Single Power Conversation Battery Charger for Light Electric Vehicles using Fuzzy Logic Controller

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Abstract: In the recent advancements in the battery technology and growing interest in green energy. In that eco-friendly vehicles play major role, the battery is the vital part of the vehicles so, for that battery charging technologies going to improve to achieve solutions for better battery charging of Light Electric Vehicle's. An onboard charger is required to charge the batteries of the Light Electric Vehicle with high efficiency for the reason single power conversation battery charger is proposed it consists of isolated step-down AC to DC Converter to meet desired output voltage level to charge the battery. The proposed system is designed to fuzzy logic controller for generating control PWM pulses to gain required duty cycle at desired level to regulate the output voltage. The structure of single power conversation is beneficial for on board charger and the results are evaluated using MATLAB/SIMULINK.

Keywords - Light Electric Vehicle; AC-DC Converter; Fuzzy Logic Controller; Battery Charger; MATLAB/SIMULINK

I. Introduction

Now a days Eco-friendly vehicles usage is goes on increasing because of increasing the cost of fossil fuels and by usage of Eco friendly vehicles like Electric Vehicles (EV's), Plug-In Hybrid Electric Vehicles (PHEV's) significantly reduce the environmental pollution. For these Electric Vehicles battery is the main source of energy to run the vehicle. To charge the battery charger is has to be designed according to requirement of the voltage to charge the battery. Here for light electric vehicles on board charger is suitable.

A Type-2 charging is using with the input voltage 240V, the charger has to be installed inside the EV it includes DC-DC converter, Step-down Transformer or mutually coupled inductors to perform energy transform by isolated method. If battery has influenced by overcharge and undercharge because of influence of overcharge Physical elements goes under damage and due to under charger power capacity of the battery goes on decreases. To overcome these issues charge controller has to be introduced. To achieve the high efficiency in the charger, the charger has designed by bridgeless single stage power conversation having advantages as high efficiency, well-regulated output achieve by at the high power factor. By overcome of the two stage power conversation method using dc-link capacitor, it's having disadvantages power loss, high current flow in the intermediate stage and low efficiency, reduces the capacitor life time due to this early failure of the capacitor, Maintainace cost is more.

In the single stage converter has merged with switches by combining dc-link capacitor stage and DC-DC converter stage. The switches are operating at high voltage rate due to this conducting loss will happens and also power factor get affect if load or grid voltage has varied. To reduce the conduction loss in the switches two diodes has introduced to perform bridgeless operation and also high duty ratio However, recently there are many researcher reported successfully adopted fuzzy logic controller (FLC) as one of the intelligent controller to their application. By comparing to open loop efficiency it gives the good result in the short time span by performing in close loop operation. The output voltage will be fed to fuzzy controller to give appropriate measure on the steady state signal and it serves as an intelligent controller. The one of the major tasks of electronic engineer to improve the efficiency of power conversation for PWM converters with less switching losses.

To overcome above problems fuzzy logic controller is the best controller. It has an attractive control method because its structure because its structure, consisting of fuzzy sets that allow partial membership and "if-then" rules, resembles the way human intuitively approaches a control problem. Recently fuzzy logic controller (FLC's) have generated a good deal of interest in certain applications. The advantages of FLC's over the conventional controllers are:
1) It does not need an accurate mathematical model
2) It can work with imprecise inputs
3) It can handle nonlinearity, and
4) It is more robust than conventional nonlinear controllers.

II. PROPOSED SINGLE POWER CONVERSATION BATTERY CHARGER

A. Circuit description of proposed charger

The proposed single power conversation of AC-DC converter along with the proposed control algorithm as a fuzzy logic controller circuit configuration shown in the Fig.1.The proposed battery charger consisting of bridgeless circuit configuration by replacing two diodes by two switches. In S1 switch will operating at the high switching frequency and switch S2 will operating at grid frequency as is always on during the positive half cycle. Hence the switching losses occurring due to only one switch therefore losses are minimized and high input current is minimized by input inductor by proper value selection.

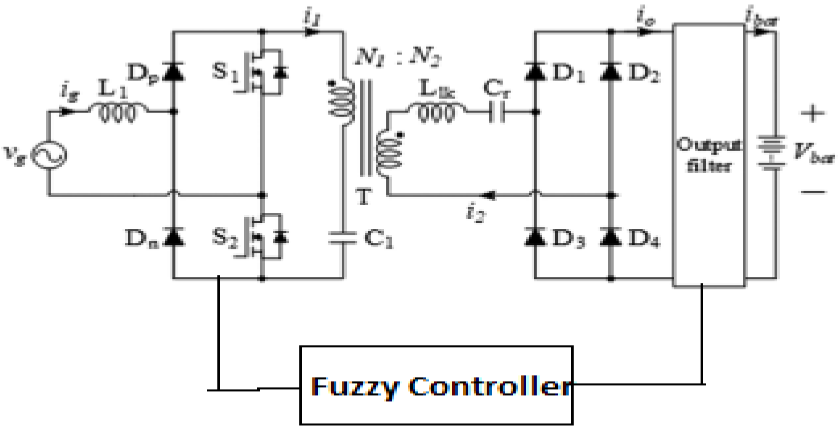

Fig.1 Circuit diagram of proposed single power conversation AC-DC converter

In the secondary side of the transformer consists of full bridge converter, series resonance along with fuzzy controller in the close loop to obtain the constant desired output voltage to charge the battery. The series resonance consisting of leakage inductance Llk and resonance capacitor to reduce the reverse recovery problems in the output diodes by providing ZCS. The galvanic isolation will be used between the grid and battery using high frequency transformer for user safety.

B. Design of fuzzy logic controller for charging system

Now a day's fuzzy logic controller (FLC) will become very famous due to its precision results for both linear and nonlinear system problems. It can be solve complex problems without solving the mathematical equations. It provides easy solutions by setting set of rules compared to the classic controllers like PID controller, this controller is having high demand in different domains of engineering fields like Power Electronics, Robotics, and Electrical Drives for their easy solution techniques for complex problems

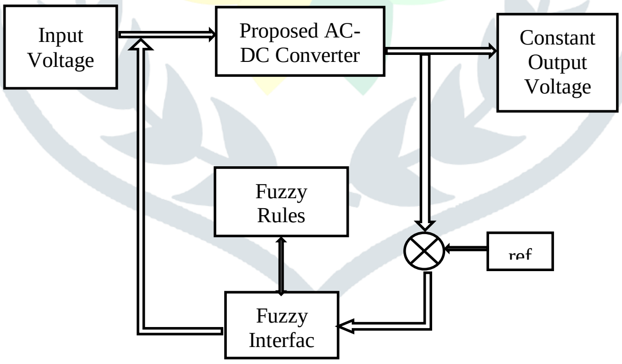

Fig.2 Block diagram of fuzzy logic controller of proposed converter

The Fuzzy logic majorly used when the control parameters are unknown. In this paper the controller is designed, to obtain the constant DC output voltage with variable AC input voltage will achieve using well advanced controller in the close loop that, fuzzy logic controller (FLC).

The block diagram of fuzzy logic controller in the proposed battery charger is shown in the Fig.2.The output voltage Vo of the proposed battery charger is compared with the reference voltage Vref. The difference generated is named as error e is fed to fuzzy interface as an input.

Error (e) =Vref – Vo ……………………………… [1]

Generated error with compared with set of rules as designed using membership function to provide proper steady state response as output. It will fed to Switches S1 and S2. The operation of the fuzzy logic controller is mainly divided into 3 parts as fuzzification, rule base and difuzzification. In part c will discuss all these.

C. Design of fuzzy controller

i) A fuzzification which converts input data value into suitable linguistic values. There 5 membership functions from E1 to E5 all are positive variables. Membership functions for error and output duty cycle are shown in Fig. 3 and Fig. 4 respectively. Triangular and trapezoidal shapes are commonly used in membership plots among the other singleton.

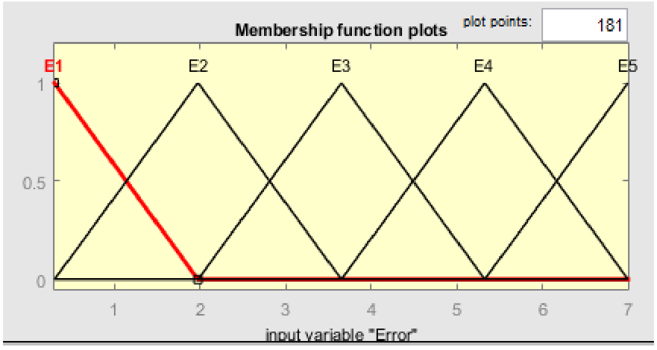

Fig.3.Membership fuction for Error

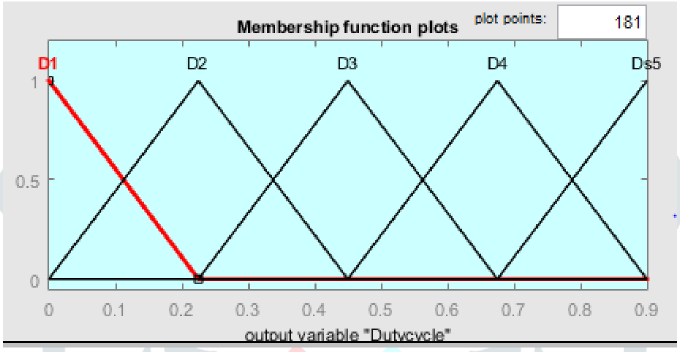

Fig.4 Membership function for duty cycle

ii) Rule base: The collection of rules is called a rule base. The rules are in "If -Then" format and formally If side is called the conditions and Then side is called the conclusion, based on the logic based rules set is used to simulating a human decision process and fuzzy control action from the knowledge of the control rules and linguistic variable definitions. Rules are defined based on the input output combinations, based on the experience there are 5 rules are defined based on the requirement is shown in the fig.5

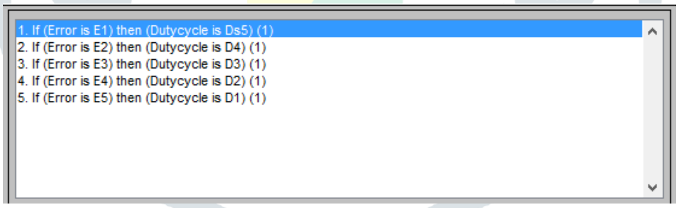

Fig.5 Fuzzy Rule base for proposed converter

iii) A difuzzification interface which yields non fuzzy control action from inferred fuzzy control action it converters human linguistic concepts into an automatic control strategy without any complicated mathematical model. Defuzzifier is used to convert the linguistic fuzzy sets back into actual value. Here Difuzzification centroid method is using.

III. SIMULATION RESULTS

Proposed simulation model of closed loop controlled AC-DC converter for battery charging of light electric vehicle's is designed in MATLAB/Simulink and shown in the fig.6 and designed parameters for the simulation are listed in Table I. As variable input voltage the corresponding constant voltage is listed below in Table II. For Vin =230V AC, duty cycle= 0.75 the corresponding waveforms are shown in the Fig.8 and for some other different input voltage range the corresponding output voltage and current waveforms are in Fig.7, Fig.9 and Fig.10.

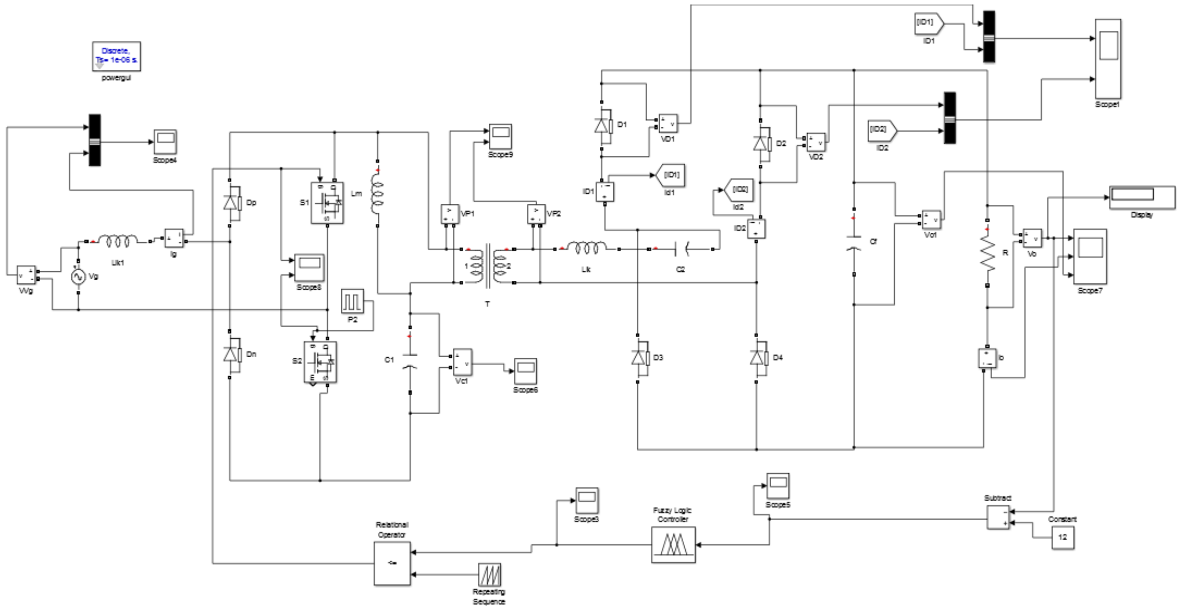

Fig.6 Simulation diagram of proposed battery charger

TABLE I: DESIGN PARAMETERS USED FOR THE SIMULATION

Parameters	**Symbols**	**Value**
Grid Voltage	v_g	240-200 V
Grid frequency	f_g	50Hz
Switching frequency	f_s	70kHz
Primary Inductance	L_1	1.5mH
Primary Capacitance	C_1	6.6μF
Magnetizing inductance	L_m	450μH
Transformer turns ratio(Step down)	$N_1 : N_2$	21:1
Resonant Capacitance	C_r	1μF
Output Capacitor Filter	C_f	3.3mF
Load Resistance	R	250 Ω

TABLE II: SIMULATION RESULTS FOR DIFFERENT INPUT VOLATGES WITH VARIABLE RESISTANCE VALUE

Input Voltage (Vin)	**Resistance Value (R)**	**Output Volatge (Vo)**
240 V	250 Ω	11.37 V
230 V	250 Ω	11.31 V
220 V	250 Ω	11.23 V
220 V	270 Ω	11.26 V
220 V	300 Ω	11.29 V

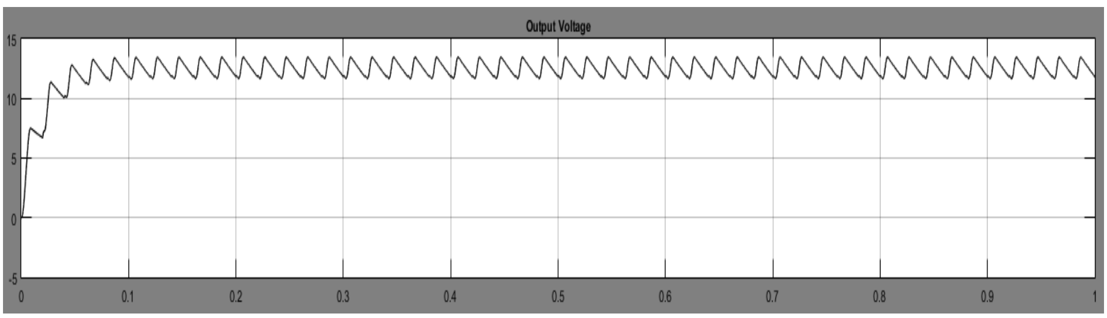

Fig.7. Output Voltage of the System without fuzzy logic controller

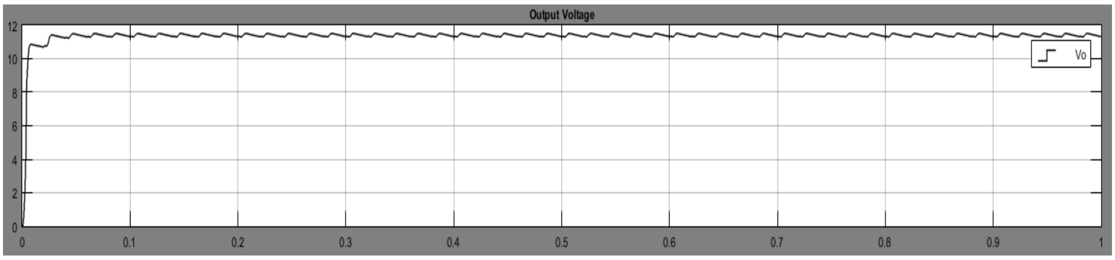

Fig.8 Output Voltage for Vin=230V, R=250 Ω

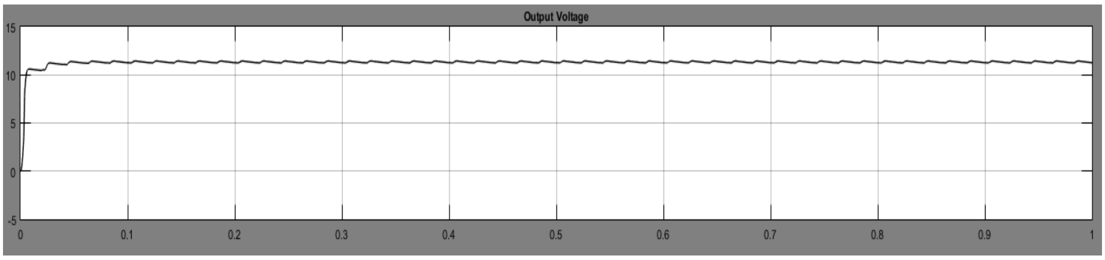

Fig.9 Output Voltage for Vin =220 V, R=300 Ω

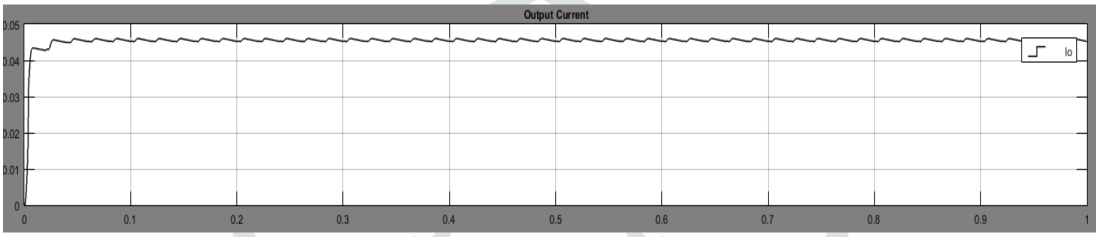

Fig.10 Output Current of the system with fuzzy logic controller

IV. CONCLUSION

The Proposed model is successfully designed using fuzzy rules technique and simulated for battery charger. By the simulation results of the close loop using fuzzy logic controller gives the healthier waveform along with less ripple content in the setting time compared to open loop simulation, and the constant output voltage has achieved to charge the battery of the light electric vehicles.

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