ESP-IJCEET
ESP International Journal of Communication Engineering & Electronics Technology
ISSN: 2583-9217 / Volume 2 Issue 4 October 2024 / Page No: 9-16
Paper Id: IJCEET-V2I4P102 / Doi: 10.56472/25839217/IJCEET-V2I4P102

Original Article

Power Allocation and EV Charging System

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Received Date: 14 August 2024 Revised Date: 26 September 2024 Accepted Date: 08 October 2024

Abstract: *The increasing adoption of electric vehicles (EVs) presents significant challenges to power grid management, particularly in balancing demand and supply while ensuring energy efficiency. This project explores a smart Power Allocation and EV Charging System designed to optimize energy distribution, enhance grid stability, and reduce charging costs. The proposed system integrates advanced algorithms for demand response, renewable energy utilization, and predictive analytics to dynamically allocate power to EV charging stations based on real-time data. By incorporating machine learning techniques, the system predicts peak usage times and adjusts charging schedules to minimize grid stress. A cloud-based monitoring and control system for real-time data collection and decision-making. An adaptive charging algorithm to prioritize critical loads and optimize charging rates. Integration of renewable energy sources like solar and wind to promote sustainability. This project aims to contribute to a scalable, cost-effective, and environmentally sustainable solution for managing the growing energy demands of EVs while ensuring grid reliability.*

Keywords: *Power Distribution, Power Management, Load Balancing, Dynamic Power Allocation, Distributed Power Systems, Demand-Side Management (DSM), Power Optimization, Electric Vehicle Charging, EV Charging Stations, Fast Charging, Slow Charging, Smart Charging, Charging Infrastructure, Charging Time Optimization.*

I. INTRODUCTION

A. Background:

The global transition to electric vehicles (EVs) represents a cornerstone of efforts to reduce greenhouse gas emissions and dependence on fossil fuels. With governments and private sectors emphasizing carbon neutrality, the deployment of EVs has surged. This growth has created a significant demand for robust and efficient EV charging infrastructures. However, integrating these systems with existing power grids presents unique challenges, particularly in terms of energy management, power distribution, and grid stability.

B. Objectives:

The primary goal of this study is to explore and develop efficient power allocation strategies for EV charging systems.

a) Specifically:

Optimal Energy Distribution: Ensuring equitable and efficient power allocation across charging stations to prevent bottlenecks.

b) Minimizing Charging Time:

Reducing the charging time for users while maintaining grid stability.

c) Incorporating Renewable Energy:

Leveraging renewable energy sources to enhance sustainability.

d) Cost Efficiency:

Reducing operational costs for both users and grid operators through advanced algorithms and dynamic pricing models.

e) User-Centric Approaches:

Enhancing user experience by incorporating real-time data and predictive analytics for

II. SYSTEM IMPLEMENTATION

A. Existing System:

In the existing power allocation and EV (Electric Vehicle) charging systems, the process often suffers from inefficiencies due to centralized control.

Static charging schedules, and a lack of adaptability to real-time energy demand and supply fluctuations. Most systems rely on fixed charging rates or schedules.

Which may lead to grid overloads during peak demand periods or underutilization during off-peak hours.
These limitations restrict the scalability of such systems as EV adoption grows.

B. Proposed System:

The proposed power allocation and EV charging system introduces a dynamic, decentralized approach to optimize energy distribution.

The system adapts in real-time to the varying energy demands and availability.

The framework incorporates renewable energy sources, such as solar and wind, to create a more sustainable charging ecosystem.

It employs smart grid technology, predictive analytics, EV charging based on user preferences, grid conditions, and cost-efficiency.

This system aims to improve scalability, reduce energy wastage, and enhance the overall reliability of the EV charging infrastructure.

C. Block Diagram:

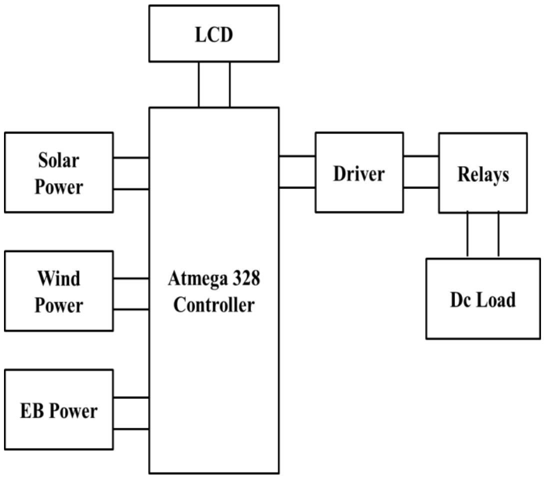

Figure 1: Proposed Block Diagram

D. Block Description:

a) Power Sources:

i) Solar Power:

A solar panel connected to a solar charge controller to regulate voltage and current for safe charging and operation.

ii) Wind Power:

A wind turbine with a charge controller and rectifier circuit to convert the alternating current (AC) generated into direct current (DC).

iii) EB Power (Electricity Board Power):

A backup grid power source that supplies electricity when renewable sources are insufficient.

iv) Microcontroller (ATmega328):

Central processing unit that monitors and manages power sources.Receives input data (such as voltage and current levels) from sensors connected to the solar and wind systems.Controls the switching logic between power sources (solar, wind, and EB) to ensure efficient usage.

v) Drivers and Relays:

Interface between the microcontroller and high-power devices, ensuring the microcontroller can safely control relays and other components. Electromechanical switches controlled by the microcontroller to toggle between power sources or activate/deactivate devices based on conditions.

b) LCD Display:

Displays real-time system status, such as the active power source, battery charge level, and energy output.Facilitates easy monitoring and debugging of the system.

E. Circuit Diagram:

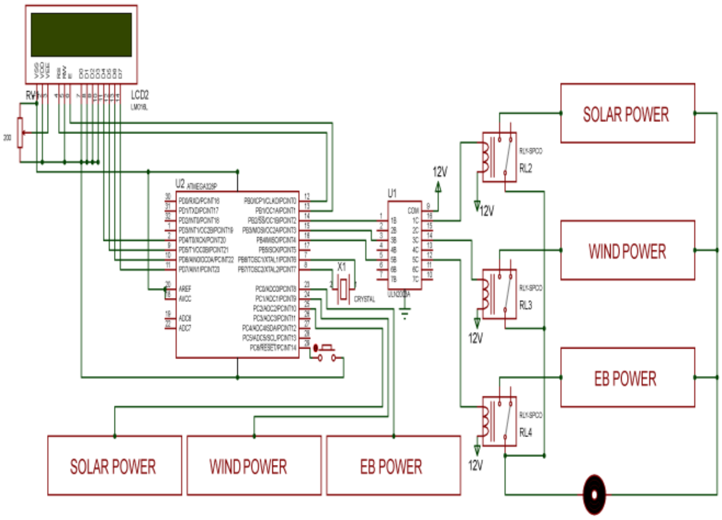

Figure 2: Proposed Circuit Diagram

F. Circuit Description:

The circuit connection involving the ATmega328 microcontroller, solar power, wind power, EB (Electric Board) power, an LCD display, and driver relays.The circuit integrates renewable energy sources (solar and wind power) with conventional EB power using an ATmega328 microcontroller as the central control unit. Solar and wind power inputs are connected to charge controllers to stabilize and regulate their outputs. These regulated DC voltages are fed to the microcontroller through voltage dividers or ADC pins for monitoring purposes. EB power acts as a backup source, and its availability is also monitored by the microcontroller. The microcontroller is programmed to prioritize renewable energy sources, switching between them and EB power as necessary via driver relays. The relays are controlled through digital output pins of the ATmega328, activated by appropriate signals.

An LCD display, connected via the I2C or parallel interface, provides real-time information such as power source status, voltage levels, and load status. The display is powered by the system's common power supply. The system logic ensures efficient power management, including preventing overcharging of batteries, optimizing load distribution, and automatically switching to the EB supply if renewable sources are insufficient. Pull-up resistors and protection diodes are employed where necessary to ensure reliable and safe operation of the circuit.

III. HARDWARE DETAILS

A. ATMEGA 328:

Figure 3(a): ATMEGA Microcontroller

ATMEGA 328 microcontroller, which acts as a processor for the arduino board. Nearly it consists of 28 pins. From these 28 pins, the inputs can be controlled by transmitting and receiving the inputs to the external device. It also consists of pulse width modulation (PWM). These PWM are used to transmit the entire signal in a pulse modulation. Input power supply such as Vcc and Gnd are used. These IC mainly consists of analog and digital inputs. These analog and digital inputs are used for the process of certain applications.

B. ATMEGA-328 IC:

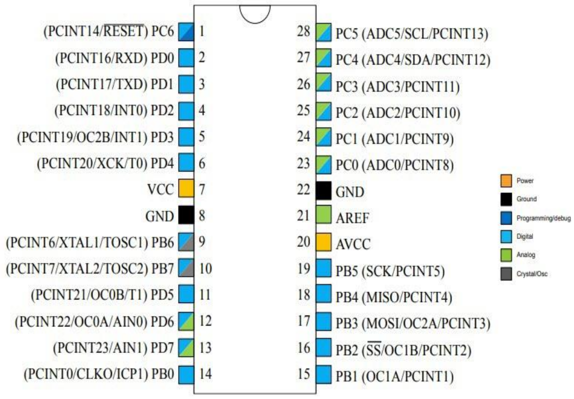

Figure 3(b): ATMEGA Microcontroller IC Diagram

C. Relay Driver:

The ULN2001A, ULN2002A, ULN2003 and ULN2004Aare high voltage, high current Darlington arrays each containing seven open collector dar-lington pairs with common emitters. Each channel rated at 500mAand can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout. The four versions interface to all common logic families.

These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors; LED displays filament lamps, thermal print-head sand high power buffers ULN2001A/2002A/2003Aand 2004A is sup-plied in 16 pin plastic DIP packages with a copper lead frame to reduce thermal resistance. They are available also in small outline package (SO-16) as ULN2001D/2002D/2003D/2004D.

D. Pin Diagram – ULN 2003

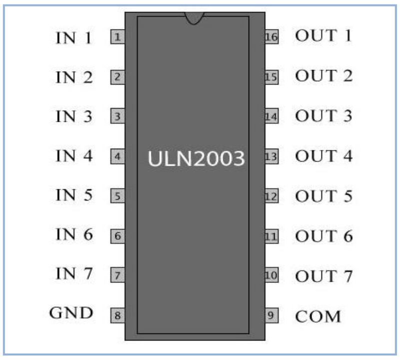

Figure 4(a): Pin Diagram ULN 2003

The ULN2003A is a high voltage, high current, Darlington Arrays each containing seven open collection Darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite to outputs to simplify layout. It is a 5V TTL, CMOS. This versatile device is useful for driving a wide range of loads including solenoids, relays, DC motors, LED displays, and high power buffers. Outputs can be paralleled for higher current.

E. Relay:

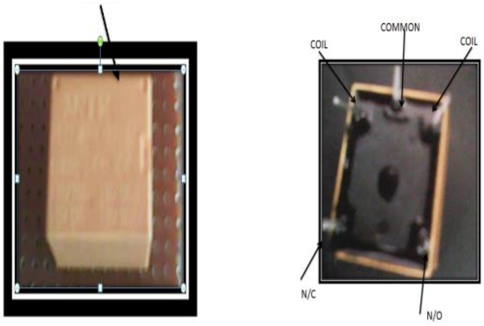

Figure 4(b): Relay Diagram

F: Relay Pin Diagram:

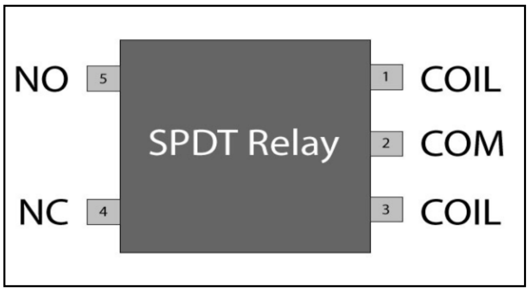

Figure 4(c): Relay Pin Diagram

Relays are switching devices. Switching devices are the heart of industrial electronic systems. When a relay is energized or activated, contacts are made or broken. They are used to control ac or dc power. They are used to control the sequence of events in the operation of a system such as an electronic heater, counter, welding circuits, and X-ray equipment, measuring systems, alarm systems and telephony. Electromagnetic relays are forms of electromagnets in which the coil current produces a magnetic effect. It pulls or pushes flat soft iron armatures or strips carrying relay contacts. Several relay contact can be operated to get several possible ON/OFF combinations.

G. LCD – Liquid Crystal Display:

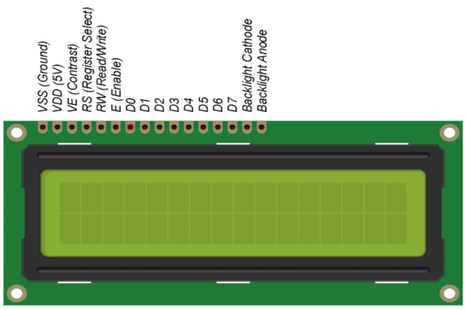

Figure 5: LCD – Liquid Crystal Display

Liquid Crystal Displays (LCDs) have materials, which combine the properties of both liquid and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal. An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle. One each polarizer are pasted outside the two glass panels.

H. Features:

- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without backlight
- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is build by a 5×8 pixel box
- Can work on both 8-bit and 4-bit mode

IV. ADAVANTAGES AND APPLICATIONS

A. Applications:

- Smart Charging Infrastructure
- Residential EV Charging
- Fleet Management
- Renewable Energy Integration
- Vehicle-to-Grid (V2G) Systems
- Smart Grids
- Emergency Situations
- Advantages
- Efficient Power Usage
- Cost Savings
- Scalability
- Reduced Environmental Impact
- Improved User Experience
- Grid Stability
- Support for Renewable Energy
- Customizable and Flexible Solutions

V. RESULTS & DISCUSSION

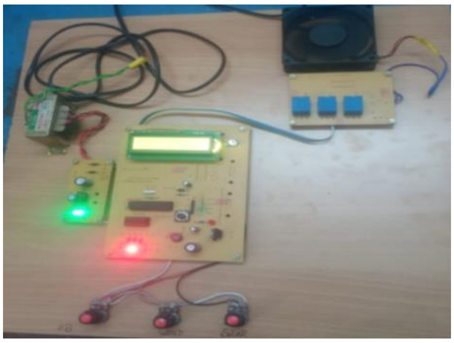

Figure 6(a): Hardware Setup

Figure 6(b): Hardware On Display

Figure 6(c): All Input Power Are Normal

Figure 6(d): Hardware Is Run Solar Power

Figure 6(e): Hardware Is Run Wind Power

Figure 6(f): Hardware Is Run EB Power

Figure 6(g): Hardware Is Run Wind and EB Power

Figure 6(h): Hardware Is Run Solar and EB Power

Figure 6(i): Hardware Is Run Solar,Wind and EB Power

VI. CONCLUSION

In conclusion, effective power allocation and electric vehicle (EV) charging systems are critical components of modern energy infrastructure, ensuring sustainable and efficient energy utilization. The integration of advanced algorithms for dynamic power distribution, coupled with smart grid technologies, enhances the adaptability and reliability of EV charging networks. By leveraging renewable energy sources and employing demand-side management strategies, these systems contribute significantly to reducing carbon footprints and optimizing grid stability. Future advancements in artificial intelligence, battery technology, and bidirectional charging capabilities hold promise for further improving the scalability and environmental impact of EV charging systems, paving the way for a cleaner and more energy-resilient future.

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