Design of Enhanced Flyback Converter for PV Application

S.Devi[a], Dr. K.Krishnamoorthi[b] and T.Ilakkia[c]
[a] Department of Electrical and Electronics Engineering, Sona College of technology, Salem-636005, India.
[b]Associate Professor, Department of Electrical and Electronics Engineering, Sona College of technology, Salem-636005, India.
[c]Assistant Professor, Department of Electrical and Electronics Engineering, Sona College of technology, Salem-636005, India.

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Abstract: The necessity of DC converters have been rapidly increasing due to the emergence of RES based electrification. However, the converter designed so far exhibits a drawback of lower efficiency and non-compactness in size. Hence, to rectify this problem, a new topology of flyback converter for PV application. The proposed converter exhibits reduced ripple current at the input side and enhances the conversion efficiency. FLC is tailored to regulate the output voltage. Finally, efficiency of this proposed converter is verified using MATLAB. The results indicate that this projected topology can be suitable for high voltage DC applications.

Keywords: FLC, Flyback converter, PV

1. Introduction

The vast development in industrial field technology has created a greater demand for power. Traditionally, fossil fuels were utilized for power generation. But it will lead to several problems like pollution, depletion of fuels etc.,. Hence, to withstand against this problem, most of the countries in the world has moved towards RES. Among various RES, solar energy plays a vital role because of plenty available in nature. However, the power acquired from PV is not constant and it varies with weather conditions [1-5].

Hence to rectify this problem, huge number of converters were formulated. A high step up (DC) converters were implemented to convert the low voltage to high level according to the need of applications [6,7]. However due to high inrush current, the efficiency gets reduced. Thus to minimize the effect of inrush current, the frequency of the system has to be increased. This reduces the stress over the switches. [8-9].

Apart from this, while implementing this in high gain applications, it suffers an input ripple current / stress (voltage or current) on the switching devices and undergoes higher switching loss while the duty cycle is widened. It also leads to Diode Reverse Recovery (DRR) loss. As a result, there will be decrease in efficiency of the converter. In order to overcome this, the converters with coupled inductance are proposed [10-11].

Hence, this work proposed Soft switched converter with fuzzy controller for PV applications. It comprises of non-isolated coupled inductor in it.

2. Proposed Topology

Figure 1 portrays the schematic diagram of a proposed converter associated with PV panel. Thus, the output of the PV panel is boosted using flyback converter. Here, the controllers are implemented to regulate an output voltage of the system by adjusting the of duty cycle of the converter.

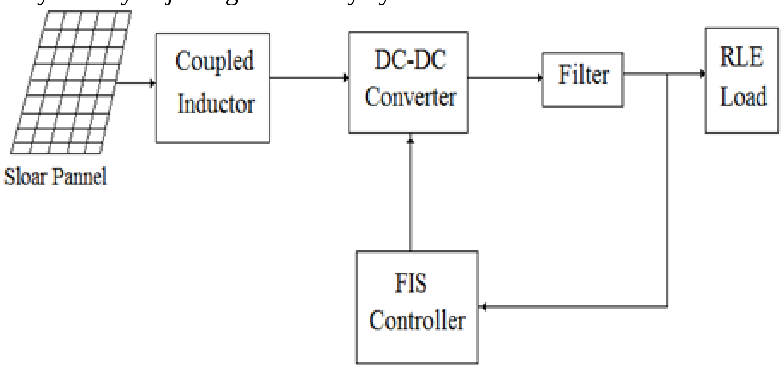

Figure 1. Schematic Diagram of a proposed module

3. Modeling of PV Array

The solar cell is the main part of the PV array. It converts the light energy into electricity. Thus, the configuration of a PV cell is depicted in Figure 2.

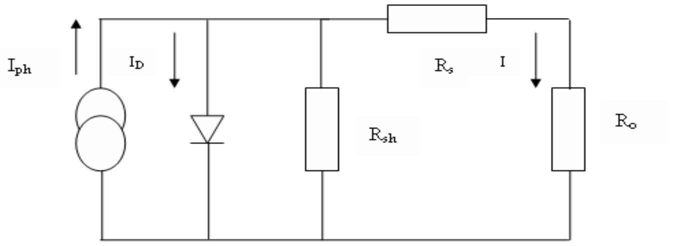

Figure 2. PV cell Configuration

Accordingly, PV power can be

$$P = IV = n_p I_{ph} V[(q/KTA)*(V/n_s)-1] \quad (4)$$

The process of PV system will vary in accordance with the weather condition. Hence a dynamic tracking scheme is necessary to attain maximum power from a PV array.

Maximum Power Point Tracker

MPPT is an electronic system which controls the PV modules so as to harvest maximum power. Hence, to attain maximized power from a PV system, various MPPT algorithms are presented. Among those, Perturb-Observe (PO) and Incremental Conductance (InC) algorithms are extensively used. In this procedure, the voltage from the array is controlled using a controller and the output power is measured. If there is an increase in power, the corrections in that direction are carried out until power remains the constant. This is known as the Perturb and Observe method. It is also identified as a hill climbing method, because it mainly depends upon the increase in value of power against voltage, below the maximum power point. Perturb and observe is the most commonly used MPPT method because to its ease implementation and high efficiency.

Design of converter

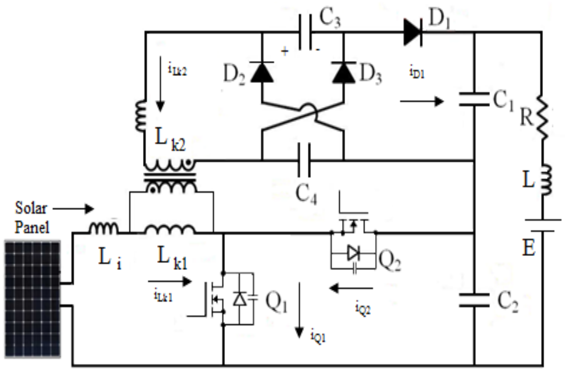

Figure 3. Design of converter

The proposed converter shown in figure 3 combines flyback mode of operation along with boosting technique. A network of step-up switched capacitor is tailored at the secondary side of a converter. Therefore, the switched capacitors boost the input to the twice that of its value.

Thus the operation of proposed Converter is explained below.

During buck mode, Q1 switch and the D2 diode is in ON state whereas during boost mode, Q2 switch and D3 diode is in ON state.

Hence, to improve both the transient and dynamic behavior of this converter, controllers are introduced. As the AI based Controller are recognized as more efficient in Industrial Drive, FLC is employed here to enrich the performance of this converter.

Design of fuzzy logic converter

The flow chart representation of proposed FLC is established in Fig.4.

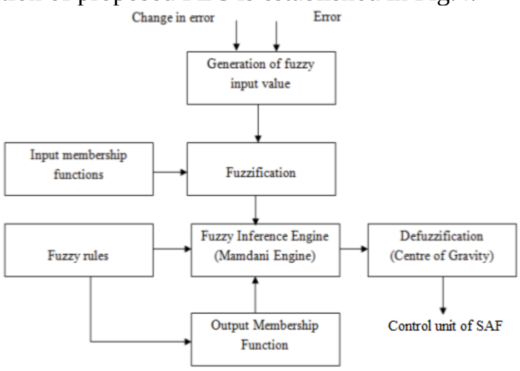

Fig. 4 Flowchart representation of FLC

The FLC implemented in this work is characterized with

− Seven fuzzy sets for each input and output
-- Designed using triangular MF.
− Continuous UoD for Fuzzification.
− Mamdani's 'min' operator for implecations.
− 'Centroid' Method for Defuzzification

Figure 4 depicts the standardized triangular MF implemented for both output and input variables. The knowledge about the system variable is represented in the form 3D surface view in Fig. 4d.

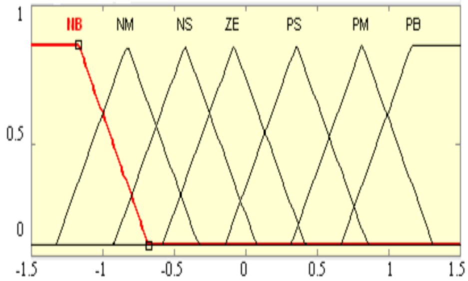

Figure 4a. MF(*e*)

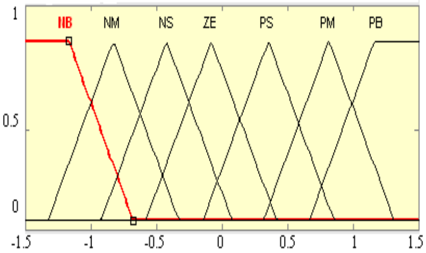

Figure 4b. MF (Δ*e*)

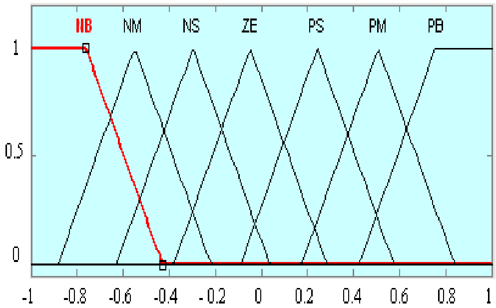

Figure 4c. MF (Δu)

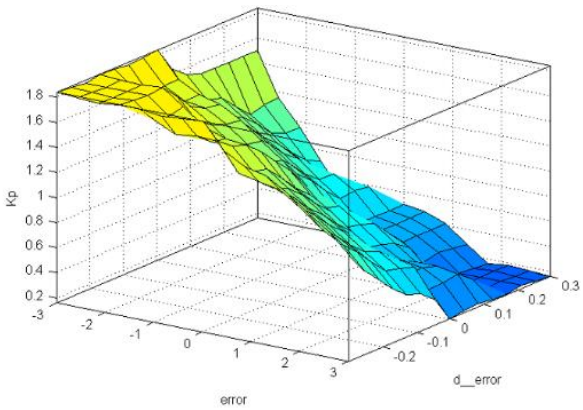

Fig.4d. 3D surface view of proposed FLC

4. Results and analysis

The simulation analysis is approved in MATLAB environment to examine the efficiency of the proposed control.

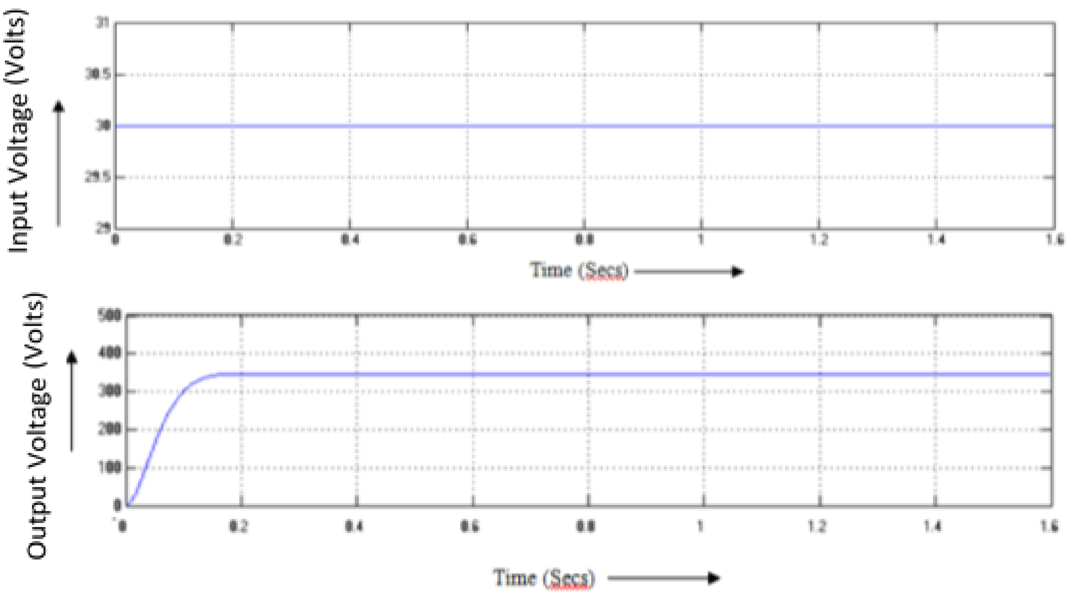

Figure 5. Analysis of proposed converter with Fuzzy controller

Figure 5 displays the response of this proposed converter with FLC. Thus, it maintains the voltage at the constant value at the output side irrespective of the changes in input voltage/load.

Table 1. Performance analysis of this converter

Controller	Ts (Sec)	Steady state error	Ts (Sec)
PID	0.0039	0.98	1.52
FLC	0.0016	0.05	0.78

From the results, it is evident that the settling time will be very less when compared to conventional controllers. At the same time, the fuzzy controller exhibits faster response time with virtually no overshoot which results in improved dynamic performance of the proposed converter.

5. Conclusion

Thus, a soft-switched high gain converter with coupled inductor has been developed in this work. In this topology, with the help of ZVS technique, the efficiency of the converter was enhanced with high voltage gain. In this, the ripple content in the input current is almost zero and hence it is more suitable for PV applications.

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