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Design and Development of fuzzy based optimal Battery Charger

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Abstract: *The charging method has a significant influence on the performance and lifetime of Rechargeable batteries. Therefore intelligent charging algorithm which can properly determine the charging current is essential. In this study, a fuzzy-logic-control-based (FLC-based) battery charger is proposed. The proposed charger takes the voltage and current of battery into account, and adjusts the pwm duty cycle accordingly. To further improve the performance of the proposed FLC, the fuzzy-based mamdani method is utilized to determine the optimal output membership functions (MFs). Comparing with the conventional constant current-constant voltage (CC-CV) method, the charging time, charging efficiency, average temperature rise and the obtained cycle life of the Li-ion battery are improved by the proposed system also the Fuzzy Logic Controller keeps the State Of Charge within limits which also enhances the life time of the battery*.

Keywords*: Electric Vehicle (EV), Fuzzy Logic Controller.*

1. INTRODUCTION

BATTERIES are widely used in the application of residential, industrial, and commercial energy storage systems [1]–[5]. Many studies on battery structures have been published in recent years [6], [7] and many other works focused on battery charger systems [8]–[20]. The conventional battery charger, which extracts power from an ac-line source, requires a diode or thyristor rectifier with an equivalent series resistance to control the charging power flow. For the reason of the presence of high ripple in charging current, the battery storage systems need a charging circuit for reducing the ripple and extending the battery life. Several charging circuits have been proposed in literature like linear regulators and switching regulators [13]–[16]. The battery charger must have most efficiency, fast charging mode, and guarantee the safe of battery from probably damage of undercharge or overcharge and the cost must be reasonable. Constant voltage (CV) and constant current (CC) charging are the usual battery charging techniques. The CV charging method keeps the battery voltage constant by using an equivalent series resistance to control the battery current. The CC charging technique maintains the charging current constant, until the battery voltage achieves a designated value. but these most broadly used constant-current and constant-voltage (cc-cv) technique [21-24],[26-31] can't give the customer all of their need. Therefore, the fuzzy control, are applied to approach better battery charging performance [33-35]. The application of these intelligent techniques in designing is quiet complicated and costly but their efficiency are increased and also the damage will be decreased. The most troubles, which happen usually with that charger, are the big charging current. It is important; an overcharging of minimum one minute can collapse the battery. And also when the temperature goes up the damage on life cycle of battery will increase. In general, better charging efficiency will result in longer battery cycle life because more charging efficiency can lead to lower power loss and lower temperature rise. Another advantage of using the fuzzy logic is the real that the software execution of complex systems is not computer intensive .In other hand phase locked-loop technique is submitted to design a PLL based battery charger to perform well and achieve low cost [25, 32]. In this paper, main focus has been given to the 'designing' of the fuzzy logic based system. Section II shows the modelling steps for the fuzzy system. Following section II, Section III proposes design steps for the battery charger while Section IV presents development of the fuzzy logic based battery charger with Simulink environment where the Fuzzy Inference based on Mamdani's scheme is defuzzified using centroid method. Next Section V is the experimental result through real test data and result figure and Section VI is conclusion about results.

2. THE FUZZY CONTROL MODEL

The fuzzy control technology is a kind of non-linear control strategy based on the reasoning of fuzzy control. It is mainly determined by people's experience thinking, test data, and methods and tactics of the control process.

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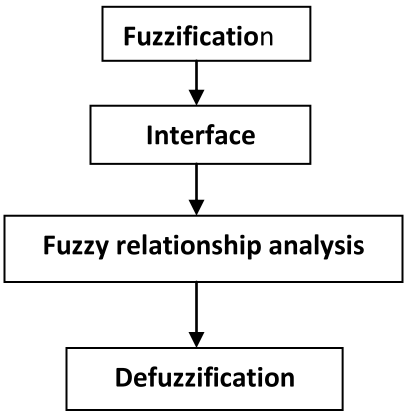
In the design of the smart charger, the fuzzy controller realizes the fuzzy control for charging current by performing tasks of fuzzy quantization, fuzzy controlling and fuzzy processing.

Fuzzy Control Process:-



3. DESIGN STEPS FOR THE BATTERY CHARGER

- Open Matlab. Type Fuzzy
- Go to File……New……..Simulink model.
- Add Variable to the inputs and also to the output of the system from edit menu….
- Select first input Variable…….Name it from the GUI….and then double clicking the block adjust the range and the membership functions as per the requirement of the system. Repeat the same steps for the second input along and also for the output.
- Name first variable as voltage from the battery and second as the current. Name the1st output as the PWM Duty Cycle for the Boost circuit.
- Adjust the range of the membership functions of input as well as for the output of the system.
- Double Click the Central Block of the system and the make rules using Rule Editor in the Fuzzy logic Toolbox. Go To view ….. Surface……so as to view the Surface…….
- Go To View ……… Rule …….. To view the rules
- Save the file.
- Export the file to the Workspace.

4. DEVELOPING THE FUZZY LOGIC FOR THE CHARGER

The *Fuzzy Logic Controller* goes through three steps: Fuzzification, Fuzzy Inference and Defuzzification.

A. Fuzzification

1) **Fuzzification of Voltage-Signal***:* The range of Voltage-signal is partitioned into three regions with triangular and trapezoidal membership functions labelled as: Low, Medium and High over Universe of Discourse (UoD) of 0 to 13 V as shown in figure 1.

2) **Fuzzification of Current-Signal:** The second input parameter is Current signal. The range of Current-signal is partitioned into three regions with triangular and trapezoidal membership functions labelled as: Increase Maintain and Decrease over UoD of 0 to 600 mA same as shown in voltage signal.

3) **Fuzzification of PWM Duty cycle-Signal:** Defuzzification converts membership functions into Crisp value for PWM signal. Three triangular partitions are labelled as Low, Medium and High over UoD of 0 to100 counts.

B. Fuzzy Inference System

Fuzzy Inference forms a key part of Fuzzy Logic Control. Fuzzy IF-THEN rule base matrix is in table 1.

Table 1: Rule Based Matrix

Current / voltage	Decrease	maintain	increase
Low	Maximum	maximum	maintain
medium	Maximum	maintain	minimum
High	Maximum	maintain	minimum

C. Defuzzification

The Fuzzy Inference based on Mamdani's scheme is shown in figure 2 for present voltage of 8.05V, current of 401 mA thereby suggesting a PWM of 47.1.

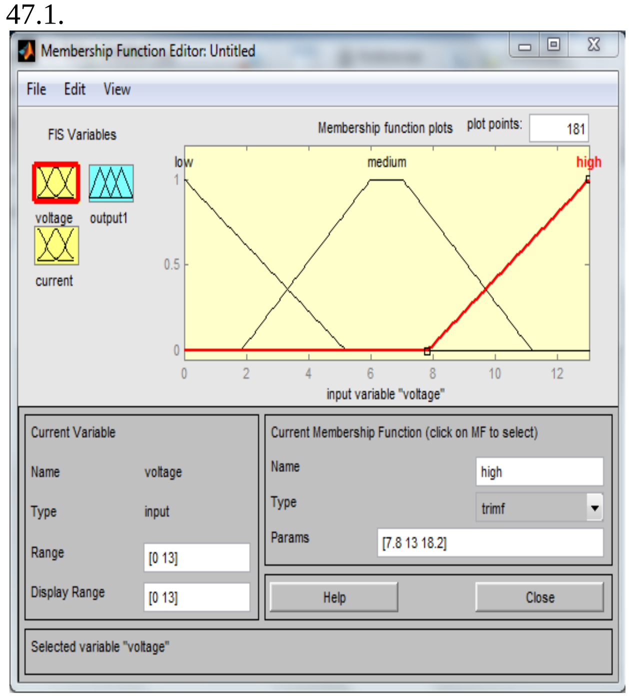


Figure 1: Fuzzification of voltage-Signal

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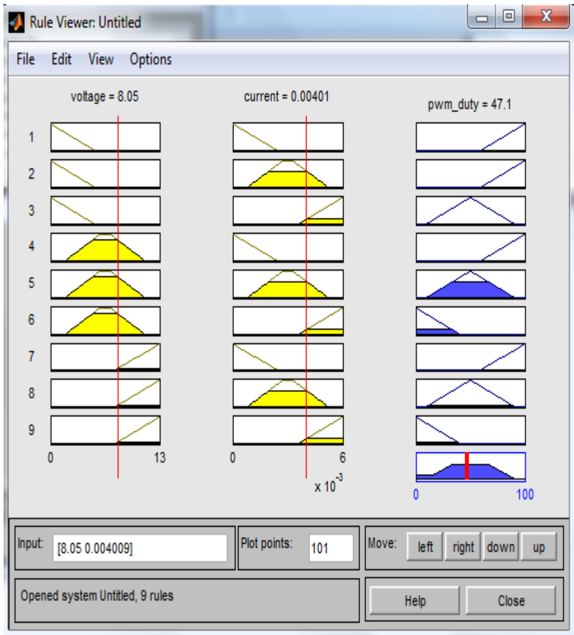


Figure 2: Rule viewer

The FIS is DISO (Dual Input Single Output) and its three dimensional view shown in figure3.

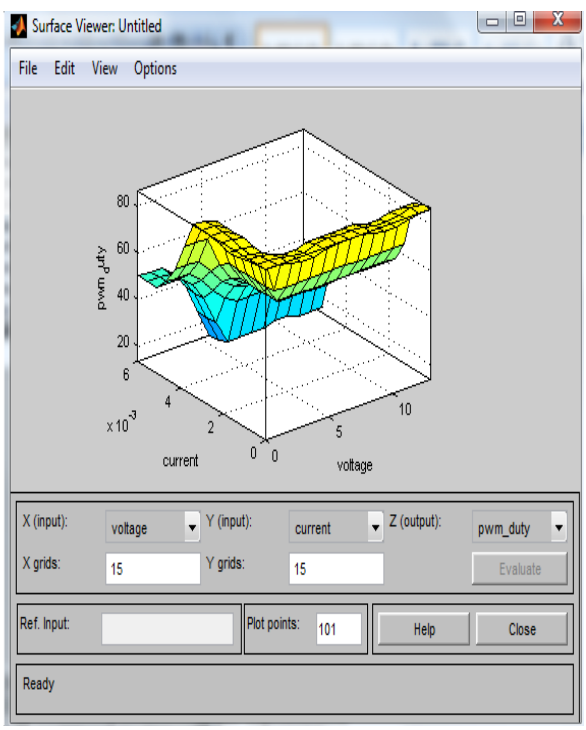
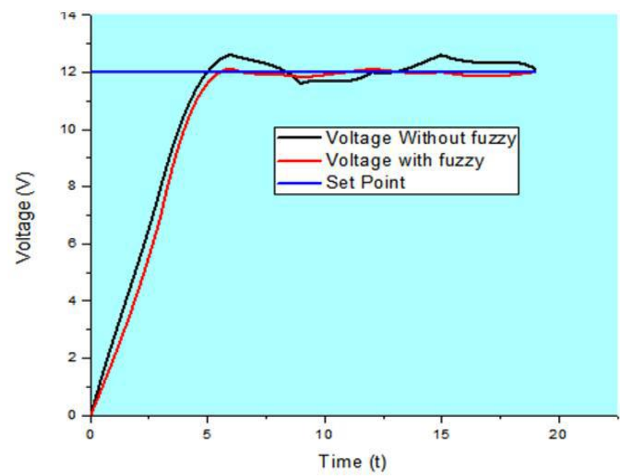


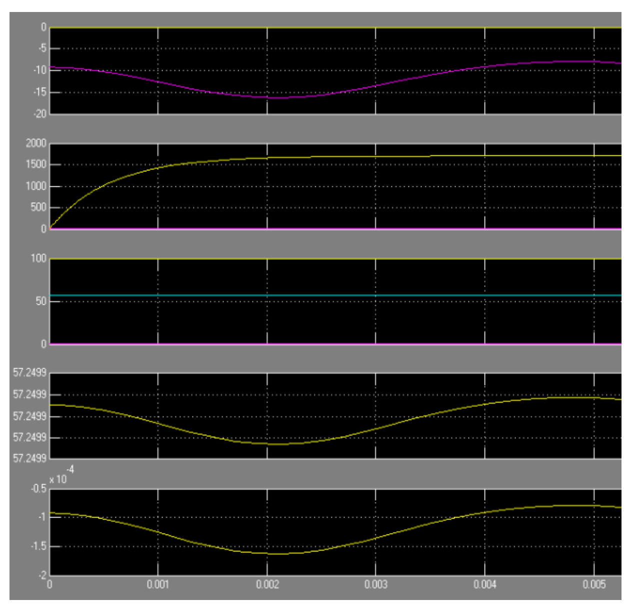
Figure3: Surface view of Fuzzy Logic Module Implementation

5. CONCLUSION

In this paper two input parameters are used and got the graphs showing the required PWM Duty Cycle variation. By using 3D graph one can find out temperature range for various input values. As all parameters are not considered so these results are approximate. More precise results can be achieved considering many more input parameters.

Undoubtedly this system is superior to the system designed and simulated till the date since this battery charger system is able to achieve desired o/p at a better dynamic performance and easy implementation can be done in various fields including electric vehicles and many other portable devices.





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