A Wireless ECG Device with Mobile Applications for Android

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Abstract— **Electrocardiograph (ECG) is a measuring device that used in hospital to monitor electrical activity of heart. Commonly used ECG device is a Holter monitor, a portable and wired device, which is bulky and not suitable for measuring and recording athlete's heart activity during training. The objective of this study was to design the ECG monitoring system as an Internet of Things (IoT) device, equipped with a temperature detector to detect user's body temperature. The ECG signals and the temperature were transmitted wirelessly using Bluetooth transmission to the mobile applications (apps). Both signals were set to display on mobile apps which was developed using Blynk application. At the end of this project, the signals were shown on the mobile apps and the user could monitor their own ECG signals as well as to share with their caretaker or physician later.**

Keywords— Blynk, body temperature, ECG signals, Holter monitor, Internet of Things

I. INTRODUCTION

Electrocardiography (ECG) is the measurement of the electrical activity of one's heart in a period of time. In addition, ECG is a significant demonstrative instrument in medicine [1] and to inspect users' heart electrical activities through ECG monitoring system [2]. As indicated by the American Heart Association (AHA), roughly at regular intervals an American experienced a condition of heart failure (or cardiovascular (CV) failure) [3]. In 2016, 2 744 248 resident deaths were registered in the United States. Ten leading causes accounted for 74.1% of all registered deaths. Most of the times, patients are late to reach the emergency room (or intensive care unit, ICU) of hospital during heart attacks since detection occurred [4].

The needs to create an adaptable ECG monitoring system even though a lot of difficulties in filtering noise, selection of board that could happen during manufacturing process, as to support market demand. The commonly used ECG device are fabricated on a rigid board (usually a woven fiberglass material, FR4) to monitor ECG signals. The device could be either wired or wireless device. However, the most used monitoring system at the hospital is Holter device [5], a wired ECG device. Holter provides a long-term monitoring for recording the ECG signals either inside or outside of the hospital. For handheld or portable type of Holter devices require the users/patients to carry it. Nonetheless, Holter software is not yet compatible to be used with the smartphone to measure the ECG signals via Bluetooth or Wi-Fi transmission channel.

A design of a portable ECG with temperature detector by using IoT technology was proposed in this study as an alternative way that could help to monitor ECG and body temperature of user, while doing any activity and give the easy access for doctors or nurses to monitor ECG waveform and temperature reading through their phone [4], or cloud server. This is a positive indicator that it can be used for sport's user and physician to monitor heart condition and body temperature regulation during training or exercise [6]. Thus, the type of communication use for IoT part could be either Bluetooth transmission with range about 100 m or 328 ft, Wi-Fi module, or etc. In addition, other studies have found that Blynk application could be used to developed mobile applications (apps) on smartphone to measure the ECG waveform via Bluetooth [7]. Thus, a wireless ECG circuit could give continuous ECG monitoring for users especially athlete to monitor their heart condition and temperature body detection due to users to avoid and give early precaution from sudden cardiac death or hyperthermia among athlete.

II. REVIEW

A. Cause of Death Due to Cardiovascular (CVD) Disease

Cardiovascular diseases (CVD) have been proliferated among world population because of their unpleasant lifestyle. Adults ≥ 20 years age, for 48.0 % population (121.5 million in year 2016) and increases with advancing age in both males and females are prone to CVD. CVD prevalence excluding hypertension (CHD, HF, and stroke only) is 9.0 % (24.3 million in year 2016). In addition, in year 2016, 2 744 248 resident deaths were registered in the United States. Ten leading causes accounted for 74.1 % of all registered deaths. The 10 leading causes of death in 2016

were the same as in 2015 [3]. It has been reported that CVD is regularly happened by the youth [8]. Today, CVD is one of the significant reasons of death around the world.

In Indonesia, approximately 700 thousand mortalities had occurred for each year as related to cardiovascular failure [4]. To prevent cardiovascular failure from getting serious, early finding is the most extreme significance. One of the symptomatic in ECG signals could be diagnosed is beneficial to examine the vital sign of heart failure.

B. ECG Signals Acquisition

The ECG signals could be used to detect the any abnormality of heart rhythm or arrhythmias. It is a non-invasive diagnostic technique which could help in evaluating the heart's electrical signals to measure the heart disease. ECG signals also could measure the rhythm and rate of the heartbeat [9]. Fig. 1 shows the ECG signals acquisition system [9].

III. METHODOLOGY

Fig. 2 shows the flowchart for this study. The operation of this project started from receiving the input from test subject by using the ECG sensor (AD8232). The data displayed input (ECG waveform) and then the output from ECG sensor (AD8232) and temperature sensor (DHT11) are sent to the microcontroller. The microcontroller (Arduino Nano) need to transmit the data to the Bluetooth module (HC-05). The Bluetooth module (HC-05) act as receiver and transmit the data to the mobile application. The data received by the mobile application Blynk displays the data signals through the apps interface developed for mobile phone. The electronic component used are summarize as in Fig. 3.
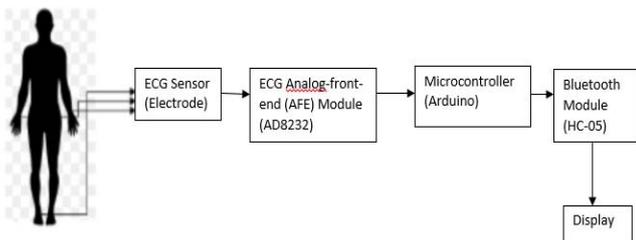

Fig. 1.   ECG signal acquisition [9]

IV. RESULTS AND DISCUSSIONS

A. Hardware Setup

Fig. 4 shows the full prototype for wireless ECG device with temperature detector and the developed mobile app. This prototype used Arduino Nano as microcontroller, AD8232 ECG bio-potential module and Bluetooth module to wirelessly transmit data to the smartphone. The Arduino IDE is used to code and program the Arduino.

After the port's selections are confirmed, the Blynk software is installed to the mobile phone and the setting to let the software communicate with the Arduino Nano is done. Fig. 5 shows the Blynk software is ready to communicate with Arduino.

Next is to read and write the data received from the input of AD8232 at the Arduino IDE serial monitor. This is to ensure the connection of the components are correct. Fig. 6 shows the digital value of output received by the HC-05 from

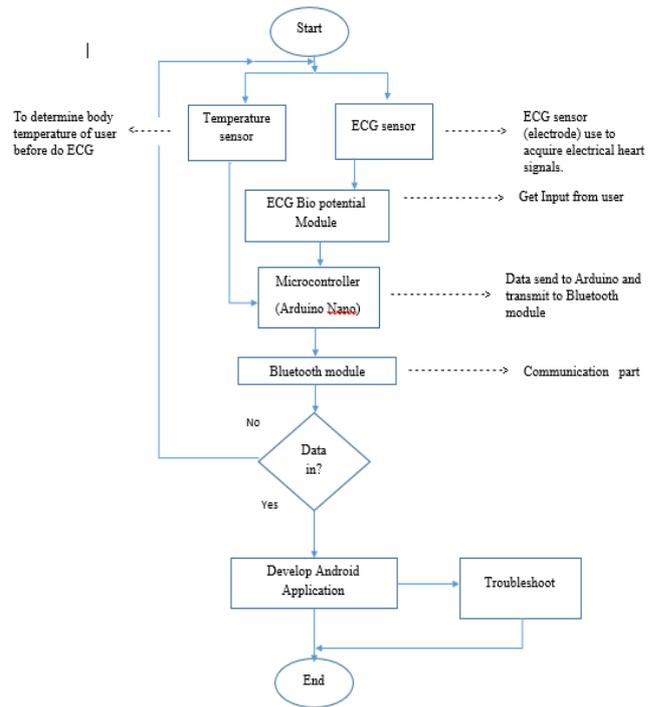the AD8232. Next is to plot the data received. Fig. 7 shows the data plotted.
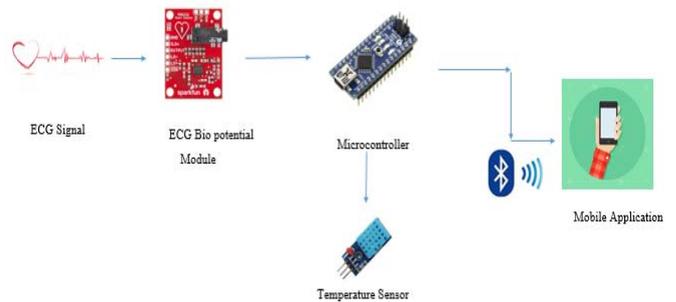

Fig. 2.   Study flowchart

Fig. 3.   Electronic components used in this study

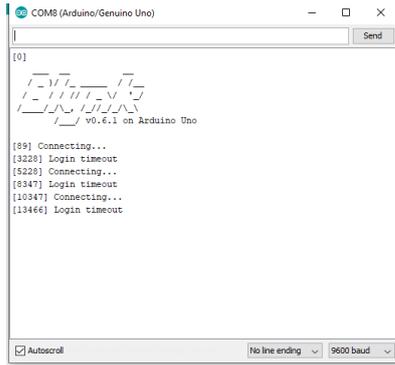Fig. 4.   Hardware setup for ECG device with temperature sensor
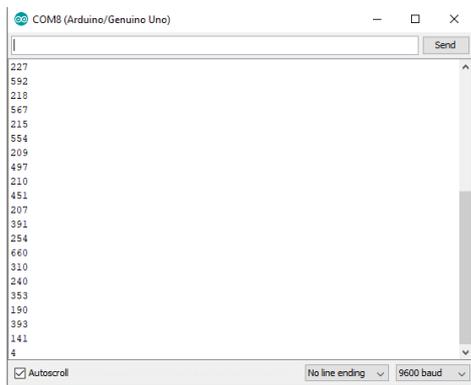
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Fig. 5. Blynk software

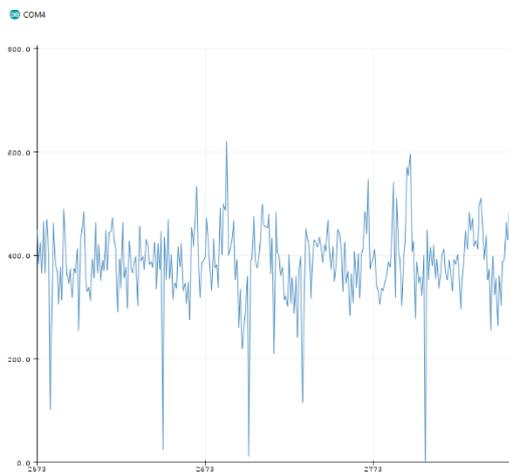Fig. 6. Digital value from AD8232 received by Bluetooth HC-05

Fig. 7. Data received is plotted

B. Data Display on Blynk Platform

The waveform of input signals is visualized on Blynk application through *superchart* graphical option provided in Blynk application. The *superchart* has four choices of graph which are line, bar, area or binary. To display ECG waveform, line graph is more suitable. For displaying ECG on Blynk data set is on virtual pin (V5). Fig. 8-11 show the data displays on Blynk application.
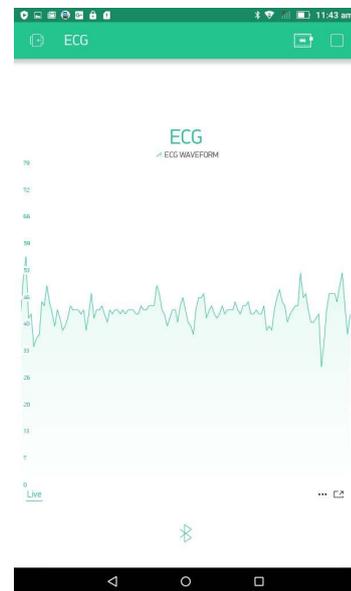

Fig. 8. ECG signals of normal beats

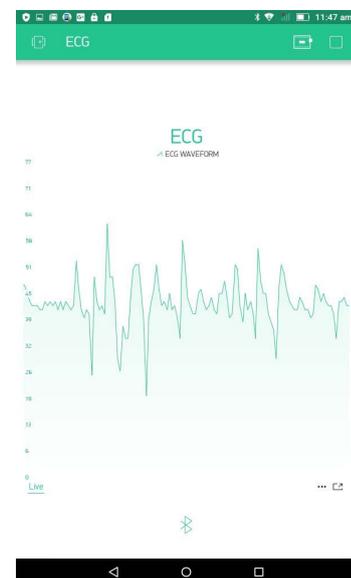Fig. 9. Abnormal ECG signals of atrial fibrillation

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Fig. 10. Abnormal ECG signals of early PVC

Fig. 11. Abnormal ECG signals of PVC R on T

Fig. 12. Temperature shows on Blynk application

Fig. 12 shows the Blynk application interface for this project to show the temperature and humidity. The arrhythmia can display on smartphone for sport's user during do their training like Atrial fibrillation, PVC early and PVC R on T.

For Blynk application, the temperature reading is set on virtual pin (V5) meanwhile, humidity is set on virtual pin (V6). The value of temperature displayed on Blynk application is set to 00○C, and humidity is set to display by percentage (%). The graph shows the increment and decrement of temperature reading (Fig. 12).

V. CONCLUSION

The prototype of a wireless ECG device is designed as portable and could be used with mobile phone, to enable ECG and temperature detector monitoring for early detection of hyperthermia and heart failure. Then, the user can monitor their body and heart condition through Bluetooth transmission on their smartphone. The wireless ECG system is suitable for sport's user to continuously monitor their body temperature and heart condition during training.
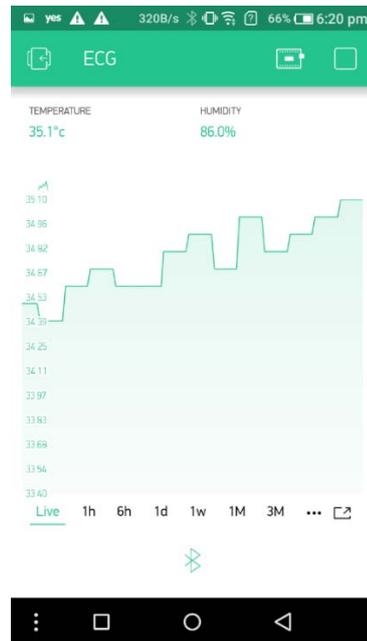
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