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A Novel Fuzzy Based DC–DC Boost Converter with Balanced Output & High Voltage Gain

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Abstract:

A fuzzy based step up converter with high voltage gain is proposed in this paper. The proposed novel topology of the boost converter can provide almost threefold output voltage. In order to guarantee small switching losses and to eliminate the current spikes problem across the switches (which usually exists in classical converter), an inductor is used in the circuit which creates a resonant tank and assist in zero current switching (ZCS). In addition, the efficiency curve of the new converter circuit shows high value for a wide range of output power which is rare in literature. Besides, this proposed topology is free from the circuitry design complexity. In renewable energy systems like photovoltaic panels or fuel cells, where a high step up voltage is required, the proposed converter can bear its suitability.

Introduction:

DEPENDING on the application nature, several types of static power converters are demanded for the adequate conversion and conditioning of the energy provided by primary sources such as photovoltaic arrays, wind turbines, and fuel cells. Moreover, considering that the overall cost of renewable energy systems is high, the use of high efficiency power electronic converters is a must [1].

Fuzzy-boost converter is an intriguing subject from the control point of view, due to its intrinsic non-linearity. DC-DC converter consists of power semiconductor devices which operate as electronic switch. Operation of various switching device causes the inherently nonlinear characteristic to DC-DC converters such as fuzzy-boost converter. Consequently, converter requires controller with high degree of dynamic response. PID controllers are generally used with converters because of its simplicity. However, implementation of this control method to nonlinear system like power converters will suffer from dynamic response of the converter output. One of the design targets for electronic engineers is to improve the efficiency of power conversion. For PWM (pulse-width modulation) converters, switching loss is an important performance measure. Fuzzy logic control has been applied successfully to a wide variety of engineering problems, including dc to dc converters. Fuzzy control is an attractive control method because its structure, consisting of fuzzy sets that allow partial membership and "if-then" rules, resembles

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the way human intuitively approaches a control problem. This makes it easy for a designer to incorporate heuristic knowledge of a system into the controller.

Proposed Methods

Fuzzy-boost converter using fuzzy logic controller is as shown in Fig-1 [3]. It shows the basic connections of the peripherals, along with description of the components such as DC-DC converter, Load, Fuzzy logic controller, PWM generator, Analog to digital converter.

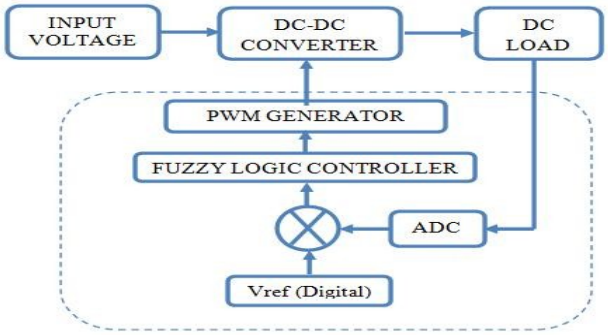

Fig-1: Fuzzy-boost converter using fuzzy logic controller

For specific application where specific output voltage is required at that time fuzzy- boost converter is used. In Fuzzy boost converter output voltage can be to step up and step down output voltage according to the variable duty cycle. Difference between the measured voltage from the Fuzzy-boost converter and reference voltage is taken as the error value. The error signal e(t) is fed forward to Fuzzy logic controller generate the variable duty cycle. Which can generates the required duty cycle for switching MOSFET of fuzzy-boost converter thereby regulating the output voltage.

Fuzzy boost converter

Fuzzy boost converter is the category of DC-DC converter which converts an unregulated DC input voltage to a regulated DC output voltage. It operates by periodically opening and closing an electronic switch, here MOSFET. Fuzzy boost regulator provides an output voltage which may be less than or greater than input voltage hence the name as fuzzy-boost converter. Output voltage has opposite polarity to that of the input voltage. Circuit diagram of fuzzy boost converter is shown in Fig-2.

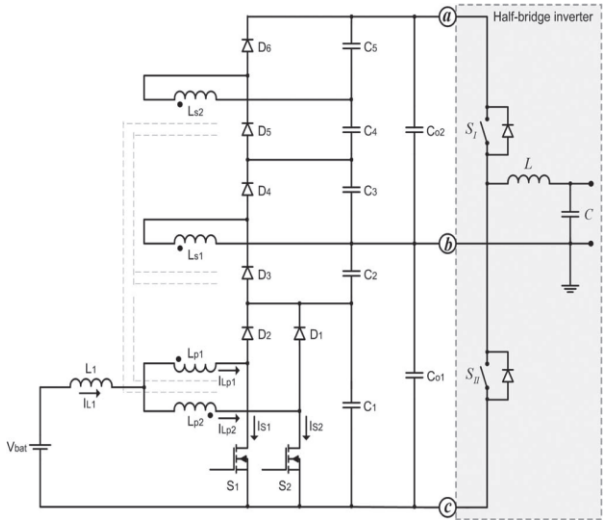

Fig. 1. Fuzzy based DC–DC boost converter using the 3SSC supplying a half-bridge inverter.

Fuzzy Logic Controller

The Concept of Fuzzy Logic was introduced by Lotfi Zadeh (1965), and its mathematical modeling which is deals with uncertainty [7]. It offers an important concept of soft computing with words. It provides technique which deals with imprecision. The fuzzy theory provides mechanism for representation of linguistic terms such as “many,” “low,” “medium,” “often,” “few.” In general, the fuzzy logic provide an inference structure that enable appropriate human reasoning capabilities. Fuzzy logic systems are suitable for approximate reasoning. Fuzzy logic systems have faster and smoother response than conventional systems and control complexity is

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less. The fuzzy inference system combines fuzzy IF–THEN rules for mapping from fuzzy sets in the input space X to the output space Y based on fuzzy logic principle. In fuzzy logic, knowledge representation, fuzzy IF–THEN rule is a technique for capturing knowledge that involve imprecision. The main feature of reasoning using fuzzy rules is its partial matching capability, An inference to be made from fuzzy rule even when the rule's conditions are partially satisfied [8].Block diagram of fuzzy logic controller is shown in Fig-3.

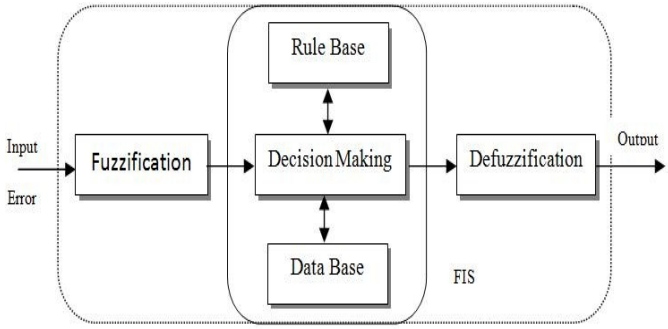
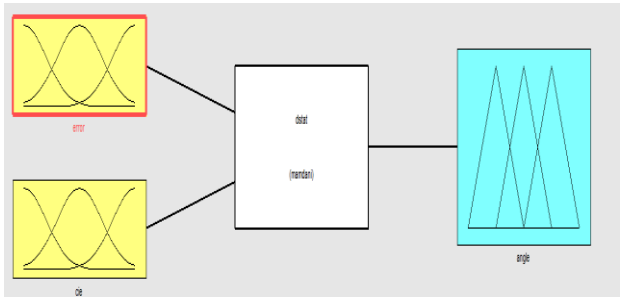


Fig-3: Block diagram fuzzy control system

FLC consists of three components namely fuzzification, fuzzy inference system and defuzzification. In general a fuzzy set issued to express a fuzzy variable which is defined by a membership function. The values of membership function vary between 0 and 1. At the heart of the fuzzy rule base are the IF-THEN rules.

Fuzzification: Fuzzification is the process of convert input data into suitable linguistic values. i.e. convert crisp facts into fuzzy sets described by linguistic expressions. Membership functions are triangle shaped, trapezoidal shaped. There are two fuzzification methods which are used mostly, Mamdani and Sugeno. Plot of membership function for input error and output shown in Fig-4 and Fig-5 respectively.



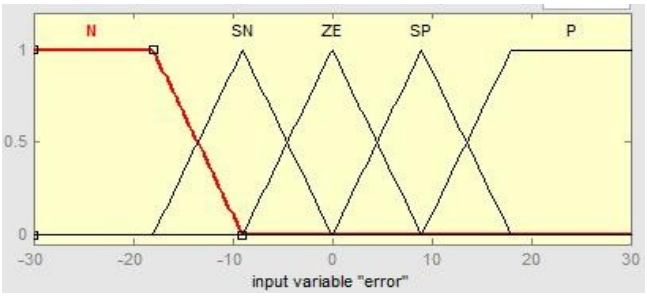
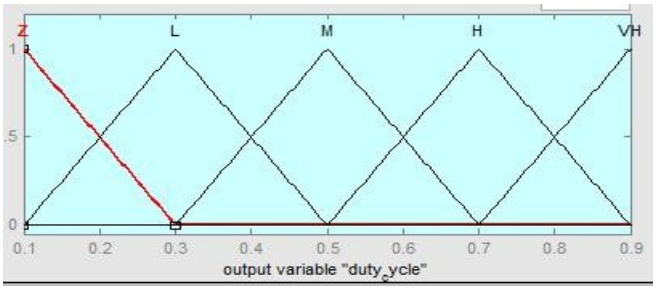


fig-4: Plot of membership function for error



F ig-5: Plot of membership function for output

Fuzzy Inference System: The fuzzy IF-THEN rule expresses a fuzzy implication relation between the fuzzy sets of the premise and the fuzzy sets of the conclusion. The rules IF part describes situation for which rules are designed and THEN part describes the response of fuzzy system. For example. IF the Error is N THEN Duty Cycle is Z.

Defuzzification**:** To obtain crisp output various defuzzification methods can be used e.g., center of gravity, bisector of area, mean of maximum,

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Adaptive integration, Fuzzy clustering defuzzification, First of maximum, Last of maximum, Semi-linear Defuzzification, Quality method, Middle of maximum. To obtain a crisp numerical output value.

Simulation Results

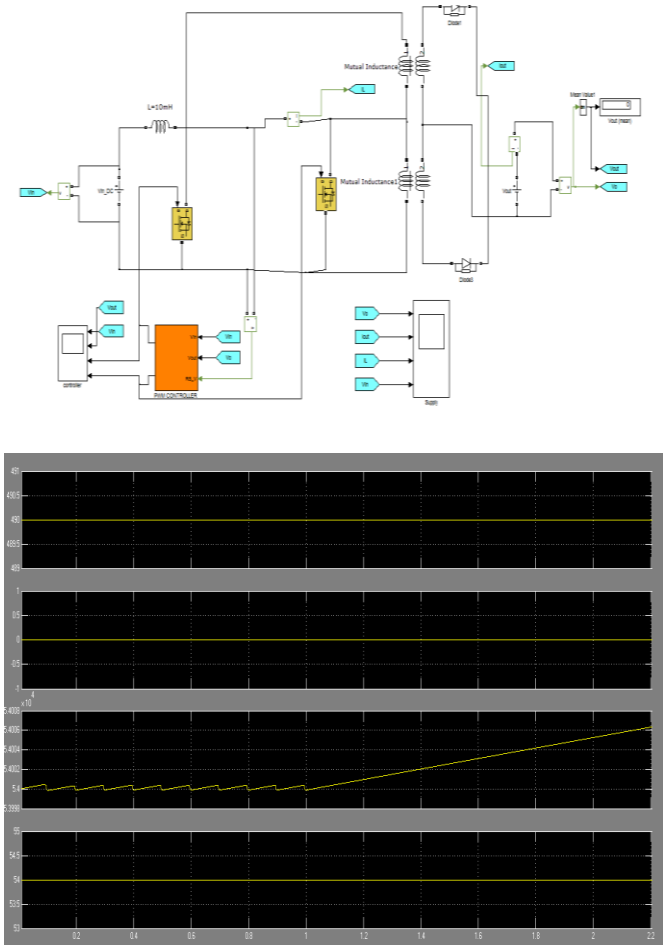

Fig.6 matlab simulation model & voltages & currents at output

Conclusion

In this paper, Analysis of Fuzzy-Boost Converter with fuzzy logic converter is presented. The output voltage of Fuzzy-Boost Converter can be stabilized using variable duty cycle generated by the fuzzy logic controller. Fuzzy-Boost converter with closed loop fuzzy logic controller precisely improved the dynamic response of the system during load as well as source variation with reduced voltage and current ripple. Moreover, the circuit is simpler and much cheaper compared to other control mechanisms where large numbers of components are needed. Finally performance analysis of Fuzzy-Boost Converter with fuzzy logic controller has been done by using of MATLAB-Simulink.

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