ISSN- 2394-5125 VOL 06, ISSUE 04, 2019

A SINGLE STAGE CCM ZETA MICROINVERTER FOR SOLAR PHOTOVOLTAIC AC MODULE

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Abstract: Microinverter mounted on each photovoltaic (pv) panel, i.e., microinverter is gaining polarity due to increased energy harvest. This paper proposes a novel single stage zeta microinverter for PV application. The proposed topology is based on zeta converter with high frequency (HF) transformer isolation and a single low side switch on the primary side of transformer. The most distinctive feature of the proposed inverter is its ability to work in continuous conduction mode (CCM) over a wide load range, which results in high efficiency, reduced current stress, and components rating. All the secondary switches operate at line frequency, thus reducing switching losses significantly. A comprehensive study of the proposed microinverter including steady-state analysis and design has been reported. A 220 W microinverter was designed, developed, and tested in the laboratory. Experimental results are demonstrated to verify the CCM operation of the inverter and its performance over a wide load range.

Index Terms— Photovoltaic, Microinverters & Continuous-Conduction Mode

1. INTRODUTION

To address the growing concern of depletion of fossil fuels,energy cost and co_2 emission, higher penetration of renewable energy source into the grid is encourage amoung various renewable energy sources, solar is most abundant form of energy. Series connected PV panels with a single large inverter (string inverter) can be used to feed power into the grid with a common maximum power point tracking (MPPT). However, this is an inefficient way of harvesting energy because individual MPPT of solar panels is not done. A panel mismatch, shading or formation of debris will reduce the energy harvest significantly. To solve the above-mentioned problem, the concept of microinverter is picking up. Microinverters are attached at the back of a PV panel and directly generate ac with MPPT. Improving the efficiency, reducing number of power conversion stages, and scalability are major design considerations.Among various microinverters reported in literature, the

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used in the front-end to track mppt and to boost the voltage while second stage pulse width modulated (pwm) inverter convert dc to ac. The major drawback of this type of inverters is the components count and cost.Non-isolated microinverters are simple and compact, but boosting the voltage to the grid level without transformer is a major concern. Third kind is single-stage microinverters where all three tasks i.e. mppt, voltage boosting and dc to ac conversion are done in one stage. Such microinverters are very promising due to reduced switch count and high power density. Other type of microinverters utilize active power decoupling that enables the use of thin film capacitors instead of electrolytic capacitors to increase the life span of the microinverter. However, this comes with an additional cost and relatively low efficiency.Third kind is single-stage microinverters where all three tasks i.e. MPPT, voltage boosting and dc to ac conversion are done in one stage. Such microinverters are very promising due to reduced switch count and high power density .DCM mode of operation leads to higher inverter losses, current stress and component rating compared to CCM operation. This is due to the control complexity caused by the right half plan (RHP) zero when flyback converter is operated in CCM. To address the problems in fly back inverter and to achieve CCM operation with a moving RHP zero, Li & Oruganti proposed control strategies and demonstrated significant efficiency improvement. However, designing controller with a moving RHP zero is always a challenge. Modeling of zeta dc/dc converter and parameter selection to eliminate RHP zero was earlier reported. It is concluded that zeta converter can achieve higher bandwidth, and good closed loop stability. A DCM mode zeta converter based inverter was earlier reported. The inverter power rating was limited to 80W. Low switching frequency (20 kHz) operation resulted into a larger filter and transformer. In this paper, a novel single stage CCM zeta microinverter is proposed with a single primary switch and four secondary switches working as LFI. The objectives and layout of the paper are as follows: Steady state operation and analysis of zeta microinverter are explained , Key design considerations and Experimental results are demonstrated and discussed. S.

B. Kjaer , J. K. Pedersen This review focuses on inverter technologies forconnecting photovoltaic (PV)modules to a single-phase grid. Theinverters are categorized into four classifications: 1) the numberof power processing stages in cascade; 2) the type of powerdecoupling between the PV module(s) and the single-phase grid; 3)whether they utilizes a transformer (either line or high frequency)or not; and 4) the type of grid-connected power stage. Various invertertopologies are presented, compared, and evaluated againstdemands, lifetime, component ratings, and cost. Finally, some of the topologies are pointed out as the best candidates for eithersingle PV module or multiple PV module applications. Vuthchhay, E Bunlaksananusorn This paper presents the designing and performance of DC-DC SEPIC (Single Ended Primary Inductance) converter (in continuous conductance mode) driven Light emitting

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diode(LED) Lamps powered by Photovoltaic (PV) System. Since the efficiency of PV system is low, thus Maximum Power Point Technique is employed to maximize the power and to improve the efficiency. The mathematical model of the PV array is developed and transformed into MATLAB/Simulink and Incremental Conductance (InC) algorithm is implemented to improve the performance of PV system. The MPPT algorithm generates proper duty ratio for interfacing DC-DC SEPIC converter driving LED Lamps with PV system.

ZETA CONVERTER

A zeta converter is an electronic circuit which converts a source of direct current (DC)from one voltage level to another. It is a Switched DC - DC converter which provides a regulated and stepped up output voltage.It is widely applied to maximize the energy harvest for photovoltaic systems and for wind turbines,hence they are called power optimizers.In this paper, ZETA converter is designed controlled using a PI controller and the corresponding output response is simulated using MATLAB software. Also the response of ZETA converter when it is subjected to line and load variations is simulated. The benefits of the ZETA converter over the SEPIC converter include lower output-voltage ripple and easier compensation. The ZETA converter topology provides a positive output voltage from an input voltage that varies above and below the output voltage. The ZETA converter needs two inductors and a series capacitor, sometimes called a flying capacitor. Unlike the SEPIC converter, which is configured with a standard boost converter, the ZETA converter is configured from a buck controller that drives a high-side PMOSFET. The ZETA converter is another option for regulating an unregulated input-power supply, like a low- cost wall wart. To minimize board space, a coupled inductor can be used. The proposed drive system is designed for zeta converter as pfc converter fed bldc motor drive operating in DICM. The output inductor value is selected such that the current remains discontinuous is a single switching cycle.

2. DESCRIPTION

The ZETA converter topology provides a positive output voltage from an input voltage that varies above and below the output voltage. The ZETA converter needs two inductors and a series capacitor, sometimes called a flying capacitor. Unlike the SEPIC converter, which is configured with a standard boost converter, the ZETA converter is configured from a buck controller that drives a high-side PMOSFET. The ZETA converter is another option for regulating an unregulated input-power supply, like a low- cost wall wart. To minimize board space, a coupled inductor can be used. Similar to the SEPIC DC/DC converter topology, the ZETA converter topology provides a positive output voltage from an input voltage that varies above and below the output voltage.

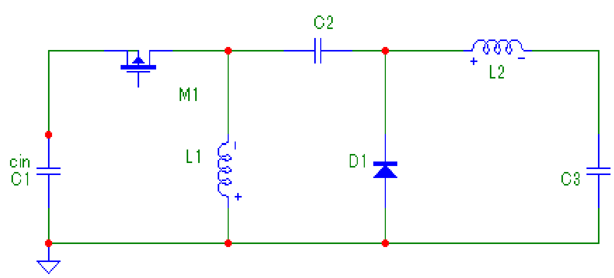

Fig 1 Zeta Converter –Basic Circuit Diagram

The ZETA converter also needs two inductors and a series capacitor, sometimes called a flying capacitor. Unlike the SEPIC converter, which is configured with a standard boost converter, the ZETA converter is configured from a buck controller that drives a high-side

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PMOS FET. The ZETA converter is another option for regulating an unregulated input-power supply, like a low-cost wall wart. This article explains how to design a ZETA converter running in continuous-conduction mode (CCM) with a coupled inductor**.** When the switch S is "on", and the diode D is "off". This region takes the time from 0 to d1 TS seconds. The inductor Lm stores the energy received from the rectifier. The capacitor C1 supplies energy to the load (R) via the inductor Lo, and the capacitor Co the currents

through the inductors Lm and Lo increase linearly, while no current flows through the diode. When the switch S is "off", and the diode D is "on". This region begins at the time d1 Ts seconds, and ends by d2 Ts seconds. The diode D is forward biased due to the voltage across the inductor Lm has reversed polarity, while the currents ILm and ILo decrease linearly. The stored energy in the inductor Lm is transferred to the capacitor C1. The load R receives energy from the inductor Lo. Hence, the current iD=iC1+iLo.

3. PROPOSED SYSTEM

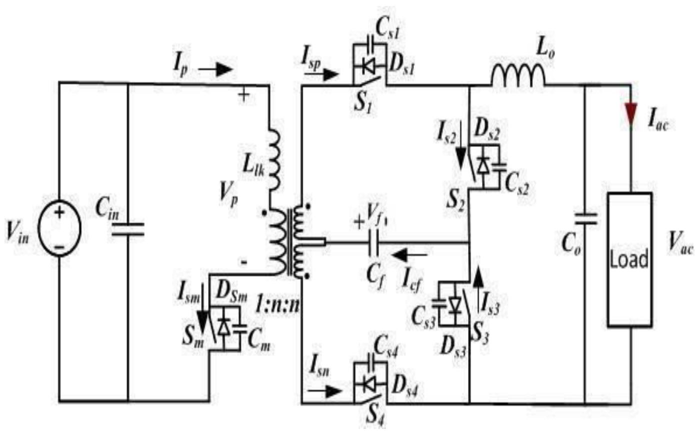

Fig.2 Proposed System circuit Diagram Operation of zeta microinverter is explained for the positive half cycle of load current at switching frequency. The main switch *sm* is modulated at high frequency (hf) with a variable duty cycle to generate rectified ac output and secondary switches *s*1 - *s*4 are operated at line frequency to produce ac output at line frequency. On the secondary side, during positive half cycle of load current switches *s*1, *s*3 are gated to conduct and during negative half cycle of load current, switches *s*2, *s*4 are gated to conduct. Steady-state operation of the proposed microinverter in dcm and ccm mode of operation is analyzed.

4. SIMULATION ANALYSIS AND RESULT

In this chapter the objective of the project is implemented through modelling of microinverter in MATLAB simulink. The necessary simulation diagram and output waveform are detailed**.**

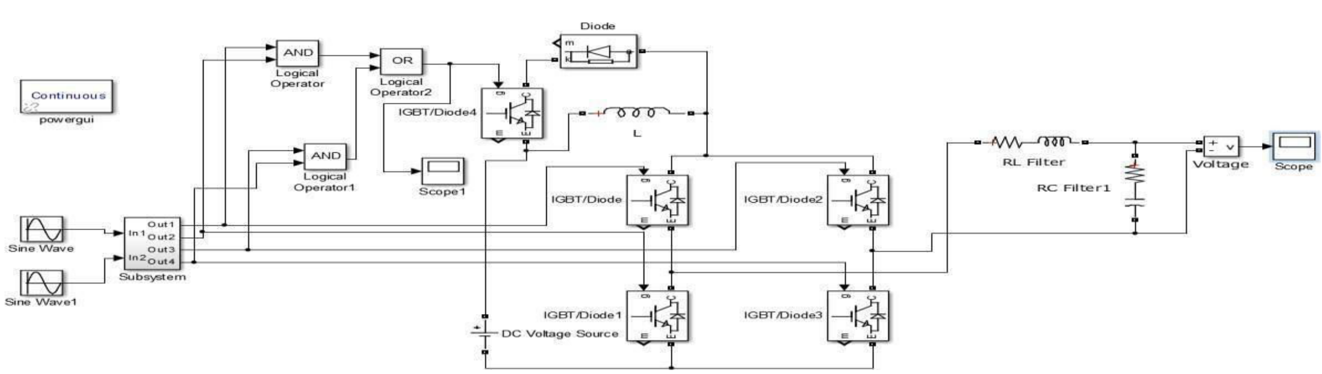

Fig.3 Simulink model of proposed system

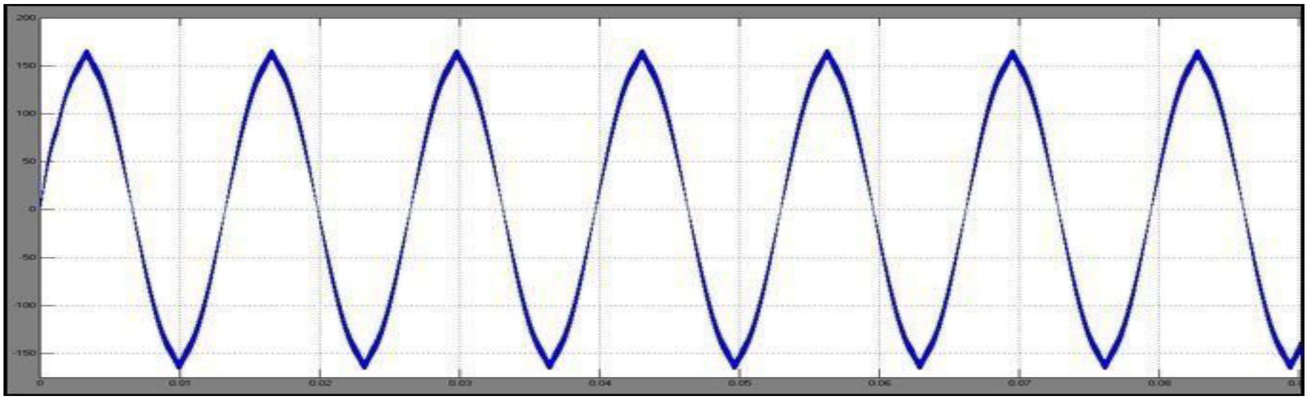

Fig.4 Sinusoidal Output Voltage

HARDWARE IMAGE

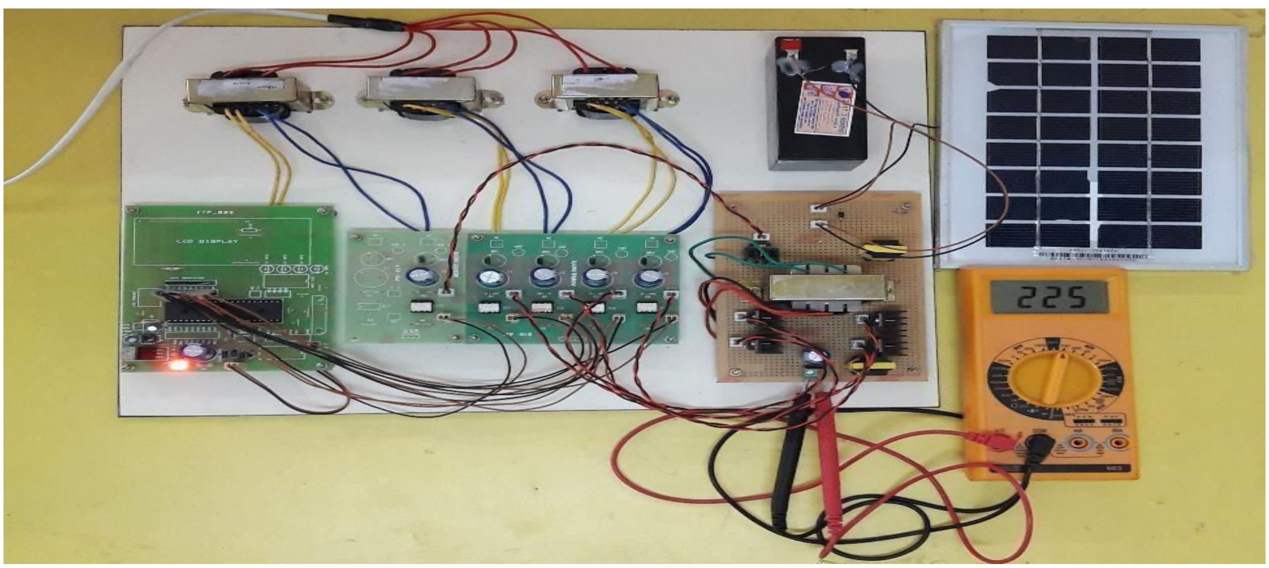

Fig 8.1 Hardware Image

5. CONCLUSION

A single stage novel CCM zeta microinverter has been proposed for solar PVAC module. Steady-state operation and analysis of proposed zeta microinverter in both DCM and CCM has been studied. Microinverter operation in CCM mode results in reduced conduction losses, switch ratings and current stress. Traditional CCM mode flyback inverters have closed loop complexity and stability issues. The proposed inverter provides HF isolation and has only a single switch operating at HF which will reduce the switching losses. The circuit is simple and easy to develop. Critical factors to consider while designing the inverter have been discussed and studied. A 220 W inverter prototype has been developed and tested in the laboratory to validate the claims, proposed operation and design. The laboratory prototype has a peak efficiency of 93% at rated power of 220 W

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