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Smart Farm Security System Powered by Solar Panels

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Abstract: One of the economic resources that are currently in great demand is in agriculture. Given that crops and cattle are the basic ingredients in food, their huge demand cannot be disputed any longer. Additionally, farmers utilize high-tech and costly agricultural equipment to facilitate their job, advance the agricultural industry, and improve the quantity and quality of the produce. This project is created specifically to assist farmers in protecting their farm from intruders like wild animals and criminals. This concept is innovative since it includes a solar system as a power source together with security tools including an electric fence, motion sensor, camera, and IoT system. If animals or evil people try to breach the fence, they will receive an electric shock, which will stop them in their tracks and serve as a deterrence to future intrusions. Additionally, an LED that serves as a warning lamp if the fence is struck by something is mounted on each fence post. The motion sensor then uses the IoT system attached to the phone to deliver a warning message to the phone when it detects the movement of intruders in the farm area. The camera simultaneously records movies and takes pictures of the area to be used as proof. This project combines a farm prototype, is controlled by ESP32, and is displayed and demonstrated via an IoT application. Last but not least, this security system is designed for farms using solar as a power supply to maintain environmental sustainability. This project helps farmers to protect their crops from destruction and thieves. As a result, the owner can monitor their farm area solely through their phone as long as the system is connected to Wi-Fi. The owner can detect any intrusions on the farm as they receive images through the Blynk application. Additionally, with the presence of the electric fence, intruders such as wild animals or thieves will be subjected to an electric shock if they trespass the fence, indirectly serving as a warning to deter them from entering the farm area.

Keywords: Farm Security System, Detect Motion, Electric Fence

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1. Introduction

This project is merely a prototype to demonstrate a function of Smart Farm Security System Powered by Solar Panels. As we all know, agriculture is currently one of the economic resources that are in high demand. Its high demand cannot be denied any more because crops are the raw material of food. In addition, farmers use sophisticated and expensive agricultural tools to make it easier for them to do farm work, improve the agriculture business, and increase the quantity and quality of the product. Due to the farm produce becoming valuable to the community, there are usually people with bad intentions who take the opportunity to invade the farm area to steal the farm produce. Therefore, security is a matter that needs to be emphasized everywhere to avoid the threat of criminals.

Although cases of theft and trespassing in farm areas do not always happen, still can lead to liability caused by criminal deeds for example thief of farm products and equipment. So, to ensure that the farm produce is not cut off and not destroyed, the farmers need to keep the farm safe from being stolen and destroyed by bad people and wild animals. However, logically, farmers cannot maintain the security of the area within 24 hours because they also have their task. So, they need a security system that can be controlled remotely automatically to facilitate their affairs. In some locations, smart farm security systems are being used to improve the management of agriculture by making it more effective, safe, and intelligent. The theft of unattended machinery and equipment by criminals as well as crop destruction by wild animals like elephants, monkeys, and pigs cause issues and losses [1].

Most farmers are always worried about the safety of their farm produce such as their crops, and agricultural tools. This is because the number of cases of theft by criminals and the invasion of wild animals in farm areas is increasing. In addition, nowadays crop production have a high market value and demand and make the farm produce their source of income. So, this is the reason why all the farmers want to ensure their farm produce and agricultural tools are safe from thieves and destroyed by wild animals like elephants, pigs, and many more.

There are three objectives of this project. Firstly, to design a security system for a farm using solar panels as a power supply. Solar panels offer a sustainable and reliable source of energy, enabling the security system to operate independently from the grid. Secondly, to construct the function of PIR motion sensor in this system. The PIR motion sensor plays a crucial role in detecting movement and potential intruders within the farm premises. Finally, to verify the functionality and stability of the prototype system, ensuring its effectiveness and durability in real-world farm conditions.

The farm security system incorporates several components to ensure comprehensive protection. Solar panels are used to capture sunlight and convert it into electrical energy, providing a sustainable and renewable power source. The energy is stored in batteries, ensuring a continuous power supply during periods of low sunlight or at night. Electric fences act as physical barriers, deterring access by stray animals and intruders by delivering electric shocks upon contact. Cameras capture visual footage and images for monitoring and surveillance, serving as evidence of any movement or suspicious activity. Motion sensors detect movement within the monitored area, triggering alarms and activating other components. Alarm and warning lights enhance visibility and sound audible alarms to alert farm owners or personnel of potential intrusions. The Blynk app connects the security system to a mobile device, sending real-time notifications when alarms are triggered. It's important to note that due to the potential risk of the electric fence, the system is appropriate only for demonstrating the function of farm security. Lastly, a prototype farm with the implemented security system will be used for showcasing and safety purposes

2. Materials and Methods

2.1 Materials

Software

- Arduino IDE
- Fritzing
- Blynk Application

Hardware

- PIR Motion Sensor
- Piezo Buzzer
- Red LED
- Solar Panel 5V + Charging Module
- Battery 5V
- FTDI 232
- ESP32 CAM
- Push Button
- TP4056 Battery Charger
- Diode IN4007
- Step Up Transformer
- FE Transistor
- Resistor
- Capacitor

2.2 Methods

Based on Figures 1 and 2, the block diagram and flowchart describe how the system as a whole works, from the solar panel that converts sunlight into electricity to the users' ability to monitor the farm's area. Through the TP4056, which works to charge the battery, it transfers light energy from the solar panel into electrical energy. Considering that this system includes an electric fence surrounding the agricultural area to keep out stray animals and unauthorized visitors. If something crosses this electric fence, it will receive a jolt from the current.

The PIR motion sensor's second job in this system is to track the wild animal and human movement throughout the farm. When it notices movement in the agricultural area, it will transmit the data to the ESP32 so that it may be processed. Then, the ESP32 sends a signal to the Red LED to alert the intruder and the alarm to activate. At the same time, the ESP32 sends a signal to the Camera to take a picture and send it to the owner via the Blynk app as a notification of trespassing in the agricultural area. With this, the farmer will be able to identify anyone who enters the farm's property without authorization.

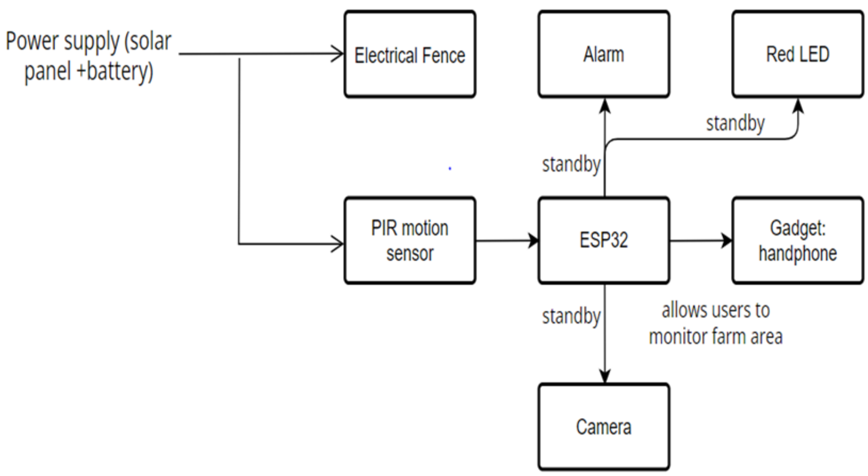

Figure 1: Overall block diagram of the project

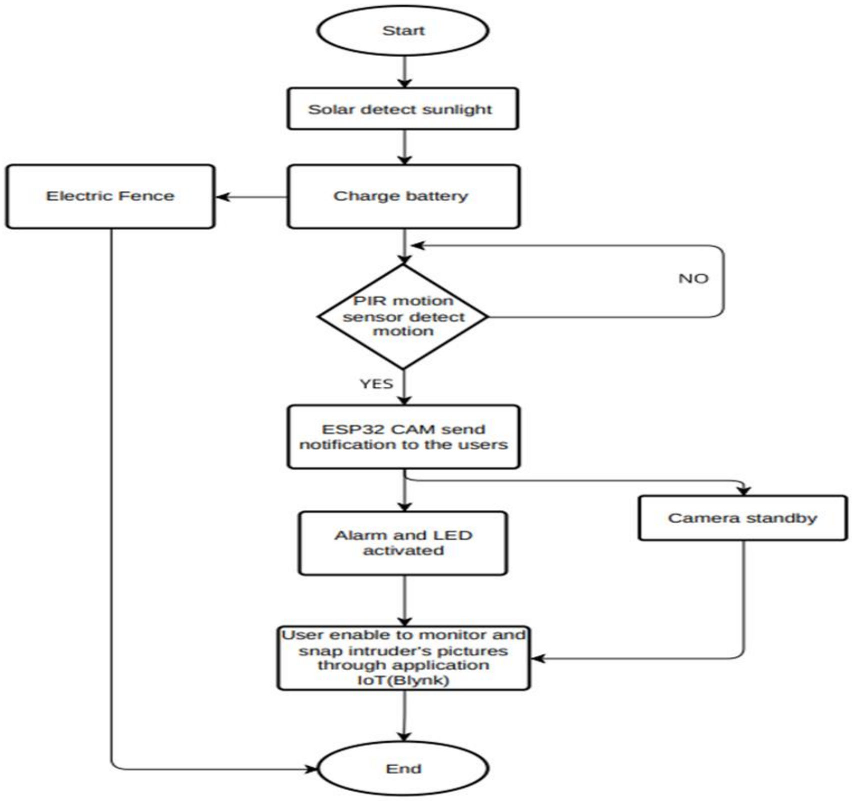

Figure 2: Flowchart of the overall project

The figure 3 shows that the camera system uses an ESP32-CAM module with an integrated microcontroller and camera sensor. It connects to Wi-Fi for wireless communication. A PIR motion sensor detects infrared radiation changes caused by moving objects. When motion is detected, it signals the ESP32-CAM. The ESP32-CAM activates the camera, captures images or streams video, and can trigger an LED for visual feedback. The LED is connected with a resistor for current control. A buzzer can emit audible alerts using a separate pin. The FTDI programmer allows programming and customization of the system. Overall, the surveillance camera detects motion, captures images, sends data via Blynk, provides visual feedback with an LED, and emits audible alerts using the buzzer.

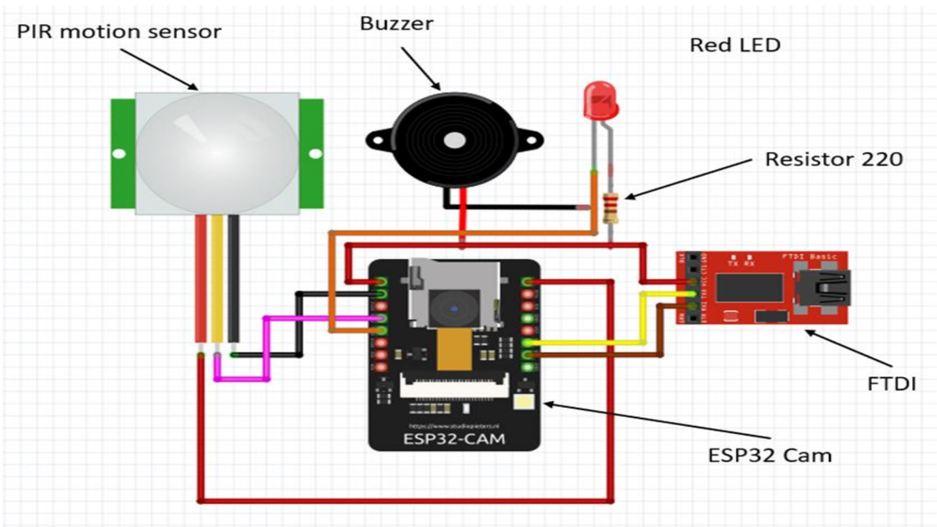

Figure 3: Circuit connection of system camera

The Figure 4 shows the electric fence system uses a power source, typically batteries or a rechargeable battery pack. A high-voltage generator with an oscillator circuit and a step-up transformer creates a high-voltage output. The high-voltage output is applied to the fence, creating an electric field. When an intruder touches the fence, they complete the circuit and receive a high-voltage shock, incapacitating them. The fence has a handle with a switch for turning the system on and off. When the switch is on, the high-voltage generator operates, and when it's off, the generator is deactivated. In summary, the powered electric fence delivers a shock to intruders upon contact, providing an effective deterrent.

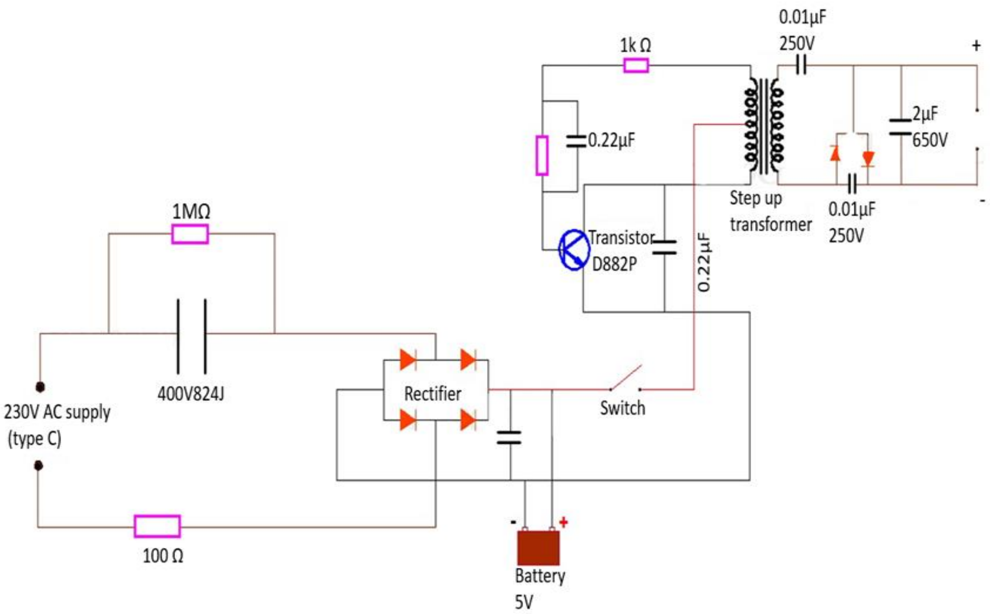

Figure 4: Circuit of electric fence

The Figure 5 shows the battery charging process using a solar panel and charger module involves harnessing solar energy through the solar panel, converting it into electrical energy, and directing it to the charger module, which regulates the charging voltage and current to ensure safe and efficient charging of the battery.

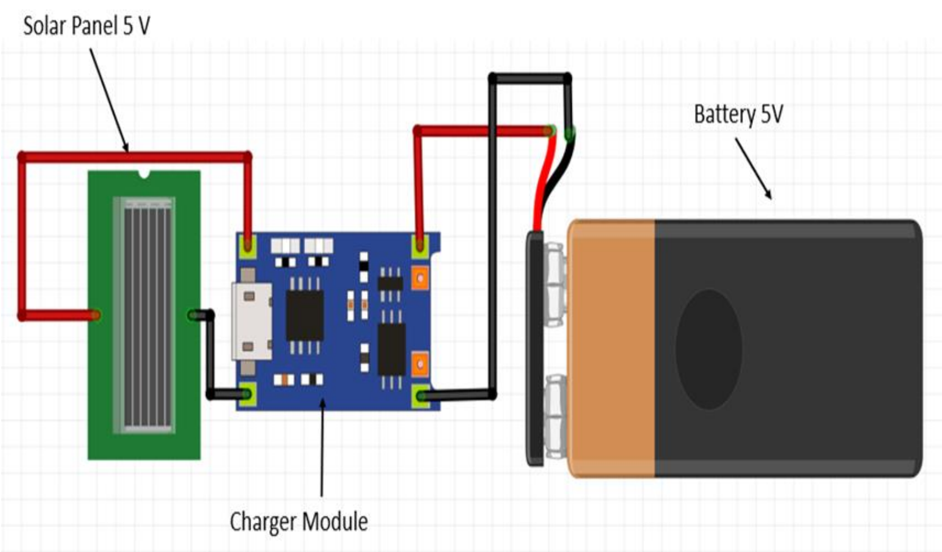

Figure 5: Circuit of battery charging

3. Results and Data Analysis

3.1 Results

Before utilizing the Blynk application to receive notifications and images from the ESP32 CAM, it is necessary to configure the settings in the application according to the project requirements to ensure a smooth and organized project workflow. Figure 6 depicts the main interface of the Blynk application after the settings have been set up, showcasing the relevant features and options available for monitoring and managing the farm security system effectively.

Figure 6: Main interface of Blynk app after having setting

Figure 7 illustrates a side view of the farm prototype, showcasing the integrated circuitry of the camera system, electric fence circuit, and solar battery charging circuit. This view provides a comprehensive visual representation of how these components are connected and positioned within the farm prototype, highlighting their functional interactions and overall arrangement.

Figure 7: Side view of farm prototype

Figure 8 depicts the spark generated upon switching on the electric fence. The electric fence circuit is equipped with a push button for safety purposes due to the high voltage it produces. To activate the electric fence, the push button needs to be pressed and held, while the live and neutral wires of the electric fence must be connected to any conductor to ensure a closed circuit. Conversely, to turn off the electric fence, simply releasing the push button will open the circuit, deactivating the electric fence.

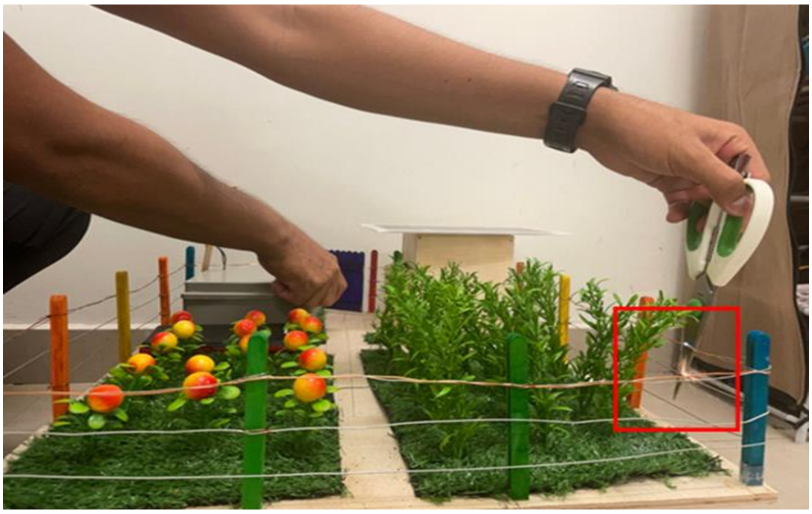

Figure 8: The spark that came out after switching on electric fence

Figure 9 demonstrates the synchronized operation of the security system components when the PIR sensor detects movement. The camera captures an image with a flash, while the LED activates as a warning light and the buzzer sounds as an alarm. This coordinated response effectively alerts and deters intruders, ensuring their presence is promptly acknowledged and discouraging any further unauthorized activities.

Figure 9: Camera captures image, LED and buzzer triggered

Figure 10 displays the image captured by the ESP32 CAM, which is then showcased on the main interface of the Blynk application. To establish a connection between the Blynk application and the ESP32 CAM, it is necessary to connect to a Wi-Fi network or hotspot, providing the correct Wi-Fi ID and password as specified in the code. This enables seamless communication and allows the image captured by the ESP32 CAM to be displayed and accessed through the Blynk application's interface. sensor is designed to detect sustained motion rather than quick movement. By having a slight delay, the sensor aims to be more accurate in detecting actual motion while reducing false alarms.

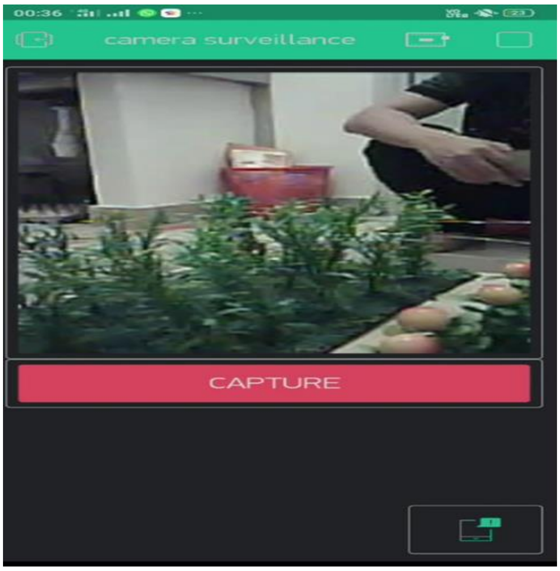

Figure 10: Image captured by ESP32 CAM at main interface of Blynk

The chart in Figure 11 presents the results of a PIR motion sensor test conducted multiple times, varying the distance between the sensor and the moving object. The recorded data represents the time taken for the sensor to detect motion at each set distance. Observing the data, it becomes evident that as the distance between the sensor and the movement increases, the detection time also increases. This indicates that the PIR motion sensor has a limited detection distance range. Additionally, it is worth noting that the sensor exhibits a certain delay in detecting movement. The delay in detecting motion with a PIR motion sensor happens because of how the sensor is designed. When you turn on the sensor or activate it, it needs a little bit of time to warm up and get ready to detect motion. During this warm-up period, it stabilizes and adjusts to the surroundings. Additionally, the sensor has a sensitivity setting that determines how sensitive it is to detecting motion. Higher sensitivity settings can reduce the delay but might also cause false alarms from things like temperature changes or small movements. The sensor uses an algorithm to analyze changes in infrared patterns to determine if there is real motion. It introduces a delay to make sure the detected motion is consistent and not just a temporary change. The sensor is designed to detect sustained motion rather than quick movements. By having a slight delay, the sensor aims to be more accurate in detecting actual motion while reducing false alarms.

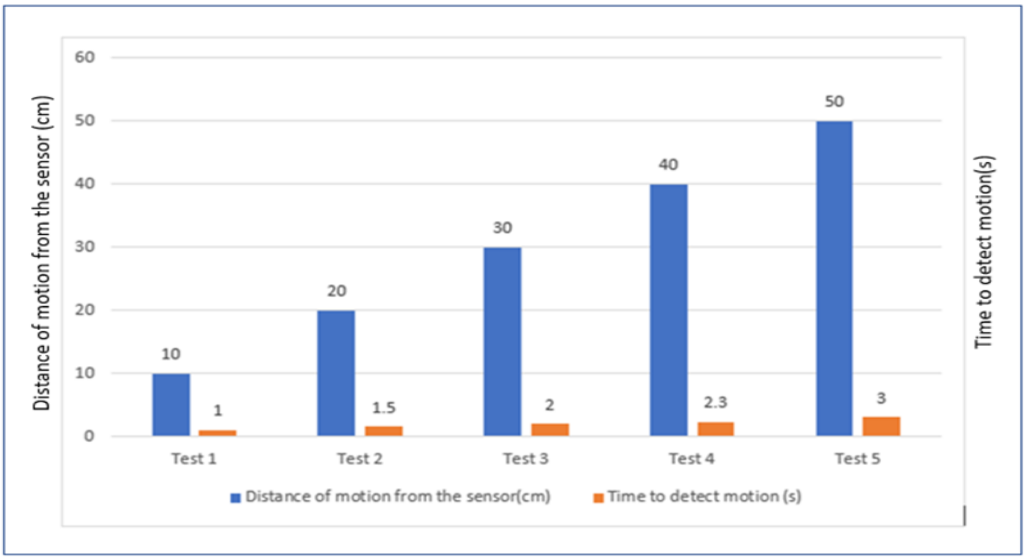

Figure 11: Graph of testing for PIR sensor detect motion

The graph in Figure 12 presents voltage generation data collected from the solar panel at 7 AM, 10 AM, 1 PM, 4 PM, and 7 PM. The data reveals that the solar panel achieves its highest voltage output at 1 PM. This is attributed to the sun's elevated position in the sky during that time, allowing for more direct and intense sunlight to reach the panel. The increased sunlight absorption enhances energy conversion, resulting in a boosted voltage output. Furthermore, favourable weather conditions with fewer clouds and optimal sunlight penetration contribute to the panel's maximum voltage generation at 1 PM. Conversely, the lowest voltage output is observed at 7 AM and 7 PM due to a lower angle of sunlight incidence and increased scattering and absorption as the sunlight passes through a denser atmospheric layer. Additionally, weather-related factors like cloud cover further reduce the amount of sunlight reaching the panel, thereby diminishing the voltage output. It is important to consider various environmental factors such as weather conditions, panel orientation, tilt angle, and system efficiency to accurately assess the voltage output during these specific timeframes.

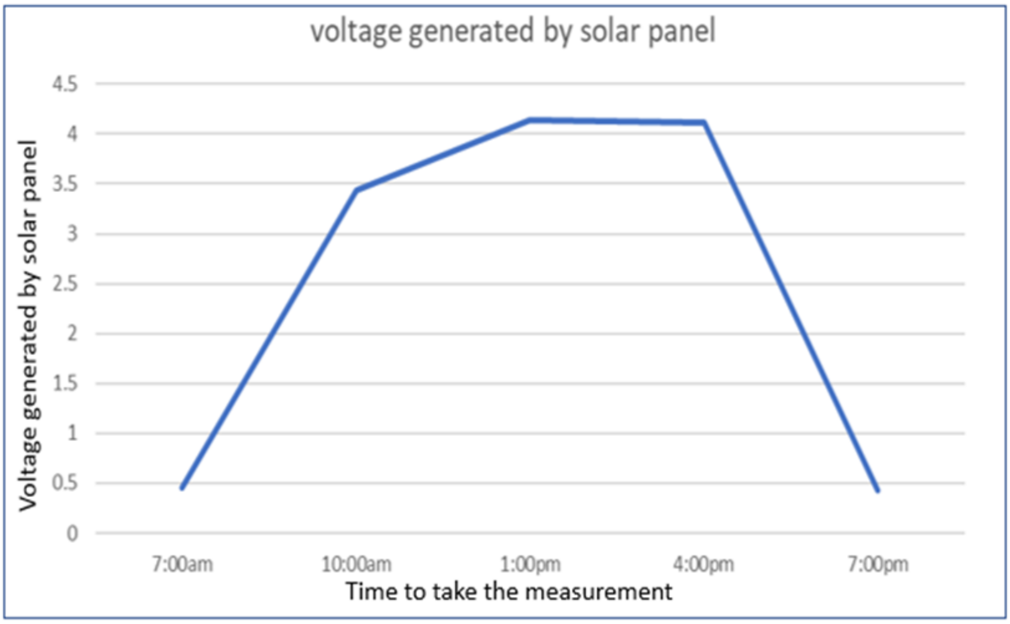

Figure 12: Voltage generated by solar panel

4. Conclusion

In conclusion, all farmers who want to protect their farms from trespassers and wild animals must consider the importance of this sophisticated security system. Farmers may now merely monitor their farms using their cell phones, eliminating the need for constant observation. It's important to pay attention to the project's production costs as well. For this final year project, for instance, simply the ESP32 is utilized to control all tasks; the Arduino UNO and GSM module are not required because the ESP32 is equipped with Wi-Fi and Bluetooth and can communicate code.

There were several issues with the circuit design for this project, specifically a lack of understanding on how to connect the solar panel to the battery and the ESP32. The connection can be accomplished by installing TP4056 to charge the battery and connecting the battery to the voltage booster after doing some study and viewing videos on YouTube. This is to guarantee the battery is fully charged for extended use and that the power delivered to the ESP32 and the electrical fence is adequate.

Acknowledgement

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