Design and Modelling of Multi-Source Self-Charging Electric Bike

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\textbf{Abstract.} The concept of electric vehicles is not new to us, the 1st documented electric vehicle was in the late 1890s, electric vehicles were far forgotten and suppressed for so long because of the domination of conventional vehicles in the commercial market. Conventional vehicles are fuelled by petroleum products which are non-renewable and not much environment friendly. We have reached a situation where we cannot depend on these fast depleting non-renewable sources of energy for better future. Hence, we are in need to develop and utilize the renewable sources of energy that are less/ non-polluting and does not get depleted. Only by the late 1960s, people started to realize the need for electric vehicles. Electric vehicles are a better replacement or the conventional vehicles and are more efficient and Eco-friendlier.

\textbf{Keywords:} Electric Bike, Electric Motorcycle, Solar Powered Electric Vehicle, Self-Charging Electric bike, Regenerative Motor, Electrical Control Unit.

1. Introduction

The problem faced by the electric vehicles to sustain in the commercial market are lack of charging ports available in the country and the time taken to charge the batteries which makes it a questionable option for the public. This problem had been overcome by making an attempt to design, develop and fabricate an electric vehicle prototype with dual battery setup, which
charges itself while running, thereby introducing a system which makes the most of the power produced by the different sources. In addition to this, an Electrical Control Unit powered by Arduino is used to switch the batteries in run time so that one of them gets charged while the other powers the drive motor. The chassis of a commercially available bicycle is modified as per the requirements of the system components. The system consists of Lithium-ion batteries, Solar panel, regenerative motor, DC motor, motor controller and Electrical Control Unit. The controller unit designed by us makes this prototype more efficient than the commercially available electric vehicles in the market. The developed prototype is then tested under several circumstances to prove its efficiency. This method can be implemented to any type of electric vehicles such as bikes, cars, trucks, etc. the prototype which was developed severs as an example to prove the increase in efficiency for electric vehicles.

2. Design and Development

2.1. Electronic Control Unit (ECU)

Electronic Control Unit acts as brain of the project taking decisions based on the conditions prevailing. ECU used in the project’s compromises of Arduino UNO board, 250V Relays and Voltmeter modules. When the bike is switched on ECU gets powered on and queries the voltages from both the batteries with the help of voltmeter modules, and the Arduino makes the decision i.e. it charges the battery with lowest voltage and the uses the other battery to power the motor, relays play the key role in this switching. When the running battery’s charge comes down to 30% the ECU again switches the batteries i.e. the battery currently in use gets charged and battery in charging is used to power the motor. Circuit diagram for the same is shown in Fig 2.1

![Circuit Diagram](image)

**Figure 2.1. Circuit Diagram**

This switching helps in efficient use of power from batteries as batteries tend to heat up when used simultaneously for charging and discharging.
2.2. Designing
The aim of this paper is to construct an e-Bike that can be charged from multiple sources of energy and to intelligently switch the batteries to prolong their lifetime and efficiency. The Components used for this e-Bike are as follows

1. DC Motor (24V, 250W)
2. Motor Controller
3. Motor Clamp
4. Batteries (4no, 12V, 7.5Ah)
5. Arduino UNO Board
6. 2 Channel 250V Arduino Relays
7. Regenerative Motor
8. Voltmeter Module for Arduino
9. Solar Panel
10. Bicycle, the model is developed and the ECU is simulated using the simulation software

![Simulation Model](image)

Figure 2.2. Simulation Model

The bicycle is modified to make is suitable for project. A base is created for batteries using a zinc sheet and mild steel. The back wheel is modified to accommodate two sprockets one for motor and the other for regenerative motor, and a luggage carrier is attached so that it can used as a base for solar panel. Motor clamp is attached to the carrier and the DC motor is mounted on it. The batteries and solar panel are mounted on their respective places and the ECU and Motor controller are placed underneath the battery base and ECU is circuited.

3. Results & Discussions
Several tests was conducted to obtain optimum results. The positioning of solar panel is needed to obtain optimum output. But as the prototype will be in motion, positioning of solar panel at a fixed position and angle is not practical. By keeping the speed constant, we found out the discharge rate of the batteries. It is not recommended to discharge a battery below 25% because of the life reduction of the batteries due to excessive usage. Hence keeping 30% as the min state of charge of the batteries for safety purpose, we found the following results
3.1 Test Run using only One Set of Batteries

- First test run was done with only one set of batteries that power the system till it fully discharges (30%).
- The batteries connection was let to cut when the state of charge reached 30% using relay in Arduino circuiting.
- The time taken to fully discharge one set of batteries (30%) was found to be around 29 min.

**Table 1 Results Obtained in Test Run using only One set of Batteries**

| Trail No | Initial Voltage | Final Voltage | Distance Travelled | Top Speed | Average Speed |
|----------|-----------------|---------------|--------------------|-----------|---------------|
| 1        | 24.2            | 23.8          | 7.5                | 17        | 15            |
| 2        | 24.1            | 23.8          | 6.45               | 16        | 13            |
| 3        | 24.2            | 23.8          | 6.8                | 17        | 14            |

**Figure 3.2. Time (Min) Vs Percentage Of Battery Charge**
3.2 Test Run using Two set of Batteries (continuous discharge)
- Next test run was done with both the sets of batteries as one set of battery powers the system after the other set is discharged completely (30%).
- Both sets of batteries were connected to the Arduino using a relay and was programmed such a way that one set of batteries will power the system while the other set will be idle till the 1st set of batteries completely discharges (30%) and as soon as the 1st set of batteries discharges the 2nd set of batteries power the system till it discharges completely (30%).
- The time taken for both the batteries to get discharge was found to be around 59 min.

Table 2 Results Obtained in Test Run using two set of Batteries

| Trail No | Initial Voltage of Battery 1 | Initial Voltage of Battery 2 | Final Voltage | Distance Travelled | Top Speed |
|----------|-----------------------------|-------------------------------|---------------|--------------------|-----------|
| 1        | 24.2                        | 24.2                          | 23.8          | 15                 | 17        |
| 2        | 24.1                        | 24.2                          | 23.8          | 14                 | 16        |
| 3        | 24.2                        | 24                            | 23.8          | 14                 | 17        |

3.3 Test Run using both the Set of Batteries (Using ECU + Charging)
- The final test run was done with both the batteries powering the system as described.
- Both sets of batteries were connected to the Arduino using two sets of relays and was programmed such a way that 1st set of battery powers the system till its state od charge reaches 30%, and as soon as it reaches
- The threshold the powering of the system is switched to the 2nd set of batteries while the 1st set of batteries gets charged using the different sources mentioned before. This cycle is repeated until both the sets of batteries reaches their threshold.
- The time taken for both the batteries to get discharge was found to be around 74.1 min
Table 3 Results Obtained in Test Run using both the set of Batteries

| Trail No | Initial Voltage of Battery 1 | Initial Voltage of Battery 2 | Final Voltage | Distance Travelled | Top Speed | Average Speed |
|----------|------------------------------|------------------------------|---------------|--------------------|-----------|---------------|
| 1        | 24.2                         | 24.2                         | 23.8          | 18.52              | 17        | 15            |
| 2        | 24.1                         | 24.2                         | 23.8          | 17.2               | 16        | 14            |
| 3        | 24.2                         | 24.2                         | 23.8          | 18.52              | 17        | 15            |

Figure 3.4. Time (Min) Vs Percentage of Battery Charge

From the above test runs we are clear that the method used to charge both the sets of batteries, while running had a great impact on the time and distance an electric vehicle can run compared to any other present type of methods used. From comparing the above result, it proves that our model has produced 20.5% more efficiency.

4. Conclusion

The controller unit makes an electric vehicle more efficient than the commercially available in the market. We developed the prototype and tested under several circumstances to prove its efficiency. Due to the cost constraint, affordability and availability, the components were selected with the minimum specifications. Components with the higher specification will yield higher performance and the efficiency of the vehicle. The observation from the tested results proves that the efficiency of our prototype model has increased by 20.5%. This efficiency can be further increased by employing components with higher specifications. Usage of super/ultra-capacitors as a battery support unit will also help in increasing efficiency.
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