Surigao City Campus

SURIGAO STATE COLLEGE OF TECHNOLOGY

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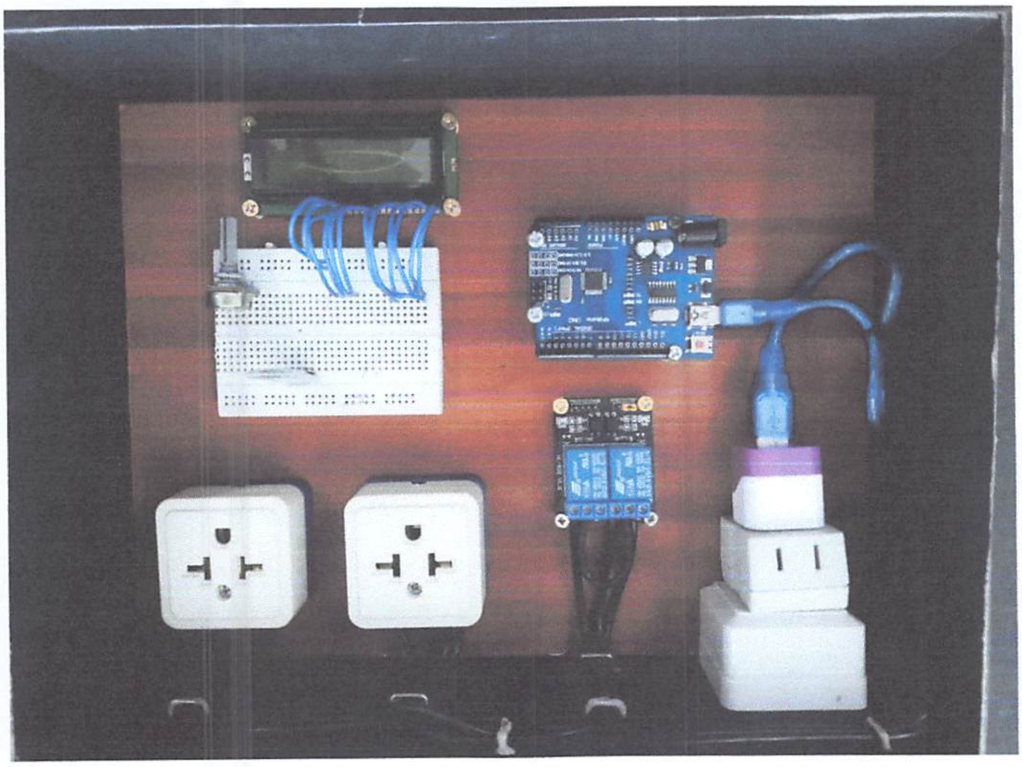
"For Nation's Greater Heights"

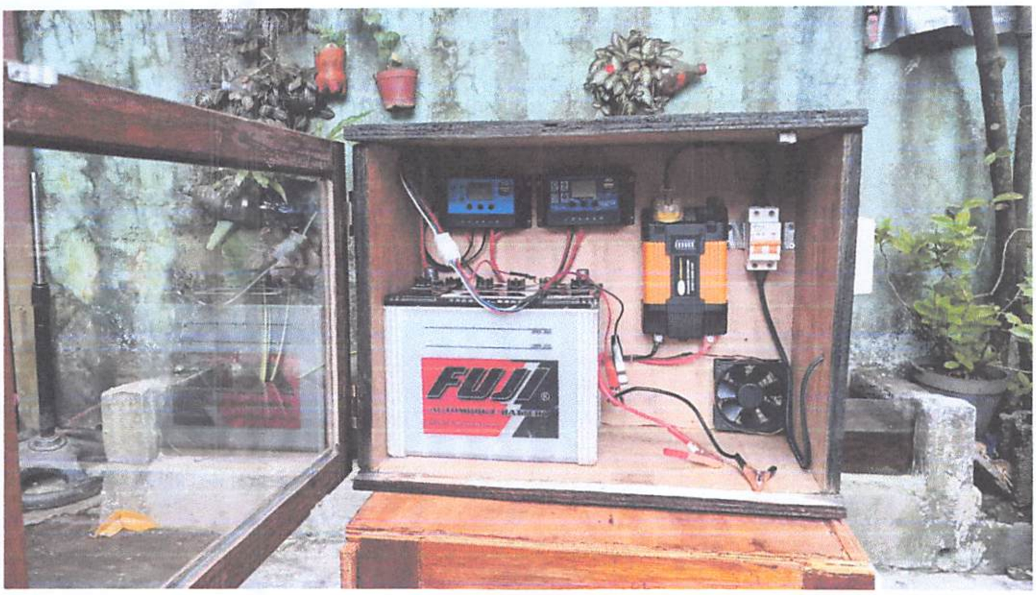
Bachelor of Science in Electrical Engineering

I.8.2. projects;

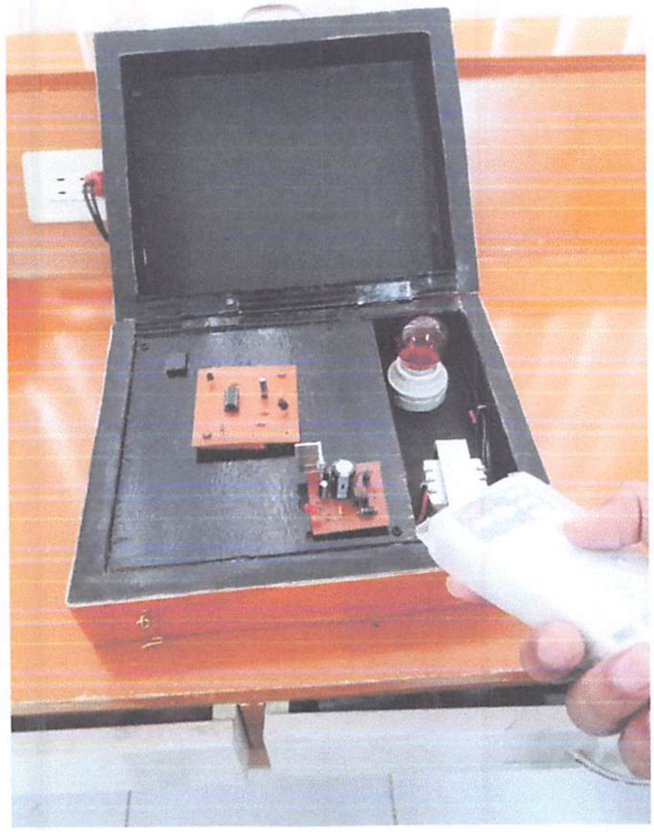
Bluetooth Switching Project

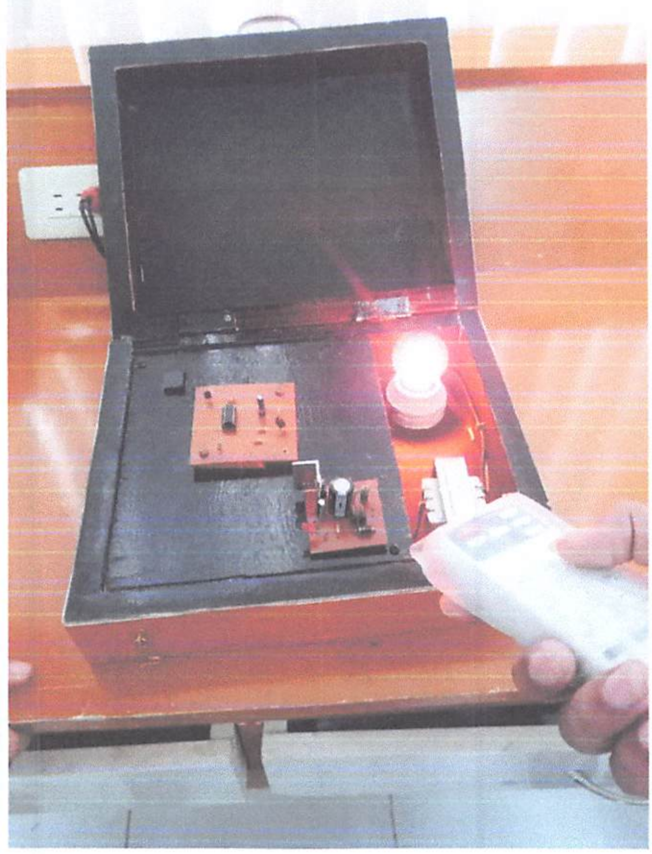


Hybrid Power System Project

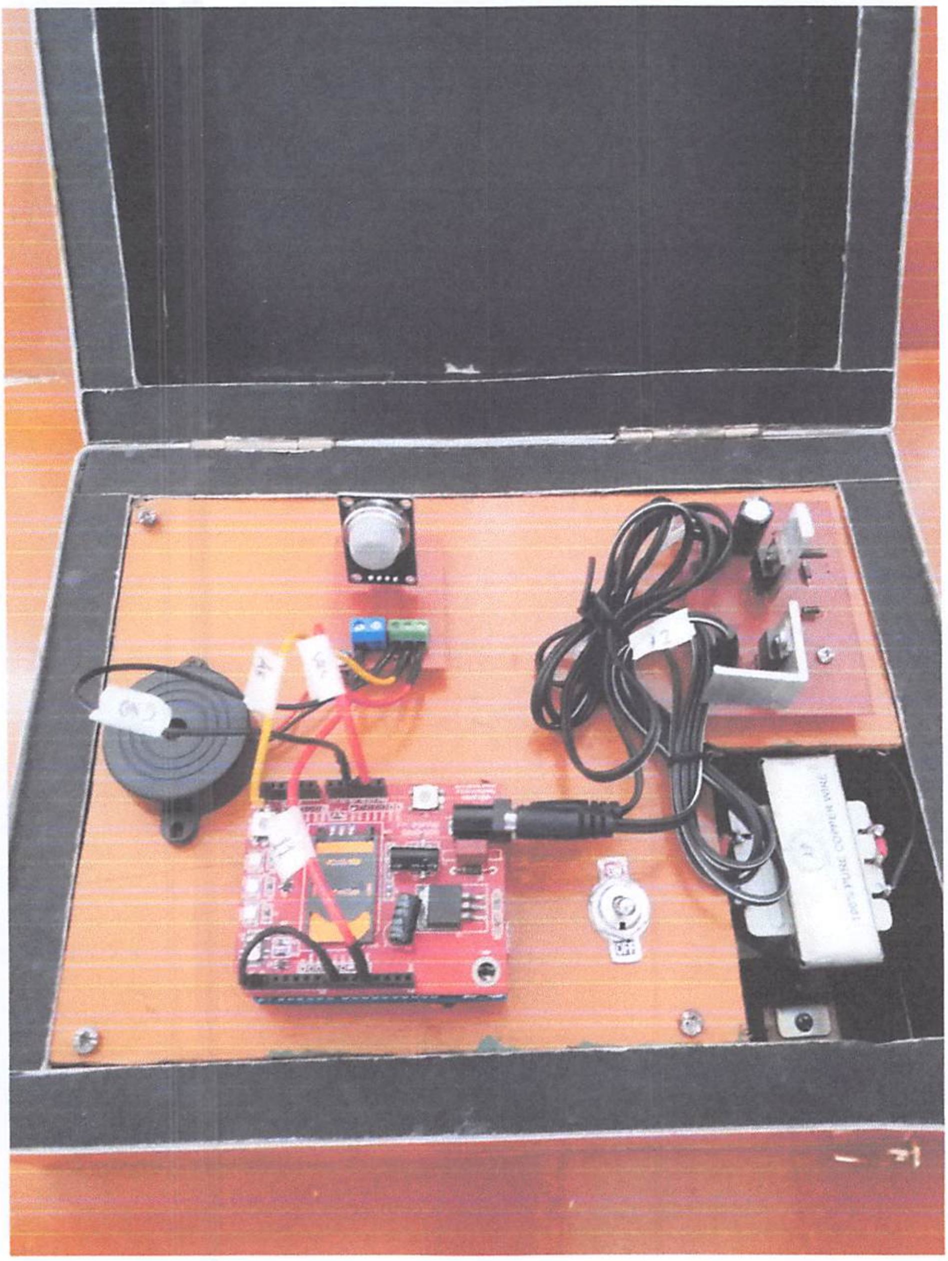


Remote Controlled Switch





GSM Based Fire Alarm System



APPROVAL SHEET

This Project Study entitled **"PHOTOVOLTAIC SOLAR TRACKING CHARGING STATION"** prepared by **Norween L. Osias, Guilbert E. Partos Jr., Renante D. Tampong** in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical Engineering** has been examined and is recommended for acceptance and approval for ORAL EXAMINATION.

ENGR. VICENTE Z. DELANTE, M.Eng'g
Co-Author

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PANEL OF EXAMINERS

Approved by the committee of ORAL EXAMINATION with a Passing Grade on June 3, 2022.

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Member

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June 10, 2022

Photovoltaic Solar Tracking Charging Station

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Abstract: A solar tracker is a device that positions an object at an angle to the Sun. Photovoltaic solar panels must be positioned perpendicular to the Sun's beams, and space telescopes must be positioned to determine the Sun's direction. This thesis proposes a method of converting solar energy into electrical energy. The tracker is made up of a photovoltaic panel that moves its surface at a right angle to the sun in order to capture the maximum amount of solar energy and convert it to electrical energy. A photovoltaic solar tracking charging station is designed to capture and store solar energy produced by a solar panel controlled by a tracking system to power any appliance or other electronic device. The study operates on the Arduino and solar charge microcontroller, which is the brain of the system, to control dual axes automatically or manually using 12v DC motors. It conducts logical and processing computations. To optimize the current and charging process, this design employs an inverter as a voltage amplifier. When tested, the data shows that solar tracking has a higher output and is better than fixed panels. The system is rated satisfactory in terms of performance and serviceability.

Index Terms: Photovoltaic, Solar energy, Tracking system, Renewable energy, Solar panel

I. INTRODUCTION

A solar cell panel, solar electric panel, photovoltaic (PV) module, or solar panel is an installation-ready arrangement of photovoltaic cells installed in a framework. Solar panels create direct current electricity by using sunlight as a source of energy. A PV panel is a collection of PV modules, while an array is a system of PV panels. As a result, we created a new source of electricity. This technology is based on the photovoltaic solar tracking method, which is used on materials that

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Electricity h
lives nowadays. Many energy resources have been depleted and wasted as a result, and brownouts, blackouts, and power outages have become commonplace. To limit and reduce pollution and degradation of the environment, it is necessary to encourage the development and adoption of green technologies. Solar, wind, biomass, hydropower, and all other non-polluting renewable energy sources must be adopted and used to replace all conventional energy sources.

To create more electricity than a typical static solar panel, a solar tracker adjusts the angle of a solar panel with respect to the sun. Solar trackers are often used to align photovoltaic solar panels with the sun's rays and to position and calculate the sun's direction. PV solar trackers rotate solar panels to align with the Sun's location in the sky. When a solar panel is perpendicular to the sun, it receives more sunlight, reflects less light, and absorbs more energy. That energy can.

This paper presents the goal to accomplish by establishing an experimental model in a specific site in Surigao City and analyzing the data collected. A simple and low-cost strategy for enhancing the performance and efficiency of solar energy to electrical energy conversion was presented in this study by situating a solar tracking panel that acts as a free generator in a specific area.

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B. Design and Construction of an Automatic Solar Tracking System by Alam (2010). This study planned and constructed a dual axis solar programmable logical controller (PLC) based automatic tracking system, as well as its supervisory and control system. The proposed tracking system generated roughly 8%--25% more electricity than the fixed-angle PV system as a consequence of the trial.

C. Performance Comparison of Mirror Reflected Solar Panel with Tracking and Cooling by Rahman (2019). This study describes a microcontroller-based solar tracking system with mirror booster. The intensity of the mirror boosted radiation over the PV panel is greater than its typical value, which raises the panel's temperature. The properties of semiconductor material are affected by temperatures above 25°C, lowering the open circuit voltage and panel efficiency.

16 Jun 2022
PASSED
Osias, Partos, Tampong
Engr. RMB

Danylenko (2018) stated that Solar panels are made up of several layers, including glass, a protective layer, and a front contact layer that covers individual solar cells that are connected in series. Metal back contacts carry electricity and are laminated to waterproof the cells and insulate them from excessive heat beneath those. Finally, there is a glass, metal, or plastic protective rear layer. Crystalline silicon (c-Si), amorphous silicon (a-Si), gallium arsenide (GaAs), and organometallics are the top four most widely utilized materials for solar panels (soluble platinum).

In the solar tracking system, a photo resistor, also known as a light-dependent resistor, was employed. It is a light-sensitive electrical component. The resistance changes when light shines on it. The resistance of the LDR can vary by many orders of magnitude, with the resistance decreasing as the amount of light rises. The output of the model is shown in the findings of this study; the results received from the system demonstrate that the model is effective because it produces acceptable values. A PV array and a solar tracking system will be used to test this behavior.

The photovoltaic panels provide enough energy to fully power the electronics. The target application determines the electronics, sensor technologies, data transmission, and data processing procedures of such wearable devices. As a result, the essay discusses essential application scenarios for solar tracking systems, as well as their pros and cons.

The main focus of this research is the conversion and production of solar energy into electricity using a solar tracking system. Another or alternate source of electricity is a solar tracking system, which absorbs the energy from the sunlight and converts them to electricity. Our design specializes in solar tracking, as it uses the Arduino to track the sunlight. This method works whenever sunlight is available and measures the amount of energy absorbed

The project's unique feature is that it has a higher tracking system output and produces more electricity. Aside from the design we created, there are just a few other studies like ours that have been done. However, we are concentrating on the capability of the area since no matter what design or equipment is built, it will be usable if there is no reliable source of energy.

1.2 Conceptual Framework

The conceptual framework for the study is divided into four steps, as shown in Figure 1. The materials must first be prepared. The second step is to plan and create the design, followed by implementation and analysis. Finally, design energy is generated, as well as testing and analysis, and storage refers to the amount of energy saved over time. Finally, the project's outcome, as depicted in Figure 1, is shown.

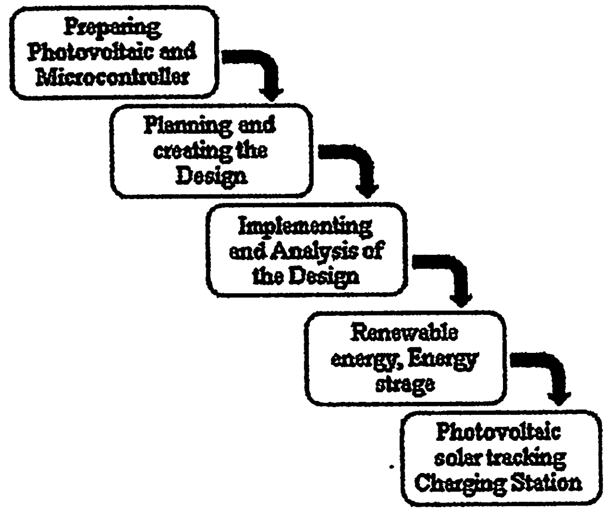

Figure 1. Waterfall Diagram of the Study

1.3 Objectives

The study's overall goal is to see if utilizing a solar tracking system is a better option than using other non-tracking renewable energy sources.

The following are the specific objectives:

1. To design the Photovoltaic solar tracking system charging station.
2. To implement the project design.
3. To test and analyze the system.

II. METHOD

2.1 Research Design

A developmental research design is used in this study. It is defined as a systematic investigation of project conception, development, and evaluation that must adhere to internal consistency and effectiveness guidelines. It was used to evaluate the accuracy, efficiency, and long-term viability of the system.

2.2 Project Design

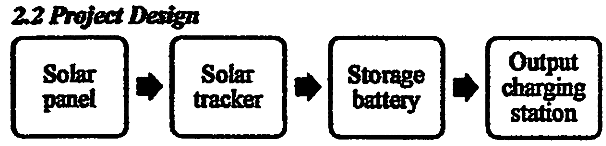

Figure 2. Block Diagram of the System

When exposed directly to the sun, a solar panel, as seen in Figure 2, can generate electricity. The solar panel's energy, which varies based on the amount of sunlight, will be directly stored in the battery. This device is used to charge any appliances or other devices.

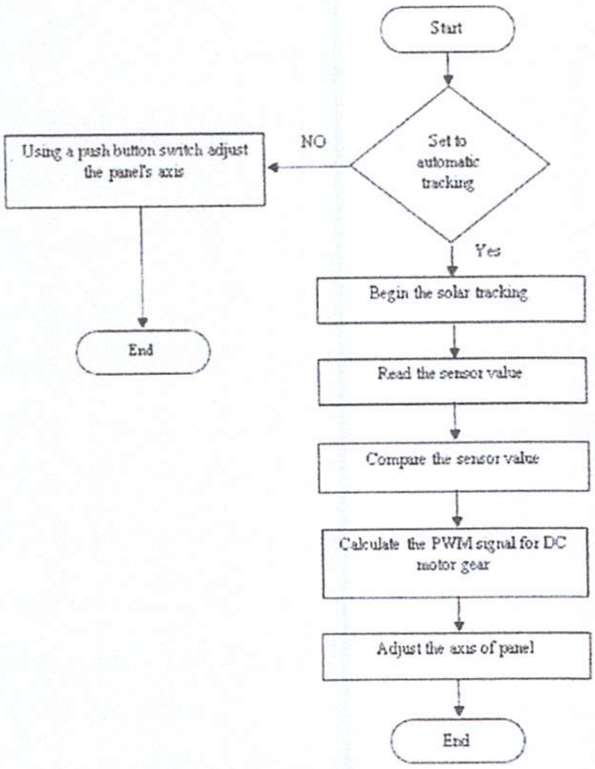

Figure 3. Flowchart of the System

2.3 Project Development

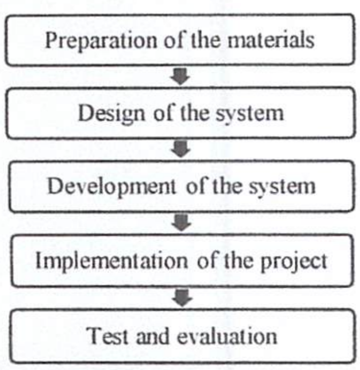

Figure 4. Project Development Flow Chart of the Project

Figure 4 depicts the flow of work design. The first step is to manufacture a photovoltaic material; the second is to construct a mechanism that charges a larger battery with a small amount of current. The link is used in the third block to boost the current so that a larger battery may be charged. The fourth block depicts the project design being implemented in any respectable Luneta Park areas that have been prepared for review.

2.4 Project Implementation

The planned project will be implemented in the Luneta Park of Surigao City. It will go through three stages. Setup, which includes hardware and software configuration, is the initial phase. The device's energy output is monitored in the second phase. The final step is the maintenance phase. This means enhancing and tailoring the project's program to the needs of the users.

2.5 Project Setting

Figure 5. Luneta Park, at San Nicolas street, Surigao City

It piqued our interest since it is in the center of the city, where a big number of people congregate and may charge their phones and other devices.

2.6 Participants of the study

Table 1. List of participants and their involvement in the study.

Participants	f(n=4)	% involvement
Electrical Engineer	1	20
Electronics Enginer	2	60
Civilians	1	20
TOTAL	4	100%

Table 1 shows approaching an electrical engineer for battery charging and storing technique. Two electronics engineers for circuit components and a local mechanic for the hardware desire.

2.7 Instruments

Laptop/PC – this helps to program, collecting data and build ideas through internet.

Tester – helps in measuring the voltage, amperage, and output power of the devices.

Arduino IDE- makes it easy to write code and upload it to the board. This software can be used with any Arduino board.

Proteus Simulator - the software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

2.8 Research Ethics

To begin with, one of the research ethics adopted by the researchers in this paper is honesty. Details were not fabricated, falsified, or distorted by the researchers. Researchers did not disappoint our peers, study sponsors, or the general public, and they collected data honestly. The researchers kept their promises and agreements as stated in the aims. According to the legislation, the project's development did not breach any laws or generate any environmental difficulties.

2.9 Data Collection

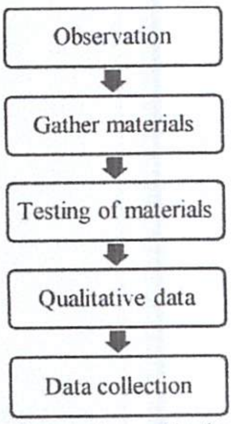

Figure 6. Block diagram for qualitative data collection

Figure 6 depicts a general overview and flow of the qualitative data acquired in the figure. First row, observation is to verify that the evidence acquired allows the researchers to properly handle the research problem. When the testing begins, the second row is where the acquired material ensures a low-cost material for the easy to replace proposals. The third row uses an Arduino Microcontroller to do manual or automatic solar exposure directly to the sun, which aids in evaluation of data. Finally, the data was grouped into categories there.

III. RESULTS AND DISCUSSION

3.1 Design of the Photovoltaic Solar Tracking Charging Station

The photovoltaic is put together using a basic circuit as shown in Figure 7. The circuit's function is to increase the photovoltaic output current. The output from the energy captured is used to charge the battery.

The tracking output current was enhanced due to the parallel circuit. Figure 7 shows how the collected energy is used to charge 12 volt batteries using two 12 volt DC motors controlled by an Arduino.

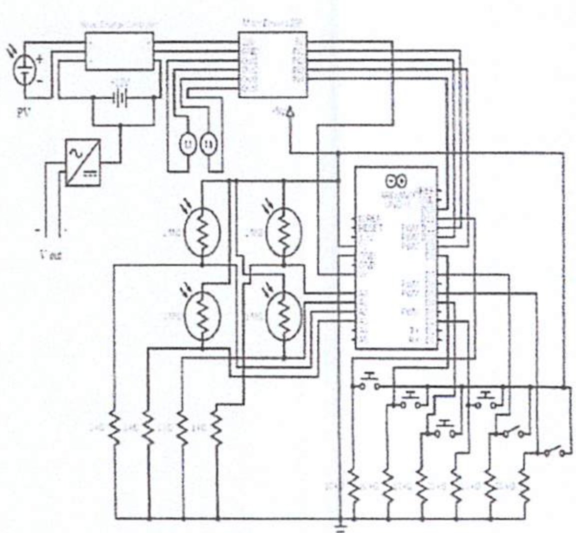

Figure 7. Schematic Diagram of the Solar Tracking System

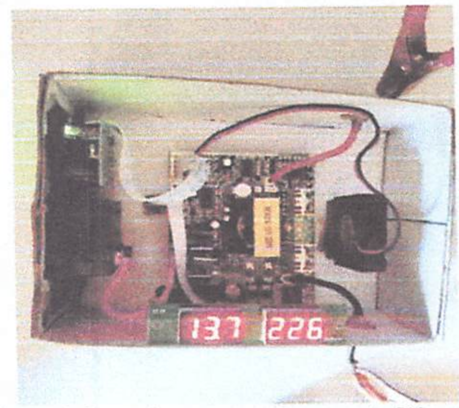

Figure 8. Power inverter can charge up to 500 watts

Figure 8 shows the Arduino diagram for the dual axis solar tracking system, which is connected to the solar charge controller.

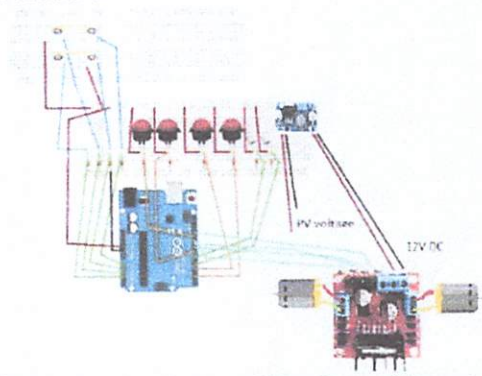

Figure 9. Wiring diagram of the solar tracking system

Table 2. Direct material and service cost.

Description of materials	QTY	Cost(PHP)
Arduino	1	300
Wires	22m	500
Electronic Components		500
Battery 12V	1	1100
DC Motor 12V	2	300
Tester	1	720
DIY Inverter	1	600
Solar Charge Controller	1	300
LM2596(voltage regulator)	1	100
Photovoltaic 15 Watts	1	700
Wood stick	1	150
Soldering iron and lead	1	500
Electrical tape	1	20
Services		
Transportation		960
Grand Total		**6750**

3.2 Implementation of a Photovoltaic Solar Tracking System

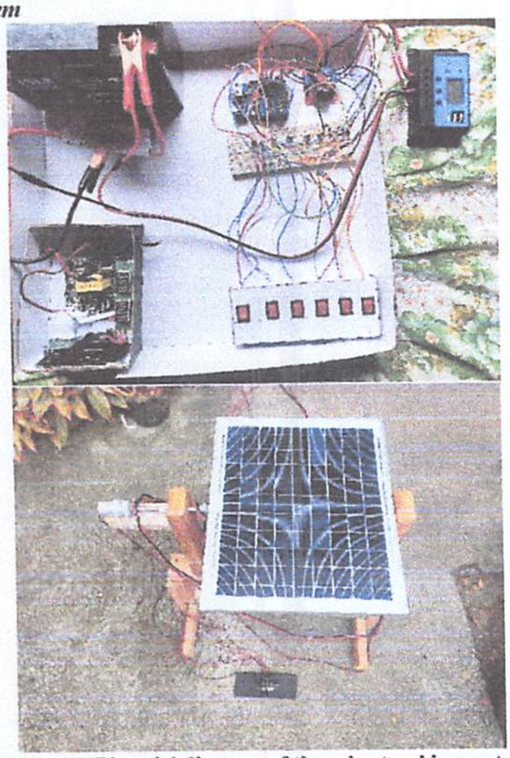

Figure 10. Pictorial diagram of the solar tracking system

When the batteries are fully charged, they are connected to the inverter, which raises and produce the voltage to 220 volts while limiting the volts to safely charge the 12v battery as shown in Figure 10. The flow of electricity from the solar panel to the 12-volt battery was controlled by a microcontroller in the study. The voltage sensor, like the current sensor, is used to determine the voltage stored in the battery. The output of the circuit is used to charge the 12V battery.

3.3 Testing and analysis of the system

Table 3. Comparison results of non-track and tracking system

Time	Fixed panel		Tracking panel		Tracking Angle
	(V)	(A)	(V)	(A)	
6:00AM	16.45	.76	17.6	2.81	E45°W
7:00AM	16.7	1.01	18.1	3.01	E45°W
8:00AM	17.0	1.25	18.5	3.43	E45°W
9:00AM	17.2	2.36	19.1	3.59	E45°W
10:00AM	17.8	2.53	19.6	4.01	E60°W
11:00AM	19.6	3.66	19.9	4.78	E75°W
12:00PM	20.0	4.47	20.6	5.42	E90°W
1.00PM	20.7	5.14	21.8	6.37	E105°W
2:00PM	21.3	5.96	21.6	6.13	E120°W
3:00PM	19.6	5.45	20.7	5.89	E135°W
4:00PM	17.4	5.03	19.8	5.28	E135°W
5:00PM	16.7	4.30	18.7	4.88	E135°W

The angle of the design were preset at 45 degrees to 135 degrees maximum, 360 degrees/24 hr = 15 degrees per hour. The Sun rises 30 degrees north of due east and sets 30 degrees north of due west at the summer solstice. It rises at 30 degrees south of due east and sets at 30 degrees south of due west on the winter solstice.

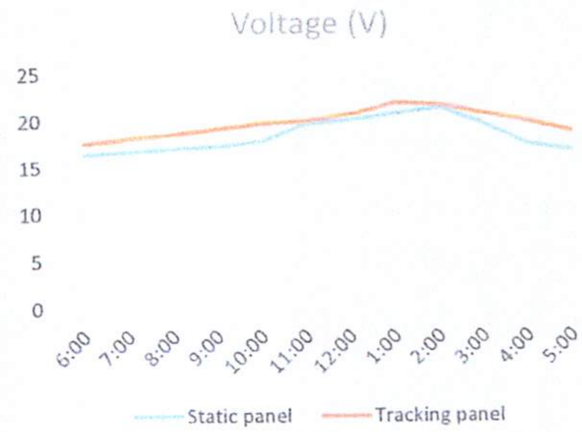

Figure 11. Voltage comparison of static and tracking panel

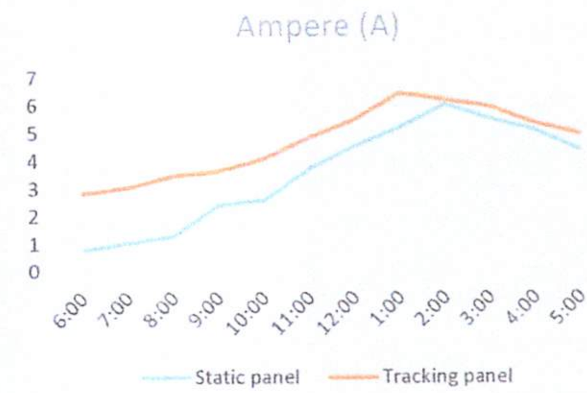

Figure 12. Ampere comparison of static and tracking panel

Figures 11 and 12 show how a tracking solar panel system is considerably superior in terms of output and power generation.

Table 4. Test charge of the battery

No.	Vin	Vo	Iin	Io	% current	Information
1	18	21.6	0.83	0.92	9.8	When the initial charging
2	18	21.6	0.75	0.81	7.4	Process charge
3	18	21.6	0.73	0.84	13.1	Process charge
4	18	21.6	0.63	0.76	17.1	Process charge
5	18	21.6	0.59	0.65	9.2	Process charge
6	18	21.6	0.58	0.64	9.4	Process charge
7	18	21.6	0.43	0.55	21.8	Process charge
8	18	21.6	0.33	0.45	26.7	Process charge
9	18	21.6	0.23	0.34	32.4	Process charge
10	18	21.6	0.1	0.1	0	Battery full

The experimental model was observed and monitored for several hours. The photovoltaic current varies with exposure and amount of sunlight, as shown in the table from time interval tests.

The sun rotates 360 degrees around the globe every 24 hours, which means it moves a quarter of a degree each minute, or 15 degrees per hour, from east to west.

When building a slanted or ground-mounted PV system, calculating the necessary separation between each row can be difficult, if not impossible. However, it's critical to do it properly the first time to prevent shading from modules ahead of each row by accident. This might result in underperforming systems and irritated consumers. That is something that no one desires. The height difference between the rear of the module and the surface is the first step in calculating inter-row spacing for your modules. To accomplish so, use the formula **Height Difference = Sin (Tilt Angle) x Module Width.**

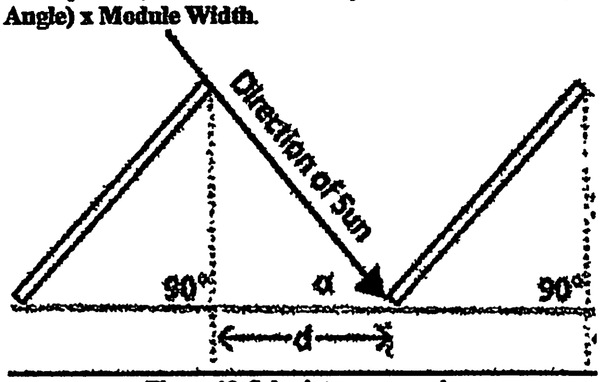

Figure 13. Solar inter row spacing

Prior to deriving the general formula, it's worth noting that the axis sun-tracking system's job is to point a solar collector towards the sun by rotating it along two perpendicular axes such that the sunray is always normal relative to the collection surface. The sun's position vector relative to the earth-center frame can be defined as illustrated in Equation 1.

$$S=\begin{bmatrix} S_M \\ S_E \\ S_P \end{bmatrix}=\begin{bmatrix} \cos\delta\cos\omega \\ -\cos\delta\sin\omega \\ \sin\delta \end{bmatrix}$$

Equation 1. By Stine & Harrigan (1985)

Where δ is the declination angle and ω is hour angle are defined as follow (Stine & Harrigan1985). The hour angle indicates the time of day in relation to solar noon. It's the angle formed by the planes of the observer and the meridian that intersects the earth-sun line. It starts at zero degrees at solar noon and rises 15 degrees per hour.

$$\omega = 15(t_s - 12) \quad \text{(degrees)}$$

Equation 2. Solar Hour Angle

The hour angle indicates the time of day in relation to solar noon. It's the angle formed by the planes of the observer and the meridian that intersects the earth-sun line. It starts at zero degrees at solar noon and rises 15 degrees per hour.

.The constructed experimental model and its analysis established the groundwork for determining the viability of installing photovoltaic at Luneta Park. The following is how the study was carried out:

A. Having a 220 volt average output from the inverter (attached from the circuit)

B. The survey was conducted for 10 hours, from 8 a.m. to 12 p.m. and 12 p.m. to 5 p.m Tables 5 and 6 provide a sample of such a survey and its results.

C. Its output is dependent on the availability of sunlight, this sort of energy can be considered a limited energy source. As a result, the expected power output was calculated as shown in the table 6.

D. The data was extrapolated to calculate the projected energy production if the panel was installed in the center of Luneta Park without any obstacles.

Table 5. Sample of collected data and analyze using a charge controller in Luneta Park Surigao city

Time	Input(V)	Input(A)	Output(V)	Output(A)
8:00	21.6	1.4	13.3	4.3
9:00	21.6	1.8	13.3	5.4
10:00	21.6	2.01	13.3	6.2
11:00	21.6	2.02	13.3	6.2
12:00	21.6	1.9	13.3	5.8
13:00	21.6	1.7	13.3	5.1
14:00	21.6	1.3	13.3	4.03
15:00	21.6	.9	13.3	3.04
16:00	21.6	.6	13.3	1.9
17:00	21.6	.5	13.3	1.7
Total	**216**	**14.13**	**133**	**43.67**

Table 6. The feasible expected power at the Luneta Park Surigao city

Time(Hour)	Power(Watt)
8:00	30.31
9:00	37.8
10:00	43.5
11:00	43.5
12:00	41.4
13:00	36.1
14:00	28.34
15:00	21.4
16:00	13.2
17:00	12.5
Sum	**308.05**

IV. CONCLUSION AND RECOMMENDATION

Conclusion

The primary goal of this research was to design a solar tracking system. In comparison to their fixed-position counterparts. Solar tracking systems with two axes are more efficient than those with one axis and are fixed.

We came to the conclusion that the project can be implemented because it uses a wood stick with a dual axes 12v DC motor mechanism, which is controlled by an Arduino and a solar-powered microcontroller.

The research was done to see how much more power could be generated if photovoltaic panels used solar tracking instead of fixed panels. With a 15 watt photovoltaic panel, the obtained results show that storing the generated energy will result in an energy of 308.05 watts in just 9 hours. This energy can be used to power phones and turn on street lights at night. For example, a ten-hour LED lamp rated at 10 to 20 W.

Recommendations

From the design that we have made, we recommend:

1. For safety reasons, the solar' span should be increased.

2. Enhance energy output by adding more photovoltaic solar panels.

3. Anodized aluminum using this material has numerous benefits, it has the ability to reflect more heat, helping to improve the overall conversion efficiency of a solar cell.

4. Add a mirror booster using microcontroller for higher output.

V. ACKNOWLEDGEMENT

The researchers would want to thank the Almighty God for educating our minds and permitting the research to take place. To the parents of the researchers for their everlasting love and support in ensuring the study's success. For their unrelenting dedication to guiding and aiding the researcher in finishing the project. In addition, we appreciate their assistance with the project's title, as well as our panelist's approval of our project's thesis defense. Thank you to our students who kindly shared their time and thoughts with us. Thank you to everyone who worked on this project for their dedication and patience.

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APPROVAL SHEET

This Project Study entitled **"PHOTOVOLTAIC SOLAR TRACKING CHARGING STATION"** prepared by **Norween L. Osias, Guilbert E. Partos Jr., Renante D. Tampong** in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical Engineering** has been examined and is recommended for acceptance and approval for ORAL EXAMINATION.

ENGR. VICENTE Z. DELANTE, M.Eng'g
Co-Author

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PANEL OF EXAMINERS

Approved by the committee of ORAL EXAMINATION with a Passing Grade on June 3, 2022.

ENGR. ROBERT R. BACARRO, MECE, MBA
Chairman

ENGR. FEDERICO A. AVES
Member

ENGR. JERRY I. TELERON, PhD, PCpE
Member

==

Accepted and approved in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical Engineering.

ENGR. ROBERT R. BACARRO, MECE, MBA
Dean, College of Engineering and Information Technology

June 10, 2022

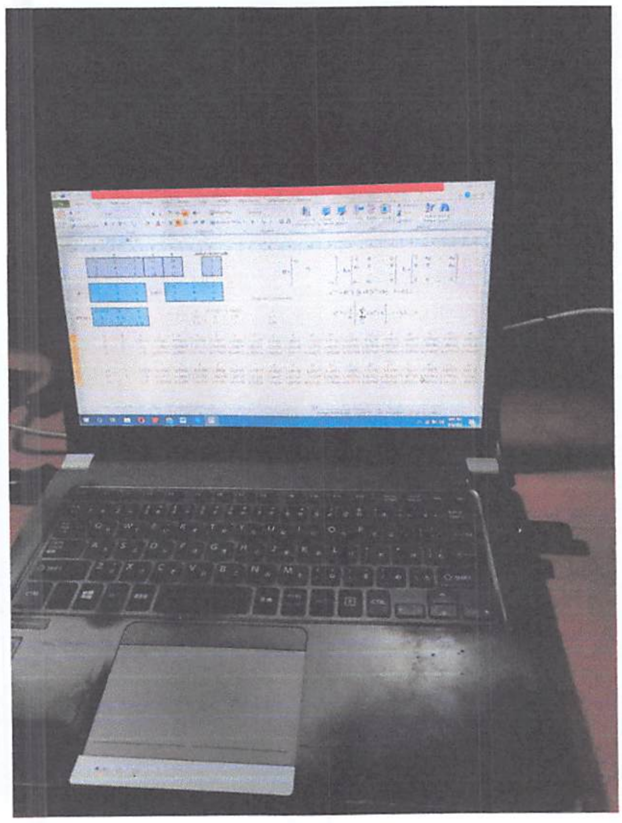
I.8.3. group dynamics;

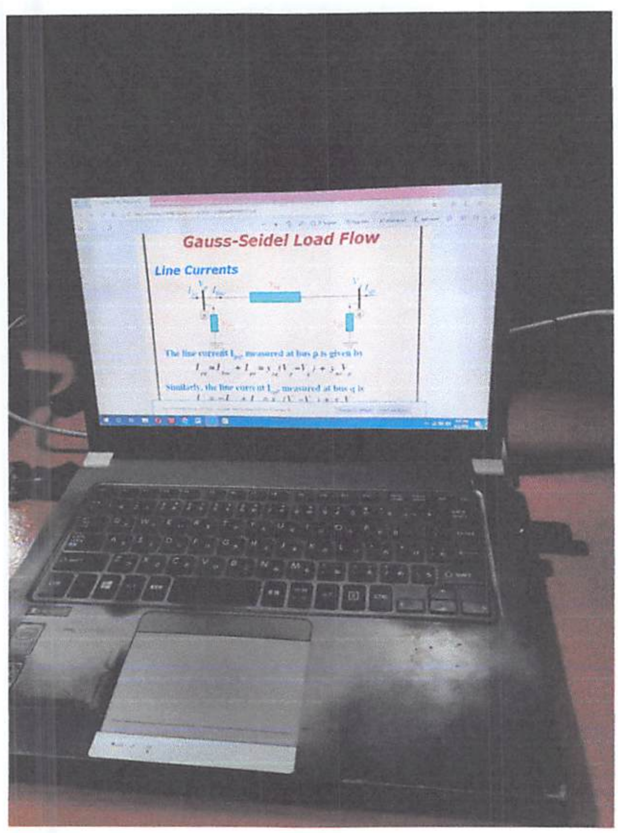
I.8.4. case study;

I.8.5. workshops;

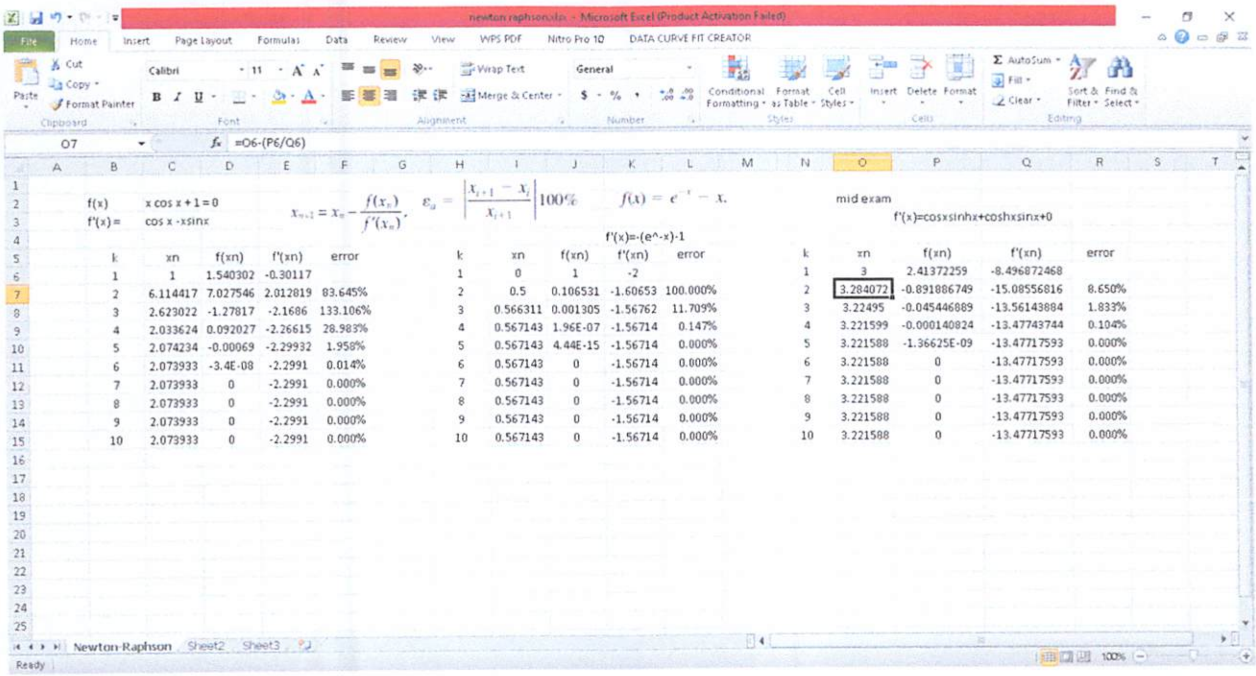
I.8.6. simulations;

Power System Simulations on Load Flow Analysis Using Newton-Raphson and Gauss-Seidel Methods on Excel





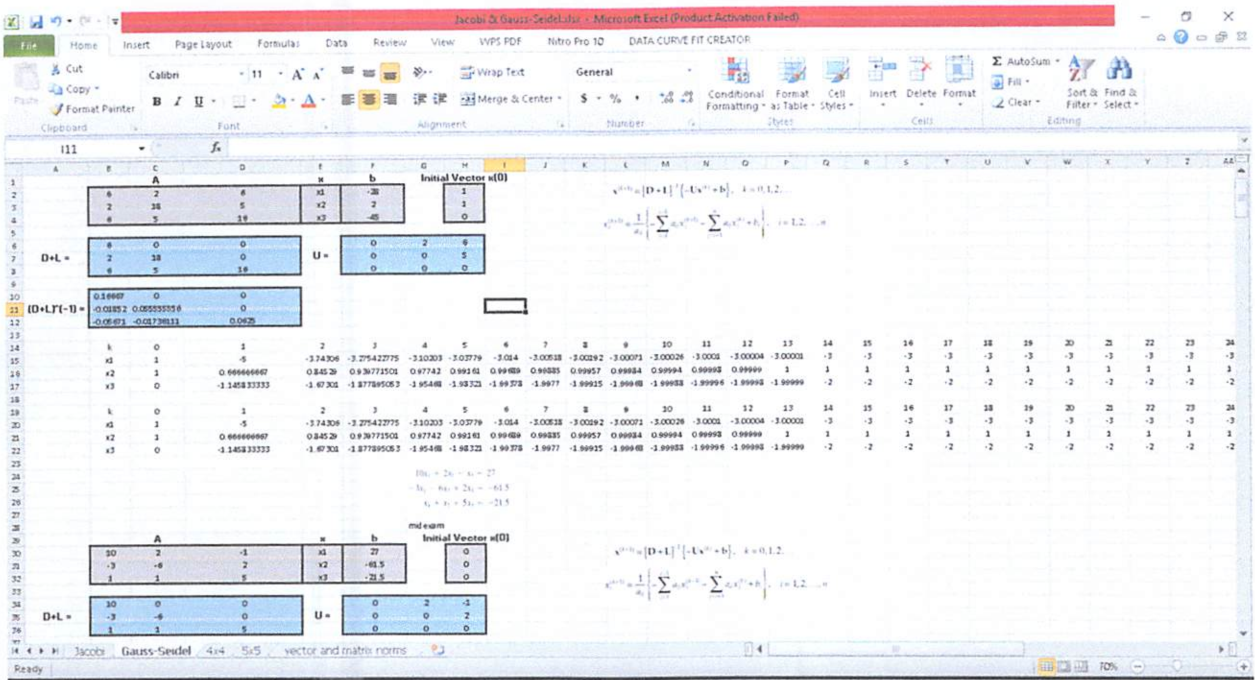
Power System Simulations on Load Flow Analysis Using Newton-Raphson and Gauss-Seidel Methods on Excel

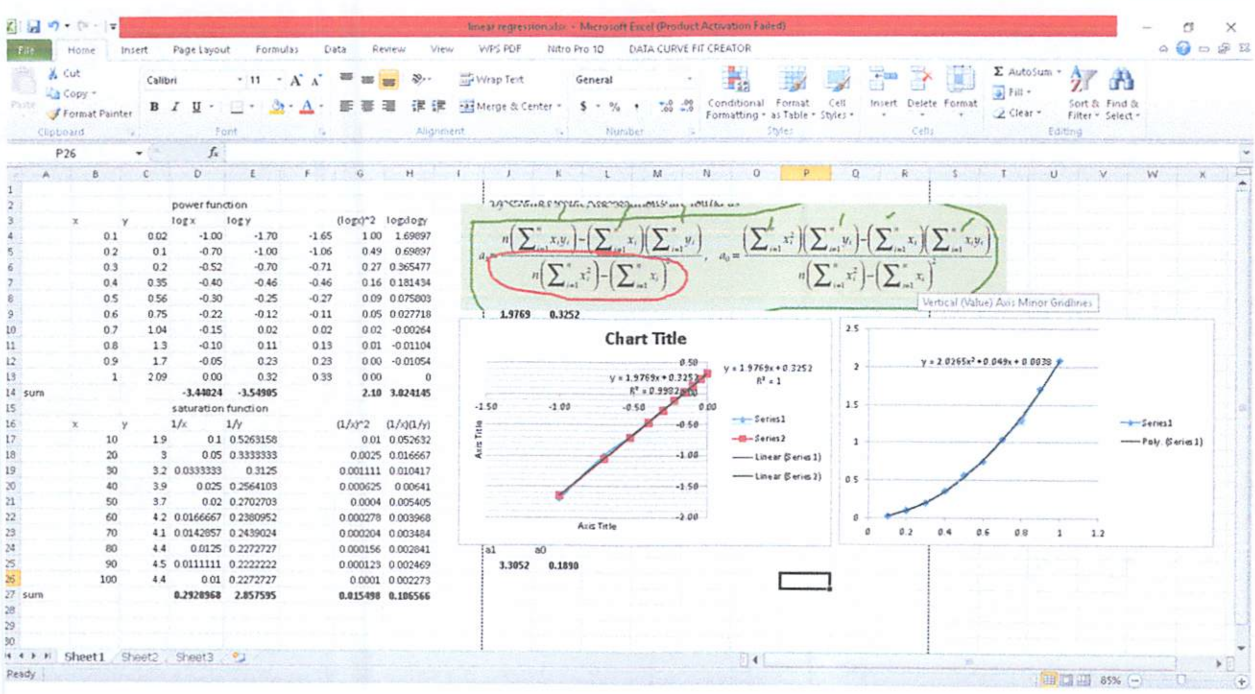


k	xn	f(xn)	f'(xn)	error
1	1	1.540302	-0.30117	
2	6.114417	7.027546	2.012819	83.645%
3	2.623022	-1.27817	-2.1686	133.106%
4	2.033624	0.092027	-2.26615	28.983%
5	2.074234	-0.00069	-2.29932	1.958%
6	2.073933	-3.4E-08	-2.2991	0.014%
7	2.073933	0	-2.2991	0.000%
8	2.073933	0	-2.2991	0.000%
9	2.073933	0	-2.2991	0.000%
10	2.073933	0	-2.2991	0.000%

k	xn	f(xn)	f'(xn)	error
1	0	1	-2	
2	0.5	0.106531	-1.60653	100.000%
3	0.566311	0.001305	-1.56762	11.709%
4	0.567143	1.96E-07	-1.56714	0.147%
5	0.567143	4.44E-15	-1.56714	0.000%
6	0.567143	0	-1.56714	0.000%
7	0.567143	0	-1.56714	0.000%
8	0.567143	0	-1.56714	0.000%
9	0.567143	0	-1.56714	0.000%
10	0.567143	0	-1.56714	0.000%

k	xn	f(xn)	f'(xn)	error
1	3	2.41372259	-8.496872468	
2	3.284072	-0.891886749	-15.08556816	8.650%
3	3.22495	-0.045446889	-13.56143884	1.833%
4	3.221599	-0.000140824	-13.47743744	0.104%
5	3.221588	-1.36625E-09	-13.47717593	0.000%
6	3.221588	0	-13.47717593	0.000%
7	3.221588	0	-13.47717593	0.000%
8	3.221588	0	-13.47717593	0.000%
9	3.221588	0	-13.47717593	0.000%
10	3.221588	0	-13.47717593	0.000%





I.8.7. dimensional question approach;

Completing the Circuit

Summary

In the everyday electrical devices we use – calculators, remote controls and cell phones – a voltage source such as a battery is required to close the circuit and operate the device. In this hands-on activity, students engage in the science and engineering practice of making observations as they use batteries, wires, small light bulbs and light bulb holders to explore the phenomenon of electricity and learn the difference between an open circuit and a closed circuit. Students engage in the disciplinary core ideas and crosscutting concepts of electric current and energy transfer as they make sense of the idea that electric current only occurs in a closed circuit.

Students explore electric current through a closed circuit

Engineering Connection

Electrical engineers design the circuits and batteries that are in the devices and appliances that we use every day. Circuits can be found in music players, computers, video games, appliances, microwaves, phones, televisions, cameras, medical equipment, vehicles and so many more products. Engineers take seriously the responsibility of designing circuits that work dependably and safely. While new devices are constantly being developed around the world, engineers strive to create safer, more efficient products that ultimately help improve people's lives.

Learning Objectives

After this activity, students should be able to:

- Define, recognize, build and draw a closed circuit.
- Explain why a closed circuit is required for any electrical device to operate.
- Describe the transformations of energy that occur in the circuit.
- Use correct operations and appropriate methods to solve Ohm's law problems.

Materials needed:

- 1 D-cell battery
- 5-7 in (13 - 18 cm) insulated wire (gauge AWG 22) (available at most hardware stores)
- 1 small light bulb holder (#40) (optional; available at most hardware stores)
- 1 small light bulb (#40) (available at most hardware stores)
- small wire strippers or sandpaper (to remove insulation at wire ends)
- tape (scotch, masking or electrical)
- 1 Completing the Circuit Worksheet
- 1 Ohm's Law Math Worksheet

Name: **Date:**

Completing the Circuit Worksheet

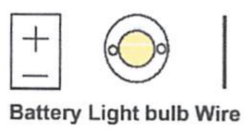
1. In the space below, draw two ways to light the bulb. Use the symbols below.

2. What do you have to do to get the bulb to light up?

3. Draw two ways to connect the bulb, battery and wire so that the bulb does not light. Use the symbols below.

4. Choose the right answer to complete the sentence: There will be an electric current in _______________ circuit.

A. an open
B. a closed
C. a big
D. a long



Name: **Date:**

Ohm's Law Math Worksheet

1. A battery is connected to a light bulb in a circuit. There is a current (I) of 3 A in the light bulb. The light bulb has a resistance (R) of 0.5 Ω. What is the voltage (V) of the battery?

   Use $V = I \times R$ to solve this problem.

2. A battery is connected to a light bulb in a circuit. There is a current of 2 A in the light bulb. The voltage of the battery is 1.5 V. What is the resistance of the light bulb?

   Use $R = \frac{V}{I}$ to solve this problem.

3. A battery is connected to a light bulb in a circuit. The voltage of the battery is 1.5 V. The light bulb has a resistance of 1.5 Ω. What is the current in the light bulb?

   Use $I = \frac{V}{R}$ to solve this problem.

I.8.8. brainstorming;

I.8.9. buzz sessions;