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CONTROLLING OF HIGH EFFICIENCY BRIDGELESS BATTERY CHARGER FOR LIGHT ELECTRIC VEHICLES USING FUZZY LOGIC CONTROLLER

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Abstract: Efficiency of the charger is one of the most important thing while charging batteries of electric vehicles. Efficiency is inversely proportional to the oscillations present in the output. Hence to improve efficiency, oscillations in the output should be reduced to great extent as possible as they can with less cost and less settling time. To meet that need this paper presents controlling of high efficiency bridgeless battery charger for light electric vehicles using fuzzy logic controller. The fuzzy control developed allows the predefined high efficiency bridgeless battery charger to regulate the output with less oscillations and high efficiency, less settling time and less cost. The model is analyzed using MATLAB software and results showing less oscillations in output hence improving the efficiency.

Index Terms **– Electric vehicles, Battery charger, Fuzzy logic, Oscillations**

I. INTRODUCTION

Electric vehicles (EVs) are preferred because they reduce environmental pollution. By using on board or off board charger we can charge batteries of electric vehicles. As on-board chargers are always kept in EV, making such charger is difficult task due to restrictions on parameters like cost, size, weight, current and voltage ratings.

In predefined work , the high efficiency bridgeless battery charger for light electric vehicles is proposed and in that PI controller method is used to control the charger.

In this paper, Fuzzy logic controller is used in place of PI controller to control the high efficiency bridgeless battery charger for light electric vehicles.

Fuzzy logic is widely used in various control applications. Many consumer products have fuzzy logic control. Fuzzy logic control saves cost with reliable operation. Fuzzy logic technique joints human decision making with control system. A fuzzy logic controller employs a knowledge base expressed in terms of fuzzy inference rules and a fuzzy inference engine to solve a problem.

When we are unable to find out right mathematical formulation, fuzzy logic controllers prove to be beneficial in that case. Non-linearities, the time-varying nature of the process, huge unanticipated environmental disturbances, and other factors all contribute to these issues. In these situations, the fuzzy system is convenient to solve this kind of problem.

Identify input and output variables and decide linguistic variables for the same, establish membership functions for each of the input and output variables, build a rule base, rule evaluation, and defuzzification are the steps for computing the output in a fuzzy logic system.

The PI controller was utilized in the previous work to control high efficiency bridgeless battery charger for light electric vehicles and the fuzzy logic controller is employed in this paper to control output of a high efficiency bridgeless battery charger for light electric vehicles.

The main thing while making electric vehicle's charger is efficiency which depends on its oscillations present in the output. Therefore, oscillations should be effectively controlled for smooth and reliable operation.

So, by using fuzzy logic controller, the intent is to reduce the oscillations in the output. Fuzzy logic controller is flexible, convenient and cheaper to develop so it is widely used nowadays.

The model is prepared and implemented in MATLAB software and the rules will be provided to the controller to control the voltage and current parameters of the system. The fuzzy logic controller has been provided with the change of error as input and designed by various rules to carry out effective operation.

II. PREDEFINED WORK (SEO-GWANG JEONG, 2018)

In predefined work high efficiency bridgeless single-power-conversion battery charger for light electric vehicles was proposed. In which input bridge diode is eliminated to reduce the conduction losses. The use of series resonance circuit in it reduces the reverse recovery problem for output diodes. Bidirectional core excitation of the transformer ensures higher power capability than conventional bridgeless converters. For controlling of this charger PI controller was implemented.

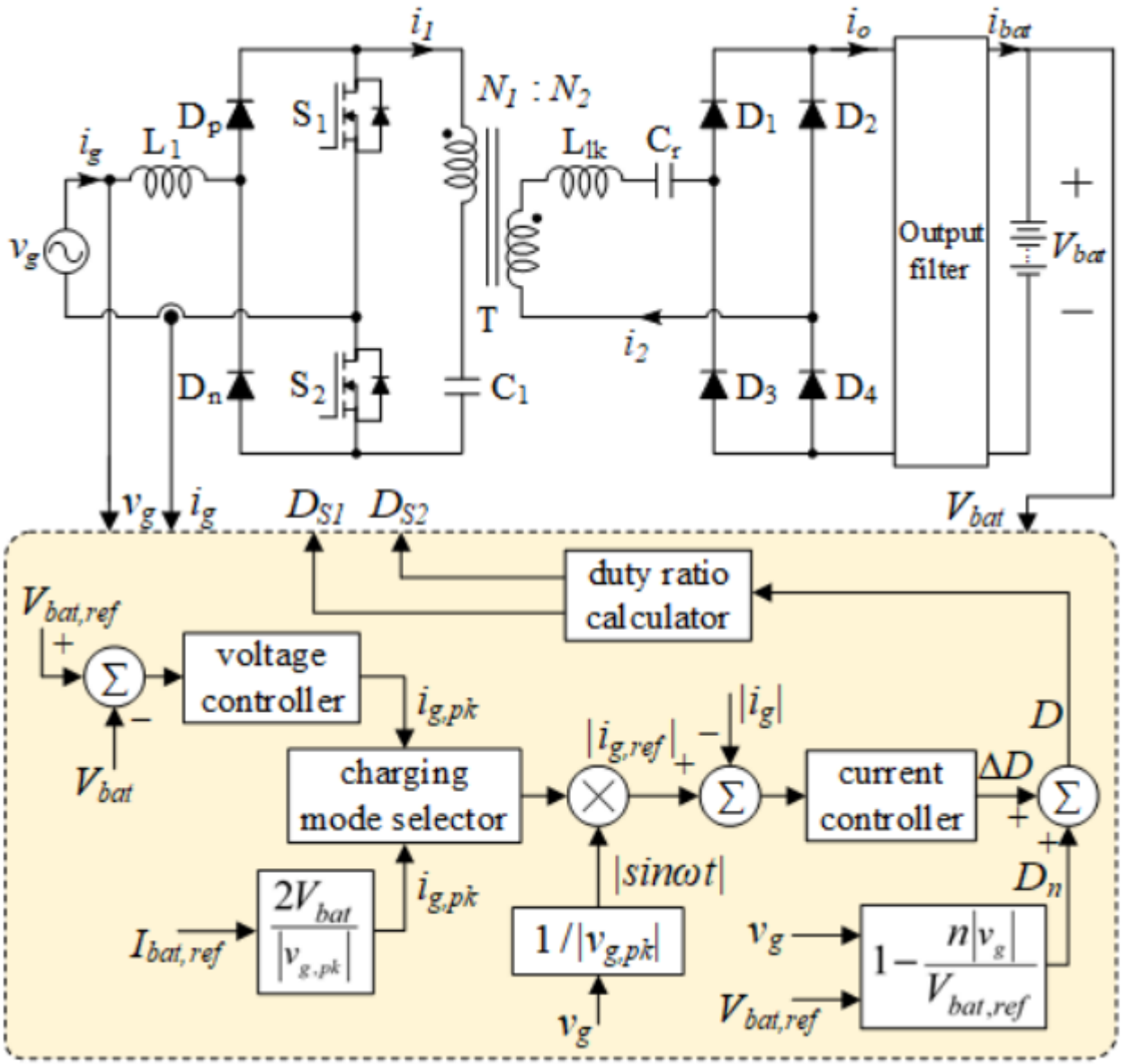

Fig.1. Predefined single power conversion high efficiency bridgeless battery charger for light Electric vehicles using PI controller (Seo-Gwang Jeong, 2018)

Table I. Parameters and components used (Seo-Gwang Jeong, 2018)

Paameter	Symbol	Value
Grid voltage	Vg	250 Vrms
Grid frequency	fg	60 Hz
Nominal battery voltage	Vbat	360 V
Rated output power	Po	1.7 kW
Switching frequency	fs	70 kHz
Primary inductance	L1	1.5 mH
Primary capacitance	C1	6.6 µF
Magnetizing inductance	Lm	450 µH
Secondary leakage inductance	Llk	1.6µH
Transformer turns ratio	N1 : N2	24 : 36
Resonant capacitance	Cr	1 µF
Output filter capacitance	Cf	3.3 µF
Output filter inductance	Lf	40 µH

Component	Symbol	Part number
Input diodes	Dp, Dn	15ETL06
MOSFETs	S1, S2	UJC06505K
Output diodes	D1 - D4	15ETL06

III. PROPOSED FUZZY LOGIC CONTROLLER :

In defined technique PI controller in predefined work is replaced by fuzzy logic controller. Mamdani's fuzzy inference method is used in this paper. Fuzzy logic technique joints human decision making with control system. A fuzzy logic controller employs a knowledge base expressed in terms of fuzzy inference rules and a fuzzy inference engine to solve a problem. Identify input and output variables and decide linguistic variables for the same, establish membership functions for each of the input and output variables, build a rule base, rule evaluation, and defuzzification are the steps for computing the output in a fuzzy logic system.

The reference voltage, current and actual voltage, current will be compared and the change or difference between them will be given to the controller as input.

$$Vout = Vin * D . \quad (1)$$

The boost converter works on above relationship in equation (1), that its output voltage depends on input voltage multiplied by duty cycle. Duty cycle is the pulses that we provide to switch. If we increase duty cycle then output voltage increases and if we decrease duty cycle then output voltage decreases.

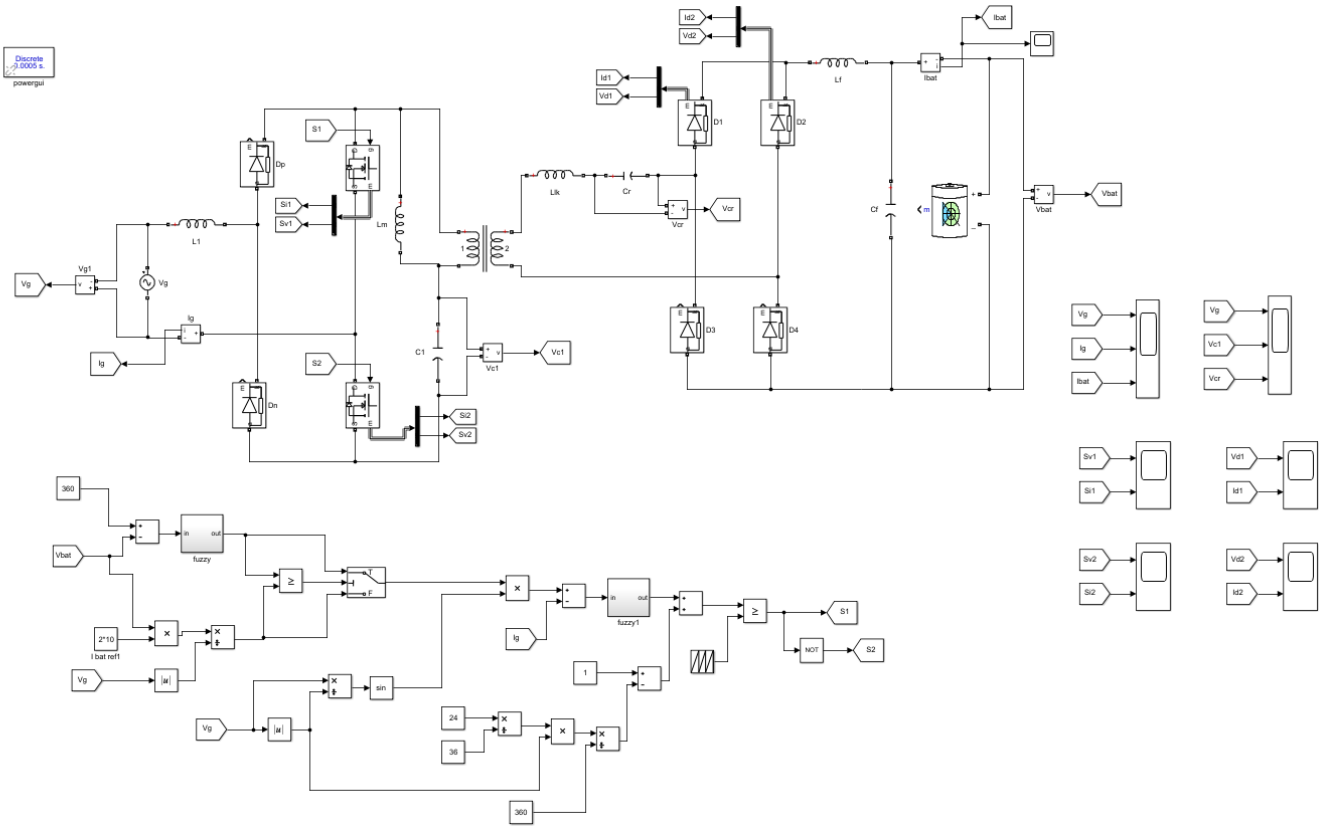

Fig.1. Simulation model of Controlling of high efficiency bridgeless battery charger for light electric vehicles using fuzzy logic control

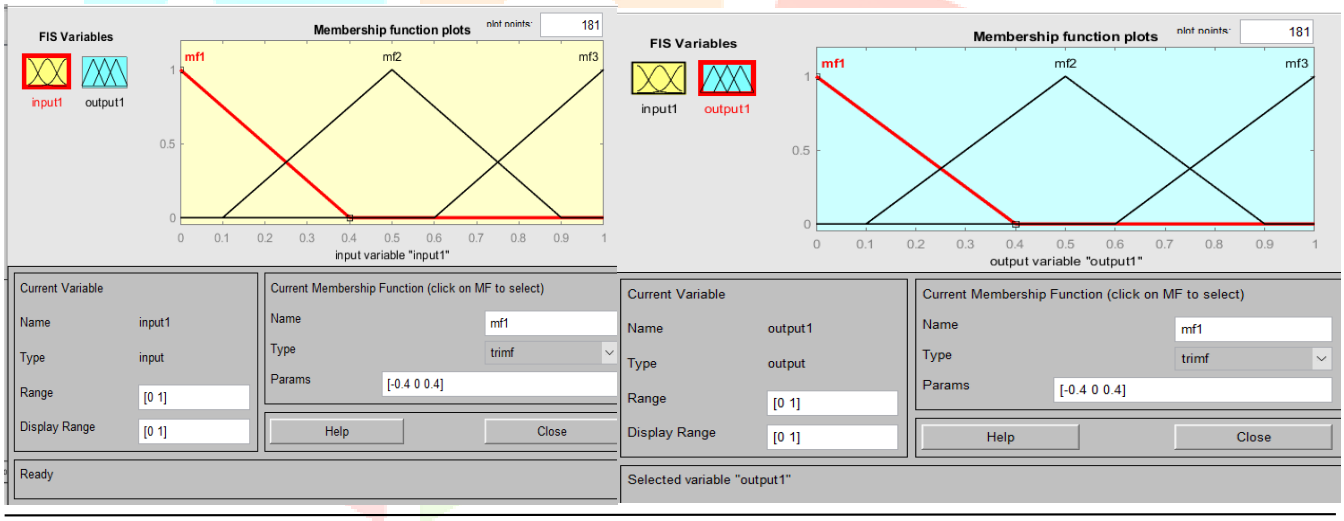

Fig.2. Membership function plots of input and output

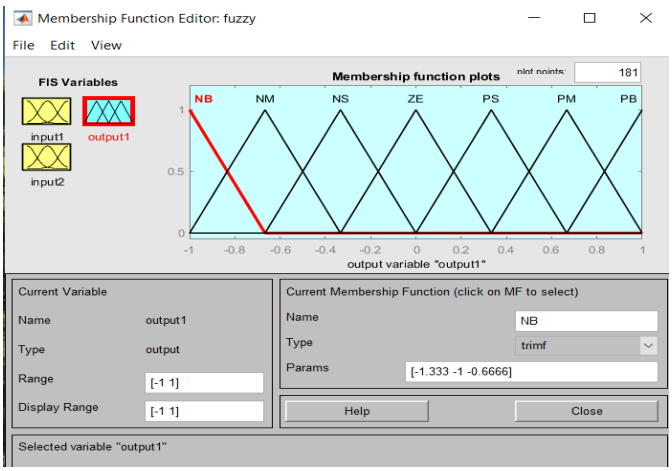

Fig.3. Membership function output and its range

Table II. Fuzzy rule editor

change in error

error	NB	NM	NS	ZE	PS	PM	PB
NB	PB	PB	PB	PM	PM	PS	ZE
NM	PB	PB	PM	PM	PS	ZE	ZE
NS	PB	PM	PS	PS	ZE	NM	NB
ZE	PB	PM	PS	ZE	NS	NM	NB
PS	PM	PS	ZE	NS	NM	NB	NB
PM	PS	ZE	NS	NM	NM	NB	NB
PB	ZE	NS	NM	NM	NB	NB	NB

IV. SIMULATION RESULTS USING PROPOSED FUZZY LOGIC CONTROLLER TECHNIQUE :

To validate the project, which is based on controlling of high efficiency bridgeless battery charger for light electric vehicles using fuzzy logic controller, in MATLAB software a simulation is developed.
The results of this simulation are shown in fig.

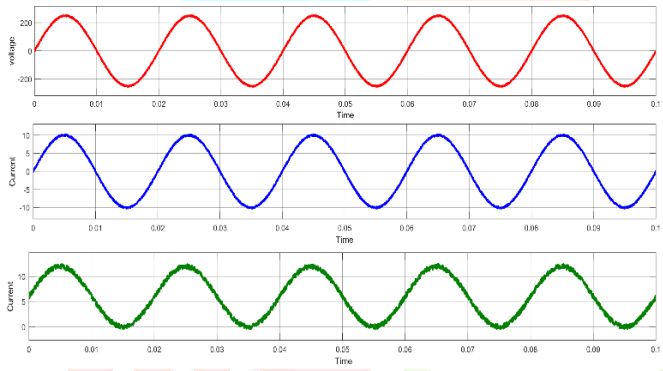

Fig.2. Simulation results for grid voltage Vg, grid current Ig, battery Current Ibat .

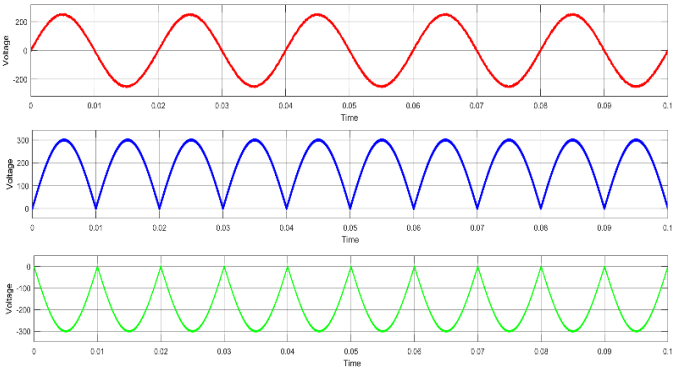

Fig.3. Simulation results for grid voltage Vg, Primary capacitor voltage Vc1, Resonant capacitor voltage Vcr

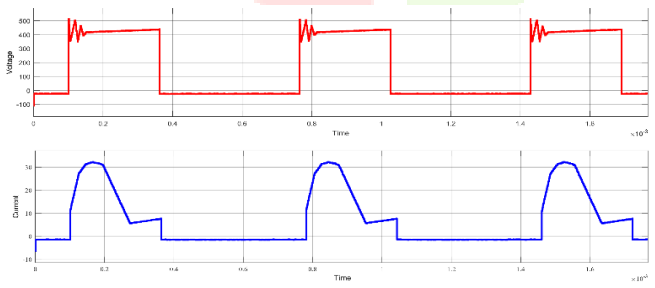

Fig.4. Simulation results for voltage stress and of the switch S1 for positive half cycle.

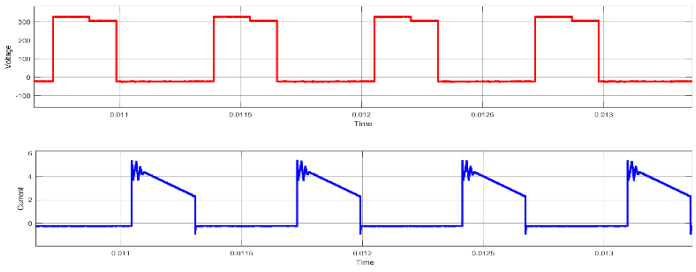

Fig.5. Simulation results for voltage stress and current current of the output diode D1

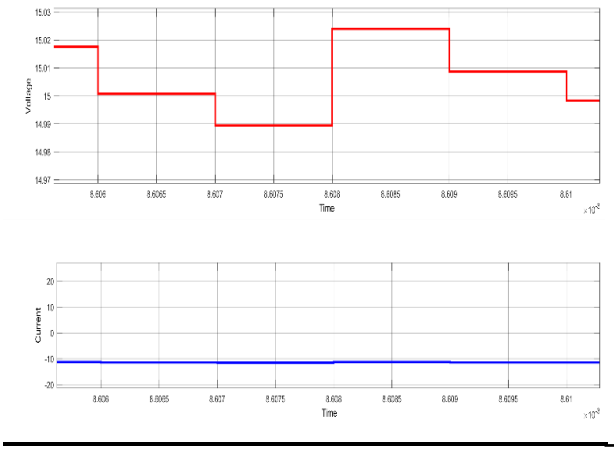

Fig. 6. Simulation results for voltage stress and current of the switch S2 for positive half cycle.

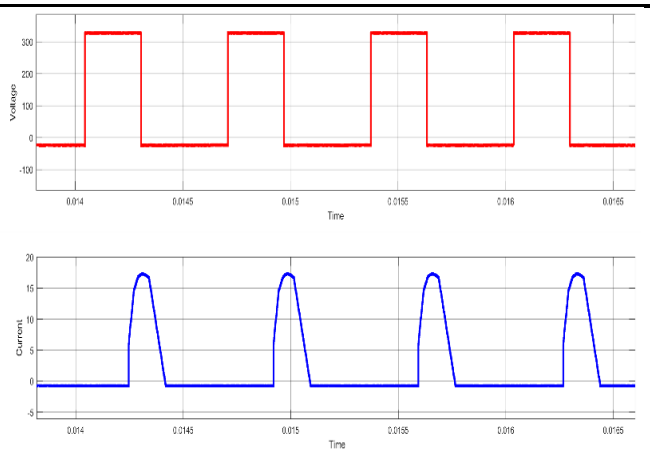

Fig.7. Simulation results for voltage stress and current of the output diode D2.

The results of MATLAB simulation show that using fuzzy logic controller we can reduce oscillations comparatively more than PI controller.

V. COMPARISON OF PROPOSED FUZZY LOGIC CONTROLLER TECHNIQUE WITH PREDEFINED PI CONTROLLER TECHNIQUE

Results of MATLAB simulation shows that fuzzy logic controller reduces oscillations better than PI controller. So, we can say that efficiency of single power conversion high efficiency bridgeless battery charger for light electric vehicles using fuzzy logic controller is more than predefined PI controller.

The proposed fuzzy logic controller has advantages over PI controller like less oscillations, comparatively higher efficiency, less settling time and less cost.

Table 1. Comparison of proposed fuzzy logic controller with predefined pi controller

Parameter	PI controller	Fuzzy logic controller
Settling Time	More	Less
Oscillations	Comparatively more	Comparatively less
Efficiency	Comparatively less	Comparatively more
Cost required	More	Less

VI. CONCLUSION

This paper proposes controlling of high efficiency bridgeless battery charger for light electric vehicles using fuzzy logic controller. When we are unable to find out right mathematical formulation, fuzzy logic controllers prove to be beneficial in that case. MATLAB simulation results shows less oscillation in the output of high efficiency bridgeless battery charger for light electric vehicles. Hence fuzzy logic controller technique improves efficiency of high efficiency bridgeless battery charger for light electric vehicles as compared to PI controller technique. The use of fuzzy logic controller has advantages like less settling time and less cost.

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