Sensors used to Record Electrocardiogram

Yeshaswini. V, Tejaswi. S. P, S. Hema Priyadarshini, Shaik Thahaseen, Varun Kumar

***Abstract:** Diagnosing the heart disorders is major challenge because of their short–lasting and intermittent character. The convincing technologies with non–invasive heart rate monitoring systems acquire Electrocardiogram (ECG) have limitations with reference to sensitivity. There are different types of wearable, flexible electrocardiogram sensors that can yield important information about underlying physiological parameters of human for applications related to real time monitoring of health, fitness, and wellness. Sensors with leads are all derived using three electrodes which are used to pick the electrical activity from a different position on the heart muscle. Lead-less sensors are now widely used for acquisition of ECG and related signals for heart rate monitoring which has more advantages compared to other sensors. Henceforth, various sensors are studied to understand their relation with heart rate monitoring. It is inferred that MAX30100 sensor can improve the accuracy of ECG recordings for early detection of cardiovascular diseases.*

***Keywords:** Cardiovascular diseases ECG, heart rate monitoring, MAX30100, sensors*

I. INTRODUCTION

The heart is said to be a central organ of human body in terms of its functionality. Where the oxygen and nutrients that are required to other organs and tissues of human body is provided through blood that is pumped by heart through blood vessels of circulatory system [1,2]. Electrocardiogram is a test which is done to trace the electrical activity to check the functioning of heart. The measured signal can be represented graphically using the electrodes that are connected to the body and is termed as electrocardiography. ECG signal is weak signal and cannot be used directly for further processes because of high impedance and low frequency, so it is necessary to perform signal processing before displaying the health trend [3]. Heart disease is the number one cause of death worldwide. In attempt to decrease the rate of diseases and thus, be able to help people to know their health conditions, is to predict the abnormalities in signal. So by using the current electronic healthcare services the serious complications and damage of heart can be prevented by detecting it in early stage [4]. The sensors are used to acquire the bio-signal which detect and provides the effective information or sense the environmental changes which can be transmitted to other electronic devices for further process.

Revised Manuscript Received on July 25, 2020.

Yeshaswini. V, Department of Medical Electronics, Dayananda Sagar College of Engineering, Bangalore, India.

Tejaswi. S. P, Department of Medical Electronics, Dayananda Sagar College of Engineering, Bangalore, India.

S. Hema Priyadarshini, Department of Medical Electronics, School of Bio Science and Technology, VIT University, Vellore, India.

Shaik Thahaseen, Department of Medical Electronics, Dayananda Sagar College of Engineering, Bangalore, India.

Varun Kumar, Department of Medical Electronics, Dayananda Sagar College of Engineering, Bangalore, India.

Certain criteria to choose a sensor are accuracy, sensitivity, range of measurement, calibration, resolutions, cost effective, and repeatability. The sensors used in the existing wearable devices are - Graphene based ECG sensor has excellent physical, electrochemical properties, and electrical properties. Graphene is a 2D element which is made of carbon atoms, its electrical conductivity which has increased its use in electronics, especially in sensors [5,6]. AD8232 is a single lead electrode. This sensor is cost effective and is used to measure the electrical activity of the heart (ECG). The output is in the form of an analog reading [7,8]. MAX32664 is a sensor with embedded firmware and algorithms for application in real-time wearable's [9]. MAX86140/MAX86141 are devices with completely integrated, Ultra-low-power, and an optical data acquisition system, with single optical channel and two optical readout channels on receiver side of MAX86140 and MAX86141 respectively [10]. BMD101 is Single chip solution, with high performance Bio-signal System-on-chip for accurate detection and processing [11-13]. The MAX30100 sensor is an integrated module ECG, PPG and Heart rate monitoring module used to acquire bio-signals in order to trace the electrical activity of heart [14,15]. In today's busy world where there are multispecialty hospitals, healthcares; the priorities when it comes to visiting medical consultant's changes regularly and the reason behind this may be an exponential increase in the number of patients and scarcity of specialists. Therefore along with increasing growth in population and also medical cost, has led for cutting down the price and produce compact gadgets that help determining various vital parameters. In order to overcome such problems, portable health monitoring device can assist patient by notifying the need of visiting nearby hospital [16,17].

II. DIFFERENT METHODS

A. Graphene

Graphene based ECG sensor has excellent physical, electrochemical properties, and electrical properties. Graphene is a 2D element which is made of carbon atoms, its electrical conductivity has increased its use in electronics, especially in sensors. That is the reason graphite is used in sensing technologies such as biosensor. The graphene layer is coated on the surface of Ag/AgCl ECG measurement electrode and is used for acquiring the ECG signal and measurement. The obtained result shows that the signal from graphene based electrode is better than the conventional electrodes in terms of SNR. Graphene improves coupling between ECG sensors and skin, to obtain qualitative ECG signal. It has sensitivity, detector limit and repeatability which are required for good performance and life of sensor.

Application of graphene in designing of an interfacial layer on graphene screen printed electrode develops biosensor which is of glycan, that detects analyte tumour associated antibody.

B. AD8232

AD8232 has a single lead, and it is cost effective using this heart's electrical activity can be measured. The output is an analog reading. It acts as an operational amplifier to amplify, filter and extract the small bio-signals, these are due to the movements of electrodes placed on the body. It includes automatic restoration, lead-off detection circuits to restore the signal back and it also includes instrumentation amplifier which is used to amplify the acquired ECG signal, while rejecting the noises. The sensor can be operated using any development board, generally Arduino is used. The rhythm of the heartbeat can be known by pulsation using an LED light and it has an operating voltage of -3.3V. The electrode used is of gel type to increase the conductivity between skin and electrodes.Its applications in smart heart-care system using internet of things, in which the probes are placed on the different positions like Right Arm, Left Arm and Right Leg, the sensor acquires the heart's electrical activity. In the Arduino UNO serial plotter the ECG curve is plotted ESP8266 sends the data through a webpage and doctor can access it by staying in any place. The physician is intimated immediately if any abnormalities are found in the waveform via simple mail transfer protocol, saying that the patient is having a problem. Now the patient's conditions can be improved by physician logging through the webpage and can see the ECG graph of the patient.

C. C.Max32664

It is a sensor which has embedded firmware and algorithms that is applicable in wearable's that enables customer-desired sensor functionality. It includes communicating with maxim's optical sensor solutions and biometric sensor enables delivering raw or processed data to users.The basic peripheral mix optimizes size and performance. The device has different versions which are interfaced with the Microcontroller host using a fast-mode one slave I2C, to give the field updates, access to raw and processed data acquired from sensor. One master mode I2C interfacing is used for communication with sensor for version A. The MAX32664 version A, C, and D supports the high-sensitivity pulse-oximetry and the heart rate sensor that can be applied in wearables for finger-based applications. One master mode SPI interfacing is used for communication with sensor for version B that supports wrist-band applications. These can also be used for portable medical and mobile devices. The sampling of the sensors is derived from the 32.768 kHz real-time clock. The sampling rate is user-configurable in order to minimize power consumption.The non-invasive measurement of blood oxygenation is done by pulse oximetry method using MAX32664. There are two types of pulse oximetry measurement – transmissive pulse oximetry and reflective pulse oximetry. SpO2 measurement solution uses reflective pulse oximetry method. The sensor gives FDA-grade SpO2 measurement for both finger and wrist. It also has an algorithm that outputs R values, along with reference SpO2 values it is easy to find the calibration coefficient. By recording PPG's (photoplethysmography) the effort to obtain R can be reduced.

D. Max86140/Max86141

These are devices with completely integrated, ultra-low-power, and optical data acquisition systems. MAX86141/MAX86141 has three programmable high current LED drivers on the transmitter side, and on its receiver side device MAX86140 has single optical readout channels, and MAX86141 has two optical readout channels. It has an industry-lead ambient light cancellation circuit and built-in replaceable algorithms. It operates on 1.8V main supply voltage and 3.1 ~ 5.5V supply voltage to drive LED.

It has well optimized architecture for reflective and transmissive oxygen saturation or heart rate monitoring. It is also designed with low dark current noise of < 50pA RMS, and high resolution with 19-bit charge integrated ADC, with three low noise, 8-bit LED current DACs, dynamic range greater than 90dB and ultra-low-power operation. Compact size 2.048 X 1.848mm, and -40 to + 85 degree Celsius operating range. The devices can be used for wide variety of applications such as, wearable devices designed for fitness, wellness of an individual and the Medical equipments. It has better performance for finger, wrist, and other locations in human body to detect the optical heart rate, SpO2, and the muscle oxygen saturation. MAX86140 and MAX86141 enable a healthier world via a personalized healthcare, where maxim's has introduced wrist based device as a solution to overcome the challenges. This wearable application can be used to continuously measure the heart rate, ECG signal, PPG, and body temperature. The contact of skin and the metal part of watch measures small voltage which gives ECG reading. The collected data can be stored on a platform that is made for patient evaluation or sent to PC for high-level extraction of data. User using the device by tapping on the file can access to the measured data. It is also stored in cloud to develop the new cloud-based 'Big data', and artificial intelligence (AI) that perform analysis, which uncovers the health trend.

E. Bmd101

The NeuroSky's technology platform enables the bio-metrics at forefront and delivers accurate metrics which will not require any medical diagnosis or regulatory approval. It has high performance bio-signal System-on-chip (SoC), also includes the analog signal detection and processing, with low-noise-amplifier (LNA), anti-alias filtering, high resolution ADC (16 bits), low input referred noise and automatic sensor-off detection which is fully integrated high pass filter. The digital signal processing with accurate heart beat detection and real time heart rate computation, notch filter with at least -60 dB rejection for 50 Hz and 60 Hz power supply noise with the built-in low pass filter with stable band pass filter ranging.

Retrieval Number: B4155079220/2020©BEIESP
DOI:10.35940/ijrte.B4155.079220

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication

It enables easy-to-use interface which has an UART with 64 Byte TX FIFO with external modules, and also supported to use SDK on iOS, android and window platforms with several ready algorithms for rapid product development and customization. It uses a single external power supply and has built-in regulator with low operating current.

It can be used in wireless low–powered wearable ECG monitor system based on BMD101 chip and also uses CC2640R2R Bluetooth LE MCU. The wearable device ECG monitoring system that is designed includes three parts, which are as follows, ECG monitoring, mobile phone and cloud server. Firstly ECG signals are collected, the raw data is processed and digitized using BMD101 sensor, which acts as a front–end in the proposed ECG monitoring device, then the digital outputs in a the form of packets are sent to CC2640R2R using UART, and also to nearby users phone to display the ECG signal. The cloud server is used to store the user's ECG data, supply the data to cardiologist, and send the cardiologists advice and suggestions to user's phone. The software design includes how to resolve a digital output packet collected using hardware part and communicate with mobile phones of user.

F. Max30100

MAX30100 is an integrated module which can acquire the bio-signals, hence it can be used to trace Pulse oximetry and Heart rate monitoring. Due to its compact size, LEDs to indicate the on/off status, a photodetector, advanced optics, and also low-noise analog signal processing. It also includes photo-sensor, integrated ambient light cancellation, long battery life, high performing analog front end, high SNR, high sampling rate capacity, and fast data outputting capability. The power supply from 1.8V and 3.3V. The device that can measure SpO2 in percentage and heart rate in BPM is developed using MAX30100 interfaced with Arduino. The data collected is sent using Bluetooth module which is operated in a slave mood to OLED screen to display the measurements. This data is also sent to android application and monitor on the application developed wirelessly to keep the track of the data recorded. It can be used by athletes to know the SpO2 and heart rate levels during workout.

III. CONCLUSION

From the study of the above sensors we can infer that the use of lead sensors to acquire a signal is not suitable in case of wearable or portable medical devices. A wearable device design can be achieved using leadless dry electrode sensor method. Bio-sensors can be used to acquire the electrical activity of heart and processed to detect the abnormalities in order to prevent the serious complications. The sensor MAX30100 can be used to acquire data. It has LEDs, a photodetector, advanced optics, with low-noise analog signal processing, photo-sensor, and high performing analog front end. It is operated by power supply ranging from 1.8V to 3.3V and can it be powered down using software with negligible standby current. Miniature size 5.6mm X 2.8mm with optically enhanced system-in-package which has 14 pins. For achieving long battery life ultra-low-power is used and it is applicable for wearable devices which power savings and low shutdown power. It also has high SNR, integrated ambient light cancellation, high sample rate capacity, fast data output capability. Applicable in wearable devices, fitness assistant device, and medical monitoring devices. The sensed raw data is acquired and continuously transmitted to decision-making-subsystem for further processes, which will amplify and filter the data. Later the processed and analyzed data is stored in the cloud. The stored data is compared with the referral ECG waveform, if any abnormalities are detected then using web applications users are intimated by alarm subsystem integrated with the hardware.

REFERENCES

1. Muhammad E. H. Chowdhury, Khawla Alzoubi, Amith Khandakar, Ridab Khallifa, Rayaan Abouhasera, Sirine Koubaa, Rashid Ahmed, and Anwarul Hasan. "Wearable Real-Time Heart Attack Detection and Warning System to Reduce Road Accidents". Received 2019 April 12; Accepted 2019 June 10.
2. Hemanth Kapu, Kavisha Saraswat, Yusuf Ozturk, A. Enis Cetin. "Resting heart rate estimation using PIR sensors". Infrared Physics and Technology, vol. 85, pp. 56-61, 15 May 2017.
3. Zeli Gao, Jie Wu, Jianli Zhou, Wei Jiang. "Design of ECG signal acquisition and processing system". School of Basic Medical Sciences, Kunming Medical University Kunming, China. 2012 international Conference on Biomedical Engineering and Biotechnology.
4. Fatma Patlar Akbulut. "e-Vital: A Wrist-Worn Wearable Sensor Device for Measuring Vital Parameters". IEEE, 2019.
5. Haizhou Huang, Shi Su, Nan Wu, Hao Wan, Shu Wan,Heng chang Bi, and Litao Sun."Graphene-Based Sensors for Human Health Monitoring". Nanoscience, a section of the journal Frontiers in Chemistry, June 2019, Volume 7, pp. 1-26, Article 399.
6. Filip Kveton, Anna Blsakova, Lenka Lorencova, Monika Je rigova, Dusan Velic, Ola Blixt, Bo Jansson, Peter Kasak, and Jan Tkac. "A Graphene-Based Glycan Biosensor for Electrochemical Label-Free Detection of a Tumor-Associated Antibody". 10 October 2019; Accepted: 2 December 2019; Published: 9 December 2019.
7. Ayaskanta Mishra, Assistant Professor. Biswarup Chakraborty, Debajyoti Das, Priyankar Bose. "AD8232 based Smart Healthcare System using Internet of Things (IoT)". UG students, School of Electronics Engineering, KIIT Deemed University, Bhubaneswar, Odisha, India. Vol. 7 Issue 04, pp. 13-16, April-2018.
8. Miguel Bravo-Zanoguera, Juan Pablo García-Vázquez. "Portable ECG System Design using the AD8232 Microchip and Open-source Platform". DOI:10.3390/ecsa-6-06584, pp. 42-49. November 2019.
9. Maxim unveils wrist-worn platform for monitoring ECG, Heart Rate, Temperature. 26, 2018.
10. Maurizio Di Paolo Emilio. "A Cuffless Blood-Pressure Measurement Solution". 11.21.2019.
11. Jeremy Cowan. "Change is coming to 'stagnant' wearables market as heart rate sensors claim accurate monitoring". December 6, 2017.
12. Zhendong Ai, Lijuan Zheng, Hongsheng Qi, Wei Cui1. "Low-Power Wireless Wearable ECG Monitoring System Based on BMD101". School of Automation Science and Engineering, South China University of Technology, Guangzhou 510641, P. R. China 2. Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing 100190, P. R. China. July 25 -27, 2018, Wuhan, China.
13. Hyun-Soo Choi, Byunghan Lee, And Sungroh Yoon. "Biometric Authentication Using Noisy Electrocardiograms Acquired by Mobile Sensors". Date of publication March 30, 2016, date of current version April 12, VOLUME 4, pp. 1266-1273, IEEE 2016.

14. Qunoot N. Alsahi, Ali F. Marhoon. "Design Health care system using Raspberry Pi and ESP32". International Journal of Computer Applications (0975 – 8887), Volume 177 – No. 36, pp. 33-39, February 2020.
15. Jiaxi Wan, Yuhua Zou, Ye Li, Jun Wang. "Reflective type blood oxygen saturation detection system based on MAX30100". 2017 International Conference on Security, Pattern Analysis, and Cybernetics (SPAC). pp. 615-619. 2017 IEEE.
16. SHREE RAKSHA M P, NANDINI B M. "Remote Monitoring of the Patients using the IoT Widget through Hrut Gati Android Application". International Research Journal of Engineering and Technology (IRJET). Volume: 07 Issue: 05, pp. 865-869, May 2020.
17. Dipika Vasava, Shripad Deshpande. "Portable Health Monitoring Device". International Journal of Engineering Research and General Science Volume 4, Issue 3, pp. 807-812, May-June, 2016.

AUTHORS PROFILE

Yeshaswini V, Final year student in Bachelor of Engineering of Medical Electronics Department from Dayananda Sagar College of Engineering, Bangalore, Karnataka, India.

Tejaswi S P, Final year student in Bachelor of Engineering of Medical Electronics Department from Dayananda Sagar College of Engineering, Bangalore, Karnataka, India.

Shaik Thahaseen, Final year student in Bachelor of Engineering of Medical Electronics Department from Dayananda Sagar College of Engineering, Bangalore, Karnataka, India.

Varun Kumar, Final year student in Bachelor of Engineering of Medical Electronics Department from Dayananda Sagar College of Engineering, Bangalore, Karnataka, India.

S. Hema Priyadarshini, She has completed her B.E. degree in Medical Electronics and Master's degree in Biomedical Signal Processing and Instrumentation from Visvesvaraya Technological University, Karnataka. She is pursuing her Ph.D. from VIT University, Vellore. She is currently working as an Assistant Professor in the Department of Medical Electronics, Dayananda Sagar College of Engineering, Bangalore, Karnataka, India for 10 years. Her research interests are biomedical signal processing and instrumentation.