

DESIGN AND DEVELOPMENT OF INTERLEAVED BOOST CONVERTER USING FUZZY LOGIC CONTROLLER

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Abstract - This paper describes an intelligent method of maximum power point tracking (MPPT) using fuzzy logic controller for standalone PV system. Here the performance of interleaved boost converter is proposed using MATLAB at simulink software. The fuzzy logic controller is implemented to the system using fuzzy logic control algorithm. The output of open loop and closed loop control interleaved boost converter has been evaluated and compared by software simulation using MATLAB software. The proposed converter module has advantages such as low switcher voltage stress, lower duty ratio and higher voltage transfer ratio.

Key Words: Interleaved Boost converter, Fuzzy Logic controller.

1. INTRODUCTION

The limited availability of fossil energy and increased air pollution has made the researchers to develop clean energy sources. One of the sources is the photovoltaic (PV) power generation system, which is quiet, clean and an efficient method for generating electricity. Now a days, the control system for many electronic appliances has been increased. To meet these demands many designers or researchers have been struggling to find the most economic and reliable controller. The idea to have control system is to ensure that the desired output voltage can be produced efficiently and to reduce the overall cost of the system, high efficiency power processors are used. The power processor usually uses the converter as its energy processing system. Power converters are requiring improvement in which the size and weight has to be especially reduced in mobile information or communication devices, traction converters, power control units for electric or hybrid vehicle, etc. A much larger space is occupied by passive components and cooling devices than semiconductor devices in power electronics building block. When many DGs are connected to utility grids, they can cause problems such as voltage rise and protection problem in the utility grid. In order to solve these problems, new concepts of electric power systems are proposed [1]. The switching losses encountered in PWM converters are eliminated using resonant converters. The switching of active device is done either with Zero Current Switching or Zero Voltage Switching. When the current flowing through

the switch is made zero, it is turned on/off. This is known as zero current switching. Similarly, when voltage across the switch is made zero, it is turned on/off. This is known as zero voltage switching. The main objective of this project is to develop a high-efficiency boost converter with a forward energy-delivering circuit integrated voltage-doubler as an interface for high power applications. The main advantage of the proposed converter is that, it has low switcher voltage stress, lower duty ratio, and higher voltage transfer ratio and high power efficiency.

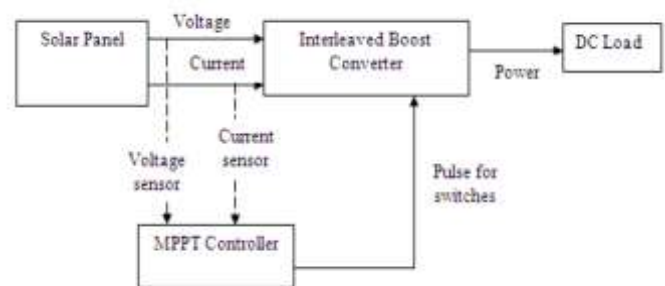


FIGURE 1: Basic block diagram of proposed system

2. INTERLEAVED BOOST CONVERTER

The Interleaved boost converter is gaining its importance. The main function of interleaved boost converter is to combine more than two conventional topologies, and the current in the element of the interleaved boost converter is half of the conventional topology in the same power condition. The efficiency of interleaved boost converters is higher than the conventional single boost converter. In the interleaved boost converter topology, one of the most important operating parameter is the duty cycle D . For the boost converter, the ideal duty cycle is the ratio of voltage output and input difference with output voltage. By interleaving operation, the input current and output voltage ripple of interleaved boost dc-dc converter can be minimized. In addition, the converter input current is shared among the phases, which is desirable for energy dissipation. As the result of this, the converter reliability and efficiency is improved significantly. By using interleaved boost converter,

the ripple present in the input current due to rise and fall of inductor current in boost converter can be eliminated. This method employs phase shifting of the control signals of cells in parallel operating at the same switching frequency. The main advantage of interleaved boost converter is current distribution in which the current in the switches are just a function of input current. So as mentioned earlier, the interleaved boost converters can reduce input current ripple and switching losses.

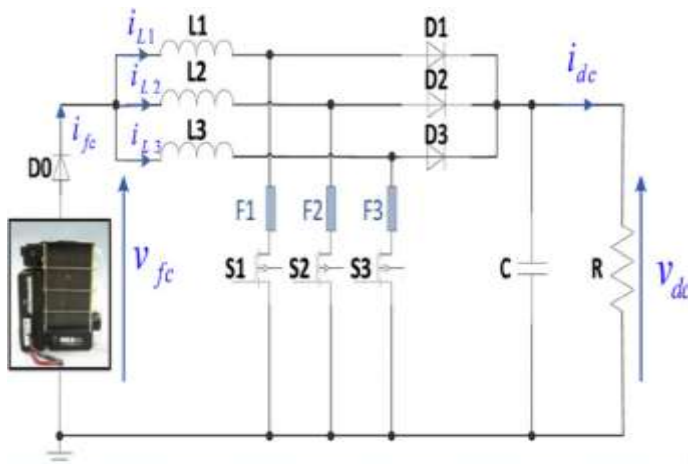


FIGURE 2: Block diagram of ILBC

3. FUZZY LOGIC CONTROLLER

In many industrial control processes, fuzzy logic controllers are successfully implemented as a closed loop feedback control because they have better precision and tracking performance when compared to classical PI, PID controllers. There are four parts in fuzzy logic controller which have been discussed in following subsections.

3.1. Fuzzifier:

The process which converts the crisp data inputs to suitable linguistic membership functions is called fuzzification. There are seven membership functions in FLC namely: NB, N, NS, ZE, PS, P, PB which is assigned to E, CE and D, where NB is Negative Big, N is Negative, NS is Negative Small, ZE is Zero, PS is Positive Small, P is Positive, PB is Positive Big. Among other membership plots, triangular and trapezoidal shapes are commonly used.

3.2. Fuzzy Rules:

Based on experience of system response, fuzzy rules describe the nonlinear control strategy of the boost converter and decided according to their input-output combinations. The table shows the 49 Fuzzy rules which are written in IF-THEN format, shown in matrix form.

E \ CE	NB	N	NS	ZE	PS	P	PB
NB	NB	NB	NB	NB	N	NS	ZE
N	NB	NB	NB	N	NS	ZE	PS
NS	NB	NB	N	NS	ZE	PS	P
ZE	NB	N	NS	ZE	PS	P	PB
PS	N	NS	ZE	PS	P	PB	PB
P	NS	ZE	PS	P	PB	PB	PB
PB	ZE	PS	P	PB	PB	PB	PB

Fuzzy rules table

3.3. Fuzzy inference:

Fuzzy inference is a system which simulates the decision making process using fuzzy rules which are written in the fuzzy inference engine. It is a methodology of mapping of fuzzy or crisp inputs to an output fuzzy sets. The two methods of fuzzy inference are Mamdani and Takagi-Sugeno. The commonly used method is Mamdani which is MAX-MIN method for AND-OR operations. The final fuzzy output is obtained as a combination of all fuzzy consequents after the aggregation process in nonlinear variables. The acceptance of Mamdani is more than Sugeno method.

3.4. Defuzzifier:

The process of transformation of fuzzy output into the crisp value is known as defuzzification. A common way to defuzzify the fuzzy quantities is centroid method. It is also known as centre of mass method. Fuzzy controller generates a fuzzy subset as output. Defuzzification is required, as the actual system requires a non fuzzy value of control.

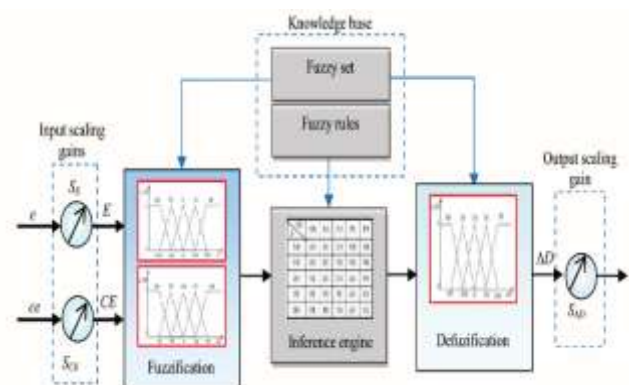


FIGURE 3: FUZZY LOGIC CONTROLLER

4. SIMULATION

The proposed simulink model of interleaved boost converter using fuzzy logic controller is shown in Fig.4. The output voltage and output current are measured by connecting the voltage and current measurement blocks. Using rather than

particular maths equations, it controls the behavior of system with rule sentences which is the major advantage of the application of fuzzy logic in the system. The ripples of output voltage reduced using filter capacitor.

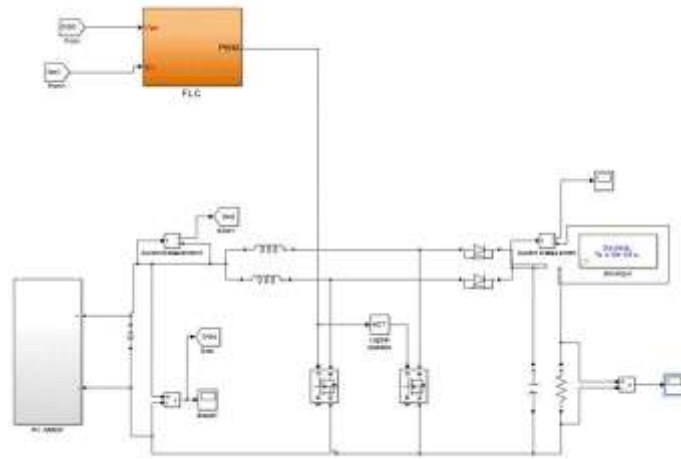


FIGURE 4: Simulation circuit diagram of ILBC using Fuzzy Logic Controller

The simulation result is given below:

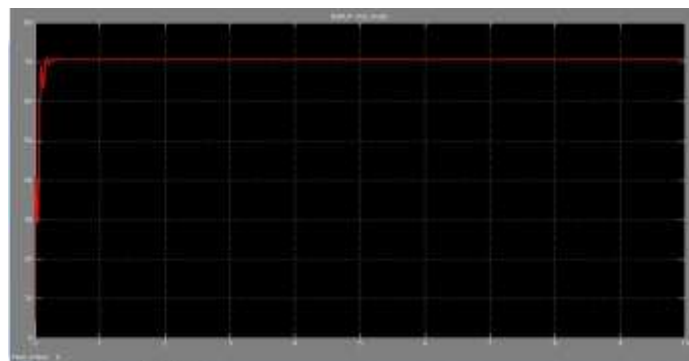


FIGURE 5: INPUT VOLTAGE WAVEFORM

The given input voltage is 70 volts and by using interleaved boost converter, the voltage is boosted to 140 volts.



FIGURE 6: OUTPUT VOLTAGE WAVEFORM



FIGURE 7: OUTPUT CURRENT WAVEFORM

5. RESULT AND DISCUSSION

The input for converter is obtained from solar panel as DC voltage. This voltage of about 70 volts is then fed to the converter. By interleaving principle, the current is split into two parts and the voltage is stepped up to 140 volts which is double the input voltage. The diode and capacitor performs the function of rectifier and filter. The values used in simulation are $R=100\Omega$, $L=100\text{mH}$, $C=2.26\text{mF}$, FET resistance= 0.1Ω , diode resistance= 0.001Ω . The obtained DC voltage is then converted into AC voltage using an inverter. This voltage can be used for any domestic application or it can be connected to the grid.

6. CONCLUSION

In this paper, interleaved boost converter for high voltage and high power application have been proposed. By determining number of series and parallel connection of basic cells, the given output voltage and power level of the optimized circuit can be configured. It leads to flexibility in device selection resulting in high component availability and easy thermal distribution. The simulation results are in line with predictions. Designing, modelling and simulation of ILBC is the scope of this work. The blocks of Simulink are used to develop this model. After this, we can conclude that the interleaved boost converter provides high step up voltage and high power, and it also minimizes the ripples of output voltage and current.

7. FUTURE SCOPE

Simulation of interleaved boost converter is done using fuzzy logic control and it can also be simulated with different types of feedback control like genetic algorithm, artificial neural network and other methods can be used for improving power quality and to get better efficiency. In addition it can be used to check the constant output voltage with least ripple and to support different appliances with different voltage ratings.

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