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Design and Implementation of IoT Integrated Electrical Solar Fence for Crop and Farm Protection Using Blynk Application

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KEYWORDS

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Solar panel,
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Ignition coil,
Blynk apps

ABSTRACT

IoT technology is widely adopted in various industries worldwide, including agriculture. It offers significant benefits to farmers by enhancing farming practices, improving productivity, and reducing costs. Threats presented by wild animals and theft of crops or farm areas cannot be effectively resolved by conventional fences in terms of ensuring security and protection. This paper discusses the design and development of an electrical solar fence equipped with an Internet of Things (IoT) based notification system applied in the agriculture industry for crop protection and security. The proposed system consists of a solar panel, solar controller, battery, pulse generator, relay, ignition coil, and ESP8266 Wi-Fi module connected to the Blynk application. This system demonstrates the electrical fence powered by solar energy by executing high voltage along the wire fence connected to the ignition coil. In this project, the system successfully notified the user through mobile phone on the Blynk application.

1.0 INTRODUCTION

Numerous industries across the world have used Internet of Things (IoT) technologies. Agriculture is one of these industries that benefits significantly from IoT technology. Agriculture technology advancements lead to a more comfortable farming practice for farmers. The IoT enables agricultural productivity to be increased at a lower cost and more efficiently.

The IoT is comprised of four primary components: things, mobile devices or back end devices, gateway nodes, and the internet [1]. Using wireless monitoring sensors and a cloud-based platform, IoT can remotely identify soil quality, meteorological conditions, crop growth, and agricultural damage caused by wild animals or any intrusion.

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One of the main risks to agricultural productivity is wild animals. By using the IoT, the integrated protection system is responsible for early notification of possible wild animal entry and danger. Other than that, the usage of an electrified fence may help to limit wild animal damage in the area of the farming area. Electric fence was deployed in Malaysia at conflict hotspots and has shown to be a significant advantage to farmers, allowing them to continue farming with less concern of wild animals ruining their crops [2].

In comparison to more established methods of crop protection, the electrical solar fence system is a relatively new method used in agriculture industry [3] . Solar energy is used to power up the electrical fence system. The purpose of this paper is to present a development of an electrical solar fence integrated with IoT system. Remote users or manpower can have access to sensing equipment and smart applications to help to secure their crops and poultry by integrating with them in an unattended situation through mobile phone.

2.0 RECENT ISSUES ON ELECTRICAL SOLAR FENCE

Solar-based electronic fence systems have been widely used to protect agricultural land from wild animals and theft. A system has been developed by converting solar energy into electrical energy and using it to give short but sharp shocks to animals or anyone who touches the fence. However, the potential risk of death due to electrical shocks has been a major concern, as even a short shock can be dangerous and life-threatening. To address this issue, researchers have proposed the use of virtual fencing techniques that utilize a GSM module to remotely alert the owner about any intrusion and enable the owner to choose the type of defense to use [4]. Studies have shown that virtual fencing techniques are effective in deterring wild animals and intruders from entering the protected land, without posing any life-threatening risks. By enhancing the security measures of agricultural settings, virtual fencing techniques can help minimize the risk of loss of crops and farm animals.

A study found out that fence-based agrivoltaic systems can provide economic advantages for farmers. This study explores the use of existing farm fencing as vertical photovoltaic racking for fence-based agrivoltaic systems. The research provides practical insights for optimal inverter selection and wire sizing to address the inherent electrical challenges of this type of system[5]. Numerical simulations were conducted to determine the levelized cost of electricity for different distances, inverter costs, and geographic locations. The results showed that microinverters are more effective for shorter fences and fewer PV modules, while string inverters are better for longer fences.

A solar fencing system has been installed in the laboratory of PES Modern College, Pune to protect the cage in a high voltage lab that consists of a power supply, oscillator, step-up transformer, voltage multiplier, and capacitor bank [6]. Based on the analysis, it is concluded that the designed solar fencing system is cost-effective, energy-efficient, and easy to assemble. Compared to other conventional methods of fencing, the proposed solar fencing system requires less maintenance.

In 2018, Bilodariya developed a solar-based electronic fence that uses solar energy to generate electrical energy, which is then used to provide a shock to any living being that touches the fence. These fences are commonly used in areas such as forests, farms, and government areas to prevent theft and keep animals away. The process involves converting solar energy into unregulated DC voltage, which is then regulated and converted into AC voltage through an inverter [7]. This high-voltage AC current provides a short but sharp shock to keep animals and thieves away. The device also includes an IR sensor that alerts the owner when someone enters the farm.

In addition to smart technology, the application areas of IoT infrastructure will be broadened to embrace the development of intelligent homes and smart cities. Access control, identity management, regulatory considerations, and technological considerations are some of the essential aspects of security. A review study by Sivanraju showed that smart farming technology allows for the remote evaluation of a variety of aspects, including the state of the soil, climate, crop production, and damage. This is accomplished by merging wireless monitoring devices with a cloud-based platform. The Internet of Things has the potential to be leveraged so that farmers may analyze the conditions of the soil, the level of moisture in the soil, the density of the animal feed levels, and the level of insect control [1]. In the future, the study conducted will emphasize the development and execution of the model.

Electric fences, referred to as elephant fences specifically in Sri Lanka, are used in several countries to separate elephant habitats from human-populated regions. Electric fences serve as a barrier for elephants attempting to enter an area populated by humans by inflicting harm on them. In order for an elephant to return to its own territory, the electric fences must be charged with an adequate amount of power. The elephants are not concerned with the presence of the barrier and will get past the area if nothing prevents them. Despite the fact that electric fences have often been shown to be efficient at causing elephants to retreat into forests, there are still a number of concerns that must be handled prior to their widespread use. Electric fences are extremely costly to install and maintain. In addition, the success of electric fences in preventing elephants from accessing the protected area depends on a variety of conditions. The most significant of these elements are the number of electrified strands or wires, the voltage level, the layout, and the efficacy of both the fence's upkeep and the authorities' responses to allegations of animal fence-breaking. A study was carried out and revealed that the design of a smart laser fence using solar energy can be used to identify elephants and chase them back into the forest with the assistance of other linked technologies. Laser detectors and a low-frequency sound detector are utilized in the proposed system to detect approaching elephants [8]. The system's tests indicate that the concept is viable and can be used in the field after comprehensive testing.

A research conducted in 2017 showed that a smart farming system equipped with an electrical fence integrated with other components such as soil sensor, PIR sensor, ultrasonic sensor, fire sensor, and humidity sensor using an IoT platform [9]. The system can be controlled and monitored remotely to provide security to grain stores and agrarian fields. The system utilized a robot to identify and avoid obstacles and also to measure the distance from the barrier. It also utilized PTC's ThingWorx for M2M services as its IoT platform.

A study proposes a method that uses IoT technology and smartphone communication to remotely control a conventional door lock for home security, drawing parallels to the electric fence commonly employed for protecting agricultural areas. The system allows for remote home monitoring through IoT methods, which proves to be more effective than other smart door systems. The system consists of an IoT system using Arduino Wemos D1 and ESP8266 as the microcontroller, with the Blynk application for monitoring [10] . The door lock can be monitored from anywhere at any time. The system's durability was tested by measuring the servo motor's ability to handle the load of the door deadbolt lock, and the results confirm its successful achievement of objectives.

Other examples of IoT technology utilization in agriculture and farming include its application as a monitoring system in hydroponic and aquarium systems. A research aimed to develop an online monitoring system using IoT technology for hydroponic systems, specifically focusing on monitoring pH values and electrical conductivity (EC) of the nutrient solution[11]. The proposed project designs a monitoring system that allows users to continuously monitor these parameters using smartphones. By uploading continuous sensor data to the internet, the system provides reliable and independent monitoring capabilities throughout the week. The primary objective is to provide real-time statistical data of the hydroponic garden directly to users through their smartphones. Additionally, the research incorporates an automated scheduling concept to achieve a fully integrated and automated NFT hydroponic system. The flexibility of this system allows its application to various types of leafy plants using the NFT hydroponic system. Another research implemented an IoT-connected system for comprehensive monitoring and control of aquarium maintenance. By utilizing electronics and sensors, this system enables constant communication and real-time status transmission to the user's smartphone. The developed system actively monitors and maintains optimal water conditions, automatically making necessary adjustments as determined by the system. It automates essential operations such as temperature control, pH regulation, turbidity control, fish feeding, and water level management [12]. As a result, the system significantly reduces the manual effort involved in managing the aquarium, offering convenience and ease of use.

Big farms with large areas of control require electric fence energizers of large capacity to maintain high voltage throughout their entire extent. For example, in Brazil, the major exporter of beef cattle, this technology is in high demand. In consideration of prevailing conditions, a solar-based electronic fencing system was developed by utilizing an electrical fence energizer circuit, an impulse transformer, and mathematical analysis of the circuit. To construct this electrical fence, an energizer, wire, insulation, and ground were used. The fence operates when the electric impulse current from the energizer passes through the animal's body upon touching the wire, completing the circuit and allowing the current to flow. Actual experiences have shown that cattle do not jump the fence when peak voltages exceed 2 kV at the point of contact with the wire, as they experience panic sensations and avoid the fence thereafter. A circuit model based on transmission line theory and propagation waves was constructed and presented a panic standard graphic, which serves as a useful tool for designing electric fence energizers. The measured results of the prototype demonstrated that this type of circuit meets standard safety requirements and is suitable for use as an Electric Fence Energizer, indicating that the circuit analysis and design of the circuit and transformer are appropriate [13].

3.0 METHODOLOGY

The idea behind this project is that the user will receive alerts on their mobile phone through the Blynk application whenever an intruder crosses the fence. The sketch for this project, as illustrated in Figure 1, includes several main components: a photovoltaic solar panel, a solar controller, a battery, a pulse generator, a relay, an ignition coil, and an ESP8266. For protection purposes, all of the main components are placed inside a circuit casing box as the system will be installed in the farming area. The wire fence will be directly connected to the ignition coil and installed around the farming area. Laser sensors will be positioned at every corner of the farming area to detect any intruder movement. ESP8266 will notify the user via the Blynk application on their mobile phone.

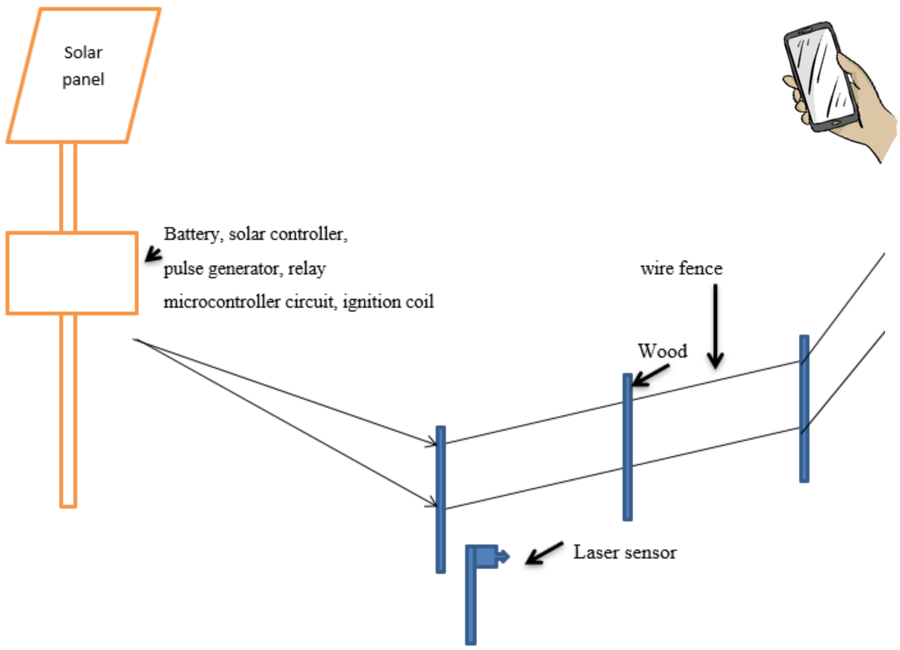

Figure 1: Sketch of the project

Figure 2 depicts the operational diagram of the system. The proposed system uses solar power. The process starts with the collection of sunlight by the photovoltaic solar panel. The solar controller is connected between the battery and the solar panel to prevent power from flowing back to the panel. Furthermore, it is used to regulate power flow and safeguard the battery against overcharging. The solar controller supplies power to the battery, which generates 12 Volts. The circuit cannot be activated if the battery is not fully charged to 12 Volts in this system. Once the battery is fully charged to 12 Volts, the NE555 component, which acts as a pulse generator, converts DC to AC signal. The AC signal is transmitted to the relay, causing it to turn on and off automatically. As a result, the ignition coil, which is linked to the relay in the system, produces a high voltage output on its secondary when the current flowing in the primary winding is interrupted. The high voltage from the ignition coil flows to the connected wire fence. In the event of intrusion, the laser sensor, which detects any object or movement near the fence, sends a notification to the mobile phone to alert the user.

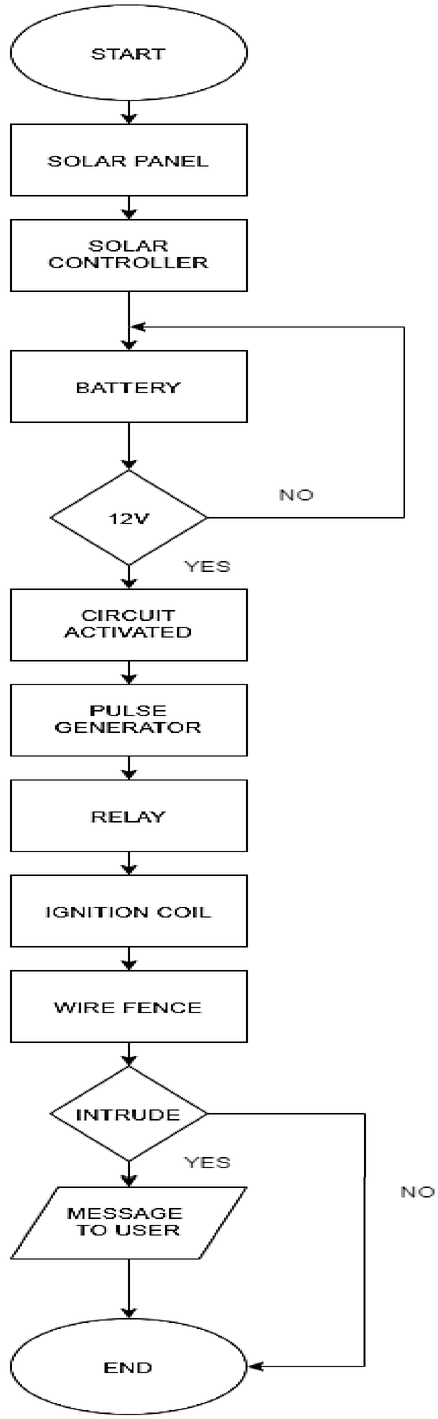

Figure 2: Operational diagram of the system

3.1 Schematic Circuit Design

As shown in Figure 3, the circuit diagram illustrates the connection between each component in the system using the Proteus Design Suite. Since the circuit is powered by a 12-volt battery generated by the solar panel, this schematic circuit consists only of the pulse generator, relay, and ignition coil. The voltage at the primary coil is 12 V, while at the secondary coil, which is the output voltage of the system, it is 3 kV.

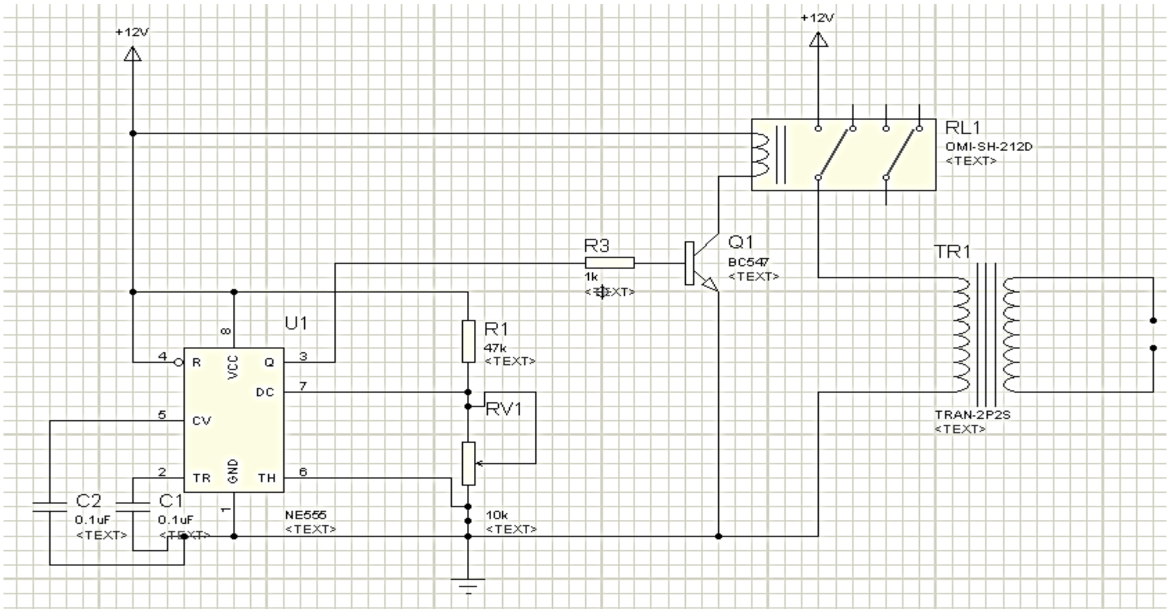

Figure 3: Schematic circuit design

3.2 Hardware Development

Figure 4 shows the circuit wiring of the system. After simulating the schematic circuit using Proteus, all the components including the solar controller, battery, NE555, ESP8266 microcontroller, ignition coil, capacitor 10uF, MOSFET, inverter, heatsink, resistor 10kΩ, and a few jumpers are wired onto the stripboard and placed in the circuit casing box as shown in Figure 5. This circuit box will be installed at the fence.

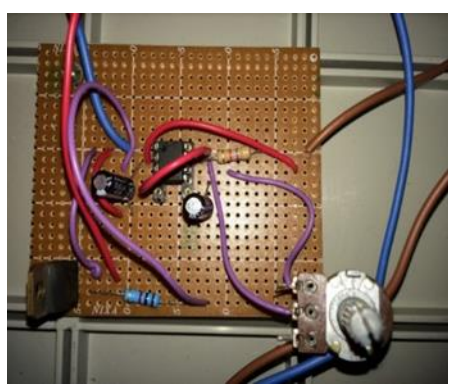

Figure 4: Circuit components wiring connection

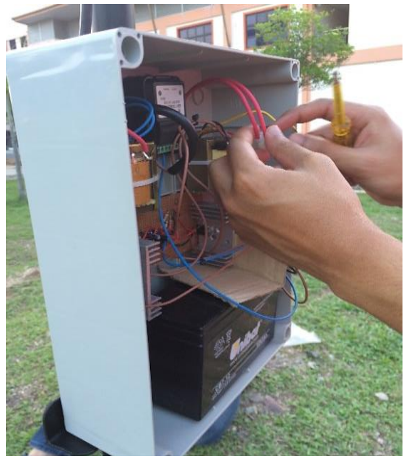

Figure 5: Components inside the casing box

In this project, the ignition coil, also known as a spark coil, is an induction coil used to step up the voltage from 12 V to 3 kV. The input voltage to the ignition coil is a 12 V square wave with a frequency of 50 Hz. Figure 6 shows the condition of the ignition coil before connecting it with 12 V from the relay, whereas Figure 7 shows the sparks generated by high voltage (3 kV). This 3 kV voltage will be applied to the wire fence.

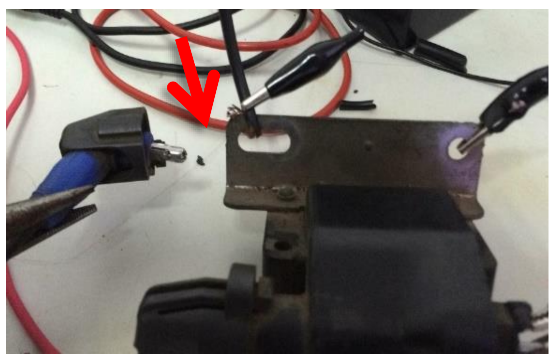

Figure 6: Testing the ignition coil

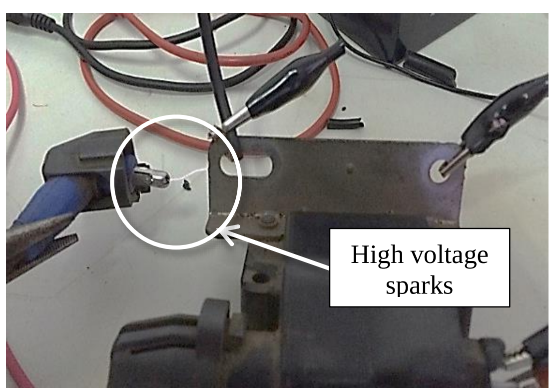

Figure 7: Ignition coil sparks due to high voltage

Meanwhile, the NE555 is used to provide time delays, function as an oscillator, and serve as a flip-flop element. This timer is used to control the relay and produce a square waveform (AC) from the battery (DC) at a frequency of 50Hz. Figure 8 shows the relay controlled by the NE555.

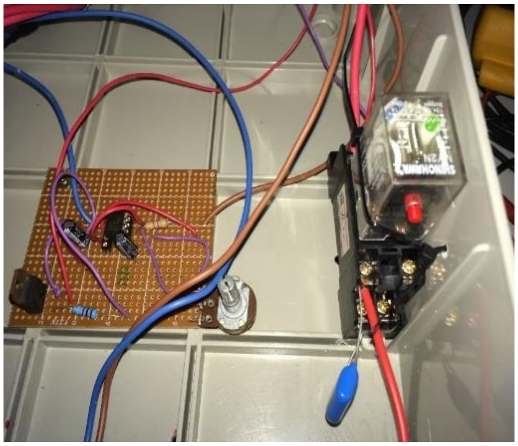

Figure 8: Relay controlled by NE555

4.0 RESULTS AND DISCUSSION

The code generated in Arduino was simulated using Proteus. The results showed that implementing an IoT solar-powered electrical fence with the chosen components is achievable and validates the physical development of the device. Figure 10 shows the complete hardware installation of the IoT-based integrated electrical solar fence at the farming area. To demonstrate the real application, this system is attached to an iron rod and placed on the ground near the fence. The parts of the system are shown in Table 1, and all components are placed in the circuit box shown in Figure 9. The copper rod shown in Figure 10 is wired to the ground for grounding purposes, and the laser sensor is placed in a container to limit the area of its detection.

Figure 9: Photovoltaic solar panel and circuit box

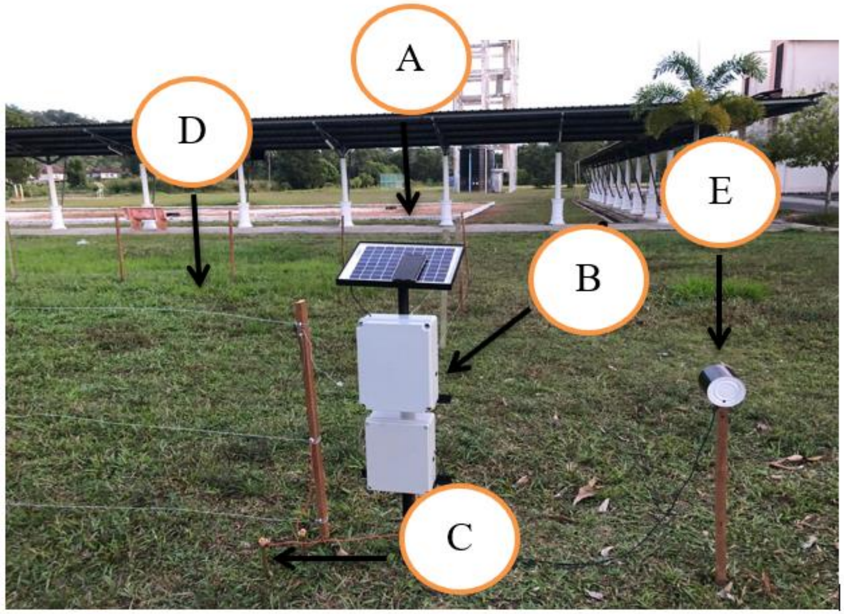

Figure 10: Installation of the hardware

Table 1: System component

Label	Component
A	Solar panel
B	Circuit box
C	Cooper rod
D	Wire fence
E	Laser sensor

For the purpose of evaluating the system, testing was done by checking for the presence of movement or objects near the fence. ESP8266 was set up with a specific mobile phone and Wi-Fi connection for the user. Any movement or the presence of a human or animal would be detected by the laser sensor, and the system would send a signal to ESP8266. A notification would be sent to the user's mobile phone that was programmed in ESP8266, saying "Ada Penceroboh" via Wi-Fi. The Blynk application was used as a platform to send notifications to the user's phone in case of a disturbance. Figure 11 shows the notifications that were sent to the user's mobile phone.

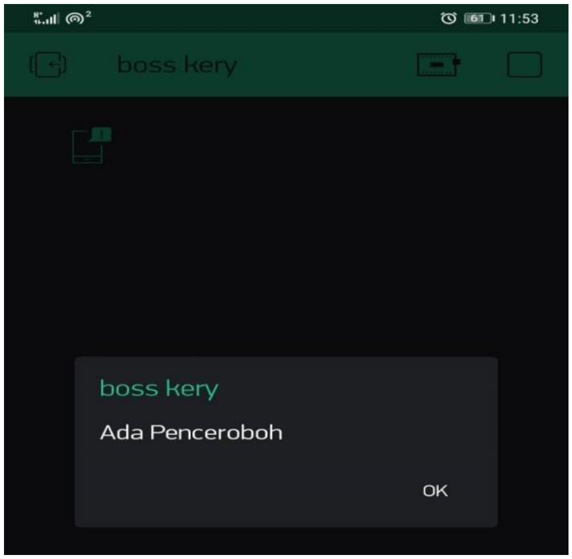

Figure 11: Mobile phone notifications

4.0 CONCLUSION

In conclusion, this research paper presents the development of an electrical solar fence integrated with an IoT system. The study utilized a combination of electrical and solar power to provide a reliable energy source for the fence. The IoT system was integrated with Blynk, a mobile application that allows for easy monitoring and management of the fence. This system provides access to the security status of the crop area at any time and from any location by notifying the user through a mobile phone using the Blynk application via the ESP8266 Wi-Fi module. However, if the network coverage or availability is restricted, the Wi-Fi module will not function, interfering with the notification system. On the other hand, the system will still be able to protect the crop area regardless of the situation since it is powered by solar energy.

This implementation of the electrical solar fence integrated with IoT technology is particularly beneficial in agricultural settings. The fence can serve as a deterrent to predators and thieves, reducing the risk of theft and loss of crops and farm animals. In rural areas, farm animals are often targeted by thieves, causing significant economic losses for farmers. The IoT system integrated into the fence can provide real-time alerts to the farmer, allowing them to quickly respond to any unauthorized access or intrusion. This ensures that any potential theft or damage to the crops and farm animals is prevented, improving the overall security of the farm. Overall, the development of an electrical solar fence integrated with IoT technology is an innovative solution that can significantly enhance security measures in agricultural settings, mitigating the risk of theft and loss of crops and farm animals.

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