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Electrosurgery Unit Monopolar Equipped with Cutting and Coagulation Function

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Abstract— Electrosurgery Unit is a medical device that utilizes high frequency and voltage used to cut and dry tissue during the surgical process. The purpose of making this tool is to damage certain body tissues by heating the tissue. Heat is obtained by concentrating high-frequency electricity on certain body tissues using active and passive electrodes as a medium. The Electrosurgery Unit involves the use of the CMOS 4069 IC as a frequency generator. The output frequency is set at 300 kHz then forwarded to the pulse regulating circuit and controlled with IC atmega328 then forwarded to the inverter circuit which functions to increase the voltage and output in the form of power. The module is calibrated using Electro Surgery Unit (ESU) Analyzer. This module is equipped with LOW, MEDIUM, HIGH. After the measurements are made, the more load is given higher to the tool, the higher the power released by the tool in each power selection. Then the loaded relationship and the power released are directly proportional. This ESU was made so that during the surgical process the body's tissue does not experience a lot of blood loss. Besides being able to use it for surgery, it can also be used to close the tissue after surgery.

Keywords— Electrosurgery Unit; Frequency; Body Tissue; Power

I. INTRODUCTION

Electrosurgery is [1] a medical-surgical device that utilizes the high frequency of electric currents used to cut, thicken, and dry tissues. By using this tool, it is expected that during the operation process, the patient will not experience a lot of blood loss because this tool can be used to perform surgery and can also be used to close the tissue after surgery. The advancement in technology makes electrosurgical become mandatory to be used during the surgical process. An electric scalpel [2] is a tool used for minor surgery in surgery, because of its ability to dissect and burn tissues at the same time, thereby reducing bleeding during surgery. An electric scalpel uses the principle of electric charge jumping in tissue surgery, or electrode contact with tissue is not needed. With the effect of jumping electrons that burn the tissue, the results of surgery will be more sterile. Through understanding [3] the output characteristics of electrosurgery will allow surgeons to be more effective in varying the power output of the device so that the power selection settings will not have an effect or negatively affect the network effect. Almost all electrosurgery has a means by which the output settings in watts can be controlled or regulated.

This ESU tool was made by Dhesy Kusumawati in 2005 with the title "Electric Surgery", the tool still has a disadvantage in the selection of modes, namely only cutting. Furthermore, the tool was developed by Much. Sufi Kurniawan in 2006 with the title "Design and Implementation of Mini Electro Surgery Unit Based on AT89S51 Microcontroller (oscillator and electrode safety)", but this tool is not equipped with power selection. Based on the results of the identification of the problem above, the author will make a tool "Electrosurgery Monopolar UNIT (Cutting and Coagulation) with the selection of power displayed to the character LCD and change the system to Arduino.

II. MATERIALS AND METHODS

A. Experimental Setup

This study uses a 300 kHz input frequency with a 100% duty cycle for 6% cutting mode on 94% off for coagulation mode. The power settings used are low, medium, high. The media used is meat.

1) Materials and Tool

This research uses CMOS CD 4069 IC as a high-frequency generator, MOSFET driver circuit as a type AB current amplifier, ferrite transformer as voltage booster. Atmega 328 IC is used as a microcontroller to regulate PWM output and power selection. Digital Oscilloscope (Textronic, DPO2012, Taiwan) is used to measure frequency. Electrosurgery Analyzer (Fluke, RF303, USA) is used for power output calibration

2) Experiment

In this study, after the entire series was completed and measured the frequency using an oscilloscope the power output of the tool was calibrated using the ESU Analyzer.

B. The Diagram Block

The switch is pressed, the input voltage from the PLN to the switch to activate the DC power supply, then the entire circuit will get a voltage from the DC supply. The input comes from the footswitch which functions as a switch for surgery with cutting and coagulation modes with the buzzer indicator beeping in addition to using the push button found on the handpiece. Next up and down buttons that function as a power regulator on cutting and coagulation. Through the microcontroller, the power settings are set according to what we want and will then be displayed on the character's LCD display for cutting and coagulation mode power selection. Next, to set the pulse or duty cycle in cut and coagulate mode, there is a pulse control block that is crawled through the microcontroller. The cutting duty cycle is 100% on coagulation duty cycle which is 6% on).

Because the surgical process uses high frequencies and has been determined, there is a block of generator circuits that produces high frequencies, namely the oscillator. From the oscillator block then enter the pulse regulating block and it will be processed on the driver block that has been made the previous power setting. Then after the problem with the driver block, it will enter the ferrite transformer circuit. Ferrite transformers on the upper block function as a voltage to increase the output of the driver. Then the output of the ferrite transformer will enter the passive electrode and can be used for the surgical process.

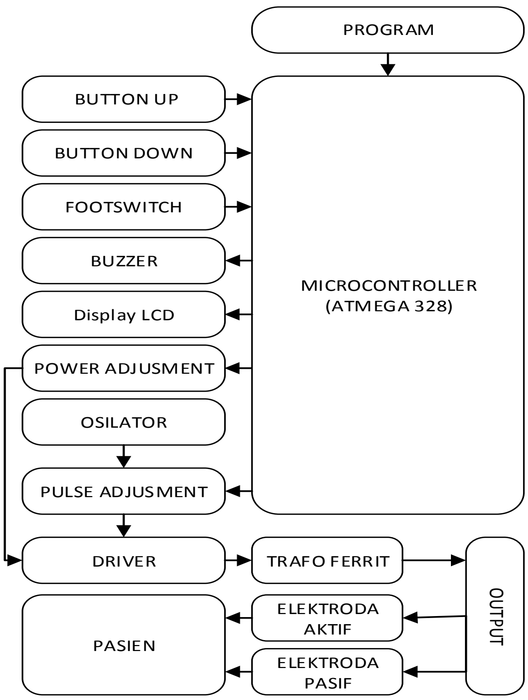

Fig. 1. The diagram *electrosurgery unit*

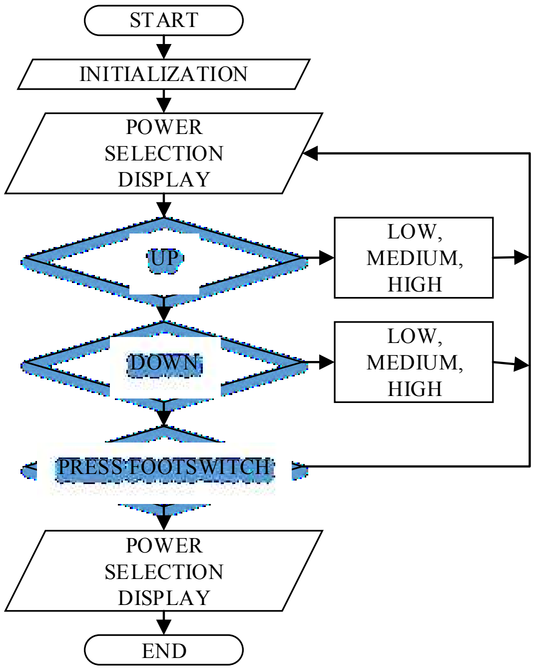

Fig. 2. The Flowchart of the Arduino Program

C. The Flowchart

The Arduino program runs like a flowchart 2. The program starts from the microcontroller initialization, then on the LCD Character, there is power selection for cutting and coagulation. When pressed the up or down button then LCD will display the selection of high, medium, or low power.

D. The Analog Circuit

The important thing in making this module is the schematic circuit as shown in Fig. 3 (microcontroller), Fig. 4 (instrumentation amplifier). The circuit is used to process analog data into digital data. Data will be processed using Arduino.

1) Microcontroller

Microcontroller circuit as shown in Fig. 3 uses Atmega328 as a Microcontroller IC. The microcontroller circuit is used to control the selection of high, medium and low power and is used as PWM processing to determine cutting or coagulation. The microcontroller pin used for PWM is pin D6. PIN D0 on the microcontroller is used to control the relay cutting, while pin D0 is used to control the coagulation relay. Footswitch gives commands on Pin ADC0 and ADC1 to choose cutting or coagulation. Pin D2 and pin D4 are used for the power selection button in cutting mode. Pin D7 and pin D8 are used for the power selection button in coagulation mode. Pin D10 and pin D11 are used to adjust cutting and coagulation through a footswitch. D3 pin is used to adjust the buzzer.

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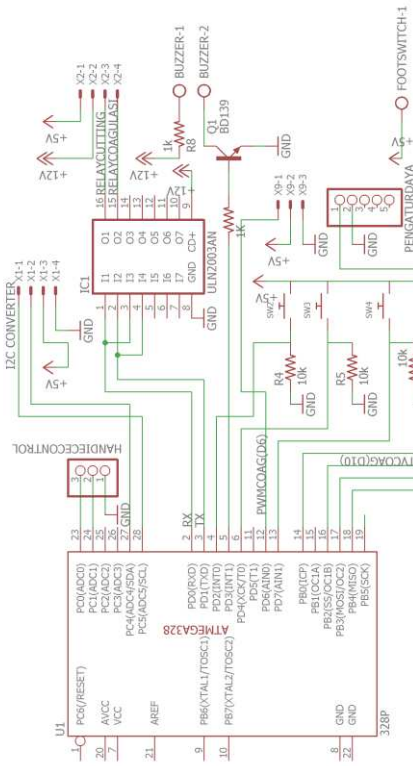

Fig. 3. Microcontroller

2) Oscillator

The 300 Khz oscillator circuit is the main pulse generator that works continuously. In this design, the author uses the NOT gate with the CMOS CD 4069 IC as a high-frequency generator that will be used in this unit monopolar electrosurgery aircraft. The high frequency used is 300 kHz. This credit is in the form of a square / square pulse. The oscillator circuit with the NOT gate is also called the Schmitt Trigger. The output is rectangular pulses with output conditions switching from high to low and returning to high conditions, and so on.

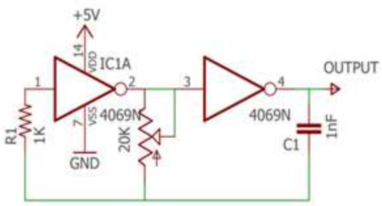

Fig. 4. Oscillator

3) Pulse Regulator Circuit

The pulse regulating circuit is a series that serves to regulate the shape of a continuous main pulse of 100% on cutting and the original continuous shape is not continuous because it is cut by pulses with a duty cycle of 94% off 6% on coagulation.

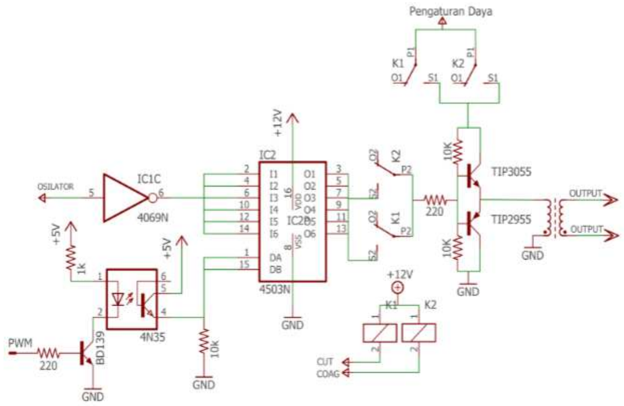

Fig. 5. Pulse Regulator Circuit

4) Power Regulator Circuit

The power regulator circuit is a circuit that functions to regulate the output frequency amplitude of the transformer. With the LM2907 IC as a frequency converter to voltage. The frequency is controlled through a microcontroller circuit.

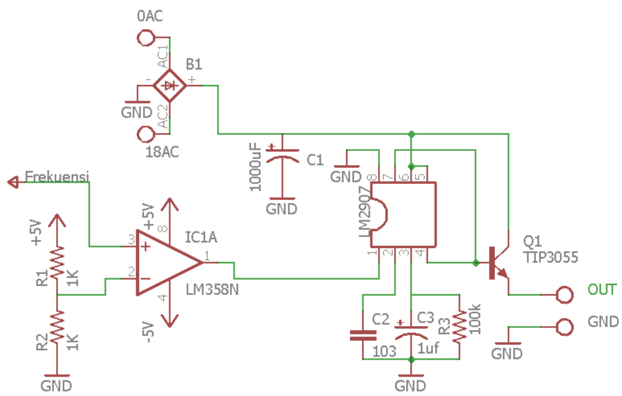

Fig. 6. Power Regulator Circuit

5) Inverter

An inverter circuit is a circuit used to convert 94 volt DC voltage into high voltage AC. In the circuit, there is a MOSFET IRF740 used for high voltage drivers.

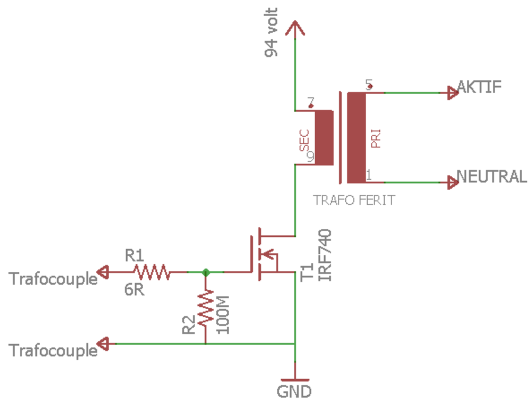

Fig. 7. Inverter Circuit

III. RESULTS

In this study, the electrosurgery unit was tested on the unit's electrosurgery analyzer. The error value was below 10%.

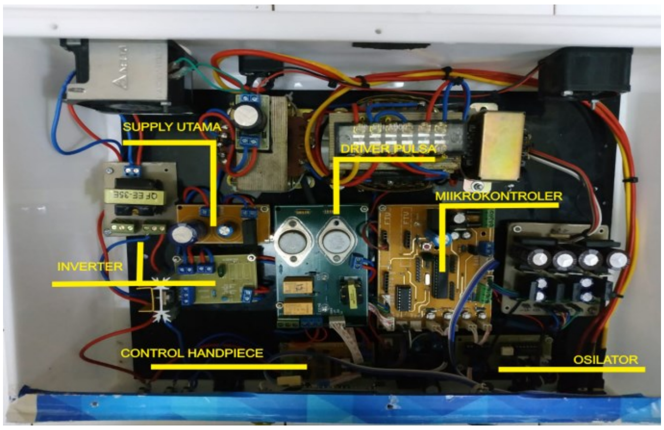

Fig. 8. Result and Circuit Design

Fig. 9. Electrosurgery Unit

1) Electrosurgery Unit Design

Images from the inside and outside of electrosurgery units can be seen in Fig. 8 and Fig. 9. The microcontroller board consists of a microcontroller circuit, pulse regulating circuit, power regulator, oscillator, and handpiece control. In Fig.9 ESU is equipped with a handpiece and footswitch as a cutting and coagulation control, as well as a ground plate as a passive electrode.

2) The Listing Program

In this study, there were 2 parts controlled using Arduino, namely the selection of power and hand switch control and footswitch.

Program listing 1. Power selection program

```
void menucutting()
{
 upcut = digitalRead(4);
 downcut = digitalRead(2);

 if (upcut==HIGH)
   {
   delay(200);
   menucut++;
   }

 if (downcut==HIGH)
   {
   delay(200);
   menucut--;
   }

 if(menucut<1)
   {
   menucut=3;
   }

 if(menucut>3)
   {
   menucut=1;
   }

  if(menucut==1)
  {
  frekwensicut=1200;
  lcd.setCursor(0,1);
  lcd.print("~");
  lcd.setCursor(0,2);
  lcd.print(" ");
  lcd.setCursor(0,3);
  lcd.print(" ");
  }

  if(menucut==2)
  {
  frekwensicut=400;
  lcd.setCursor(0,1);
  lcd.print(" ");
  lcd.setCursor(0,2);
  lcd.print("~");
  lcd.setCursor(0,3);
  lcd.print(" ");
  }

  if(menucut==3)
  {
  frekwensicut=300;
  lcd.setCursor(0,1);
  lcd.print(" ");
  lcd.setCursor(0,2);
  lcd.print(" ");
  lcd.setCursor(0,3);
  lcd.print("~");
  }
}

 void menucoagulating()
```

```
{
upcoag = digitalRead(8);
downcoag = digitalRead(7);

 if (upcoag==HIGH)
    {
    delay(200);
    menucoag++;
    }

 if (downcoag==HIGH)
    {
    delay(200);
    menucoag--;
    }

 if(menucoag<1)
    {
    menucoag=3;
    }

 if(menucoag>3)
    {
    menucoag=1;
    }

 if(menucoag==1)
  {
   frekwensicoag= 800;
   lcd.setCursor(13,1);
   lcd.print("~");
   lcd.setCursor(13,2);
   lcd.print(" ");
   lcd.setCursor(13,3);
   lcd.print(" ");
  }

  if(menucoag==2)
  {
   frekwensicoag=500;
   lcd.setCursor(13,1);
   lcd.print(" ");
   lcd.setCursor(13,2);
   lcd.print("~");
   lcd.setCursor(13,3);
   lcd.print(" ");
  }

  if(menucoag==3)
  {
   frekwensicoag=400;
   lcd.setCursor(13,1);
   lcd.print(" ");
   lcd.setCursor(13,2);
   lcd.print(" ");
   lcd.setCursor(13,3);
   lcd.print("~");
  }
```

Listing Program 2. Program kontrol

```
  void loop()
  {
    footswitchcoag = digitalRead(12);
    handswitchcoag = digitalRead(A1);

  if((footswitchcut==HIGH)||(handswitchcut==LOW))
   {
    digitalWrite(relaycoag,HIGH);
    analogWrite(dutycycle,0);
    digitalWrite(buzzer, HIGH);
    tone(ftv,frekwensicut);
   }

   else i
((footswitchcoag==HIGH)||(handswitchcoag==LOW))
   {
    digitalWrite(relaycoag,HIGH);
    analogWrite(dutycycle,240);
    digitalWrite(buzzer, HIGH);
    tone(ftv,frekwensicoag);
   }
   else
   {
    digitalWrite(buzzer, LOW);
    analogWrite(dutycycle,255);
    digitalWrite(relaycoag,LOW);
    noTone(ftv); }
```

3) Table results of frequency measurements using an oscilloscope

Measurements are made on the oscillator output which is influenced by the value of resistance on multiturn and capacitor. Measurement using an oscilloscope.

TABLE I. MEASUREMENT TABLE OF 300KHZ OSCILLATOR OUTPUT

Oscillator circuit	
Measurement	**Oscilloscop Display (Khz)**
1.	301
2.	300
3.	300
4.	301
5.	300
Mean	**300.4**

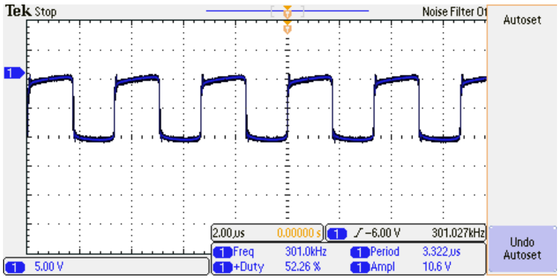

Fig. 10. Output oscillator 300kHz

4) Table of results of power measurements using ESU Analyzer

The error value is obtained by comparing the final step up output with ESU Analyzer.

TABLE II. LOW POWER MEASUREMENT TABLE IN CUTTING AND COAGULATION MODES

Inverter Circuit		
Measurement	**Electrosurgery Analyzer Display (W)**	
50	7,3	0
75	9,2	0,1
125	13,6	0,1
200	21,7	0,2
350	32,1	0,3
500	39,1	0,5

TABLE III. MEDIUM POWER MEASUREMENT TABLE IN CUTTING AND COAGULATION MODES

Inverter Circuit		
Measurement	**Electrosurgery Analyzer Display (W)**	
50	8,4	0
75	11,3	0,1
125	17,7	0,1
200	25,2	0,2
350	36,6	0,4
500	43,7	0,5

TABLE IV. HIGH POWER MEASUREMENT TABLE IN CUTTING AND COAGULATION MODES

Inverter Circuit		
Measurement	**Electrosurgery Analyzer Display (W)**	
50	7,5	0
75	11,3	0,1
125	18,2	0,1
200	25,3	0,3
350	36,3	0,4
500	44,2	0,6

IV. DISCUSSION

Overall this research can be concluded that it can be electrosurgery unit cutting and coagulation mode with low, medium, high power selection mode. Using a frequency generator with an output of 300 kHz.

The power that is read through the electrosurgery analyzer cutting mode calibration in reading low mode, which is 28 watts. Then in the medium power mode that reads 36.5 watts. And in the high power mode that reads 43.5 watts. The coagulation mode on the reading setting is low of 2.2 Watt, the medium is 2.8 Watt, high is 3.1 Watt. The tool can be controlled using a handpiece and footswitch.

V. CONCLUSION

Based on the results of the discussion and the purpose of making the module it can be concluded that the oscillator circuit can issue a frequency and the inverter circuit can increase the desired voltage to perform a surgery and can be controlled using footswitch and hand switch with the selection of low, medium and high modes in each mode.

VI. REFERENCES

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