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A Negative Pressure for Thoracic Suction Pump

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Abstract

Thoracic Suction Pump is a medical device used in the medical world to carry out the action of sucking fluid in the thorax cavity, then the liquid that has been sucked will be accommodated in a vacuum tube. Thoracic Suction Pump this model uses a DC voltage motor that is controlled by a motor driver by giving Pulse width modulation that comes from a minimum system circuit. In the use of this tool, the compiler uses 4 pressure selection modes, namely -5, -10, -15, and -20 kPa which is done by pressing the Push button Up and Down for selection of pressure. After the pressure is selected, the pressure value will appear on the 2 x 16 LCD display. This study used a pre-experimental type with One group post-test design research design. After measurements and calculations are obtained the results of the pressure values are read by the MPXV4115V sensor which is obtained the biggest error at maximum pressure with the setting of -10 obtained an average value of 2.78% error, in the -5 setting obtained an error value of 2.70%, in the settings -20 obtained an error value of 1.59%, and the smallest error in the setting of -15 obtained an error value of 1.09%. For the minimum pressure error, the biggest error value with the setting of -10 is 0.33% error, the setting of -15 is 0.20%, the error-setting is 0.19%, and the smallest error is set - 20 obtained an error value of 0.18%.

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I. INTRODUCTION

Suction Pump is a medical device that functions to remove fluids from the human body by suctioning or suctioning. This tool generally consists of several parts including the engine, vacuum hose, and tube. Suction Pump [1] is widely used in Clinics and in Hospitals for various purposes such as during the operation process, for handling patients with respiratory disorders caused by mucus and many others. Thorax is a cone-shaped cavity, at the bottom larger than the top and at the back longer than the front. The chest cavity contains the lungs and mediastinum. Inside the [2] chest cavity there are several systems including the respiratory and circulatory systems. Respiratory organs located in the chest cavity, the esophagus, and lungs, while in the circulatory system, namely the heart, blood vessels and lymph channels. The blood vessels in the circulatory system consist of arteries that carry blood from the heart, a vein that carries blood to the heart and capillaries, which are the roads of food and waste.

Pleura is a serous membrane that covers the lung parenchyma, mediastinum, diaphragm, and ribs; consists of visceral pleura and parietal pleura. The pleural cavity is filled with a certain amount of fluid that separates the two pleura, allowing the movement of both pleura unhindered during the process of respiration. Pleural fluid originates from the pleural capillary vessels, pulmonary interstitial space, intrathoracic lymph nodes, intrathoracic vessels, and peritoneal cavity. The amount of pleural fluid is influenced by the difference in pressure between the pleural capillaries and the pleural cavity according to Starling's law and the ability to eliminate fluid by the lymphatic pleural system of the parietal pleura.

Pleural pressure [3] is a mirror of pressure inside the thoracic cavity. The difference in pressure caused by the pleura plays an important role in the process of respiration. Pleural disease [4] is very common, almost 3,000 of a million human populations experience this disease which has a significant impact due to respiratory problems. The pleural disease has a broad scope in the field of pathological systems using further measurement and research. For that, further medical treatment and treatment is needed. Suction to [4] helps pleural drainage before and after pleurodesis is usually not needed but, if applied, a low-pressure system is recommended Subscription for airway obstruction due to accumulation of secretions in the Endotracheal Tube is by taking suction by inserting a catheter hose. However, if the suction action is not done properly, the patient will experience a lack of oxygen supply "hypoxemia"). Complications that[5] often occur due to suction are the occurrence of hypoxemia, the effect of the occurrence of hepoxemia will cause a state of hepoksia, where patients who are in critical condition coupled with the incidence of hepoksia will worsen the patient's condition.

Breath failure occurs when the exchange of oxygen to carbon dioxide in the lungs cannot maintain the rate of oxygen consumption (O2) and the formation of carbon dioxide (CO2) in the body's cells. This results in an arterial oxygen pressure of less than 50 mmHg (Hypoxemia) and an increase in carbon dioxide pressure greater than 45 mmHg (Hypercapnia). Even though the progress of the diagnosis and intervention therapy techniques has developed rapidly, respiratory failure is still the cause of morbidity and mortality. high in intensive care.

Where as [6] for the suction pressure in the maximal thoracic cavity is -20kPa to protect soft tissue in suction surgical wounds.

Suction Pump[7] was previously made by Siti Muthmainnah and YundaWulandari (in 2010) with Rinsing and Nebulizer. The virtue of this model Suction Pump is that with Rinsing there will be automatic washing of the Suction Pump tube, making it easy to clean the Suction Pump tube after being filled with liquid. Furthermore,[1] it has been developed by Fahim Umar Djawas (in 2017), namely the Continuous Automatic Suction Pump equipped with Microcontroller-based Safety where the device is fully operational, the tool will move to the next tube, when the next tube is also full the tool will turn off automatically. In 2018,[8] the engine pump transport was also made by M. HilmiNaf'an where the equipment was specifically for ambulances, evacuation of helicopters, aircraft, evacuation of drowned people and others. But the tool has a weakness that is only used for first aid. Based on the results of the identification of problems from several suction pumps that have been made before, this time the author makes a Thoracic suction pump, in which the suction pump is used to absorb pleural fluid in the thoracic cavity.

II. MATERIALS AND METHODS

A. Research Design

This study uses the Digital Pressure Calibrator with the Ametek brand as data retrieval. The researcher took data 6 times to 6 respondents.

1) Tools and Materials

This study uses an Mpx4115 sensor as a negative pressure reading and uses Mosfet as a motor driver and solenoid valve as a pressure drop. Display on this tool using LCD.

2) Tools and Materials

In this study, after the design was finished, the results of the reading of the Mpx4115 sensor were tested. The reading results are compared by comparison to determine the measurement results.

B. Diagram Block

In this study, the Mpx4115 sensor performs a negative pressure reading, then the data is processed using Atmega 328 which will then be displayed on the LCD.

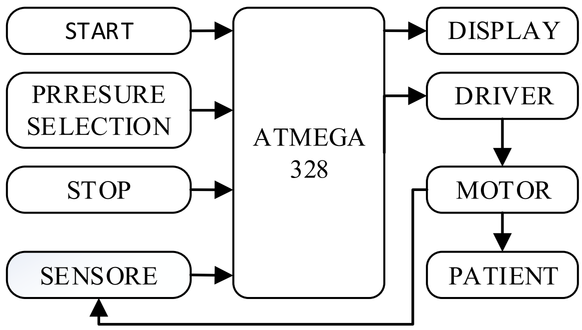

Fig. 1. Blok Diagram

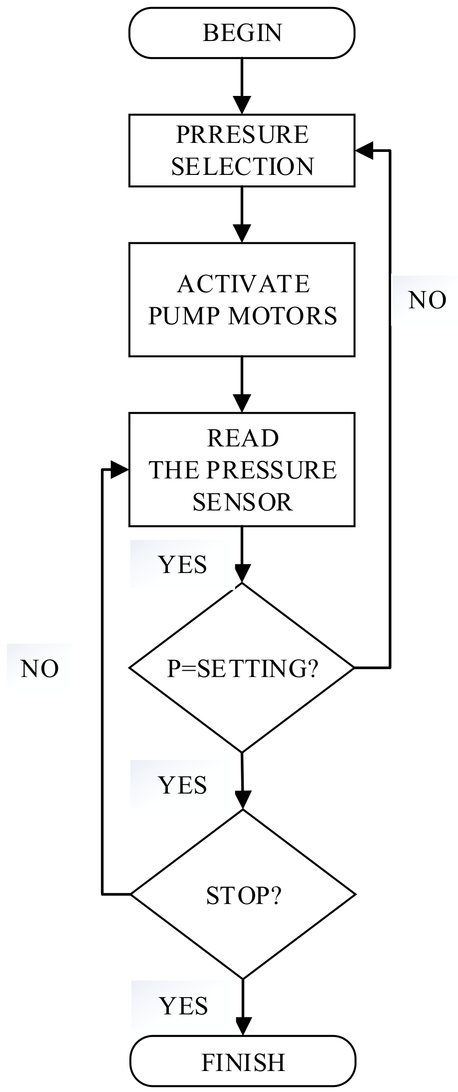

Fig. 2. Flowchart

The power supply provides voltage to all blocks so that all the circuit blocks work. then in the input block, there is a selection of starters, up, down, stop which has a different function. To start it functions to execute commands that have been set, function up, and down to select the mode to be selected, while the stop button functions to stop the command.

For the process block, there is an Atmega 328 microcontroller which functions to control all circuit blocks. The output of the microcontroller is the driver whose function is to drive the motor, after the motor moves it produces suction power and pressure, then from the motor output will be read by a pressure sensor, the pressure sensor has a pressure reading function, the results of the sensor data are processed into the microcontroller after processed then the results of the microcontroller are displayed to the LCD display.

C. The Flowchart

When the switch is ON then the appliance turns on and the next process will start, then the pressure level is selected, the selector is at -5, -10, -15, and -20 kPa, when the pressure level is selected then press the start button to start the motorbike, the motor pump is active, After the start button is pressed, then the motor will give negative pressure then the sensor will read the negative pressure on the motor pump and the results of the readings from the sensor are then displayed to the LCD. If you want to change the pressure level, select the pressure selection again, after the selection of the pressure has just been chosen, the pressure on the motor pump will change according to the pressure selected, the tool will continue to operate as long as the stop button is not pressed.

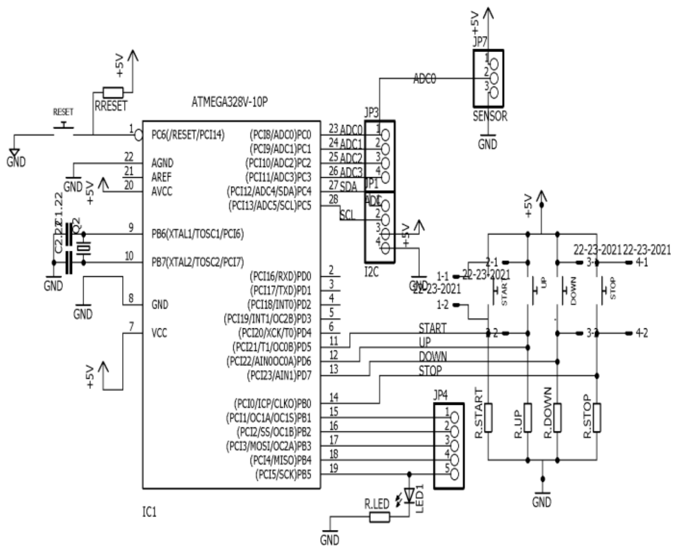

Fig. 3. Minimum System

1) Minimum System

The minimum circuit module of the system can work if given a voltage of 5 vdc and ground, the microcontroller ic used is atmega 328 to enter the program requires a rx, tx, dtr, and reset connection, on port D 5, 6, 7, and port B 0 connected by push start, up, down, and stop buttons. the mpxv4115v pressure sensor is connected by port C - a0, and the display is connected to port C 4 - sda and port C 5 - scl, on port D 3 connected to the motor driver.

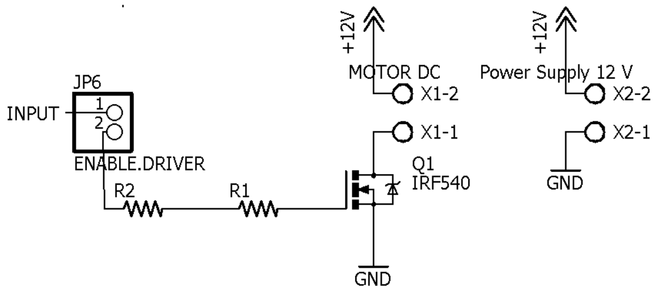

Fig. 4. Driver Motor

2) Driver Motor

The Driver circuit module Using the MOSFET the module requires a 12-volt input voltage that enters the drain, the gate is connected to the port D to be controlled, and the source is connected to the ground.

Fig. 5. Modul.

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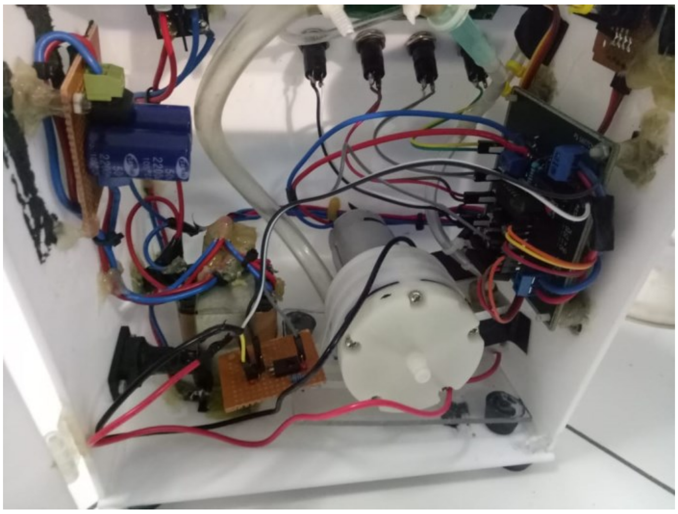

Fig. 6. Circuit Modul

Listing program 1.Program to sensore Mpx4115

```
int sensor = analogRead(tekanannegatif);
float tegangansensor = (sensor*5.0/1023)*1000;
kPa = (teganganawal-tegangansensor)/38.26;
Serial.print(tegangansensor);
unsigned long currentMillis2 = millis();
if (currentMillis2 - previousMillis2 >= interval2)
{
   previousMillis2 = currentMillis2;
lcd.setCursor(8, 1);
lcd.print(-kPa,0);
lcd.print(" kPa    ");
}
```

3) The Listing Program for Sensor Mpx4115v

This program is used to see the results of negative pressure "intsensor = analogRead (negative pressure);" to read sensors on analog pins, "float voltage sensor = (sensor * 5.0 / 1023) * 1000;" the result of sensor value multiplied by 5.0 divided by 1023, value 5.0 obtained from the maximum voltage value of 5 volts and divided by the ADC value and at 1000 times.

"KPa = (voltage voltage sensor) /38.26;" the initial voltage is obtained from the voltage obtained at the supply, minus the sensor voltage obtained from the float sensor voltage, then divided by 38.26, value 38.26 obtained from the negative pressure value with units of kPa which is converted to voltage with units of mV. "Lcd.setCursor (8, 1);" is the location of coordinates that displays the results of the program, "LCD.print (-kPa, 0);" is a command that displays the results of the program.

Listing Program 2. Program to motor driver settings

```
int sensor = analogRead(tekanannegatif);
if (kPa<=tekanan&&kondisimotor==1)
     {
analogWrite(pinPWM,tekananmotor);
     //delay (1000);
     }

 else if (kPa>=tekanan&&kondisimotor==1)
     {
analogWrite(pinPWM,0);
     }
if (buttonUp2 == HIGH)
  {
   delay (200);
   Mode++;
  }
  if (buttonDown3 == HIGH)
  {
   delay (200);
   Mode--;
  }
  if (buttonStart1 == HIGH)
  {
   //delay (2000);
kondisimotor=1;
  }
if (buttonStop4 == HIGH)
  {
   //delay (2000);
kondisimotor=0;
analogWrite(pinPWM,0);
  }
if (Mode == 1)
  {
lcd.setCursor(0, 1);
lcd.print("-5    =-");
tekananmotor=75;
tekanan=5;
  //delay (1000);
  }
  if (Mode == 2)
  {
lcd.setCursor(0, 1);
lcd.print("-10   =-");
tekananmotor=100;
tekanan=10;
  }
if (Mode == 3)
  {
lcd.setCursor(0, 1);
lcd.print("-15   =-");
tekananmotor=130;
tekanan=15;
```

```
  }
   if (Mode == 4)
  {
lcd.setCursor(0, 1);
lcd.print("-20   =-");
tekananmotor=160;
tekanan=20;
  }
```

4) The Listing Program for Motor Driver Setting

In the.This program is to control motor drivers with PWM, "if (kPa <= pressure &&condimotor == 1) junction less than the pressure set then the motor condition is active," analogWrite (pinPWM, motor pressure); "and PWM is active. "Elseif (kPa> = pressure && motor condition == 0)" if the pressure is not more than the pressure set then the motor condition is not active. "AnalogWrite (pinPWM, 0);" and PWM are also not active.

"If (buttonUp2 == HIGH)" if the Push Button Up is tipped then it will make a pressure selection, "if (buttonDown3 == HIGH)" if Push Button Down is pressed then it will make a selection, "if (buttonStart1 == HIGH)" if Push The Start Button is pressed, it will execute the command to activate the motor, "if (buttonStop4 == HIGH)" if the Push Button is pressed it will execute the command not to stop the motor.

"If (Mode == 1) motor pressure = 75; "If mode 1 is selected then activate the motor and provide PWM with 75 pulses," if (Mode == 2) motor pressure = 75; "if mode 2 is selected then activate the motor and provide PWM with 100 pulses," if (Mode == 3) motor pressure = 75; "if mode 3 is selected then activate the motor and provide PWM with 130 pulses," if (Mode == 4) motor pressure = 75; "if mode 4 is selected then activate the motor and provide PWM with pulses of 160.

TABLE I. THE ERROR OF MEASUREMENT FOR PRESSURE BETWEEN THE DESIGN AND CALIBRATOR.

Modul Setting (kPa)	Maximum Pressure Error	Minimal Pressure Error
-5	2,70 %	0.19 %
-10	2,78 %	0.33 %
-15	1,09 %	0.20 %
-20	1,59 %	0.18 %

The biggest error at maximum pressure with the setting of -10 is obtained by the result of 2.78% error in the -5 setting obtained by the error value of 2.70%, in the -20 setting the result is an error value of 1.59%, and the smallest error in setting -15 obtained the result of error value 1.09%.

At the minimum pressure the biggest error value obtained with the setting of -10 is obtained by the results of the error value of 0.33%,%, in setting -15 the results of the error value 0.20%, the setting of -5 is the result of error value 0.19% 12 results with an error of 0.18%.

III. DISCUSSION

The measurement results for the calibrator are obtained from measuring the module output which is connected with the Ametek Brand Digital Pressure Calibrator as its calibrator and it can be concluded that the measurement results in the module are compared with the comparison device, the maximum error with the setting of -10 results in an uncertainty value of 0.08 with 2.78% error, in the -5 setting the result is an uncertainty value of 0.05 with an error of 2.70%, in the setting of -20 the result is an uncertainty value of 0.17 with an error of 1.59%, and the smallest error in the setting - 15 the result is an uncertainty value of 0.11 with an error of 1.09%.

For the minimum pressure error, the biggest error value with the setting of -10 is obtained with the result of an uncertainty value of 0.05 with 0.33% error, in setting -15 the result of uncertainty value is 0.02 with error 0.20%, in setting -5 the uncertainty value is 0.10 with error 0.19% and the smallest error in the setting of -20 results in an uncertainty value of 0.12 with an error of 0.18%.

IV. CONCLUSION

Overall this research can be concluded that: It can be concluded that the measurement results in the module are compared with the comparison tool, the biggest error at maximum pressure with the setting of -10 is obtained by the uncertainty value of 0.08 with an error of 2.78%, in the setting of -5 the resulting uncertainty value is 0.05 with 2.70% error, in the -20 setting, the resulting uncertainty value is 0.17 with an error of 1.59%, and the smallest error in setting -15 is the result of an uncertainty value of 0.11 with an error of 1.09%. For the minimum pressure error, the biggest error value with the setting of -10 is obtained with the result of an uncertainty value of 0.05 with 0.33% error, in setting -15 the result is an uncertainty value of 0.02 with a 0.20% error, at the setting of -5 the result is an uncertainty value of 0.10 with a 0.19% error, and the smallest error in the setting of -20 is obtained by an uncertainty value of 0.12 with an error of 0.18%.

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