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UTILIZATION OF WIND ENERGY USING NOVEL POWER ELECTRONICS CONVERTER FOR STAND-ALONE SYSTEM

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Abstract:

This paper narrates the working of a certain type of buck boost converter. This converter is named as Zeta converter. Zeta converters are widely used in renewable energy conversion systems. It is also known as inverse SEPIC converter since it can do the inverted operation of a SEPIC converter. The scope of this paper is to design a highly efficient Zeta converter for a 1KW wind energy conversion system. Here the DC output from an inverter is fed as the input which is variable. Further the variable DC is converter into fixed DC of the required voltage by this zeta converter. This is a fourth order DC to DC converter consisting of two inductors and two capacitors. The non-pulsating current output of the converter permits to the use of small capacitors at the output for satisfying the requirement of load voltage ripple. A PID controller corrects the error between a measured value and a desired set value by processing and finding then taking a corrective action by adjusting the process as per the requirement. The zeta converter is capable of doing both step up and step down operation. Here they are used for converting variable DC of 24V to fixed DC of 24V and is further fed to the battery storage.

Keywords **—Zeta Converter, Continuous Conduction Mode (CCM), Total Harmonic Distortion (THD), Power Factor Correction (PFC), MATLAB.**

I. INTRODUCTION

The conventional rectifier which is used to convert AC voltage to DC voltage uses a very large capacitor which has the limitations such as lower order harmonics injection, power factor reduction, high peak current, extra burden on lines, extra losses and distortion of line voltage. The solid state rectifiers used the power factor correction (PFC) and total harmonic distortion (THD) techniques to improve the power quality, but in this case controlling the output voltage at the same time improving the PFC has become difficult. In the application of power system there are so many limitations especially in basic DC-DC converter. Boost converter and Buck-Boost converter have their intrinsic limitations when used for active

power factor correction along with voltage regulation purposes. To maintain power quality with good improvement with respect to harmonic reduction, PFC etc and also the output voltage is controlled. A non linear non - inverting forth order converter called Zeta converter can be operated as buck as well as boost converter. Thus we can use the wind energy conversion system for the input to the zeta converter, as the renewable energy is more popular. The AC output from the wind mill is converted to DC by a three phase rectifier to fulfil the requirement of DC input to the zeta converter. Gate pulse is given by the Driver circuit to turn ON the MOSFET. The output is connected to the battery. We can use many types of converters in the place of zeta converters, but they have certain limitations such as buck converter is not capable of handling inrush current and protecting against over load, Boost converter in only increase the output voltage and have less protection circuits, CUK and SEPIC converter needs additional circuit to limit the inrush current.

II. EXISTING SYSTEM

There are several converters available in the market for the conversion of variable DC to fixed DC.A Buck converter is a DC to DC converter of switch mode whose output voltage can be converted to a level less than the input voltage. The magnitude of the output voltage depends on the duty cycle (Ton/T) of the switch. It is also known as step down converter. There are certain drawbacks in buck converter, Input current and charging current of the capacitor at the output is discontinuous resulting in large sized filters. The output is inverted which introduces complexity in the sensing the polarity. The efficiency is poor for high gain implies for very small or large duty cycle.

A boost converter is a DC to DC converter with an output voltage greater than the input voltage. A boost converter is also called a step-up converter since it steps up the input voltage. There are certain drawbacks in boost converter, Large output capacitor is required to reduce ripple voltage since the output current is pulsating. Transient response is very slow and difficult feedback loop compensation due to presence of right half zero in continuous conduction mode of the boost converter.

The buck–boost converter is a DC-DC converter that can produce an output voltage with magnitude either greater than or lesser than the input. It is similar to a flyback converter using a single inductor instead of a transformer circuit. Following are the drawbacks of Buck Boost Converters, Input current and charging current of output capacitor is discontinuous resulting in large sized filters. Output is inverted which introduces complexity in sensing the output. As sensed voltage is negative, inverting operational amplifier is necessary for feedback and closed loop control. High gain is difficult to achieve with this converter type as efficiency is poor for high gain. There is no isolation between the input side and the output side which is critical for many applications. Transfer function of the converter contains right half plane as zero which introduces complexity in control. Hence it is very difficult to control such type of converter.

SEPIC is the Single-Ended Primary Inductor Converter. Although Buck-Boost converter is capable of both stepping up and stepping down the input voltage, its output voltage is negative with respect to ground whereas in SEPIC converter positive voltage is obtained at the output. There are certain drawbacks in SEPIC converter , the SEPIC has a pulsating output current. The SEPIC converter transfers all its energy through the series capacitor, a capacitor with high capacitance and current handling capability is needed. The 4th order nature of the converter makes it difficult to control therefore it is suitable only for very slowly varying application.

The CUK converter is also a type of DC to DC converter that can produce an output voltage with magnitude either greater than or lesser than the input voltage. It is possible to side by side eliminate the ripples in both the inductors of the CUK regulator completely, leading to lower external filtering. However a major drawback of this converter is the requirement of a large capacitor with large current carrying capacity.

III. PROPOSED SYSTEM

In the proposed module a relatively new class of DC-DC converter, consists of the MOSFET switch, two inductors (L_1 & L_2), two capacitors (C_1 & C_2) and Diode (D) and a load resistor (R). For switching condition like ON & OFF, the system in operating under continuous conduction mode (CCM), where the inductor current must follow a sinusoidal voltage waveform to active power factor correction (PFC). The zeta converter is a converter which performs non inverting SEPIC operation, but in high power applications, the converter when operated in discontinuous mode produce high RMS value of current causing high levels of stress in Semiconductors. The zeta converter is connected to the PMSG fed wind energy conversion system. Since the output of wind is alternating in nature it is connected to the three phase rectifier to convert the AC to variable DC. The proposed zeta converter will convert the variable DC to fixed DC that can be stored in battery.

IV. PRINCIPLE OF OPERATION

The components of the zeta converter are a MOSEFT Switch, 2 Capacitors (C_1 & C_2), 2 Inductors (L_1 & L_2), a Diode D and a load resistor (R_1).The working of the zeta converter is divided into two parts i.e. the mode 1 operation and the mode 2 operation.

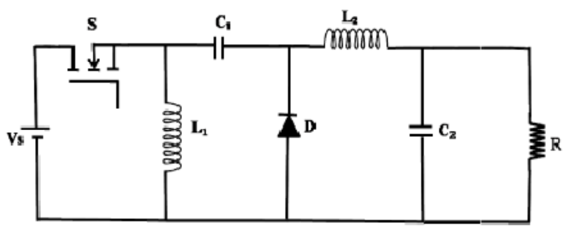

Fig 1:Proposed structure of Basic Zeta converter

In mode 1 operation the will be closed. When the switch is in ON-state, the Diode is OFF. This implies an open circuit for the Diode and a short circuit for the Switch. In this period the Diode D is OFF with a reverse bias of voltage equals to - (V_i +V_o). During this state, Inductor L_1 and L_2 are in charge phase. This means that the Inductor current I_{L1} and I_{L2} are increasing linearly.

The capacitor C_1 will discharge and the energy will be charged to V_0 which is connected in series with L_2. The sum of the charging inductor current flows through the MOSFET Switch.

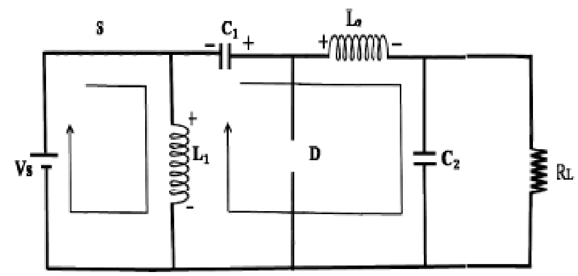

Fig 2: Zeta converter during MOSFET ON time

In mode 2 operation the switch is open i.e. the MOSFET is in OFF-state. The Diode is in ON-state. The diode is short circuited and the switch is in open circuit condition. The inductor L_1 that was charged earlier in mode 1 will be discharging now. In this stage Inductor L_1 and L_2 are in discharge phase. Since the voltage polarity of the inductor changes the diode is in forward bias condition and the conduction takes place.

Energy in L_1 and L_2 are discharged to capacitor C_1 and V_0. As a result of this the Inductor I_{L1} and I_{L2} decreases linearly.

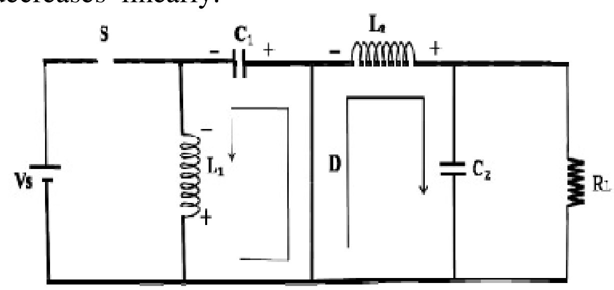

Fig 3:Zeta converter during MOSFET OFF time

V. DESIGN FEATURES

A. Duty cycle

The ZETA converter performs a non inverting buck boost function. The duty cycle for the zeta converter operating in CCM is

$$D= V_o/V_{in} + V_{out} \qquad (1)$$

where, V_o is the DC link voltage, V_{in} is the RMS value of input voltage, D is the duty cycle

B. Inductor selection

The value of inductors L_1 and L_2 can be expressed as

$$L_1 = L_2 = 1/2*(V_{in}.D) / (\Delta I_L.f_{sw}) \quad (2)$$

where f_{sw} is the switching frequency, ΔI_L is the peak to peak current.
Here, the peak to peak ripple current is taken approximately 10 to 20% of the average output current.

C. Capacitors selection

On the basis of the ripple voltage, the coupling capacitor (C_1) is designed. The maximum voltage that can be handled by the coupling capacitor is equal to the input voltage of the converter. It can be expressed as

$$C_1 = (I_o.D)/(\Delta VC_1.Fs) \quad (3)$$

To maintain the DC link voltage the output Capacitor (C_2) must have the enough capacitance and also provide continuous load current at high switching frequency. It can be estimated as

$$C_2 = (I_o.D)/(\Delta VC_o (0.5Fs)) \quad (4)$$

where I_o is the output rated current, Fs is the switching frequency, V_{C1} is the ripple voltage of the coupling capacitor, V_{Co} is the ripple voltage of output capacitor.

VI. SIMULATION

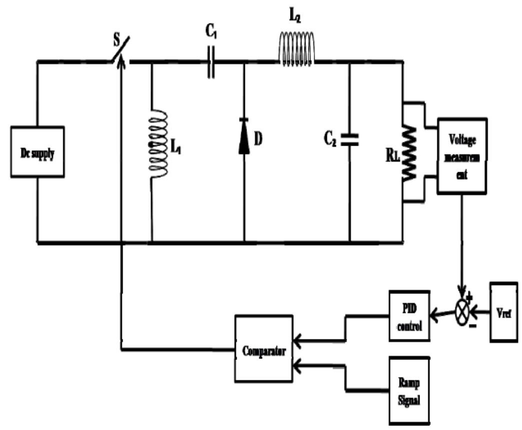

Fig 4: Open loop simulation of Zeta converter

The simulink/MATLAB model for the proposed system is shown below

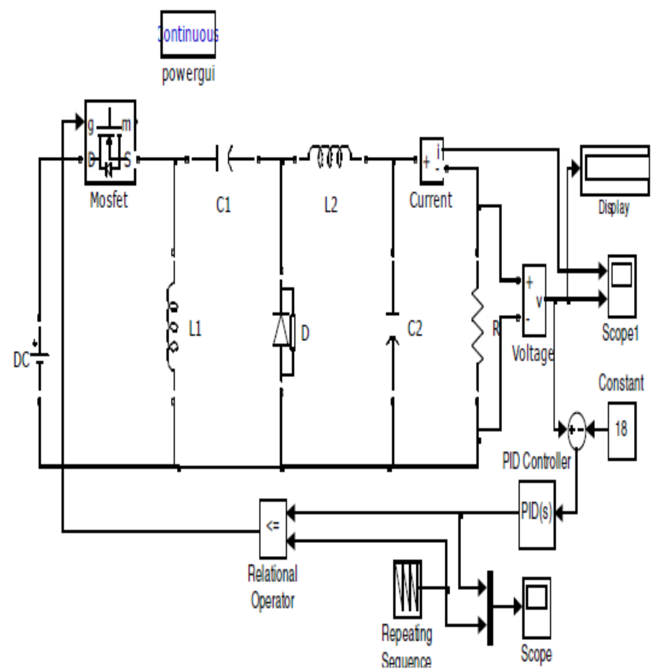

Fig 5:Closed loop simulation of Zeta converter

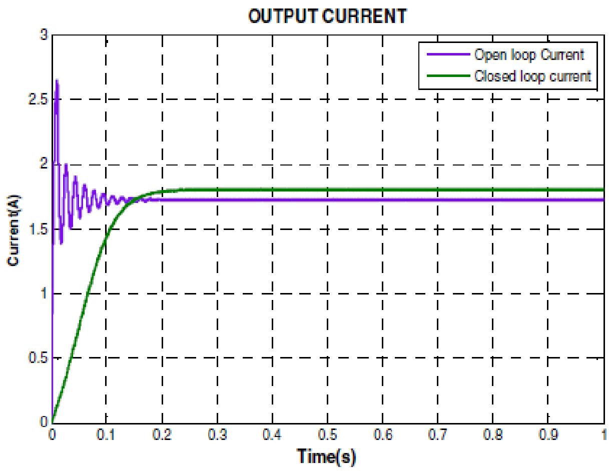

Fig 6: Output of zeta converter

IX. CONCLUSION

The control of three phase standalone wind energy conversion system using zeta converter has been analysed in this paper. The simulation results have been added to verify the output. The purpose of the zeta converter is especially to maintain the constant output voltage across the load under different speed conditions. This is a highly efficient one compared to other step-up and step-down converters. Zeta converter is widely used in producing power from renewable energy sources

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