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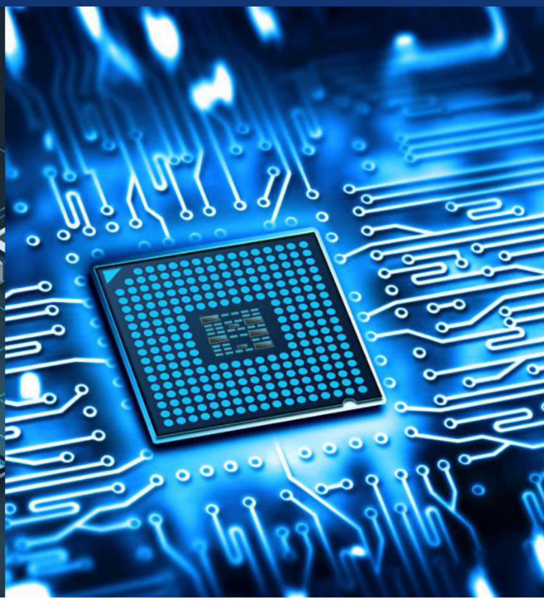


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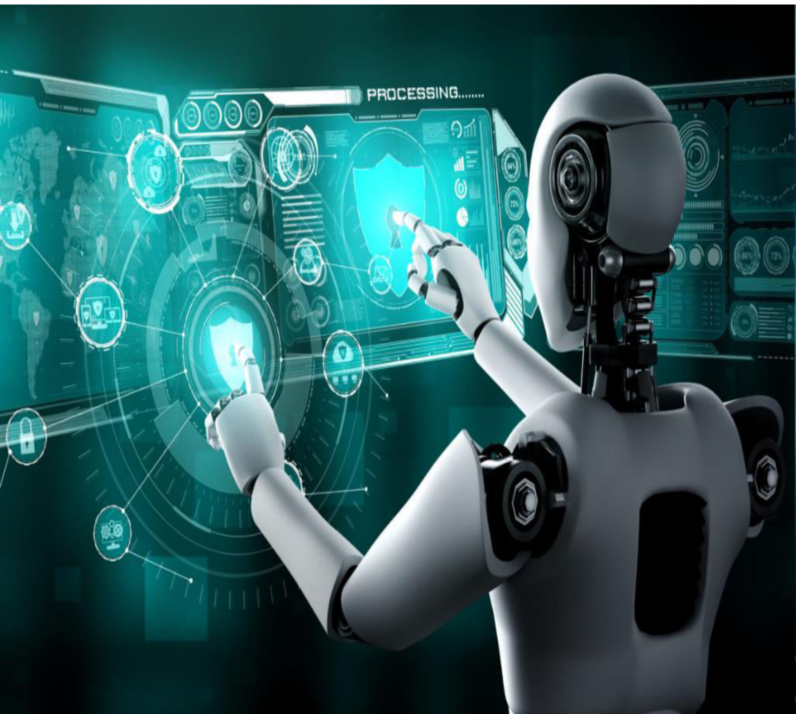

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Charging Station for E-Vehicle using Solar with IoT

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ABSTRACT: In the recent years, the globe has changed dramatically. is moving towards the usage of electric vehicles which is more comfortable as well as more economical than the normal petrol/diesel operated vehicles. This study has created a battery monitoring system based on the internet of things (IoT) to track the functionality and performance of batteries in a smart E vehicle system. The main concern of the electric car is battery charging time, which consumes more demand from the supply network. An intelligent electronic device (IED), PV system, battery pack, grid connection, and electrical load are all components of this smart microgrid. The Internet of Things (IoT) established in this study consists of an IED communication channel, a data collection mechanism, a cloud system, and a human-machine interface (HMI). The main idea behind this work creates a charging station with solar and implement the IoT concept to monitor the performance and to cut the greenhouse gases and the usage of fossil fuels.

I. INTRODUCTION

With growing environmental concerns and the depletion of fossil fuel resources, the global transportation sector is undergoing a revolutionary transformation. One of the key components of this transformation is the adoption of Electric Vehicles (EVs), which are increasingly seen as an eco-friendly and sustainable alternative to conventional internal combustion engine (ICE) vehicles. These electric vehicles offer numerous advantages, such as lower operational costs, reduced greenhouse gas emissions, and improved energy efficiency. However, to fully embrace this shift towards electrification, it is essential to develop a reliable, efficient, and sustainable charging infrastructure. A promising solution to this challenge lies in the integration of renewable energy sources, particularly solar power, with smart Internet of Things (IoT) technologies to create advanced charging stations

The primary limitation of electric vehicles today is their dependency on long battery charging times and the pressure they impose on the existing power grid. With the increasing number of EVs on the road, there is a risk of power shortages, voltage instability, and higher demand during peak hours. This scenario calls for an intelligent and autonomous solution that not only manages the energy supplyefficiently but also reduces the strain on the grid. The incorporation of solar energy as a primary or supplementary energy source in EV charging stations serves as a game-changing approach. Solar energy is clean, abundant, and cost-effective, making it ideal for supporting the changing needs of EVs without contributing to environmental pollution In this context, the development of a solar-powered EV charging station integrated with IoT technologies emerges as a highly viable and scalable solution. Such a system consists of a smart microgrid comprising a photovoltaic (PV) solar panel system, a battery energy storage unit, a grid connection, and an intelligent electronic device (IED) that manages data communication and control mechanisms. The Internet of Things (IoT) acts as the backbone of this setup, enabling real-time data acquisition, remote monitoring, and system automation. IoT devices collect data on battery performance, solar energy generation, charging patterns, and grid usage. This information is then transmitted to a cloud platform, where it is analyzed and presented to users and operators through a user-friendly Human-Machine Interface (HMI).

II. LITERATURE SURVEY

2.1 Qahtan, Mahmood H., Emad A. Mohammed, and Ahmed J. Ali. "Charging Station of Electric Vehicle Based on IoT: A Review." Open Access Library Journal 9, no. 6 (2022):

In recent years, one of the most pressing global challenges faced by humanity is the scarcity of fossil fuels and the adverse impact of environmental pollution caused by conventional fuel-based vehicles. These vehicles emit a significant amount of carbon dioxide and other harmful pollutants that contribute to climate change, air quality degradation, and various health issues. As a solution to these growing concerns, the adoption of electric vehicles (EVs) has been widely promoted across the globe. Electric vehicles offer a clean and efficient alternative to traditional gasoline- powered cars, as they produce zero tailpipe emissions and have the potential to be powered by renewable energy sources. By shifting towards EVs, societies can significantly reduce their carbon footprint, improve urban air quality, and mitigate the long-term effects of global warming However, despite the numerous benefits associated with electric vehicles, their widespread adoption has been hindered by several critical factors. One of the primary obstacles is the limited availability of charging infrastructure. The number of charging stations is still insufficient in many regions, especially in developing countries and rural areas. This lack of accessibility discourages potential buyers from investing in EVs due to concerns about range anxiety—the fear that a vehicle will run out of battery power before reaching a charging point. Additionally, the initial cost of electric vehicles remains relatively high compared to internal combustion engine (ICE) vehicles, which further slows down their market penetration.

To address the infrastructural challenges and facilitate the adoption of electric vehicles, recent research and technological advancements have focused on the integration of the Internet of Things (IoT) into the design and operation of EV charging stations. The Internet of Things enables devices to communicate with each other over a network, collecting and sharing data in real-time. When applied to charging stations, IoT technology plays a pivotal role in streamlining operations, enhancing user experience, and increasing the efficiency of energy usage. Through IoT-enabled systems, users can easily locate nearby charging stations using their smartphones or navigation systems. This eliminates the need for lengthy searches and reduces the time spent driving around in search of an available station, thereby improving convenience and overall satisfaction for EV users.

Moreover, the application of IoT in EV charging infrastructure allows for smart management of energy resources. Charging stations equipped with IoT sensors can monitor power consumption, battery levels, and vehicle status, and they can communicate this data to central control systems or user applications. This facilitates the scheduling of charging sessions, load balancing, and predictive maintenance, ultimately enhancing the reliability and performance of the entire network. Such intelligent systems can also provide real-time information about station availability, pricing, charging speed, and estimated waiting times, empowering users to make informed decisions based on their needs.

Another important aspect discussed in current literature is the classification of charging types used in electric vehicle stations. Generally, EV charging is categorized into three levels: Level 1, Level 2, and DC Fast Charging. Level 1 charging is the most basic type, using a standard household outlet and providing slow charging speeds. It is suitable for overnight home charging. Level 2 charging uses a higher voltage and delivers faster charging, making it appropriate for residential, workplace, and public settings. DC Fast Charging, also known as Level 3, provides rapid charging by directly supplying power to the vehicle's battery, and it is ideal for highway rest stops and commercial charging hubs. Each charging type has its own applications, cost implications, and infrastructural requirements, and understanding their differences is essential for developing a comprehensive and efficient charging network.

In terms of energy sources for EV charging stations, both renewable and non-renewable options are currently in use. Renewable energy sources, such as solar, wind, and hydroelectric power, offer a sustainable and environmentally friendly solution that complements the clean energy goals of electric mobility. Solar-powered charging stations, for instance, utilize photovoltaic panels to harness sunlight and convert it into electricity, which can then be used to charge EVs. These stations reduce dependency on the traditional power grid and lower greenhouse gas emissions. On the other hand, some charging stations still rely on non-renewable sources like coal or natural gas, which, while more readily available in certain regions, undermine the ecological advantages of EV adoption. The integration of renewable energy into EV charging infrastructure is a crucial step toward achieving a greener and more sustainable transportation system.

III. EXISTING SYSTEM

3.1. INTRODUCTION

The comfort and cost-effectiveness of electric cars (EVs) over conventional gasoline and diesel vehicles have caused a global change in recent years. An Internet of Things-based battery monitoring system is created in this work to monitor the performance of batteries in electric car systems. Long charging times for EVs are a big problem since they put a lot of strain on the energy supply network. Developing a solar-powered charging station with IoT-based battery performance monitoring is the aim. Reducing greenhouse gas emissions and dependency on fossil fuels are the goals of this strategy

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3.2 DISADVANTAGES

- Setting up solar panels, IoT devices, and cloud infrastructure can be expensive.
- IoT systems are vulnerable to cyberattacks and data breaches.
- System performance heavily relies on stable internet connectivity.
- Continuous monitoring may drain EV battery faster if not optimized.
- Requires regular updates and technical maintenance for IoT devices.
- Expanding the system to support multiple vehicles or stations can be challenging.
- Solar charging depends on weather and may not provide consistent power.
- Simultaneous charging from multiple stations may stress the local grid.
- Requires trained personnel to manage and troubleshoot the system.
- Real-time data transmission delays may affect decision-making.

IV. PROPOSED METHOD

4.1. INTRODUCTION

To overcome the limitations of the existing system, this proposed method introduces an enhanced IoT-based smart electric vehicle charging and battery monitoring system powered by a hybrid energy source. The system integrates solar energy with grid support and utilizes advanced IoT-enabled sensors and controllers to monitor battery health, charging status, and energy flow in real time. A smart algorithm is embedded within the intelligent electronic device (IED) to optimize charging schedules and reduce energy consumption during peak hours. The data collected from the system is processed and visualized through a cloud-based dashboard for remote monitoring and decision-making. Additionally, the proposed system ensures secure data transmission, efficient energy management, and a user-friendly interface. This approach not only improves the reliability and performance of EV charging infrastructure but also contributes to reducing carbon emissions and enhancing the adoption of green energy solutions.

4.2 BLOCK DIAGRAM

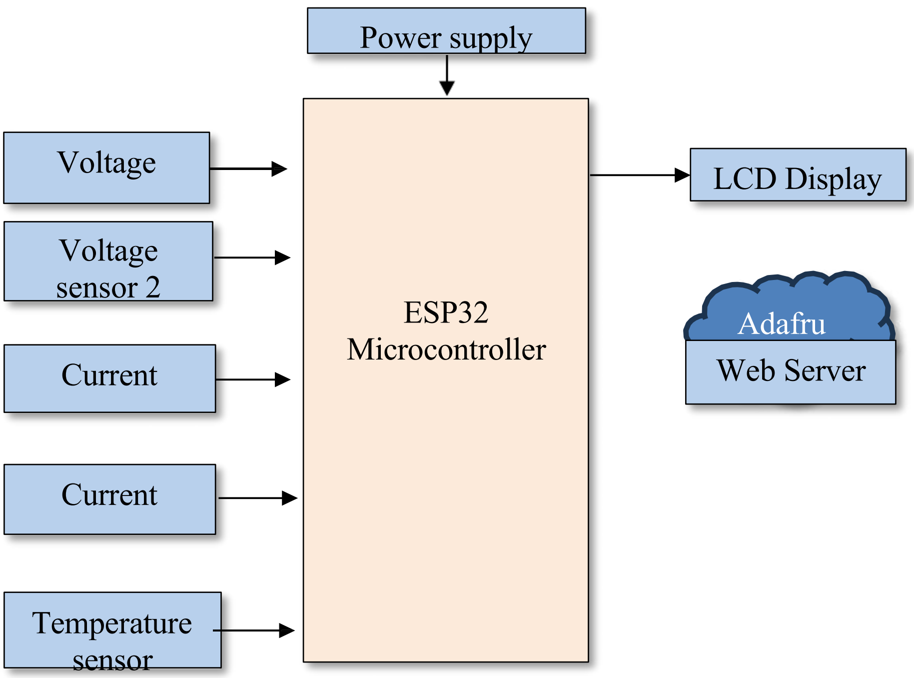

Figure 1 Proposed Block Diagram

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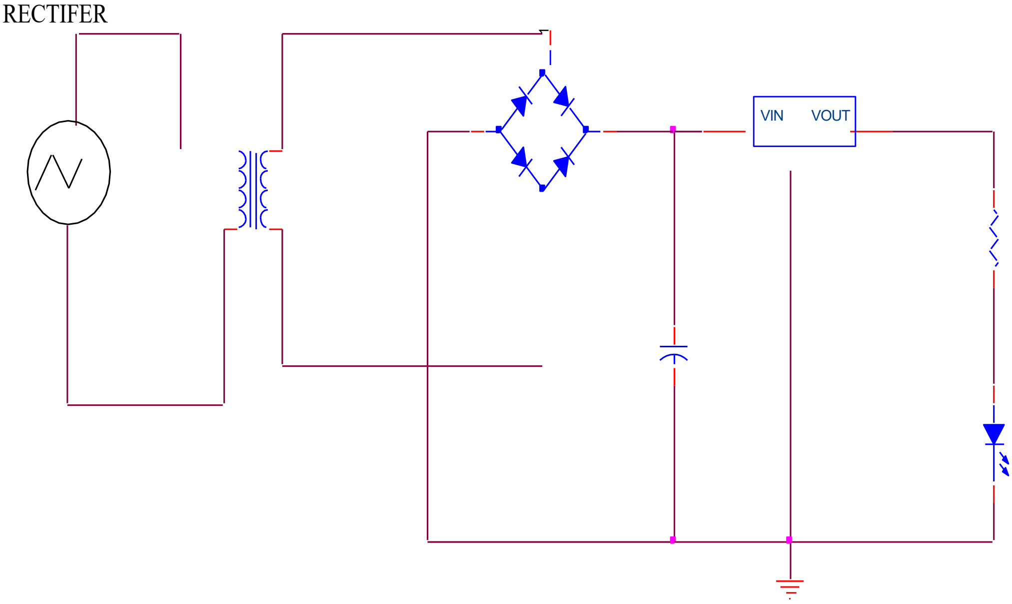
4.3 BLOCK DIAGRAM EXPLANATION

4.3.1 POWER SUPPLY

The electrical power is almost exclusively generated, transmitted and distributed in the form of ac because of economic considerations but for the operation of most of the electronic devices and circuits, a DC supply is required. Dry cells and batteries can be used for this purpose. No doubt, they have the advantages of being portable and ripple-free but their voltages are low, they need frequent replacement and are expensive in comparison to conventional DC power supplies. Now a day, almost all electronic equipment includes a circuit that converts ac supply into dc supply.

BRIDGE RECTIFER
AC 230v



4.3.1 Circuit Diagram of Power supply

The part of the equipment that converts ac into dc is called the DC power supply. Almost all basic household electronic circuits need an unregulated AC to be converted to constant DC, to operate the electronic device. All devices will have a certain power supply limit and the electronic circuits inside these devices must be able to supply a constant DC voltage within this limit. This DC supply is regulated and limited in terms of voltage and current. But the supply provided from mains may be fluctuating and could easily break down the electronic equipment, if not properly limited. This work of converting an unregulated alternating current (AC) or voltage to a limited Direct current. (DC) or voltage to make the output constant regardless of the fluctuations in input, is done by a regulated power supply circuit.

4.3.2 ESP 32 MICROCONTROLLER

The ESP32 microcontroller is a compact integrated circuit that contains a processor core, memory, and programmable input/output peripherals. It is based on the Xtensa LX6 dual-core processor, which allows for parallel processing and efficient multitasking. The ESP32 comes with built-in support for Wi-Fi and Bluetooth communication, with a variety of Wi-Fi modes,including Station, Access Point, and both simultaneously in SoftAP mode. Bluetooth functionality includes both Classic Bluetooth and Bluetooth Low Energy (BLE). The ESP32 provides a wide range of peripherals, such as GPIO (General Purpose Input/Output) pins, SPI (Serial Peripheral Interface), I2C (Inter-Integrated Circuit), UART (Universal Asynchronous Receiver/Transmitter), PWM (Pulse Width Modulation), and more.

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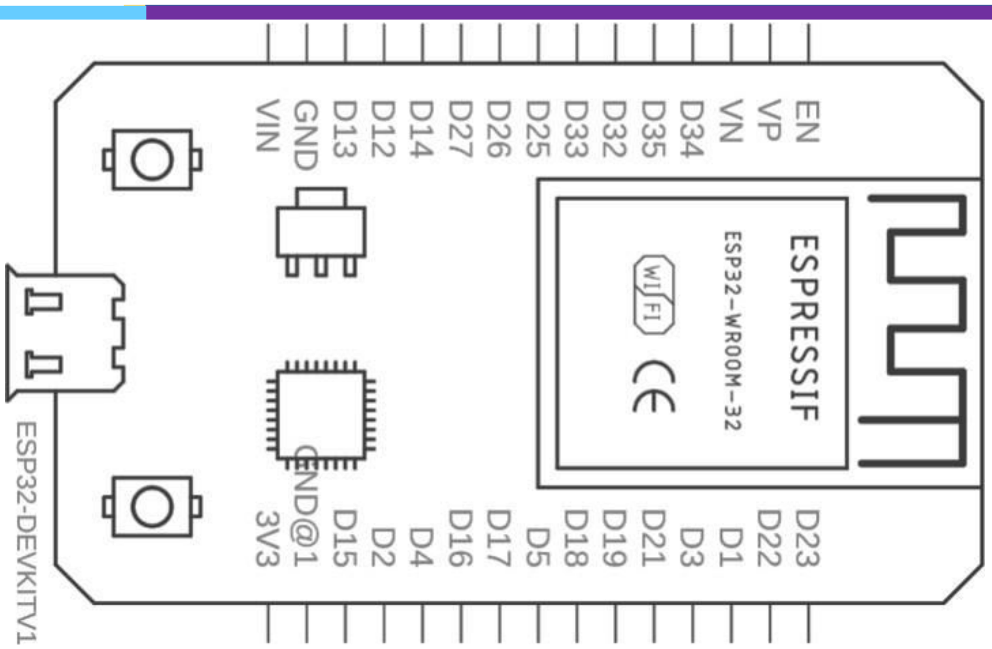

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Figure 4.3.2 Pin Diagram of ESP 32 Microcontroller

These peripherals enable the ESP32 to interface with various sensors, actuators, and other devices. The ESP32 typically comes with flash memory for program storage and SRAM (Static Random Access Memory) for data storage. The amount of flash and SRAM can vary depending on the specific ESP32 module or development board. The ESP32 can be programmed using the Arduino IDE, which provides more low-level control. A variety of programming languages, including C and C++, can be used to develop applications for the ESP32.

NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

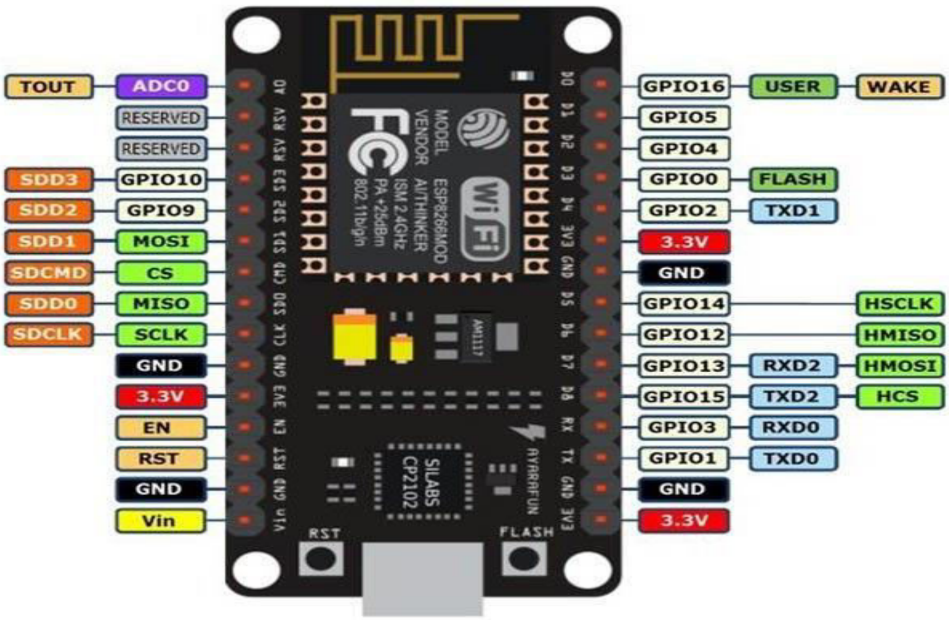

Figure 4.3.3NodeMCU ESP8266 Pinout

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The NodeMCU ESP8266 is a versatile and popular microcontroller designed for Internet of Things (IoT) applications, combining robust features with compact size. At its core, it uses a Tensilica 32-bit RISC CPU Xtensa LX106, which is optimized for both low power consumption and high performance. Operating at 3.3V, the board can accept an input voltage of 7-12V, making it compatible with various power sources. It includes 16 digital I/O pins for flexible peripheral connectivity, along with a single 10-bit analog input pin for reading sensor data. Communication capabilities are extensive, with one UART for serial communication, one SPI for connecting SPI- based devices, and one I2C for interfacing with I2C-compatible sensors and modules.

With 4 MB of flash memory, the NodeMCU can store extensive program code and Wi- Fi credentials, while its 64 KB of SRAM provides sufficient memory for data handling and processing tasks. Operating at a clock speed of 80 MHz, it can also be overclocked to 160 MHz for more demanding applications. An integrated CP2102 USB-TTL converter enables easy programming and USB communication, making it plug-and-play. The board's PCB antenna ensures a strong and stable Wi-Fi connection, critical for IoT deployments. Its compact design makes it ideal for embedding in various IoT projects, from smart home automation to sensor networks and beyond, making the NodeMCU ESP8266 a powerful, affordable choice for IoT enthusiasts and developers alike.

The NodeMCU ESP8266 development board comes with the ESP-12E module containing the ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects. NodeMCU can be powered using a Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.

ESP32 PIN DIAGRAM

Fig 4.3.4 ESP32 PIN DIAGRAM

ESP32 Pinout

- 18 Analog-to-Digital Converter (ADC) channels.
- 3 SPI interfaces.
- 3 UART interfaces.
- 2 I2C interfaces.
- 16 PWM output channels.
- 2 Digital-to-Analog Converters (DAC)
- 2 I2S interfaces.
- 10 Capacitive sensing GPIOs.

4.3.5 LCD DISPLAY

A 16x2 LCD is a widely used type of liquid crystal display in electronic projects, embedded systems, and various devices for displaying information. The dimensions of the display are 16 characters in each of its two rows, hence the term "16x2". Each cell in the grid can display an alphanumeric character or symbol. The display uses LCD (Liquid Crystal Display) technology, where liquid crystals are manipulated to control the passage of light. The display is

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usually backlit, providing better visibility in various lighting conditions. To interface 16x2 LCDs with digital devices, they are often connected with microcontrollers.

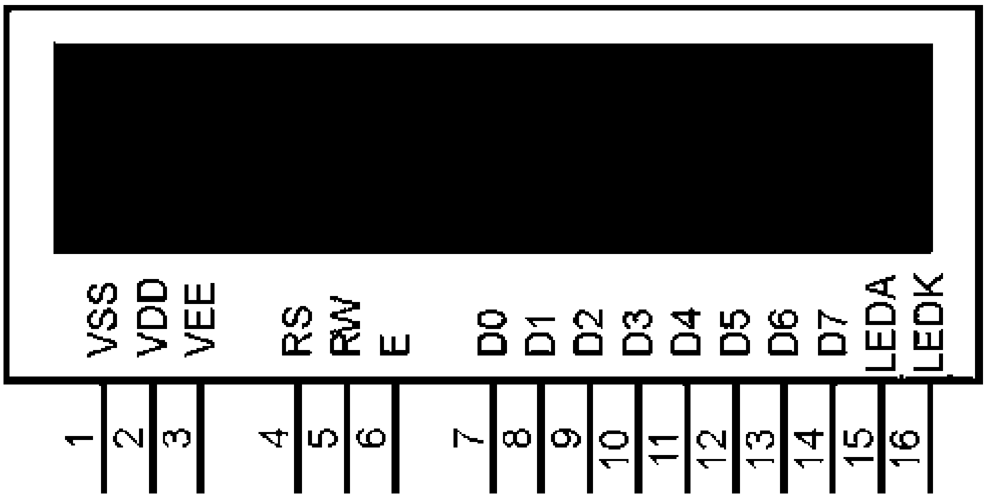

Figure 4.3.5 Lcd Display Pin Diagram 16 x 2

The most common interface is the HD44780 controller, which simplifies the process of sending data and commands to the display. A typical 16x2 LCD has 16 pins for connection, including power (VCC and GND), contrast adjustment, and data and control pins for communication with a microcontroller. To use a 16x2 LCD in a project to write code that sends commands and data to the display. Common programming languages for this purpose are C, C++, and Python. Many microcontroller platforms have libraries or modules that simplify the integration of 16x2 LCDs into projects. These libraries abstract the low-level details of communication with the display. Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

V. RESULT&DISCUSSION

The world has changed dramatically in recent years, with a noticeable move toward environmentally friendly modes of transportation. Among them, electric cars (EVs) have become more popular because of their advantages over conventional gasoline or diesel-powered vehicles in terms of comfort, economy, and the environment. However, a key concern associated with EVs remains their battery charging time, which not only affects user convenience but also imposes substantial demand on the electrical supply network. To address this challenge, this study presents an advanced battery monitoring system based on the Internet of Things (IoT), aimed at tracking and optimizing the functionality and performance of batteries in a smart electric vehicle ecosystem.

The proposed system is designed around a smart microgrid architecture that includes several critical components: an Intelligent Electronic Device (IED), a photovoltaic (PV) solar system, a battery pack, a grid connection, and an electrical load. The integration of these elements allows for efficient energy management and sustainable charging. The IoT framework developed in this study encompasses an IED-based communication channel, a real-time data collection mechanism, a cloud computing system for storage and analytics, and a human-machine interface (HMI) to enable user interaction and monitoring. Through this setup, the system is capable of continuously collecting and analysing battery-related parameters such as voltage, temperature, state of charge, and overall health, thereby enabling informed decision-making and predictive maintenance.

A primary objective of this research is to establish a solar-powered charging station that not only utilizes renewable energy to reduce dependence on fossil fuels but also minimizes greenhouse gas emissions. The integration of IoT ensures that the charging process is monitored and managed efficiently, enhancing the overall performance and longevity of the battery system. Results from the implementation indicate a significant improvement in battery efficiency, reliability, and reduced operational costs. Moreover, the cloud-based monitoring system provides real-time alerts and diagnostics, allowing users and service providers to take proactive measures to prevent faults or failures. The combination of IoT technology with a solar-powered smart microgrid for electric vehicle charging presents a sustainable and efficient solution to the growing energy demands of the transportation sector. This system not only addresses key challenges in EV battery management but also contributes meaningfully to environmental conservation and the global transition toward greener mobility solutions.

VI. CONCLUSION

In conclusion, the development of an IoT-based battery monitoring system integrated with a solar-powered smart microgrid offers a promising solution to the current challenges faced by electric vehicles. By enabling real-time monitoring, data analysis, and intelligent control, the system significantly improves battery efficiency, reduces charging time, and supports predictive maintenance. The incorporation of renewable solar energy not only eases the load on the conventional power grid but also contributes to reducing greenhouse gas emissions and the dependence on fossil fuels. The intelligent electronic device (IED) and cloud-based interface ensure seamless communication and accessibility, making the system user-friendly and highly functional. This approach aligns with global sustainability goals and supports the future expansion of green mobility solutions. Overall, the project demonstrates how advanced technologies such as IoT and solar energy can be combined to enhance the performance, reliability, and environmental impact of electric vehicle infrastructure.

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