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Fuzzy Logic Based Battery Charger For Inverter

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ABSTRACT: In this paper Li-Ion battery charger techniques are reviewed and compared. The fuzzy logic battery charging method is proposed to optimize and improve the battery charger performance, reducing damage of battery during the charging process. Some recent designs are discussed and the results are compared. According to results of comparison, the fuzzy control charging system can shorten the charging time with higher efficiency and lower temperature rise. Additionally, we have used optimal Li-ion battery charging frequency by using AC impedance technique which means if the battery is charged by the optimal charging frequency fZmin, the charging time and charging efficiency will improve. The proposed charger is capable of charging the Li-ion batteries with higher efficiency 97.16%, lower temperature rise and life cycle of battery is improved.

Keywords - Li-Ion Battery charger, Fuzzy logic, fZmin

1. INTRODUCTION

Now days the portable electronic devices have become the main applications of advanced technical products and become more popular devices like mobile phones, laptops, MP3 players etc. So the rechargeable batteries become an important and essential power source also the battery charging technique becomes more important. A single Li-Ion cell voltage is equal to three Ni-Cd or Ni-MH cells with the same weight, volume, high energy density and low self discharge have always been key to the Li-Ion's success in the market. The battery charger must have most efficiency, fast charging mode, and guarantee the safe of battery from probably damage of undercharge or overcharge, the cost must be reasonable. The basic essential item designer of battery should have to check included factor, voltage, energy density, temperature performance, drain rate, and cycle life. It must have minimized size, weight and no memory accumulation. Battery life is also one of important properties. Rechargeable battery life is relation not only charger times [3, 4, 5, 9, 10]. As for the recharging of lithium-ion batteries, several types of chargers have been proposed with great success simple charger was first been constructed to deliver a constant voltage charge whereby the charge current is reduced to zero or trickle as the battery voltage rises. However, this way of charging came with a non-optimal charging profile, hence resulting in a long charging interval Next, based on the close monitoring of battery current and voltage, some sophisticated chargers has suggested to employ high charge currents during the initial stage of charging cycle, then reduce gradually till the full electricity-charging is reached. This idea is feasible, yet to ensure that the battery is fully charged, the small charging current at the final stage may slow down the charging speed. Rechargeable battery life is relation not only charger times But overcharging control and charger way We must submit some battery charger with best efficiency, more safe from damage of overcharging or under charging. The life cycles of Li-Ion batteries are simply is influenced by overcharge or undercharge, because overcharge can damage the physical elements of the battery and undercharge can decrease the energy capacity of the battery. The Charger controller has duty of creating a feasible electro power for rechargeable battery and it must identify the point that is stopping charging to avoid rechargeable battery explosion [1, 2, 6, 7, 8]. The fuzzy control, are applied to approach better battery charging performance. 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 .We have submitted the usage of the fuzzy logic approach a fast smart Li-ion battery charger. 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 achieve the purpose of good performance and low cost In this paper, Section 2 shows the comparison table and evaluates the specifications and real test data of different previous techniques. Section 3 proposed new technique in fuzzy logic battery charger method by applying fuzzy logic in order to decrease temperature during charging period, that can increases charger efficiency and lead to quick charging. And Section 4th is conclusion about results.

2. COMPARISON TRADITIONAL METHODS LI-ION BATTERY CHARGER

We survey all of the ten methods and we find out that the best one for increasing the efficiency and reducing damage. Below table shows experiment data and specifications of all of charging technique for rechargeable li-ion battery. The power efficiency of fuzzy method [11] that is 96.623%, and it is better than the others one, and decrease temperature and increase life cycle of battery. Table is shown below. According to this table, results Using fuzzy logic technique, there will be many advantages over the previous charger, which are: it has small rise temperature during charging process that results high charging efficiency, decreasing the charging time, it doesn’t have any shut-offs during charging process, the life cycle will improve because of low temperature rise. Discharging process can be monitored and optimized in a similar way. Another advantage of using the fuzzy logic is the fact that the software implementation of complex systems is not computer intensive. This Fuzzy charger is capable charge the battery with higher efficiency and lower temperature rise comparing with other different method, because Using fuzzy technique can decrease temperature during charging period, that can increases charger efficiency and lead to quick charging, there won’t be stop errors during charging, and the temperature range is decreased. In other hand According to optimal Li-ion battery charging frequency by using AC impedance technique, So if the battery charged by the optimal charging frequency fZmin (the minimum AC impedance frequency) the charging time and charging efficiency are improved [5]. Thus we can propose fuzzy logic battery charger with higher efficiency that will be more than 96.623% and faster and high protection battery with low temperature rise.

parameter	2006[1]	2007[10] & 2006 [2]	2007[9]	2005[8]	2006[7]	2009[6]	2011 [15]	2009 [20]	2007[19]	2004[18]
technology	TSMC 0.35 µm 2P4M	TSMC 0.35 µm 2P4M	NA	NA	AMI 0.5 µm technology	TSMC 0.35 µm 2P4M	AMI 0.5- m	Using Fuzzy in dsPIC	0.6 µm 3M-2P CMOS technology	TSMC 0 .3 5 2~P 4M CMOS
Power supply voltage	5 V or adaptive	5 V	24 V	3.9 V	2.7V-4.5 V	2.3V-4.5 V	4.3 V	NA	4.3 v	4.5 v
Average power consumption	825 mW	837mW	NA	NA	NA	1.24 W	NA	NA	NA	NA
Output voltage	4.2 V	4.2 V	10 V	2.5-4.2 V	2.5 V-4.2V	2 V-4.2V	4.2 V	NA	4.1 V	4.2V
Maximum switching frequency	1MHz	10 MHz	18 KHz	20 KHz	600KHz	100KHz	6.75 MHz	50 kHz	NA	NA
Maximum charging current	700 mA	694 mA	2 A	1 A	800 mA	698 mA	3 mA	NA	1.5 mA	312mA
Chip area(with PADs)	1.71x1.52mm2	1.455mm x 1.348 mm	NA	NA	NA	1.32 mm x0.95 mm	0.16 mm^2	NA	1.74 mm^2	Not specified
Average power efficiency	82%	67.89%	84%	55%	85%	91.2%	89.7%	high (96.623%)	73%	72.3%

Table-1 Comparison Table

3. FUZZY LOGIC BASED LI-ION BATTERY CHARGER

A. Fuzzy Application:-

One of the advantage of fuzzy logic controller is that, it could apply for non linear elements without finding exact mathematical model, therefore we can apply fuzzy logic controller for battery charger system, because the lithium ion battery is a nonlinear element and has complex mathematical model, the fuzzy logic controller is suitable method to have better charging efficiency and also reduce the charging time without finding exact mathematical model.

B. Fuzzy logic Controlled Charging System:-

For decreasing the temperature of a battery during charging process, we must control all those parameters which effect the input charging current because if we control input charging current then the temperature of the battery will not high. There are following three parameters which affect the input charging current.

1) Rate of cooling
2) Rate of heating
3) Temperature

C. System Structure:-

The system structure identifies the fuzzy logic inference flow from the input variables to the output variables. The fuzzification in the input interfaces translates analog inputs into fuzzy values. The fuzzy inference takes place in rule blocks which contain the linguistic control rules. The output of these rule blocks is linguistic variables. The defuzzification in the output interfaces translates them into analog variables.

The following figure shows the whole structure of this fuzzy system including input interfaces, rule

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blocks and output interfaces. The connecting lines symbolize the data flow.

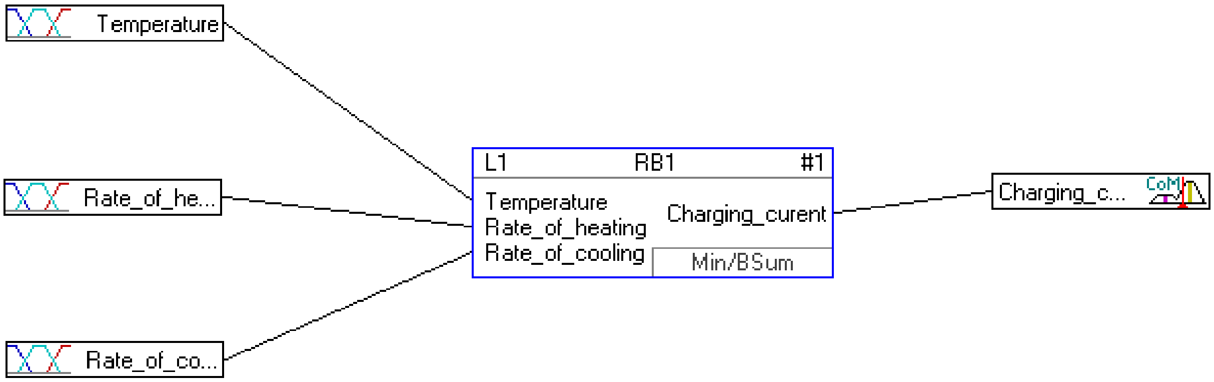

Figure 1: Structure of the Fuzzy Logic System

D. Input

#	Variable Name	Type	Unit	Min	Max	Default	Term Names
1	Rate_of_cooling		Units	0	1.5	0.75	low moderate high_moderate high
2	Rate_of_heating		Units	0	2	1	small medium_small medium_large large
3	Temperature		Units	0	150	75	low medium_low medium_high high

Table 1: Variables of Group "Inputs"

E. Outputs

#	Variable Name	Type	Unit	Min	Max	Default	Term Names
4	Charging_current		Units	0	15	7.5	very_low low medium high very_high

Table 2: Variables of Group "Outputs"

F. Variables

This chapter contains the definition of all linguistic variables and of all membership functions. Linguistic variables are used to translate real values into linguistic values. The possible values of a linguistic variable are not numbers but so called 'linguistic terms'. Linguistic variables have to be defined for all input, output and intermediate variables. The membership functions are defined using a few definition points only. The following tables list all variables of the system as well as the respective fuzzification or defuzzification method. Also the properties of all base variables and the term names are listed

G. Input Variable "Rate of cooling"

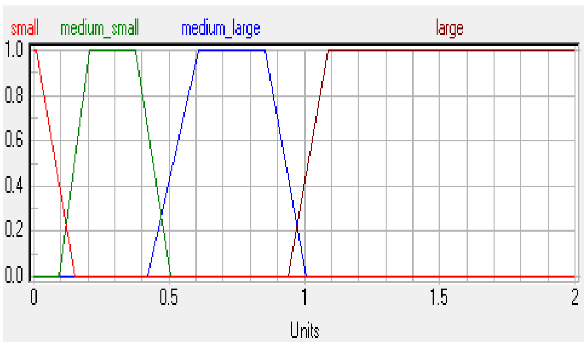

Figure 2: Membership function of Input Variable "Rate of cooling"

3.9 Input Variable "Temperature''

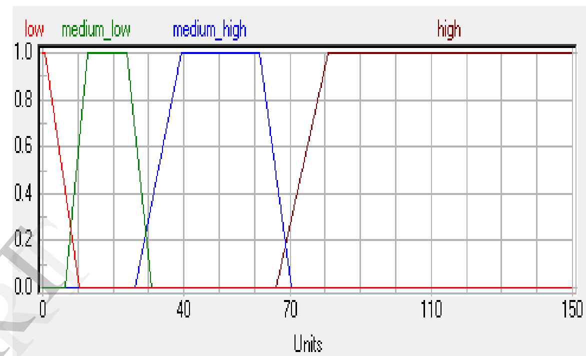

Figure 4: Membership function of input variable "Temperature"

3.8 Input Variable "Rate of heating"

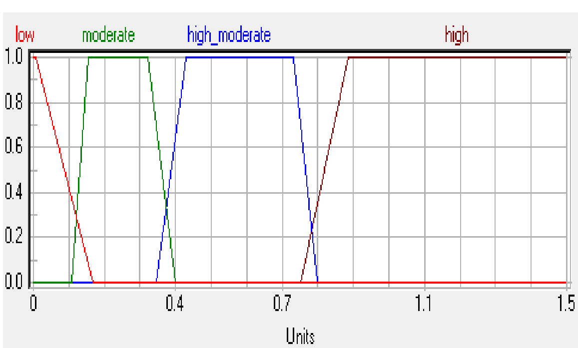

Figure 3: Membership function of Input Variable "Rate of heating"

3.10 Output Variable "charging Current"

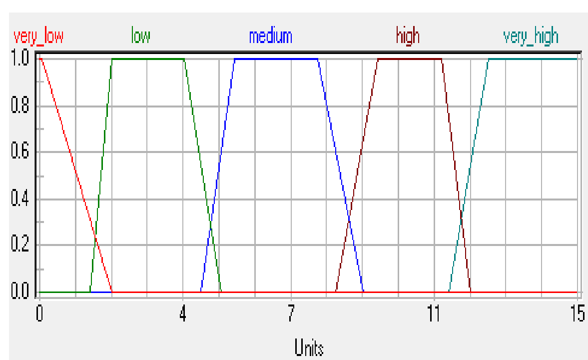

Figure 5: Membership function Output variable "charging current"

In this paper we have considered three input parameters and got the graphs showing the required probability of temperature variation.

The 3D graph showing three input parameters and output parameter.

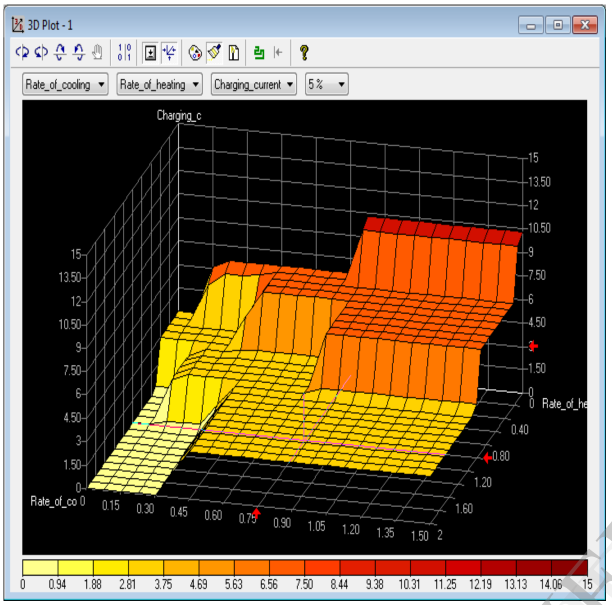

Figure 6: Graph between Rate of heating and Rate of cooling

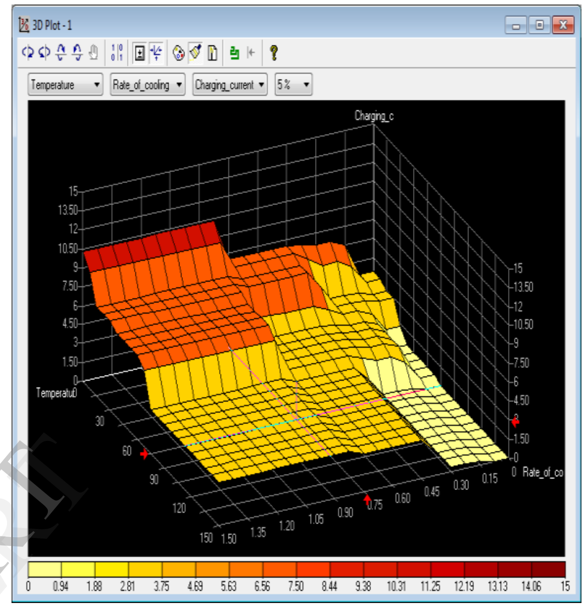

Figure 7: Graph between Temperature and Rate of cooing

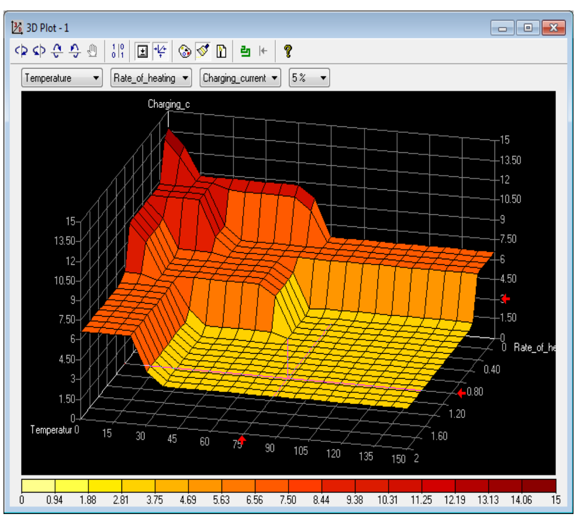

Figure 8: Graph between Temperature and Rate of heating

4. RESULTS CONCLUSION AND FUTURE SCOPE

In this paper some charging methods are proposed and compared which the best one is fuzzy logic controller with the best efficiency and it can adjust the charging current level according to the battery temperature rise. We have proposed a new fuzzy logic controller that can decrease the temperature and improve the efficiency of fuzzy logic battery charger and reduce the battery charger temperature and keep the battery life cycle long. According to the results this method improve the efficiency of the conventional fuzzy logic battery charger to 97.16% and also by applying this method the battery is charged by lowest temperature that it lead to increase the life cycle of battery and speeding up the charger process. In this paper we have considered three input parameters and got the graphs showing the required temperature variation. By using 3D graph we can find out temperature range for various input values.

As we have not considered all parameters so these results are approximate. To get more precise results we have to consider many more input parameters.

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