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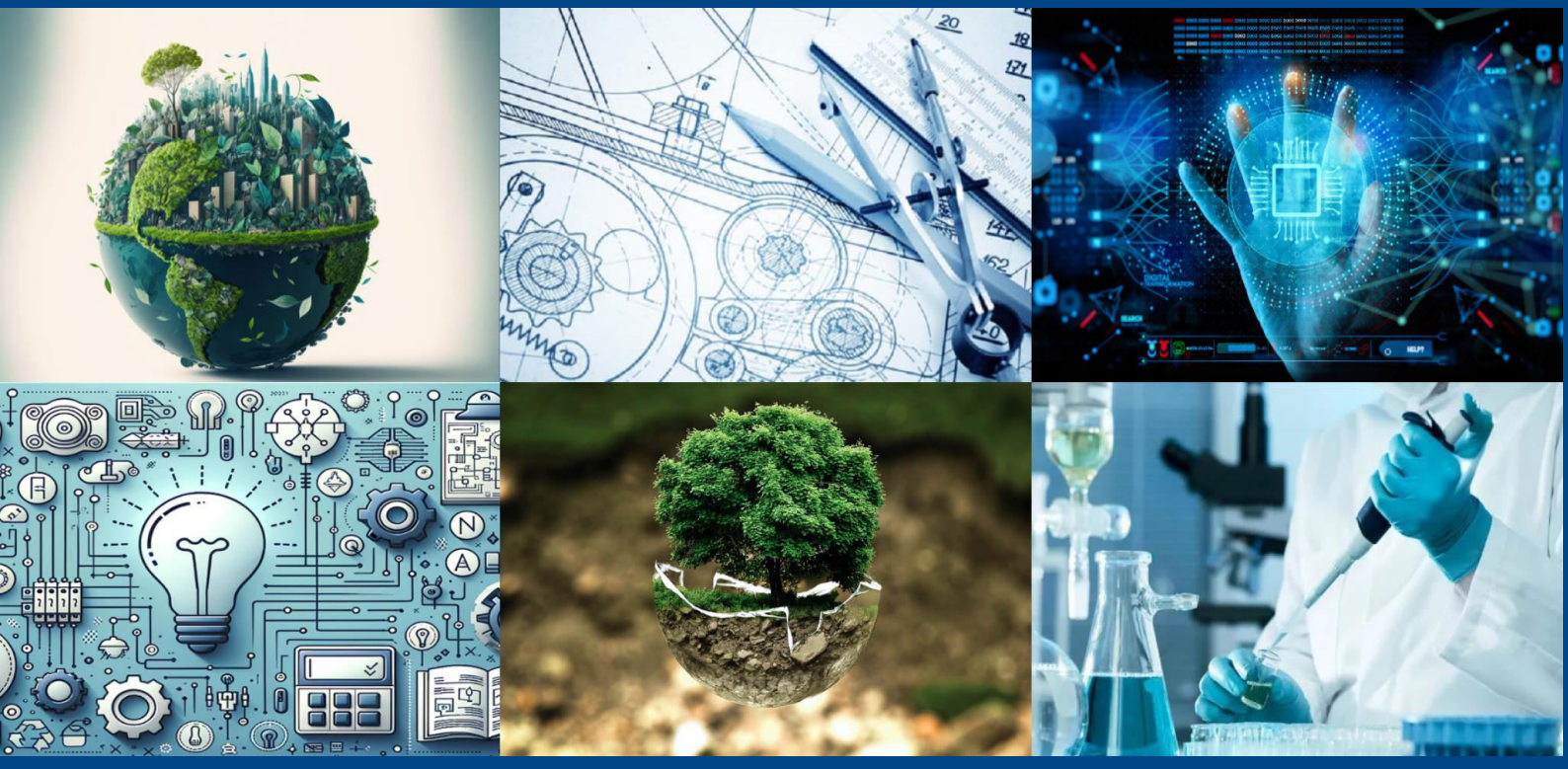

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Solar Powered IoT-Based Automated Electric Fencing and Intrusion Alert System

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ABSTRACT: This project focuses on developing a solar-powered IoT-based automated electric fencing and intruder alert system to enhance security in restricted areas. The system utilizes an ESP32 microcontroller to control and monitor the fence while detecting unauthorized access using PIR sensors or other intrusion detection mechanisms. Upon detecting an intrusion, the system activates the electric fence and triggers real-time alerts through a buzzer and notifications using ThingSpeak. Additionally, the system continuously monitors voltage and current levels in the fence to ensure proper operation and detect faults. The collected data, including fence status, voltage, and current readings, is uploaded to ThingSpeak, allowing remote monitoring. Powered by solar energy, the system ensures sustainability and cost effectiveness. This solution is ideal for agricultural fields, industrial zones, and residential areas, providing an efficient and automated security mechanism to prevent unauthorized access.

Keywords: IoT Based, Electric fence, ESP32, Microcontroller, PIR Sensor, Intrusion Detection, Thingspeak, Voltage Current levels, Remote Monitoring.

I. INTRODUCTION

In recent years, advancements in technology have led to the development of smart security systems that ensure enhanced protection for agricultural lands, commercial properties, and restricted areas. One such innovation is the Solar-Powered IoT-Based Automated Electric Fencing and Intrusion Alert System, designed to provide an energy-efficient and highly reliable security solution. Traditional fencing methods often fail to prevent intrusions effectively, and manual monitoring is both time-consuming and inefficient. This project integrates solar energy, the Internet of Things (IoT), and automation to create a sustainable and intelligent security mechanism. The system operates on solar power, ensuring uninterrupted functionality even in remote areas with limited access to electricity. IoT technology enables real-time monitoring and control, allowing users to receive alerts and manage the system remotely through a mobile application or web interface. The electric fence is designed to deliver a controlled shock upon intrusion, acting as a strong deterrent without causing severe harm. Sensors such as PIR (Passive Infrared), ultrasonic, and vibration sensors detect unauthorized movements near the fence. When an intrusion is detected, the system triggers an alert mechanism that includes alarms, SMS notifications, or email alerts to notify the owner or security personnel. Additionally, a surveillance camera can be integrated to capture images or live-stream video of the intrusion event. The use of IoT in this system enhances its functionality by enabling real-time data logging, analytics, and remote accessibility. One of the major advantages of this system is its solar-powered operation, which ensures energy efficiency and cost-effectiveness while reducing dependence on conventional power sources. The system also includes an energy storage mechanism to maintain continuous operation during nighttime or cloudy conditions. Moreover, this smart fencing system offers scalability, allowing users to customize settings and expand coverage as per their security needs. The implementation of automated monitoring and response mechanisms minimizes human intervention, reducing labor costs and improving efficiency.

II. PROBLEM STATEMENT

Unauthorized intrusions into farms, industries, and restricted zones pose security risks, requiring costly human surveillance. Traditional fences lack real-time monitoring and deterrence, while existing electric fences rely on grid power, making them unsuitable for remote areas. To address these issues, a solar-powered smart electric fence is

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needed, integrating motion detection, electric shock deterrence, real-time mobile alerts, and buzzer-light warnings. This automated, eco-friendly system ensures continuous protection with minimal human intervention, enhancing security in off-grid locations.

III. LITERATURE REVIEW

The integration of renewable energy sources, IoT, and security technologies has opened new avenues for enhancing perimeter protection systems. Numerous studies have explored electric fencing mechanisms, IoT-based surveillance, and solar-powered solutions independently, and some have investigated their integration. Electric Fencing for Security Electric fences have been traditionally used for perimeter security in agricultural, industrial, and military applications. Early systems relied heavily on manual operation and grid electricity. According to [Singh et al., 2017], electric fencing systems effectively deter intruders but are limited by power availability and lack of automation. IoT in Security and Surveillance The rise of the Internet of Things (IoT) has revolutionized real-time monitoring and automation. IoT-based security systems can send alerts, detect anomalies, and provide remote access. [Kumar and Sharma, 2019] implemented a GSM-based intrusion detection system using sensors and microcontrollers, significantly improving response time in unauthorized access scenarios. However, these systems often depend on stable power sources and limited communication protocols. Solar-Powered Embedded Systems Renewable energy, especially solar power, is increasingly being used to power embedded systems in remote or off-grid locations. [Patil et al., 2020] proposed a solar-powered automatic irrigation system, demonstrating the feasibility of using solar panels with microcontrollers for continuous field operations. The study confirms that solar energy can effectively support low-power embedded systems, even in rural or forested areas. Combined IoT and Renewable Energy Solutions Few studies have integrated solar power with IoT in the context of security. [Desai and Rathi, 2021] proposed a solar-powered surveillance system using PIR sensors and Wi-Fi modules for intrusion detection. Although effective, the system lacked an active deterrent mechanism like electric fencing. Smart Fencing Innovations Advanced smart fencing systems now include technologies like GSM, GPS, LoRa, and cloud-based control. [Ahmed et al., 2022] developed a LoRa-based perimeter security system with GPS tracking, enabling wide-area monitoring. Despite its communication efficiency, the project relied on non-renewable power sources.

IV. EXISTING SYSTEM

Current security systems for perimeter protection include conventional electric fences, IoT-based intrusion detection systems, and solar-powered security devices. Traditional electric fences offer basic intrusion deterrence but lack automation and remote monitoring. IoT-based systems enable real-time alerts through sensors and GSM/Wi-Fi modules but usually depend on grid power and lack active deterrents. Solar-powered systems provide sustainable energy solutions for remote areas but are often standalone, with limited integration of smart technologies. Overall, existing systems either lack sustainability, intelligence, or a combination of both, highlighting the need for an integrated solution.

V. PROPOSED SYSTEM

The proposed system is a smart, sustainable, and automated solution for perimeter security that integrates solar energy, IoT-based intrusion detection, and electric fencing. It is designed to operate effectively in remote or off-grid areas, offering real-time monitoring and alerting capabilities. The entire system is powered by solar panels, which charge a battery to ensure uninterrupted functioning even in the absence of grid electricity. This makes the system energy-efficient and suitable for rural or forest environments. To detect intrusions, the system employs ultrasonic sensor that monitor the surroundings for unauthorized movement. When an intrusion is detected, the sensor data is processed by a ESP32, which then triggers the electric fence to emit high-voltage pulses, acting as an immediate deterrent to trespassers. Simultaneously, the system sends real-time alerts via thingSpeak to the user and concerned authorities, enabling a quick response. The system is designed to activate the electric fence only when necessary, thereby conserving energy and improving safety. Overall, this integrated approach addresses the limitations of existing systems by offering a cost-effective, self-sustaining, and intelligent security solution suitable for modern smart infrastructure.

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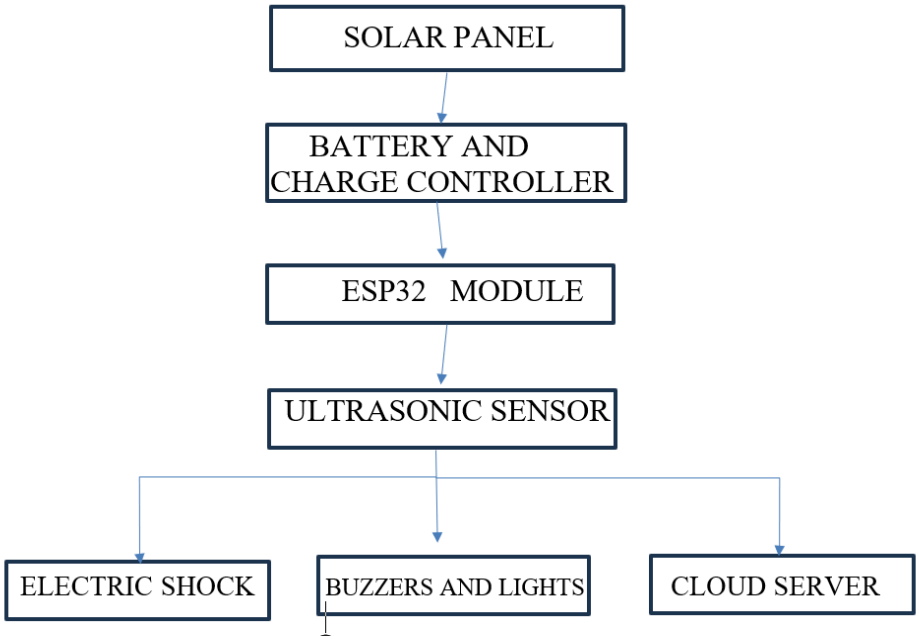

Figure 5.1 Block diagram of proposed system

VI. HARDWARE AND SOFTWARE IMPLEMENTATION

The system consists of both hardware and software components working together to provide automated, solar-powered security. The hardware includes a solar panel connected to a charge controller and a 12V battery that powers the entire setup, making it suitable for off-grid use. A microcontroller ESP32 serves as the brain of the system, interfacing with sensors ultrasonic sensors to detect intrusions. When motion is detected, the microcontroller activates the electric fence through an energizer circuit and simultaneously sends real-time notification to thingSpeak. The software is developed using the Arduino IDE with embedded C code. It handles sensor monitoring, decision logic, electric pulse control, and communication functions This efficient integration of hardware and software ensures smart, real-time, and sustainable perimeter protection.

VII. OPERATIONAL SCENARIOS FOR THIS PROJECT

The system is designed to function effectively in various real-life scenarios, particularly in areas where security, automation, and sustainability are essential. In a remote agricultural field, for example, the system continuously monitors the perimeter using ultrasonic sensors. When an animal or intruder attempts to cross the fence, the sensors detect movement and trigger the microcontroller. The system then activates the electric fence to deter the intruder and simultaneously sends a notification to the farmer, enabling immediate response—despite the absence of physical supervision or grid power. In residential or industrial settings, the system offers real-time intrusion detection and alerting through IoT communication modules. If an intruder tries to climb or tamper with the fence, the sensors detect the disturbance, the electric fence delivers a non-lethal shock, and the user receives a alert with the exact time of the incident. This can be especially useful during night hours or when the property is unattended.

In wildlife conservation areas or forest borders, the system prevents wild animals from entering villages or protected zones by automatically detecting and deterring them without human intervention. Since the system is solar-powered, it ensures continuous operation in off-grid areas while minimizing the risk of human-wildlife conflict. Overall, the system's flexibility, automation, and remote alert capabilities make it ideal for multiple use-cases where intrusion detection and deterrence are critical, especially in power-scarce and unattended environments.

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VIII. CIRCUIT DIAGRAM

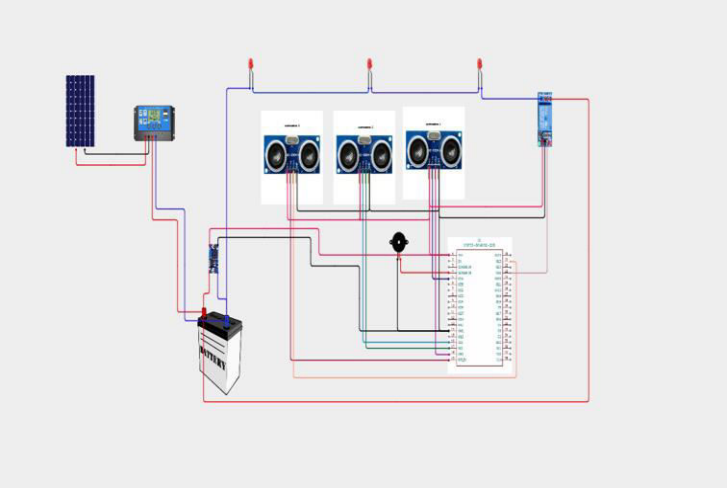

Figure 7.1: Circuit diagram

XI. RESULT & DISCUSSION

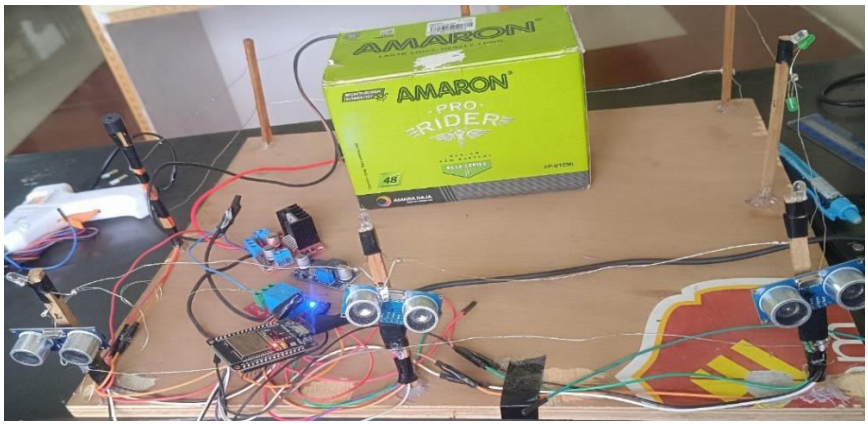

Figure 9.1: Hardware setup

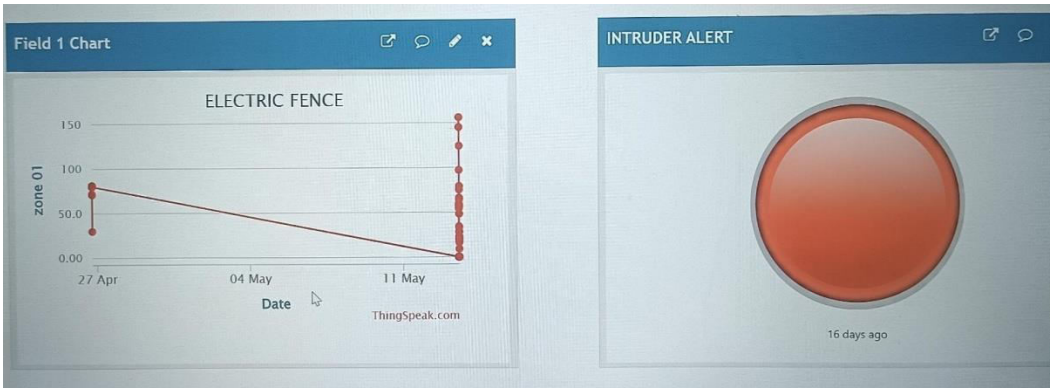

Figure 9.2: ThingSpeak view of Proposed System

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X. CONCLUSION

The solar-based smart fencing system developed in this project provides a practical, eco-friendly, and cost-effective solution for perimeter security in both rural and urban areas. The implementation successfully combines solar power technology with embedded systems to ensure autonomous and uninterrupted operation. By utilizing a photovoltaic panel and rechargeable battery, the system remains functional without the need for conventional electrical infrastructure, making it ideal for remote locations where power supply is unreliable or unavailable. The microcontroller efficiently manages inputs from multiple sensors, such as Ultra sonic and vibration sensors, and ensures timely detection of intrusion or tampering. The high-voltage pulse generator provides an effective physical deterrent, while the software-controlled alert mechanism using buzzer, LED, and ThingSpeak communication ensures immediate response and remote notification. Experimental testing confirmed the system's reliability under different environmental conditions, with successful detection and response to simulated intrusions. The system maintained stable performance during day and night thanks to efficient battery charging and power management. Real-time alerts through ThingSpeak enabled the user to monitor fence status from anywhere, ensuring a high level of situational awareness and security.

While the project achieved all intended objectives, there remains significant potential for further enhancement. In future versions, the system can be upgraded with IoT capabilities to allow cloud-based remote monitoring, real-time data logging, and mobile app control. Integrating a camera or thermal imaging module would provide visual confirmation of intrusions, improving threat assessment. Solar tracking systems could be introduced to increase the efficiency of power generation by aligning the panel with the sun's position. Additionally, artificial intelligence or machine learning algorithms could be used to differentiate between human intruders, animals, and environmental disturbances, reducing false alarms. A centralized dashboard could also be developed for managing multiple fence installations over a large area. With these improvements, the solar-based smart fencing system can be transformed into a scalable, intelligent, and highly secure solution for agricultural fields, military zones, industrial facilities, and residential properties. Its ability to combine renewable energy, automation, and wireless communication makes it a promising technology in the field of smart security systems.

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