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High Efficiency Flyback Inverter for PV application using FPGA

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Abstract— In this paper, Field Programmable Gate Array (FPGA) is described to control the Flyback inverter to achieve high efficiency. This paper is described on Discontinuous Conduction Mode (DCM) to control the converter. In flyback converter output voltage is performed in a closed loop using a fuzzy logic algorithm. The fuzzy logic controller acts fast to the changes in the converter output voltage producing good regulation. This control technique offers converter stability for robustness and good dynamic response. This paper also implemented in FPGA Spartan-6 processor for flyback inverter to high efficiency.

Index Terms— Fuzzy logic algorithm, FPGA, Closed loop control, Flyback converter, DCM.

I.INTRODUCTION

Day by day, the problems caused by global warming and pollution effect become the important issues for research. Renewable energy resources are considered as a technological option for generating clean energy. In Photovoltaic (PV) applications for grid connection, conventional PV systems make use of a PV array in which many PV modules are connected in series or parallel to obtain sufficient energy for generating power into AC power. PV system cannot be modeled as a constant DC current source because its output power is varied depends on load current, temperature, and irradiation. To improve efficiency and powerdensity, the DCM and CCM (Discontinuous Conduction Mode and Continuous Conduction Mode)operations of the flyback micro-inverter have been comprehensively analyzed and a hybrid switching strategy has been adopted [1],[2]. In PV ac module system, a flyback inverter (single-phase inverter) is an attractive solution because of the advantages of fewer components, simplicity, and isolation between the PV modules and load [3]**.**To enhance the Performance of P&O (Perturb and Observe)technique and fuzzy logic algorithm to control the Maximum Power Point Tracking (MPPT)to be analysis [4]. Performance of a two-stage grid-tied low-voltage SPV system with efficient quality power injection capability is evaluated [5]. In simulation and experimental result of P&O algorithm has been implemented on FPGA for real time tracking of MPPT of PV system [6]. FPGA hardware for this paper described on fuzzy logic algorithm in flyback inverter for simulation and experimental design.
Fig.1 represents a schematic diagram of flyback inverter.

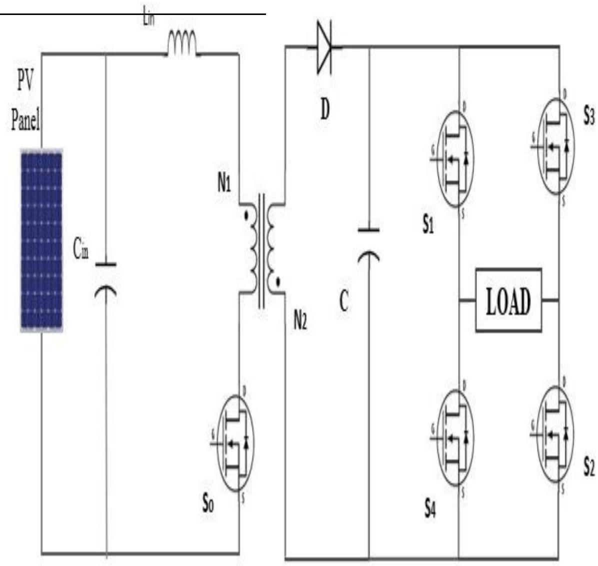

Fig. 1Schematic diagram of flyback inverter

II. PV SYSTEM STRUCTURE& ANALYSIS

The PV AC module system consists of three parts. The first part is the PV module which generally generates output power. The second part is the PV power conditioner for converting Direct Current (DC) power to Alternate Current(AC) power. Finally, the third part is the load that generates 50Hz voltage and current.When switch S_0 is driven by a high frequency Pulse Width Modulation (PWM) signal to conduct current passing through the transformer. Hence, energy is stored in primary side of the transformer, and the output capacitor supplies power to load.

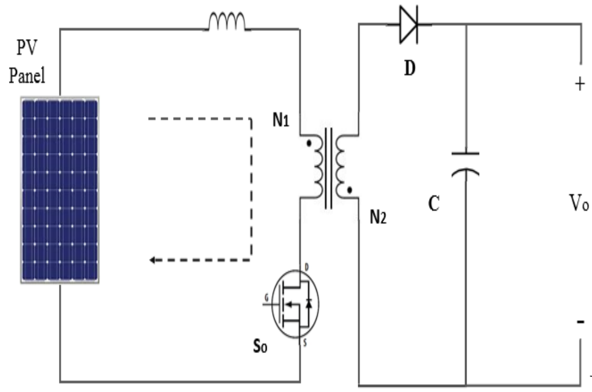

Fig.2

MOSFET-ON state

Fig.2 represents MOSFET-ON state when S_0 is turned on, the panel voltage is conducted through S_0.The primary inductor stores the energy in magnetizing form depending upon the switch S_0 on-off period.

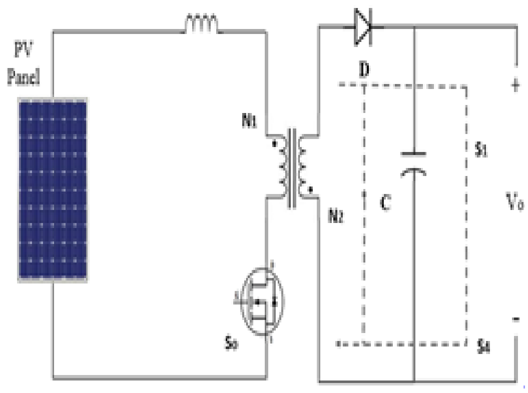

Fig.3

MOSFET-OFF state

Fig.3 represents MOSFET-OFF state when S_0 is turned off, stored energy in the magnetizing branch is transferred to the secondary side of the coupled inductor coil and the diode is rectified and passed to the load by charging thecapacitor. The capacitor charging to boost up the voltage and discharging to the load.

III`. CONVENTIONAL SYSTEM

3.1.Introduction to conventional method

In the conventional method the flyback micro-inverter is used with high efficient adaptive snubber circuit. The soft switching is also used for triggering the switches used in the circuit. The PWM ramp circuit is used to generate the gate pulse.The PWM gate pulse control both the converter and H-bridge inverter circuit. This system preferred hybrid (DCM-CCM) Discontinuous Conduction Mode and Continuous Conduction Mode operation of the flyback micro-inverter. Fig.4 represents simulation diagram for existing method.

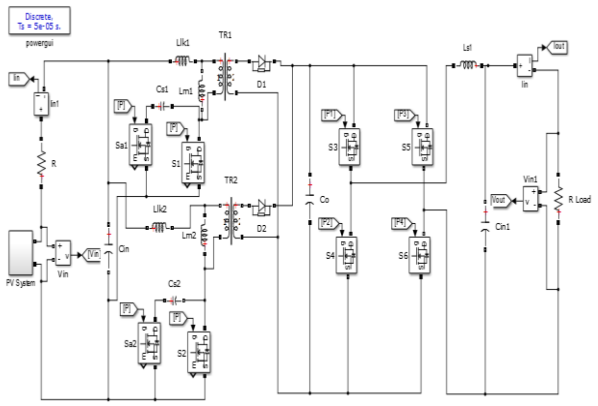

Fig.4 Simulation diagram for existing method

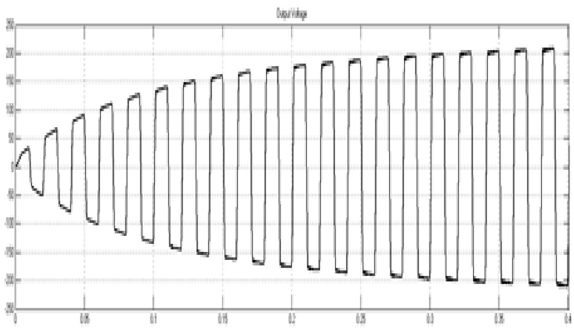

Fig.5.(a) Existing simulation output voltage waveform

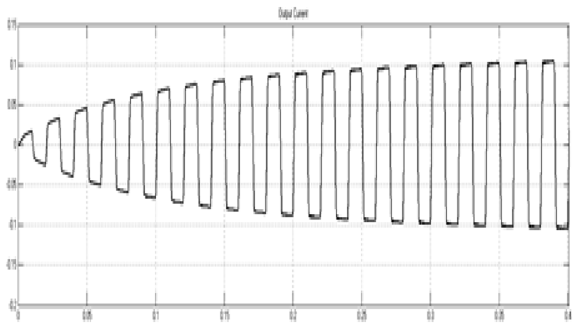

Fig.5.(b) Existing simulation output current waveform

Fig.5.(a&b) respectively presents existing simulation output waveform. It contains more harmonics and ripples.

3.2. Disadvantages

This method has larger size due to more number of switches. It produces harmonics and ripples.

IV.PROPOSED SYSTEM

The proposed Fuzzy logic control based Flyback inverter has been modeled and simulated using MATLAB/Simulink.The proposed fuzzy logic control system is a closed loop to improve the system performance. The advantages of the system to reduce the components and switches. Therefore,reduces the inverter size and cost.

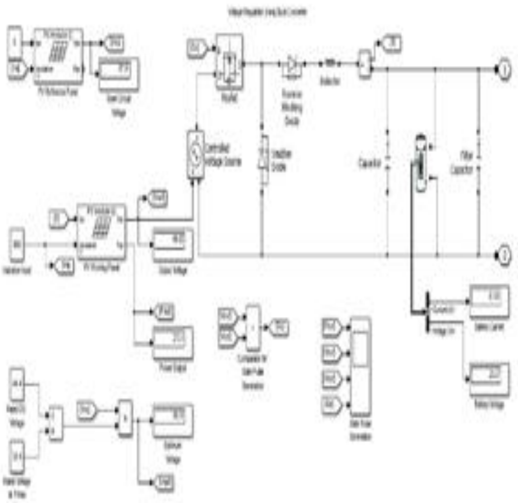

Fig.6 PV simulated modeling block

Fig.6 represents simulated pv modeling block to photovoltaic equivalent is generated dcvoltage.

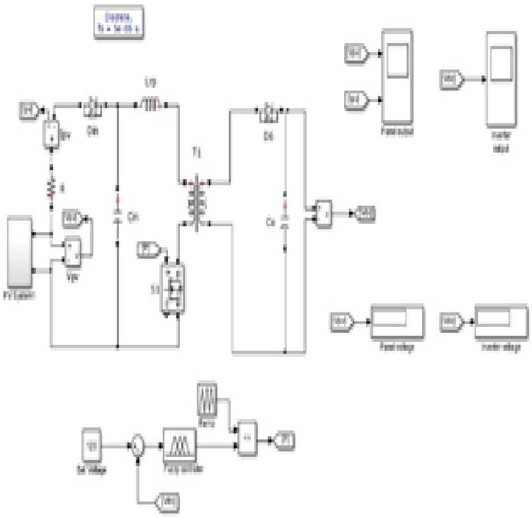

Fig.7 simulated flyback converter

Fig. 7 presents simulated flyback converter. The flyback converter switch S_0 is controlled by using fuzzy logic control pulse.

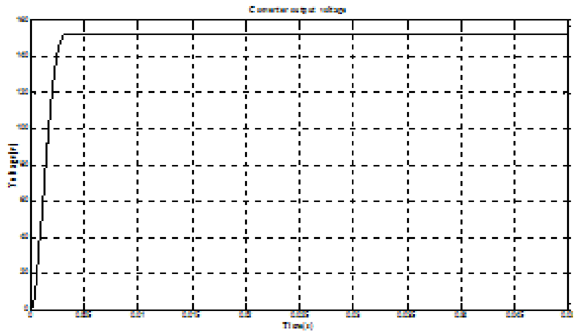

Fig.8 Converter output voltage waveform

Fig.8 represents converter output voltage waveform the voltage gradually increases and maintain constant voltage.

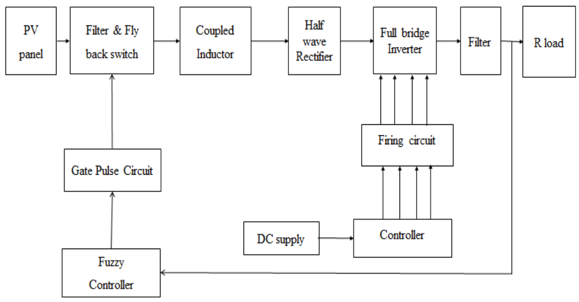

Fig.9 Block diagram of proposed system

Fig.9 represents block diagram of proposed system

4.1. Proposed system for R load

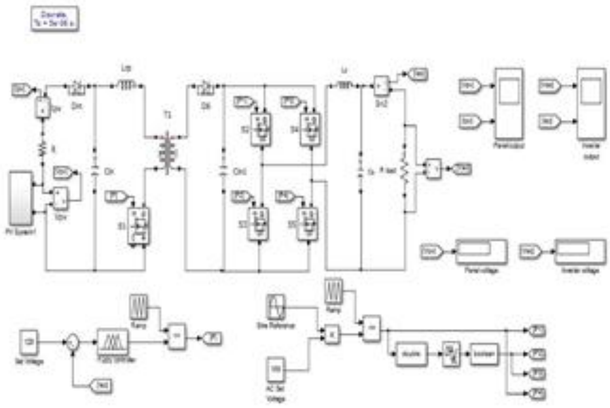

Fig.10 Proposed simulation diagram for R load

Fig.10 represents proposed simulated diagram for R load.The PV panel is produce the dc voltage to the flybackconverter. The converted voltage is passed to the inverter.The inverted voltage to the R load. The fuzzy logic control pulse is given to the converter switch and ramp signal is control the inverter circuit.

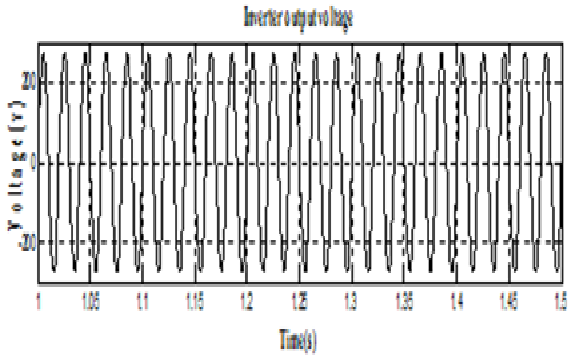

Fig.11.(a) Proposed simulated output voltage waveform for R load

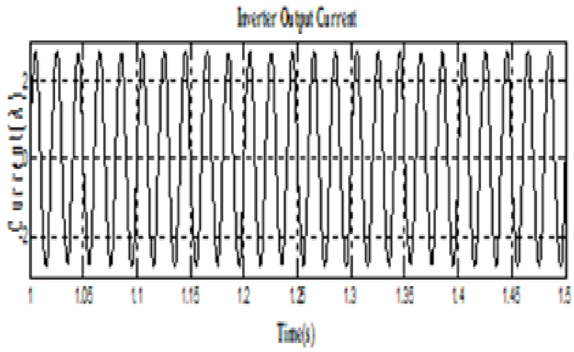

Fig. 11.(b) Proposed simulated output current waveform

Fig.11 Proposed simulation output waveform for R load (R=100ohm)

The inverter voltage is a sinusoidal wave. In R load, the inverter voltage and current isinphase.In R load, harmonics and ripples are mitigated.

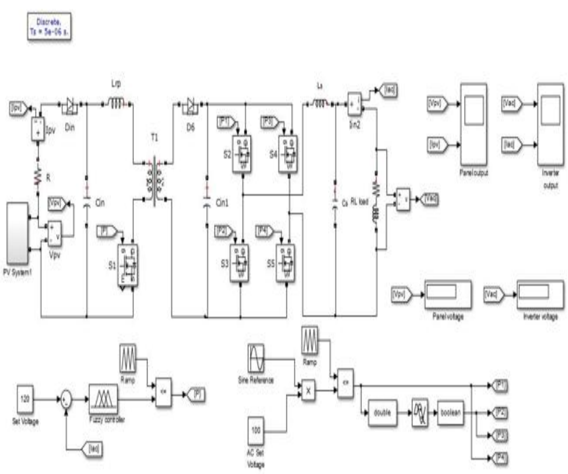

Fig.12 Proposed simulated diagram for RL load

Fig.12 represents proposed simulated diagram for RL load.

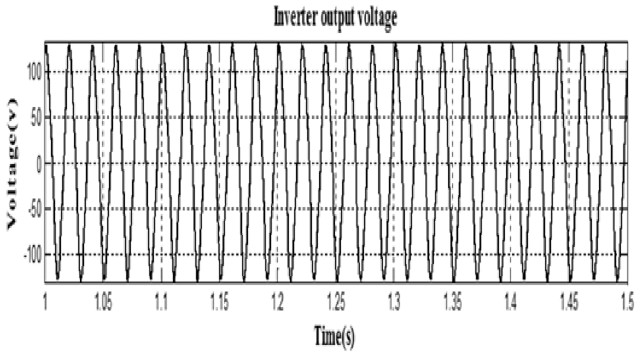

Fig.13.(a) Proposed simulated output voltage waveform for RL load

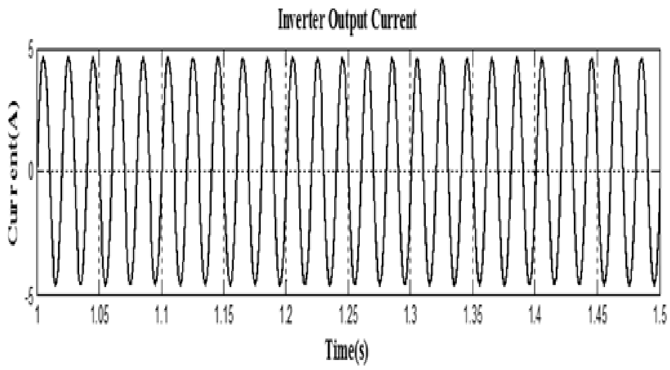

Fig.13.(b) Proposed simulated output current waveform for RL load

The RL load in the output voltage and current is does not ininphase.

4.2. FUZZY CONTROL SYSTEM DESIGN

In photovoltaic power generation system, you can use the fuzzy control to track the maximum power point of photovoltaic. Fuzzy controller structure is shown a fig. The design of fuzzy logic controller mainly include the following elements.

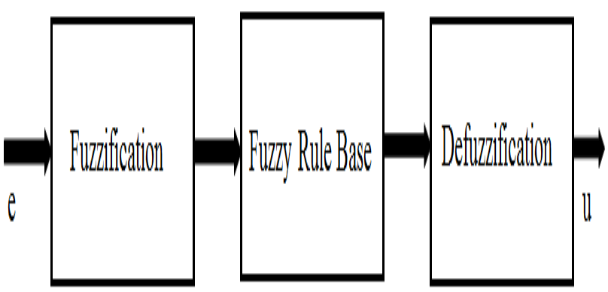

Fig.14 Fuzzy logic control

1) Fuzzification: The input exact value will be converted into the

blur value including external reference input, the systems output.

2) Fuzzy rule base: The formed rule and reference value is compared.

3) Defuzzification: The role of defuzzification is to transformat the amount of fuzzy reasoning to the actual control amount.It contains the amount of fuzzy control transformat to the defuzzification volume will be clear definition transformationandvolume will be clear by the transformation to the actual amount of control.

TABLE.1.FUZZY RULE TABLE

E \ CE	NB	NS	Z	PS	PB
NB	Z	PS	PB	PB	PB
NS	NS	Z	PS	PS	PB
Z	NB	NS	Z	PS	PB
PS	NB	NB	NS	Z	PB
PB	NB	NB	NB	NB	Z

The fuzzy logic is compared with this rule table based.

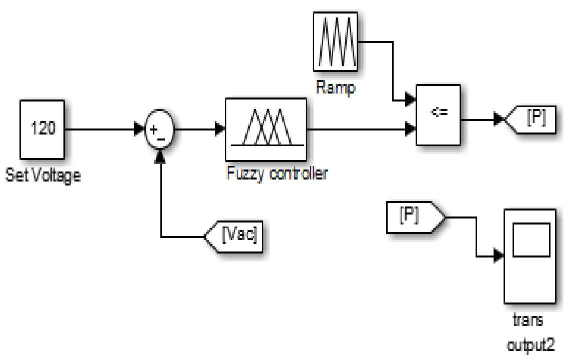

Fig.15 Fuzzy control circuit

Fig.15 Fuzzy control circuit it is a compare the set value and output. The ramp signal is combined to get the control pulse.

4.3. FPGA SPARTAN-6

Spartan-6 FPGA Xilinx Spartan-6 FPGA offers advancedpower management technology.The Xilinx, Spartan-6 FPGA family delivers an optimal balance of low risk, low cost, low power, and performance for cost-sensitive applications. These FPGAs use a proven low-power 45nm process technology. Also, the Spartan-6 series offers an advanced power management technology, up to 150k logic cells, integrated PCI Express® blocks, advanced memory support, 250 MHz DSP slices, and 3.2 Gbps low-power transceivers.

4.4. FEATURES OFFPGA SPARTAN-6

The FPGA Spartan-6 is high performance, high power and input output optimized for cost-sensitive applications.

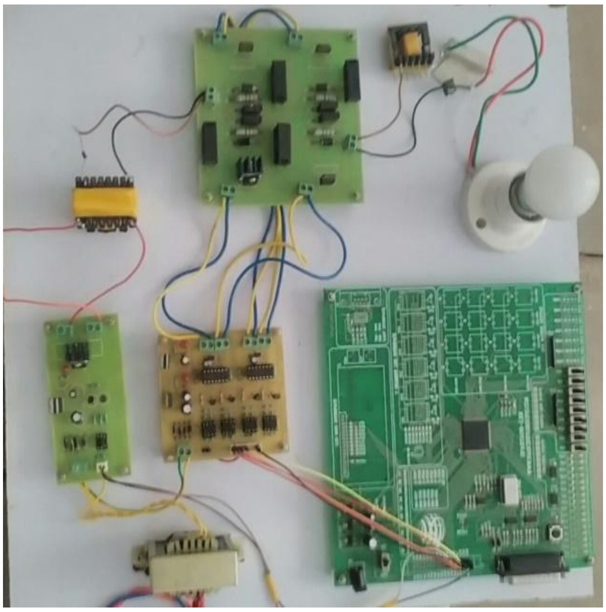

Fig.16 Hardware prototype photo

V.CONCLUSION

Thus the project can be concluded that, good dynamic response, improved efficiency and better regulation can be obtained by using fuzzy logic in FPGA.

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