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Defibrillator with Monophasic and Biphasic Fibrillation Signal

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ABSTRACT Lack of knowledge about functions, working methods, and safety can pose a big risk (death). Defibrillators are electronic devices that flow the shock electrical signal (pulse) to the heart muscle to maintain myocardial depolarization that is experiencing cardiac fibrillation (ventricular fibrillation or atrial fibrillation). The purpose of this study is make a defibrillator as a learning material so that anyone can have sufficient knowledge about the working principle and function of the defibrillator tool. This defibrillator is equipped with two wave selections namely monophasic and biphasic with asynchronous and synchronous modes, the energy provided ranges from 10-50 joules with use on tools 10, 20, 30, 50 joules. The energy will be flowed to the patient by pressing the Discharge button on Paddle which equivalently is adapted to humans. Energy disposal is controlled by a driver then the relay will work alternately from the first condensator then the second condensator to Paddle. Energy testing is done by 10 times using a defibrillator analyzer in a predetermined test point, the results of the monofacic wave measurement obtained by the error value of each setting with the smallest value of 0.0024% and the largest error value of 0.023%. To produce energy (joule) that appropriate capacitor is needed with real value. Bifasic waves cannot be tested because the defibrillator analyzer measuring instrument cannot detect the energy value (joule) capacitor that has been delivered.
Keywords: defibrillator, monophasic,biphasic, capacitor

I. INTRODUCTION

A defibrillator is a very important medical device to help patients who have a serious disorder of the heart rate called ventricular fibrillation. The general principle of this instrument is that it draws power from the capacitor by discharge and stored through the paddle electrodes to the patient's chest, the larger the capacitor increases the increase in joules [1][2][3][4]. Defibrillators have three waveforms namely monophasic, biphasic, and triphasic. For decades, defibrillators have used monophasic waveforms where current flows in one direction, from one electrode to the other, which can stop the heart momentarily allowing the patient's heart rhythm to return to normal . Monophasic waveforms have one peak where this peak current is very important in determining the success of fibrillation because the current required to reach the heart to stop the fibrillation must be sufficient, while too high a peak current can also cause more serious damage to the heart. Biphasic waveforms can replace monophasic waves because they use less energy and avoid injury to the myocardium and thus potentially survivability. The recommendation from the International Liaison Committee on Resuscitation (ILCOR) is that the biphasic energy is less than or equal to 200 joules[5][6][7]. Defibrillation using Monophasic waves requires a large enough energy value of 360 Joules, this large enough energy can cause more serious damage to the heart. [8][9]. Leakage current that can flow into the human body because a healthy human body has an average resistance of 1000 , the resistance is from the human body from hand to foot and also from hand to hand, or from one foot to another . The resistance of the human body on dry skin conditions ranges from 1000 Ω to 100,000 Ω , while on wet skin conditions it will decrease to Ω 1000 Ω [10][11][12].

To overcome the impact that can be caused by monophasic waves, in the mid 90's, biphasic waves were created. In a biphasic wave the direction of current flow will change as well as the resulting pulse. In its use, biphasic waves require lower energy than monophasic waves, if the first monophasic shock wave is given an energy of 360 Joules then in the first biphasic shock wave it only requires energy of 200 Joules [13][14][15]. Even so, defibrillation using the monophasic wave type can be said to be still effective and no more dangerous than defibrillation using the biphasic wave type. [16][17]

In 2010, Wenguang Han, Yongjun Li and Rui Zhang designed the ECG System-Based Automatic External Defibrillator in this study to have ECG signal inaccuracy and low charging speed. In 2011, Ferry Pratama, Munnik Haryanti and Yohannes Dewanto carried out the design Design of the AT89C51 Microcontroller-based Defibrillator due to the absence of wave mode research. In May 2017 Irawan Sukma, Siddiq Wahyu Hidayat and Wuwus from LIPI Testing Quality and the Center for Technology System Research conducted a study on the Effect of Inductor Resistance on Defibrillation Energy of the Electrocardiograph Resistance Test System [18]. Using this reference, in 2019 Muhammad Amir Ma'ruf designed a DC Shock Simulation tool, which can produce energy of 10-30 Joules with monophasic wave type and the mode used is asynchronous. The researcher only focuses on joules, the type of wave used is monophasic, and there is no synchronous

mode. Judging from the defibrillator equipment in the field, the device can be said to be inadequate to be used as a learning material for operators, technicians, and electromedical candidates[19]. In 2020, Fahmi Ardhi designed a defibrillator with the research objective of Effectiveness of Biphasic Signals in Defibrillators with a Discharge Condenser System which can produce joules of energy of 10-50 Joules with Monophasic and Biphasic wave types. This research is still not perfect and not good because the researcher cannot measure the energy value, causing uncertainty in the level of accuracy of the energy value generated by the tool, the researcher also does not provide data in the form of charging time for the device, this tool also cannot display the ECG signal [20][21][22][23][24].

Based on the identification of the problem above, the author intends to create a module Defibrillator With Fibrillation Signals (Monophasic and Biphasic). The purpose of this study is make a defibrillator as a learning material especially in life support laboratories, namely about defibrillator devices so that students have sufficient knowledge about working principles, functions, and safety. from defibrillator devices and have good provisions in overcoming problems that may occur in equipment in the field and can carry out proper maintenance on defibrillator devices.

II. MATERIALS AND METHODS

A. EXPERIMENTAL SETUP

This study, it was made to be used as a learning material so that anyone can have sufficient knowledge about the working principles and functions of a defibrillator. This defibrillator is equipped with two signal/wave selections, namely monophasic and biphasic, the energy given ranges from 10-50 Joules with use on the device 10, 20, 30, 50 Joules. Tool testing is carried out on the phantom by paying attention to the equivalent resistance of the patient's tissue.

1) MATERIALS AND TOOL

The components used in this study were relay (Omron MY2N 12v 8 pin) as a discharge driver, 4 pieces of 347uf 450V capacitors and 3.2 inch TFT touch to display. The Arduino Mega microcontroller is used to control charge and discharge. A Defibrillator Analyzer (Datrend Phase 3) was used to measure energy (joule) values.

2) EXPERIMENT

In this study, it was made to be used as a learning material so that anyone can have sufficient knowledge about the working principles and functions of a defibrillator. This defibrillator is equipped with two signal/wave selections, namely monophasic and biphasic, the energy given ranges from 10-50 Joules with use on the device 10, 20, 30, 50 Joules. Tool testing is carried out on the phantom by paying attention to the equivalent resistance of the patient's tissue.

B. THE DIAGRAM BLOCK

When the main switch is pressed, the circuit will receive a voltage supply from PLN as shown in **FIGURE 1**. Press the wave setting button to select the band to be used. If using a monophasic wave, the device can be used in synchronous or asynchronous mode by pressing the mode setting button. As for biphasic waves can only use Asynchronous mode. At the time of discharge of the device the energy discharge wave from the paddle to the patient will be determined from the mode we choose. The TFT LCD will display the energy value that will be given to the patient, the LED will give an indication that the energy charge on the device has been reached and will give an indication when charging takes place. After the active charge process, the capacitor charging process will take place, the comparator will provide logic to the program to charge the capacitor, the loop capacitor block circuit functions as a safety, after the energy is appropriate, the energy in the capacitor will be discharged to the paddle (patient) when the shock process takes place during discharge and the LED will give a discharge indication. The function of the Phantom ECG is as an artificial heart instead of human leads.

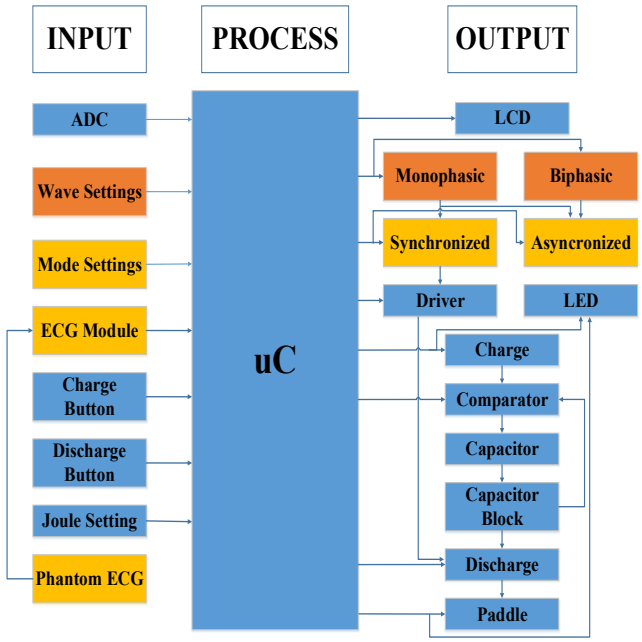


FIGURE 1. The diagram block of the Defibrilator

C. THE FLOWCHART

The Arduino program is built based on the flowchart as shown in **FIGURE 2**. After initializing the TFT LCD the tool is on. TFT LCD will display the joule value and the ON indicator is active. When the wave selection button is pressed, the tool will select the wave to be used and the indicator will turn on. When the mode selection is pressed the tool will see what wave selection is used, after that uC will initialize what mode can be used and will turn on the indicator. When the charge is pressed, the capacitor charging process occurs, when charging the capacitor the LED indicator is on, the comparator will provide logic to the program to charge the capacitor, when the capacitor contents are appropriate, the LED indicator will light up indicating that charging has been completed and discharge can be carried out, when the discharge button is pressed The LED indicator lights up then the discharge command will be active

then the discharge will be carried out through the paddle, but in synchronous mode the discharge command also pays attention to the R signal contained in the ECG signal. In the tool there is a Phantom ECG so that it can perform simulations in synchronous mode.

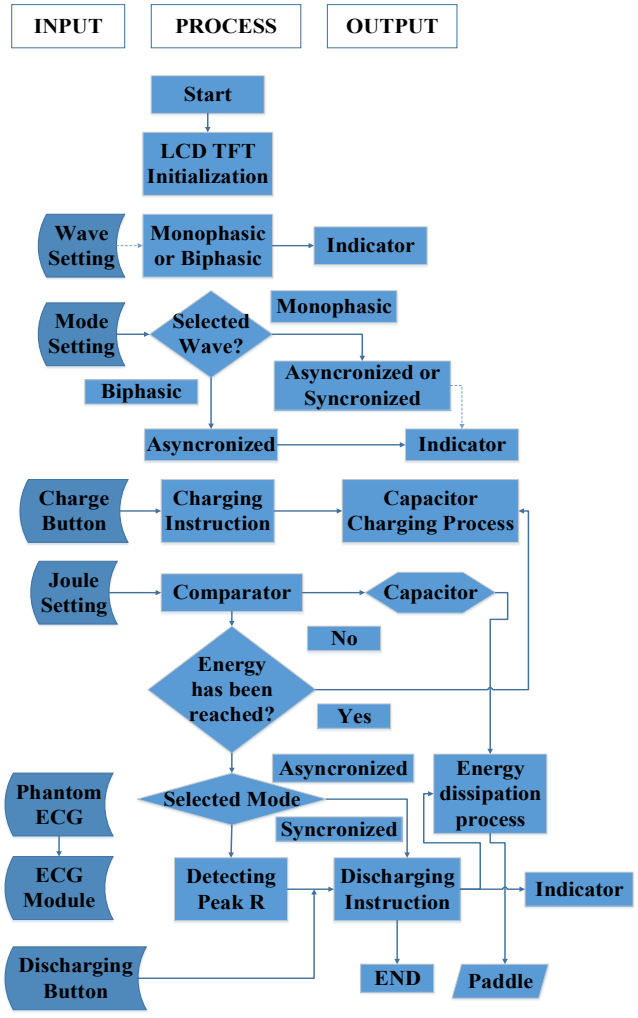


FIGURE 2. The flowchart

III. RESULT

In this study, the Defibrillator module with Fibrillation Signals has measured the energy (joule) values.. The results biphasic cant showed that in synchronous mode the discharge was right at the peak of the R wave. The results of the defibrillator design are a charge circuit, a phantom circuit and a capacitor block circuit.

In monophasic waves, the defib analyzer can detect the energy value (joules) well, but it is necessary to pay attention to the capacitor used, and the energy value (joules) must also be calculated so that there is a match between the voltage and the voltage received by the defibrillator analyzer. While in biphasic waves, the measurement of the two capacitors can drain the charge, but this tool is still not perfect because the defibrillator analyzer cannot detect the energy value (joules) of the second capacitor. This condition causes the writer to be unable to collect data.

FIGURE 3. The result of the Defibrilator design

1) *DEFIBRILLATOR DESIGN*

The analog section consists of a Control Circuit, a capacitor charging circuit, a discharge circuit containing Drivers and Relay, a high voltage generator circuit, a capacitor block circuit, The digital part consists of an Arduino Mega microcontroller and 3,2 inch TFT LCD for display.

2) *THE LISTING PROGRAM FOR CHARGE PROGRAM*

In this study the author uses a program in C language with the Arduino application. The listing program for charge program was shown in the Pseudocode 1 At the beginning of the program there is a library for the Nextion TFT LCD. When the required initialization is complete, the monophasic void biphasic and synchronous monophasic void functions can be executed

Pseudocode: 1. Charge Program

```
1.  void monofasik(){
2.  if (MP==1){ //setting 10 joule
3.  if (digitalRead(13)==HIGH){
4.  digitalWrite(cap1,HIGH);
5.  digitalWrite(charge,HIGH);
6.  digitalWrite(LEDcharge,HIGH);
7.  delay (620);
8.  digitalWrite(cap1,LOW);
9.  digitalWrite(cap2,HIGH);
10. delay (625);
11. digitalWrite(LEDcharge,LOW);
12  digitalWrite(cap1,LOW);
13. digitalWrite(cap2,LOW);
14. digitalWrite(charge,LOW);
15. digitalWrite(LEDp,HIGH);
16. MP=0; }}
17. void bifasik(){ //setting 10 joule
18. if (BP==1){
19. if (digitalRead(13)==HIGH){
20.
```

```
digitalWrite(cap1,HIGH);
digitalWrite(charge,HIGH);
digitalWrite(LEDcharge,HIGH);
delay(400);
digitalWrite(cap1,LOW);
digitalWrite(cap2,HIGH);
delay(400);
digitalWrite(cap1,LOW);
digitalWrite(cap2,LOW);
digitalWrite(cap3,HIGH);
delay(500);
digitalWrite(cap3,LOW);
digitalWrite(charge,LOW);
digitalWrite(LEDcharge,LOW);
digitalWrite(LEDp,HIGH);
BP=0;}}
void monofasik_sinkron(){setting 10 joule
if (S==1){
if (digitalRead(13)==HIGH){
digitalWrite(cap1,HIGH);
digitalWrite(charge,HIGH);
digitalWrite(LEDcharge,HIGH);
delay (600);
digitalWrite(cap1,LOW);
 digitalWrite(cap2,HIGH);
delay (620);
digitalWrite(LEDcharge,LOW);
digitalWrite(cap2,LOW);
digitalWrite(charge,LOW);
digitalWrite(LEDp,HIGH);
S=0, MP=0;
}}
```

Pseudocode 1 is used to initialize conditions for charge and for each joule settings. There is a comparator that provides logic so that each wave mode will not error when charging.

3) THE LISTING PROGRAM FOR DISCHARGE PROGRAM

To get rid of the voltage on the capacitor that has been charged, the researchers used a plate whose equivalent is equivalent to a resistance human, namely 1000 ohm. The researcher uses Pseudocode 2 to initialize the comparator so that there is no disposal error on the device

Pseudocode: 2. Disharge Program

```
if (D==1){ //komparator driver
if(digitalRead(4)==HIGH){
digitalWrite(LEDp,LOW);
digitalWrite(disc1,HIGH);
digitalWrite(LEDdischarge, HIGH);
delay (1500);
digitalWrite(disc1,LOW);
digitalWrite(LEDdischarge, LOW);
 D=0;
}
if (D==2){ // komparator driver
if(digitalRead(4)==HIGH){
digitalWrite(LEDdischarge,HIGH);
digitalWrite(disc1,HIGH);
digitalWrite(LEDp,LOW);
delay(300);
digitalWrite(capblok,HIGH);
digitalWrite(disc1,LOW);
delay(1);
digitalWrite(disc2,HIGH);
delay(300);
digitalWrite(disc2,LOW);
delay(50);
digitalWrite(capblok,LOW);
digitalWrite(LEDdischarge, LOW);
D=0;
}
if (D==3){ // komparator driver
if(digitalRead(4)==HIGH){
if (hasil >= 2.027){
digitalWrite(LEDp,LOW);
digitalWrite(disc1,HIGH);
digitalWrite(LEDdischarge, HIGH);
delay (500);
digitalWrite(disc1,LOW);
digitalWrite(LEDdischarge, LOW);
D=0;
}}}
```

Pseudocode 2 is used to initialize conditions for discharge. There is a comparator that provides logic so that each wave mode will not error when charging.

4) THE LISTING PROGRAM FOR SERIAL COMMUNICATION

To connect two arduinos, researchers used a serial communication program to connect two arduinos with a TFT LCD. The listing program for serial communication was shown in the Pseudocode 3

Pseudocode: 3. Serial Communincation Program

```
Int nilaiInput1 = analogRead(sinyal);
nilaiInput1 = map(nilaiInput1, 0,255, 0,  100);
String kirimInput1 = "add "; //kirim data String "add "
kirimInput1 += 2;  // Kirim  ID waveform
```

```
6.  kirimInput1 += ",";
7.  kirimInput1+= 0; //Channel waveform yang
8.  digunakan
9.  kirimInput1 += ",";
10. kirimInput1 += nilaiInput1; //kirim data
11. Serial.println(kirimInput1);
12  Serial2.print(kirimInput1);
13. Serial2.write(0xff); Serial2.write(0xff);
14. Serial2.write(0xff);
```

Pseudocode: 3. is used as an initialization condition to send serial communication between two Arduinos. Besides that, it also communicates on the TFT LCD, this is done for better program reading.

5) CAPACITOR CHARGING CIRCUIT MEASUREMENT RESULTS (MONOPHASIC)

The data below is the data obtained from the measurement results of the capacitor to the output of the capacitor circuit as shown in **Table I.**

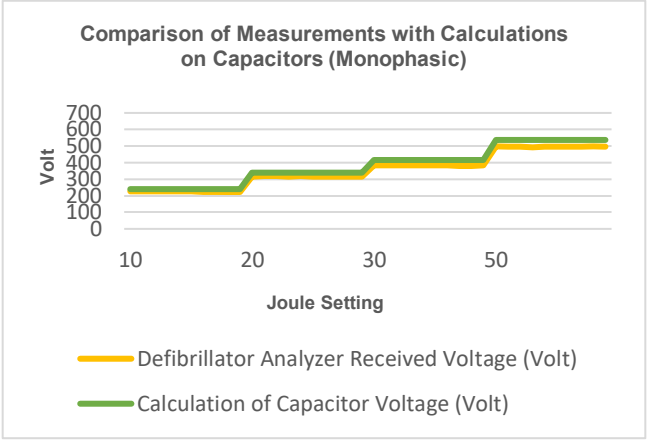
TABLE I. CAPACITOR CIRCUIT CHECK RESULTS (MONOPHASIC)

Energy Settings (Joules)	Capacitor Voltage Measurement (Volt)	Defibrillator Analyzer Received Voltage (Volts)	Calculation of Capacitor Voltage (Volt)
10	305	225	240
	308	228	
	304	225	
	306	227	
	305	225	
	305	225	
	303	223	
	304	223	
	303	224	
	302	224	
20	432	317	339.5
	434	318	
	432	318	
	430	317	
	432	318	
	430	317	
	430	317	
	430	317	
	429	316	
	430	316	
30	523	384	415.8
	524	385	
	522	383	
	520	383	
	523	383	
	523	385	
	520	382	
	517	381	
	520	381	
	519	382	
50	680	498	536.8
	676	495	
	676	497	
	676	494	
	680	497	
	676	495	
	679	495	
	679	497	
	682	498	
	679	497	

Calculation of capacitor voltage using the formula to find energy, with a capacitance of 347uf . Setting 10 Joules requires a capacitor voltage of 240V, 20 Joules requires a capacitor voltage of 339.5V, 30 Joules requires a capacitor voltage of 415.8V, 50 Joules requires a capacitor voltage of 536.8V.

6) Comparative Analysis of Capacitor Measurement with Calculation of Capacitor Voltage

FIGURE 4 Comparison graph of received voltage with capacitor voltage calculation



The graph above explains the difference between the capacitor voltage received by the defibrillator analyzer and the capacitor voltage calculation. The capacitor used is 500uf 900V, with the actual measured capacitor being 347uf 900V.

7) The Error of Energy Measurement value (Monophasic)

Data below obtained from the measurement of the overall circuit output. The results are shown in **Table II.**

TABLE II. ENERGI MEASUREMENT RESULTS (MONOPHASIC)

Energy (Joule)	Error(%)
10	0,023
20	0,016
30	0.006666667
50	0,0024

The Measurement of energy value where the value of energy released is compared in this study, between the defibrillator design and the defibrillator analyzer.

8) High Voltage Generator Circuit Measurement Result

TABLE III. HIGH VOLTAGE GENERATOR CIRCUIT MEASUREMENT RESULTS

Energy Settings (Joule)	PLN Voltage	*Input High Voltage Transformer*	*High Voltage Transformer Output*
10	220	41	320
	220	41	320
	220	39	320
	220	41	319
	220	41	321
	220	39	320
	220	41	320
	220	40	320
	220	40	321
	220	40	319
	220	40	321
	220	41	321
	220	39	320
	220	41	321
	220	40	321
20	220	39	319
	220	41	320
	220	40	319
	220	40	321
	220	40	321
	220	39	321
	220	41	319
	220	40	320
30	220	40	320
	220	39	320
	220	41	319
	220	41	321
	220	40	320
	220	40	321
	220	41	321
	220	40	321
	220	40	320
	220	39	320
50	220	40	321
	220	40	319
	220	41	321
	220	39	320
	220	41	320
	220	41	319
	220	41	320

Measurements were carried out 10 times for each setting with a test point for each input and output transformer as well as the PLN input voltage

9) Capacitor Remaining Charge (Monophasic)

Below is the residual discharge of the capacitor on the resistor and on the defibrillator analyzer as shown in **Table IV.**

TABLE IV. THE REST OF CAPACITOR DISCHARGE (MONOPHASIC)

Energy Settings (Joule)	*Discharge with 1kΩ 10watt (Joule)*	*Discharge with Defibrillator Analyzer (Joule)*
10	0.047293	0.018766
	0.03956	0.021377
	0.047235	0.018407
	0.042766	0.019128
	0.051927	0.019864
	0.051927	0.017699
	0.039038	0.018051
	0.034494	0.018407
	0.036478	0.01735
	0.03956	0.018051
20	0.136024	0.030231
	0.146922	0.033522
	0.141916	0.03069
	0.150988	0.028872
	0.188942	0.029322
	0.156671	0.028426
	0.143908	0.028872
	0.133125	0.029774
	0.172155	0.028426
	0.117286	0.031154
30	0.207707	0.042766
	0.304598	0.044416
	0.212538	0.041683
	0.265249	0.039038
	0.233685	0.042223
	0.28599	0.043313
	0.245287	0.038519
	0.250534	0.037492
	0.295937	0.040615
	0.223609	0.03956
50	0.546041	0.064627
	0.534423	0.062634
	0.536351	0.061322
	0.517231	0.063295
	0.563702	0.065973
	0.526748	0.063959
	0.549941	0.067334
	0.542155	0.068019
	0.559753	0.070096
	0.522931	0.068708

For each joule setting, the more joules produced, the more joules remaining. In the defib analyzer there are fewer joules left because the device is both resistive and capacitive, and removal with a 1kΩ resistor results in more joules remaining.

IV. DISCUSSION

Based on the capacitor value measurement data in **Table I**, the results of checking the capacitor circuit (monophasic), the calculation of the energy value (joules) based on a real capacitor is 347uf with the energy formula W=1/2 CV^2, measuring the capacitor voltage according to the charging time and the voltage received by the defibrillator. analyzer, and based on **Table II** the energy measurement results (monophasic) the data is taken 10 times for each setting, then different results are obtained or there is a difference between measurement and calculation, causing the largest error value of 0.023% and the smallest error value of 0.0024% . The permissible tolerance is ±15%, so it can be concluded that the tool is feasible.

The difference in the input voltage produced in **Table III** results of the measurement of the high voltage generator circuit causes different capacitor charging. It is expected that the value of the real capacitor is in accordance with the calculation so that the voltage received by the defibrillator analyzer is in accordance with the energy value (joules) that has been determined.

The remaining charge on the capacitor (monophasic) in **Table IV** describes the discharge with a resistor which is equivalent to the human equivalent of 1kΩ which produces more residual energy charge (joules) compared to the discharge charge with a defibrillator analyzer.

In monophasic waves, the defibrillator analyzer can detect the energy value (joules) well, but it is necessary to pay attention to the capacitor used, and the energy value (joules) must also be calculated so that there is a match between the voltage and the voltage received by the defibrillator analyzer. While in biphasic waves, the measurement of the two capacitors can drain the charge, but this tool is still not perfect because the defibrillator analyzer cannot detect the energy value (joules) of the second capacitor. This condition causes the writer to be unable to collect data. This defibrillator can be used as a learning material, especially in life support laboratories, so that students have sufficient knowledge about working principles, functions, and safety.

V. CONCLUSION

Based on the results of the discussion and the purpose of making the module, it can guarantee that this module can be used as a lesson for Electrical Engineering students, defibrillators can be made with a condenser discharge system only on monophasic waves. Biphasic waves cannot be tested because the defibrillator analyzer cannot detect the energy value (joules) of the discharged capacitor. In producing the appropriate joule energy, it is necessary to calculate the real value of the capacitor. For future research can increase joules, increase the use of drivers that can deliver DC voltage better so that there is no delay when draining DC voltage and, and look for literature studies on components that can create biphasic waves.

REFERENCES

[1] M. Reeson, K. Kyeremanteng, and G. D'Egidio, "Defibrillator Design and Usability May Be Impeding Timely Defibrillation," *Jt. Comm. J. Qual. Patient Saf.*, vol. 44, no. 9, pp. 536–544, 2018.
[2] T. Kaewgun, R. Deepankaew, and N. Thongpance, "Design and construction the low - Cost defibrillator analyzer," in *BMEiCON 2013 - 6th Biomedical Engineering International Conference*, 2013, pp. 1–4.
[3] N. Thongpance, "Implementation of Defibrillator Calibrator for Working Standard," in *International Journal of Applied Biomedical Engineering*, 2017, vol. 10, pp. 24–29.
[4] Joseph D. Bronzino, *Quantitative active dynamic thermal ir-imaging and thermal tomography in medical diagnostics*. 2006.
[5] G. Nichol, M. R. Sayre, F. Guerra, and J. Poole, "Defibrillation for Ventricular Fibrillation: A Shocking Update," *J. Am. Coll. Cardiol.*, vol. 70, no. 12, pp. 1496–1509, 2017.
[6] S. Committee, *IEEE Guide for Safety*, vol. 2000, no. February. 2000.
[7] G. N. Reddy and G. J. U. Reddy, "Effects of Wireless Electricity on Human Bodies," vol. 4, no. 6, pp. 2567–2569, 2013.
[8] Y. Huang, X. Wen, J. Wang, L. Jin, L. Qian, and X. Wu, "Toward Miniaturization of Defibrillators : Design of a Defibrillation Charge / Discharge Circuit," *2019 41st Annu. Int. Conf. IEEE Eng. Med. Biol. Soc.*, pp. 6155–6158, 2019.
[9] C. Y. F. Lee *et al.*, "Singapore defibrillation guidelines 2016," *Singapore Med. J.*, vol. 58, no. 7, pp. 354–359, 2017.
[10] W. Han, Y. Li, R. Zhang, C. Hu, and M. Q. H. Meng, "A new ECG-based automated external defibrillator system," in *Proceedings of the World Congress on Intelligent Control and Automation (WCICA)*, 2010, pp. 2204–2209.
[11] I. Sukma, S. W. Hidayat, and W. Ardiatna, "the Effect of Inductor Resistance on Defibrillation Energy From Electrocardiograph Endurance Test System," *Widyariset*, vol. 3, no. 1, p. 1, 2017.
[12] J. A. Gomes, *Heart Rhythm Disorders*. 2007.
[13] I. Mughnifar, "Bagian – Bagian Dari Jantung – Definisi, Penjelasan Dan Fungsi," 2019.
[14] L. Irawati, "Aktifitas Listrik pada Otot Jantung," *J. Kesehat. Andalas*, vol. 4, no. 2, pp. 596–599, 2015.
[15] Y. U. S. Rendra, "ELEKTRO-KARDIOVERSI PACING," 2017.
[16] M. Hammad, A. Maher, K. Wang, F. Jiang, and M. Amrani, "Detection of Abnormal Heart Conditions Based on Characteristics of ECG Signals," *Measurement*, 2018.
[17] D. M. S. H. A. Permana, "Elektrokardiograf (ekg) berbasis bluetooth," *Fis. Fak. Sains Teknol. , UIN Sunan Gunung Jati Bandung*, vol. 2, no. 1, pp. 38–46, 2015.
[18] F. Pratama, M. Haryanti, and Y. Dewanto, "The Design Defibrillators Based on AT89C51 Microcontroller," 2011, no. July.
[19] M. Amir Maruf, B. Guruh Irianto, and T. Bowo Indrato, "Dc Shock Simulator," *J. Electron. Electromed. Eng. Med. Informatics*, vol. 1, no. 2, pp. 18–24, 2019.
[20] W. B. Nurdin *et al.*, "Identifikasi Karakter Temporal dan Potensial Listrik Statis dari Kompleks QRS dan Segmen ST Elektrokardiogram (EKG) Pada Penderita dengan Kelainan Jantung Hipertrofi Ventrikel Kiri," pp. 1–12, 2011.
[21] O. Kelompok, M. Y. Firmansyah, M. F. F. Syahrir, J. T. Elektro, and B. A. B. I. Pendahuluan, "Tugas elektronika biomedik defibrillator," 2018.
[22] A. J. Camm *et al.*, "Guidelines for the management of atrial fibrillation," *Eur. Heart J.*, vol. 31, no. 19, pp. 2369–2429, 2010.
[23] S. Tanabe *et al.*, "Comparison of outcomes after use of biphasic or monophasic defibrillators among out-of-hospital cardiac arrest patients: A nationwide population-based observational study," *Circ. Cardiovasc. Qual. Outcomes*, vol. 5, no. 5, pp. 689–696, 2012.
[24] S. M. George, J. D. Ferguson, A. W. Weimer, and C. A. Wilson, *Patent Application Publication (10) Pub. No.: US 2004 / 0194691 A1*, vol. 1, no. 19. 2004.

ATTACHMENT

https://drive.google.com/drive/folders/1zj1W8ERPsoDs_D30YeB0IweCeKCo-gAS?usp=sharing