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# Designing ECG Monitoring Healthcare System Based on Internet of Things Blynk Application

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***Abstract***
**Nowadays, heart diseases are considered to be the primary reasons for unexpected deaths. Thus, various medical devices have been developed by engineers to diagnose and scrutinize various diseases. Healthcare has become one of the most substantial issues for both individuals and government due to brisk growth in human population and medical expenditure. Many patients suffer from heart problems causing some critical threats to their life, therefore they need continuous monitoring by a traditional monitoring system such as Electrocardiographic (ECG) which is the most important technique used in measuring the electrical activity of the heart, this technique is available only in the hospital which is very costly and far for remote patients. The development of wireless technologies enables to build a network of connected devices via the internet. The proposed ECG monitoring system consists of AD8382 ECG sensor to read patient's data, Arduino Uno, ESP8266 Wi-Fi module, and IoT Blynk application. The implementation of the proposed ECG healthcare system enables the doctor to monitor the patient's remotely using IoT Blynk application installed on his smartphone for processing and visualizing the patient's ECG signal. The monitoring process can be done at any time and anywhere without the need for the hospital.**

***Keywords:*** *ECG, IoT, AD8232, Arduino Uno, ESP8266, Blynk.*

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## I. INTRODUCTION

The heart diseases are the main reason for the sudden deaths and causes a high mortality around the world yearly. Unfortunately, heart diseases patients are obligated to stay at their home without making any potential that stress the heart. However, most of the patients die before they get any treatment because they do not feel sick until the disease become at a critical stage [1]. Therefore, the physician has to monitor the physical status of the patient's heart continuously to prevent any urgent relapse in heart status and then reducing the deaths. It is difficult to keep all heart patients in the hospital to monitor their status. Instead, developing real-time monitoring healthcare system based on wireless technology is an effective solution for the physician to monitor their patients remotely [2].

The Electrocardiogram is physiological wave signal that describes the electrical activity of the heart. It is generated as a result of pumping and squeezing blood between the atria and chamber inside the heart [3]. ECG enables the physicians to determine the medical state of the heart by measuring the time needed for the electrical signal to be travelled through the heart. ECG signal is measured using a set of electrodes that are placed non-surgically on the body surface to obtain information about the electrical activity produced by the heart [4].

The phrase "Internet of Things" IoT was used for the first time in 1999 by Kevin Ashton during his works at MIT's Media Center [5]. This concept is used to express the connection between the machines and computers through sensors and using the internet as a mean to accept control commands and reporting status [6]. IoT is around for a long time but without a name, machine-to-machine (M2M) was available for many decades and is the nearest concept to IoT. There are many other names for IoT such as Ubiquitous computing and internet of everything [7]. Generally, the term (IoT) refers to a dynamic and global network infrastructure which consists of a large number of network connections and computing capabilities extend to objects, sensors and everyday items not normally considered computers [8]. These devices are allowed to generate, consume and exchange data with a little human intervention. The large-scale implementation of IoT transforms many aspects to the products such as home automation, energy management devices, networked vehicles, intelligent traffic and health monitoring devices [9]. IoT brings great convenience to the healthcare field, especially for patient monitoring and tracking management. Accelerated development of the internet, cloud computing and Internet integration of medical monitoring and management platform provides new opportunities for the hospitals and care centers to



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improve access and interconnection of devices used in healthcare [10]. Embedded technologies have an important role in delivering healthcare to people in separated and far locations by providing them with a monitoring system which presents a continuous stream of accurate data for better healthcare decisions. As the technology is to collect, analyze and transmit data, IoT continues to improve; the IoT-driven healthcare applications and systems emerge [3, 11]. This paper utilized the IoT Blynk platform to present a cost-effective, remotely used, easily equipped, and real-time healthcare system for monitoring the ECG of the heart patients using Arduino Uno and. This system provides optimal solutions for heart patients that are living in remote regions and having limited income.

The rest of the paper is organized as follow. Section two focuses on the related works, and Section three describes the system from three aspects: the system components, its data acquisition, data processing, data transmission and data visualization parts. In Section Four, we present the implementation steps and result visualization. Section five discusses the obtained results and comparison with some related works. Section Six gives the conclusions and future works.

## II. Related Works

A. G. Ismaeel and E. K. Jabar. [12] intended to reach m-health by designing a health care system for pregnant women using Mobile GIS. This system enables the pregnant woman which needs advice, revision and succoring (from their home) to register in maternity care center via the web interface by sending SMS to the system server including her ID, phone number, name, age, as well as locating the position using a mobile built-in GPRS technique.

B. M. Lee and J. Ouyang. [13] designed an intelligent service model for healthcare. A collaboration protocol has been proposed to send and receive the factors related to the risks between IoT healthcare devices. The collaboration protocol is an application protocol consisting of many events which are applied to organize the flow of data between IoT's devices, the boot event initializes all the IoT's devices in the system by broadcasting join message.

A. Ahamed et al. [14] implemented a low-cost ECG monitoring system. This system consists of four units, an ECG acquisition unit senses the patient's ECG data signal by using the Bio Protech T716 electrode, this data is transferred to the amplifier input. Signal conditioning unit uses the AD620 amplifier as well as many other techniques to get a pure data signal by amplifying the data signal and reducing the noise.

B. Padmavathi and S. T. Rana. [8] designed and implemented a framework for IoT based healthcare solution based on cloud computing. This framework includes five layers. Data processing layer identifies and locates the data from sensor-based technology by using RFID, ZigBee, NFC, Barcode technologies and digital cameras.

S.LAVANYA et al. [15] proposed a healthcare system based on IoT to collect the medical data of patient such as heart rate and blood pressure using Raspberry Pi microcontroller. The heartbeat of the patient is measured every 10 minutes at home. In case of an emergency, this system will send an alert to the patient's doctor by SMS in a fast and reliable way. This system consists of three parts, the first part is smart medical service, it collects data from the sensors and analyzes it by raspberry pi then displaying the results on the monitor.

P.Kalaivani, et al. [16] aimed to provide a healthcare system by designing a wireless patient monitoring system consisting of IR sensor for measuring the saline level and AD8232 ECG sensor to read the electrical activity of patient's heart. Both sensors are connected to the Arduino Microcontroller, Arduino processes the data read by sensors then display the result of saline level on LCD while the ECG output signal can be visualized through a serial plotter or can be transmitted via Bluetooth module to be displayed on a smartphone.

Z. U. Abideen and M. A. Shah. [17] designed a robust healthcare module consisting of five layers. The IoT sensors layer collects the data from sensors connected to the patient's body then sent it to the upper layer through the 6LoWPAN border router (6LBR) works as a gateway. Network layer uses the advantage of 6LBR with wi-fi interface, when the patient's wi-fi turned on, the 6LBR will be connected directly to the internet via patient's smartphone wi-fi to transmit the collected data to the server.

A. Kubal and C. K. [9] used the raspberry pi board with four sensors to design an E-Health monitoring of the patient. It collects patient's health data from these sensors through the configured GPIO port, then processes the data to get the health data on the graphical user interface webpage. This page is locally hosted by raspberry pi, the page is displayed when the healthcare provider connects to the raspberry pi local IP address, therefore the doctor can monitor the health state of the patient easily on the internet browser.

In summary, the related works discussed previously don’t present an ECG healthcare system that has the four main features: real-time, low-cost, easy equipped and remotely used. Any healthcare with these four features will be satisfied for the low-income and remote living heart patients. The proposed healthcare system assists the physicians to follow the physical status of their patients at anytime and anywhere on using mobile phone or laptop.

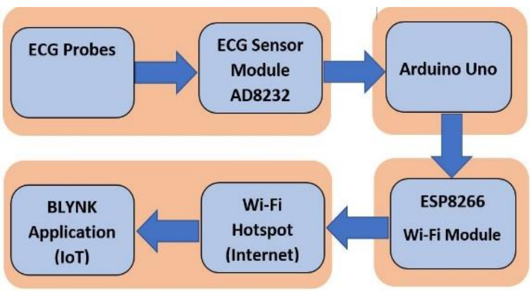



Fig. 1. Flow Diagram of the Proposed System.

## III. Materials And Methods

The proposed system consists of a set of hardware and software components that are interacted together to build the overall system. These components can be divided into four units, the data collecting unit that is responsible for reading heart activity signals from the human body, Arduino Uno microcontroller that processes the received data from ECG probe, ESP Wi-Fi module that transmits the produced information to the remote API application, and finally, Blynk IoT application that displays the received information on the mobile screen. Figure 1 shows the main four units for the proposed system.

The proposed system performs the reading data, processing data, sending data, and displaying data according to the following flowchart shown in Figure 2.

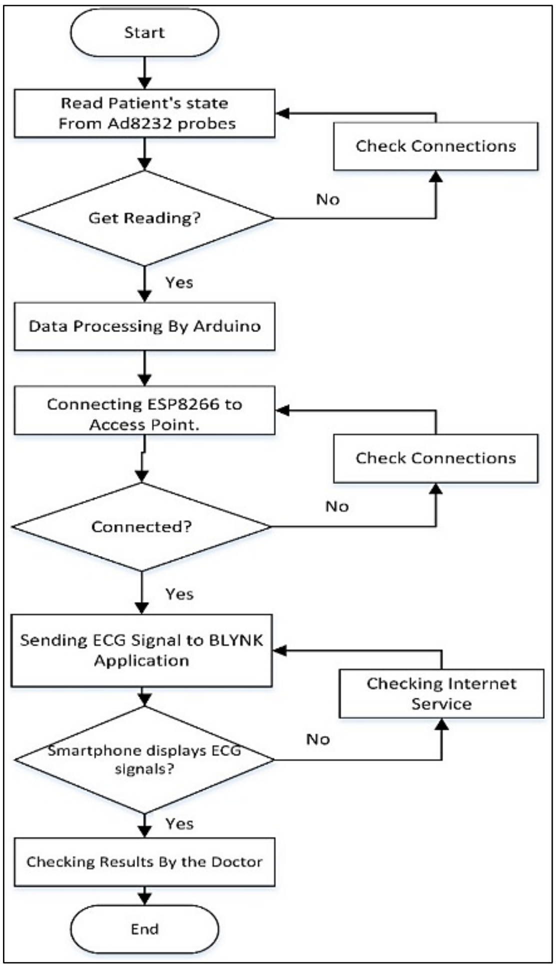
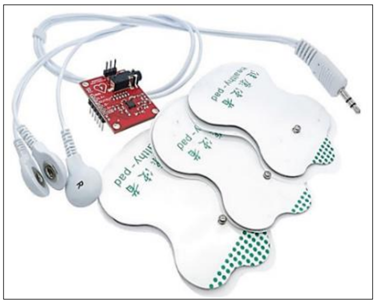



Fig. 2 . Flowchart of The Proposed System Architecture.

## A. Data Acquisition

The essential components of the data acquisition unit are AD8232 chip and three adhesive electrodes terminals pointed as R for the right side, L for the left side and COM as aground as shown in Figure 3(a). The main task of the AD8232 chip is extracting, amplifying, and filtering the small signals of the heart electrical activity when a noisy condition occurs due to motion or remote electrode placement. Signal conditioning is achieved using a bipolar point high pass filter which is coupled with the instrument amplifier structure. The AD8232 chip contains a nonoperational amplifier that creates a three-pole low pass filter as well as reducing the additional noise. AD8232 contains a fast recovery function, you can reduce the long high pass filter to establish the long tail phenomenon. If the amplifier rail voltage signal mutation (such as the lead out of the case), AD8232 built in an amplifier for the right-side driver (RLD) and other drive lead applications. AD8232 will automatically adjust to a higher filter cutoff state. This feature allows the AD8232 to achieve rapid recovery, and thus the lead connection to the measurement of the object can be achieved as soon as possible after the measurement of the value. AD8232 is connected with the Arduino Uno microcontroller as illustrated in fig.3(b).



a- AD8232 Module

| Board Label | Pin Function | Arduino Connection |
|---|---|---|
| GND | Ground | GND |
| 3.3v | 3.3v Power Supply | 3.3v |
| OUTPUT | Output Signal | A0 |
| LO- | Leads-off Detect – | 11 |
| LO+ | Leads-off Detect + | 10 |
| SDN | Shutdown | Not used |

b- Pins Layout

Fig. 3. Data Acquisition Components of the Proposed System.

## B. Arduino UNO Microcontroller

Arduino UNO is the main processing unit utilized in our proposed healthcare system that consists of ATmega328T microchip as the microcontroller. Arduino UNO involves a 10-bit built-in analogue to digital (ADC) converter, which reduces the system complexity and performs a vital role in acquisition and processing analogue data signal from AD8232 chip. For serial data transmission, Arduino UNO is also equipped by a set of communication terminals. The output data is transmitted from the AD8232 module to Arduino by connecting the OUTPUT pin to A0 analogue pin as shown in Figure 3(b). The data will be processed using A/D converter and USART as explained in [14] to transmit the data serially via pin 2 and 3 to ESP8266 wi-fi module. Figure 4 shows the connection layout between the Arduino Uno microcontroller and the AD8232 model.

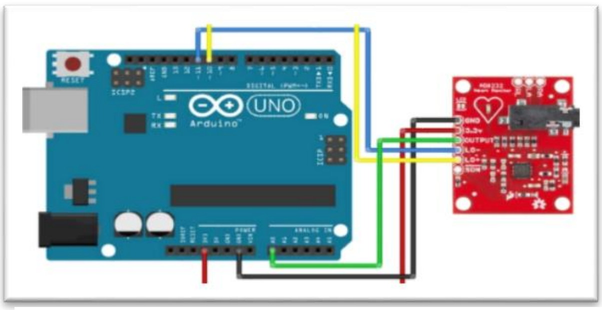



Fig. 4. Connection Between Arduino UNO and AD8232 Module.

## C. ESP8266 Wi-Fi module

It is a self-contained system on chip (SOC) with an integrated TCP/IP protocol stack. The ESP8266 module enables any microcontroller such as Arduino UNO to be connected to Wi-fi access point which is already connected to the internet. The user has to be careful about the connection between the ESP8266 module and Arduino UNO microcontroller. Figure 5 illustrates that TX and RX pins of ESP8266 module are connected to the digital pin number 2 and 3 respectively in Arduino Uno. The power is provided for ESP8266 module via the VCC 3v and GND pins from of the Arduino Uno.

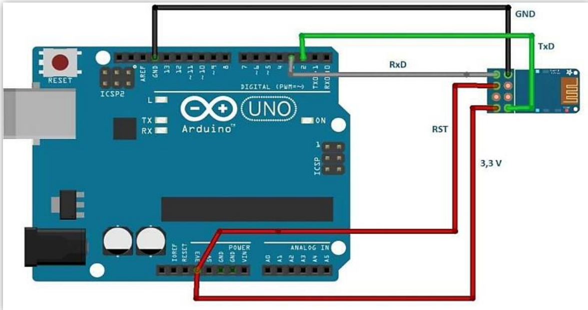



Fig. 5. Connection Between Arduino UNO And ESP8266 Module.

### D. *Blynk IoT Application*

It is utilized to control hardware remotely, displaying sensor data, storing data, visualizing it and performing many other tasks. As shown in Figure 6, Blynk consists of the following major components:

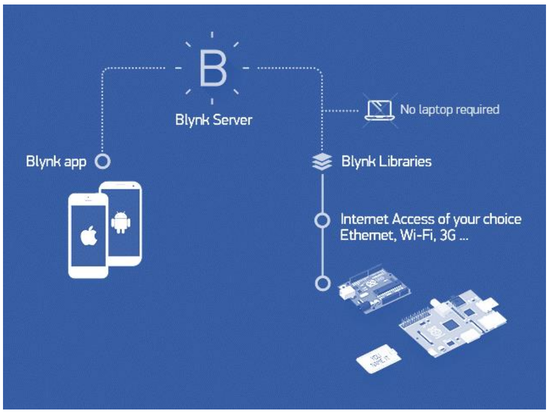



Fig. 6. Blynk Platform Components.

- **Blynk App** allows creating interfaces for different projects using various provided widgets.
- **Blynk Server**: performs all communications between the hardware and smartphone. Blynk Cloud can be used to run a private Blynk server locally. It's open-source, it can handle thousands of devices and can even be launched on a Raspberry Pi.
- **Blynk Libraries**: enable communication with the server and process all the incoming and outcoming commands for all the popular hardware platforms.

## IV. SYSTEM IMPLEMENTATION

In this section, the components of the proposed system are connected. The implementation begins with initializing Blynk application, the first step is to download it from the apple store or google play store and install it on the smartphone, the next step is to create an account using a valid e-mail address to receive an authentication code data field where the data can be displayed in the form of a graph so that variation of the ECG data signal of the patients can be visualized. The software is designed for performing this task. Figure 7 illustrates the experimental application of the proposed system components.

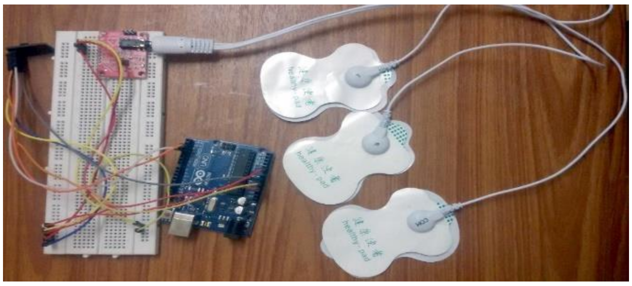


Fig. 7. The Proposed Work Connection.

The program code is written using Arduino IDE 1.8.5 environment, this code starting to prepare the necessary library for ESP8266 module <ESP8266_Lib.h> and Blynk application <BlynkSimpleShieldEsp8266.h>. The ECG analogue signals from the probe's terminals are read through Arduino pin A0. The probe terminals have to be placed properly at the specified part of the human body. Arduino processes the data by converting the analogue data to digital information using Analog to digital conversion. The output data will be passed to the ESP8266 module through pin 2 and pin 3. ESP8266 Module is connected to the internet hotspot using the name of the hotspot (SSID) and (PASSWORD) and then sending the data to the Blynk application platform. Blynk IoT application receives the data via the virtual channel (V5) to be visualized by a doctor in his smartphone as shown in Figure 8.

## V. RESULTS AND DISCUSSION

The essential aim of the proposed system is minimizing the time between the moment of getting patient's data and displaying the results through Blynk application on the physician phone or laptop. Figure 8 visualizes the ECG signal of the patient's heart. The x-axis of the wave signal represents the time of reading the patient's heart data.


Fig. 8. ECG Output Signal on Blynk Application.

If we compare the x-axis time with the mobile time then we can conclude that the proposed system success to transfer the heart status information from the remote patient to the physician in real-time mode.

Many systems have been proposed to design a healthcare system for monitoring remote patient's status using different techniques in data acquisition, data processing, data sending, and data displaying. In [14], [16] and [17], the ECG data are read using various ECG sensor models such as AD8232 and T7016 sensors, while [9] and

[14] focused on heartbeat reading from remote patients. Most of the systems have used Arduino Uno and Raspberry Pi microcontroller because of its effectiveness and cost-effective. With the use of the internet as a transmission media, most of the systems achieve unlimited distance monitoring except [13] and [15] that used Bluetooth to monitor the patient's status data locally. Our proposed system achieves a significant task by monitoring the remote patient's data using IoT Blynk application. However, Table I illustrates the main differences between the proposed system and other related systems.

TABLE I. COMPARING THE PROPOSED SYSTEM WITH OTHER RELATED SYSTEMS.

| Parameter | **Proposed System** | A. Kubal and C. K. [9] | A. Ahamed et al. [14] | S.LAVANYA et al. [15] | P.Kalaivan et. al. [16] | Z. U. Abideen and M. A. Shah. [17] |
|---|---|---|---|---|---|---|
| Data Reading | **AD8232 ECG sensor** | Heartbeat pulse, blood pressure and heart sound sensors kits | Bioprotech ECG T7016 | Heart Beats sensor | AD8232 ECG sensor | The pulse oximeter, blood oxygen saturation, ECG, glucose sensors connected to a gateway router |
| Micro-controller | **Arduino Uno** | Raspberry Pi | Arduino Uno | Raspberry Pi | Arduino Uno | 6LoWPAN |
| Transmission Technique | **Wi-Fi** | Wi-Fi | Bluetooth | GSM+Wi-Fi | Bluetooth | 3G and 4G |
| Distance | **Unlimited** | Unlimited | 10 meters | Unlimited | 10 meters | Unlimited |
| Displaying Results | **Blynk Application on smartphone** | Web Page IP address | Processing application and smartphone | SMS Acknowledgment and Web page IP | Serial plotter and smartphone | Reporting emergency case as an email |
| IoT | **Yes** | Yes | No | Yes | No | Yes |
| Time | **Real-time** | Real-time | Real-time | Real-Time | Real-time | Real-time |
| Cost-Effective | **Yes** | Yes | Yes | Yes | Yes | No |

## VI. CONCLUSION

This paper aims to design an ECG healthcare system based on IoT for patients who are suffering from problems in heart activity. The system utilizes the Blynk IoT application which is a free application to be used by the physicians to monitor the heart state of their patients. The main strength points of our proposed system are easy to connect and use by anyone, can be carried anywhere, remotely used, cost-effective, and easily equipped. This system can be developed in future by increasing the number of the electrode for ECG sensor to obtain more accurate results, also can be extended by adding more sensors for measuring other parameters such as blood pressure and heartbeats. Creating a cloud database will be very effective to store the patient's health information involving patient's health history, however, in each time the doctor performs a new ECG reading the data will be directly stored in the patient's record in the database, then it may be analyzed and the doctor can send an advisory report to the patient.

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