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Design and Development of Solar Electric Vehicle with four different Charging System

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ABSTRACT— All the global import and export from basic to complex commodities after reaching the economic port zone should be distributed throughout the country. The world logistics and freight sectors are mainly dependent on fossil fuels to operate. Given the world scenarios and monopoly of oil supply may affect the overall budget allocated to logistic sector. Shifting from non-renewable sources to renewable sources of energy is the best choice given the option as the extent of distance travelled in transportation is huge. Developing a vehicle that fulfills the requirement is the need of the hour, not just at the point charging, also requires on the go charging. The primary purpose of this project is to develop solar powered electric vehicle with multiple charging options. Solar E-Freight is designed with an aim to carry goods and provide on the go charging utilizing solar panel and reverse charging, with an efficient battery management system. The vehicle is designed and developed with a 3D diagram and assisted from Simulink model simulations. The battery management system is developed with Arduino uno board that monitors the battery conditions. Solar E-Freight consists of all the features of a traditional internal combustion engines and much more, while being less harm to environment compared to emissions from combustion of fuels.

Keywords—3D design, Simulink model, BMS, Arduino UNO, Regenerative braking, Electric vehicle, Solar EV

I. INTRODUCTION

Fossil fuels as we know are non-renewable resources. They might get exhausted anytime in the future. As an alternative to vehicles that use fossil fuels, we aim at designing an Electric Vehicle (EV) which is eco-friendly. Gasoline and diesel operated vehicles can be replaced by electric vehicles in order to reduce pollution. The main aim of this project is to reduce the usage of organic fuel powered vehicles by designing a vehicle which works efficiently in the emerging electric vehicle sector. Electric vehicles are gaining more attention from citizens due to reduction in greenhouse gas emission in the atmosphere. EVs can reduce gasoline consumption up to 75%. Electric vehicles can be powered through the use of renewable energy resources such as solar and wind energies. In this project we use solar energy to power up the electric vehicle. It is also ensured that the electric vehicle is designed with a battery management system. The battery management system is designed by using Simulink in MATLAB. In tropical countries where there is high temperature during summer, the renewable resource i.e., solar energy can be made use to run the electric vehicle. This helps in reducing the use of fossil fuels along with reduction in the

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pollution caused by these fuels. Electric vehicles can be used for various applications once they are made ready to use products. Electric vehicles already in use are replacing traditional fuel-based vehicles slowly. In this project we aim at designing an electric vehicle which works by making use of solar energy as its primary source of energy. When solar energy can't be afforded, the Electric Vehicle can run by the means of battery which can be charged through a plugin of cable.\

II. BACKGROUND

A. Rationality behind choosing the project

All vehicles that are being used today cause pollution at least in minimal amounts. The fuel cost is also increasing day by day. In order to compensate the fluctuating fuel cost and the pollution, a good remedy is needed i.e., our transport system. Due to ignition of the hydrocarbon fuels in the vehicle, sometimes difficulties such as wear and tear may be high, and more attention is needed for proper maintenance. Electric vehicle can solve the above-mentioned problems as it is easy to handle, and no fuel cost is required. According to a survey in the year 2020, 62% of fuel, more specifically petrol is used by two wheelers and 27% by four wheelers. A total of 70% of diesel and 99.6% of petrol was consumed by transport sector. The amount of pollution caused by these vehicles is enormous. This is also reducing the availability of fossil fuels day by day as they are non-renewable resources. To overcome all this, the society is making a transition from fuel-based vehicles to electric vehicles. The electric vehicle does not make use of fossil fuels, instead it is operated by battery. The battery obtains energy from the vast renewable energy resource, the sun. The solar energy is converted to electrical energy and stored in the battery. In order to efficiently use the energy that is stored, we design a battery management system. In port areas like sea-shores, they use vehicles in order to transport goods, but the use of electric vehicles for the same is seen very rarely. The solar electric vehicle can be used in such supply and logistic applications to improve the efficiency of transportation in such routes.

III. LITERATURE SURVEY

A. Alam Tahjib, Humaiya Tanzin, S M Imrat Rahman, Bhuiyan Shariful Islam, Hasan Azim [1]

The abovementioned authors have proposed a new simulation-based design in their paper "Development of a Solar Powered Electric Vehicle based on Tadpole Design" in the year 2021. A simulation-based design of a solar powered 3-wheel tadpole vehicle has been presented in this research paper. The paper focuses on the motor control circuit and the battery charging circuit in addition to the suspension system of the vehicle. The design proposed in this paper can be applied to investigate the performance of solar powered tadpole vehicles. The design of the suspension system can be validated using Lotus Shark software. They have used PROTEUS software in order to perform the simulation of the motor control circuit. The current, voltage and power related data of the vehicle can be read successfully.

B. Pranesh Dewangan, N Chandrasekaran, Sumn Basu [2]

The authors have worked on the paper "Methodology development to study the effect of solar load on an electric vehicle battery pack" in the year 2019 in which they develop a methodology to model the solar heating on electric vehicles. Keeping in mind the high temperatures in tropical countries during summer, they came up with this methodology to reduce the heat load on the electric vehicles especially on their battery packs. The model can be used to study the effect of solar load on battery packs with similar vehicular conditions, irrespective of the cell type and arrangement inside the battery pack.

C. Christen Rogerand, Hamid El Omari [3]

These researchers worked on a project called "Solar-E-Cycles, Empowering People Project 2014-2019" in the year 2019. The paper mainly focuses on the progress made in the Solar-E-Cycle Empowering People project since 2014. It covers design evolution of a solar-powered LEV on a mountain bike chassis powered by solar PV, intended for individuals in regions with high levels of solar radiation. They have mentioned that the future work underway for their project includes team member and driver training.

D. Chia-Chen Lin, Ying-Chuan Lai, Chih-Chiang Wang, Liren Tsai, Jing-Wein Wang [4]

The authors conducted research on "Development and Implementation of Solar-Assisted Electric Bicycle with GPS Tracking Service over Cloud" in the year 2019 where they emphasize on the necessity of reduction in vehicular emissions in order to reduce air pollution caused by the same. They propose a design of solar-assisted electric bicycle with GPS tracking service over cloud in this paper. The prototype of their work adopts a solar assisted battery design, which serves as an inexpensive, eco-friendly alternative to gasoline-powered two-wheeler motor vehicles. Enhancement of the battery's power supply is one of the future scopes of their work.

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E. L. Zhao, S. Prousch, M. Hübner, A. Moser [5]

These researchers studied "Simulation Methods for Assessing Electric Vehicle Impact on Distribution Grids" in the year 2010 where they discuss about the drawbacks of the present transport system especially about the road transport and fuel types. The EVs enhance the ecological condition in the world because they neither contain tailpipe nor produce noise like traditional vehicles. A simulation method based on a comprehensive model of the distribution grid is proposed by them in their paper. They explain about how existing distribution grids cope with the novel technical challenges due to EV integration.

IV. OBJECTIVES

- To design and develop an Electric Vehicle to run on battery.
- To Develop a Simulink model of hybrid electric vehicle.
- To implement the battery system into an Electric Vehicle to suit motor requirements and successfully run the vehicle.
- To provide an interface to access the battery conditions and vehicle performance.

V. METHODOLOGY

A. Block diagram

The block diagram of Electric Vehicle is as shown in Fig. 1. The block diagram consists of the following:

1) Battery management system: The battery management system includes the main battery made up of Lead Acid batteries. The Solar E-Kart utilizes 4 batteries of 12 Volts. The battery system used is more green than any other battery in the market. It has higher life and more efficient than any other battery to use and run for a higher time period. The battery is sufficient to drive at rpm of 2000 for half hour , with help of regenerative braking it can recharge the battery in turn. The transformation of mechanical energy into electrical energy takes place through the help of a DC generator. The principle of induced EMF is used by the generator in order to function properly. Hence magnetic field and conductors are two important parts of DC generator.

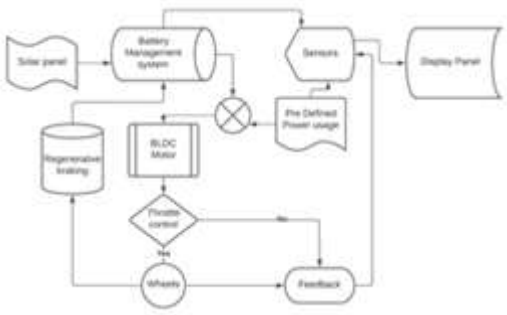

Fig. 1. Block Diagram

Fig. 2. Battery System

These are the earliest available rechargeable battery types. The cells' capacity to supply strong surge currents allows them to maintain a very high power-to-weight ratio despite having very low energy-to-weight and energy-to-volume ratios. Batteries are appealing for use in motor vehicles because of all these qualities and their inexpensive price, which enables them to supply the high current needed by the motors.

2) Camera Modules: The Electric Vehicle employs one camera module for the live display. The Quantum QHM495LM 6 Light Webcam and the ESP32 CAM are the two. For efficient display, the camera interpolates images up to 25 megapixels, providing a good depiction of all boundaries and pixels. The ESP32 CAM module is used to broadcast live video collected with the help of a mobile hotspot to an IP address preset. The ESP Cam is a low-cost IP address video telecasting Wifi enabled module that is very similar to Arduino coded in the Arduino IDE and may be quickly implemented.

3) Solar Panel: A solar cell operates on the photovoltaic principle, and solar energy conversion using photovoltaic technology is one of the most alluring non-conventional energy sources with a track record of dependability from microwatt to megawatt

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levels. Solar cells are really joined to one another in certain series and parallel configurations to form modules. If the orientation of the array is changed to face the sun's rays at any time, the production can rise by 30%. A solar PV system can only create energy if there is sunshine. On a typical bright day, a square metre of fixed array facing south yields about 0.5 kWh of electrical energy. It will need an appropriate system of storage batteries if it to be operated outside of daylight hours. Modules, tracking arrays, and fixed arrays are all possibilities. A tracking array is one that is perpetually maintained mechanically perpendicular to the solar array line in order to intercept the most insulation possible at all times. These arrays are typically much more sophisticated than fixed arrays and must be physically moved by a suitable primary mover.

4) Sensor Modules: In EV, two sensors are used. Ultrasonic Sensor (HCSR-04) and Temperature and Humidity Sensor are the two sensors (DHT11). The ultrasonic sensor is mounted on EV-back. It is in charge of identifying any obstacles, such as large plants, animals, rocks, or anything else that could injure EV and directing it away. The ultrasonic sensor operates similarly to a radar system. It sends a trigger signal to the sensor, which emits an acoustic wave that bounces back if it hits an obstruction. Meanwhile, the ultrasonic sensor runs a clock cycle to determine the time it takes for the wave to reflect and be sensed by the echo pin. The DHT11 sensor is used in EV to monitor the temperature and humidity of the battery, which is then relayed through Bluetooth to the user's phone. The humidity sensing component, which consists of two electrodes separated by a moisture-holding substrate, is used to measure humidity. When a result, the conductivity of the substrate or the resistance between these electrodes changes as the humidity changes. The IC measures and processes the change in resistance, preparing it for reading by a microcontroller. These sensors, on the other hand, use an NTC temperature sensor or a thermistor to measure temperature.

5) Bluetooth Module (HC-05): The Electric Vehicle communicates wirelessly with the help of the HC-05 module, which may be configured as a master or slave. Through serial communication, the Bluetooth both broadcasts and receives orders and data. Bluetooth sends data from dht11 and ultrasonic sensors, and Arduino and the user's phone receive movement commands such as forward, backward, right, and left.

6) BLDC Motor: A device that transforms electrical energy into mechanical energy is an electric motor. Based on the idea that a current-carrying conductor receives a magnetic force whose direction is determined by Fleming's left hand rule when it is exposed to a magnetic field, this device works. A motor produces torque when it is running. Mechanical rotation may be produced by this torque. Similar to generators, DC motors are divided into shunt wound, series wound, and compound wound motors. A soft iron core is wrapped with the conductors. The field poles get a DC supply to generate flux. Brushes are used to connect the conductors to the DC supply. A soft iron core is wrapped with the conductors. The field poles are provided with a DC supply for generating flux. Brushes are used to connect the conductors to the DC supply. Let's begin by taking a look at the general layout of a straightforward 2-pole DC electric motor. An armature or rotor is one of the simple motor's six components. a DC power source of some kind, brushes, an axle, a field magnet, and a commutator. A motor employs magnets to produce motion, therefore an electric motor is all about magnets and magnetism. If you've ever played with magnets, you're aware of the universal magnetic law, which states: Similarities repel and opposites attract. The north end of one magnet will therefore pull on the south end of the other if you have two bar magnets with their ends designated north and south. On the other side, a magnet's north pole will push away a magnet's north pole (and similarly south will repel south). These attracting and repelling forces produce rotational motion inside an electric motor.

7) Arduino: The Microcontroller used is Arduino Uno R3. The main reason behind the use of Arduino UNO are: Efficient communication with motor drivers and several components without internet. Aids in regulating pump and trimmer motor with a simple code. Receives inputs from Raspberry Pi regarding Object Detected.. Provides an excellent transmission and Receiving of Data through Bluetooth. Can easily start the Electric Vehicle with just a simple command through a Bluetooth terminal. As the Atmel AVR family runs on RISC commands, Arduino can control basic motion. be effectively used to Considering all the above-mentioned specifications, Arduino is useful compared to other controllers.

B. Software analysis

The Arduino is programmed in C language to control the sensors of Electric vehicle. To begin, initialize all of the libraries and then set a few test conditions to ensure that the various components are functioning properly. Then, after initializing the motor and sensor pins and taking inputs from them, as well as the

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Bluetooth module for receiving commands and relaying data to Bluetooth, you'll be ready to go. The code then exits the loop after specifying the H-bridge switches for motor rotation and the trimmer delays. The ESP32 CAM is programmed in the Arduino IDE in a similar way, by supplying the mobile hotspot's name and password so that it may get an IP address. The Simulink model is shown in the Figure 3.

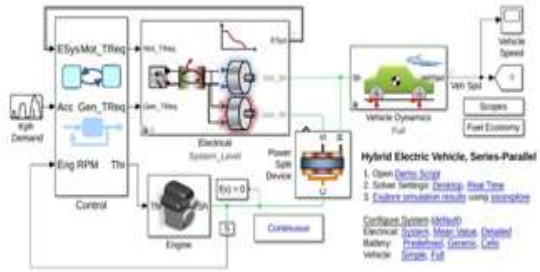

Fig. 3. Simulink Model of EV

VI. OUTCOME OF PROPOSED RESEARCH

Figure 4 depicts the finished Electric Vehicle model. The way solar energy works In essence, an electric car has two processes: the first is when a solar panel is used to charge the battery during the day, and the second is when an electric motor drives the car while draining power from the battery that has already been charged. A motor is used to move the vehicle. The battery, which has already been charged by the solar panel power, is used to power the motor. The speed of the car will be lower during this process, and no pollutants that cause smog will be created as the vehicle runs. The car is propelled by a solar-powered electric motor. The time it takes to charge the battery and its capacity both have an impact on how far a vehicle will go when powered by an electric motor. When a battery is used to power the vehicle, the vehicle acts as a motor. In Figure 5, the Simulink model is displayed. An ARDUINO microcontroller equipped with a Bluetooth HC05, an ultrasonic sensor, a DHT11, and an ESP32 camera module was used to create the BMS. When a battery is used to power the vehicle, the vehicle acts as a motor.

Fig. 4. EV Final Model

Fig. 5. Simulink model output

The Arduino with several sensors such as Temperature sensor, Ultrasonic sensor, Gas sensor is displaying the sensory values in the Bluetooth app indicating the battery system conditions. The electric vehicle was successfully implemented and the various sensory values are displayed in the app. The sensor values are shown in Figure 6. Electric vehicles can be used in various applications such as public transport, military vehicles, vehicles for individuals. They reduce the pollution and cost required for the fuel. Battery management system (BMS) ensures that the battery is in good working order. An explosion is prevented by constant monitoring of battery health. BMS increases the battery's lifespan, shows the battery level and the location of the closest charging station. The use of solar energy benefits society financially, minimizes environmental pollution because it is a green energy source, and is accessible.

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Fig. 6. Battery conditions being displayed in Bluetooth App

VII.DRAWBACKS AND FUTURE SCOPE

The battery needs to recharged as the charge from the solar and reverse braking will not sufficient. As the size of the electric vehicle increases, the battery capacity and size also must be increased. Electric fueling stations are still under development. They might not be present in all the places. This makes the recharging of battery difficult. Not suitable for areas with no electricity or minimal electricity. The vehicle dynamics is an issue depending on the weight of the driver and the load of goods carried inside. As the battery isn't designed and developed by us requiring the use of four 12Volts lithium-ion batteries in series. An integrated battery of 48Volts or higher voltage depending on the requirement and the load would provide a higher mileage. The regenerative braking and solar panel would generate a substantial amount charge that supply wouldn't be enough to drive unless the electric vehicle is fully charged. The battery management system with a higher microcontroller and CAN protocol would be efficient to display the real time values of the battery conditions to driver.]

VIII. SUMMARY

The design and development of the electric vehicle was successful. The electric vehicle running on a 48V lithium-ion battery provides a mileage of 15 Km on a full charge and a top speed of around 20Km.The electric vehicle was modified further to carry goods to act as a means of freight. The graphs of various parameters in the electric vehicle are displayed in the Simulink model. The Arduino based battery management system was successfully implemented which records various values regarding the battery conditions and send it over the Bluetooth app. The rear camera was implemented using ESP32 cam which displays live video with the help of an IP address. The solar panel and a reverse braking provide a minimal amount of charge to the battery. The EV can be charged by four means, firstly through the solar panel, second by plug-in of charger, third by reverse braking and forward braking, fourth by on the go charge system which is still under development.

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