Electrocardiogram (ECG) Application for Checking Heart Conditions Based on Android

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Abstract— **Based on Indonesia Health Research Data globally the number one cause of death is caused by cardiovascular diseases, namely heart and blood vessel function disorders such as Coronary Heart Disease, Heart Failure or Heart Disease, Hypertension and Stroke. In 2008 it was estimated that 17.3 million deaths were caused by cardiovascular disease, and more than 3 million of these deaths occurred before the age of 60 years where this age could have been prevented. With the advancement in technology, it is now needed tools/applications that can monitor heart conditions at any time and any time to prevent deaths caused by sudden heart attacks. The research method used is the QRS approach and use AD8232 to get ECG data. Where to prove the results of the research conducted are appropriate or not by comparing the real ECG data in the hospital with ECG data obtained from the results of the study. The results of testing the data collected in this study can be said that the data in the application built is almost matched with the data obtained from the test results using hospital tools, with a data matching percentage of 96% for QRS interval and 90% for RR interval.**

Index Terms— **ECG, AD8232, QRS Interval, RR Interval.**

I. INTRODUCTION

An ECG (Electrocardiogram) is a test performed to see electrical activity in a person's heart, usually the result of an ECG on an ECG paper or on a screen that describes a line in the form of heart activity [1]. The ECG analyzing machine, such as monitoring patients for stress testing systems, and Holter analysis systems, is used to detect heart rate and classify arrhythmias [2]. ECG waves consist of 5 different wave components, namely P, Q, R, S, and T [3].

Based on the 2013 Basic Health research data, the Indonesian Ministry of Health's Research and Development Agency and Target Population Data, Pusdatin. The number of the prevalence of coronary heart disease in Indonesia in 2013 at the age of 15 years was 0.5% or estimated at around 883,447 people, while based on a doctor or symptom diagnosis of 1.5% or an estimated 2,650,340 people [4].

Currently, ECG monitoring tools available today can be said very expensive with limited availability and accessibility. With the existence of mobile health technology, we can build ECG tools that able to monitoring and analyzing ECG with an affordable price and easy to get [5]. Besides that, with equipment that is not portable, the activity of people with heart disease is limited when going to do an ECG test because they often have to go to the hospital if they are going to do a test [6].

AD8232 is a chip that can be used to measure heart electrical activity that works on 3.3 volts, the sensor of AD8232 ECG sends a signal to Arduino [7]. AD8232 sends data to Arduino for further processing on smartphones. Thus, the application to be built in this study is expected to provide data on information about the initial diagnosis of the ECG so that users can find out information about the condition of their heart.

II. LITERATURE REVIEW

A. Electrocardiography (ECG)

Electrocardiography (ECG) is a device used to record biological signals formed as a result of the electrical activity of the heart. This signal is obtained by attaching the electrode to a certain point on the patient's body. ECG recordings have a specific shape so that it can be used as a reference to determine the condition of one's heart health by a cardiologist. ECG signals have a voltage of up to 0.3mV and a frequency range between 0.03 - 100 Hz. This signal is detected and recorded using an electrocardiography device. The ECG consists of many waves, each wave representing one heartbeat (one time the electrical activity of the heart) [8]. ECG waves can be seen in fig 1.
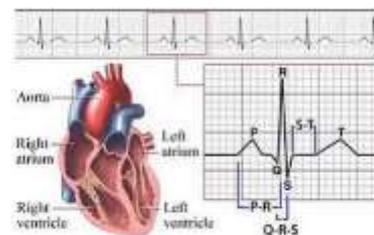

Fig. 1. ECG Waves

An ECG is performed by attaching the electrode (receiver of the heart's electrical impulse) at several

predetermined locations. After that, information about the state of the heart can be known through the resulting graph pattern [9].

The primary function of the electrode is to detect the heart's electrical signals. In other words, as a transducer to convert biological information into measurable electrical signals. This transducer is used using the jelly electrode-electrolyte interface. Using Ag / AgCl electrodes reduces noise with low frequency on ECG signals that occur due to movement [10]. Electrode pad can be seen in Fig 2.

Fig 2. Electrode Pad

The placement of an electrode pad on the body can be seen in Fig. **3**.
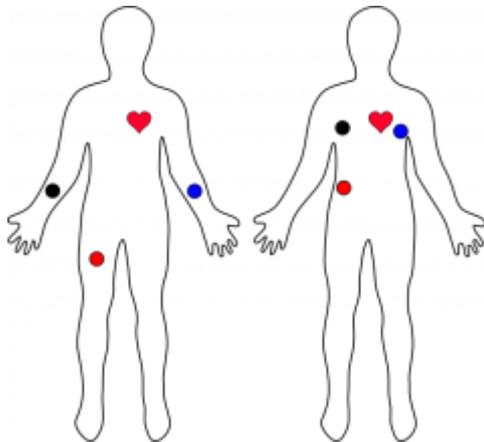
Fig. 3. Placement of an electrode pad

Explanation of colors from fig 3 can be seen in table 1 below.

TABLE 1. TABLE OF ECG ELECTRODE PAD

Cable Color	Signal
Black	RA (Right Arm)
Blue	LA (Left Arm)
Red	RL (Right Leg)

B. AD8232

AD8232 is a module used to obtain data obtained from electrodes that come into contact with the human body [11]. AD8232 has 9 pins LO +, LO, Output, 3.3v, GND, RA, LA, RL [12]. From the data, it is then processed on Arduino to produce an ECG graph like in Fig. **4**.

Fig. 4. Signal Output at Arduino Serial Plotter

From the signal data analysis can be performed on QRS waves obtained by RL [12]. QRS waves can be seen in fig 5.
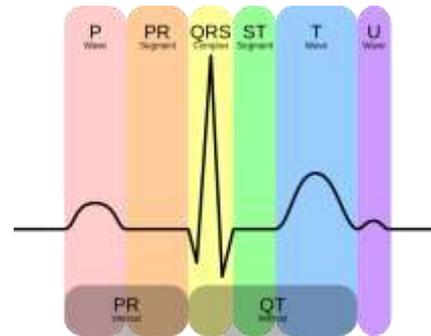

Fig. 5. QRS waves

C. Android

Android is a Linux kernel based operating system developed by Google and used for mobile devices. Android allows developers to create programming using the Java language, can also control devices through Java libraries that have been developed by Google. The first step in developing android applications, developers make apps using the Java language, then the apps are downloaded through third-party sites or online application stores [13]. There have been many uses of Android in various fields, starting from education [14] [15], health [16] [17], and social [18] [19].

D. Internet of Things

Within a few years, the Internet of Things (IoT) received significant attention in research. IoT becomes part of the future of the internet which will consist of billions of intelligent "objects" communication [20]. IoT allows physical objects to see, hear, think and do work by asking them to "talk" together. IoT transforms these traditional objects into smart by exploiting the underlying technology [21]. There have been many uses of the Internet of Thing in various fields, ranging from education [22] [23], health [24] [25], and social [26] [27].

III. RESEARCH METHODOLOGY

Research methodology in computer science/information systems/information technology is "steps/stages of planning with the help of several methods, techniques, tools, and documentation with the aim of helping researchers to minimize the risk of failure and emphasize research processes/objectives in the field CS / IS / IT." The research flow steps carried out in this study can be seen in
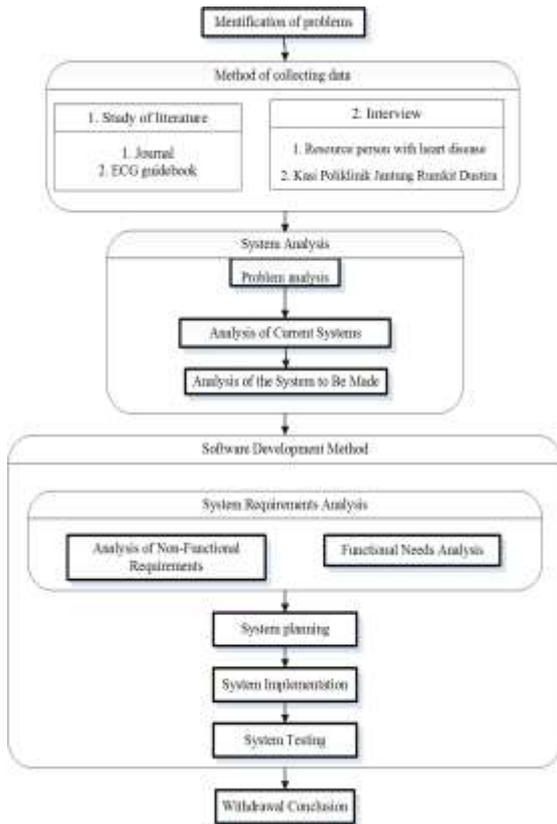
Fig. 6.
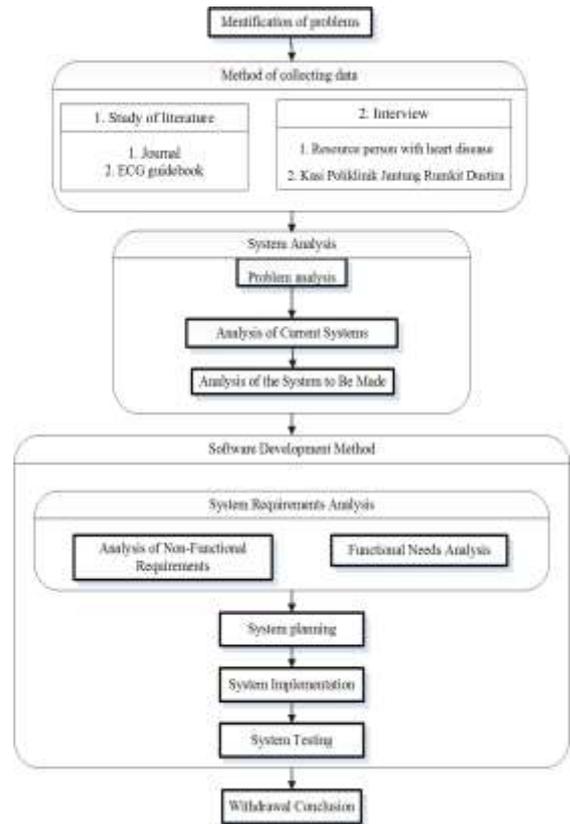
Fig. 6. Research Methodology

IV. RESULT AND DISCUSSION

At this stage consists of the steps of research carried out. These stages include analysis and system design, analysis of the technology used.

A. System Analysis and Design

The system to be built is an electrocardiogram (ECG) application for checking mobile heart-based conditions. The architecture of the system to be developed is as shown in Fig. 7 below :
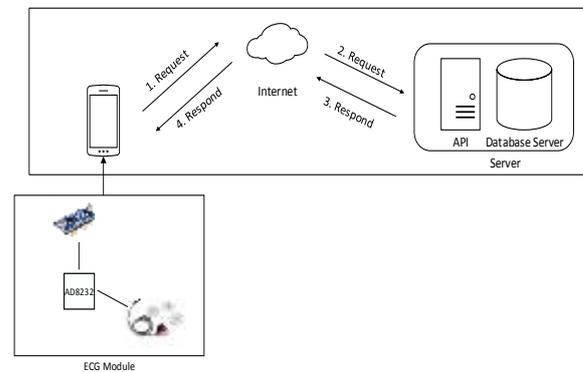
Fig. 7. System Architecture

1. First, the User requests the device to do ECG detection where the previous method has been connected to the ECG Module to get analog data from the module, then it is processed to obtain the ECG graph data along with the graph analysis is healthy or not and the data is sent to the Server via the Internet.

2. Request on the server to save data to the server.

3. The response from the server is in the form of message data successfully saved.

4. Message response data is successfully stored on the server.

B. ECG Sensor Analysis at AD8232

AD8232 functions to get serial data from the electrode sensor pad that is attached to the body. Then the data will be processed by Arduino. The data transferred from Arduino will be transferred to the smartphone device to analyze the ECG signal data obtained, then the data is stored on a server.

At AD8232 9 pins can be used, namely; LO +, LO-, Output, 3.3v, GND, RA, LA, RL. While the pin used is only 5 pins LO +, LO-, Output, 3.3v, GND. As in Fig. 8.
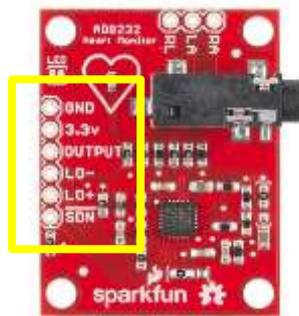
Fig. 8. Pin label on AD8232

TABLE 2. AD8232 PIN CONNECTION TO ARDUINO

| Pin label	Function	Arduino pin connection
GND	Ground	**GND**
3.3v	3.3v Power Supply	**3.3v**
Output	Output Signal	**A0**
LO-	Leads-off -	**11**
LO+	Leads-off +	**10**
SDN	Shutdown	Not used
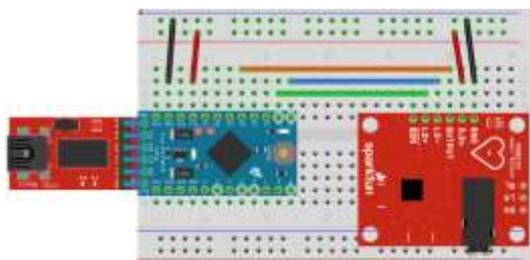
Fig. 9. AD8232 pins connection to Arduino

To get a data signal from AD8232, it is generated using the following syntax.

```
1   Void setup()
2   {
3       Serial.begin(9600) ;
4       pinMode(10, INPUT);
5       pinMode(11, INPUT);
6   }
7   void loop() {
8
```

```
9
10  if((digital.Read(10)==1)||(digitalRead(1
11  1)==1)){
12          Serial.println("Failed");
13      }
14      else{
15
16  Serial.println(analogRead(A0));
17      }
18      delay(10);
19  }
```

Fig. 10. Syntax of sensor data retrieval

After the data is processed from Arduino, the data will be sent to an Android device and then analyzed and compared to the standard ECG parameters. Normal ECG parameters can be seen in TABLE 3. Normal ECG Parameters below.

TABLE 3. NORMAL ECG PARAMETERS

ECG Wave	Amplitudo	ECG Interval	Duration
P	<0.3 mV	P-R	0.12-0.20 sec
R	1.6 – 3 mV	Q-T	0.35-0.44 sec
Q	25% from R	S-T	0.05-0.15 sec
T	0.1 – 0.5 mV	Q-R-S	0.08 – 0.10 sec

C. Use Case Diagram of Android Mobile Applications

The use case diagram of the mobile application built consists of six functional, i.e., see the latest conditions, see history, see forecasting, get data, calculate prediction and add data while the actors involved are the microcontroller and user as can be seen in Fig. 11.
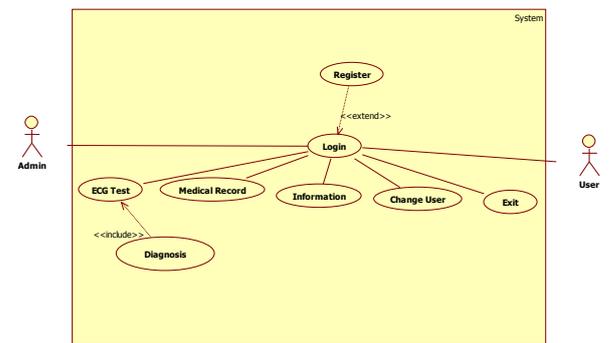
Fig. 11. Application Use Case Diagram

D. System Implementation

System implementation is the system design stage based on the results of the analysis into a particular programming language and the application of the system to be built in the real environment. The discussion of system implementation consists of hardware implementation, software implementation.

D.1. Hardware Implementation

The hardware implemented in the Electrocardiogram (ECG) Application for checking mobile-based heart conditions is a hardware

requirement determined at the previous analysis stage. There are hardware devices that are implemented in TABLE 4. Hardware Implementation below:

TABLE 4. HARDWARE IMPLEMENTATION

Server		
No	Hardware	Specification
1.	vCPU	4 core
2.	RAM	4GB
3.	Harddisk	SSD 70GB
User		
No.	Hardware	Specification
1.	Monitor	1080x1920p
2.	Processor	Octa-core 2Ghz
3.	Memory	4GB RAM & 64GB ROM
4.	Network	4G
5.	Arduino	Nano
6.	Electrode Pad	3 pieces
7.	ECG Module	AD8232

For the shape of the final result of the tool can be seen in Fig. 12 below.
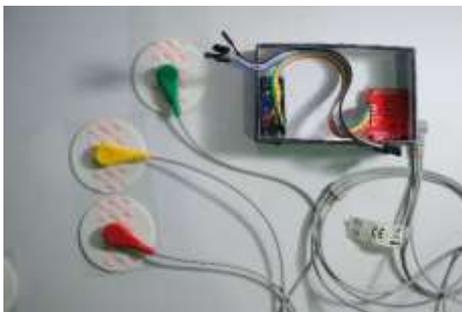
Fig. 12. Tool Implementation

D.2. *Software Implementation*

The software needed to implement the Electrocardiogram (ECG) Application for checking mobile-based heart conditions can be seen in TABLE 5. Software Implementation below.

TABLE 5. SOFTWARE IMPLEMENTATION

D.3. *Implementation of the ECG tool used in RS. Dustira*

ECG tool used in RS. Dustira as a comparison of test data that is using 12 lead leads that can be seen in Figure 13.

Figure 13 ECG tools in RS. Dustira

D.4 *Application Implementation*

An electrocardiogram (ECG) application for checking heart-based mobile conditions requires an installation process on an Android device. Users must have an application installed on the smartphone device. For the results of the implementation of the display on the Android application can be seen in Fig. 14.

Server		
No.	Software	Specification
1.	Web Browser	Mozilla Firefox, Google Chrome, Opera, Microsoft Edge
User		
No.	Software	Specification
1.	Operating System	Android Nougat 7.0

Fig. 14. Android interface

The interface for the ECG test is shown in the upper leftmost figure. On this page, there is an ECG graph along with interval values on ECG wave parameters. The diagnostic page is displayed by the top right Figure, where on this page there is an initial diagnosis of the ECG results obtained along with the QRS interval value and Heart Beat whereas the medical record page is in the leftmost bottom figure. This page displays medic record data stored in the database. Also the information page is in the lower right picture. This page shows information on application usage and installation of sensor devices on the body.

E. *Testing of Medical Record Data*

At this stage a medical record data obtained from the test results using an ECG device in RS. Dustira Cimahi will be tested and compared with the results of the medical record of the ECG obtained from the results of the ECG test using a built-in tool. In this test, the data compared came from 3 sources, namely data from M Yasin Tahir, Mrs. Sri Cahyani and Fauzan Ahmad.

1. ECG M Yasin Tahir data uses ECG RS.Dustira Cimahi tool

Fig. 15. The results of the medical record M Yasin Tahir using a tool in the RS.Dustira Cimahi

In Fig. **15** the QRS interval can be calculated by calculating the number of small boxes from point Q to point S. The value of 1 small box is 0.04 seconds or 40ms.

Fig. 16. QRS M Yasin Tahir uses the ECG RS.Dustira Cimahi tool

In Fig. **16** we can see that from point Q to point S there is one small full box and half a little box that is worth 0.04 seconds and 0.02 seconds resulting in a QRS value of $0.04 + 0.02 = 0.06$ seconds or 60ms. Next we will calculate the RR interval / Heart Beat, there are 2 ways first to estimate the number of R waves in 6 seconds (30 large boxes) then multiply by 10 or the second method 300 divided by the number of large boxes between 2 waves R. In this test will be used the first way is to count the number of R waves in 6 seconds (30 large boxes) then multiply by 10.

Fig. 17. RR interval / Heart Beat M Yasin Using ECG RS.Dustira Cimahi tool

In Fig. 17 it can be seen that the R wave obtained using an ECG device in the hospital. Dustira Cimahi as many as nine waves, which means if multiplied by 10 RR intervals / Heart Beat is 90ms.

2. ECG data M Yasin Tahir uses an application that was built

Fig. 18. Medical Record Data M Yasin Tahir uses an application that was built

In Fig. 18 we can see the results of the calculation of the QRS interval obtained are 61ms and 75ms RR / Heart Beat interval.

3. ECG data Ms. Sri Cahyani uses ECG RS.Dustira Cimahi tool

Fig. 19. The results of the medical record of Ibu Sri Cahyani used a tool in the RS. Dustira Cimahi

In Fig. **19** QRS interval can be calculated by calculating the number of small boxes from point Q to point S. The value of 1 small box is 0.04 seconds or 40ms.

Fig. 20. QRS Mrs. Sri Cahyani uses ECG RS.Dustira Cimahi tool

In Fig. **20** we can see that from point Q to point S there is one small full box and half a little box that is worth 0.04 seconds and 0.02 seconds resulting in a QRS value of 0.04 + 0.02 = 0.06 seconds or 60ms. Next we will calculate the RR interval / Heart Beat, there are 2 ways first to estimate the number of R waves in 6 seconds (30 large boxes) then multiply by 10 or the second method 300 divided by the number of large boxes between 2 waves R. In this test will be used the first way is to count the number of R waves in 6 seconds (30 large boxes) then multiply by 10.

Fig. 21. RR interval / Heart Beat Mrs. Sri Cahyani Using ECG RS.Dustira Cimahi tool

In Fig. **21** it can be seen that the R wave obtained using an ECG device in the hospital. Dustira Cimahi as many as 8 waves, which means if multiplied by 10 RR intervals / Heart Beat is 80ms.

4. ECG Data Ms. Sri Cahyani uses an application that was built

Fig. 22. Medical Record Data Ms. Sri Cahyani uses an application that was built

In Fig. **22** we can see that the results of the QRS interval calculation obtained are 58ms and the RR interval / Heart Beat is 78ms.

5. Fauzan Ahmad's ECG data uses ECG RS.Dustira Cimahi tool

Fig. 23. The results of Fauzan Ahmad's medical record using a tool in the RS. Dustira Cimahi

In Fig. **23** QRS interval can be calculated by calculating the number of small boxes from point Q to point S. The value of 1 small box is 0.04 seconds or 40ms.
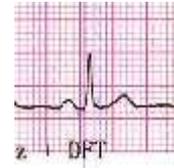

Fig. 24. QRS Fauzan Ahmad uses ECG RS.Dustira Cimahi tool

In Fig. **24** we can see that from point Q to point S there is one small full box and two little half boxes which are 0.04 seconds and 0.02 seconds, resulting in a QRS value of 0.04 + 0.02 + 0.02 = 0.08 seconds or 80ms. Next we will calculate the RR interval / Heart Beat, there are 2 ways first to estimate the number of R waves in 6 seconds (30 large boxes) then multiply by 10 or the second method 300 divided by the number of large boxes between 2 waves R. In this test will be used the first way is to count the number of R waves in 6 seconds (30 large boxes) then multiply by 10.

Fig. 25. RR interval / Heart Beat Fauzan Ahmad Using ECG RS.Dustira Cimahi tool

In Fig. **25** it can be seen that the R wave obtained using an ECG device in the RS. Dustira Cimahi as many as nine waves, which means if multiplied by 10 RR intervals / Heart Beat is 90ms.

6. Fauzan Ahmad's ECG data uses an application that was built

Fig. 26. Fauzan Ahmad medical record data uses an application was built

In Fig. **26** we can see the results of the QRS interval calculation obtained are 76ms and 99ms RR / Heart Beat interval.

From the results of testing the medical record data using an ECG device located in the RS. Dustira Cimahi and the ECG device that was built was obtained data as in TABLE 6. Results of ECG Medical Record below:

TABLE 6. RESULTS OF ECG MEDICAL RECORD

Tools used	Source Name	QRS Inter-val	% match QRS Interval	RR Inter-val	% match RR interval
ECG Tools RS. Dustira	M Yasin Tahir	60ms	98%	90ms	83%
ECG application that was built	M Yasin Tahir	61ms		75ms	
ECG Tools RS. Dustira	Ibu Sri Cahyani	60ms	96%	80ms	97%
ECG application that was built	Ibu Sri Cahyani	58ms		78ms	
ECG Tools RS. Dustira	Fauzan Ahmad	80ms	95%	90	90%
ECG application that was built	Fauzan Ahmad	76ms		99	

In TABLE 6. Results of ECG Medical Record it can be concluded that the results of the ECG test on the application that was built are matched with the tools used in the RS. Dustira Cimahi, where the% value of the compatibility of the QRS interval obtained if average is 96% and the% match for the RR interval obtained if average is 90%. The difference in test results obtained is biased because of differences in the test equipment used. Where is the test equipment used in the RS. Dustira uses an ECG tool with 12 leads and the test equipment used in the application uses three leads which cause the difference in data obtained is not significant, namely 4% difference in QRS Interval and 10% difference in RR Interval.

Furthermore, the ECG graph was tested with M Yasin Tahir as a source through testing, which was displayed in the condition of lying down, sitting and standing. The results of the tests can be seen in Fig. **27**.

Lie down

Sit down

Stand up
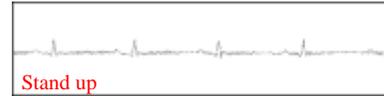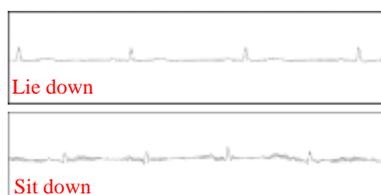
Fig. 27. ECG Signal Testing Results

From the data obtained results as can be seen in TABLE 7. Results Comparison of ECG Charts below.

TABLE 7. RESULTS COMPARISON OF ECG CHARTS

Test Position	QRS Interval	RR Interval
Lie Down	63	68
Sit Down	84	148
Stand Up	86	115

From the data in TABLE 7. Results Comparison of ECG Charts , it can be concluded that when testing the sitting and standing positions it dramatically affects the results of the ECG obtained. This is due to the noise that appears more often when during a test with a sitting and standing position.

V. CONCLUSION

The conclusion of the research that has been done is that the application built can help users to do ECG testing without having to come directly to the hospital. The percentage of QRS intervals and RR Intervals has good values. However, these results still use limited testing. Future research will be more focused on increasing the accuracy of the test results carried out by further increasing the testing of many users who are the object of research..

REFERENCES

[1] M. S. Thaler, MD, Satu-satunya Buku EKG Yang Anda Perlukan (Edisi 7), EGC, 2016.

[2] P. Hamilton, "Open Source ECG Analysis," *Comput Cardiol,* no. 29, pp. 101-104, 2002.

[3] A. T. Astuti, N. and A. Lestari, "Pembuatan Elektrokardiogram dan Penentuan Interval QRS Secara Otomatis," *Jurnal Fisika Dan Aplikasinya,* vol. 13, no. 1, pp. 6-9, 2017.

[4] I. Datin, "Situasi Kesehatan Jantung," pp. 1-8, 2014.

[5] S. S. Sylvester, E. L. M Su, C. F. Yeong and F. K. Che Harun, "Miniaturized and Wearable Electrocardiogram (ECG) Device with Wireless Transmission," *Journal of Telecommunication, Electronic and Computer Engineering,* vol. 9, no. 3-9.

[6] Y. Zhe, Z. Qihao, L. Lei, Z. Kan and X. Wei, "An IoT-cloud Based Wearbale ECG Monitoring System for Smart Healthcare," *Mobile & Wireless Health,* 2016.

[7] "AD8232 Data Sheet," in *Analog Device.*

[8] R. Rickards and D. F. Chapman, Anatomy and Physiology: The Respiratory System and the Cardiovascular System, Churchill Livingstone, 1997.

[9] I. Prasojo and S. Kusumadewi, "Diagnosis EKG dengan Sistem Pakar menggunakan K-NN," *Seminar Nasional Informatika Medis (SNIMed),* 2013.

[10] Ir. Sudjadi, MT., I. A. D. Warsito and E. S. Nugroho, "Pengenalan Pola Sinyal Elektrokardiograf (EKG) dengan Jaringan Syaraf Tiruan Backpopagation untuk Diagnosa Kelainan Jantung Manusia".

[11] X. Ji, C. Ning, C. Zhao and X. Zhang, "Design of The HRV Analysis System Based on AD8232," *3rd International Symposium on Mechatronics and Industrial Informatics,* 2017.

[12] M. C. Manik Kalsi, "Real Time ECG Monitoring System Based on Internert Of Things (IOT)," *International Journal of Scientific and Research Publications,* vol. 7, no. 8, 2017.

[13] S. Bhardwaj, P. Chouhan, R. Sharma and P. Sharma, "Android Operating Systems," *International Journal Of Engineering Technology & Management Research,* vol. 5, no. 1, 2015.

[14] P. Pocatilu, "Developing Mobile Learning Application for Android using Web Services," *Informatica Economica,* vol. 10, no. 3, 2010.

[15] H. A. Al Rekhawi and S. S. Abu Naser, "An Intelligent Tutoring System for Learning Android," *International Journal of Engineering and Information System,* vol. 2, no. 1, pp. 1-14, 2018.

[16] E. B. Setiawan and R. Herdianto, "Penggunaan Smartphone Android sebagai Alat Analisis Kebutuhan Kandungan Nitrogen pada Tanaman Padi," *JNTETI,* vol. 7, no. 3, pp. 273-280, 2018.

[17] C. Liu, H. Sun, N. Du, S. Tan, H. Fei, W. Fan, T. Yang, H. Wu, Y. Li and C. Zhang, "Augmented LSTM Framework to Construct Medical Self-Diagnosis Android," *IEEE 16th International Conference on Data Mining,* 2016.

[18] E. B. Setiawan and H. Pranoto, "Android Smartphone Remote Monitoring Application Using SMS Service," *International Journal of New Media Technology,* pp. 112-119, 2017.

[19] G. B. Satrya, P. T. Daely and S. Y. Shin, "Android Forencics Analysis: Private Chat on Social Messenger," *IEEE,* 2016.

[20] S. Li, L. D. Xu and S. Zhao, "The Internet of Things : A Survey," *Journal of Research and Innovation,* vol. 17, no. 2, pp. 243-259, 2014.

[21] A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari and M. Ayyash, "Internet of Things : A Survey on Enabling Technologies, Protocol, and Applications," *IEEE Communications Surveys & Tutorials,* vol. 17, no. 4, pp. 2347-2376, 2015.

[22] J. Gomez, J. F. Huete, O. Hoyos, L. Perez and D. Grigori, "Interaction System Based on Internet of Things as Support for Education," *Procedia Computer Science 21,* pp. 132-139, 2013.

[23] K. Michael, K. Ellis and L. McRae, "Internet Of Things (IoT): Education and Technology. The Relationship Between Education and Technology for Strudents with Disabilities," *Curtin Research Publications,* 2018.

[24] M. Hassanalieragh, A. Page, T. Soyata, G. Sharma, M. Aktas, G. Mateos, B. Kantarci and S. Andreescu, "Health Monitoring and Management Using Internet-of-Things (IoT) Sensing with Cloud-Based Processing: Opportunities and Challenges," *IEEE,* 2015.

[25] M. S. Hossain and G. Muhammad, "Cloud-assisted Industrial Internet of Things (IIoT) – Enabled framework for health monitoring," *Computer Networks,* vol. 101, pp. 192-202, 2016.

[26] A. Paul, A. Ahmad, M. M. Rathore and S. Jabbar, "Smartbuddy: defining human behaviors using big data analytics in social internet of things," *IEEE Wireless Communications,* vol. 23, no. 5, pp. 68-74, 2016.

[27] I.-R. Chen, F. Bao and J. Guo, "Trust-Based Service Management for Social Internet of Things Systems," *IEEE Transactions on Dependable and Secure Computing,* vol. 13, no. 6, pp. 684-696, 2016.