SOLAR BASED ELECTRIC VEHICLE FAST CHARGING SYSTEM, USING RFID WITH AUTO BATTERY SWITCHING

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Doi: https://doi.org/10.56975/ijcrt.v14i7.309889

Abstract— **The increasing demand for sustainable and efficient transportation has led to the development of solar-powered electric vehicles (EVs). This project presents a Solar-Based Electric Vehicle Fast Charging System using RFID with Auto Battery Switching to improve energy efficiency, charging speed, security, and uninterrupted vehicle operation. The system utilizes solar panels as the primary renewable energy source to charge lithium-ion batteries through a DC-to-DC converter. Supercapacitors are incorporated to support fast charging and rapid energy discharge during peak load conditions.**

An Arduino Nano microcontroller acts as the central controller, monitoring battery voltage levels through voltage sensors and managing automatic battery switching using relay modules. When one battery becomes weak, the system automatically switches to another charged battery, ensuring continuous operation without interruption. RFID technology is integrated to provide secure access, allowing only authorized users to operate the vehicle. An LCD display provides real-time information such as battery status, charging condition, and access authentication.

The system also includes wireless communication support through RF and Wi-Fi modules for remote monitoring and control. By combining renewable solar energy, intelligent battery management, and secure authentication, the project offers an eco-friendly, reliable, and cost-effective solution for future electric mobility systems.

INTRODUCTION:

The transition from conventional internal combustion engine (ICE) vehicles to electric vehicles (EVs) is becoming essential to reduce carbon emissions and achieve sustainable transportation. Although EV technology has advanced significantly, challenges such as long charging time, dependence on grid electricity, limited energy availability, and inefficient battery management still exist. The proposed system uses solar panels as the primary energy source to generate clean and renewable electrical power. A DC-to-DC converter regulates the generated voltage to safely charge lithium-ion batteries and supercapacitors. Supercapacitors are included to provide fast charging capability and quick energy discharge during high-power demand conditions such as vehicle acceleration. An Arduino Nano microcontroller serves as the central control unit of the system. It monitors battery voltage through voltage sensors, controls relay-based automatic battery switching, and displays system information using an LCD display. When one battery becomes discharged, the system automatically switches to another charged battery, ensuring uninterrupted vehicle operation and improved efficiency.

This paper focuses on the integration of solar and wind energy systems for sustainable electric vehicle charging applications. The proposed hybrid renewable energy system aims to reduce dependency on conventional grid electricity, minimize carbon emissions, and enhance energy efficiency. By utilizing energy storage systems and intelligent energy management techniques, the system ensures stable and efficient operation. This approach supports the development of smart and sustainable transportation infrastructure for future energy demands.

I. SYSTEM AND METHODOLOGY:

METHODOLOGY:

The methodology of the **Solar-Based Electric Vehicle Fast Charging System using RFID with Auto Battery Switching** involves the integration of renewable energy generation, intelligent battery management, fast charging techniques, and secure user authentication. The system is designed to provide efficient and uninterrupted operation of an electric vehicle using solar energy as the primary power source.

Phase 1: Solar Power Generation

The system uses solar panels rated at 12V/5W and 12V/10W to convert sunlight into direct current (DC) electrical energy. The generated solar power is utilized to charge the batteries and supply energy to the electric vehicle system Architecture: Solar Panel + Wind Turbine + Grid Supply →

Power Conversion → Battery Storage → Arduino Nano → Relay Source Selection → Motor Driver → EV Motor.

Phase 2: DC-to-DC Voltage Conversion

Since the output voltage from solar panels varies with sunlight intensity, a DC-to-DC buck-boost converter is used to regulate and stabilize the voltage. This ensures efficient charging of batteries and reliable operation of electronic components under different environmental conditions.

Phase 3: Energy Storage System

The system incorporates lithium-ion batteries and supercapacitors for energy storage. The batteries act as the main power source for the vehicle, while the supercapacitors support fast charging and rapid energy discharge during sudden power demands. This combination improves charging speed, energy efficiency, and battery lifespan.

Phase 4: RFID-Based Secure Access

An RFID module is integrated into the system to provide secure user authentication. Only users with authorized RFID cards or tags can access and start the vehicle. When a valid RFID card is scanned, the Arduino verifies the data and activates the system, thereby preventing unauthorized usage

SYSTEM:

The proposed system integrates solar and wind energy sources for sustainable electric vehicle operation. An Arduino Nano controls voltage monitoring, battery storage, and automatic source selection using relay circuits. The regulated power drives the EV motor through a motor driver board, ensuring efficient energy utilization, reliable operation, and reduced dependence on conventional grid power.

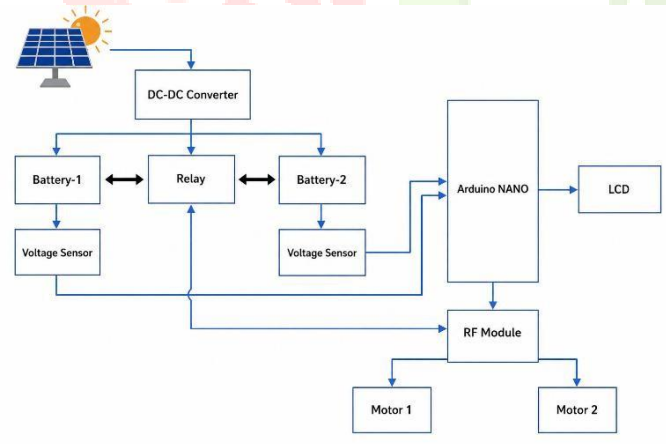

Fig1: SOLAR BASED ELECTRIC VEHICLE FAST CHARGING SYSTEM, USING RFID WITH AUTO BATTERY SWITCHING

System Overview

The block diagram represents the working architecture of a **Solar-Based Electric Vehicle Fast Charging System using RFID with Auto Battery Switching**. The system is designed to provide efficient energy management, secure user authentication, and uninterrupted power supply for electric vehicle operation.

1. Solar Panel

The solar panel is the primary energy source of the system. It converts sunlight into direct current (DC) electrical energy using photovoltaic cells. The generated energy is used to charge the batteries and power the electric vehicle system. Solar panels help reduce dependence on conventional electricity and promote eco-friendly transportation.

2. DC-DC Converter

The DC-DC converter regulates and stabilizes the varying voltage obtained from the solar panel. It ensures that the output voltage is maintained at a suitable level for charging batteries and operating electronic components safely. The converter improves energy efficiency and protects the system from voltage fluctuations.

3. Battery-1

Battery-1 acts as one of the main energy storage units of the system. It stores electrical energy generated from the solar panel and supplies power to the motors and electronic components during operation. It works alternately with Battery-2 through the automatic switching mechanism.

4. Battery-2

Battery-2 serves as the backup power source of the system. When Battery-1 becomes discharged, the relay automatically switches the load to Battery-2. This ensures uninterrupted vehicle operation and increases the reliability of the system.

5. Relay Module

The relay module controls the automatic switching between Battery-1 and Battery-2. It receives control signals from the Arduino Nano and switches the power supply according to battery voltage conditions. This automation improves efficiency and prevents complete battery discharge.

6. Voltage Sensor

Voltage sensors continuously monitor the voltage levels of both batteries. The sensed voltage data is sent to the Arduino Nano for analysis and decision-making. These sensors help in maintaining battery health, avoiding over-discharge, and enabling automatic battery switching.

7. Arduino Nano

The Arduino Nano acts as the central control unit of the system. It processes data received from voltage sensors and controls the relay module, LCD display, RF module, and motors. The Arduino executes the programmed logic for battery management, system monitoring, and overall operation.

8. LCD Display

The LCD display provides real-time information about the system. It displays battery voltage, charging condition, battery status, and other important system parameters. This helps the user monitor the working condition of the electric vehicle system easily.

9. RF Module

The RF (Radio Frequency) module enables wireless communication and control within the system. It is used to send and receive signals for controlling the motors or performing remote operations. The RF module enhances user convenience and system flexibility.

10. Motor 1

Motor 1 represents one of the driving motors used for vehicle movement or load operation. It operates using the power supplied from the selected battery and is controlled through the RF module and Arduino Nano.

11. Motor 2

Motor 2 acts as an additional driving motor that supports vehicle movement and load handling. It works along with Motor 1 to provide efficient motion and balanced operation of the electric vehicle system.

WORKING:

The working of the **Solar-Based Electric Vehicle Fast Charging System using RFID with Auto Battery Switching** starts with the generation of electrical energy through the solar panel. The solar panel converts sunlight into direct current (DC) electrical energy, which acts as the primary power source for the system.

The generated solar power is supplied to the **DC-DC converter**. Since the output voltage from the solar panel varies depending on sunlight intensity, the converter regulates and stabilizes the voltage to a suitable level required for charging the batteries and operating the system components safely.

The regulated power is then supplied to **Battery-1** and **Battery-2** through a **relay-based switching circuit**. These batteries store the electrical energy and provide power to the motors and electronic devices of the vehicle. At any time, one battery powers the system while the other battery can be charged simultaneously.

The voltage level of both batteries is continuously monitored using **voltage sensors**. These sensors send real-time voltage information to the **Arduino Nano microcontroller**. The Arduino acts as the central control unit and compares the battery voltage with predefined threshold values.

When the voltage of the active battery drops below the specified limit, the Arduino automatically activates the **relay module** to switch the power supply from the discharged battery to the fully charged backup battery. This automatic battery switching ensures uninterrupted operation of the electric vehicle without manual intervention.

The system also includes an **RFID authentication module** for secure access control. When an authorized RFID card or tag is scanned, the Arduino verifies the user information and allows the system to operate. Unauthorized users are denied access, improving system security.

The **LCD display** continuously shows important system parameters such as battery voltage, charging status, battery in use, and RFID authentication messages. This enables users to monitor the condition and operation of the system easily.

The **RF module** provides wireless communication and control functionality. It sends control signals to **Motor 1** and **Motor 2**, which are responsible for the movement and operation of the electric vehicle.

Overall, the system combines solar energy generation, intelligent battery management, automatic switching, and secure user authentication to create an efficient, eco-friendly, and reliable electric vehicle charging and operating system

II. RESULTS:

The developed **Solar-Based Electric Vehicle Fast Charging System using RFID with Auto Battery Switching** was successfully designed and tested under different operating conditions. The system demonstrated efficient utilization of solar energy for charging and operating the electric vehicle components.

The solar panel was able to generate sufficient DC power under normal sunlight conditions, and the DC-DC converter successfully regulated the voltage for safe battery charging. The lithium-ion batteries stored the generated energy effectively and supplied continuous power to the motors and electronic components.

The **automatic battery switching mechanism** operated successfully. When the voltage of the active battery dropped below the predefined threshold value, the Arduino Nano automatically activated the relay module and switched the load to the backup battery without interrupting the system operation. This ensured uninterrupted power supply and improved system reliability.

The **RFID authentication system** accurately identified authorized users and prevented unauthorized access to the vehicle system. The RFID module responded quickly during testing and provided secure operation.

The **LCD display** successfully showed real-time information such as battery voltage, charging condition, battery status, and system activity. This improved user monitoring and system visibility.

The **RF communication module** effectively controlled Motor 1 and Motor 2 wirelessly, and the motors operated smoothly using the battery power supplied by the switching system.

The integration of supercapacitors improved the charging response and supported fast energy delivery during high power demand conditions. The overall system operated efficiently, reduced dependency on grid electricity, and demonstrated the practical implementation of renewable energy- based electric vehicle technology.

The project results confirmed that the proposed system is reliable, eco-friendly, secure, and suitable for future smart electric vehicle applications.

SUSTAINABLE DEVELOPMENT GOALS (SDGs)
& MAPPING FOR THE PROJECT

PROJECT: SOLAR-BASED EV FAST CHARGING SYSTEM USING RFID WITH AUTO BATTERY SWITCHING

SDG	GOAL & TARGET	RELEVANCE TO PROJECT	PROJECT CONTRIBUTION	INDICATORS / METRICS
7 AFFORDABLE AND CLEAN ENERGY	Ensure access to affordable, reliable, sustainable and modern energy for all. Target 7.2: Increase substantially the share of renewable energy in the global energy mix.	Uses solar energy for EV charging, reducing dependency on conventional fossil fuel based electricity.	• Promotes renewable and clean energy usage. • Reduces reliance on grid electricity for EV charging.	• % of solar energy utilized • Reduction in grid energy usage • Renewable energy adoption rate
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. Target 9.4: Upgrade infrastructure and retrofit industries to make them sustainable.	Integrates Arduino, RFID, sensors, DC-DC converter, auto battery switching and IoT modules for a smart and efficient charging system.	• Encourages innovation in EV charging technology. • Supports development of smart infrastructure.	• Use of advanced electronics & IoT • System efficiency & reliability • Scalability of the solution
11 SUSTAINABLE CITIES AND COMMUNITIES	Make cities and human settlements inclusive, safe, resilient and sustainable. Target 11.2: Provide access to safe, affordable, accessible and sustainable transport systems for all.	Supports adoption of electric vehicles by providing a clean and efficient charging solution, reducing urban pollution.	• Promotes sustainable and eco-friendly transport. • Reduces vehicular emissions in cities.	• Reduction in CO_2 emissions • Increase in EV usage • Improvement in air quality
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Ensure sustainable consumption and production patterns. Target 12.2: Achieve the sustainable management and efficient use of natural resources.	Optimizes energy usage through auto battery switching and supercapacitors, minimizing energy wastage.	• Improves energy efficiency and system reliability. • Encourages efficient use of resources.	• Energy utilization efficiency • Reduced energy wastage • Battery life improvement
13 CLIMATE ACTION	Take urgent action to combat climate change and its impacts. Target 13.2: Integrate climate change measures into national policies, strategies and planning.	Reduces greenhouse gas emissions by promoting solar energy-based EV charging system.	• Lowers carbon footprint. • Supports climate-resilient and sustainable systems.	• CO_2 emissions avoided (kg/year) • Renewable energy generated (kWh/year)

OVERALL IMPACT This project supports clean energy, innovation, sustainable infrastructure, eco-friendly transport and climate action, contributing towards a greener, smarter and more sustainable future.

SDG CONTRIBUTION SUMMARY

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