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Design System of Artificial Light Red LED for Growing Plants

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Abstract

Aim: This study aimed to design an artificial light electronic circuit for growing plants using red LEDs as the main components.
Methodology: The type of research used in this study is applied research. Specifically, it used the research and development method. To design an electronic circuit of artificial light red LED for growing plants, the following stages were done. These are plan, development, and evaluation. On the plan stage, the researcher utilized the basic circuit of LED as a reference to devise the electronic circuit artificial light red LED. With this prototype, the components are LED, resistor, and voltage source. The equipment and measuring instruments used are multimeter, oscilloscope, and wattmeter. On the development stage, the electronic circuit has been drawn and values for its electrical parameters has been calculated using Ohm's Law equation. This equation is already an established theory in computing the voltage, current, resistance, and power in a closed circuit. Lastly, on the evaluation stage, the electronic circuit was analyzed through the computer software simulation. The voltage, current, and power were measured to verify that the calculated value of the circuit is accurate.
Results: With a supply voltage of 40 V, the electrical characteristics for LEDs and resistor were calculated, then run on a simulation software. For LEDs, the calculated value for voltage, current, and power are 2 V, 20 mA, and 40 mW, respectively. When run in software simulation application, the values are 1.826 V, 20.007 mA, and 36.531 mW. For resistors with a resistance of 53 Ω, the calculated value for voltage, current, and power are 12.7 V, 240 mA, and 3.05 W, respectively. When run in simulation application, the values are 12.725 V, 240.089 mA, and 3.055 W.
Conclusion: The calculated values have little difference with that value when run in a simulation application. Therefore, it indicates that the design system of artificial light red LED for growing plants will work.

Keywords: design system, electronic circuit, artificial light, red LED, growing plants

INTRODUCTION

Light is essential in plants in order to produce food through the process called photosynthesis. Through this photosynthesis, plants use the green chlorophyll, a pigment, to help convert carbon dioxide, water, and light into carbohydrates and oxygen. This is needed so that plants can grow.

The plants needed the spectrum of light in order to grow healthy. There are different colors in the visible spectrum of light. The rainbow contains all the different colors in the spectrum. One of these colors is red. The wavelength of red color ranges from 650 to 700 nm. Although all the colors of light spectrum are useful for plants in different ways, this study focused only on the design system of artificial light using red color light emitting diode (LED).

Artificial lighting for plants has gained significant attention in the agricultural and horticulture industry. It offers advantages over the location where there is no sunlight or less sunlight available in a certain area. In due time, it is anticipated that artificial light will increase its usage, especially growing plants inside the home or greenhouses where not enough sunlight is seen.

The researcher developed a design system of electronic circuit using the red LEDs as its main electronic components to generate light with the wavelength of 650 to 700 nm. It will be used as the main light for plants in a home or greenhouse that lacks sunlight. There is already an artificial light in the online market but not common in

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many electronics stores. You can seldom find artificial light for plants that is available in the major markets. Aside from that, this system is also cost-effective because the cost of the components is minimal so anyone who is interested can construct the circuit being introduced here. The LED is becoming less expensive and even more effective and efficient to design the circuit as used for growing plants.

The LED circuit can be wired in three ways: series connection, parallel connection, or series-parallel connection. The series connection consists of a collection of LEDs joined in such an array that allows the flow of current within the loop. It has no branches, and several LEDs are connected one after the other. In parallel connection, unlike in the series connection, the LEDs connection have branches not end-to-end connection. In series-parallel connection, the LEDs are connected in a combination of series and parallel connection. With this connection, some of the LEDs are joined in series and some are in parallel arrangement.

There is a lot of research about the artificial sunlight for growing plants over the years. Many have already applied it and done experiments on the effect of it in plants. Different colors have in light spectrum has been affected on plants to differentiate its effect.

Okamoto, Baba and Yanagi (2000) wrote that chlorophyll, which is contained in green leaves of plants, performs photosynthesis. The chlorophyll absorbs selectively blue and red light components in the sunshine. The blue absorption region is 430-450 nm and that of red is 650-670 nm. This suggests that it is possible to cultivate green plant under a blue and red composite light. The authors succeeded in the growth of plant (lettuce seedlings) with healthy morphology using blue (450 nm) and red (660 nm) high-brightness LEDs.

Yen, Lee and Chan (2013) examined the use of artificial-lighting sources for indoor photosynthesis and proposes a novel indoor plant-lightning scheme in which red LEDs, blue LEDs and CCFLs are combined to work as effective light sources. The lightning combinations confirmed in this study have been proven effective in improving the growth uniformity of Anoectochilus Formosanus Hayata. Furthermore, the study has also demonstrated that lowered growth racks contribute to higher yield per unit area.

Liang, Tian and Ning (2017) stated that Light emitting Diode (LED) technology has numerous advantages in comparison with other light sources. LEDs are capable of providing specific wavelengths according to crop requirements, enhancing yield without the excessive thermic energy generation of traditional light sources such as metal-halide lamps.

In Takahashi, Aihara and Tomioka (2022), many plant cultivation systems using LED light source have been developed. In such systems, the height of the LED light source above the plants is generally fixed, and this height is set so that the plants do not come in contact with the light source during cultivation. As a result, in the early stages of growth, the light source is located a long distance away from the plants. Therefore, it is logical to assume that cultivation efficiency could be improved by altering the height of the light source as the plants grow.

This study is comparable to the above research when its application is artificial light for growing plants is concern. But the difference is that this study focused on the electronic circuit to be designed and fabricated to be utilized on growing plants. This is low cost and easy to lay out even by novice technician or learning technician. Even those that have little knowledge on the electronics technology can easily learn this because all the components have been specified.

Objectives

This study aimed to design an artificial light electronic circuit for growing plants using red LEDs as the main components. The following are the specific objectives of this study:

1. To design an electronic circuit of artificial light red LED for growing plants.
2. To analyze the electronic circuit design using software simulation to determine if the circuit is working.

METHODS

Research Design

The type of research used in this study is applied research. Specifically, it used the research and development method. Research and development method is a type of applied research that is focused on developing new products and services based on the needs of target markets.

Procedures

To design an electronic circuit of artificial light red LED for growing plants, the following stages were done: plan, development, and evaluation.

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The plan stage includes what prototype to be used, the equipment and materials needed to design the electronic circuit. Next is the development stage which is the step to develop the circuit. Finally, the evaluation stage uses simulation software application to determine if the circuit is working.

a. Plan stage

The researcher utilized the basic circuit of LED as a reference to devise the electronic circuit artificial light red LED. With this prototype, the components are LED, resistor, and voltage source. The equipment and measuring instruments used are voltmeter, oscilloscope, ammeter, and wattmeter.

b. Development stage

The electronic circuit has been drawn and values for its electrical parameters has been calculated using Ohm's Law equation. This equation is already an established theory in computing the voltage, current, resistance, and power in a closed circuit.

c. Evaluation stage

The electronic circuit was analyzed through the computer software simulation. The voltage, current, resistance, and power were measured to verify that the calculated value of the circuit of Figure 2 is accurate.

Ethical Consideration

The researcher guaranteed that the design of this circuit is not copyrighted. It was personally being done by the researcher himself and no restriction whatsoever to develop this circuit. Likewise, this circuit has no harmful effect on plants and environment.

RESULTS AND DISCUSSION

1. Design of an Electronic Circuit of Artificial Light Red LED for Growing Plants

1.1. Light Emitting Diode (LED)

Figure 1 shows the basic circuit of light emitting diode (LED). The schematic symbol of LED has an arrow pointed outwardly which means it radiates light. Forward-biasing is the normal operation for an LED. Here, the free electrons cross the junction and fall into holes. The free electrons and holes are the charge carrier in different types of diode like the LED. In LED when the free electrons move from higher to lower energy level, they radiate energy in the form of light. It has the ability to radiate energy across a wide wavelength spectrum.

The manufacturing of LEDs uses the materials or elements such as phosphorus, arsenic, and gallium. They can produce LEDs with a color like that of red, green, yellow, blue, orange, or even infrared. In this study, the researcher used the red LED as the main component for the design of electronics circuit of artificial light for growing plants which falls under the wavelength of 650 to 700 nm in light spectrum. To limit the current flowing in the LED, a resistor is needed to protect the diode from its maximum current rating. Without the resistor limiting the flow of a current handling capability of the LED, it will be destroyed or burned. The equation to be used is Ohm's law to solve for the value of its current, which is:

$$I_S = \frac{V_S - V_D}{R_S} \quad \text{Equation 1}$$

where I_S = series current
V_S = source voltage
V_D = LED voltage drop
R_S = source resistance

Typical values for commercially available LEDs ranges from 1.5 to 2.5 V for currents from 10 to 50 mA. Its voltage drop varies on the current, color, tolerance, and other parameters. The researcher assumed a voltage drop of 2 V (volts) for the analysis of red LED lighting for plants.

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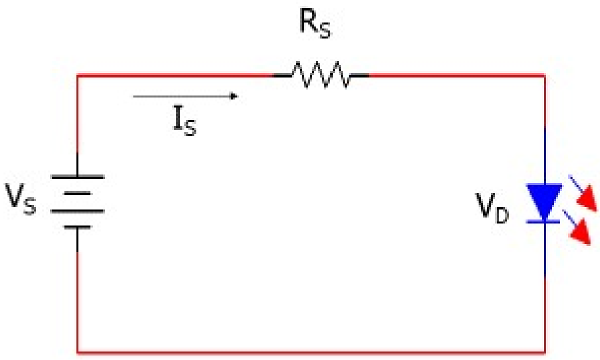

Figure 1. Basic Circuit of LED

1.2. Calculation of the Circuit Parameters

The researcher used the parallel connection in the design of the electronic circuit of the artificial light red LED for plants, as shown in Figure 2. The electronic circuit that looks like a composition of 10 columns by 12 rows of LED has a total of 120 LEDs. The LEDs are labeled LED1, LED2, LED3, up to LED120.

The researcher calculated the electrical parameters of the circuit with a voltage source of 40 V. First, he computed the electrical parameters of the LED. Second, he solved for the parameters of the resistor.
The electrical parameters of an LED are solved with the given equation below.

The assumed voltage drop, VD of each LED is:

$$V_D = 2V$$

and $V_D = V_{D_1} = V_{D_2} = V_{D_3} = \dots\dots\dots$

The forward current for an LED is:

$$I_{LED} = 20mA$$

and $I_{LED} = I_{LED_1} = I_{LED_2} = I_{LED_3} = \dots\dots\dots$

The power in each LED was computed as:

$$P_{LED} = I_{LED} \times V_D$$

and $P_{LED} = P_{LED_1} = P_{LED_2} = P_{LED_3} = \dots\dots\dots$

Next, to compute for the electrical parameters of the resistors, the following equations were used:
The total current flowing in the LEDs in a row, IT can be solved as:

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$$I_T = I_{LED} \times 12\,LEDs$$

The total voltage drops of resistors in a row, V_R was computed as:

$$V_R = V_{CC} - V_D$$

where V_{CC} is the source voltage, like the V_S of Figure 1
V_D is the assumed voltage drop of LED

The total resistance of the resistors in a row, R_{Total} can be computed as:

$$R_{Total} = \frac{V_R}{I_T}$$

The available power rating of a color-coded resistor is 5 watts, hence, the researcher divided the R_{Total} by 3:

$$R_1 = \frac{R_{Total}}{3}$$

and, $R_1 = R_2 = R_3 = \ldots\ldots$

The current flowing in each resistor is I_T since it is connected in series. Therefore,

$$I_T = I_1 = I_2 = I_3 = \ldots\ldots$$

Also,

$$V_{R_1} = I_T R_1$$

and, $V_{R_1} = V_{R_2} = V_{R_3} = \ldots\ldots$

The power in resistor R_1 were computed as:

$$P_1 = I_T^2 \times R_1 = (0.24\,A)^2 \times 53\,\Omega = 3.05\ W$$

Also, $P_1 = P_2 = P_3$

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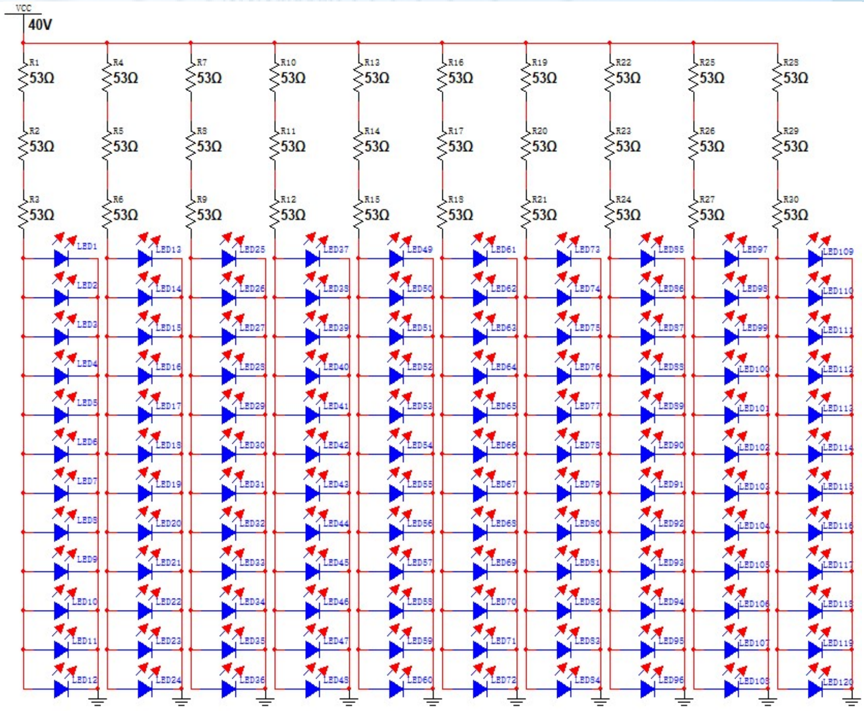

Figure 2. The electronic circuit diagram of the artificial light red LED for plants

The Electrical Characteristics of Electronic Circuit

Electrical Characteristics for V_{CC} = 40 V

Device	Voltage	Current	Power
Light Emitting Diode (LED)	2 V	20 mA	40 mW
Resistor (for 53 Ω)	12.7 V	240 mA	3.05 W

Table 1. Summary Table 1

Table 1 shows the electrical characteristics of the electronic circuit of artificial light red LED for growing plants with supply voltage, VCC of 40 V. The two devices' parameters being calculated were that of LEDs and resistors. The table data shows that each LED has a voltage drop of 2 V, a current of 20 mA, and a power of 40 mW. While the resistor with 53 Ω, each has a voltage drop of 12.7 V, a current of 240 mA, and a power of 3.05 W.

The values being recorded in this table should have a little difference when run in a simulation application to indicate that the circuit is working.

2. Analysis of the Electronic Circuit Design Using Software Simulation

2.1. Multisim

Multisim is industry standard SPICE simulation and circuit design software for analog, digital, and power electronics in education and research. Multisim integrates industry standard SPICE simulation with an interactive schematic environment to instantly visualize and analyze electronic circuit behavior. Multisim has an intuitive interface that helps educators reinforce circuit theory and improve retention of theory throughout engineering curriculum. Researchers and designers use Multisim to reduce PCB prototype iterations and save development costs by adding powerful circuit simulation and analyses to the design flow.

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2.2. Presentation of the Simulation Using Multisim

This section constitutes an analysis of the artificial light red LED circuit. The electronic circuit of Figure 2 has been constructed in the workspace of Multisim. Then, the electrical characteristics of LEDs and resistors have been measured with multimeter, oscilloscope, and wattmeter. The voltage drops, the current flowing, and the power dissipation of the LEDs and resistors have been run on the simulation mode.

For LEDs:

Voltage Drop of LEDs:

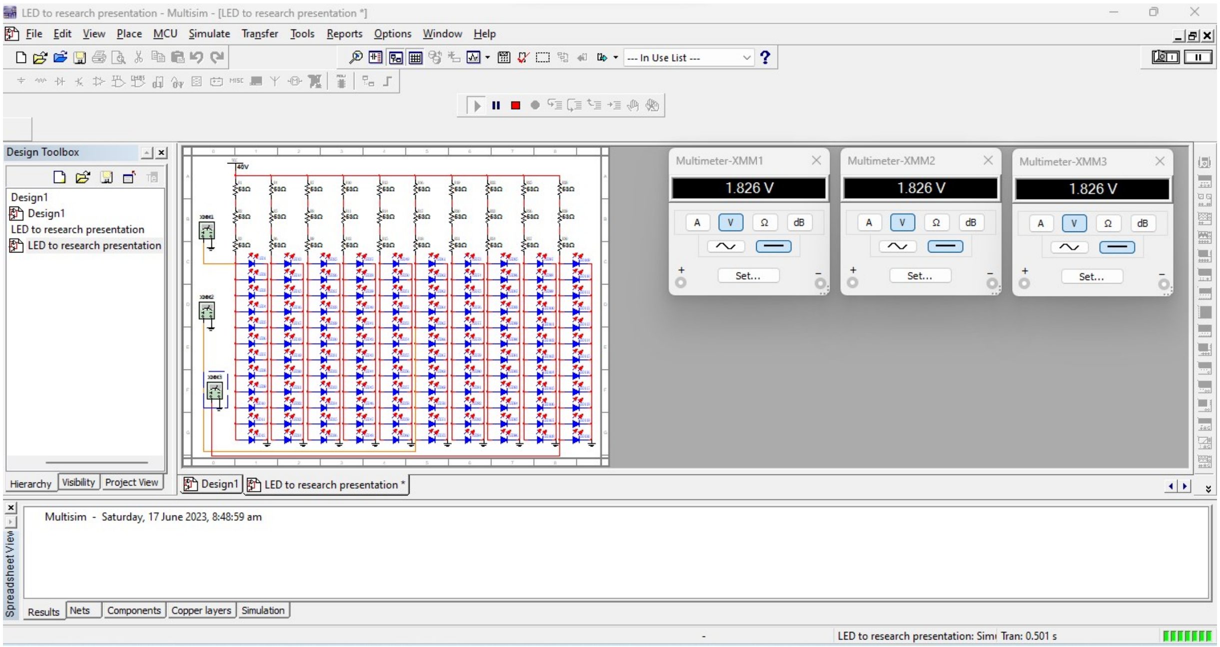

Figure 3. Simulation of the design circuit that measure the voltage drop of LEDs using voltmeter

Figure 3 shows three multimeters measuring the dc voltage drop of 3 LEDs. Multimeter-XMM1 measured the voltage drop of LED1 that shows a reading of 1.826 V. Multimeter-XMM2 measured the voltage drop of LED65 that shows a reading of 1.826 V. Multimeter-XMM3 measured the voltage drop of LED120 that shows a reading of 1.826 V. The three multimeters measured the same value of 1.826 V which also indicates that all LEDs in the circuit has the same voltage drop.

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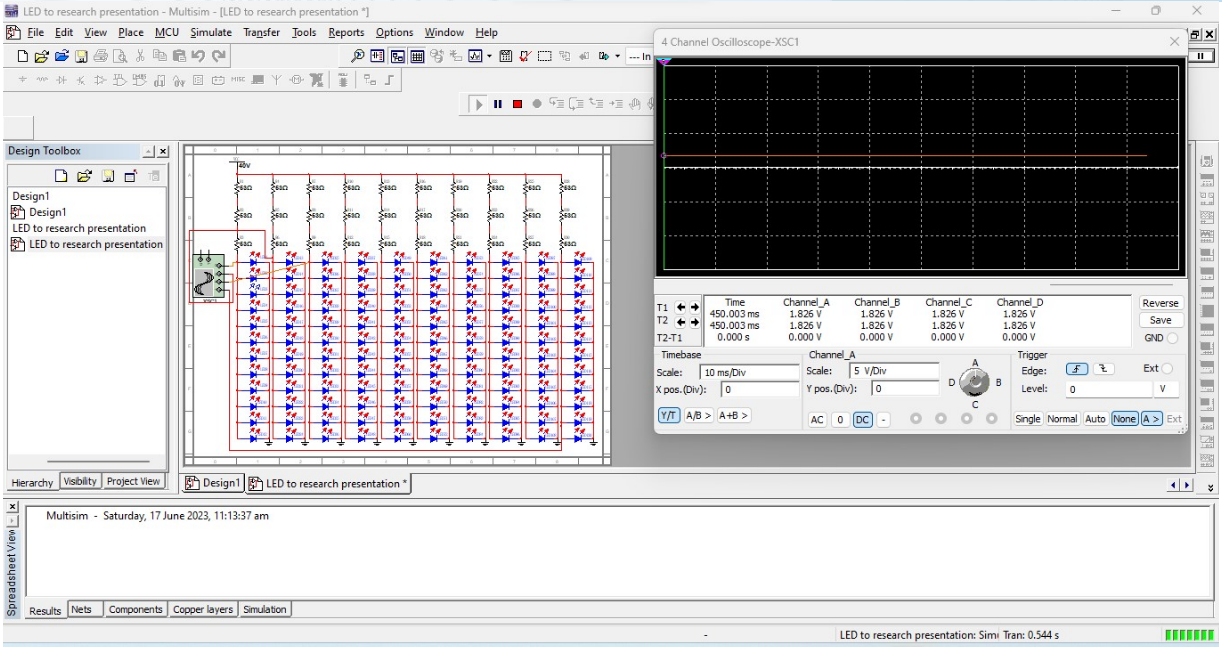

Figure 4. Simulation of the design circuit that measure the voltage drop of LEDs using four-channel oscilloscope.

Figure 4 shows four-channel oscilloscope measuring the dc voltage drop of LED1, LED12, LED25, and LED120 showing the dc signal in its scope. Channel A measured the voltage drop of LED120 that shows a reading of 1.826 V. Channel B measured the voltage drop of LED25 that shows a reading of 1.826 V. Channel C measured the voltage drop of LED12 that shows a reading of 1.826 V. Channel D measured the voltage drop of LED1 that shows a reading of 1.826 V. The four-channel oscilloscope measured the same value of 1.826 V which also indicates that all LEDs in the circuit have the same voltage drop. The measured value of the oscilloscope is the exact value with that of multimeter.

Current of LEDs:

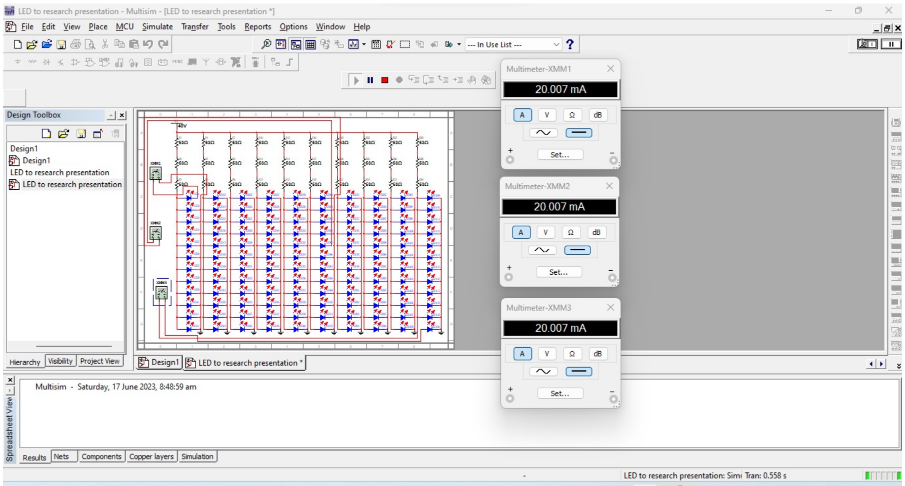

Figure 5. Simulation of the design circuit that measure the current flowing in LEDs using ammeter

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Figure 5 shows three multimeters measuring the dc current flowing in the three LEDs. Multimeter-XMM1 measured the current flowing in LED1 that shows a reading of 20.007 mA. Multimeter-XMM2 measured the current flowing in LED65 that shows a reading of 20.007 mA. Multimeter-XMM3 measured the current flowing in LED120 that shows a reading of 20.007 mA. The three multimeters measured the same value of 20.007 mA which also indicates that all LEDs in the circuit has the same current flowing through it.

Power of LEDs:

LEDs:

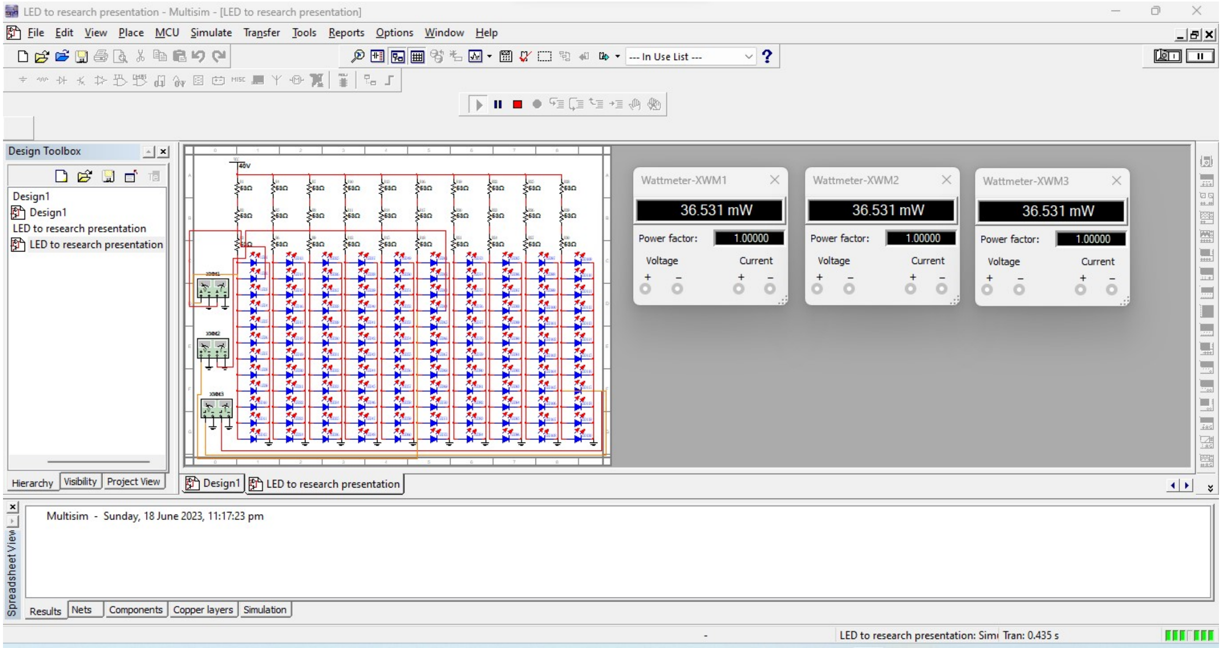

Figure 6. Simulation of the design circuit that measure the power dissipation of LEDs using wattmeter

Figure 6 shows three wattmeters measuring the power of the three resistors. Wattmeter-XWM1 measured the power of LED2 that shows a reading of 36.531 mW. Wattmeter-XWM2 measured the power of LED64 that shows a reading of 36.531 mW. Multimeter-XMM3 measured the power of LED117 that shows a reading of 36.531 mW. . The three multimeters measured same value of 36.531 mW which also indicates that all LEDs in the circuit has the same power.

For Resistors:

Voltage Drop of Resistors:

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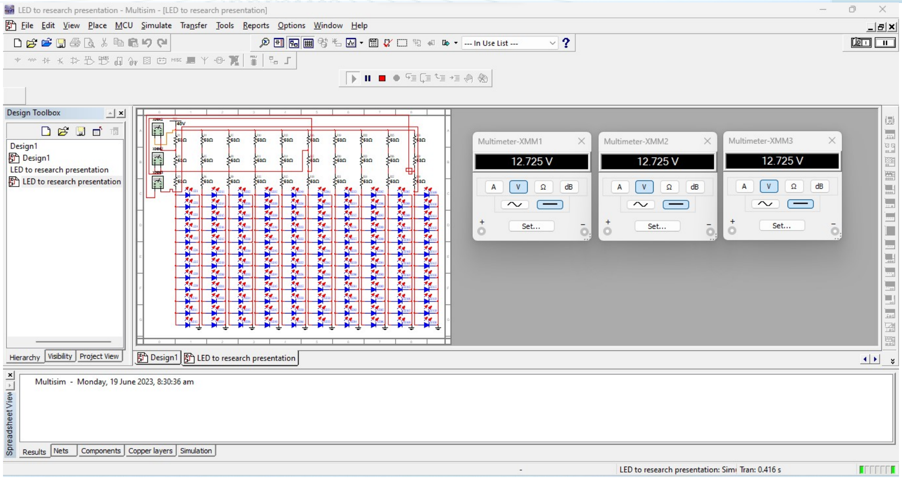

Figure 7. Simulation of the design circuit that measure the voltage drop of resistors using voltmeter

Figure 7 shows three multimeters measuring the voltage drop of 3 resistors. Multimeter-XMM1 measured the voltage drop of R_1 that shows a reading of 12.725 V. Multimeter-XMM2 measured the voltage drop of R_{17} that shows a reading of 12.725 V. Multimeter-XMM3 measured the voltage drop of R_{30} that shows a reading of 12.725 V. The three multimeters measured same value of 12.725 V which also indicates that all resistors in this circuit has the same voltage drop.

Current of Resistors:

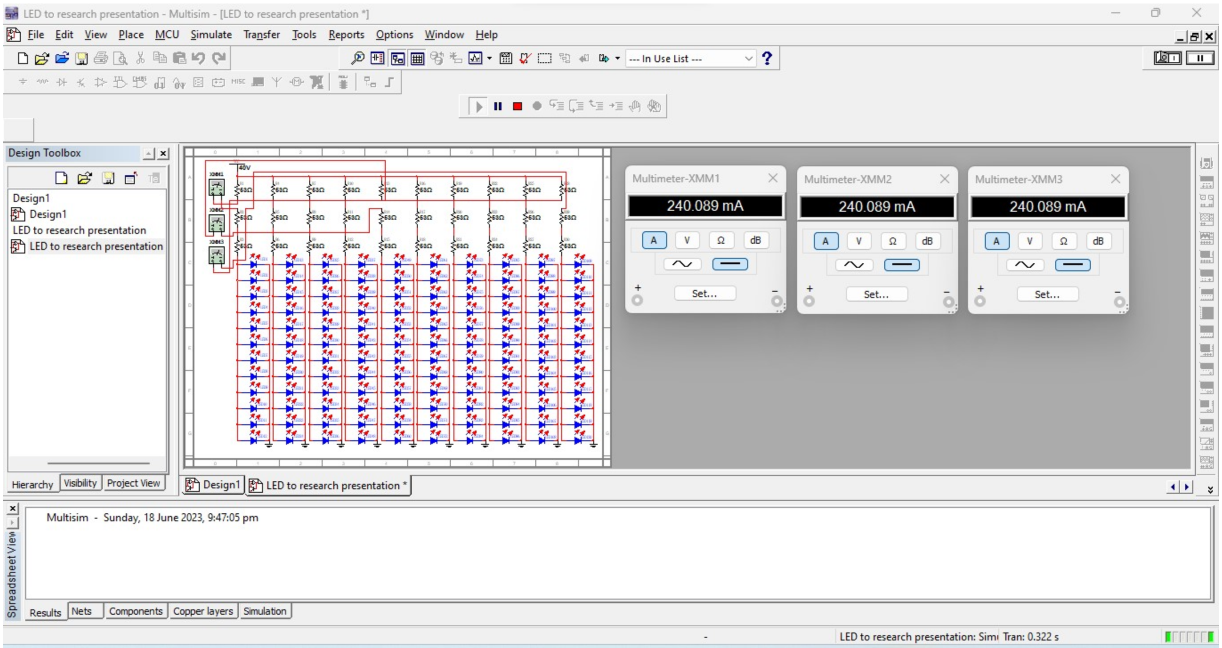

Figure 8. Simulation of the design circuit that measure the current flowing in resistors using ammeter

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Figure e shows three multimeters measuring the dc current flowing in the three resistors. Multimeter-XMM1 measured the current flowing in R_2 that shows a reading of 240.089 mA. Multimeter-XMM2 measured the current flowing in R_{14} that shows a reading of 240.089 mA. Multimeter-XMM3 measured the current flowing in R_{29} that shows a reading of 240.089 mA. The three multimeters measured same value of 240.089 mA which also indicates that all resistors in this circuit has the same current flowing through it.

Power of Resistors:

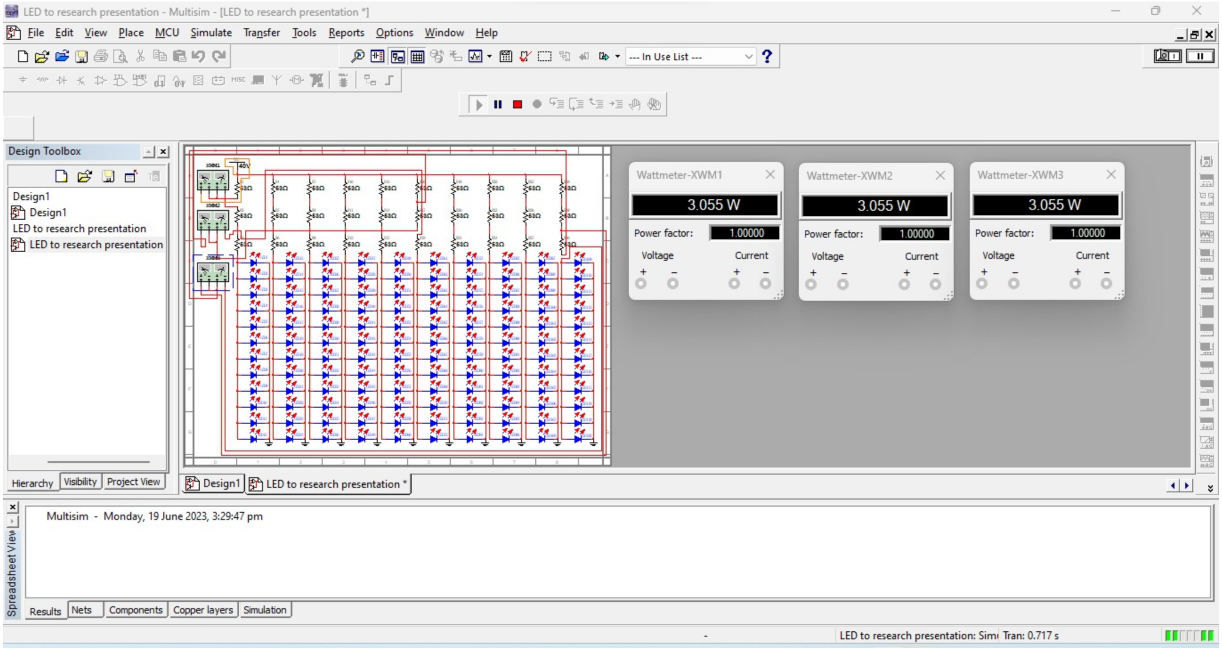

Figure 9. Simulation of the design circuit that measure the power dissipation of resistors using wattmeter

Figure 9 shows three wattmeters measuring the power of the three resistors. Wattmeter-XWM1 measured the power of R_1 that shows a reading of 3.055 W. Wattmeter-XWM2 measured the power of R_{17} that shows a reading of 3.055 W. Multimeter-XMM3 measured the power of R_{30} that shows a reading of 3.055 W. The three multimeters measured same value of 3.055 W which also indicates that all resistors in this circuit has the same power.

Summary of the Electrical Characteristics of Electronic Circuit Using Simulation Application

Table 2 shows summary of the electrical characteristics of the electronic circuit of artificial light red LED for growing plants with supply voltage, V_{CC} of 40 V when run in Multisim. The two devices' parameters being simulated were that of LEDs and resistors. The table shows that each LED has a voltage drop of 1.826 V, a current of 20.007 mA, and a power of 36.531 mW. While the resistor with 53 Ω, each has a voltage drop of 12.725 V, a current of 240.089 mA, and a power of 3.055 W.

The values being recorded in this table have a little difference when run in a simulation mode. Therefore, it indicates that the circuit being design is working.

Electrical Characteristics for V_{CC} = 40 V

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Device	Voltage	Current	Power
Light Emitting Diode (LED)	1.826 V	20.007 Ma	36.531 mW
Resistor (for 53 Ω)	12.725 V	240.089 Ma	3.055 W

Table 1. Summary Table 2

SUMMARY, CONCLUSIONS, and RECOMMENDATIONS

The researcher designed an electronic circuit artificial light using the red LED as the main device or component. He calculated the electrical parameters that are needed in the circuit using Ohm's law equation. Using Multisim, the calculated values were verified to determine that the electronic circuit is working. With a supply voltage of 40 V, the electrical characteristics for LEDs and resistor were calculated, then run on a simulation application. For LEDs, the calculated value for voltage, current, and power are 2 V, 20 mA, and 40 mW, respectively. When run in Multisim, the values are 1.826 V, 20.007 mA, and 36.531 mW. For resistors with a resistance of 53 Ω, the calculated value for voltage, current, and power are 12.7 V, 240 mA, and 3.05 W, respectively. When run in Multisim, the values are 12.725 V, 240.089 mA, and 3.055 W.

The calculated values have little difference with that value when run in a simulation application. Therefore, it indicates that the design system of artificial light red LED for growing plants will work.

Because it is concluded that the design system is working, it is recommended that the electronic circuit of artificial light red LED for growing plants can be fabricated. Once done, it can be immediately utilized in lighting plants, especially those located in lacking sunlight or no sunlight at all.

REFERENCES

Liang, L., Tian, H., & Ning, P. (2017). Artificial light LED planting system design, 2017 14th China International Forum on Solid State Lightning: International Forum on wide Bandgap Semiconductor's China (SSLChina: IFWS), Beijing, China. 2017, pp. 88-90, doi: 10.1109/IFWS.2017.8245981.

Okamoto, K., Baba, T., & Yanagi, T. (2000). Plant growth and sensing using high-brightness white and red light-emitting diodes. Conferecne on Lasers and Electro-Optics (CLEO 2000). Technical Digest Postconference Edition. TOPS Vol. 39 (IEEE Cat. No. 00CH37088), San Francisco, CA, USA, 2000, pp 450-451, doi: 10.1109/CLEO 2000.907236.

Takahashi, Y., Aihara, K., & Tomioka, R. (2022). Effect of adjusting the height of an LED light source on plant yields in cultivation systems, 2022 22nd International Conference on Control, Automation and Systems (ICCAS), Jeju, Korea, Republic of, 2022, pp. 1836-1841, doi: 10.23919/CCAS55662.2022.10003755.

Yen, H. C., Lee, C. R., & Chan, S. Y. (2013). Artificial sources for plant growth, 2013 IEEE 10th International Conference on Power Electronics and Drive Systems (PEDS), Kitakyushu, Japan, 2013, pp. 779-803, doi: 10.1109/PEDS 2013.6527126.