Water Flow Control by using Solar PV Array with Zeta Converter and BLDC Motor Drive

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Abstract - *In order to obtain full available power from an SPV array, this article proposes an array of photovoltaic pumping systems using a Zeta converter as an intermediate DC-DC converter. It is an easy and inexpensive concept that requires a pumping water system that, in turn, increases efficiency for manufacturers and ensures that the resolution and the quality of life are implemented without pollution. Using the Zeta converter allows farmers to adapt to their problem's beneficial features of the BLDC motor. It is a specific renewable resource framework, including the BLDC motor for barriers to agriculture. To extract the available maximum power from the SPV array, a zeta converter is used. The proposed control algorithm removes phase current sensors and adapts a simple voltage source (VSI) switching, preventing high frequency switching losses due to this. For BLDC motor speed control, no additional control or circuitry is used. DC variable link voltage of VSI regulates the speed. This device prevents loses of power to the high-frequency switch by eliminating the stage for certain sensors and switches of VSI basic frequency[1-5]. MATLAB / Simulink is used to simulate the findings and present them.*

***Key Words*: BLDC Motor, Maximum power point Tracking (MPPT), Solar Photovoltaic (SPV), Water Pump, Zeta converter.**

1. INTRODUCTION

With rapid surge in population around the world, there is an increase in the demand for electrical energy. Be it industries, homes or any other workplace, power forms the fundamental commodity of productivity. Since ages people have made use of coal, diesel, fossil fuels and other conventional energy sources to meet their energy requirements. Though their needs have been sufficed until now, it is necessary to realize the issues these sources create when it comes to cost and environment. Firstly, these sources release tremendous amount of nitrogen, carbon and oxides of sculpture roving to be dangerous for human health and hygiene. Secondly, they are costly as the excavation work is time consuming, health affecting and exhausting. In addition, all these sources are consumed at a higher rate as compared to their manufacturing rate which will exhaust them sooner as these are non-renewable. These constraints have brought an overall focus and emphasis on non-conventional energy sources. One of the foremost contenders is the solar power as the credit goes to its ease of availability, abundance and eco-friendly nature.

Water pumping being one of the significant applications of SPV array, it is under a lot of consideration for various projects. The system undergoes the usage of maximum power point tracking (MPPT) algorithm to augment the efficiency of SPV array and in turn the entire system irrespective of the operating conditions. Generally, DC-DC converters are utilized for the purpose of maximum power point tracking. However, a Zeta converter based MPPT is still uncharted in any kind of SPV array-based applications. Higher conversion efficiency is seen in the Zeta converter as it accommodates a single switch-based working. Its operation is introduced in the following paper for soft initiation of the BLDC motor fixed to a centrifugal pump for water pumping. Availability in terms of wide range of heads and flow rates, simplicity, low maintenance requirements and cost effectiveness has increased the probability to use a centrifugal pump.

The centrifugal pump is driven by the BLDC motor having the merits of high efficiency, high reliability, high ruggedness, low EMI problems and excellent performance over a wide range of speed. The proposed system makes use of appropriate ratings of BLDC motor and solar PV array which makes it applicable under any atmospheric conditions. Analysis of various parameters is done using the MATLAB/Simulink software. Simulated outcomes verify the correctness of the proposed system for solar PV based water pumping.

2. EXISTING SYSTEM

In the existing system each small PV plant containing the PV inverters are provided with wide range of input voltage. Due to varying input voltages, a number of different configurations of the PV field are possible. Besides, typically the operation of a voltage-source inverter (VSI) takes place due to high-frequency PWM pulses which leads to increased switching losses and furthermore decreases the efficiency of the inverter. In the given schematic of Fig. 1, Z-source inverter (ZSI) substitutes dc– dc converter while other components including BLDC motor remains as it is. The provided substitute is capable of upraising efficacy with an additional advantage of low cost. Nevertheless, ZSI has its own demerits when compared to the proposed system as it demands phase current and dc link voltage sensing which results increased control complexity and expenditure[4]. In order to solve these issues and overcome the drawbacks, an efficient water pumping system based on SPV array-fed BLDC motor is projected by modifying the current topology as shown in Fig. 1.

The proposed system is proved to be a simple, cost effective, and efficient whose schematic is shown in Fig. 2. A Zeta converter is used to extract full power, soft start and speed control of the BLDC motor, combined with the water pump, from an SPV array. Also, single switch reduces losses and thus improves efficiency of the system.

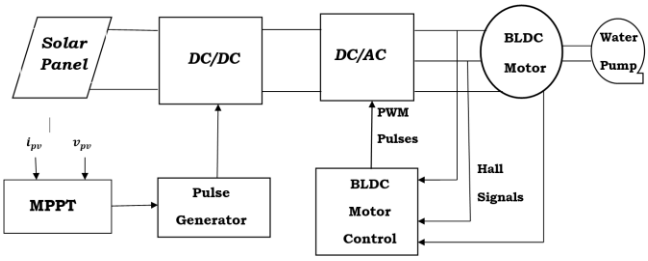


Fig-1: Conventional system

3. PROPOSED SYSTEM

Fig. 2 displays the proposed BLDC motor driven water pumping system with a Zeta converter involving the proposed system involving SPV collection. A SPV array (left to right), a zeta converter, a three-phase VSI, a motor of the BLDC and a centrifugal water pump constitute the proposed system.

The pulse generator is attached to the zeta converter for the purpose of the operation of the converter [3-6]. The zeta converter operates in continuous conduction mode (CCM) which results in lessening of strain on its power devices and other components.

The VSI operates on the fundamental frequency technique which helps in reducing switching losses and hence saves power. The dc link voltage sensors and phase current sensors are totally eradicated hence making the system simple and inexpensive.

The variable dc link voltage of VSI controls the speed of BLDC motor thus eliminating the use of any supplementary controller. These requested features support the development of a cost-effective, simple and reliable solar PV-based water pumping system.

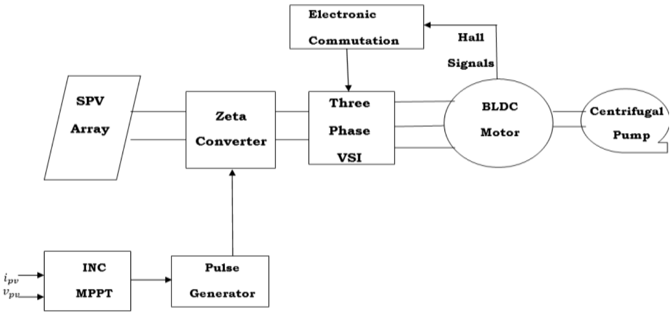


Fig-2: System Proposed

4. OPERATION OF PROPOSED SYSTEM

The motor pump demands electrical power for its operation which is satisfied by the Solar PV array. This electrical power is initially fed to the zeta converter and further fed to the VSI which then reaches the motor pump. The power given at the input of the zeta converter is transferred equally in terms of amount at the converter output that serves as the VSI input source. Practically, dc-dc converter creates various losses thus; the power moved to the VSI is comparatively less.

Insulated gate bipolar transistor (IGBT) switch is used in zeta converter and it receives the switching pulses from the pulse generator attached to it as shown in the above Fig.2 Each time the duty cycle is compared to the high frequency carrier wave and the required switching pulse is generated. This leads to the extraction of maximum power and thus achieves the necessary efficiency of the SPV array.

As the BLDC motor requires ac input for its operation, the VSI helps convert the dc output of zeta into ac which further helps to drive a water pump attached to the shaft. The BLDC motor electronic switching with its integrated encoder helps to work the VSI in the fundamental switching frequency mode. Thus, the whole system eliminates the losses and becomes more efficient.

4.1 SOLAR PHOTOVOLTAIC ARRAY

The performance of the BLDC motor-pump is influenced by the mechanical and electrical losses associated with them. To compensate these losses, the size of SPV array is selected with slightly more maximum power capacity to ensure the satisfactory operation regardless of the power losses.

Solar water pumping system is run under the sunlight on a range of capabilities 200 W/m^2 to 1500W/m^2 which is usable in a standard test involving some solar panels to capture the maximum amount of sunlight to convert into electricity conditions. And the use of the number series should be enough to get the required output power of the solar array parallel.

4.2 ZETA CONVERTER

Zeta converter is followed by the solar array. At the end of the 1980s, Kazimierczuk created the sixth DC-DC converter to be studied separately under the names of Dual SEPIC and Barbi with the name Zeta (from the sixth letter of the Greek alphabet, to refer to the sixth). Zeta is a DC-DC converter in fourth order. Without changing the output polarity Zeta converters vary above or below the input voltage. It maintains a constant dc output voltage of the fourth order. It operates without changing the output polarity and varying above or below the input voltage. The Buck-Boost and Zeta converter are almost the same except the fact that the zeta converter gives a non-inverted output. The inductors and the capacitors can also have large effects on the converter efficiency and ripple voltage. In order to adjust the voltages, the energy is moved from inductors to capacitors. There are two inductors and a capacitor as shown in fig (3).

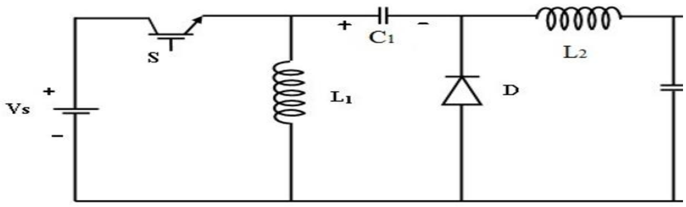


Fig.3: Zeta Converter

4.2.1 Zeta Converter's merits over other similar converters:

• Minimum power loss and total power extraction from SPV array.

• Output non inverted. This method removes the need to resolve the most complicated circuits of negative voltage related to the possibility of less dense being identified.

• Improved power factor, low input current distortion, low output current ripple and large variety of products.

• Fast and steady economic growth and productivity is their current production. It's free to ripple.

4.3 BLDC MOTOR

A BLDC engine is a brushless electronic DC engine that controls the torque rotor speed. The two coils are induced by a magnetic field to rotate; the induced voltage is produced in this coil, called "back motive force" or "back EMF." Superior power and solar-based application priority are given by the BLDC engine [7]. The engines give a large range of speeds, low maintenance, high efficiency, low noise, high strength and long service life. All these advantages make it possible to pick the BLDC engine from all other systems engines.

4.3.1 TOPOLOGY CONTROL PROPOSAL

There are two ways to monitor the proposed topology:

i. **ALGORITHM OF PERTURBATION AND OBSERVATION (P & O MPPT):**

The MPPT method creates a minor perturbation in this algorithm. The power of the module changes because of this disturbance. If power is increased because of the disturbance, the disturbance in that direction is continued. Conversely, disruption. The algorithm oscillates around the peak if the steady state is reached. The disturbance size is kept very small to keep the power variance small. The algorithm is developed such that it sets a module reference voltage that is compatible with the module's peak voltage. Then a PI controller transfers the module's operating point to the same voltage level. The loss of power due to this disruption can also be observed if power is not monitored under very complex atmospheric conditions. But it's still a common and simple algorithm. This algorithm is chosen and certain modifications are made [8-9]. The controller takes more time to monitor the SPV array MPP as the disturbance size decreases. The aim of MPPT and the soft start of the BLDC engine is to achieve intellectual agreement between the tracking time and perturbation. The initial value of the engine is to obtain a soft start. The initial value of the service cycle is set to null to achieve a soft start. Furthermore, an optimal perturbation size value ($D = 0.001$) is chosen, which helps to soft start and also minimizes MPPT oscillations.

ii. **ELECTRONIC COMMUTATION:**

BLDC motor movement is generated by the switch are placed for six-step trapezoidal control where the starting or appropriate phases of the motor rotation every 60 degrees. Depending on the rotor position, including three Hall effect is created in the signal encoder motor. These signals are three Hall Effect 3 EMF signal. Then, the three-emf signal is given according to the different combinations of pulses that are generated, resulting in the switch switches, six VSI control BLDC motor

5. SIMULATION & RESULTS

The performance assessment is performed by simulating the motor driven water pumping system with zeta converter from the BLDC motor fed SPV array in the MATLAB / Simulink system. Taking into account the spontaneous and instant variance of the amount of solar radiation, the device is planned, modeled and simulated.

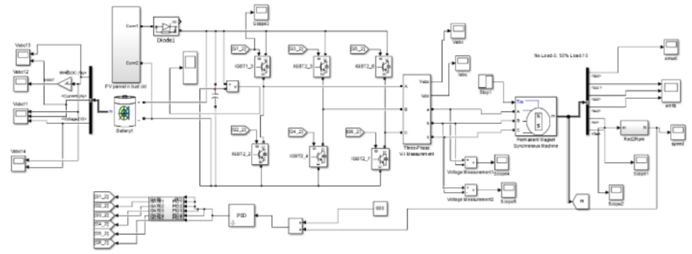


Fig-4: Zeta Water Pumping System Converter Solar PV Fed BLDC Motor Simulation

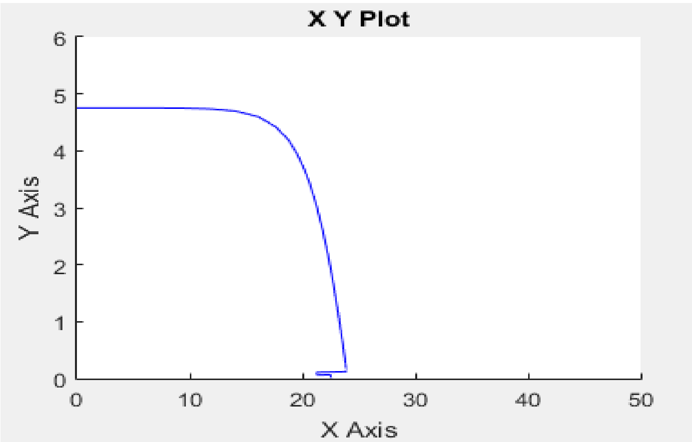


Fig-5: IV curve

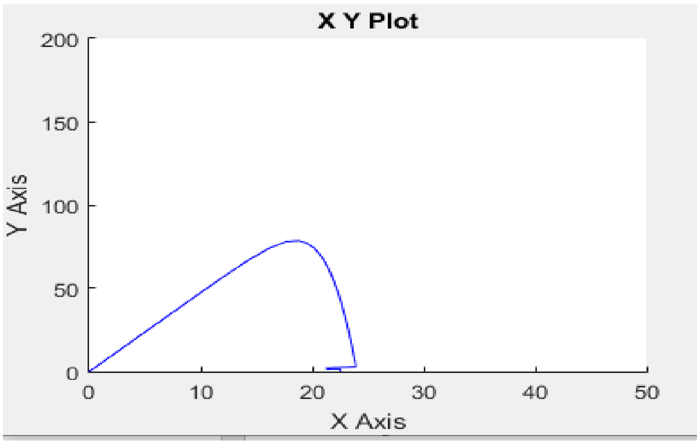
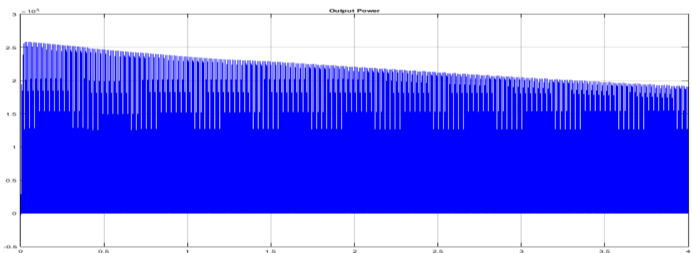
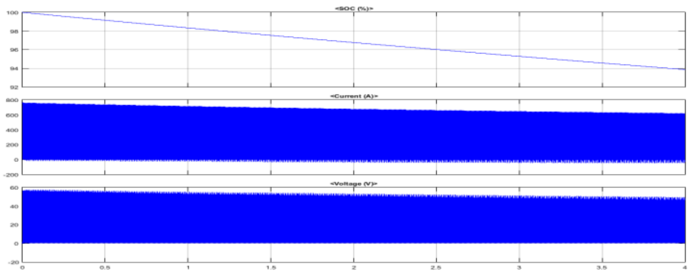


Fig-6: PV curve

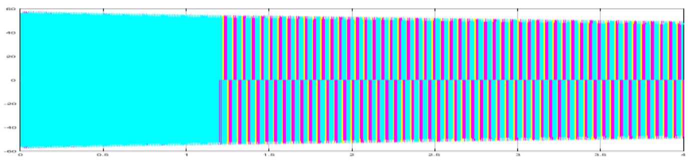
Fig. 5. Shows the current v/s voltage curve and Fig. 6. Shows the power v/s voltage curve which is the output of Solar.



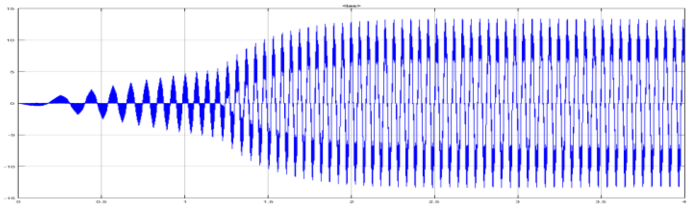
(a)



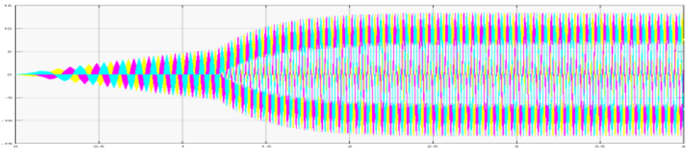
(b)



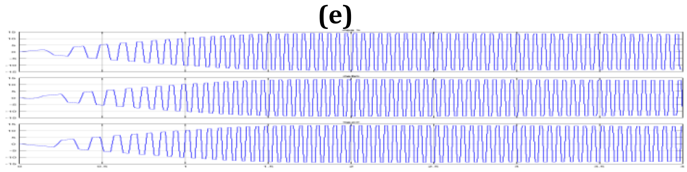
(c)



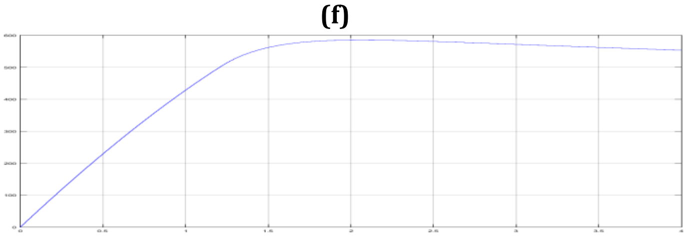
(d)



(e)



(f)



(g)

Fig-7:
(a) Output power of zeta converter **(b)** Output of battery **(c)** Output voltage of VSI **(d)** Output current of VSI **(e)** Stator current of motor **(f)** EMF of motor **(g)** Speed of motor

6. CONCLUSIONS

The drive of the water pumping system has been suggested with a photovoltaic solar array feeding Zeta converter-based BLDC. The system proposed was developed and modeled with MATLAB and its Simulink and simulated Toolboxes for sim power system. The suitability of the proposed water pumping system was demonstrated by the simulated performance. SPV array is correctly sized to prevent a change in atmospheric conditions that affect system output and achieve associated losses and optimum usage of the Zeta conversion unit. In order to minimize stress on power supplies, the Zeta converter has been worked in CCM. VSI conduction drive mode with simple frequency switching reduces losses due to high frequency switching Service-Operation. Stable motor pump system operations and safe starting of BLDC are other essential features of the BLDC engine.

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