IMEDITEC 2017

ORIGINAL PAPER

A Wearable ECG Device using Neurosky Cardio Module

Nurul A. Abdul-Kadir [a], Fatimah S. A. Wahab [a], Noor S. Sahar [a], Fauzan K. C. Harun [a,b,*]

[a] *Faculty of Biosciences and Medical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*
[b] *Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

* *Corresponding author: fauzan@utm.my*

ABSTRACT

The purpose of this study is to design a wearable electrocardiograph (ECG) device which is to monitor the electrical activity of the heart in real time. The development of a wearable ECG device is by using Neurosky Cardio module (BMD101) and Photon Wi-Fi development kit from Particle. Photon Wi-Fi is a Wi-Fi which is integrated with a microcontroller. Both components are chosen and the circuit connection is done using Eagle software. After the fabrication process, the components are assembled onto the fabricated board, the printed circuit board (PCB), to be further testing of functionality. Finally, the acquired ECG data is processed by using BMD101, then the data is analysed using Arduino platform. After that, the signals detection is sent wirelessly to the cloud or web server using Photon Wi-Fi. This design can be used widely at home, or healthcare due to its compact size.

INTRODUCTION

According to previous studies, CVD is the first killer in many countries, including Malaysia (Lauren, 2013). The total number of deaths in Malaysia resulted from coronary heart disease in 2010, was 22,701 according to the World Health Organization (WHO) and constitutes to about 22.18% of the total deaths in the country (Lauren, 2013). CVD remains the leading cause of death in the world (Alwan 2011, Mendi et al, 2011). The statistics for the cause of death in 2011 shows CVD contributes 31 %, non-communicable diseases 33%, communicable conditions 27%, and injuries 9%. Non- communicable diseases include stroke, cancer, asthma, and more. In addition, statistics provided by an earlier study by Schiller et al, (2012), Malaysia (2010) and Caplan (2006) mentioned the deaths caused by stroke is increased yearly.

One of the ways to diagnose heart condition is by using electrocardiograph (ECG). ECG is a test that measures the electrical activity of the heart by using electrodes attached to the skin (Beckerman, 2015). This device is important to detect the heart rate and heart's rhythms as well as blood flow in the body by interpreting the ECG signal. The most important characteristic that ECG device must have is the ability to interpret signal accurately thus the physician could analyze the individual condition.

Currently, there are several technologies and designs of ECG devices which have been developed to identify heart-related problems by being more efficient and have a fast reaction. Wireless ECG device has received much attention in recent years because it is easy to be set up and to be used. It is able to capture and measure the reliable and accurate heart signals. Moreover, the 'wearable' define the ECG device to be light weight and portable, equipped with a wireless communication channel for ECG signals transmission.

However, the commercial ECG devices that have been used in the hospitals to monitor heart is not user-friendly. Most of the ECG device can only be used at the specific place such as in the hospital's treatment room, so patients who wanted to go for health examination have to go to the hospitals or other treatment centers. The ECG device is bigger with wires attached to the machine and could increase the potential of spreading infection as it is used by many patients (Korniewicz, 2008).

Thus, the aim of this study is to design a wearable wireless ECG device which is built from commercially available electronic components.

METHODOLOGY

This study is divided into several steps which is sent in Fig. 1. This study begins with components selections. To begin, two main components are the ECG module and WiFi integrated microcontroller, a system-on-a-chip (SoC) from Neurosky Cardio Module (BMD101) and Photon Wi-Fi Development Kit from Particle, respectively. The circuit layout is designed using Eagle Design software and fabricated. Then, the software development for operating the microcontroller with the ECG system is coded and the functionality of the designed circuit is determined.

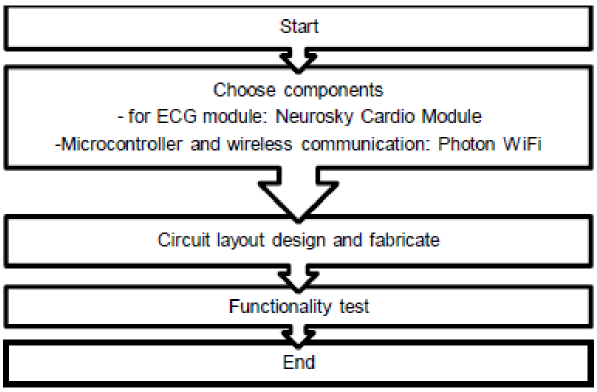

Fig. 1 Steps for this study.

NEUROSKY Cardio Module – BMD101

SoC BMD101 is NeuroSky's third generation of bio-signal detection and processing with high-performance SoC device (Neurosky, 2012), as shown in Fig. 2. BMD101 is designed with an analog front-end circuitry and a powerful digital signal processing structure. It targets bio-signal inputs ranging from uV to mV level and implemented with Neurosky proprietary algorithms. BMD101 has low system noise and programmable gain, it is designed to detect bio-

OPEN ACCESS Freely available online

eISBN 978-967-0194-93-6 FBME

signals and convert them into digital using a 16-bit high-resolution ADC.

Fig. 2 SoC BMD101 from Neurosky.

The SoC consists of an analysis and acquisition software, BMD101, and two electrodes (Wang, 2015). BMD101 is designed to be connected with Wi-Fi and a pair of electrodes. BMD101 receives analog signals from the electrodes by SEP and SEN and then transforms the analog signals into digital signals. After that, it is transmitted to the cloud or web server thru TX and RX output.

The output data from BMD101 can be read using software Terminal.exe. For the software itself, it can get data directly from TX/RX port of BMD101 using Universal Serial Bus (USB) to universal asynchronous receiver/transmitter (UART) converter connected to the software. The raw ECG data is displayed on the screen when the software is connected to the COM port of the personal computer (PC). A series of data is shown on the screen and disconnect to stop loading the ECG data. By using this technique, the output measure from BMD101 could be determined either is well functioned and able to capture data, for example by using the patient simulator connected to the input port.

PARTICLE Photon Wi-Fi development kit

Particle's Internet-of-Things (IoT) hardware development kit, is a Wi-Fi connected microcontroller, namely the Photon Wi-Fi (Particle). The development kit has a Broadcom Wi-Fi module which is shown in Fig. 3.

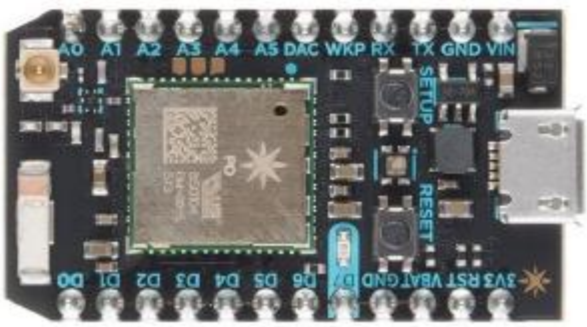

Fig. 3 Photon Wi-Fi development kit from Particle.

To minimize the required space, the Photon form factor is without header, thus allowed to surface mounted directly onto PCB design. For the Wi-Fi setting, it is not recommended using WEP Wi-Fi settings, for security reasons or enterprise network. In addition, Webhook is a simple and flexible way to send data from Particle devices to web services around the Internet. Webhook is used to save valuable information in a database, visualize data being read from a sensor, send a text message, and so much more. For this study, Webhook is used to send data via ThingSpeak to visualize the ECG data.

RESULTS AND DISCUSSION

Fig. 4 illustrates the block diagram of this study. A lithium ion battery is the power supply to the Photon and BMD101, of which it can provide up to 3.7 V for both components. Then, two electrodes are connected to BMD101 to detect the ECG signals. After that, the receiver either laptop or mobile phone are used to receive the signals via Wi-Fi communication channel and analyze them. For the Wi-Fi application created, the data is send to the cloud and the result can be displayed or viewed in any IoT platform. Results of this study are discussed as follow.

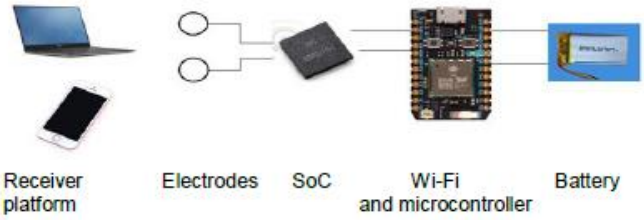

Fig. 4 Block diagram.

The device is designed to be attached to the chest of which the circuit is placed in the middle of the board (PCB). Fig. 5 shows the prototype ECG.

Fig. 5 Prototype of the ECG designed.

The electrodes are connected at both sides of the PCB. The battery is rechargeable and the electrodes can be changed or be disposed. The suitable distance for the electrodes of the bipolar leads were arranged approximately 6.0 cm diagonally, 5.2 cm vertically and 6.0 cm horizontally (Atkinson, 2013). In this study, the distance between electrodes is 6.5 cm horizontally.

Procedure for Software implementation

The microcontroller is programmed to read and convert the ECG data obtained in hexadecimal form into decimal numbers. The conversion formula is obtained from datasheet and the coding is uploaded into Arduino Integrated Development Environment (IDE).

The Photon development kit is turned on and connected to PC, and the code is uploaded into IDE of the Particle Build. Then, the Particle Apps from the Google Playstore is installed to PC or mobile phone. After that is to scan the Photon Wi-Fi device and connect it to

the Wi-Fi channel. Flash the tinker to turn on the device. After the device is in online state, the code is run in IDE of the Particle Build.

ECG signal acquisition

The patient simulator is connected to the ECG circuit. The output (Fig. 6) is send wirelessly to the web server, Webhook and the graph is displayed at ThingSpeak channel.

OPEN ACCESS Freely available online
eISBN 978-967-0194-93-6 FBME

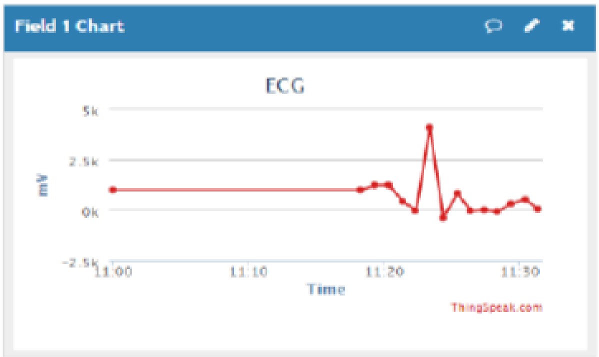

Fig. 6 The output of ECG signals using patient simulator as the input to ECG circuit.

CONCLUSION

This study has successfully designed a wearable ECG device using the ECG module and WiFi integrated microcontroller, BMD101 and Photon Wi-Fi respectively. The study consists of the hardware and software for a wireless ECG device. The device is well fabricated on a PCB. The acquired ECG signals is detected using BMD101, then the data is analysis using Arduino platform. After that, the detection of data is sent wirelessly to cloud or server using Photon Wi-Fi development kit.

ACKNOWLEDGEMENT

The authors would like to thank Ministry of Higher Education Malaysia and Universiti Teknologi Malaysia for supporting and funding this study under Research University Grant No. Q.J130000.2601.14J50 and Collaborative Research in Engineering, Science & Technology Center (CREST) for their continuous support for this research.

REFERENCES

Alwan, A. (Ed.) (2011). Global Status Report on Noncommunicable Disease 2010. Italy: World Health Organization.
Atkinson, M. P.C., James Hollinger, Chris Rennie and Brian Richter, Android Bluetooth Electrocardiogram, in University of Victoria. 2013, University of Victoria: University of Victoria.
Beckerman, J. Heart Disease, Electrocardiogram, and Specialized EKGs. 2015.
Caplan, L.R. (2006). *Stroke* 1st ed., Demos New York: American Academy of Neurology.
Korniewicz, D. M. A Disposable Wireless Electrocardiogram Monitoring System Designed to Reduce Healthcare-associated Infections. 2008.
Malaysia, Dept. of Statistics Malaysia, (2010). Statistics on Causes of Death Malaysia 2008, Malaysia.
Lauren. Heart Disease in Malaysia – No.1 Killer. 2013.
Mendi, S., Puska, P. and Norrving B. (Eds.) (2011). Global Atlas on Cardiovascular Disease Prevention and Control. Geneva: World Health Organization.
Schiller, J. S., Lucas, J. W., and Peregoy, J. A. (2012). Summary Health Statistics for U.S. Adults: National Health Interview Survey, 2011. Vital and Health Statistics, 10(256). 1–207.
Wang Tingyu, J.G., Development and application of the ECG acquisition based on BMD101, in International Conference on Electrical and Computer Engineering g (ICECE'2015) Dec. 2015: Pattaya (Thailand).
NeuroSky, BMD101 Product Brief. 2012: China.
Particle, Photon Datasheet. UK.

eISBN 978-967-0194-93-6 FBME