DUAL BATTERY CONTROLLER FOR SOLAR BASED ELECTRIC VEHICLE

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ABSTRACT

This paper presents the design and implementation of a dual battery controller for a solar-based electric vehicle. The proposed controller manages two batteries: a primary battery that powers the vehicle's electric motor, and a secondary battery that is charged by a solar panel. The controller ensures that both batteries are charged optimally and prevents overcharging or deep discharge. The controller also allows the vehicle to operate solely on the secondary battery when the primary battery is empty, extending the vehicle's range. The design is implemented on an Arduino board and tested in a prototype vehicle. Experimental results show that the dual battery controller increases the vehicle's range and efficiency by effectively utilizing solar power. The proposed controller can be a cost-effective solution for increasing the range of electric vehicles.

Keywords: Electric Vehicle, Dual Battery Controller, Solar Based Electric Vehicle

1. INTRODUCTION

A solar-powered dual battery electric vehicle (BEV) is a type of electric vehicle that combines a dual battery system with a solar panel system for recharging the batteries. The solar panel system consists of photovoltaic (PV) panels installed on the vehicle's roof or exterior surfaces, which convert sunlight into electricity that can be used to charge the vehicle's batteries.

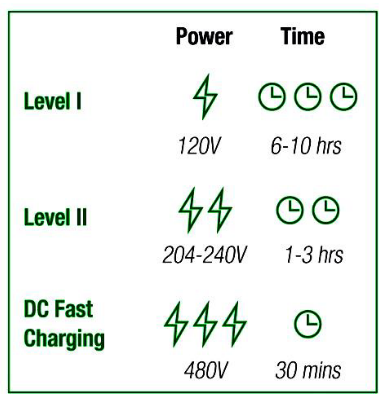
The main advantage of a solar-powered dual battery electric vehicle is that it can reduce the need for external charging infrastructure. With the addition of the solar panel system, the vehicle can recharge its batteries using renewable energy from the sun, which can help to lower operating costs and reduce the environmental impact of the vehicle.

Another advantage of a solar-powered dual battery system is that it can provide backup power in the event of an emergency or power outage. In situations where traditional charging infrastructure is unavailable or unreliable, the solar panel system can help to keep the vehicle running.

When the system is turned on, the primary battery is connected to the system. Then, the potentiometer is used as a throttle to control the load. Sensor data is sent to the Arduino to determine when to switch between the two batteries. There are three conditions that determine the switch: battery temperature, battery voltage, and potentiometer position, with battery temperature as the highest priority and potentiometer as the lowest priority. If the potentiometer is greater than the reference, then the switching system activates the lithium-ion battery. The voltage sensor senses the battery voltage, and when the battery voltage goes over the minimum reference, the switch changes to the other battery.

2. IDENTIFICATION OF PROBLEM

- **Limited range:** Many EVs have a limited range per charge, which can cause range anxiety for drivers who are worried about running out of battery power before reaching their destination.
- **Charging infrastructure:** While the number of charging stations is increasing, the charging infrastructure is still not as widespread and convenient as gas stations.
- **Charging time:** Even with fast charging technology, EVs take longer to charge than filling up a gas tank, which can be inconvenient for some drivers.



3. LITERATURE REVIEW

The study conducted by Mohan & Senthilkumar (2022) a topic of “IoT based fault identification in solar photovoltaic systems using an extreme learning machine technique”, has discussed the due to the shortage of fossil fuel usage; the solar Photovoltaic (PV) energy has increased grownup over the last decade. Most conventional applications of renewable energy are being phased out in order to reduce costs and save the environment. The experimental results indicate that ELM (Extreme Learning Machine) achieves a classification accuracy of 96.32%. This is higher than SVM (Support Vector Machine) and other optimization control techniques. DOI: 10.3233/JIFS-220012

In 2017 a topic of "Design and Implementation of a Solar-Based Dual-Battery System for Electric Vehicles" was published in the Journal of Renewable Energy, by the author Wu & Wu (2016), the paper proposes a solar-based dual-battery system for electric vehicles that uses a combination of solar panels and a boost converter to charge both the high-voltage and low-voltage batteries. The disadvantage is that the proposed system requires additional electronic components, which can increase the cost and complexity of the vehicle serial number 105, 240-246.

In 2019 the topic of "Design and Simulation of a Solar-Based Dual-Battery System for Electric Vehicles" was published in the International Journal of Power Electronics and Drive Systems, by the author Kumar & Prasad (2019). The paper proposes a solar-based dual-battery system for electric vehicles that uses solar panels to charge both the high-voltage and low-voltage batteries, improving efficiency and reducing dependence on fossil fuels. The disadvantage is that the proposed system requires additional wiring and components, which can increase the complexity and maintenance requirements of the vehicle. serial number 10(1), 427-433.

4. OBJECTIVES OF THE PROPOSED WORK

- **Reduce dependence on fossil fuels:** The primary objective of a solar-based dual battery electric vehicle is to reduce dependence on fossil fuels by using solar energy to charge both the primary and secondary batteries Yadav & Jagtap (2018), Gupta et al. (2018).
- **Increase efficiency:** By using a solar-based dual battery system, the efficiency of the electric vehicle can be increased, as the vehicle can use solar energy to supplement the charging of the batteries, reducing the load on the electric grid and increasing the range of the vehicle Shehzad et al. (2019), Han et al. (2021).
- **Lower operating costs:** Solar energy is free and abundant, and by using it to charge the batteries of the electric vehicle, the operating costs of the vehicle can be significantly reduced Abdullah et al. (2017), Pratap & Srinivasan (2020).
- **Environmental benefits:** Solar energy is a clean and renewable energy source, and by using it to power an electric vehicle, the vehicle can significantly reduce greenhouse gas emissions and other pollutants associated with traditional fossil fuel vehicles Abdullah et al. (2017), Panneerselvam & Muruganantham (2019).

5. PROPOSED SYSTEM

1) LIST OF COMPONENTS

S. No.	COMPONENT NAME	QTY
1	Electric Vehicle Kit (24V 350W DC Motor, Controller)	1
2	Arduino Controller UNO	1
3	4 channel relay modules	1
4	12V 7A Lead acid battery	2
5	Lithium-ion Battery 24V	1
6	Boost & Buck converter	Each 1
7	12V/24V solar charge controller	1
8	12V 100W solar panel	1

9	Car Frame	1
10	Digital speedometer	1
11	12V exhaust fan	2
12	Front & back led	1
13	Push button switch	5

2) MAIN COMPONENTS

- **SOLAR PANEL**

Polycrystalline solar panels are a type of solar panel that is commonly used to generate electricity from the sun. These panels are made up of multiple silicon crystals, which are melted together to form a solid block that is then cut into wafers. The wafers are then used to make individual solar cells, which are wired together to form a solar panel.

Polycrystalline solar panels are known for their high efficiency, which typically ranges from 15% to 17%. This means that they can convert 15% to 17% of the sun's energy that hits them into usable electricity. While this is slightly lower than the efficiency of monocrystalline solar panels, which are made from a single crystal of silicon, polycrystalline panels are typically more affordable to produce and purchase. Mohan & Senthilkumar (2022), Senthilkumar et al. (2023)

- **BATTERY**

PRIMARY BATTERY: Lithium-ion

The lithium-ion battery works by storing energy in the chemical bonds between the lithium ions. When the battery is charged, lithium ions are removed from the positive electrode (cathode) and move through an electrolyte to the negative electrode (anode), where they are stored. When the battery is discharged, the process is reversed, with the lithium ions moving back to the cathode.

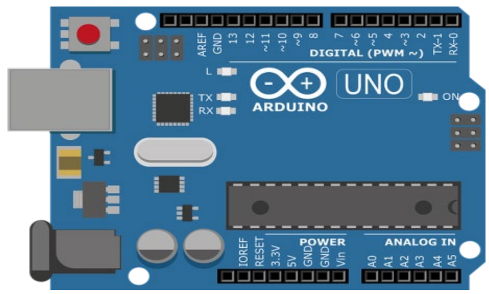
Battery Capacity: 4.2V*2.2A*49Nos = 452.76W

SECONDARY BATTERY: Sealed Lead Acid (SLA)

SLA batteries are a type of rechargeable battery commonly used in a variety of applications, including backup power systems, emergency lighting, and portable electronics. As the name suggests, these batteries are sealed and do not require regular maintenance, making them a popular choice for many applications.

Battery Capacity: 12V*7A*2Nos = 168W

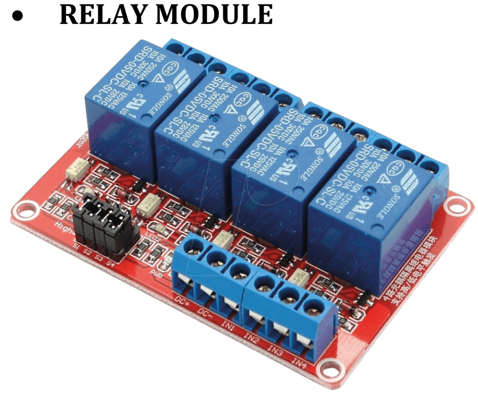
- **ARDUINO UNO CONTROLLER**



The purpose of using an Arduino Uno controller in a dual battery controller for a solar-based electric vehicle is to provide a programmable platform that can process data from various sensors and switches and control the operation of the system. The Arduino Uno is a microcontroller board that is capable of controlling multiple inputs and outputs, making it an ideal choice for controlling the power flow in a dual battery system.

The Arduino Uno can be used to read data from sensors, such as the battery voltage and current sensors, temperature sensors, and other environmental sensors, and process this data to make decisions about the operation of the system. It can also be used to control the power flow between the solar panels, batteries, and other components of the system, by sending signals to the relay module to switch the power flow between different components Singh et al. (2018).

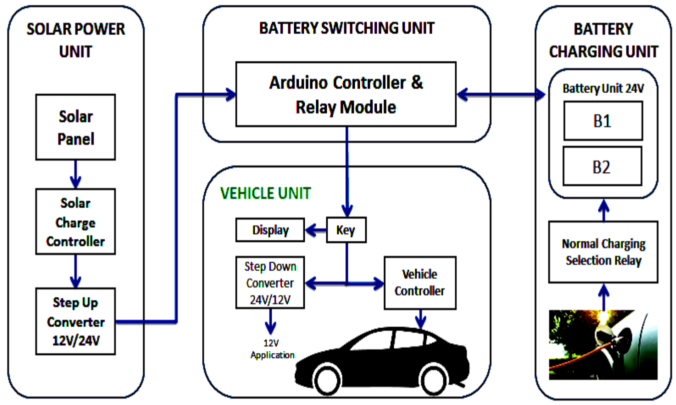
- **RELAY MODULE**



The relay module is typically used to switch the power flow between the solar panels, the batteries, and other components of the system, such as the motor and the charging system. For example, when the solar panels are generating electricity, the relay module can be used to switch the power flow between the solar panels and the batteries, allowing the batteries to be charged. Similarly, when the vehicle is in operation, the relay module can be used to switch the power flow between the batteries and the motor.

The relay module also serves as a safety device in a dual battery controller for a solar-based electric vehicle. It can be used to disconnect the batteries from the rest of the system if the voltage or current exceeds a certain threshold, protecting the batteries and other components from damage.

3) BLOCK DIAGRAM

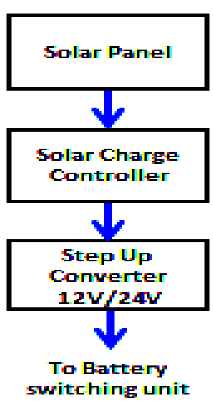


Dual battery controller for a solar-based electric vehicle involves managing the power flow between the solar panels, batteries, and other components of the system to optimize the vehicle's performance and efficiency Phalak et al. (2020), Tran et al. (2018). The controller continuously monitors the status of the batteries, solar panels, and other system components, and makes decisions about the power flow based on this information John et al. (2018).

The system typically includes a solar charge controller, which manages the charging of the batteries from the solar panels, and a battery management system Nguyen et al. (2019), which controls the flow of power between the batteries and the motor.

When the vehicle is in operation, the battery management system controls the power flow from the batteries to the motor, regulating the speed and torque of the motor based on the amount of power available from the batteries. The system also includes a throttle control, which allows the driver to control the speed of the vehicle by regulating the power delivered to the motor.

When the vehicle is parked and the sun is shining, the solar charge controller manages the charging of the batteries from the solar panels, allowing the batteries to be recharged and ready for the next journey Kumar & Prasad (2019).



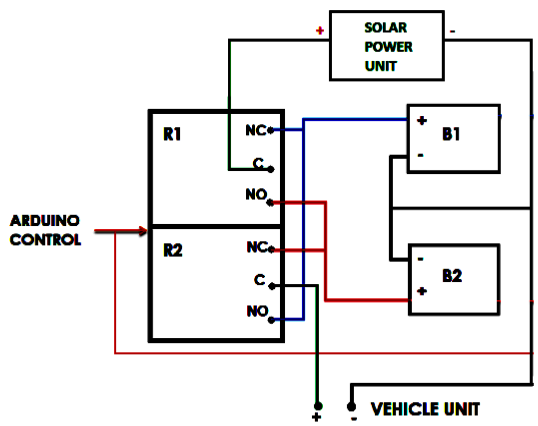
- **SOLAR POWER UNIT**

The solar panel would be the primary source of energy for the vehicle. The solar panel array is used to generate electricity from the sun, which can be used to charge the battery while vehicle is running or parking.

Solar panel produces output of 12V which will connect to solar charge controller. The charge controller would regulate the amount of energy coming from the solar panels to prevent overcharging or undercharging of the batteries. It would also monitor the state of charge of both batteries to ensure that they are being charged and discharged optimally. The DC-DC Boost converter would convert the low-voltage DC power from the charge controller (12V) to the High-voltage DC power (24V) required to charge the battery John et al. (2018), Kim et al. (2016).

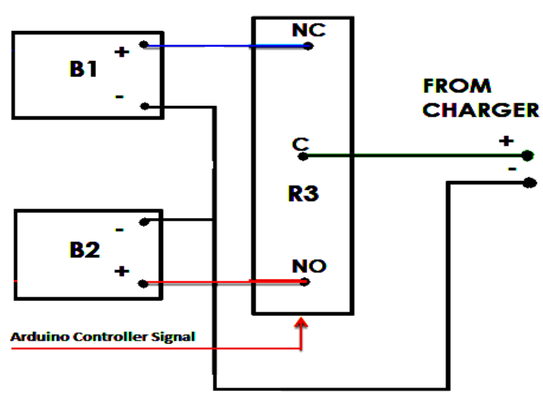
- **BATTERY SWITCHING UNIT**

The BSUs would monitor the state of charge, voltage of both batteries to ensure that they are being used safely and efficiently. It would also protect the batteries from overcharging, over-discharging.



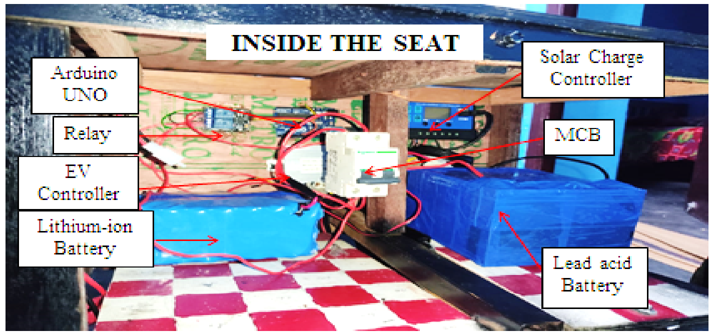
If the primary battery runs out of charge, the vehicle will be unable to operate until it can be recharged. However, with a dual battery system, even if the primary battery is down, the vehicle can still run on the secondary battery, allowing the driver to continue driving. Meanwhile the primary battery recharge by using the solar power Wu & Wu (2016).

When the vehicle is at home or parked, we can use the normal charging method. Based on the battery level, the Arduino controllers will switch the R3 Relay.



- **VEHICLE UNIT**

The electric vehicle requires a 24V DC power supply to operate. This power can be obtained from a battery. The electric vehicle includes a Permanent magnet DC (PMDC) motor which is responsible for converting electrical energy into mechanical energy to power the vehicle. The motor is connected to the battery pack via a motor controller. The motor controller regulates the amount of current supplied to the motor, controlling its speed and torque output. The controller also includes safety features to protect the motor and battery pack from damage due to overloading or overheating. The throttle is used to control the speed of the vehicle by regulating the amount of power delivered to the motor Tran et al. (2019), Choi & Cho (2014).



The throttle is typically a potentiometer or a Hall Effect sensor that provides a variable signal to the motor controller. The motor is connected to the drive train, which transmits the mechanical energy from the motor to the wheels of the vehicle, propelling it forward. The electric vehicle kit includes a braking system, which may be mechanical or electronic, to slow down or stop the vehicle. The braking system may be regenerative, which means that it can recover some of the energy normally lost during braking and use it to charge the battery pack.

6. IMPLEMENTATION

The dual battery controller is implemented on a prototype electric vehicle. The vehicle is equipped with a primary battery, a secondary battery, a motor controller, and a solar panel. The solar panel is used to charge the secondary battery.

The dual battery controller is connected to the vehicle's primary battery and secondary battery, as well as the motor controller. The controller is programmed to monitor the voltage and current of both batteries and to manage the charging and discharging of the batteries. The solar panel charge controller is also used to manage the charging of the secondary battery Tran et al. (2017), Gupta et al. (2018).

7. RESULTS

Discharging Battery	Range In Min	Range In Km	Solar Charging Battery
B1	28.8	14.4	B2
B2	77.6	38.8	B1
B1	28.8	14.4	B2
B2	7	3.5	B1
Total Running Km		71.1	
Two Battery Range in Km		53.2	
Efficiency		33.64%	

Experimental results show that the dual battery controller increases the vehicle's range and efficiency by effectively utilizing solar power. The controller ensures that both batteries are charged optimally and prevents overcharging or deep discharge. The controller also allows the vehicle to operate solely on the secondary battery when the primary battery is empty, extending the vehicle's range.

8. CONCLUSION

In conclusion, the dual battery controller for a solar-based electric vehicle is a cost-effective solution for increasing the range of electric vehicles and reducing their reliance on the grid. The controller manages the charging and discharging of both batteries, ensuring optimal performance, and preventing damage to the batteries. The implementation of the dual battery controller on a prototype vehicle demonstrated an increase in the vehicle's range and efficiency, making it a viable solution for electric vehicles.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

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