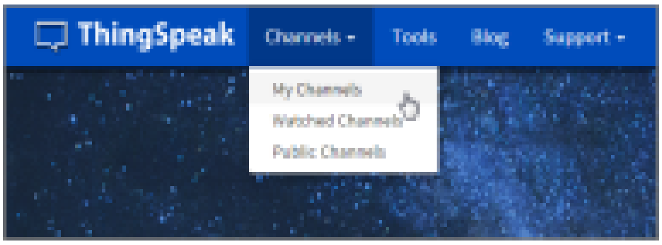

Figure 10: ThingSpeak Illustration

3. On the Channels page, click New Channel.
4. Check the boxes next to Fields 1–3. Enter these channel setting values:

- Name: MR OKEREKE NWAFOR
- Field 1: Temperature (F)
- Field 2: Blood Pressure
- Field 3: Heart Beat

5. Click Save Channel at the bottom of the settings.
   You now see these tabs:

- Private View: This tab displays information about your channel that only you can see.

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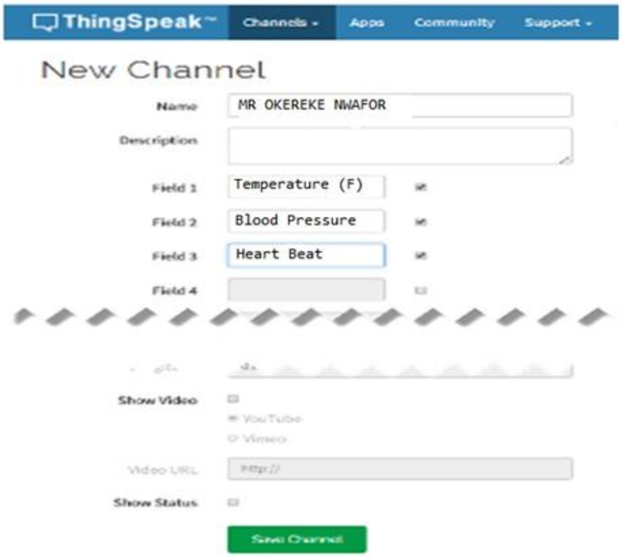

Figure 11: Creating a channel on ThingSpeak

- Public View: If you choose to make your channel publicly available, use this tab to display selected fields and channel visualizations.
- Channel Settings: This tab shows all the channel options you set at creation. You can edit, clear, or delete the channel from this tab.
- Sharing: This tab shows channel sharing options. You can set a channel as private, shared with everyone (public), or shared with specific users.
- API Keys: This tab displays your channel API keys. Use the keys to read from and write to your channel.
- Data Import/Export: This tab enables you to import and export channel data [12].

MatLab can then be used to carryout any type of analysis required by the medical personnel.

G. Keypad

The keypad used in this project is for identification purposes. The keypad has four functional keys alongside a start and stop key. The function keys are used as shift key, delete key and reset key. This key pad is cost effective and easy to interface with the microcontroller.

Figure 12: keypad

H. LCD display unit

The display device includes a 216 liquid crystal display as part of the output or load (LCD). The major use of the LCD in this project is to show the body temperature, blood pressure, and heartbeat. The LCD is utilized because it is affordable and simple to program [12].

Figure 13: 2x16 LCD

I. Mobile user unit

Any GSM mobile phone that can send and receive SMS is simply a mobile user. Every time a reading is taken, the microcontroller instructs the GSM module to send an SMS to the mobile phone of the remote doctor.

J. Buzzer

A 5v buzzer was chosen in order to ensure that the project consumes low power. The buzzer triggers on receiving a high signal from the transistor which serves as a switch interfaced to the microcontroller. This indicates that the threshold is exceeded [12].


Figure 14: Buzzer

V. System Performance

The unit test of this project started with continuity test on the PCB design to ensure that there was no short circuit of the electrical parts (i.e. the conductive parts). The WIFI Module, LCD display, and sensors devices were all tested individually. After integration of all the components, the complete system was also tested on a volunteer as shown below:


Figure 15: Testing of the designed system on a volunteer

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The results of the sensor data obtained are displayed on the LCD as shown below:

Figure 16: Temperature reading of the system test

Figure 17: Blood pressure and heart rate of the system test

Test was carried out on a volunteer and the graphical representation of a volunteer's parameter as displayed on the ThinkSpeak platform is shown below.

- *Blood Pressure:*

The wearable blood pressure sensor was wrapped around the volunteer's arm, when the push BP button was pressed, the volunteer's diastolic pressure, systolic pressure and heart rate was detected, collected and transmitted to the cloud using the WiFi module. The graphical representation of the data is shown below.

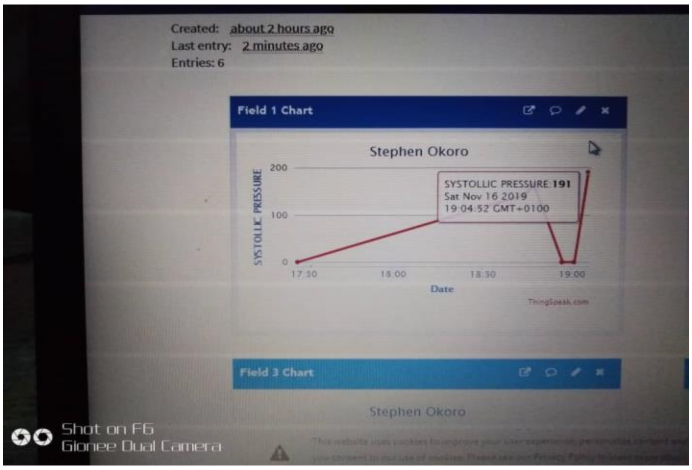

Figure 18: Graphical Representation Systolic Pressure

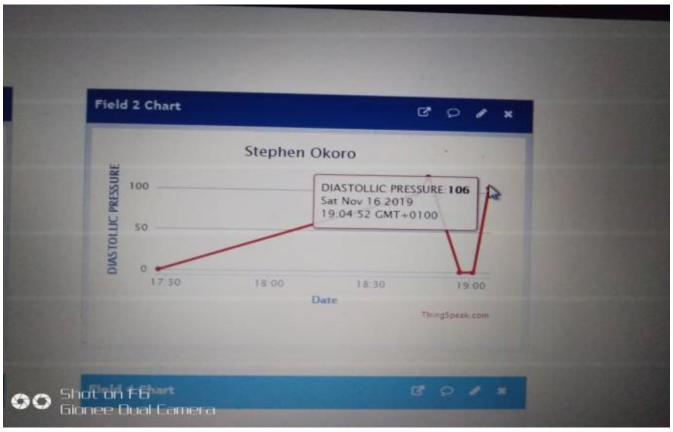

Figure 19: Graphical Representation Diastolic Pressure

Figure 20: Graphical Representation of Heart Rate of the Volunteer

- *Temperature*

The Temperature of the volunteer was tested using the LM 35 temperature sensor; the temperature was detected, collected and transmitted to webserver using the Wi-Fi module. Then graphical representation of the test result is shown below.

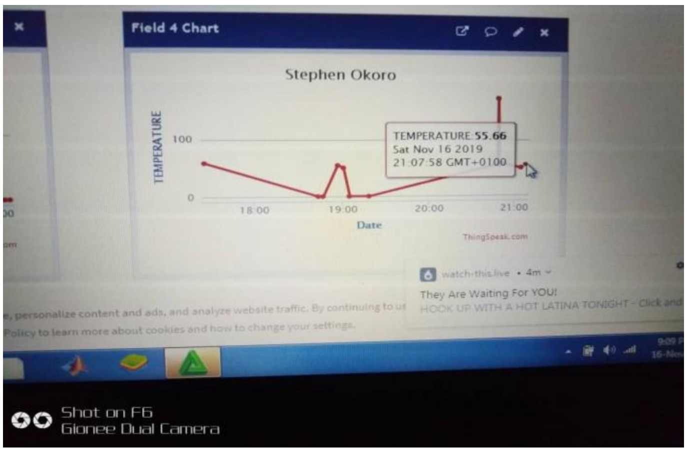

Figure 21: Graphical Representation of Temperature of the Volunteer

- *ECG Signal*

The serial data obtained from the ECG sensor is hard to visualize if one is just viewing the values. Using the Arduino IDE one can view the data on a graph using the Arduino Serial Plotter as one option. In the Arduino IDE, select Tools > Serial

Plotter. The obtained waveform is as shown in figure 22 when the sensors are placed correctly and not moving.

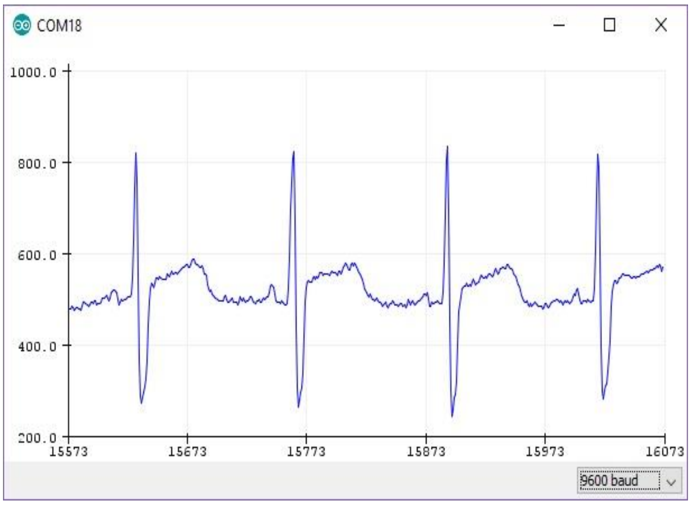

Figure 22: ECG signal graph

VI. PACKAGING

Packaging of this project follows after system testing and observation of system performance. The following factors were considered before carrying out the packaging of this project, they include: portability, easy accessibility of the power supply unit without opening the entire circuit, mechanical damage protection, cost etc. The packaging was done using a Perspex material (plastic in nature).

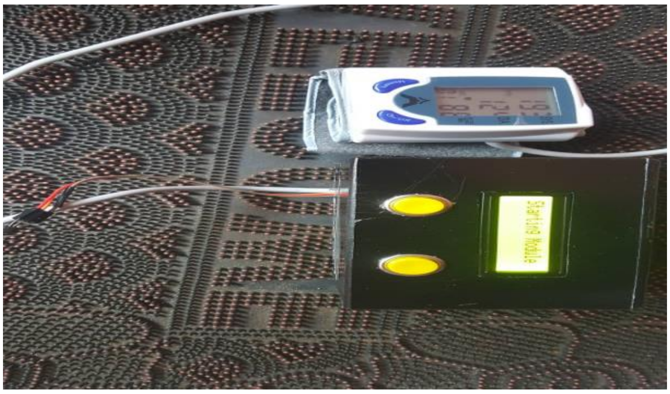

Figure 18: System Package

VII. CONCLUSION

The patient's health status changes were successfully tracked by the remote health monitoring system, which also sent vital signs via GSM technology. Through lower costs than would be incurred if they were hospitalized, patients profit from this system. Patients can keep their doctors informed about their health state remotely. The medical staff is freed from the tiresome duty of routinely monitoring patients. In addition to monitoring ECG signals, the work implements an upgrade to current systems by integrating a database and identification system.

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REFERENCES

[1] UK Essays. (2013, November) Health is Important to the Society. [Online]. http://www.uniassignment.com/essay-samples/health/healthcare-is-important-to-the-society

[2] Agu, E., Pedersen, P., Strong, D., Tulu, B., He, Q., Wang, L., Li, Y. (2013). The smartphone as a medical device: Assessing enablers, benefits and challenges. 2013 IEEE International Workshop of Internet-of-Things Networking and Control (IoT-NC), pp. 48-52. http://dx.doi.org/10.1109/IoT-NC.2013.6694053

[3] Riazul Islam, S.M., Kwak, D., Kabir, H., Hossain, M., Kwak, K.S. (2015). The internet of things for health care: a comprehensive survey. IEEE Access, 3: 678-708. http://dx.doi.org/10.1109/ACCESS.2015.2437951

[4] Ufoaroh, S. U., C. O. Oranugo, and M. E. Uchechukwu. "Heartbeat monitoring and alert system using GSM technology." International Journal of Engineering Research and General Science 3.4 (2015): 26-34.

[5] Mohammad, S.I.; Mohammad, T.I.; Ali, F.A.; Gan, K.B.; Norbahiah, M.; Amin, N. Monitoring of the Human Body Signal through the Internet of Things (IoT) Based LoRa Wireless Network System. Appl. Sci. 2019, 9, 1884, doi:10.3390/app9091884.

[6] Majumder, A.K.M.; ElSaadany, Y.A.; Young, R.; Ucci, D.R. An Energy Efficient Wearable Smart IoT System to Predict Cardiac Arrest. Adv. Hum.-Comput. Interact. 2019, 2019, 1507465, doi:10.1155/2019/1507465.

[7] Mrs. Rajashri Patil, Prof.Balaji Hogade, "On Line Real Time Health Monitoring of ICU Patients using," International Journal of Computer Science and Network (IJCSN), vol. Volume 1 , no. Issue 3, p. 6, June 2012.

[8] Nnanyelugo Chibuikem Echezonam, Ukadike Charles Ekene, Awgu Chukwuemeka Chidoh, "Remote Patient Monitoring System using GSM," Awka, 2016.

[9] Sunrom. (2017) Blood pressure sensor. [Online]. www.sunrom.com/electronics/blood pressure sensor

[10] "DS18B20 Temperature Sensor." Components101, https://components101.com/sensors/ds18b20-temperature-sensor.

[11] The MathWork Inc. https://thingspeak.com. [Online]. https://thingspeak.com

[12] The MathWorks,Inc. https://www.mathworks.com/help/thingspeak/collect-data-in-a-new-channel.html. [Online]. https://www.mathworks.com/help/thingspeak/collect-data-in-a-new-channel.html.