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Solar Operated Smart Valet Parking System with Cloud Monitoring

Miss. Amale Ashlesha Rajendra[1], Mr. Dagale Vikrant Vishnu[2], Miss. Datrange Sakshi Sandip[3], Mr. Yewale Shubham Babasaheb[4], Prof. J. N. Pote[5]
BE, E & TC Engineering[1-5]
AVCOE, Sangamner, A. Nagar, Maharashtra, India
amleashlesha@gmail.com, dagalevikrant8@gmail.com, datrangesakshi1@gmail.com,
shubham192426@gmail.com, jayarani.pote@avcoe.org

Abstract: *This project focuses on designing an automated parking system using a robotic module to streamline vehicle parking. The system consists of multiple parking slots, each categorized as either reserved or available. Instead of manually searching for a vacant space, drivers can park their vehicles at a designated entrance slot, after which the robotic module autonomously moves the vehicle to an available parking space. Real-time parking slot availability is communicated to the driver, ensuring an efficient and time-saving experience.*

A key feature of this system is its integration with renewable energy. By eliminating human intervention, the system improves parking efficiency, reduces traffic congestion, enhances safety, and minimizes fuel consumption.

The Solar Operated Smart Valet Parking System leverages advanced technologies, including IoT-based sensors, automated valet parking, and cloud-based monitoring. IoT sensors detect available spaces and assist in guiding vehicles, while cloud connectivity allows drivers to track their vehicles in real-time and receive parking status updates. Additionally, the cloud-based infrastructure collects and analyzes parking data, enabling centralized monitoring, space optimization, and energy management.

By utilizing solar energy, the system ensures continuous operation even during power outages while significantly reducing environmental impact. This innovative approach aims to address urban parking challenges by providing a sustainable, automated, and user-friendly solution that enhances convenience, safety, and energy efficiency.

Keywords: Automated Parking System, IoT-based Sensors, Solar Energy, Cloud-based Monitoring

I. INTRODUCTION

With rapid urbanization and a growing number of vehicles, parking has become a major challenge in cities. Traditional parking systems often lead to traffic congestion, increased fuel consumption, and inefficient space utilization due to the time spent searching for a vacant slot. To address these challenges, a solar-powered automated valet parking system is introduced, integrating robotic automation, IoT-based monitoring, and cloud-based control. This system eliminates the need for manual parking by employing a robotic module that detects available slots and autonomously parks vehicles, ensuring efficient and organized parking management. The system also provides real-time updates about parking slot availability, allowing drivers to receive live notifications and track their vehicles remotely through cloud integration.

The core of the system relies on a PIC18F4520 microcontroller, which processes sensor data and controls various components to automate parking operations. The system is equipped with ultrasonic sensors to detect obstacles and determine slot availability, infrared (IR) sensors for navigation and alignment, and an RFID module to authenticate vehicles and ensure authorized access. A GSM module is used to send notifications to vehicle owners about the parking status, enhancing user convenience. Additionally, DC motors drive the robotic valet module, while a 16x2 LCD display provides real-time information about system operations.

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One of the key advantages of this system is its solar-powered operation, which makes it environmentally friendly and sustainable. The solar panel generates electricity to power the entire parking mechanism, ensuring uninterrupted functionality even during power outages.

This automated valet parking system offers numerous benefits, including reduced parking time, optimized space management, decreased traffic congestion, and lower fuel consumption. By utilizing IoT-based sensors and cloud monitoring, the system provides real-time slot detection and seamless vehicle management. Moreover, security features such as RFID authentication and GSM alerts enhance the safety of parked vehicles, preventing unauthorized access. The integration of renewable energy and smart automation makes this system an ideal solution for modern urban parking problems.

In conclusion, the Solar-Based Smart Valet Parking System is an innovative and sustainable approach to addressing parking challenges. By combining automation, IoT technology, and renewable energy, the system enhances user convenience, improves security, and reduces environmental impact. Its ability to optimize space utilization and provide real-time monitoring makes it a promising solution for smart cities, commercial parking lots, and urban infrastructure, ultimately contributing to an eco-friendly and efficient parking ecosystem.

II. PROBLEM STATEMENT

Parking congestion in urban areas is a growing problem due to inefficient space utilization, increased vehicle ownership, and time-consuming manual parking processes. Traditional systems lead to traffic delays, excessive fuel consumption, and security concerns. To address these challenges, this project proposes a Solar-Based Smart Valet Parking System that integrates automation, IoT-based monitoring, and solar energy to create an efficient and sustainable parking solution. The system uses a robotic valet module, sensors for real-time slot detection, cloud-based tracking, and RFID authentication to optimize space utilization while reducing human effort. By automating the parking process and utilizing renewable energy, this solution enhances convenience, minimizes congestion, improves security, and promotes eco-friendly urban infrastructure.

III. LITERATURE SURVEY

Mariem Turki, Bouthaina Dammak, and Amnah Alshahrani, “PufParkChain: Secure and Smart Parking Based on PUF Authentication and Lightweight Blockchain” (2024),

This paper presents PufParkChain, a smart parking solution integrating Physically Unclonable Function (PUF) technology for secure car authentication and a lightweight blockchain for operational efficiency. The system improves user experience, reduces congestion, and enhances traffic flow by allowing only authorized vehicles to access parking, supporting smart city sustainability.

Chinmay Kulkarni, Vishakh Khandizod, Ajay Malunjkar, “Solar Powered Automated Parking System” (2020),

This paper discusses a solar-powered robot that autonomously parks vehicles in a lab setup. The robot operates along node lines and uses an ultrasonic sensor to detect available parking slots. The system, powered by a 12V battery charged by solar energy, demonstrates a sustainable solution for parking management.

Mr. T. Joby Titus S. Abhisheik, V. Balakrishnan Jemy Sam and M. Mohan “Fully Automated Valet Car Parking System” (2017),

This research proposes a fully automated valet parking system that eliminates human involvement. A robotic arm controlled by an Arduino lifts and parks cars in available slots, using PIR sensors to detect vehicle presence and an RFID reader for user authentication

Abhishek Belsare, Shubhangi Jawalkar, Jennifer Kachhap, and Reshma Padwal, “Vacant Parking Space Detection System” (2016),

The paper presents a system that uses computer vision techniques and video surveillance to detect vacant parking spaces. By tracking and identifying empty spots, the system helps guide drivers efficiently to available parking, enhancing parking management.

Dr. Y. Raghavender Rao, “Automatic Smart Parking System using Internet of Things (IOT)”, International Journal of Engineering Technology Science and Research (2017),

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This paper discusses a smart parking system that leverages IoT technology to help users find available parking spaces quickly. The system reduces time spent searching for parking, minimizes unnecessary travel, and lowers fuel consumption, contributing to reduced carbon footprints.

Thanh Nam Pham, Ming-Fong Tsai, Duc Binh Nguyen, Chyi-Ren Dow, And Der-Jiunn Deng, "A Cloud Based Smart-Parking System Based on Internet-of-Things Technologies" (2015),

This research introduces a cloud-based smart parking system that uses IoT technology to help users find available parking spaces at the lowest cost. The system evaluates new performance metrics, such as distance and free spots, and suggests alternative parking locations when a slot is full.

IV. EXISTING SYSTEM

Current parking systems are largely manual and require drivers to search for vacant spaces, leading to inefficiencies, congestion, and increased fuel consumption. Some parking facilities use basic automation such as barrier gates and ticketing systems, but they still lack real-time monitoring and automated valet services. Traditional multi-level parking lots also suffer from improper space utilization and require human assistance for operations.

Some modern solutions incorporate IoT-based parking sensors, which detect slot availability and display information on digital boards. However, these systems are still dependent on the driver's ability to navigate and park the vehicle manually. Additionally, most parking lots rely on grid electricity, making them energy-intensive and unsustainable. The lack of an integrated cloud-based monitoring system limits remote accessibility and real-time data processing.

Furthermore, many existing smart parking solutions focus only on slot detection rather than fully automating the parking process. There is minimal use of robotic valet mechanisms, and solar-powered solutions are not widely implemented. To overcome these limitations, a fully automated, energy-efficient, and cloud-integrated valet parking system is necessary

V. PROPOSED SYSTEM

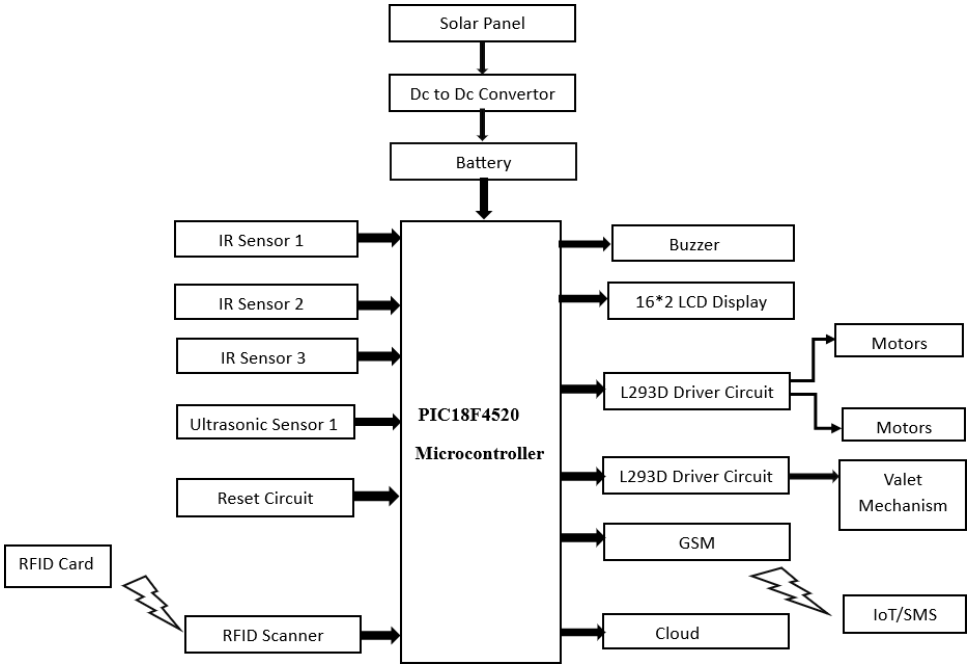

Fig.1 System Block Diagram

The block diagram of the Solar Operated Smart Valet Parking System illustrates the integration of various components to automate vehicle parking and provide real-time updates. The system consists of:

Microcontroller (PIC18F4520): Central unit that controls the entire parking process by processing signals from sensors and controlling the motors.

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Ultrasonic Sensors: Detect available or occupied parking slots by measuring distance to obstacles.
IR Sensors: Confirm the presence of vehicles and detect obstacles in the parking area.
RFID Scanner: Identifies authorized vehicles by scanning RFID tags, allowing only verified users access.
Motors (Controlled by L293D Driver Circuits): Handle the movement of the parking mechanism, positioning the vehicle in the slot.
16x2 LCD Display: Shows the parking slot number for the parked vehicle.
GSM Module: Communicates with the vehicle owner, sending real-time notifications about parking status through IoT or SMS.
Solar Panel: Powers the entire system, with a DC-DC converter managing the energy supply to the battery for continuous operation.
Cloud Monitoring: Provides remote access to the system, allowing users to track parking availability and receive notifications.
This system minimizes human intervention and ensures efficient parking management through automation and real-time updates.

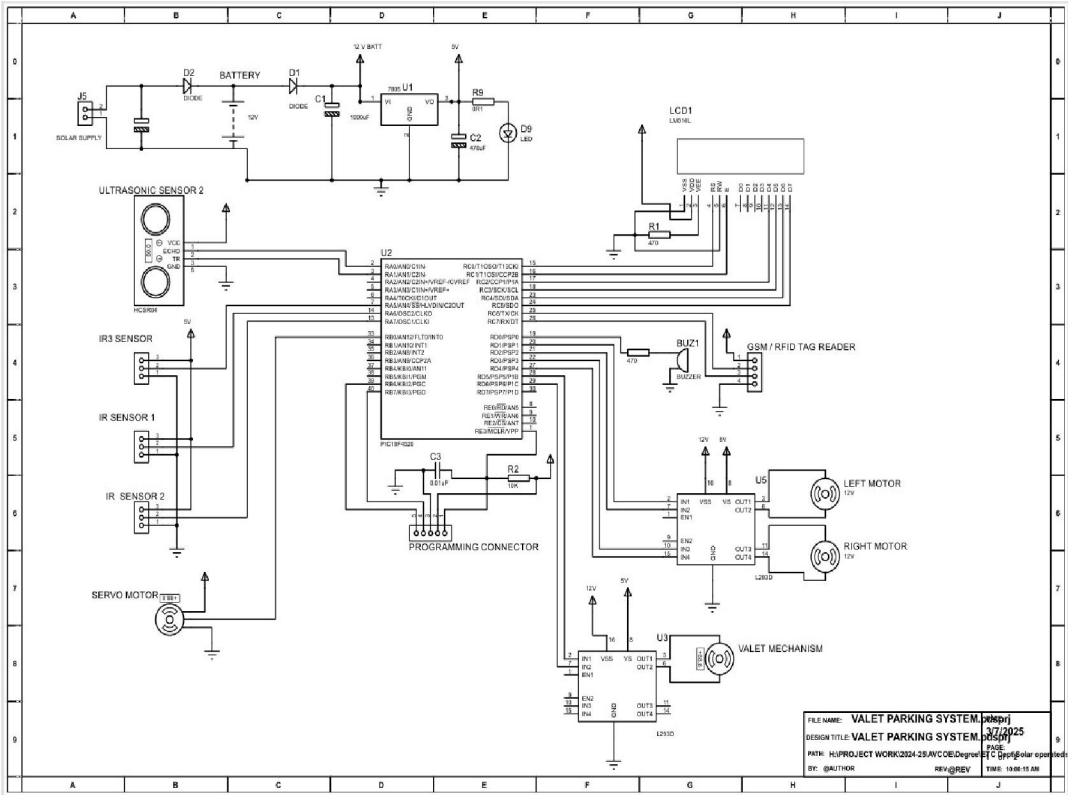

Fig.2 Circuit Diagram of System

The circuit diagram of the automated valet parking system operates through a series of components controlled by the PIC18F4520 microcontroller. Here's a concise explanation of its working mechanism:

Power Supply and Regulation

The system is powered by a 12V battery and supplemented by a solar power source. A LM7805 voltage regulator steps down the voltage to 5V to supply power to the microcontroller and other components such as the sensors, RFID/GSM module, and LCD display.

Microcontroller(PIC18F4520)

The PIC18F4520 microcontroller acts as the brain of the system, processing inputs from various sensors and controlling the outputs, including motors, displays, and notifications.

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Vehicle Detection and Positioning

IR Sensors detect the presence of a vehicle in the parking area. These sensors send signals to the microcontroller when an object is detected, signalling the entry or exit of a vehicle.

Ultrasonic Sensors (HCSR04) measure the distance to objects, helping to accurately determine the vehicle's position within the parking slot.

Identification and Access Control

The RFID/GSM Module plays a key role in vehicle identification. The RFID reader scans tags for registered vehicles and grants access to the parking system. For unregistered vehicles, the GSM module can send alerts to the owner or an operator.

Motor Control for Valet Mechanism

L293D Motor Drivers control the movement of the valet mechanism using two 12V motors. The microcontroller adjusts the motors speed and direction to move the vehicle or guide the automated platform, allowing forward and reverse movement.

Display and Alert Mechanism

The LCD Display (LM016L) communicates essential messages like "Park Here" or "Parking Full" to the user, providing guidance through the parking process.

A Buzzer emits sound alerts for events like vehicle entry, exit, or system errors.

Operation Flow

Entry Detection: The IR sensors detect the vehicle as it approaches. Once RFID/GSM authentication is confirmed, the ultrasonic sensors assess the vehicle's position.

Guidance and Parking: The microcontroller activates the motors based on sensor data to guide the valet mechanism, with the LCD providing step-by-step instructions.

Exit Detection: When the vehicle exits, IR and ultrasonic sensors detect its departure, resetting the parking slot for future use.

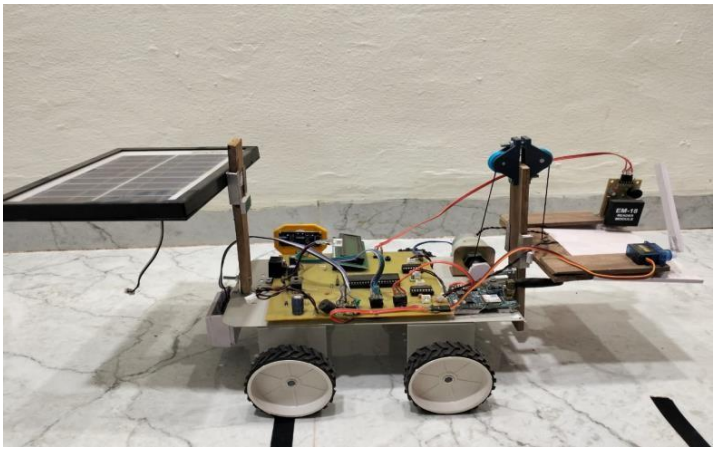
Additional Power Components

Capacitors help smooth out voltage fluctuations to maintain stable power supply for sensitive components.

Diodes protect the circuit, especially around the motors, by preventing back-voltage from affecting the system.

This system integrates these components seamlessly to automate parking tasks, ensuring smooth operation and efficient management of parking spaces.

VI. RESULT



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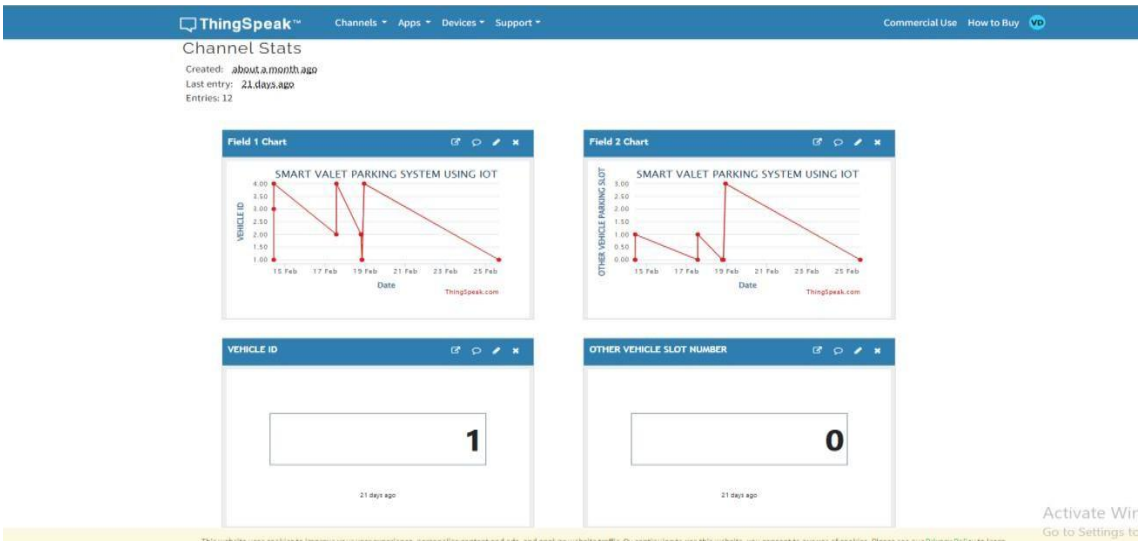

Fig.3 Result

VII. CONCLUSION

In conclusion, the Solar-Powered Autonomous Valet Parking System offers a modern solution to the growing parking challenges in urban areas by combining renewable energy, automation, and smart technology. Powered by solar energy, the system operates efficiently while minimizing battery discharge, supporting eco-friendly urban development. The autonomous mechanism, utilizing a line-following robot and ultrasonic sensors, enables real-time detection of available parking spaces, maximizing the use of parking infrastructure. This automation reduces traffic congestion, time spent searching for parking, and fuel consumption, making it a practical and sustainable option for smart cities. By leveraging cost-effective sensors commonly found in conventional vehicles and avoiding the need for external infrastructure, the system is both scalable and easily deployable. The ability to pre-reserve parking slots and manage spaces efficiently further enhances its real-world application potential. Overall, this innovative system not only enhances parking efficiency but also contributes to the creation of intelligent, sustainable urban environments.

VIII. FUTURE SCOPE

The future scope of the Solar Operated Autonomous Valet Parking System is vast, with numerous opportunities for expansion and improvement. As electric vehicles (EVs) become more prevalent, the system can be enhanced to include EV charging stations within parking slots, allowing users to park and charge simultaneously. Additionally, integrating artificial intelligence and machine learning could optimize parking management by predicting peak times, improving space allocation, and enhancing vehicle navigation. A mobile application could also be developed, enabling users to reserve parking slots, receive real-time updates, and track parking availability. The system could further expand to multi- level parking structures, allowing it to manage larger areas and maximize vertical space. Integration with smart city infrastructure would enable the valet parking system to communicate with city-wide traffic management systems, optimizing traffic flow and reducing congestion. The system's scalability could be extended to other high-demand locations such as airports, shopping centres, and office complexes, offering a flexible solution to various parking challenges. Furthermore, advanced security features, including real-time surveillance and vehicle tracking, could be incorporated to ensure safety. As technology advances, this system holds the potential to revolutionize urban parking, contributing to smarter, more sustainable cities.

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