PV Fed BLDC Motor using Zeta Converter-Review Paper

L. Praisy[1], N. Prakash[2], P. Maithili[3]

[1]*PG Student, Department of EEE, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India*
[2, 3]*Assistant Professor, Department of EEE, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India*

Abstract:- **This paper proposes a zeta converter fed photovoltaic array as input power source for effective control of BLDC motor. The maximum power available from the SPV array is obtained and it is efficiently utilized by the Zeta converter. The voltage source inverter (VSI) is used to perform electronic commutation of the BLDC motor and it plays a vital role in avoiding switching losses caused by the high frequency switching pulses. The output power of the zeta converter is used to drive the BLDC motor. The speed control of BLDC motor is achieved by controlling the switching pulses of VSI by the electronic commutation of the BLDC motor.**

Key words: **BLDC motor, SPV array, DC-DC converters, Zeta converter.**

I. INTRODUCTION

In current scenario, solar energy is an important non-conventional energy resource to meet the electrical load demand for the consumer and to supply the electricity for rural areas. Solar Photovoltaic system is one of the non – conventional energy sources which are used for various applications like lightening load, water pumping and fan etc. Optimization of Photovoltaic system is performed by using Maximum power point tracking (MPPT) algorithm for better efficiency. Generally, in MPPT, Perturb and Observe (P&O) algorithm is widely adopted. However, the zeta converter has been used in some other SPV based applications. Nowadays BLDC motor is becoming popular because of the low power consumption as compared to conventional motors. BLDC motor attracts the attention to utilize in solar powered application. Belonging to a family of buck-boost converters, the zeta converter may be operated either to increase or to decrease the output voltage. The MPPT can be performed with simple buck and boost converter if MPP occurs within certain described limits. In this Zeta converter is preferred when compare to the other conventional DC-Converters due to the advantages of soft starting, continuous output current, low ripple input and output currents. In general, a zeta converter has many advantages over the conventional buck, boost, buck-boost converters and Cuk converter when it is combined with SPV applications. The speed of the BLDC motor is controlled through the variable link voltage, hence no additional sensors are required for speed control. Furthermore, the VSI is operated, by electronic commutation, with the pulses of fundamental frequency, which minimizes the switching losses.

Bhim Singh et al (2014) this paper deals with study of solar photovoltaic array fed permanent magnet brushless DC motor (BLDC) drive for water pumping system using Cuk converter. The cuk converter is operated both in buck and boost modes and the MPPT can be tracked when it is lies within the bounded regions. The main advantage of this cuk converter is a continuous current at its input and output. It has the capability to eliminate ripples in current at input and output. The maximum power is obtained by using Incremental Conductance (INC -MPPT) technique from PV array. A centrifugal pump is coupled with BLDC motor for pumping purpose. Soft starting of the BLDC motor is obtained by selecting optimum step size in MPPT technique. Thus the cuk converter reduces the current ripples to enter the motor windings. This system is operated under the different atmospheric conditions [1].

Rajan Kumar et al (2014) studied the solar photovoltaic array fed water pumping system with the Single Ended Primary Inductor Converter (SEPIC). In this soft starting of the BLDC motor is done by controlling the SEPIC converter by obtaining the optimum maximum power through the power tracking process by incremental conductance (INC-MPPT) technique. The SEPIC converter has the characteristics of unbounded maximum power point tracking, non-inverting polarity output voltage and negative voltage feedback sensing. The disadvantages are adding complexity to the system and slow response of the system. This converter is operating under continuous conduction mode to limit the voltage and current stress in the power device and components.The electronic commutation of the BLDC motor provides the switching sequence for 6 switches of the VSI. The converter plays the role in easy to drive switch and low input current pulsation for high precision MPPT. This proposed system is mostly used in applications like spray irrigation system and drinking water system [2].

Bhim Singh et al (2014) this paper deals with solar photovoltaic array based water pumping system by utilizing Buck –Boost converter. The switch of the buck –boost converter is IGBT (Insulated Gate Bipolar Transistor) and it is operated with Incremental Conductance (INC-MPPT)

algorithm. This algorithm is used for the operation of PV array to be optimized and for the soft starting of BLDC motor. The Buck-Boost converter always operated in continuous conduction mode it reduces the stress on the power devices. A DC-DC Buck-Boost Converter provides the flexible increasing and decreasing voltage levels and it does not possess a limited region of MPPT. It has good conversion efficiency [3].

V.S. Nandanwar et al (2014) this paper explained that BLDC motor drive using a single voltage sensor fed by zeta converter for fan applications. In this BLDC motor is fed by an uncontrolled bridge rectifier with DC link capacitor which results in high distorted current that results in low PF (Power Factor) and THD (Total Harmonic Distortion). In this zeta converter is operated in the Discontinuous Inductor Current Mode. A simple voltage follower control technique is used for voltage control and power factor correction of BLDC drive [4].

Bhim Singh et al (2015) explained about the DC-DC Boost converter as an intermediate power conditioning unit in solar photovoltaic array fed brushless DC motor(BLDC) driven water pump. The PV array is selected such that its maximum power point always occurs within the bounded MPP region of the boost converter. The features of boost converter are good switch utilization, high conversion efficiency, low stress on power devices. The inductor of the boost converter acts as an input ripple filter. The boost converter is operating under continuous conduction mode. The switching signals of the VSI is generated through the electronic commutation of the BLDC motor. The integration of boost converter and BLDC motor with PV array for water pumping has a feasible solution in context of simplicity, economical, compactness, efficiency, reliabity and availability. The speed is controlled by variable DC link voltage. In this 20% of solar irradiance has revealed that the proposed system is undoubtedly utilized for water pumping. [5]

Rajan Kumar et al (2016) proposed the application of water pumping with a simple cost effective and efficient brushless DC motor drive using solar photo voltaic array. The zeta converter has a continuous output current. The output inductor of the zeta converter makes the current continuous and ripple free. An incremental conductance (INC –MPPT)algorithm is used to operate the zeta converter in bounded region such that PV array always operates at its MPP.The efficiency of the system includes the efficiency of the INC –MPPPT algorithm, zeta converter ,VSI and BLDC motor. A very good efficiency of 83% is obtained at the solar insolation level of $1000 W/m^2$ whereas it is 71% at $400 W/m^2$. The proposed system is operating under minimum solar irradiance. [6]

Venma Prabash et al (2016) discussed about the solar energy extracted and it is used to drive motors for water pumping application. A bulkier DC link capacitor is connected in between the DC-DC converter and inverter to obtain the constant voltage at the input of the inverter and it makes voltage ripple free. The disadvantage is DC link capacitor is bulky in size and its life span is easily affected by the operating temperature. In this new torque ripple compensation technique is proposed by PV array fed BLDC motor with compensation capacitor for water pumping applications using zeta converter is performed. The idea to eliminate the bulkier DC link capacitor causes torque ripples at the output of motor. The ceramic capacitor used to reduce the torque ripple with the value of 25µF which replaces a 335 µF DC link capacitor. The performance of the motor with the compensation technique was analyzed by different irradiance levels of $1000 W/m^2$ and $600 W/m^2$. This method can be modified by using wind and other hybrid combination systems. [7]

M.S. Aspalli et al (2016) discussed about the Brushless DC (BLDC) motor drive with power factor correction (PFC) and improvement of power quality for low power applications. The main aim is to achieve the improvement in the power quality and power factor at the AC mains and using the DC link voltage and controlling the BLDC motor. The zeta converter is designed to operate in the Discontinuous Current Mode (DCM) to provide the inherent PFC at AC mains. The VSI has operated in low frequency thus reduces the switching losses.A single phase AC supply is converted to DC by using the double bridge rectifier and then it is passed through the filter to remove the spikes from the supply for smooth DC voltage. The filter is used to eliminate the spikes but it injects the harmonics into the supply and lowers the power factor at AC mains.The reference voltage is obtained based on the reference speed obtained from the BLDC Motor. The output voltage of the zeta converter is compared with the reference voltage through the BLDC Motor and we obtain an error voltage. The error voltage is processed through the controller. Based on the error voltage, the pulses are generated using the PWM generator. The pulses are used to control the ON/OFF period of the switch. This makes converter conduct in discontinuous mode of operation. [8]

Rashmi et al (2016) this paper presents a speed control of the BLDC motor using synchronous zeta converter for standalone PV system. In the synchronous converter the diode is replaced by the MOSFET. The main advantage of this configuration is that the voltage drop of the diode is much higher to the MOSFET as a second switch which results in the high efficiency. The Synchronous zeta converter is controlled by the Perturb and Observe algorithms (P& O) in which it generates PWM with high precision. The output power of the synchronous zeta converter drives the BLDC motor. The variable speed of the BLDC motor is achieved by voltage at converter by controlling the duty cycle of the converter. [9]

Hemanthakumar R Kappali et al (2017) this paper describes about the low power consuming solution by using solar PV array used for water pumping applications. The zeta

converter is connected as an intermediate DC-DC converter to get more power from the solar panel. The zeta converter is controlled by using Incremental Conductance (INC-MPP) algorithm. This is used for smooth starting of brushless DC motor connected to the centrifugal pump connected to the shaft.The switching frequency of the voltage source inverter is controlled by electronic commutation of BLBC motor which reduces the VSI losses of high switching frequency. The DC link capacitor is connected across the VSI.Then the proposed system is synchronized with grid supply; grid is a bus which connects two or more power house, power networks with same frequency, phase sequence, terminal voltage. The pulse generator generates the PWM pulses, through INC-MPPT algorithm, the switching pulse for the IGBT (Insulated Gate Bipolar Transistor) switch of the zeta converter. The proposed system has operated successfully even under the minimum solar irradiance. In this the modified system is synchronized with grid supply which automatically connects to the gird when solar power is not available. So it is easy to convert it into AC-DC & DC-AC converters and controlling because of its low loss, low cost of power electronic devices. [10]

II. CONCLUSIONS

The merits of both BLDC and zeta converter is nowadays is mostly contributing to develop a SPV array fed water pumping system. The zeta converter has many advantages when compared to other conventional converters like buck, buck-boost, boost and cuk converters. From the study of papers storing of energy and utilization is depending upon the designing of capacitors and inductors of the converter side. Instead of zeta converter, synchronous zeta converters are playing vital role due to the replacement of diode using the MOSFET and it produce less voltage drop across the load. The zeta converter which is operated in continuous conduction mode reduces the stress on the power devices. Thus the combined system with the zeta converter has simplicity economical, compactness, efficiency, reliabity and availability for day to day life applications. With these advantages the system is operated under the different irradiances for irrigation, pumping applications, fan loads etc.

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