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# High Frequency Soft Switching Boost Converter with Fuzzy Logic Controller

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***Abstract*— in this paper, a high frequency soft switching boost converter is proposed along with a fuzzy logic controller. Usually, conventional boost converters the efficiency is highly reduced due to hard switching. Due to this this reason here it introduces the soft switching method in which the boost converter is implemented with a simple auxiliary resonant circuit (SARC). The switches in this adopted circuit will turned on at zero current condition (ZCS) by resonant inductor and turned off at zero voltage condition (ZVS) by resonant capacitor. And hence the switching loosed will be greatly reduces and efficiency increases. Compared to the open loop circuit, closed loop will provide more efficient output. Fuzzy Logic Controller is used to provide the closed loop. The simulation is done at MATLLAB @ Simulink software.**

***Index Terms*— Fuzzy Logic Controller, Boost DC-DC Converter, Soft switching, ZCS, ZVS, Boost converter, SARC**

## I. INTRODUCTION

In order to reduce the periodic losses during turn on and turn off of switching mode power supplies, a new method called soft switching is introduced. Since the switching frequency of these devises are increased, the size become smaller and lighter. And this high switching frequency is directly proportional to the periodic losses at turn on/off. In effect, this loss takes along increasing loss of whole system. Therefore, to diminish these switching losses, a soft-switching method is proposed. Instead of a conventional hard-switching converter, an auxiliary circuit is employed with the soft switching. But, the auxiliary circuit for resonance increases the cost and complexity. Here, the main switch achieves soft-switching but auxiliary switch performs hard switching. Therefore, these converters cannot improve the whole system efficiency owing to switching loss of auxiliary switch. In cases of converters performing hard switching at a high frequency, the switching loss and switching frequency are proportional to each other. Thus, to reduce the switching losses, the soft switching method, which uses resonance by inductor and capacitor, has been proposed.

The open loop performance of the boost converter is very poor when it compared with the closed loop output. Thus the introduction of a feed-back controller can improve the performance of these converters. Fuzzy Logic Controller is used for this purpose. It does not need an accurate mathematical model of the plant. Also it is nonlinear and adaptive in nature which gives it robust performance under parameter variation and load disturbances. Simply it control the converter output voltage.

## II. DC-DC CONVERTER

A DC-DC converter is an electronic circuit which converts a source of direct current from one voltage level to another voltage level. It is a kind of power converter. DC-to-DC converters are needed because DC can’t simply be stepped up or down using a transformer unlike AC. In many ways, a DC-DC is a DC equivalent of a transformer. They basically just vary the input energy into a different impedance level. The output power all comes from the input regardless of the output voltage level; there is no energy manufactured inside the converter.

### *Boost Dc-Dc Converter*

The Boost Converter is a popular non-isolated power converter and is sometimes called step-up converter. The output voltage for a boost converter is always greater than the input voltage. Since the output diode conducts only during a portion of the switching cycle, the input current is non-pulsating or continuous. For the rest of the switching cycle the output capacitor supplies the entire load current.

Boost converter is a type of switching mode power supply which have at least two semiconductor switches. It may be diode and transistor and it should have an energy storage element Filters are added along with these circuits in order to improve the performance.

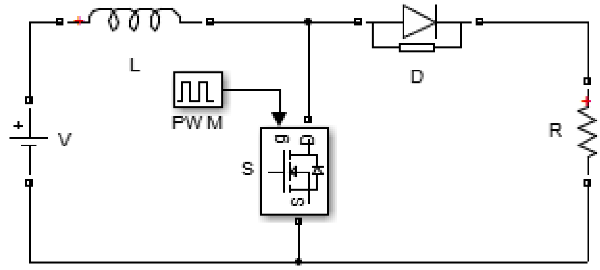


Fig. 1 Boost DC-DC converter

***Soft Switching Boost converter***

The soft switching boost converter consist of a simple auxiliary resonant circuit which is composed of a main switch(S1), auxiliary switch (s2),resonant inductor ($L_r$), resonant capacitor ($C_r$) and two diodes ($D_1$ and $D_{2}$).

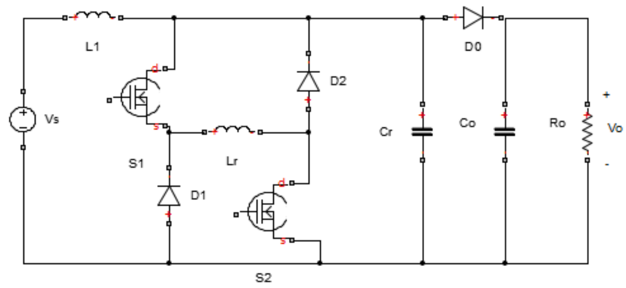


Fig. 2 Soft switching Boost DC-DC converter

***Fuzzy Logic Controller***

Fuzzy control is a control method based on fuzzy logic. Just as fuzzy logic can be described as “computing with words rather than numbers ". Fuzzy control can be simply described as “control with sentence rather than equations”. Fuzzy logic controllers give the linguistic strategies control conversion from expert knowledge in automatic control strategies.

Fuzzy logic controller consists of four principal components. They are,

1. Fuzzification interface, which converts input data into suitable linguistic values.
2. Knowledge base, which consists of a data base with the necessary linguistic definitions and the control rule set.
3. Decision-Making logic (Inference Engine) which, simulating a human decision process, conclude the fuzzy control action from the information of the control rules and linguistic variable definitions.
4. Defuzziffication interface which yields non fuzzy control action from an inferred fuzzy control action.

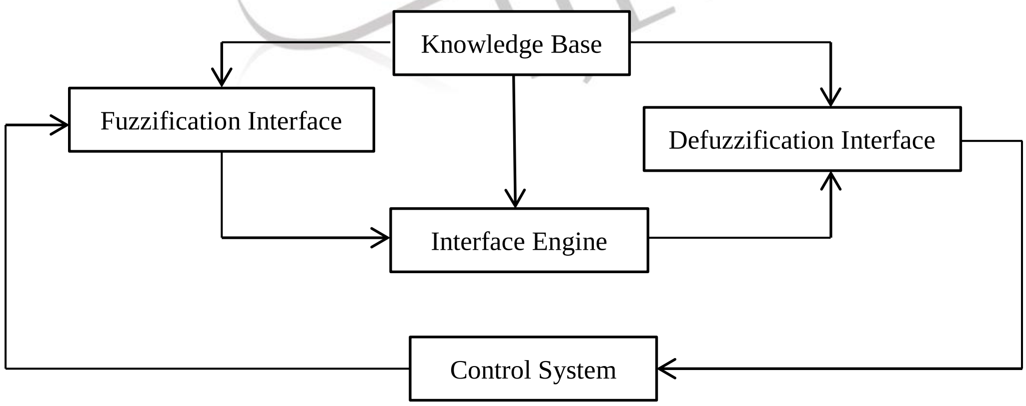


Fig. 3 Block diagram of a Fuzzy logic controller

The boost dc-dc converter is a nonlinear function of its duty cycle. Fuzzy controllers do not need a precise mathematical model. Rather, based on general knowledge of the plant they are designed. Also they are designed to adapt to varying operating points and it is designed to control the output of boost dc-dc converter using Mamdani style fuzzy inference system. There are two input variables for the fuzzy logic controller. They are, error (e) and change of error (de). The single output variable (u) is duty cycle of PWM output. The inputs of FLC are defined as the voltage error, and change of error. The input and output variable value is normalized in the universe [-1, 1] by suitable scale factors. Fuzzy sets are defined for each input and output variable. Five fuzzy levels (Negative big-NB, Negative small- NS, Zero ZO, Positive small-PS, and Positive big-PB) are used here. The input and output membership are triangular. The interface engine used is min-max method interface engine. The center of area fuzzy method used in this FLC.

TABLE I. Rules for error and change in error

| de \ e | NB | NS | ZO | PS | PB |
|---|---|---|---|---|---|
| NB | NB | NB | NB | NS | ZO |
| NS | NB | NB | NS | ZO | PS |
| ZO | NB | NS | ZO | PS | PB |
| PS | NS | ZO | PS | PB | PB |
| PB | ZO | PS | PB | PB | PB |

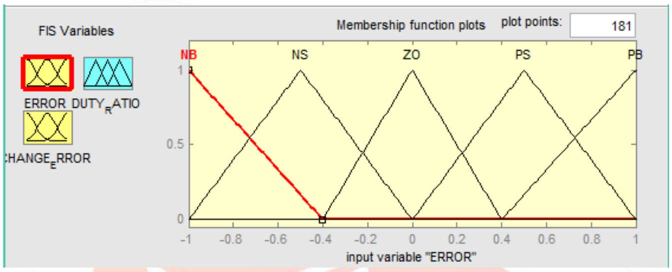

Fig. 4 The membership function plot for error

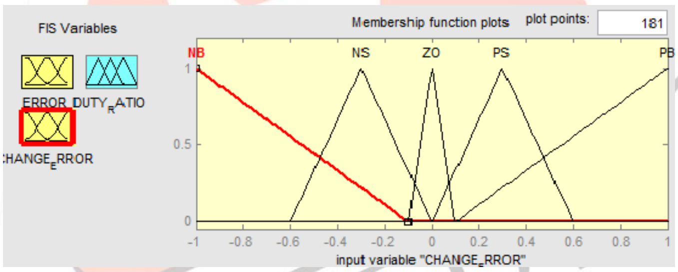

Fig. 5 The membership function plot for change error

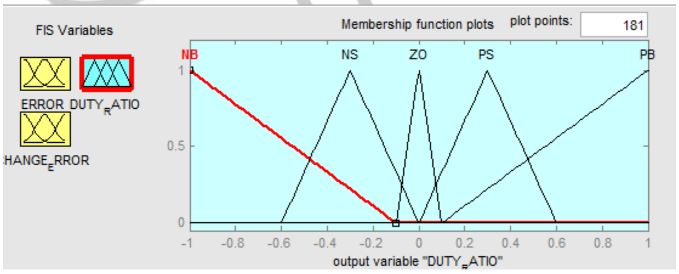

Fig. 6 The membership function plot for duty ratio

The analysis of system behavior will gives the rules of fuzzy logic controller. These control action will greatly improve the converter performance. First, when the output voltage is too much away from the set point i.e error (e) is PB or NB, the corrective action taken by the controller must be strong. Second, when output voltage error approaches zero i.e error (e) is NS, ZE, PS the current error should be properly taken into account similarly to current-mode control, in order to guarantee stability around the working point. Hence, when the current approaches the boundary value, suitable rules must be presented in order to achieve the current limit action while avoiding large overshoots.

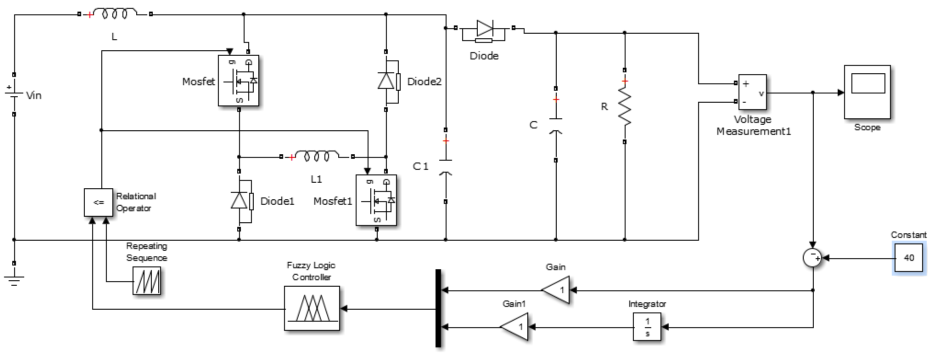


Fig. 7 Closed loop Simulink model of boost converter using fuzzy logic controller

## III. SIMULATION RESULTS

The evaluation of the soft switching boost converter using fuzzy logic controller has been done. The input voltage given is 20 V and the reference voltage was set at 40 V.

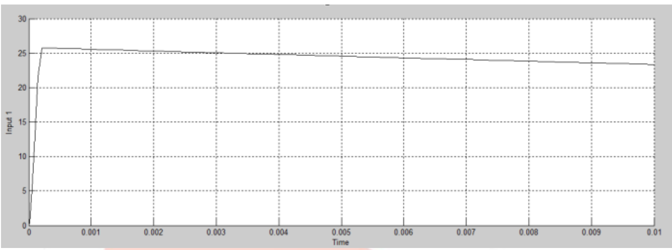

Fig. 8 Output waveform of boost converter using open loop control

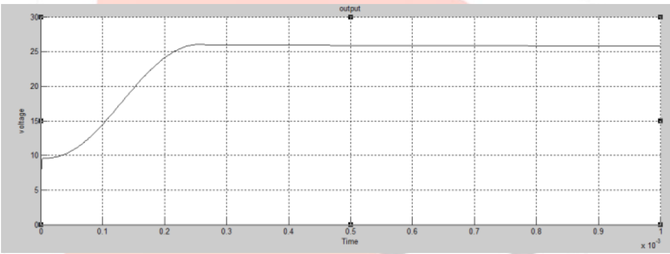

Fig.9 Output waveform of soft switching boost converter using open loop control.

Figure 8 shows the output of the open loop control boost converter. Which gives an output of 25 V for 20 V input voltage. Whereas the figure 9 shows the soft switching boost converter whose output is also about 25 V but the difference is that it have a better performance compared to the first.

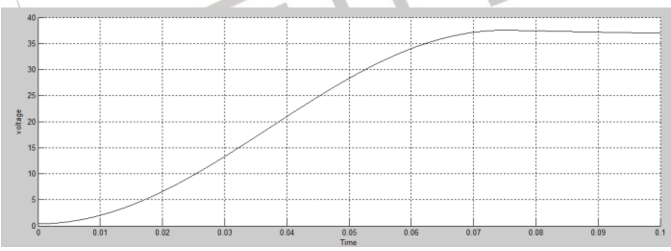

Fig.10 Output waveform of soft switching boost converter using PI controller

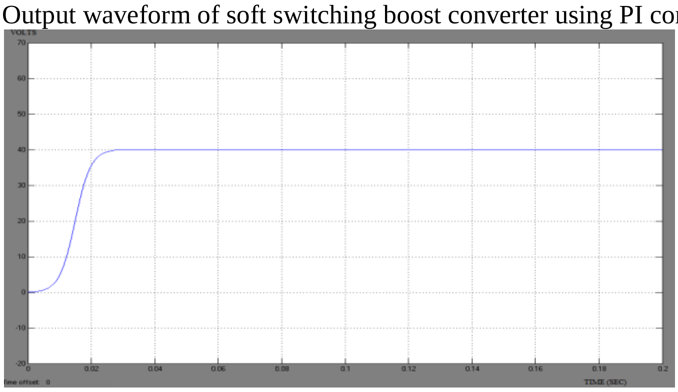

Fig. 11 Output waveform of soft switching boost converter using fuzzy logic controller

In figure 11, the output voltage of soft switching boost converter is approximately 40 V for 20 V input. Whereas for PI controller it gives only 37 V and which is not in a steady state.

## IV. CONCLUSION

Design of a fuzzy logic controller on soft switching boost dc-dc converter by using MATLAB has been successfully realized. It is clear from the analysis that the output of soft switching boost converter using fuzzy logic controller has an improved output compared to the open loop boost converter and soft switching boost converter using PI controller. Thus the fuzzy logic controller is an intelligent controller since it solves many problems irrespective of the stability.

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