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Research Article

Design and Manufacturing of a Simple Plasma Blood Separator Based on Arduino Uno with Servo Motor Drive

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Abstract : This research aims to design a Plasma Blood Separator that can separate plasma from red blood cells automatical-ly using an Optocoupler sensor and a specimen tube cutter. This sistem is equipped with an Arduino Uno as the microcontroller, a servo motor to clamp the hose, a servo to open the blood bag pressure, a series of push buttons to open the servo, and a buzzer to indicate the completion of separation After testing the Arduino Uno-based Plasma Blood Separator, all functions can work well by showing the results of three experiments that varied the length of the hose. The length of the hose that was varied was 30 cm, 50 cm, 70 cm. The estimated separation time was 20 seconds, 30 seconds, and 40 seconds for mode 1, The estimated separation time was 40 seconds, 60 seconds, and 80 seconds for mode 2, In the results of the measurement of the voltage of the tool, the measurement results were obtained with a small percentage of error with a value of <5% and a high accuracy value with >90%.

Keywords: arduino, microcontroller, Optocoupler sensor, plasma blood, separator

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1. Introduction

Blood plasma is a clear yellow fluid that is an important component of human blood. Blood plasma contains various nutrients, hormones, proteins, and other substances needed by the body to carry out various functions. In addition, blood plasma also contains blood clotting factors, so it is very important in the blood clotting process that allows the body to stop bleeding in the event of a wound or injury.

In the world of health, blood plasma plays an important role in medical procedures, including blood transfusions, immunoglobulin therapy, and the treatment of various diseases (Weltman, 2012). Blood plasma is also used to make plasma products, such as albumin, clotting factors, and immunoglobulins. In medical procedures, blood plasma can be used to detect the presence of viruses, bacteria, and certain harmful chemicals. In addition, blood plasma can also be used for blood transfusions and to obtain important materials such as enzymes, proteins, and hormones (Drew,2017).

The importance of blood plasma in the world of health can be seen from the increasing demand from patients who need blood transfusions and other plasma products. Therefore, the development of technology and tools that can facilitate the separation of blood plasma from red blood cells is very important (Robert, 2019). Therefore, in this study, a blood plasma separator will be designed that uses an Optocoupler sensor to differentiate blood from blood plasma. Optocoupler is a type of sensor that can detect the presence of light produced by blood plasma when passing through infrared light. By using an Optocoupler as a sensor, it is expected that the blood plasma separation process will be faster and more efficient, and safer for blood plasma components. Currently, there are still many manual blood plasma separators used, namely by using a lever that is pressed by hand so that it is inefficient and unhygienic (Vemulapati,2019). The development of technology and tools that can facilitate the separation of blood plasma from red blood cells is very important. Therefore, in this study, a blood plasma separator will be designed that uses a DC motor and an optocoupler sensor to differentiate blood from blood plasma. Blood plasma donors can be used for patients with albumin disorders, such as burn patients, trauma patients, or patients who have just undergone surgery (Prabhu, 2020). By utilizing optocoupler sensor technology as a blood plasma differentiator, it is expected to produce a more effective, efficient, and cost-effective blood plasma separator. In addition, this tool is expected to help improve the quality of health services, especially in the process of blood transfusion and treatment of diseases related to blood plasma components (Yu Zen, 2012). Therefore, to improve the quality of health services, the author intends to submit a research title Development of Smart Blood Plasma Separator as a Supporting Tool for Blood Plasma Donors for Handling Albumin Disorders in the Body. Therefore, the development of technology and tools that can facilitate the separation of blood plasma from red blood cells is very important (Gonzales, 2025).

Research on blood plasma separators has previously been carried out by researchers published in reputable international journals, including: Localized surface plasmon resonance (LSPR) biosensor based on thermally annealed silver nanostructures with on-chip blood-plasma separation for the detection of dengue non-structural protein NS1 antigen, using the Design method Using a Localized surface plasmon resonance (LSPR) biosensor and annealing in a nanostructure with the results can detect dengue fever with a high percentage The design of this tool is complicated and accompanied by annealing treatment that requires a lot of power. Furthermore, Blood Cells Separation and Sorting Techniques of Passive Microfluidic Devices: From Fabrication to Applications, Using the Design of a microfluidic filter in separating blood plasma and red blood cells. The separation process on a cellular scale with high accuracy. The design of a microfluidic membrane requires expensive equipment and the blood plasma separation process takes a long time. By utilizing Optocoupler sensor technology as a blood and blood plasma differentiator, it is expected to produce a more effective, efficient, and cost-effective blood plasma separator. In addition, this tool is expected to help improve the quality of health services, especially in the process of blood transfusion and treatment of diseases related to blood plasma components. Therefore, to improve the quality of health services, the author intends to submit a research title "Design and Construction of Arduino Uno-Based Blood Plasma Separator". From this review, the author intends to redesign the Plasma Blood Separator tool with a working principle using a DC Gearbox motor and equipped with two servo motors as hose clamps which will later make it easier for users to cut the hose so that it is more efficient. Researchers also use batteries equipped with charger modules on the tool so that it is easy for users to carry or use the tool when the electricity goes out or there is a lack of space for electrical outlets in the room.

2. THEORETICAL STUDY

Supporting Theory

Blood Plasma

Blood plasma is a part of blood that tends to be forgotten. In fact, the role of blood plasma in body functions is no less important than red blood cells, white blood cells, and platelets. Blood plasma is a clear yellow liquid that is an important component of human blood (Garcia,2017). Blood plasma contains various nutrients, hormones, proteins, and other substances needed by the body to carry out various functions. In addition, blood plasma also contains blood clotting factors, so it is very important in the blood clotting process that allows the body to stop bleeding if there is a wound or injury. In the world of health, blood plasma plays an important role in medical procedures, including blood transfusions, immunoglobulin therapy, and the treatment of various diseases. Blood plasma is also used to make plasma products, such as albumin, clotting factors, and immunoglobulins.

Figure 1 Blood Plasma.

Blood Plasma Extractor

A Blood Plasma Extractor is a tool used to separate blood plasma from red blood cells and white blood cells in a blood sample. This separation process is done by placing the blood bag on the clamp then the officer applies pressure so that the blood plasma can be extracted.

Figure 2 Blood Plasma Separator.

The separation of blood plasma from blood cells has many uses in the medical and health fields, such as to make convalescent plasma as a therapy to treat certain diseases, process blood products, and separate materials needed in research or medical diagnostics. A blood plasma extractor can be one of the tools used in the separation process (Fitzpatrick, 2017).

Servo Motor

A servo motor or commonly called a servo motor is a simple electric motor that is controlled using the help of a servo mechanism. Servo motors have been around for a long time and are used in many applications, for example, they are used in operating robots, toy cars or airplanes that are controlled remotely or via radio, in addition, servo motors are also used in industry, pharmaceuticals, in-line manufacturing, robotics and food service (Haliciouhu,2016).

Figure 3 Servo Motor.

Servos are controlled by sending electrical pulses with variable width, or commonly called Pulse Width Modulation (PWM) through the control cable. There is a minimum pulse, maximum pulse, and repetition rate. Servo motors can usually only rotate 90° in any direction with a total movement of 180°. The neutral position of the motor is defined as the position where the servo has the same amount of potential rotation in both directions clockwise or counterclockwise. The PWM sent to the motor will determine the position of the shaft, and based on the duration of the pulse sent through the control cable, the rotor will rotate to the desired position. Servo motors are required to be able to see pulses every 20 milliseconds (ms), where the length of the pulse will determine how far the motor rotates.

For example, a 1.5ms pulse will cause the motor to rotate to a 90° position. If it is shorter than 1.5ms, the motor will move counterclockwise to the 0° position, and if it is longer than 1.5ms it will change the servo rotation to the clockwise direction to the 180° position

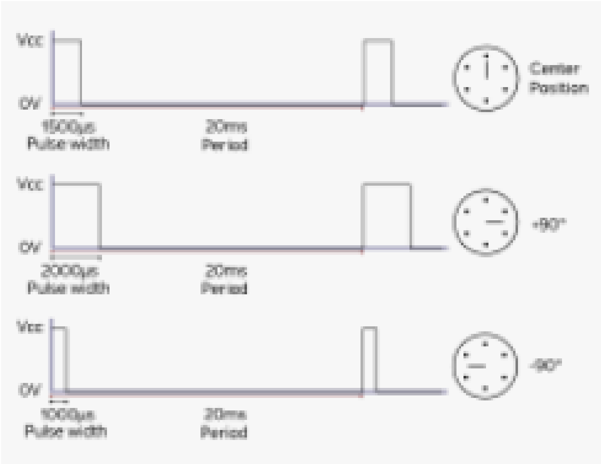

Figure 4 Servo Motor Pulse.

When this servo is ordered to move, it will move and stay in that position. If the servo is forced to move from a rest position, the servo will refuse to move outside of that position. The maximum amount of force that can be provided by the servo is called the servo torque level. The servo will not stay in that position forever, so the position pulse must be repeated to instruct the servo to stay in position.

3. RESEARCH METHODS

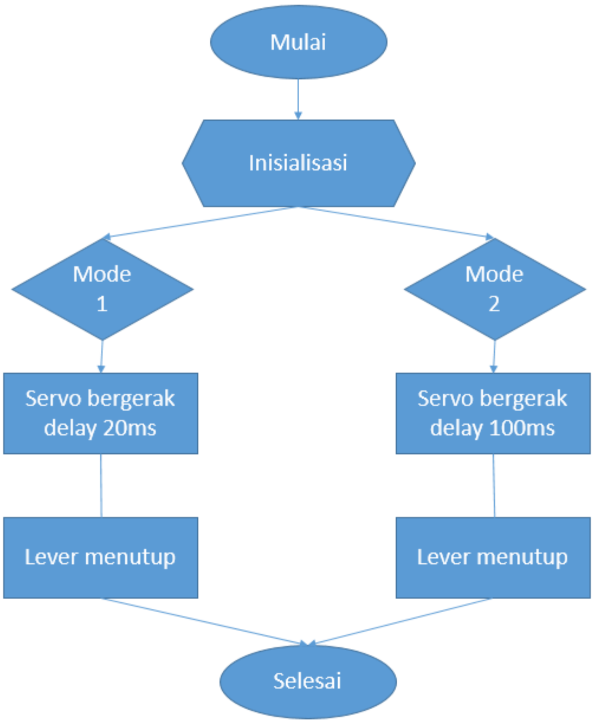

Figure 5 Tool Flowchart.

The following is a picture above of the tool flow diagram that the researcher used, which is explained in the flowchart above.

Tool Block Diagram

Figure 6 Block Diagram of the Tool.

4. RESULTS AND DISCUSSION

Results of measurement points (TP1)

In this measurement, 9 batteries were used with a voltage output of 3.6 V which were arranged in series and parallel to produce a total voltage of 10.8 V. With battery details as shown in Figure 7 as follows.:

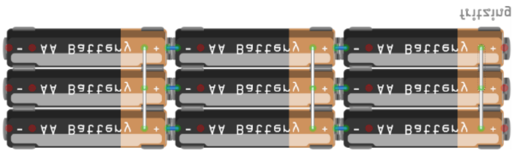

Figure 7 Battery Circuit.

In a series circuit, the total voltage of the batteries connected in series will be the sum of the voltages of each battery. While in a parallel circuit, the total capacity of the batteries connected in parallel will be the sum of the capacities of each battery. In a parallel circuit, the voltage will remain the same on each battery, but the capacity (mAh) will be added. In one parallel circuit, the voltage is 3.6 V, referring to the explanation that has been presented so that it only counts the number of series circuits. So it can be calculated using the following calculation:

Total voltage = 3.6 + 3.6 + 3.6

Total voltage = 10.8 V DC

Measurements were made at a battery voltage of 10.8 V. Measurements were made using a digital multimeter. After measuring three times, the average value was taken. The results of the TP1 measurements can be seen in table 1 below.

Tabel 1 TP1 measureme	Tegangan Baterai (Volt)	Rata-rata	Datasheet (Volt)
1	10,96		
2	10,71	10,76	10,8
3	10,63		

Error% = 0.3%

To find out the accuracy value of the measurement, the author made the following calculations:

Accuracy% = 100% - Error% Accuracy% = 100% - 0.3%

Accuracy = 99.7%

The measurement results from TP1 show that the percentage of error is 0.3% and the accuracy value is 99.7%. These results are obtained from the formula above so that the battery is in good condition. Analysis of the results of the battery in good condition refers to the battery datasheet.

Measurement Point Results (TP2)

Measurements are made on the adapter output voltage. Measurements are made using a digital multimeter. Measurements are made three times to take the average value. The measurement results can be seen in the following table 2.

Table 2 TP2 Measurement.

Data Ke-	Tegangan (Volt)	Rata-rata (Volt)	Datasheet (Volt)
1	12		
2	12,08	11,9	12
3	11,9		

Error value = 0.05%

To find out the accuracy value of the measurement, the author made the following calculation:

Accuracy% = 100% - Error% Accuracy% = 100% - 0.05%

Accuracy = 99.95%

The measurement results from TP2 show that the error percentage is 0.05% and the accuracy value is 99.95%. These results are obtained from the formula above and the adapter is in good condition.

Measurement Point Results (TP3)

This measurement was carried out on the output of the step-down module which is connected as a circuit supply. measurements were carried out 3 times to take the average value. The measurement results can be seen in the following table 3.

Table 3 TP3 Measurement.

Data Ke-	Tegangan (Volt)	Rata-rata (Volt)	Datasheet (Volt)
1	4,7		
2	4,89	4,83	5
3	4,9		

Error Value = 3.4%

From the calculation results, it can be concluded that the step-down module is categorized as being in good condition referring to the accuracy value, where if the accuracy value has a value of >90%, the results can be categorized as good.

Blood plasma separation time estimation test

This test is to measure the time needed by the plasma blood separator to separate plasma and blood. Time testing is carried out using a stopwatch. In this test, the author used a 350 ml blood bag for testing.

Table 4 Testing Mode 1

No	sampel	Variasi Panjang selang	waktu
1	Sample 1	30 cm	20 detik
2	Sample 2	50 cm	30 detik
3	Sample 3	70 cm	40 detik

Table 5 Testing Mode 2.

No	sampel	Variasi Panjang selang	waktu
1	Sample 1	30 cm	40 detik
2	Sample 2	50 cm	60 detik
3	Sample 3	70 cm	80 detik

All functions can work well, from the control button to the sensor reading. In other tests, a time estimation test was also carried out using a hose with varying lengths. The results in table 8 show that the longer the distance between the blood bag and the sensor, the more time is needed to separate the blood plasma.

5. Conclusions and Suggestions

After testing the Arduino Uno-based Plasma Blood Separator, all functions can work well by showing the results of three experiments that varied the length of the hose. The length of the hose that was varied was 30 cm, 50 cm, 70 cm. The estimated separation time was 20 seconds, 30 seconds, and 40 seconds for mode 1, The estimated separation time was 40 seconds, 60 seconds, and 80 seconds for mode 2, In the results of the measurement of the voltage of the tool, the measurement results were obtained with a small percentage of error with a value of <5% and a high accuracy value with >90%.

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