paper 1 - Design and Development of Power and Time Control System of Various Color Laser as a Beauty Therapy Application

by Nur Aini Fauziyah

Design and Development of Power and Time Control System of Various Color Laser as a Beauty Therapy Application

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Abstract:- The demand for fair skin has influenced the beauty clinics' advancement in treatment and tools. Laser is one of the innovations which will minimize the pain during the treatment and obtain a prompt result. However, to meet the therapeutic needs, a system for controlling the power and energy of laser exposure is needed for each wavelength. This study is conducted to design and build an instrumentation system for controlling the Red and Blue-Violet laser power and time as a beauty therapy application. This study designed a red and blue laser control system to emit six energy variations and set the output power output to 3 levels. Thus, the current source for the red laser and the voltage source values for the blue laser need to be adjusted to set the current and voltage source variants using the LM317 circuit. The test results of the timeliness value of the system obtained that the percentage of timeliness is 99.88%. It can be assumed that the laser exposure time is relatively accurate. Thus, the value of the energy accuracy depends on the value of the power and time stability. In testing the energy stability of the design of the red diode laser control system, it is 99.5%, and for the blue-violet diode laser, it is 98.5%. In conclusion, the diode laser output power is relatively stable, and the system can work with a stable and precise dose of energy, output power, and time.

***Keywords*:-** *Power; Energy; Blue-Violet and Red Diode Laser; Exposure Time.*

I. INTRODUCTION

Laser acupuncture is defined as the stimulation of traditional acupuncture points with low-intensity, nonthermal laser irradiation [1]. The development of skin beauty care can be performed in several ways, such as using drugs, injections, cosmetic ingredients, heat therapy, and laser therapy. The widely used and developed therapy is laser therapy because it can minimize pain, reduce the spread of the virus through needles and reduce the side effects of chemicals [2].

Low-level laser therapy (LLLT) applies light (usually a low power laser or LED in the range of 1mW – 500mW) to pathology to promote tissue regeneration, reduce inflammation and relieve pain. The light is typical of narrow spectral width in the red or near-infrared (NIR) spectrum (600nm – 1000nm), with a power density (irradiance) between 1mw-5W/cm^2 [3]. Laser therapy areas located on the skin for each skin disease/problem require different laser characteristics in several aspects, such as wavelength, energy dose, and exposure time. Some patients experienced mild pain during laser treatment but no bleeding or oozing during or after treatment [4].

According to several studies, the application of laser for beauty therapy that is often used is a blue laser with a wavelength between 405nm - 450nm, which can reduce acne growth [5]. Beauty therapy using red (660nm) and blue (410nm) lasers can more effectively reduce inflammation due to acne on the skin [5]. A previous study from Oshiro showed that LLLT with 830 nm therapy is used to effectively control and treat atopic dermatitis, an increasing problem here in Japan. Figure 22 shows the use of laser therapy in the combination of iatrogenic vitiligo and border hyperpigmentation caused by overtreatment of systemic vitiligo with PUVA (psoralen and UVA) therapy [6].

A system for controlling the power and energy of laser exposure for each wavelength is needed to meet therapeutic needs and facilitate the operation of lasers with different wavelengths [7]. This system is essential because each laser diode wavelength and power requires a different voltage and current source. Thus, in this research, the design of the instrumentation system for controlling the power and time of the Red and Blue-Violet lasers will be carried out as a beauty therapy application. The advantage of this system is that it can be used simultaneously if different values of wavelength, output power, and energy are needed.

This system is also designed to produce voltage and current stability of the source to guarantee the stability of the output power of the laser diode used. Stable Output power can facilitate the process of controlling the required energy. Energy control can be done by setting or controlling the laser exposure time in an automatic timer with variations according to the required energy dose. Thus, if the laser output power value has stabilized and the exposure time has also been correct, the energy dose value will also be precise and stable during the exposure time.

ISSN No:-2456-2165

II. MATERIALS AND METHOD

In this research, the first thing to characterize red and blue-violet lasers with a digital power meter. By varying the current and voltage at the laser characterization stage, data is obtained from the current, voltage, and output power values. At the tool design stage, the main power supply system was designed using IC 7810 [8], designed a red laser (650nm) power regulator (LM317) with a constant current source and a constant voltage source as a blue-violet (405nm) laser power regulator, a timer circuit as an energy dose controller, and a 7-segment display circuit [9]. The next stage, the assembly stage of the tool, is carried out. It is necessary to test and calibrate the laser power and energy control system to obtain the stability value of the laser output power, the accuracy and stability of the exposure energy, and the exposure time. The flow of the research procedure is in Figure 1.

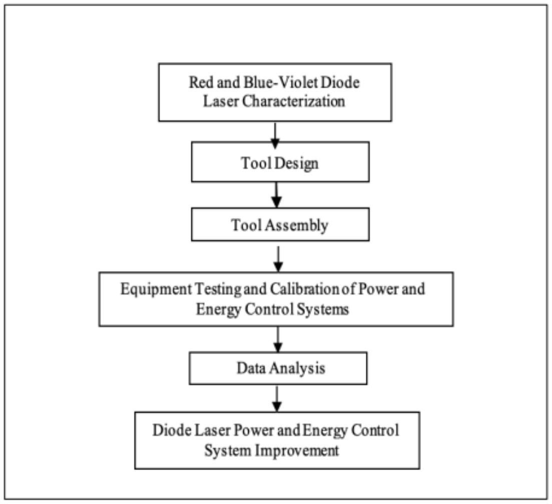

Fig 1. Block Diagram of Research Procedures

III. RESULTS

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A. Tool Design Results

A regulated power supply is used with an output voltage of 10 V with DC current in the main power supply circuit. In this circuit, a regulator IC 7810 is used. A timer circuit with a crystal oscillator automatically adjusts the laser activation when the energy dose has reached the desired output power in the red and blue-violet diode laser energy control circuit. The crystal oscillator circuit uses three frequency variations, namely 2MHz, 3MHz, and 4MHz. The frequency variations are connected to the IC 4518 decimal divider circuit and the IC 4017 counter circuit to produce the desired count time for each red and blue-violet laser power and energy variation.

The LM317 circuit as a red diode laser output power regulator uses a constant current source with a current variation of 58.3mA for an output power of 9.92mW, a current of 63.2mA for an output power of 15.2mW, and a current of 66.1mA for a laser output power of 17.5mW. As for the blue-violet laser, a constant voltage source circuit using LM317 is used. The voltage value used is 1.69V; 1.99V; 2.27V for 10mW, 15mW and 20mW output power. Then assemble the electronic circuit for the system display using a 7-segment common cathode display as it is shown in Figure 2.

Fig 2. Red and Blue-Violet Diode Laser Control System Display.

B. Measurement Results of Diode Laser Power Characterization 405 nm and 650 nm

Both lasers have a maximum laser output power of 20 mW. By varying the current value for the characterization of the red diode laser and varying the value of the source voltage for the blue-violet diode laser, the resulting graph of the relationship between current, voltage, and laser output power is obtained. For the relationship between the output power of the laser to the variation of the given current for a red diode laser (650nm). The relationship between voltage and output power of a blue-violet laser (405nm) was also obtained, which can be seen in Figure 3.

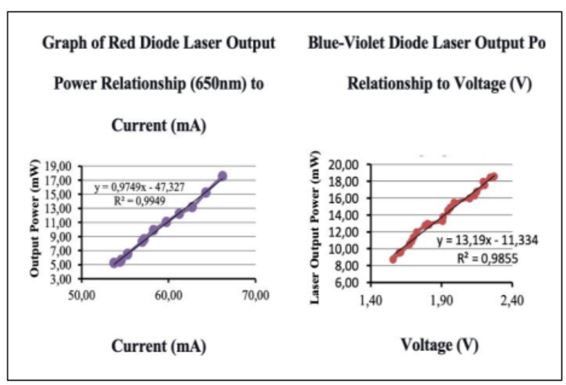

Fig 3. Graph of Relationship of 650nm Red Laser Power and Current (left) and Graph of Relationship of Blue-Violet Laser Power (405nm) with Voltage (right)

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C. Measurement Results of Power Stablitiy to Time Laser Diode Red (650nm) and Blue-Violet (405nm)

In the stability test of the red and blue-violet diode laser output power values with three variations of 10mW, 15mW, and 20mW laser diode power values, each output power was tested within 200 seconds. The laser output power stability test graph is presented in Figure 4.

The output power of the 650nm red diode laser for 200 seconds is 9.91mW – 10.08mW with a standard deviation (SD) value of ≤0.17mW and an error percentage of ≤2.5%. The stability test results of the red laser output power to the exposure time with a power of 15mW are in the range of 14.41mW – 15.39mW with ≤0.17mW SD value and an error percentage of ≤1.15%. The stability test results of the 20mW red laser output power against time in the range of 17.95mW – 18.05mW with SD ≤0.15mW and error percentage ≤0.74%.

Meanwhile, the results of the 405nm blue-violet diode laser output power stability test for 200 seconds for a power value of about 10mW in the range 10.30mW – 10.55mW with a standard deviation (SD) value of ≤0.15mW and an error percentage value of ≤1.50%. Stability test results of 15mW blue-violet diode laser power with SD value ≤0.35mW and error percentage value ≤2.50%, and stability with 20mW power with SD value ≤0.25mW and error percentage value ≤1.20%.

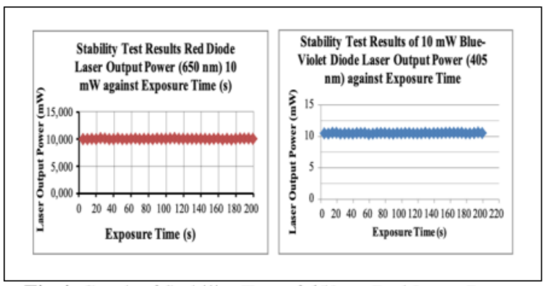

Fig 4. Graph of Stability Test of 650nm Red Laser Power (left) and Blue-Violet Laser Power Stability (405nm) (right) at 10mW output power

The energy accuracy test refers to the timeliness value and each laser's output power value. With a relatively small power fluctuation value and a short time standard deviation, it can be said that the laser exposure energy value is stable according to the desired value. The inaccuracy of the laser output power value for each wavelength is caused by the tolerance value of the resistance used in the current and voltage source circuit assemblies.

D. Measurement Results of The System Exposure Timeliness

From the data results obtained, the error percentage value of the timeliness of laser exposure is ≤0.12%. It can be said that the time control system has an accuracy of ≥99.88% so that the system can operate according to the set time and can precisely deactivate the laser flame.

E. Energy Accuracy Results of Red (650 nm) and Blue-Violet (405 nm) Diode Laser Exposure

The precision values of the red (650nm) and blue-violet (405nm) diode laser exposure values can be obtained using the standard deviation of the output power and the standard deviation of the laser exposure time for each variation of the laser output power. From the accuracy of power and exposure time, the accuracy value of the red diode laser energy is obtained with an error percentage of ≤0.5%, which means the energy accuracy is ≥99.5%. Furthermore, the energy accuracy of the blue-violet diode laser with an error percentage of ≤1.5% so that the energy accuracy is ≥98.5%. From the research results, the energy stability value for each red diode laser output power is 99.5%, and the energy stability for blue-violet diode laser exposure is 98.5%. Thus, the red and blue-violet diode laser control system can control the very high exposure energy stability of ≥98.5%.

IV. DISCUSSION

One of the most important therapeutic factors for a Photodynamic Therapy laser system to be used in cancer therapy is the type of radiation delivered by the laser system. Experience has taught us that the laser system must incorporate a laser capable of delivering continuous wave (CW), pulsed (long pulse, short pulse), and burst pulse [10]. During tissue irradiation with a laser beam, an interaction between cells and photons occurs--photochemical reaction. After a cell absorbs the photon, the photon stops existing, and its energy is incorporated into the molecule which has absorbed it [11].

The use of lasers as a medical therapy tool must have energy dose accuracy and supervision by an expert. If the energy given is too low, it can cause the laser therapy to be less effective. Low-level laser therapy (LLLT) has been clinically applied to a broad spectrum of disorders. This therapeutic method has proven effective, less invasive, and devoid of severe side effects for numerous diseases [12]. Meanwhile, when the dose of energy given is too high, it can cause damage to the cells that the laser passes. Therefore, we need a system that can control the energy dose to use laser therapy safely, effectively, and successfully in the healing process. The laser beam falls divergently or convergently in the skin (the tissue), making it safe and generating minor effects. The effect of exposure to laser therapy on the skin is influenced by several things, for example, wavelength, radiation dose, power density, irradiation time, polarization, and the distance between the laser and the skin surface [13].

The red and blue diode laser control system has six variations of energy dose, which can be achieved by adjusting the laser output power value with three power variations. The dose amount is the dose of laser energy generated from the power output of the laser exposed within a particular therapeutic time range. The system is assembled to facilitate the operator operating a tool with two diode laser wavelengths that can be used simultaneously. Thus, in the assembly of electronic circuits used, two identical and identical circuit blocks must be used to make it easier for operators.

ISSN No:-2456-2165

In the embodiment of the multi-colored diode laser energy control system, a system is needed to maintain the laser output power value's stability and the timeliness of exposure. The LM317 circuit is used to adjust the output power of the red diode laser (650nm) as a constant current source with a current value that can be varied as desired. The blue-violet laser diode uses the LM317 circuit as a constant voltage source with a significant voltage value that can be varied. A constant current source as a red diode laser power controller and a constant voltage source selected as a blue-violet diode laser power controller aims to show that the activation of the two lasers can be carried out by two methods that both lasers can use because the power value is proportional to the value of the voltage if the current is constant and vice versa.

In terms of determining the current and voltage value, it is still necessary to pay attention to the threshold value of the allowable current and voltage values. This is because laser diodes have different threshold values for current and voltage. If the current or voltage value exceeds the threshold, the laser diode used can be damaged.

The red and blue-violet diode laser control system uses a laser source with a continuous laser beam with a laser output power of 20mW. In its application, a laser with a continuous beam has been widely used in the medical field, especially in beauty. The beauty sector uses many diode lasers with a power of up to 100mW at a dose of 4J. The red and blue-violet diode laser control system uses a laser source with a continuous laser beam with a laser output power of 20mW. In its application, a laser with a continuous beam has been widely used in the medical field, especially in beauty. The beauty sector uses many diode lasers with a power of up to 100mW at a dose of 4J. With the design of the power and time control system for the red and blue-violet diode lasers, it is necessary to know more about the positive and negative effects of using low-power lasers in the field of beauty therapy. In addition, it is also necessary to know the threshold dose value of laser administration as a cosmetic therapy which may be related to age, sex, weight, skin allergies, and other variables. Suppose a laser diode with a higher output power is needed, with the design of red and blue-violet laser power and a timing control system to control higher output power. In that case, it is only necessary to change the resistance value in the diode laser power control circuit.

V. CONCLUSION

In conclusion, the power and time control system design for red and blue-violet diode lasers with power variations of 10mW, 15mW, and 20mW can adjust the dose of red and blue-violet diode laser energy with a choice of 0.05J energy; 0.10J; 0.50J; 1.00J; 1.50J; 2.0 J.

In addition, each diode laser data and timing control system can produce a constant output power value with a standard deviation value of ≤0.35mW and a laser exposure time with an accuracy of 99.88%. The percentage value of accuracy and energy stability of exposure to red diode laser is 99.5% and blue-violet laser diode 98.5%. Thus, it can guarantee that the value of the displayed laser energy is appropriate and stable at the desired value.

ACKNOWLEDGMENT

The authors would like to thank the lecturers for their comments and insights suggestions during the writing process. The authors would also like to thank the institutions for providing the tools for the research.

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