Indonesian Journal of Electronics, Electromedical Engineering, and Medical Informatics
Multidisciplinary : Rapid Review : Open Access Journal Vol. 4, No. 2, May 2022, pp.48-54 eISSN: 2656-8624

RESEARCH ARTICLE OPEN ACCESS

Manuscript received October 30, 2021; revised March 3, 2022; accepted April 21, 2022; date of publication May 30, 2022
Digital Object Identifier (DOI): https://doi.org/10.35882/ijeeemi.v4i2.1

A Low Cost Electrosurgery Unit (ESU) Design with Monopolar and Bipolar Methods

Bambang Guruh Irianto[1] and Levana Forra Wakidi[1], Ade Ryan Endarta[1], Madeha Ishag Adam[2], and Hafsa Aamir[3]
[1] Department of Electromedical Engineering, Poltekkes Kemenkes Surabaya, Indonesia.
[2] Department of Clinical Applied Anatomy Fujian Medical University, Fuzhou, China
[3] Department of Biosciences, Shaheed Zulfikar Ali Bhutto Institute of Science and Technology, Karachi, Pakistan
Corresponding author: Levana Forra Wakidi (e-mail: lep.forra@poltekkesdepkes-sby.ac.id)

ABSTRACT Surgery using a conventional scalpel causes the patient to lose a lot of blood; this needs to be avoided. The purpose of this research is to make a replacement for the conventional scalpel using a device that utilizes high frequency with a duty cycle setting that is centered at one point. The design of the device is equipped with monopolar and bipolar pulse selection with an increased frequency at 400 kHz, where the duty cycle of bipolar mode can be set to 100% on and the coagulation duty cycle is 6% on and 94% off. The power output of the module was tested using an ESU Analyzer, while cutting the bipolar forceps used soap and meat media. The power inverter circuit was set with the module impedance values of 300Ω, 400Ω, and 500Ω. Power settings were set at high, medium, and low with 2 pulse cutting and coagulation modes. The average power resulted in the lowest power of 32.3Watt and the highest power cutting mode of 58.3Watt. Meanwhile, in the coagulation mode of the lowest power of 3Watt and the highest power of 3Watt, the impedance setting is 500Ω. The module can output power linearly according to settings and can cut media well. Furthermore, the development of making Electrosurgery design in this study is expected to facilitate the surgical process during the surgical procedures.

INDEX TERMS Electrosurgery, Bipolar, cutting, coagulation, Low Cost

I. Introduction

Electrosurgery is a medical surgical instrument that utilizes high-frequency electric currents used to cut, thicken, and dry tissue, using frequencies above 100 kHz, which leads to decrease of the faradic effect. Up to frequencies above 300kHz, the faradic effect is further negligible [1][2]. Bipolar electrosurgery uses some kind of instrument, usually forceps through which a current is passed. The current pathway will originate from one side of the forceps, through the tissue, and the other side kc and forceps [3][4]. Meanwhile, major surgery is a major surgical procedure that uses general anesthesia, which is one of the most commonly performed surgery [5][6].

Electrosurgery will never completely replace the scalpel but it requires knowledge, skill, and understanding, which is more complete about the biophysical aspects and interactions of energy and electrosurgical tissue [7][8]. Electrosurgery electricity is utilized to create various thermal effects to achieve resection, incision, hemostasis, and tissue devitalization. The basic therapeutic target of all electrosurgery is the production of thermal energy at the cellular level [9]. This very high-frequency current results in heating and evaporation of the tissue resulting in cutting and freezing of the tissue which takes the advantage of the high frequency used to cut, thicken, and dry the tissue with frequencies above 300 kHz using high frequencies 100Khz – 300 kHz, where faradic effects begin to decrease [10] [11].

Up to frequencies above 300 kHz, the faradic effect can be neglected [12][13]. The use of high frequencies is intended so as not to stimulate nerve and muscle tissue which can cause unwanted seizure states during medical surgery [14]. Operative ESU is divided into 2 (two)) modes, namely bipolar and monopolar [15].

Bipolar electrosurgery is one of the most commonly used surgical instruments and is used in all surgical disciplines [16][17]. Because this mode operates at lower voltages, less energy is required [18] and uses some types of instrument, including forceps, through which the current is passed. The current path will come from one side of the forceps, through the tissue, and to the other side of the forceps [19]. This provides better control over the targeted area and helps prevent damage to other sensitive tissues [20], because of its limited ability to excise and coagulate large bleeding areas. It is more ideally used for procedures where tissue can be easily removed by forceps electrodes [21]. There are two broad categories of currents cutting and freezing and there are different forms of mixed or pulsed currents that allow for various tissue effects [22]. In cutting, a frequency wave with a duty cycle of 100% active is used, since it produces heat very quickly [23]. Meanwhile, coagulation (freezing) which uses an active duty-cycle wave is only about 6% [24][25].

Ali Idham Alzaidi conducted research on ESU through the development of ESU Bipolar cutting. In this study, only the Bipolar mode was implemented (pure cut) [19]. In another study regarding the design of low power electrosurgery (electric scalpel) at a frequency of 10 kHz, the result obtained are 26.0096 Watts and a frequency of 11.16 kHz [24]. In this case, The purpose of this research is to make a replacement for the conventional scalpel using a device that utilizes high frequency with a duty cycle setting that is centered at one point. Based on the result of the identification of the problem above, the author will applied 2 Methods of Monopolar and Bipolar Electrosurgery Unit (Bipolar Cutting and Coagulation) using a frequency of 400 kHz equipped with low, medium, and high power selection [24].

This paper contains several sections. Section 1 of introduction explains the problem and the purpose of this research. Section 2 of materials and methods contains information on experimental settings that describe what materials and devices were used in this research, the steps for conducting research, block diagrams explaining how the circuit in the electrosurgical unit research module works, as well as a flow chart that explains how the electrosurgical unit research module system works. Section 3 of result that explains program listings, measurement result, and our output result. Section 4 contains a discussion result and section 5 contains the conclusions made by the researcher.

II. Material and Methods

A. Data Collection

This monopolar and bipolar electrosurgery unit module has a working frequency of 400Khz, with each method having a cutting and coagulation mode. This study used a CMOS IC (CD4069B, Texas Instrument, America) as a high-frequency generator, MOC (4N35, Agilent Technologies, America), and MOSFET regulator or driver circuit (740B, Fairchild Semiconductor, America) as a current amplifier type A and B, and ferrite transformer type: 42-M58802P01 as a voltage amplifier before entering the electrodes. A microcontroller (Uno, Arduino, Italy) was also used as a microcontroller to adjust the PWM output which will produce a cutting mode output to issue a duty cycle of 100% and 6% on 94%. Power selection was also used and will issue a frequency of 280Hz for low power, 350Hz for medium power and 600Hz for high power. Furthermore, IC frequency into voltage (LM2907, Texas Instruments, USA) was also utilized to convert frequency into voltage.

A Digital Oscilloscope (Textronic, DPO2012, Taiwan) was used to measure and adjust the output of the frequency generator. In addition, reed relay was used as a current separator between bipolar and monopolar, 12V 5A ampere switching supply as a circuit power supply, buzzer as a discharge indicator during cutting or coagulation, forceps bipolar as a cutting knife, and measurement devices such as an oscilloscope to measure the output of the oscillator circuit, FTV and secondary couple transformers. Last, an ESU Analyzer was utilized to measure the result of the electrosurgery unit module.

The manufacture of the module started from an oscillator circuit as a frequency generator to produce a frequency of 400 kHz. The measurements were carried out using an oscilloscope plugged into the oscillator output test point and using Arduino Uno as a cutting mode regulator to issue a duty cycle of 100% on and a coagulation duty cycle of 6% on 94% off. Measurements were carried out using an oscilloscope to see the result of the continuous signal and difference on the oscilloscope display. Power regulation further utilized a frequency to voltage circuit so that there is a difference in voltage output from the circuit that can be controlled from the microcontroller which was further channeled to the class b amplifier circuit.

In this class b amplifier output, there is a couple transformer as an initial voltage booster which then beame the input of the inverter circuit which has a ferrite transformer as a high voltage booster whose output is connected to the jack as a bipolar forceps socket. The measurements using an ESU Analyzer were further done by plugging one side of the forceps on the active probe of the ESU Analyzer and one side of the forceps on the passive probe of the ESU Analyzer.

After the installation setting was complete, the settings on the ESU Analyzer were set by adjusting the impedance used in the measurement process. After all the circuits are complete, the next step is a series of function tests using a Digital Oscilloscope for the measurements. Measurements were made on the oscillator circuit at the oscillator output test point using an oscillator to determine the amount of frequency generated. In this case, measurements were also further made on the same board to determine the output of the measurement regulator. Pulses were carried out at the output using an oscilloscope to know the difference in signal between cutting and coagulation then measurements are made on the power regulator setting using the Avometer at the output of the circuit to measure the voltage difference between low, medium, and high. Measurements were further made on the driver circuit after the three circuits. Measurements were also done on the secondary transformer pair to determine the difference in the shape of the cutting and coagulation signals as well as the voltage difference between low, medium and high. After that, the circuit was fed to the Inverter circuit. The next step after a series of function tests was carried out is to test the engine function using meat and soap media using an ESU Analyzer.

In the measurement using an ESU Analyzer, one side of the forceps was plugged into the active probe of the ESU Analyzer and the other side was plugged to the passive probe of the ESU Analyzer. After that, the electrosurgery unit and ESU Analyzer module were prepared, setting the electrosurgery unit module with

FIGURE 1. **(a) Electrosurgery unit module hardware form and circuit. (b) Electrosurgery design consists of analog and digital circuits. Analog circuit is in the form of pulse adjustment button, buzzer, power adjustment, pulse adjustment, oscillator, driver, and inverter. The digital circuit is a microcontroller system controller and an LCD display. The design of the device was made in such a way to adjust the needs and safety of the circuit. The footswitch port, plate, and active electrode were also placed in front of the device to facilitate installation and user movement.**

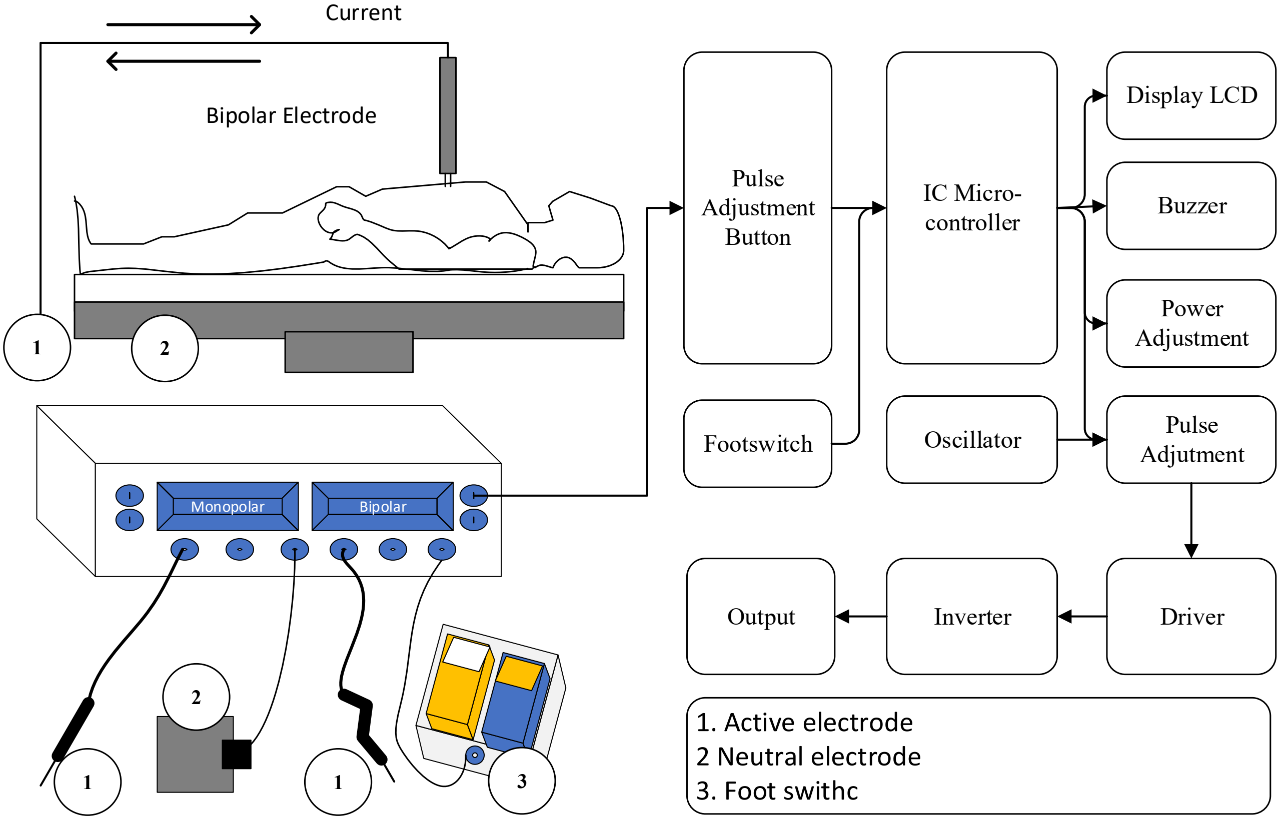

FIGURE 2. **The block of Electrosurgical Unit Bipolar. When the switch is on the input voltage from PLN to the switch to activate the DC power supply and power supply, the entire circuit will get a voltage from the DC supply and the interlock and buzzer circuit is active because it gets supply from the switching power supply voltage. After that, the input comes from the foot of the switch, entering the microcontroller to perform operations with cutting and coagulation modes. It also adjusts the interlock circuit so that it can adjust the on and off of the reed relay which functions as a separator between bipolar and monopolar outputs. In this case, a buzzer indicator sound and the button were used to adjust the duty cycle connected to Arduino Uno. Furthermore, the cutting and coagulation buttons function as mode regulators on the ESU. There are power selection buttons up and down to adjust the power and are connected to the input of the microcontroller. Then the power selection menu will be displayed on the character LCD screen through the microcontroller for the selection of the power used and the mode between cutting and coagulation which can be set according to the user's wishes.**

alternating cutting and coagulation modes as well as the power difference to be measured. In this case, the load on the ESU Analyzer was set with three different load settings of 300 Ω, 400 Ω and 500Ω measurements. The power output was carried out in all modes and different power settings. Measurements were repeated at each different load setting on the ESU Analyzer. FIGURE 2 shows a block diagram of the Electrosurgical Unit Bipolar. The small box represents the electrosurgical unit and its accessories. FIGURE 3 shows a flowchart of the Electrosurgical Unit Bipolar. The flowchart shows the software design for the microcontroller systems.

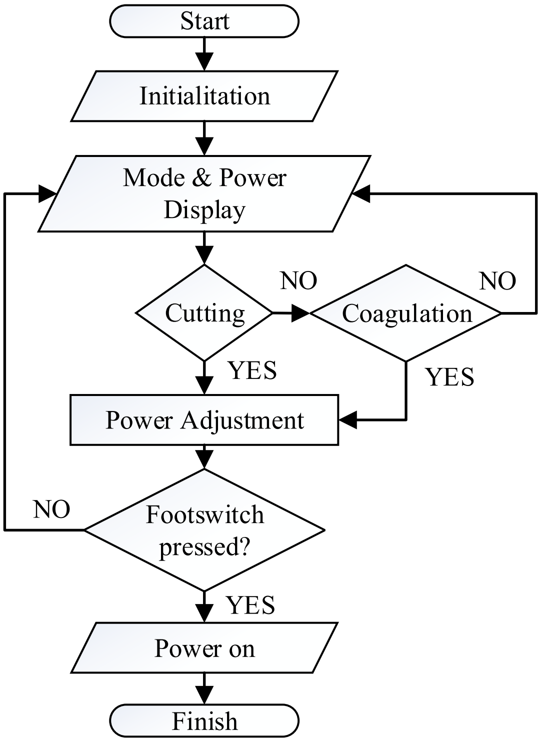

FIGURE 3. The flowchart of Electrosurgical Unit Bipolar. When power is on, the character of the LCD screen will be initialized. On the LCD screen, the character will display the power selection parameters in cutting and coagulation mode. If you want to cut, the system will continue on power selection. If you do coagulation, the system will switch to select the coagulation control which is carried out via the footswitch which will appear on the LCD when it is pressed. There are up and down buttons that function to select the desired power difference between low, medium, and high. When the power selection is finished, the power will then be displayed on the LCD character screen for cutting and coagulation modes. When the foot switch is pressed, the device will work with the power display on the LCD character screen complete

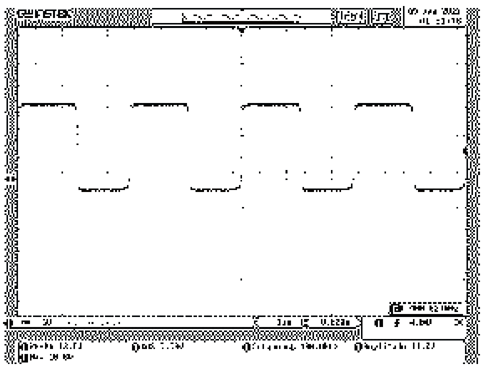

FIGURE 4. This figure shows the results of one of the output measurements of the oscillator circuit measured using an oscilloscope. Measurements were carried out five times with an oscillator setting of 400KHz and an amplitude of 12V with an average measurement of 400.4KHz.

B. Data Analysis

The measurement process will go through a measurement process using a digital oscilloscope for oscillatory measurements, then measuring the ESU output in cutting and coagulating modes in each mode. The result of this measurement will be searched for the average value using the equation (1) based on the data analysis formula [26]:

$$\bar{x} = \frac{x1+x2\ldots+xn}{n} \quad (1)$$

Where $\bar{x}$ is the average measurement of n measurements, x1 is the first value that appears during the measurement, x2 is the second value that appears during the measurement, and xn is the value that appears during the nth experiment. The standard deviation is a value that indicates the level (degree) of variation in a group of data or a standard measure of deviation from its mean. The standard deviation (STDEV) formula can be shown in equation (2) based on the data analysis formula [26]:

$$StDev = \sqrt{\frac{\sum(xi-u)^2}{N}} \quad (2)$$

where xi indicates the amount of the desired values, x indicates the average of the measurement result, and n shows the number of measurements.

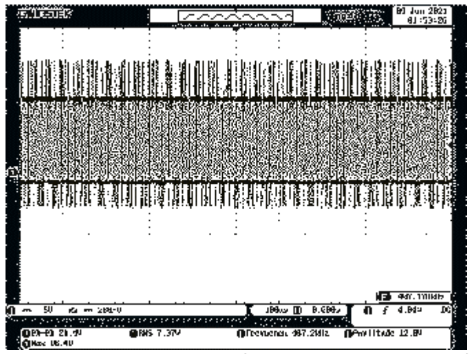

FIGURE 5. This image is the result of measuring the output of the pulse control circuit using an oscilloscope which produces a 100% continuous signal used for cutting mode.

III. Result

FIGURE 4 is the result of the measurement of the oscillator output using an oscilloscope with an oscillator setting design of 400KHz and amplitude of 12V with 5 times measurements producing data with a mean of 400.4KHz. Then, FIGURE 5 is the result of measuring the pulse control circuit using an oscilloscope which produces a continuous signal of 100% which is used for cutting mode. Furthermore, FIGURE 6 is the measurement result of the pulse control circuit measured using an oscilloscope which produces an intermittent signal (a signal that appears disappears and then reappears within a certain period) of 94% off and 6% on which is used for coagulation mode. In this case, pulse control circuit produces a voltage of 12V.

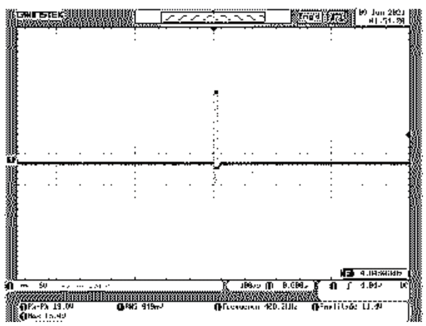

FIGURE 6. This figure is the measurement result of the pulse control circuit using an oscilloscope which produces intermittent signals of 94% off and 6% on for coagulation mode. The pulse control circuit produces a voltage of 12V.

TABLE 1
This picture is the final output of Electrosurgery on the Power circuit measured using the ESU Analyzer. Impedance settings at 300Ω, 400Ω, and 500Ω and power settings at HIGH, MEDIUM, and LOW with 2 pulse cutting and coagulation modes.

Measurement	Cut. 300 Ω (W)	Coag. 300 Ω (W)	Cut. 400 Ω (W)	Coag. 400 Ω (W)	Cut. 500 Ω (W)	Coag. 500 Ω (W)
Mean LOW	24	3	28	3	32.3	3
Mean MEDIUM	38	3	44.5	3	50	3
Mean HIGH	44	3	49.3	3	58.3	3

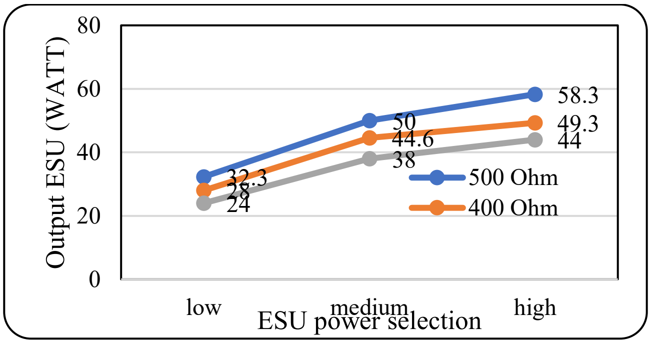

FIGURE 7. This figure shows the results of the output measurement on the power inverter circuit in bipolar cutting mode.

4) Measurement Result Of Final Output Using Esu Analyzer

The final output of electrosurgery is at Power Inverter circuit and the measurement used ESU Analyzer with setting impedance at 300Ω, 400Ω, and 500Ω. The result used HIGH, MEDIUM, and LOW setting power with 2 pulse mode pf cutting and coagulation as shown in TABLE 1. FIGURE 8 shows the output of the electrosurgical unit module in cutting mode, while FIGURE 9 in coagulating mode.

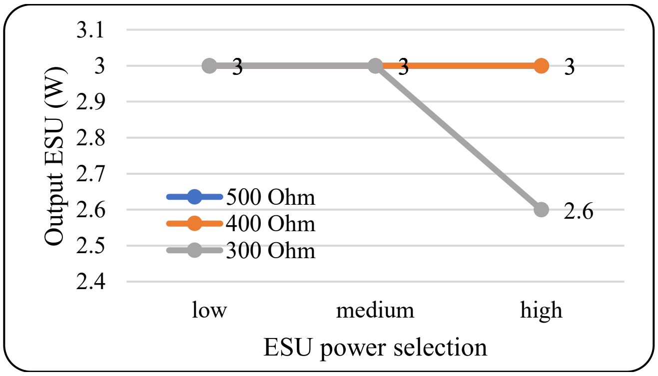

FIGURE 8. The results of the output measurement on the power inverter circuit in bipolar coagulation mode.

IV. Discussion

The result of the electrosurgery research using an oscillator can be seen in FIGURE 5 with an error of less than 1%. Furthermore, the final power result of the Electro Surgery Unit with cutting and coagulation modes can be seen in TABLE 1. The Oscillator result shows that the power usage settings and the modes used are running well. This study wmployed a frequency-to-voltage converter circuit, a pulse control circuit, a power control circuit, and a frequency generator that produces a frequency of 400Khz to avoid faradic effects. In addition, a combination of two monopolar and bipolar methods were also used, which were equipped with safety features so that they cannot suppress two operation buttons simultaneously and the addition of an interlock circuit as a monopolar and bipolar current output separator.

This research is a development of previous research on the manufacture of Bipolar ESU which has only one mode, which is pure cutting, while this research also had monopolar cutting and coag ESU. The difference in the working frequency of the ESU used was also employed both in this study and previous study. However, this study is still far from perfect.

In practice, the use of power settings and correct mode selection can minimize unwanted tissue damage during surgery. However, this has weaknessed in the forms of the power setting which has not been used with a predetermined value and the power is less than sufficient for the operation of the microcontroller and the small output power on the module.

Briefly, this study describes the difference in the signal generated in each mode due to the use of a different duty cycle, and also its effect on power regulation. This study used three types of power settings including low, medium, and high which can be applied to several cutting. Coagulation modes also used to produce difference in power output in the electrosurgery unit module according to the power setting level. This has been measured on the ESU Analyzer. In this case, monopolar and bipolar methods were successfully merged in one electrosurgery unit module. In addition, there was also an increase in the frequency by 400 Khz, as well as an increase in power output generated.

V. Conclusion

This study aims to make power settings and several modes to minimize network damage during surgery. The power regulation applied in this study is quite good. In this research, it is also possible to make an oscillator circuit through simple method that can generate high frequencies and increase the frequency greater than in previous studies. All modules can be controlled using a footswitch and muddy the network. The electrosurgery unit module can produce an average power with the lowest power of 32.3 Watt and the highest power of 58.3 Watt in the cutting mode. Meanwhile, in the coagulation mode, the lowest power is 3 Watt and the highest power is 3 watts with 500 Ω impedance setting on ESU Analyzer, which also combines monopolar and bipolar methods. For further development, several modes can be added such as blending on cutting and spraying on coagulation and many more. In addition, the power setting needs to be increases so that it can measure the output of the inverter so the power can be known and adjusted. Additionally, the addition of power to the transformer can be used to supply current in the inverter circuit and improve the quality of the ferrite transformer so that it can increase the voltage and produce more power. It also has an addition of a smoke exhaust to reduce the smoke quickly during the surgical process.

References

[1] N. Aggarwal, K. Ahuja, N. Pal, R. Pannu, and V. Berwal, "Electrosurgery: Welcome Part of Modern Surgery A R T I C L E I N F O," *J. Appl. Dent. Med. Sci. NLM ID*, vol. 3, no. 3037, pp. 2454–2288, 2017.

[2] S. Yan, Y. Zhou, W. Xu, and C. Song, "An adaptive vessel closing generator in electrosurgery," *2012 5th Int. Conf. Biomed. Eng. Informatics, BMEI 2012*, no. Bmei, pp. 711–715, 2012, doi: 10.1109/BMEI.2012.6512999.

[3] P. C. Benias and D. L. Carr-Locke, *Principles of Electrosurgery*, Third Edit. Elsevier Inc., 2019.

[4] R. E. Dodde, J. S. Gee, J. D. Geiger, and A. J. Shih, "Monopolar electrosurgical thermal management for minimizing tissue damage," *IEEE Trans. Biomed. Eng.*, vol. 59, no. 1, pp. 167–173, 2012, doi: 10.1109/TBME.2011.2168956.

[5] V. Dafinescu, V. David, and A. Tutuianu, "Electromagnetic emissions due to electrosurgery," *EPE 2012 - Proc. 2012 Int. Conf. Expo. Electr. Power Eng.*, vol. 20, no. Epe, pp. 525–528, 2012, doi: 10.1109/ICEPE.2012.6463880.

[6] M. G. Munro, *The SAGES Manual on the Fundamental Use of Surgical Energy (FUSE)*. 2012.

[7] P. S. Yalamanchili, P. Davanapelly, and H. Surapaneni, "Electrosurgical applications in Dentistry," vol. 1, no. 5, pp. 530–534, 2013.

[8] C. Bk, K. Kalaivani, T. Kalaiselvi, K. R. Sugashini, and B. Chinthamani, "Design of Improved Electrosurgical Unit with Pad Plate Design," *Int. J. Recent Technol. Eng.*, vol. 8, no. 4, pp. 10706–10711, 2019, doi: 10.35940/ijrte.d4322.118419.

[9] D. L. Carr-Locke and J. Day, "Principles of Electrosurgery," *Success. Train. Gastrointest. Endosc.*, pp. 125–134, 2011, doi: 10.1002/9781444397772.ch11.

[10] K. Roby *et al.*, "A novel electrocautery device to increase coagulation rate and reduce thermal damage," *2011 IEEE 37th Annu. Northeast Bioeng. Conf. NEBEC 2011*, no. 2, pp. 2–3, 2011, doi: 10.1109/NEBC.2011.5778527.

[11] A. Taheri, P. Mansoori, L. F. Sandoval, S. R. Feldman, D. Pearce, and P. M. Williford, "Electrosurgery: Part II. Technology, applications, and safety of electrosurgical devices," *J. Am. Acad. Dermatol.*, vol. 70, no. 4, pp. 607.e1-607.e12, 2014, doi: 10.1016/j.jaad.2013.09.055.

[12] D. A. Friedrichs, R. W. Erickson, and J. Gilbert, "A new dual current-mode controller improves power regulation in electrosurgical generators," *IEEE Trans. Biomed. Circuits Syst.*, vol. 6, no. 1, pp. 39–44, 2012, doi: 10.1109/TBCAS.2011.2159859.

[13] K. Rauff, A. Rilwan, U. Farouk, and D. Joshua, "Construction of a Simple Transformer to Illustrate Faraday's Law of Electromagnetic Induction along Side Mutual Inductance," *Phys. Sci. Int. J.*, vol. 12, no. 1, pp. 1–5, 2016, doi: 10.9734/psij/2016/28280.

[14] W. Zhao, H. Shao, H. Zhang, B. Liang, and Z. Li, "Development of HF power source for the calibration of electrosurgical analyzer," *CPEM 2016 - Conf. Precis. Electromagn. Meas. Conf. Dig.*, pp. 0–1, 2016, doi: 10.1109/CPEM.2016.7540547.

[15] M. Electrosurgery, B. Electrosurgery, and B. Medical, "Monopolar Electrosurgery vs . Bipolar Electrosurgery To learn more , download our free ebook : Understanding Electrosurgery," pp. 10–13, 2020.

[16] R. Ricks, S. Hopcroft, M. Powari, A. Carswell, and P. Robinson, "Tissue Penetration of Bipolar Electrosurgery at Different Power Settings," *Br. J. Med. Med. Res.*, vol. 22, no. 1, pp. 1–6, 2017, doi: 10.9734/bjmmr/2017/33773.

[17] J. L. Tokar *et al.*, "Electrosurgical generators," *Gastrointest. Endosc.*, vol. 78, no. 2, pp. 197–208, 2013, doi: 10.1016/j.gie.2013.04.164.

[18] A. Ayesha, A. Nigam, and A. Kaur, "Principles of electrosurgery in Laparoscopy," *Pan Asian J Obs Gyn*, vol. 2, no. 1, pp. 22–29, 2019, doi: 10.7439/ijbar.v10i11.5163.

[19] A. I. Alzaidi, A. Yahya, T. T. Swee, and N. Idris, "Development of high frequency generator for bipolar electrosurgical unit," *Int. J. Eng. Technol.*, vol. 7, no. 2, pp. 20–23, 2018, doi: 10.14419/ijet.v7i2.29.13118.

[20] B. Crossley, "Dispelling confusion among various electrosurgery technologies," *Biomed. Instrum. Technol.*, vol. 52, no. 1, p. 76, 2018, doi: 10.2345/0899-8205-52.1.76.

[21] A. K. Ward, C. M. Ladtkow, and G. J. Collins, "Material removal mechanisms in monopolar electrosurgery," *Annu. Int. Conf. IEEE Eng. Med. Biol. - Proc.*, pp. 1180–1183, 2007, doi: 10.1109/IEMBS.2007.4352507.

[22] K. Gallagher and J. Miles, "Electrosurgery," pp. 70–72, 2010, doi: 10.1016/j.mpsur.2010.11.009.

[23] N. Sanajit and W. Meesrisuk, "A High-Frequency PWM Half-Bridge Inverter for Electrosurgical Cutting Applications," *ICEMS 2018 - 2018 21st Int. Conf. Electr. Mach. Syst.*, pp. 827–830, 2018, doi: 10.23919/ICEMS.2018.8549089.

[24] Ridho Armi Nabawi, Dhany Alvianto Wibaksono, Tri Bowo Indrato, and Triana Rahmawati, "Electrosurgery Unit Monopolar (Cutting and Coagulation)," *J. Electron. Electromed. Eng. Med. Informatics*, vol. 1, no. 1, pp. 33–38, 2019, doi: 10.35882/jeeemi.v1i1.7.

[25] N. N. Massarweh, N. Cosgriff, and D. P. Slakey, "Electrosurgery: History, principles, and current and future uses," *J. Am. Coll. Surg.*, vol. 202, no. 3, pp. 520–530, 2006, doi: 10.1016/j.jamcollsurg.2005.11.017.

[26] D. K. Lee, J. In, and S. Lee, "Standard deviation and standard error of the mean," *Korean J. Anesthesiol.*, vol. 68, no. 3, pp. 220–223, 2015, doi: 10.4097/kjae.2015.68.3.220.

Attachment

https://drive.google.com/drive/folders/1t9J_K4fOq16EzKpuY4pLwCZZH5dekmHZ?usp=sharing