Indonesian Journal of Electronics, Electromedical, and Medical Informatics (IJEEEMI)
Vol. 3, No. 1, February 2021, pp. 21-28
DOI: 10. 35882/ijeeemi.v3i1.4 **ISSN: 2656-8624**

Development of a Low-Cost and Efficient ECG devices with IIR Digital Filter Design

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Article Info

Article History:
Received Jan 5, 2021
Revised Feb 19, 2021
Accepted Feb 21, 2021

Keywords:
Electrocardiograph, Digital Filter, Infinite Impulse Filter

Abstract

Measurement of biosignals such as electrocardiograph has the interpretation of noise from other signals. The noise can interfere with the measurement of the heart signal and make the measurement inaccurate, so the purpose of this study is to make a 6-Lead Electrocardiogram module with an Arduino-Based Digital Filter. By using a digital filter. The contribution of this research is the use of digital filters to eliminate noise in electrocardiograph signals. This research uses Infinite Impulse Filter digital filters such as Butterworth, Chebyshev I, Chebyshev II, and Elliptic in order 2, 4, 6, 8, and 10. The study was conducted by providing input from the Function Generator on Arduino which has been applied digital filters with Frequency with 0.5Hz – 100Hz cut-off. The instrument is compared with a factory electrocardiograph. Filter measurements using 460 input data. Butterworth filter with the greatest emphasis on order 8 frequency 0.5Hz produces an emphasis of -5.74298158 dB and a frequency of 100Hz produces an emphasis of -5.93529424 dB. The Chebyshev I filter has the greatest emphasis on order 6 frequency 0.5Hz producing an emphasis of -3.27104076 dB and on order 8 frequency 100Hz producing an emphasis of -5.08730424 dB. Chebyshev II filter the biggest emphasis on the order of frequency 0.5Hz produces a suppression of -44,66011104 dB and 80Hz frequency produces a suppression of -37,3653957 dB. Elliptic filters the greatest emphasis on order 6 frequency 0.5Hz produces an emphasis on -1.55429354 dB and 100Hz frequency on order 8 produces an emphasis on -2.2849115 dB. The results showed that what was appropriate with the cut-off frequency was the Butterworth order 8 filter which was suitable for the application of the Electrocardiograph signal filter because it had bandwidth that suppressed the signal outside the cut-off frequency. The results of this study can be implemented on a 6-Lead ECG module to eliminate noise or interference when tapping ECG signals.

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I. INTRODUCTION

Unhealthy lifestyles such as high cholesterol or high-fat foods and can reduce the risk of heart disease. Heart disease is generally difficult to detect[1]. Heart disease affects the structure and function of the heart caused by various factors[2]. At present, heart disease is one of the leading causes of death worldwide. In Indonesian, around 700 thousand deaths per year are caused by heart attacks[3]. Types of diseases related to heart organs needed are coronary heart disease (CHD), angina pectoris, congestive heart failure, cardiomyopathy, congenital heart disease, arrhythmia, myocarditis, heart attack, heart cancer, and others[2]. Basic Health Research Data (RISKESDAS) by the Indonesian Ministry of Health's Research and Development Agency in 2018 caused the most disease to occur in populations requiring 75 years and over (4.7%), continuing at 65-74 years (4.6%), aged 55-64 years (3.9%), aged 45-54 years (2.4%), 35-44 years (1.3%), 25-34 years (0.8%) and aged 15-24 years (0.7%). The highest percentage of heart disease in the Indonesian population is 75% and above. Nevertheless, populations that are still in the vulnerability of productive age also have heart disease. This shows that heart disease occurs in all age groups, whether productive or unproductive age. To prevent a heart attack from becoming severe, early diagnosis is very important. One reading technique is an electrocardiogram (ECG)[3]. Electrocardiograph is a recording of cardiac bioelectric activity that represents cyclic contraction and atrial and ventricular relaxation. The most important feature with ECG information found in P, Q, R, S, and T waves relating to atria and depolarization and repolarization[4]. Important information in ECG signals lies at 0.5 Hz to 100Hz[5][6]. Usually ECG can be contaminated from various interference where the interference can change the waveform and amplitude of the ECG signal[7]. Very filtering is needed to eliminate noise. Disturbances or noise that commonly occurs namely: ECG noise from powerline interference, baseline wander or a low-frequency ECG artifact, electrode motion noise, and Electromyography (EMG) noise[8], [9].

Previous ECG devices have been made by several researchers. The study was conducted by Parin Dedhia et al used 2 displays, namely on dot-matrix LCD (LCD-128G064E) and on a PC via Bluetooth transmission with a voltage source using solar cells. However, the filter used is still using an active analog filter with Butterworth filter type 2 and only displays leads I lead [10]. Subsequently the study was conducted by Asiya M. Al-Busaidi and Lazhar Khriji must use analog filters and digital filters in its application. However, this tool only displays 1 leads that is lead I and use the power source as a voltage source [11]. This research was conducted by Madiha Yunus, Amna Talib, and Arsalan Khan used gloves with electrodes located above the thumbs to knock the signal. However, this study still has a weakness that is still using 3-Lead [12]. Then the study was conducted by M. Ryan Fajar Nurdin, Sugondo Hadiyoso, and Achmad Rizal applied internet of thing system (IoT) for multi-patient ECG monitoring. Researcher M. Ryan et al discussed this ECG tool to be able to display multiple signals from several patients into one display on a PC using a ZigBee transmission module. However, this tool can only display 1 leads that is lead 1 with analog filters of Hpf 0.05Hz and Lpf 40Hz. The voltage source of the device is also not changed [13]. Parmveer Singh and Ashish Jasuja also conducted a study of patient ECG monitoring which the ECG device was displayed on a website (IoT) and can be seen on PCs and cellular. However, this tool can only display 1 lead and only use the ECG sensor AD8232 without using a filter so that there is still a lot of noise [14]. Furthermore, Abhishek B. Jani et al. conducted a study low-cost ECG & EMG Sensors for usable biometric and medical applications which are devices and electrodes placed directly on the body. However, tapped signals can only display 1 lead and use an analog filters of Lpf 400Hz filter [15]. The research was also conducted by Md. Asif Ahamed and Mohiuddin Ahmad studied for multichannel wireless ECG. The device has 3 channels to display three Leads (leads I, II, and III) and uses battery power or portable but has a lack of improvements made by making 3 instrumentation, the display must be with a computer to install a signal making a compilation so there is no computer tool cannot work, and the filter still uses analog filters [16].

Based on the description of literature studies that must be completed, several things need to be completed through research. EKG is the heart's reflection organ in humans which reflects the physical part of the heart organ so to understand this it needs a lead that represents the physical heart. Likewise, interference at the time of deviation is one of the most important problems for seeing ECG signals so that they can be diagnosed correctly. In addition to the effectiveness of instrumentation, it can make efficient and inexpensive ECG. Therefore, this research will design a 6-lead ECG tool with a digital application filter with the aim of an ECG tool that is made to be able to read more with effective and inexpensive leads and the filtering results can be diagnosed correctly. The use of this range is more effective because it has the advantage of being able to tap 6-lead ECG (leads I, II, III, aVR, aVL, and aVF) using 1 instrumentation. The selection of leads is done by a switching system using a multiplexer and a digital filter is applied to the devices. This study is composed of: Chapter I contains the introduction, Chapter II contains the review literature, Chapter III contains the results, Chapter IV contains the results and analysis, Chapter V contains the discussion, and Chapter VI contains the closing.

II. MATERIALS AND METHODS

A. Experimental Setup

This study discusses digital IIR filters such as Butterworth, Chebyshev I, Chebyshev II, and Elliptic with the number of orders 2, 4, 6, 8, and 10 and then applied to ECG module.

B. Materials and Device

This study uses the function of a generator as a sine signal generator with a certain frequency in data collection, on the ECG module including IC AD620 on the instrument circuit, IC multiplexer CD4051, and TL081 IC on the amplifier circuit. Arduino Nano is used to process data. 5inch TFT LCD screen for display. Uses Maxtron batteries

C. Experiment

In this study, researchers measured the emphasis that occurred on each filter and calculated the value of dB. filter cut off frequency is 0.5Hz - 100Hz. The study was conducted by giving an input function generator to the Arduino's analog input that has been inserted a digital filter and seeing the filter response at frequencies of 0.5Hz, 10Hz, 25Hz, 40Hz, 60Hz, 80Hz, 100Hz, 110Hz, and 120Hz. The input is 460 digital data. After measuring the filter will be applied to the ECG module.

D. The Diagram Block

Heart signals in patients are detected using electrodes that are attached to the patient in the right hand (RA), left hand (LA), left foot (LL), and right foot (RL). In the processing block, a signal buffer is used using a buffer circuit so that the detected signal is the actual signal and no signal is lost. Then the signal will be selected alternately (switching) using a multiplexer to select the signal to be tapped. The multiplexer output will enter the instrumentation circuit used to process the body signal. Then the signal will be filtered using a passive BPF circuit with a lower limit frequency value of 0.05Hz to the upper limit of 100Hz so that the signal passed is only a heart signal and blocks other body signals. After that the signal will enter the Adder

DOI: 10. 35882/ijeeemi.v3i1.4 ISSN: 2656-8624

circuit which serves to increase the signal reference from negative to positive because the microcontroller can only read the positive voltage so that the signal will be processed all and nothing is cut off. The adder circuit output is connected to the ADC microcontroller pin to be changed from analog signals to digital. Data that has been changed will be processed on the microcontroller and filtered digitally (using formulas) implemented in a microcontroller program. Data that has been filtered digitally will be displayed in the form of an ECG signal graph on the TFT LCD. (**Fig. 1**).

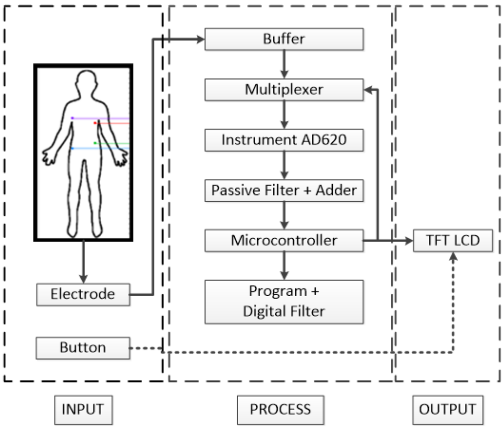

Fig 1. The diagram block of development of a low-cost and efficient ecg devices with II digital filter design.

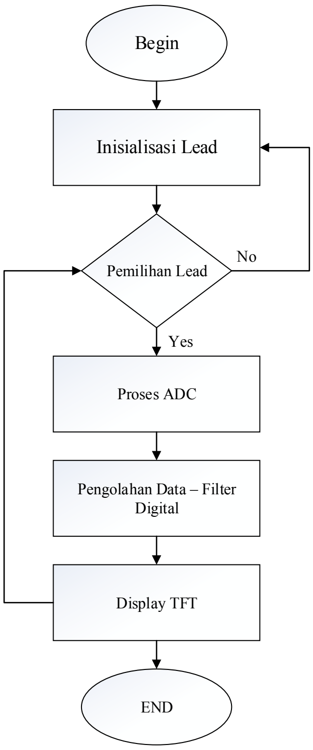

Fig 2. The flowchart of development of a low-cost and efficient ecg devices with IIR digital filter design

E. The Flowchart

By the time the power button is pressed then all the circuit will have voltage including sensor, if the sensor has been getting a voltage means the sensor is in a state ready or standby. The flowchart of the proposed method is showed in (**Fig. 2**). Lead initialization is carried out to pick up body signals using electrodes then lead selection multiplexers (**Fig. 3)** is works using IC multiplexers (**Fig. 4**) and tapped using a series of instrumentation and filters (**Fig. 5**). Then the signal is changed from analog to digital on the ADC microcontroller and the data is processed and a digital filter is carried out on the signal data. The signal that has been processed and carried out digital filter is displayed on the TFT LCD. Lead selection is selected using the buttons on the LCD TFT.

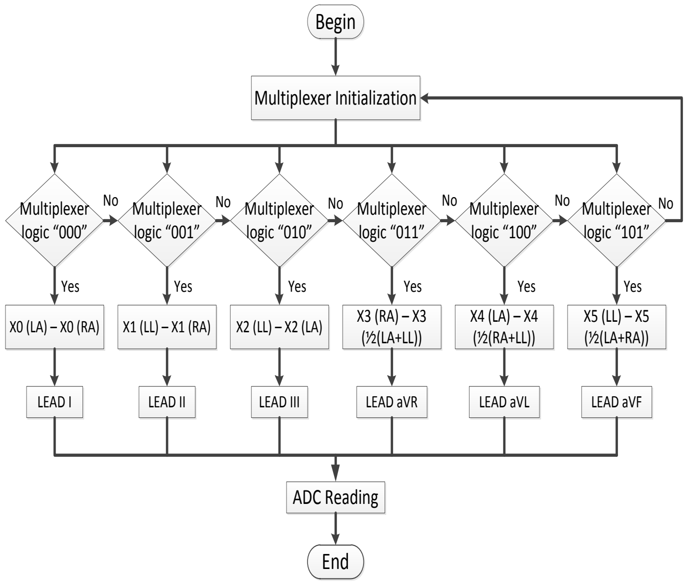

Fig 3. The Flowchart of the Multiplexers

Multiplexer initialization is works when the module is activated through the program. When the program gives logic "000" to IC multiplexers 1 and 2. IC multiplexer input will continue input X0 (LA) to Output Y active IC multiplexer 1 and input X0 (RA) to output Y active IC multiplexer 2. Then the value will be read ADC. When the program gives logic "001" to IC multiplexers 1 and 2. IC multiplexer input will continue input X1 (LL) to output Y active IC multiplexer 1 and input X1 (RA) to output Y active IC multiplexer 2. Then the value will be read ADC.

F. Circuit

1) Circuit of Selection leads with multiplexers

In **(Fig. 4)** is a picture of a series of a selection of leads with a multiplexer. This circuit is used to select the signal to be tapped. This circuit consists of a buffer and IC multiplexer circuit

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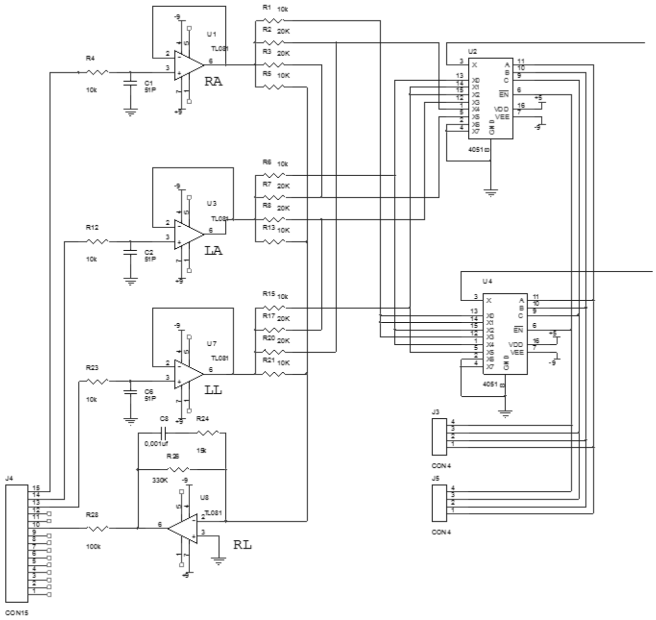

Fig 4. Circuit of Selection leads with multiplexers

2) Circuit of Instrumentation

In (**Fig. 5**) is a series of instruments used to tap body signals. This instrument uses the AD620 IC.

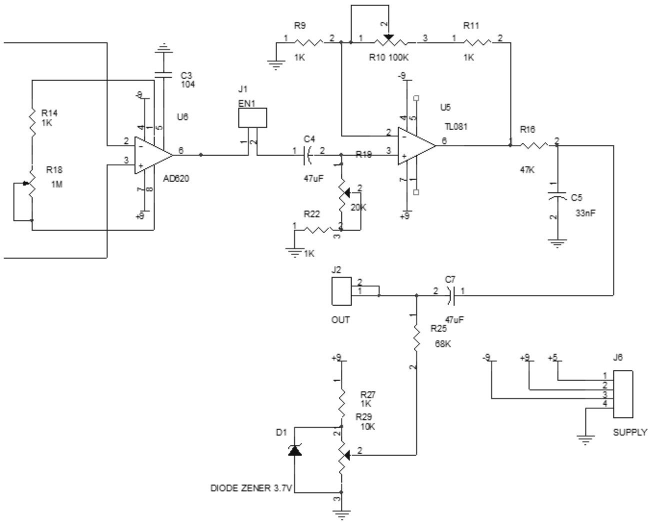

Fig 5. Circuit of Instrumentation

There is a main circuit, body signals are analog signals. the signal will enter the buffer circuit to output the actual output. then a lead selection occurs in the lead configuration series **(Fig. 4**). After selecting the leads will be tapped on IC AD620. then the signal will be passively filtered, amplified using a non-inverting circuit TL081, and raising the reference by the adder circuit **(Fig. 5**). Then the signal will be processed on the Arduino Nano ADC.

III. Results

In this study, the ECG Module proposes using the ECG phantom. While digital filters use the generator function to see the response filter.

A. Results of main circuit design

There is a main circuit design include circuit of selection lead with multiplexer and circuit of instrumentation**(Fig. 6)**.

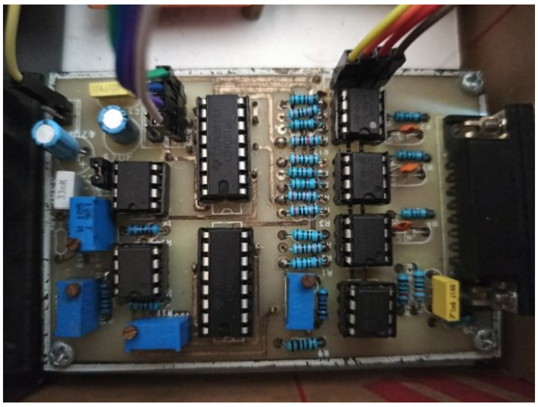

Fig 6. Results of main circuit design

B. Program of Selection leads with multiplexers

```
if(CurrentPage == 0){   }

if(CurrentPage == 1){                    //LEAD I
  digitalWrite(pin_A, LOW);
  digitalWrite(pin_B, LOW);
  digitalWrite(pin_C, LOW);
  digitalWrite(pin_INH, LOW);                    }
if(CurrentPage == 2) {       //LEAD II
  digitalWrite(pin_A, HIGH);
  digitalWrite(pin_B, LOW);
  digitalWrite(pin_C, LOW);
  digitalWrite(pin_INH, LOW);                    }
if(CurrentPage == 3){                    //LEAD III
  digitalWrite(pin_A, LOW);
  digitalWrite(pin_B, HIGH);
  digitalWrite(pin_C, LOW);
  digitalWrite(pin_INH, LOW);                    }
if(CurrentPage == 4){                    //LEAD aVr
  digitalWrite(pin_A, HIGH);
  digitalWrite(pin_B, HIGH);
  digitalWrite(pin_C, LOW);
  digitalWrite(pin_INH, LOW);                    }
if(CurrentPage == 5){                    //LEAD aVl
  digitalWrite(pin_A, LOW);
  digitalWrite(pin_B, LOW);
  digitalWrite(pin_C, HIGH);
  digitalWrite(pin_INH, LOW);                    }
if(CurrentPage == 6){                    //LEAD aVf
  digitalWrite(pin_A, HIGH);
```

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```
digitalWrite(pin_B, LOW);
digitalWrite(pin_C, HIGH);
digitalWrite(pin_INH, LOW);       }
```

Lead selection based on page on the TFT display. On the start page the logic sent by TFT is CurrentPage == 0. When TFT is pressed the START button the page will change to 1 or CurrentPage == 1. Arduino will give the LOW, LOW, LOW logic to pins A, B, and C that contained in the multiplexer IC so that it produces LEAD I configuration output. Similarly, when TFT is pressed the LEAD II button, the page will change to 2 or CurrentPage == 2. Arduino will give logic HIGH, LOW, LOW on pins A, B, and C which contained in the multiplexer IC to produce LEAD II configuration output. The same goes for LEAD III, LEAD aVr, LEAD aVl, and LEAD aVf.

C. Listing program of digital filter applied to module

```
 x=analogRead(A5);
  delayMicroseconds(3200);
  y6=y5;
  y5=y4;
  y4=y3;
  y3=y2;
  y2=y1;
  y1=y;
  //
  x6=x5;
  x5=x4;
  x4=x3;
  x3=x2;
  x2=x1;
  x1=x0;
  x0=x;
  y=b[0]*x0 + b[1]*x1 + b[2]*x2 + b[3]*x3 + b[4]*x4 +
b[5]*x5 + b[6]*x6 - a[1]*y1 - a[2]*y2 - a[3]*y3 - a[4]*y4 -
a[5]*y5 - a[6]*y6;
  y=y;
}
```

Variable X is the input signal originating from the A5 analog pin then the signal is sampled at 250Hz using delayMicroseconds (3200). Then the signal will be processed using a digital filter formula and generate a signal after filtering with the variable Y.

D. Listing program for BPM

```
 void BPM()
{
 x=analogRead(A5);
 if (ref<=x){ref=x;logikakomparator=1;}
 else
  {
  ref=ref;hold=(ref*0.8);
   if(logikakomparator==1)
   {
     if(waktumonostabil > delayMonostabil)
     {
      bpm++;
      adadetak=true;
      if(bpm==1) { waktumulai=millis();}
      else if(bpm==5)  {
        bpm=0;
        waktuselesai=millis()-waktumulai;
        heartrate=240000/waktuselesai;  }
      waktumonostabil=0;
      ref=0;
     }
   }
  logikakomparator=0;
 }
 if(waktumonostabil < 60000)
 {
  waktumonostabil=waktumonostabil+10;
 }
 timercekdetak++;
 if(timercekdetak>=100)
 {
  timercekdetak=0;
```

The variable x is the signal input derived from the analog pin A5. Furthermore, the ref variable is a reference which will be the threshold or limit of the bpm reading. During the first beat, the time will count to the fourth beat. The time for 4 beats or 4 minutes is changed to seconds which is 24000 seconds. To calculate the BPM, the 4 minutes will be divided by the time it takes to reach 4 beats.

E. Listing program for Display Functions

```
  if(millis()-Report1>waktuecg)
 {
  int Value = map(x,0,1023,0,200);

  Serial.print("add 2,0,");
  Serial.print(Value);
  Serial.write(0xff);
  Serial.write(0xff);
  Serial.write(0xff);

  int Value2 = map(x,0,1023,0,200);
  Serial.print("add 2,0,");
  Serial.print(Value2);
  Serial.write(0xff);
  Serial.write(0xff);
  Serial.write(0xff);
  Report1 = millis();              }

 if(millis()-Report>waktukirim)
 {
```

```
Serial.print("bpm.val=");
Serial.print(heartrate);
Serial.write(0xff);
Serial.write(0xff);
Serial.write(0xff);
Report = millis ();                    }

Serial.print("np.val=");
Serial.print(CurrentPage);
Serial.write(0xff);
Serial.write(0xff);
Serial.write(0xff);
```

The above program is a program for sending data to a TFT display. Variable value to display the original ECG signal or signal before it is filtered digitally. Value2 for displaying ECG signals after a digital filter. While the heart rate variable sends the BPM value to the TFT display and CurrentPage is a variable to display the page being opened.

F. Table of Measuring Results of Digital Filters on Arduino

In **(Fig. 7) (Table 1)** it can be seen that the lowest frequency of 0.5Hz occurs in order 8, with 460 inputs producing an output of 237.47 with a dB calculation of -5.74298158. Whereas the highest frequency of 100Hz occurs in order 8 with 460 producing an output of 232.27 with a dB calculation of -5.93529424. Seen from the other orders, order 8 occurs a significant frequency at the frequency of 0.5Hz and 100Hz as the cut off frequency of the filter that has been made.

TABLE I. FILTER BUTTERWORTH

F(Hz)	Input (Data)	Orde 2 (Data)	Orde 4 (Data)	Orde 6 (Data)	Orde 8 (Data)
0.5	460	330.04	316.35	321.9	237.47
5	460	475.93	454.02	463.92	469.05
10	460	470.86	454.17	458.33	438.14
25	460	450.09	446.32	439.76	430
40	460	419.73	433.15	451.15	432.14
60	460	431.24	441.76	433.28	427.18
80	460	319.45	422.45	379.69	343.22
100	460	329.29	328.35	299.16	232.27
110	460	269.56	195.64	140.14	68.37
120	460	-	62.58	27.94	22.55

In **(fig. 8) (Table 2)** it can be seen that at a frequency of 0.5Hz the greatest emphasis occurs in order 6 with 460 inputs producing an output 315.65 with a dB calculation of -3.27104076. Whereas at the frequency of 100Hz the greatest emphasis occurred in order 8 with 460 producing an output of 256.09 with a dB calculation of -5.08730424. Seen from other orders of order 6 there was a significant emphasis on the frequency of 0.5Hz and order 8 there was a significant emphasis on the frequency of 100Hz as the cut-off filter frequency that was made. The ideal order for a Chebyshev I filter is Order 8 because the emphasis that occurs at frequencies from 100Hz upwards is very large even though the frequency at 0.5Hz is not too pressing.

TABLE II. FILTER CHEBYSHEV I

F(Hz)	Input (Data)	Orde 2 (Data)	Orde 4 (Data)	Orde 6 (Data)	Orde 8 (Data)
0.5	460	453.38	417.44	315.65	402.85
5	460	474.95	418.81	413.19	410.28
10	460	469.05	416.81	419.03	417.44
25	460	461.89	397.62	421.12	400.87
40	460	439.32	389.59	425.4	421.09
60	460	448.22	409.02	409.62	442.04
80	460	451.66	333.88	366.57	358.21
100	460	423.84	420.85	406.85	256.09
110	460	356.77	264.87	127.69	37.78
120	460	277.49	81.9	27.76	14.76

In **(fig. 9) (Table 3)** it can be seen that at the 0.5Hz frequency the greatest emphasis occurs in order 6 and 8 namely in order 6 with 460 inputs producing an output of 1.31 with a dB calculation of -50.90973072. Whereas in order 8 with input 460 produces an output of 2.69 with a dB calculation of -44.66011104. Then at 100Hz the greatest emphasis occurs on all orders. However, it can be seen that Order 2 has a significant emphasis on each frequency so that it does not match the cutoff frequency of the filter made. Likewise with Order 4, it only passes the 5Hz to 25Hz frequencies apart from the frequency being suppressed so that it does not match the cutoff filter frequency. Whereas Order 6 only passes the frequency of 0.5Hz to 60Hz so it does not match the cutoff frequency of the filter made. Order 8 is the most ideal filter from this Chebyshev II filter. Although at 80Hz the input frequency has been suppressed it produces an output of 6.23 digital data with a dB calculation of -37,3653957. Judging from the data above, order 8 is the ideal filter for Chebyshev II filters.

TABLE III. FILTER CHEBYSHEV II

F(Hz)	Input (Data)	Orde 2 (Data)	Orde 4 (Data)	Orde 6 (Data)	Orde 8 (Data)
0.5	460	0.61	0.76	1.31	2.69
5	460	1.28	12.75	278.48	478.9
10	460	4.88	388.02	478.32	468.66
25	460	1.07	15.05	269.62	467.09
40	460	0.88	4.15	45.35	327.32

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60	460	0.92	1.53	8.82	45.75
80	460	0.83	1.51	3.83	6.23
100	460	0.8	0.96	1.87	1.73
110	460	0.78	0.7	4.96	1.25
120	460	0.7	1	4.13	2.73

In **(fig. 10)** it can be seen that at a frequency of 0.5Hz the greatest emphasis occurs in order 6 ie with 460 inputs producing an output of 384.63 with a dB calculation of -1.55429354. Whereas at the frequency of 100Hz the greatest emphasis occurred in order 8 with 460 producing an output of 353.6 with a dB calculation of -2.2849115. The ideal order for an Elliptic filter is order 6 because at the 0.5Hz frequency the greatest emphasis occurs compared to other orders while order 8 occurs the least emphasis. Even though the frequency at 100Hz Order 8 has greater emphasis, the difference is not too far apart.

TABLE IV. FILTER ELLIPTIC

F(Hz)	Input (Data)	Orde 2 (Data)	Orde 4 (Data)	Orde 6 (Data)	Orde 8 (Data)
0.5	460	453.38	417.44	315.65	402.85
5	460	474.95	418.81	413.19	410.28
10	460	469.05	416.81	419.03	417.44
25	460	461.89	397.62	421.12	400.87
40	460	439.32	389.59	425.4	421.09
60	460	448.22	409.02	409.62	442.04
80	460	451.66	333.88	366.57	358.21
100	460	423.84	420.85	406.85	256.09
110	460	356.77	264.87	127.69	37.78
120	460	277.49	81.9	27.76	14.76

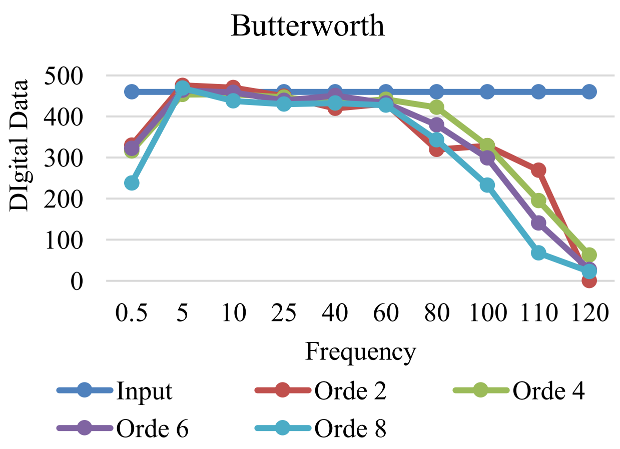

Fig 7. Digital Filter using Butterworth Type

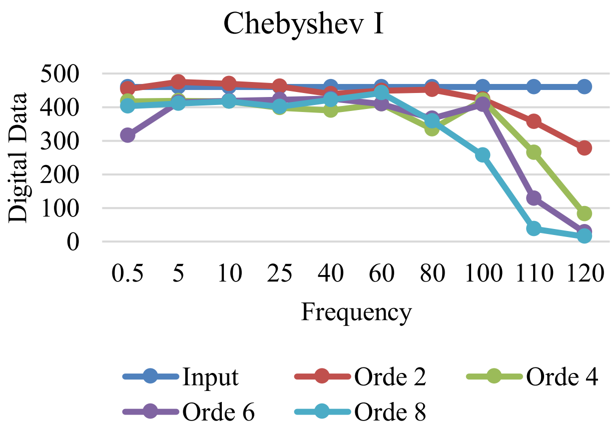

Fig 8. Digital Filter using Chebyshev I Type

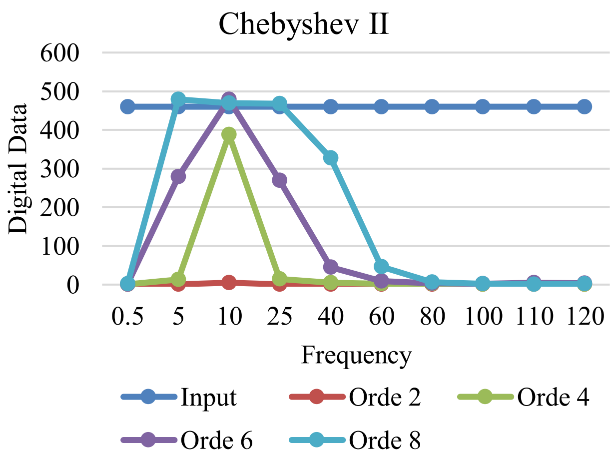

Fig 9. Digital Filter using Chebyshev II Type

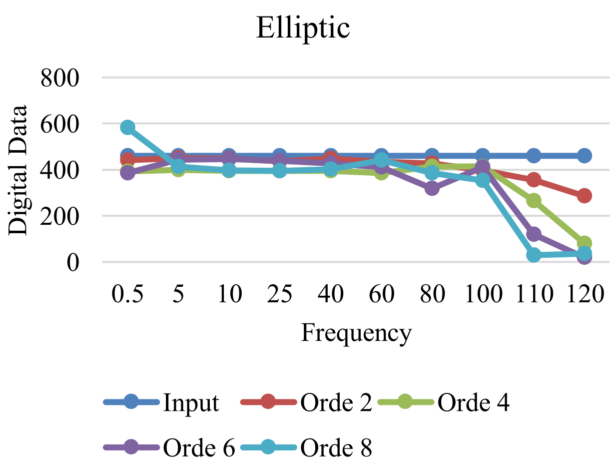

Fig 10. Digital Filter using Elliptic Type

Indonesian Journal of Electronics, Electromedical, and Medical Informatics (IJEEEMI)
Vol. 3, No. 1, February 2021, pp. 21-28
DOI: 10. 35882/ijeeemi.v3i1.4 **ISSN: 2656-8624**

In **(fig. 11)** all of the IIR filters above are concluded that the ideal filter for an IIR filter is the 8th butterworth filter because at the 0.5Hz frequency the resulting output is 237.47 with a dB calculation of -5.74298158. Whereas at the 100Hz frequency the resulting output is 232.27 with a dB calculation of -5.93529424. Compared to the 8th order Chebyshev II filter at the 0.5Hz frequency the resulting output is 2.69 with a dB calculation of -44.66011104. However, at an 80Hz frequency the input has been suppressed and produces an output of 6.23 with a dB calculation of -37,3653957. So the resulting cut off frequency is not appropriate ie 0.5Hz to 80Hz. The 8th order Butterworth filter has an appropriate cut-off frequency of 0.5Hz to 100Hz with the greatest emphasis by the desired cut-off frequency.

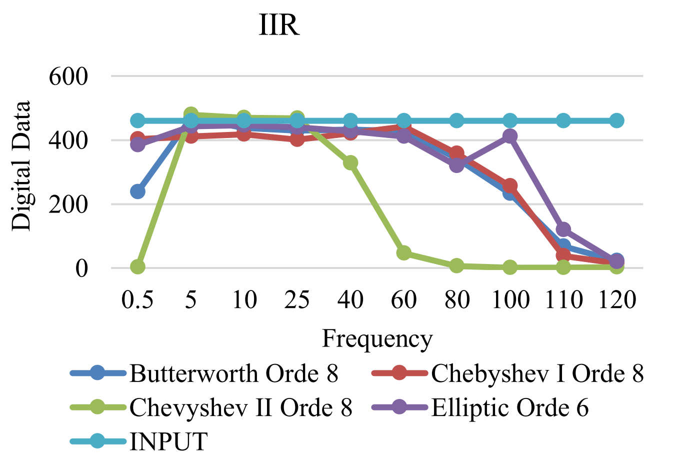

Fig 11. Digital Filter IIR

IV. DISCUSSION

In (Fig. 7, Fig. 8, Fig. 9 & Fig. 10), it is the result of a digital filter response to the Butterworth, Chebyshev I, Chebyshev II, and Elliptic filters. Order 8 Butterworth filter has an appropriate cut-off frequency of 0.5Hz to 100Hz with the greatest emphasis by the desired cut-off frequency. At a frequency of 0.5Hz produces an emphasis of -5.74298158 dB while at a frequency of 100Hz produces an emphasis of 5.93529424 dB (Fig. 11). In the cost-effective Multichannel wireless EKG study [9], this study uses a wireless system to display 3 signals simultaneously on a personal computer. But this research has a weakness, which is still using 3 instrumentation to knock the signal and still using an analog filter. In sweeping it is more effective to use 1 instrumentation by using a multiplexer to exchange lead data. And filters will be more effective using digital filters because the order is not limited to the number of circuits. Compared to analog filters digital filters are more effective because they are implemented in software and arranged according to need [16]. From this study, the results obtained are still using 6 leads and 1 channel as a display.

V. CONCLUSION

The purpose of this study was to determine the IIR digital filter method that can be applied to ECG filters. From this study, it was obtained the 8 order Butterworth filter is appropriate because it has a good bandwidth for the cut off frequency of 0.5-100 Hz. Users of this IIR digital filter can be applied in making ECG modules. Further development can be done by adding the number of leads and channels to get a more complete .

REFERENCES

[1] M. A. Spektrum, "Journal of Control and Network Systems," *J. Control Netw. Syst.*, vol. 4, no. 1, pp. 92–99, 2015.
[2] C. Sowmiya, "Analytical Study of Heart Disease Diagnosis Using Classification Techniques," *IEEE*, 2017.
[3] M. W. Gifari, H. Zakaria, and R. Mengko, "Design of ECG Homecare : 12-Lead ECG Acquisition using Single Channel ECG Device Developed on AD8232 Analog Front End," *IEEE*, pp. 371–376, 2015.
[4] Y. Ohta and H. Yoshida, "ECG-based Biometric Authentication Using Mulscale Descriptors," *IEEE*, pp. 1–4, 2015.
[5] K. M. Gaikwad, "Removal of High Frequency Noise from ECG Signal Using Digital IIR Butterworth Filter," pp. 121–124, 2014.
[6] S. Deb, S. R. Islam, J. Robaiatmou, and T. Islam, "Design and Implementation of Low Cost ECG Monitoring System for the Patient using Smart Device," *Int. Conf. Electr. Comput. Commun. Eng.*, pp. 774–778, 2017.
[7] N. Das, "Performance Analysis of FIR and IIR Filters for ECG Signal Denoising based on SNR," pp. 90–97, 2017.
[8] T. M. Chieng, Y. W. Hau, and Z. Omar, "The Study and Comparison between Various Digital Filters for ECG De-noising," *2018 IEEE-EMBS Conf. Biomed. Eng. Sci.*, pp. 226–232, 2018.
[9] A. D. Jeyarani and T. Jaya Singh, "Analysis of noise reduction techniques on QRS ECG waveform - by applying different filters," *Proc. Int. Conf. "Recent Adv. Sp. Technol. Serv. Clim. Chang. - 2010", RSTS CC-2010*, pp. 149–152, 2010.
[10] P. Dedhia, "Low Cost Solar ECG with Bluetooth transmitter," *Int. Conf. Biomed. Eng.*, no. February, pp. 27–28, 2012.
[11] A. M. Al-busaidi and L. Khriji, "Digitally Filtered ECG Signal Using Low-Cost Microcontroller," *IEEE*, pp. 258–263, 2013.
[12] M. Yunus, "Designing A 3- Lead Cost Effective Ecg Recording Glove For Home Monitoring," *Biosci. Eng. An Int. J.*, vol. 1, no. April, 2014.
[13] "A Low-Cost Internet of Things (IoT) System for Multi-Patient ECG ' s Monitoring," *Int. Conf. Control. Electron. Renew. Energy Comun.*, pp. 7–11, 2016.
[14] P. Singh, "IoT Based Low-Cost Distant Patient ECG Monitoring System," *Int. Conf. Comput.*, pp. 1330–1334, 2017.
[15] A. B. J. Member, R. B. Member, A. K. Roy, and S. Member, "Design of a Low-power , Low-cost ECG & EMG Sensor for Wearable Biometric and Medical Application," *IEEE*, pp. 3–5, 2017.
[16] S. K. Jagtap, "Butterworth Filter Application," *Int. Conf. Commun. Inf. Comput. Technol.*, pp. 1–6, 2012.