BLDC Motor driver solar PV array fed water pumping System Employing Zeta converter

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Abstract

This paper proposes a simple, cost effective and efficient brushless DC (BLDC) motor drive for solar photovoltaic (SPV) array fed water pumping system. A zeta converter is utilized in order to extract the maximum available power from the SPV array to run the BLDC motor .BLDC motor controlled by zeta converter using maximum power point tracking(MPPT) for soft starting of the BLDC motor i.e. the reduced current starting inhibits the harmful effect of the high starting current on the windings of the BLDC motor to drive a water pump which is attached to the shaft. The proposed control algorithm eliminates phase current sensors and adapts a fundamental frequency switching of the voltage source inverter (VSI), thus avoiding the power losses due to high Frequency switching. The project corresponding results will be plot on MATLAB using MATLAB/Simulink software .

Keywords: BLDC motor, SPV array, Water pump, Zeta converter, VSI, MPPT.

1. Introduction

Brushless dc motor are synchronous motors which are given supply with an inverter which converts the available dc into ac which is given to winding of motor with the help of a closed loop controller. Brushless dc electric motor is also known as electronically commutated motor. There are two ways to control the speed of BLDC motor, in conventional way we feed the bldc motor by boost convertor, the dc link voltage (output of boost convertor or input of VSI) is maintained constant with the help of boost convertor. Switches of VSI are controlled by PWM for speed control. Now this type of configuration have drawback of high switching losses as we are using switching of VSI switches for speed control which varies according to PWM switching frequency. The other and better way is supplying a variable dc voltage to VSI at input for speed control of bldc motor; this allows VSI to operate in fundamental switching frequency for achieving speed control of bldc motor. The variable dc-link voltage is achieved by using a zeta convertor which is operated in discontinuous inductor current mode operation.

Solar photovoltaic (**PV**) panels use cells containing a semi-conductor material to capture the sun's energy and convert **solar** radiation into electricity. When light shines on the semi-conductor the electric field across the junction between these two layers causes electricity to flow, generating direct current (DC). **Photovoltaic cells** are connected electrically in series and/or parallel circuits to produce higher voltages, currents and power levels. A **photovoltaic array** is the complete power-generating unit, consisting of any number of **PV modules** and **panels**.

The proposed converter is based on DC-DC Converter to maintain the constant output voltage. Hence a single stage Zeta converter is proposed which is used for DC link voltage control, power factor correction and bucking and boosting the voltage. It is a naturally isolated

structure. A Zeta is similar to a BUCK – BOOST converter but has advantages of having non-inverted output (the output voltage is of the same polarity as the input voltage). The inductors and the capacitors can also have large effects on the converter efficiency and ripple voltage. This converter transfers the energy between the inductance and the capacitance in order to change from the voltage to another. The transferred energy is controlled by switching device S(MOSFET).

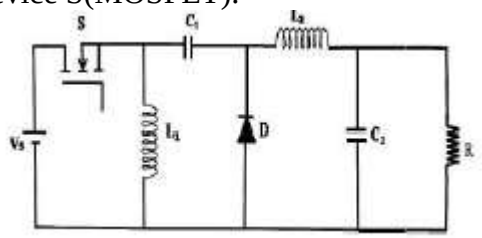


Fig.3.Schematic Diagram of Zeta Converter

The INC-MPPT algorithm uses voltage and current as feedback from SPV array and generates an optimum value of duty cycle. Further, it generates actual switching pulse by comparing the duty cycle with a high-frequency carrier wave. In this way, the maximum power extraction and hence the efficiency optimization of the SPV array is accomplished.

2. LITERATURE SURVEY

1. Nevertheless, a Zeta converter [5-9] based MPPT is still unexplored in any kind of SPV array based applications. An incremental conductance (INC) MPPT algorithm is used in this work in order to generate an optimum value of duty cycle for the IGBT(Insulated Gate Bipolar Transistor) switch of Zeta converter such that the SPV array is constrained to operate at its MPP. Various configuration of Zeta converters such as self-lift circuit, re-lift circuit, triplelift circuit and quadruple-lift circuit using voltage lift (VL) technique have been reported in aforementioned topologies have high voltage transfer gain but at the cost of increased number of components and switching devices. Therefore, these topologies of Zeta converter do not suit the proposed water pumping system.

2. Ashta, a single phase supply is given to the zeta converter through diode bridge converter. Instead of two stage converters, a single stage Zeta converter is used for DC link voltage control and power factor correction. The controlled voltage is fed to voltage source inverter. The main objective of this paper is to control Output of Zeta converter to achieve speed control of BLDC motor

3. IMPLEMENTATION:

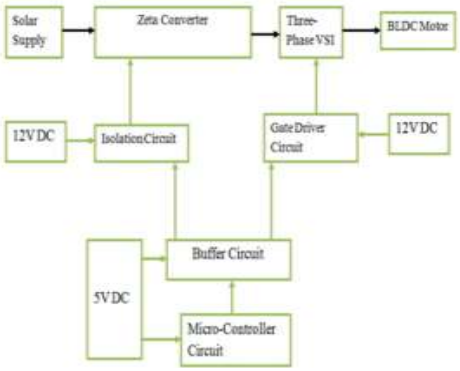


Figure: Block diagram of proposed SPV-Zeta converter fed BLDC motor driver for water pump

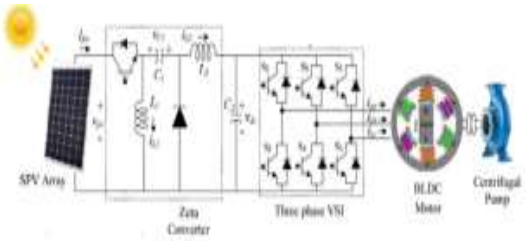


Figure: circuit diagram of proposed SPV-Zeta converter fed BLDC motor driver for water pump

The SPV array generates the electrical power demanded the motor-pump.

This electrical power is fed to the motor-pump via a zeta converter and a VSI. The SPV array appears as a power source for the zeta converter. Ideally, the same amount of power is transferred at the output of zeta converter which appears as an input source for the VSI. In practice, due to the various losses associated with a DC-DC converter, slightly less amount of power is transferred to feed the VSI. The pulse generator generates, through INCMPPT algorithm, switching pulses for IGBT (Insulated Gate Bipolar Transistor) switch of the zeta converter. The INC-MPPT algorithm uses voltage and current as feedback from SPV array and generates an optimum value of duty cycle. Further, it generates actual switching pulse by comparing the duty cycle with a high frequency carrier wave. In this way, the maximum power extraction and hence the efficiency The VS, converting DC output from a zeta converter into AC, feeds the BLDC motor to drive a water pump coupled to its shaft. The VSI is operated in fundamental frequency switching through an electronic commutation of BLDC motor assisted by its built-in encoder. The high frequency switching losses are thereby eliminated,

contributing in an increased efficiency of proposed water pumping system.

The advantages and desirable functions of zeta converter and BLDC motor drive contribute to develop a simple, efficient, cost-effective and reliable water pumping system based on solar PV energy. Simulation results using MATLAB/Simulink and experimental performances are examined to demonstrate he starting, dynamics and steady state behavior of proposed water pumping system subjected to practical operating conditions. The SPV array and BLDC motor are designed such that proposed system always exhibits good performance regardless of solar irradiance level.

.4. RELATED WORK:

This system consists of different modules which is used in this project is discussed below:

a. PHOTO VOLTAIC SYSTEM:

Photovoltaic systems research seems largely to be divided into two, fairly distinct areas; namely array physics, design and optimization, and solar power con- version systems. This paper is not concerned with the design of the arrays but rather with development of a model of an array that is useful for power electronics applications. Better, more efficient converter systems may be developed by matching the control and drive requirements of the converter system to the characteristics of the array. Alternative energy specialists often appear not to have sut1icient expertise in power electronics to be able to develop advanced converter systems, which can match the input characteristic of the power electronic system to those of the array, in order to make best use of the array. Examples of such no optimal systems can be found in the field of solar array/battery combinations for stand-alone use [2--4] and in the area of utility interactive systems.

b. BLDC MOTOR:

BLDC motors are classified into two sub categories. The first category uses continuous rotor-position feedback for supplying sinusoidal voltages and currents to the motor. The ideal motional EMF is sinusoidal, so that the interaction with sinusoidal currents produces constant torque with very low torque ripple. This called a Permanent Magnet Synchronous Motor (PMSM) drives, and is also called a PM AC drive, brushless AC drive, PM sinusoidal fed drive, sinusoidal brushless DC drive, etc. The second category of PMBL motor drives is known as the brushless DC (BLDC) motor drive and it is also called a trapezoidal brushless DC drive, or rectangular fed drive. It is supplied by three phase rectangular current blocks of 120° duration, in which the ideal motional EMF is trapezoidal, with the constant part of the waveform timed to coincide with the intervals of constant phase current. These machines need rotor-position information only at the commutation points, e.g., every 60°electrical in three-phase motors. The PMBLDC motor has its losses mainly in the statordue to its construction; hence the heat can easily be dissipated into the atmosphere. As the back EMF is directly proportional to the motor speed and the developed torque is almost directly proportional to the phase current, the torque can be maintained constant by a stable stator current in a PMBLDC motor. The average torque produced is high with fewer ripples in PMBLDC motors as compared to PMSM. Amongst two types of PMBL motors, PMSM is, therefore, preferred for applications where accuracy is desired e.g. robotics, numerical controlled machines, solar tracking etc. However, the PMBLDCM can be used in general and low cost applications. These motors are preferred for numerous applications, due to their features of high efficiency, silent operation, compact in size and low maintenance.

c. Zeta Converter:

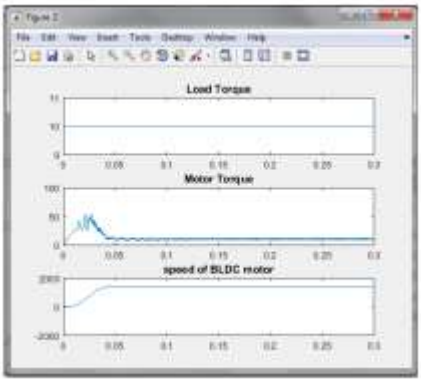
Nowadays a dc-dc converter is widely used as power supply in electronic systems. A zeta converter is a fourth order dc-dc converter capable of amplifying and reducing the input voltage levels without inverting the polarities. The reason being is that it includes two capacitors and two inductors as dynamic storage elements. Compared with a Cuk or Sepic converters, the Zeta converter has received the least attention.Among the renewable options, solar PV energy has been drawing increasing interest in recent years as an alternative and important source of energy for the future. Solar cells transform energy from an essentially unlimited source „the Sun“ into useable electricity. PV systems constitute an environmentally friendly alternative way for energy production using the energy from the sun. PV system, virtually zero running cost energy is the input source of power.

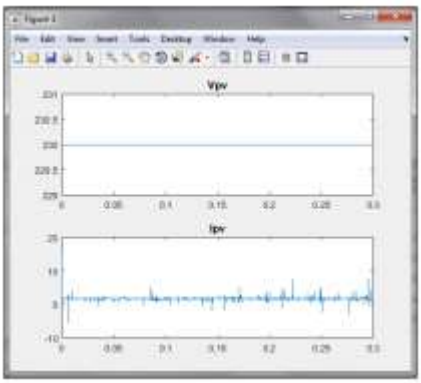
They operate quietly without emissions, even if the load increases. With recent developments,

solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance. However, the output power induced in the photovoltaic modules depends on solar radiation and temperature of the solar cells. Photovoltaic modules have a very low conversion efficiency of around 15% for the manufactured ones. Besides, due to the temperature, radiation and load variations, this efficiency can be highly reduced. In fact, the efficiency of any semiconductor device drops steeply with the temperature.

In order to ensure that the photovoltaic modules always act supplying the maximum power as possible and dictated by ambient operating conditions, a specific circuit known as Maximum Power Point Tracker (MPPT) is employed therefore, to maximize the efficiency of the renewable energy system, it is necessary to track the maximum power point of the PV array. In most common applications, the MPPT is a DC-DC converter controlled through a strategy that allows imposing the photovoltaic module operation point on the Maximum Power Point (MPP) or close to it. The proposed scheme consists of a solar panel, a zeta dc- dc converter, and MPPT controller. In this Maximum power point tracking is achieved by using Perturbation and Observation (P&O) method, also known as hill climbing method, is popular and most commonly used in practice because of its simplicity in algorithm and the ease of implementation.

5.Results:





6. CONCLUSION:

Mathematical analysis of ZETA converter is carried out for design values of the capacitor and inductor. A simple power

electronic controller for interfacing PV array with the load has been simulated using ZETA converter. The subsystems of overall scheme such as PV array model, ZETA converter model have been built and tested individually before integrating to the overall system. A maximum power point tracking algorithm has also been incorporated. The simulation studies of the proposed scheme MPPT have been carried out and the results are furnished. The values of parameters used for simulation are listed.

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REFERENCES:

[1] Adriano Peres, Denizar Cruz Martins and Ivo Barbi," Zeta converter applied in power factor correction", Power Electronics Research Group Federal University, Brazil, July 2010.

[2] K.A. Ajith, V.M. Manikumar and P.A. Shemi, "An isolated two stage PFC converter fed BLDC motor drive", IOSR Journal of Electrical and Electronics Engineering, 2016.

[3] Albert John Varghese, Rejo Roy and Prof. S. Thirunavukkarasu, "Optimized speed control for BLDC motor", International Journal of Innovative Research in Science, Engineering and Technology, vol.3, no.1, Feb 2014.

[4] Ashok Kumar, Pradeep Kumar and P. R. Sharma, "Simulation and design of power factor correction prototype for

BLDC motor control", European Scientific Journal., vol.9, No.12, ISSN :1857 – 7881, April 2013.

[5] Fred C. Lee, Jindong Zhang and Milan M. Jovanoviu, "Comparison between CCM single-stage and two-stage boost PFC converters", Blacksburg, VA 24061-0111, May 2009.

[6] HemchandImmaneni, "Mathematical modelling and position control of brushless DC (BLDC) motor", International Journal of Engineering Research and Applications, Vol. 3, Issue 3, pp.1050-1057, May-Jun 2013.

[7] Heung-Kyo Shin, Hwi-Beom Shin, Soon-Young Lee and Tae Heoung Kim, "A study on characteristic analysis of BLDC motor considering various PWM modes", Journal of electrical engineering, May 2005.

[8] Jeff Falin, Senior Applications Engineer, Texas Instruments "Designing of DC-DC converters based on zeta topology", Analog Applications Journal, 2010.

[9] Kajal D. Parsana and Hitesh M. Karkar, "Analysis of open loop speed control of brushless DC motor", National Conference on Emerging Trends in Computer & Electrical Engineering, 2014.

[10] K. Karkkinalderin and M. Prabu, "An adjustable speed PFC bridgeless buck–boost converter-fed BLDC motor drive with three switch leg VSI inverter", International Journal for Technological Research in Engineering,Volume 2, Issue 7, March 2015.

[11] Y. KusumaLatha and V. Ramesh, "PFC-based control strategies for four switch VSI fed BLDC motor", Indian Journal of Science and Technology, Vol 8(16), July 2015.

[12] N. Manju Vani, M.B. Pavankumar and T. Rajesh Raju, "Characteristics comparison of brushless DC motor drive using pi and PWM techniques", International Journal of Engineering and Innovative Technology, Volume 4, Issue 11, July 2015.

[13] Rd. D. Bale Gang Reddy, J. Manasa and P. Nageswara, "Analysis of BLDC Drive Performance with Hysteresis and PWM Control Techniques", Rao International Journal of Scientific Engineering and Technology Research, July 2015.

[14] N. Sowmiya Smith Raj, and B. Urmila, "PV Fed ZETA Converter", International Journal of Engineering Research and Applications, vol. 3, Issue 4, Aug 2013.