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E-Vehicle Solar-Powered Charging Station with IoT

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ABSTRACT
This project uses an IOT solar panel to monitor the maximum power produced by an e-vehicle charging module. There is a correlation between the increase in car use and population growth. The majority of modern cars run on fossil fuels like gasoline, diesel, LPG, and so on. Fossil fillers are one-time-use, non-renewable materials. Vehicle engines have evolved in a variety of ways in an attempt to produce a widely accessible, sustainable energy source for everyday use. Electrical energy is one type of this type of energy source. Because of their many benefits, electrically powered vehicles have progressed effectively over the years and are starting to become the standard everywhere. As a result, electric car charging stations are required. We have created a solar-powered charging station for convenience. Solar energy is a renewable energy source that can be simply obtained from the sun. An Arduino controller that tracks light levels using LDR sensors, stores data in the cloud, observes solar energy using a solar cell, and stores batteries.

KEYWORDS
Solar Panel; Arduino Uno; GSM Modem; Servo motor; Rechargeable battery; LDR; Rain Sensor; LCD

1. INTRODUCTION

Researchers are under pressure to develop renewable or non-conventional energy resources due to the increased demand for conventional energy sources like coal, natural gas, and oil. Sales of solar-electric vehicles will increase in the coming year due to the following factors: (1) Cutting back on fossil fuel emissions in order to obtain energy from renewable sources (2) Astute adherence to energy laws to enable Internet of Things power monitoring; and (3) Constant monitoring of solar radiation. Because an electric vehicle uses a rechargeable battery to generate its power, its field of vision is limited. Battery electric vehicles (BEVs), plug-in hybrid vehicles (PHEVs), extended-range electric vehicles (EREVs), and hybrid electric vehicles (HEVs) are the four categories of electric vehicles [1]. The primary objective of this article is to use solar photovoltaic cells to power the car charging station. Additionally, the availability status of the charging station may be monitored using Internet of Things technology. An Internet of Things system will improve the efficiency of charging electric vehicles.

Appropriate reservations are necessary for the charging of electric vehicles in order to handle the growing issues with the network. Future issues could arise from not maintaining voltage and frequency, which could eventually cause the network to fail [2, 11]. For 15-minute offering time squares. The Indian Power Exchange (IEX) supplied a one-day average interest profile. This trend is comparable to the energy usage in India, where the primary load is observed both at night and during the day.

The device with the LDR sensor aids in locating the source of energy flow when solar cell power generation is needed.

LDR sensor is stored into a rechargeable battery that can power automobiles and add to the solar cell's charging process. If the cell generates findings that are skewed, a loss will happen. To smoothly coordinate the force needed for the module, the converter yield voltage must first take the DC input voltage and then supply the same DC voltage as the output in the subsequent level, regardless of whether it is higher or lower. A voltage sensor that is powered by the rechargeable battery measures voltage [3, 12].

2. LITERATURE REVIEW

"Power-Based IOT System using Connected to the Grid Solar Wind Hybrid" Written in February 2018 for Volume: 0.5, Issue: 02 by Shweta Dhage, Mohini Pranjale, Sachin Jambhulkar, and Nisha Warambhe. The utilization of renewable energy sources is increasing the quantity of energy produced for homes, companies, and appliances. The hybrid solar and wind power system is affordable and easily available in the natural environment. The design of hybrid solar and wind generation systems that use renewable energy sources is primarily driven by two factors: power stability in the face of unpredictable weather and affordability. We are adding the capacity to give a constant load and monitor it via the Internet of Things interface to the proposed system [4, 13]. The wind turbine, photovoltaic solar panel, charge controller, battery, inverter, grid, and internet of things system make up the electrical parameter monitoring system. An IOT system's operator can access the most recent electrical characteristics at any time and from any location.

"Electric vehicle charging station powered by solar and wind energy" Volume 7, Issue 1, January 2018, published by C. Chellasamy, V. Nagaraju, and R. Muthammal. The sun and wind energy-based charging mechanism (Swcm) used by EVs to produce the electricity needed to charge their battery packs is the subject of this research. A wind generator and a solar photovoltaic (PV) module make up the Renewable Charging Station [5, 14].

The Swcm significantly lowers emissions of CO2 and other greenhouse gases by lowering the requirement for fossil fuels to create power. Analytical modelling has been done for wind energy generation, and single-diode models have been utilized to represent renewable energy sources like solar and wind. For the suggested SWCM, a Matlab-Simulink simulation model has been created [6, 15]. Two distinct loading scenarios (1 Kw and 3 Kw) were used to examine various wind turbine parameters, and the I-V and PV properties of the solar panel have been examined at various irradiance levels. Six bidirectional direct current (Dc-Dc) converters are connected to the ten charging points, while two unidirectional Dc-Dc converters are connected to the PV module and wind turbine to enable the charging of electric vehicles[7,16]. A three-phase bidirectional dc-ac (alternating current) inverter links the suggested system to the grid in order to balance the load demand. The findings demonstrate that charging EVs with the suggested renewable charging mechanism is feasible and will result in a pollution-free environment [8, 17].

In 2021, the utilization of solar energy systems for electric vehicles has witnessed a significant paradigm shift. With the introduction of innovative approaches, there has been a proposal to leverage existing solar PV panels at selected locations to optimize their use for charging electric vehicles. This proposal represents a transformative application of renewable energy infrastructure, capitalizing on the synergy between solar power generation and electric vehicle technology. By repurposing the installed solar PV panels, these locations can serve as integrated charging hubs, offering sustainable and convenient charging solutions for EV owners. This approach not only maximizes the utilization of existing renewable energy assets but also fosters the development of a comprehensive clean energy ecosystem. Moreover, it reflects a strategic alignment with the growing demand for sustainable transportation solutions and reinforces the role of renewable energy in driving environmental stewardship and energy independence. Through this innovative utilization of solar energy systems for electric vehicles, stakeholders can harness the potential of renewable resources to power the future of mobility while advancing towards a greener and more sustainable future.

In 2020, there was a notable focus on the sketching and modeling of a Romanian Solar Energy Charging Station for Electric Vehicles (EVs), marking a pivotal step towards exploring the potential of solar energy assets in facilitating sustainable transportation infrastructure. This initiative aimed to examine the feasibility of utilizing solar energy resources to provide electricity for EV charging stations, thereby showcasing the versatility of renewable energy technologies in addressing various societal needs. Through meticulous sketching and modeling processes, stakeholders sought to visualize the design and layout of the charging station, considering factors such as solar panel placement, charging station configuration, and integration of energy storage solutions. This endeavor represented an initial foray into demonstrating the practicality and viability of leveraging solar energy for powering EV charging infrastructure, serving as a crucial proof-of-concept for future endeavors in this field. By showcasing the potential of solar energy assets for versatile purposes beyond traditional applications, such as electricity generation, this initiative underscored the role of renewable energy in driving innovation and sustainability across diverse sectors. Moreover, it laid the groundwork for further research, development, and deployment of solar-powered EV charging stations, contributing to the ongoing transition towards a cleaner, greener, and more resilient energy future in Romania and beyond.

3. PROPOSED METHODOLOGY

Fig. 1 shows a general view of an electric vehicle that the sun can charge. Fuels like gasoline, diesel, and LPG, or fossil fuels, power the majority of modern cars. One-time use, non-renewable resource fossil fill. Hazardous gases to use as a case study example Global environmental contamination levels rise as a result [18]. Using electric or hybrid vehicles is the best approach to minimize pollution, according to study published recently, and this notion has been implemented in numerous countries. Demonstrate to consumers how nimbly these vehicles may be used to make up for the increased expense of purchasing an electric vehicle. Another benefit of electric vehicles is that they improve air conditioning in regions with high population density by eliminating motion. EV growth is expected to accelerate despite the fall in revenue [19]. The horrible impacts that penetrate have various underlying origins, all of which are connected [20].

The vehicle's main energy system, which is solar power collected by solar panels. The primary source for electricity for the car is its solar panel system, which transforms sunlight into electrical energy. The electrical power produced is subsequently fed into the car's batteries, where it is kept for later use. The propulsion system of the vehicle is powered by a 24 V Direct Current (DC) high torque DC sequence motor, which is fueled by these batteries [21]. A consistent and sustainable power source is ensured by the direct integration of solar panels into the vehicle's charging system, particularly during the day when sunshine is abundant. By using solar energy to charge the batteries, Because of its ability to run on less external power, the car is more ecologically friendly and self-sufficient. For best results, the paragraph stresses how crucial it is to keep the battery's cycle of charging and draining intact.

The car's energy system makes sure the batteries go through a full cycle of charging and discharging by first fully charging them and then recharging them with solar energy. In order to keep the batteries healthy and effective, extend their lifespan, and guarantee steady performance over time, this cyclic action is essential [22]. The paragraph also describes the mechanical configuration of the car's propulsion system, which includes a chain notch connecting the motor's shaft to the rear wheel. This mechanical linkage makes it easier for the motor to provide power to the wheels, allowing the car to move smoothly and effectively.

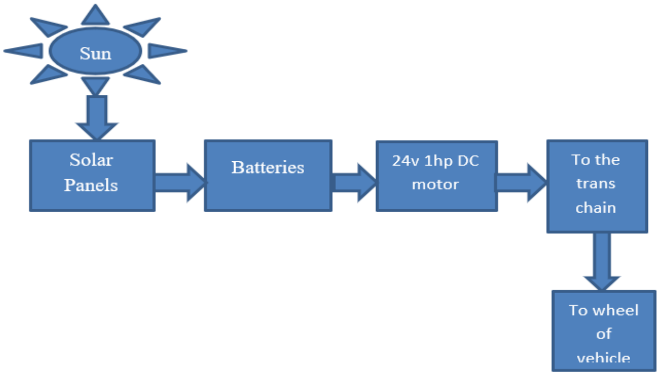


Fig. 1: Methodology

4. SOFTWARE COMPONENTS

The simulation extremely utilizes torches fitted with LDR sensors in order to generate electricity from the source and aid in the continual drift of energy—a solar PV array is a critical component of any project. Since the sun's tilting viewpoint varies from 0 to 180 degrees, two sensors should be built for each course, one on the left and one on the right. The control is then stabilized when the converter receives the buck controller and the PV phone's collected power supply.

To prevent the procedure from getting too complicated, the Arduino receives the controlled steady-state voltage as an analog input. The meter aids in the steady voltage screening process. The features maintain the setup in good condition because the availability of solar insulation changes depending on the location of the car [23]. The Indian Power Exchange (IEX) provided an example of a typical demand outline for a single day with request time blocks of 15 minutes. The energy demand in India is exactly like this, with the least amount of load occurring at night and in the middle of the day. These non-renewable petroleum fuels have the drawback of releasing a lot of hazardous and dangerous sculpture dioxide, nitrogen oxides, and carbon dioxide into the atmosphere during combustion. All of these hazardous compounds have contributed, directly or indirectly, to global warming. These greenhouse gas emissions are the main reason for increasing interest in electric transport.

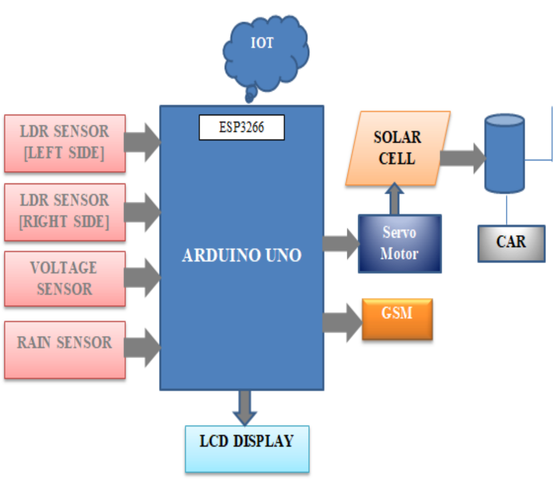


Fig. 2: System architecture of charging station e-vehicle

5. SOFTWRE REQUIREMENTS

-Software Requirements
-IoT
-Arduino IDE/Embedded C
-Hardware Requirements
-Arduino Uno
-LDR Sensor
-Rain Sensor
-Servo Motor
-LCD Display
-GSM
-Solar Cell
-12V Battery
-Voltage Sensor

6. COMPONENTS OF PROPOSED WORK

1. The model Arduino UNO R3: The Arduino UNO R3 is a microcontroller board that is based on the ATmega328 (datasheet). In addition to being used for communication, the 16 MHZ crystal oscillator is housed on 14 digital input/output pins. It features an ICSP header in addition to power and reset controls. In Italian, the UNO stands for uno. Standard versions of both the Arduino and UNO will be available going forward, both at 1.0. The UNO is the newest board in the USB Arduino board family. Even though an input voltage of 7 to 12 volts is recommended, it operates on a 5 volt supply. The Arduino board may become unstable if the voltage is less than 7 volts, and the voltage regulator may overheat and cause damage to the board if the voltage is more than 12 volts. The ATmega328 is the Arduino model that is currently in use. Although the Arduino UNO R3 has 32KB of flash memory, it only has about 2KB of system RAM and 1KB of RAM EEPROM, and a clock speed of 16 MHz [24]. An ATmega328P-based microcontroller board is the Arduino UNO. It features a 16 MHz ceramic resonator, 6 analog inputs, 14 digital input/output pins (six of which can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button. It comes with everything needed to support the microcontroller; all you need to do is power it with a battery or an AC-to-DC adapter or connect it to a computer via a USB cable to get going.

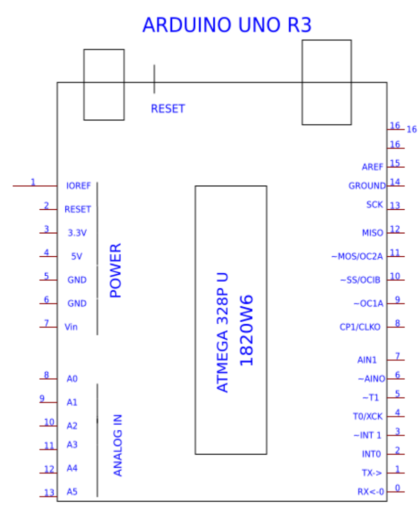


Fig.3: Arduino UNO R3

2. Modeling a DC-DC Converter: A DC-DC converter is an electromechanical or electronic circuit that adjusts a direct

current (DC) source's voltage level. This kind of converter converts electric power. Extremely low to extremely high power levels, or small batteries to high-voltage power transmission, are possible. A closed feedback loop maintains a consistent voltage output even in the event that the input and output voltage current fluctuate. The four widely used topologies are Buck-Boost Converter, Boost Converter. Buck-Boost Converter and SEPIC Converter. An electrical system (device) that changes the voltage level of direct current (DC) sources is called a DC-DC converter. Another name for a DC-DC converter is a voltage regulator or DC-DC power converter.

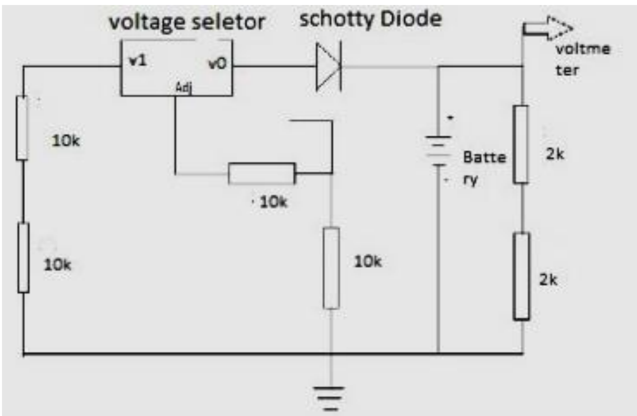


Fig.4: DC-DC converter

3. Motor drive modeling: An amplifier that has the ability to control a motor's speed in both directions is called a motor drive. The tracking position of the solar panel, which can be left or right, determines how the motor drives work. Furthermore, it determines the maximum radiation the panel can absorb or the angular location of the sun's light, which transforms the low current signal generated by the solar panel into a high current signal. The motor drive initiates the rotational speed. Other uses for a potentiometer include achieving the required charging capability by varying the overall output voltage from the maximum to the minimum or vice versa. It was designed for the circuit to transform the low-current signal into a high current signal.

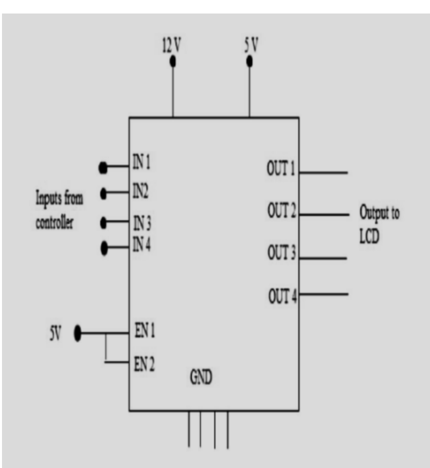


Fig.5: Motor Drive: L293D

4. Battery Voltage Sensors: Basically, a voltage sensor helps with battery recharging by determining the precise voltage that the charging station requires. In this case, it can detect both the AC and DC voltage levels. The voltage resistor of the motor can be used to regularly adjust the output voltage while preserving the battery's capacity. The sensors react effectively to optical or electrical signals. While some voltage sensors can produce outputs in the form of pulse trains or signs, others can produce outputs in the form of modulations of frequency, pulse width, or amplitude.

Fig.6: Voltage Sensor

- How does a battery voltage sensor work?

The electronic battery sensor (EBS), which takes into consideration the effects of battery aging, offers accurate and dependable information on the condition of 12V lead-acid batteries. The sensor facilitates the installation of an efficient electrical energy management (EEM) system in the vehicle and supports CO2 and fuel-saving technologies by giving this pertinent information [25]. Along with enabling other applications like firmware over-the-air, predictive diagnostics, and predictive maintenance, it is also an essential part of automated and electrified cars.

Evaluation Value is equal to (accuracy)

1mA to 1500A of current (+or-1%)

Voltage: 6V-18V (plus or minus 0.2%)

-400C to 1050C is the temperature

5. LCD modeling:

Definition:

LCD is an acronym used for Liquid Crystal Display. It is basically a display technique in which liquid crystals are used in order to produce an image on the screen.

Liquid crystal displays, or LCDs, function by obstructing light rather than emitting it. Its ability to consume less power than LEDs (light-emitting diodes) is one of its unique advantages. Its components include electrodes, two polarized panel filters, and a lens that projects light onto a liquid crystal layer. A gray scale picture of the framed crystal being charged with electricity is combined with colored light to create the colored image. The applied current should control the image that is shown on the screen and LCD. It is necessary to use polarized light. It should be possible for liquid crystals to alter the polarized light or regulate the transmission and reception processes. As a result, the sensed signal and battery voltage appear on the liquid crystal display.

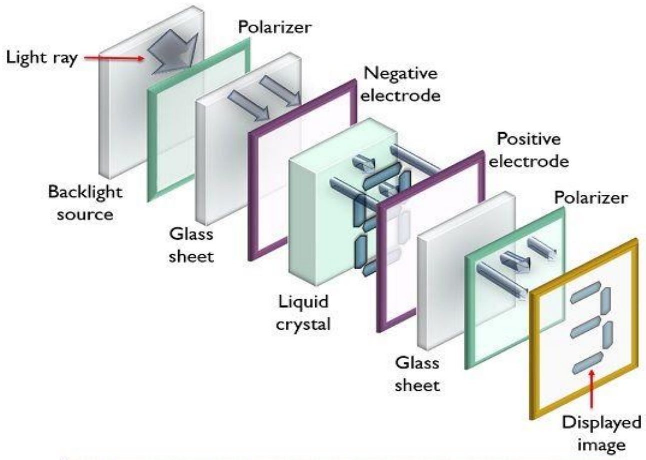
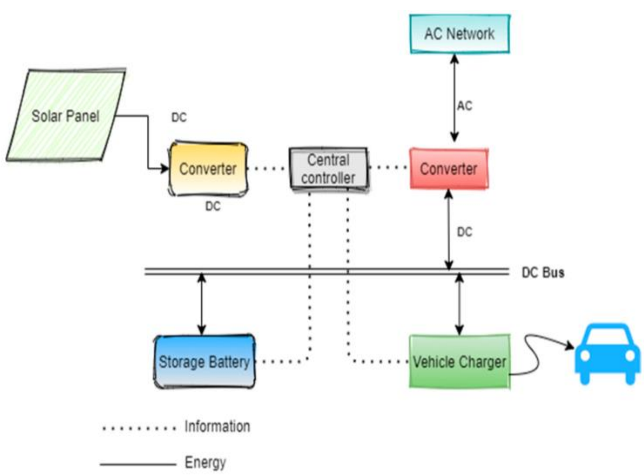


Fig.7: LCD's Operational Structure

6. IOT Device modeling: IOT has shown benefits for various industries because it can link computers and other electronic devices. To move data or communicate information across a network, no interfaces are needed. IOT can currently be applied to improve wireless connectivity in useful scenarios. The user interacts with the system in real time and achieves optimal results while enhancing time-space interaction. IOT offers a useful user interface application to help prevent errors and blind spots that can compromise the system's correctness.



Modern technology enhances and perfects customer engagement and product functionality, and it also supports automation technology. It produces trustworthy information with intricate functionality so that a large number of people can view it simultaneously. The current state of data analytics provides an external IOT that, from an angle, provides the actual data that creates the ideal, safe environment for resource collection.

Requirements Analysis: Understanding the functional and non-functional requirements of an IoT device, including its intended use, environmental conditions, power limitations, communication protocols, and security considerations.

Sensor and Actuator Selection: Selection of appropriate sensors and actuators based on data to be collected and actions to be taken. This may include aspects such as accuracy, range, power consumption and interface compatibility.

Embedded System Design: Development of IoT device hardware and software components, including microcontrollers, communication modules, power management circuits and firmware. This step often involves the use of development tools, circuit design software, and programming languages such as C/C++ or Python.

Simulation and Testing: Using simulation tools to validate the design and operation of an IoT device under various scenarios and conditions. This can include simulating sensor inputs, network communication, power consumption and fault tolerance.

Integration and Deployment: Assemble hardware, update firmware, configure network settings, and deploy an IoT device in its operating system. This step may include provisioning, registration and management of IoT platforms or ecosystem devices.

Monitoring and Maintenance: Mechanisms are established to monitor the health, performance and security of IoT devices throughout their life cycle. This can include online updates, remote diagnostics and predictive maintenance to ensure optimal performance and longevity.

7. PROPOSED SYSTEM

Operating Principle of the Module: Since a solar PV array is an essential component of a project, the model only employs torches equipped with LDR sensors to detect the source's location and generate electricity that contributes to an on-going energy flow. Two sensors need to be built because there are two conceivable sun tilt angles: 0 and 180 degrees for each direction. The converter receives the gathered electric source from the PV cell and the buck regulator, which keeps the power stable. To prevent a hysteresis loss and preserve the output reliability of the cell, the entire DC-DC converter arrangement should offer an unbiased output when the result exceeds expectations.

The range of the 1.4 MHZ switching clock frequency is VIN to 0.8V. An analog receives a controlled, steady voltage in order to simplify the operation. Arduino data input. Monitoring the constant voltage should be made easier with the help of the meter. The Arduino UNO R3 microcontroller board has twenty digital inputs and six analog inputs. The 0.8V to VIN range is covered by the 1.4 MHZ switching clock frequency. To make things simpler, an analog gets a continuous, regulated voltage. Data input from Arduino. The meter should make it simpler to keep an eye on the steady voltage. The Arduino UNO R3 microcontroller board has twenty digital inputs and six analog inputs.

The user-friendly Arduino computer program can be used to install programming on it in order to monitor, supply, and display the necessary power output supply. These techniques are as follows: Not only is Arduino R3 the latest version, but it also boasts a strong community, which makes it a very simple platform to start working with electronics on. The battery voltage sensor and motor drives both act as inputs on the opposite side concurrently in order to successfully eliminate overload and supply interruption issues. Battery voltage sensor is a potentiometer with two electrical circuit points. It converts voltage data into a physical signal that is sent as the digital input for an Arduino.

The motor measures the flow of charges across the circuit and modifies its direction when the torches swap places in regard to the LDR sensor. The motor appears to rotate counter-clockwise when the torch is held in a leftward orientation, and vice versa. The L293 driver makes it simple to maintain the alignment of the LDR sensor in either direction by using two motors running at the same time. In the event that the chip becomes too hot, an automated thermal shutdown mechanism will cause it to switch off. The LCD displays the actual output of the Arduino after each electrical circuit action.

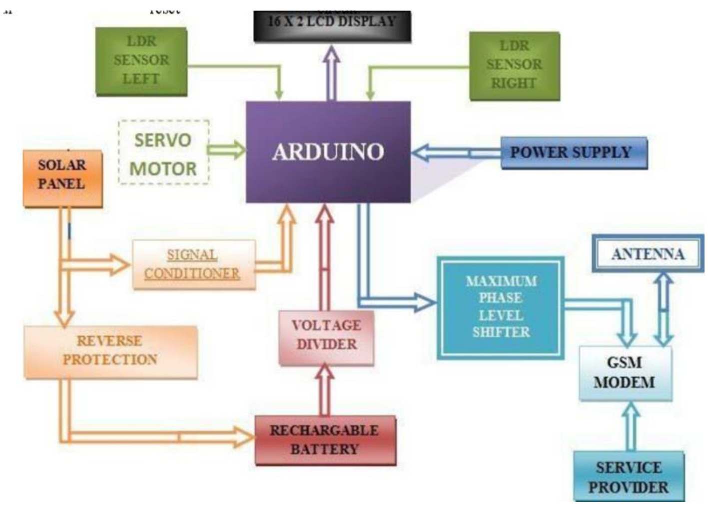


Fig.8: Block diagram of charging module

A well-liked LCD used for integrating various microcontrollers (8-bit or 16-bit) is the LM016L. When the torches switch locations in relation to the LDR sensor, the motor reacts by changing direction, indicating that charges are moving through the circuit. The motor seems to rotate counter-clockwise when the torch is held to the left, and vice versa. With the aid of the L293 driver, it is easy to maintain the LDR sensor's orientation in any direction by concurrently controlling two motors. If the chip overheats, it can automatically turn off thanks to a function called automatic thermal shutdown. The LCD displays the actual output of the Arduino after each electrical circuit action. A well-liked LCD for interface that uses various microcontrollers—either 8-bit or 16-bit—is the LM016L. The screen should display the left/right tilting position, the actual battery voltage, and the on/off state of the motors. Before use, the LCD should display the motors on/off status, the real battery voltage, and the tilting orientation (left or right). Before the LCD is initialized, a set of commands as well as an internal one.

THE PROPOSED EV CHARGING STATION SYSTEM OR CHARGING MODULE IS MODELED USING THE SIMULINKLANGUAGE:

"A dynamic method for controlling electric vehicle battery charging is provided by the suggested EV charging station system or charging module, which was created and simulated using Simulink. This approach effectively forecasts and modifies the battery's capacity over time by combining sophisticated algorithms with real-time data processing. Through the use of Simulink's powerful simulation capabilities, the system optimizes charging techniques by taking user preferences, grid stability, and energy demand into account. This creative strategy promotes sustainable mobility options for the future by improving the performance and dependability of EV charging infrastructure and facilitating the smooth integration of electric vehicles into the larger energy ecosystem."

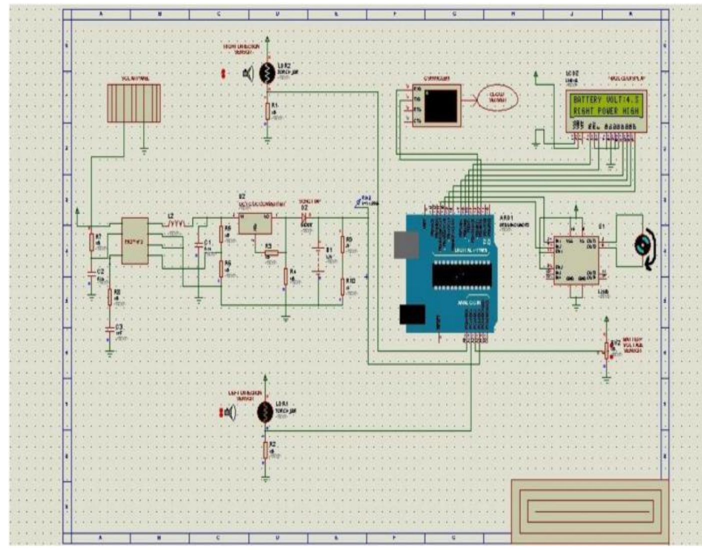


Fig.9: Capacity of battery with time in the webpage

8. RESULT

This study focuses on using a web page to inform automobile users when charging stations are available via the Internet of Things. The content of the website is readily and plainly accessible because it was created following the standard HTML design method. The Google map on the page and the graph displaying it would be possible to compare battery voltage, time, and the locations of tracked charging stations. The IOT-designed webpage allows visitors to access the necessary battery charge information. All you need a browser and a network that is up and running all the time to load data using a URL address. Regular updates are made to the data, which includes battery capacity, voltage, charging time, and associated location. The general public has access to these data for viewing. You can obtain the current status of these webpages by clicking on a secure link address.

As part of an energy storage management system, a battery sensor with an Internet of Things (IoT) basis tracks the battery's state in real time. The cloud platform is used for management by the IOT built here. The car's driver may swiftly determine how to travel to the charging station by seeing the system's decline in battery voltage. The data on the Arduino is reliable up until the point at which the battery runs out of power. The e-vehicle that settles the stations updates and stores the database so that numerous users can track the distribution to various users at a later time.

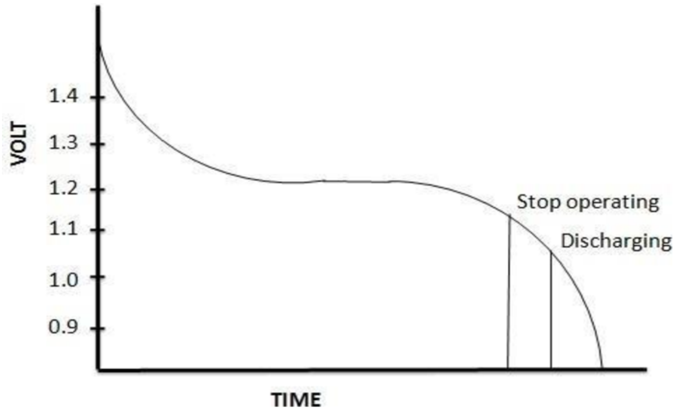


Fig.10: Continuous operation

9. CONCLUSION

The IOT scientific pilot program is a rapidly emerging possibility for EV assembly to expand their market presence. Other than that, IOT remains devoid of isolation, trendy community treaties, and platform standards. Manufacturers of IOT products have contributed concepts and formulas for the development of an exceptionally robust certification. Given how swiftly IOT technology is advancing now is a great time for EV manufacturers to take advantage of both potential retail debuts. In short, it can be stated that the development of a charging station for electric cars powered by solar energy and integrated with IoT technology is a significant step towards a sustainable transport infrastructure. Using renewable solar energy, this charging system reduces dependence on non-renewable energy sources, reduces environmental impact and promotes energy independence. Incorporating IoT enables seamless monitoring, management and optimization of loading processes, improving efficiency and user experience. As electric vehicles gain more and more traction, initiatives like these are paving the way to a cleaner, greener future where transportation is both environmentally friendly and technologically advanced.

10. FUTURE SCOPE

At the convergence between connected technology, mobility, and renewable energy, the idea of an electric vehicle (EV) solar-powered charging station integrated with the Internet of Things offers a ground-breaking solution. By using solar energy to charge electric cars, this cutting-edge infrastructure minimizes carbon emissions and lessens reliance on traditional power sources. This charging station offers numerous benefits, such as dynamic power management, predictive maintenance, and remote monitoring, by utilizing Internet of Things technology. Operators may ensure effective use of renewable resources while maintaining dependability and scalability by optimizing charging schedules based on variables like weather, energy consumption, and grid availability using real-time data analytics and connectivity.

The potential applications of IoT-enabled EV solar-powered charging stations seem extremely wide. The need for a reliable and easily available infrastructure for charging electric vehicles will increase as they continue to gain popularity across the globe. Advanced features like demand-response systems, user identification, and automatic invoicing are made possible by the integration of IoT, which improves user experience and encourages the broad usage of electric vehicles. In addition, these charging stations can play a crucial role as nodes in the ecosystems of smart cities, promoting environmental sustainability, urban mobility, and energy resilience. The history of EV solar-powered charging stations offers a fascinating narrative of moving towards a cleaner, smarter, and more networked future, especially in light of ongoing advancements in renewable energy technologies and IoT innovations.

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