Solar Photovoltaic Water Pumping System Utilizing An BLDC Motor Drive

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Abstract-
This research describes a cost-effective BLDC motor-driven solar photovoltaic (PV) water pumping system. We're working with a dual stage power conversion here with this solar PV water pump setup. To get the most power out of a solar PV array, the duty ratio of a DC-DC boost converter is adjusted at the first stage. By adjusting the motor speed, the DC bus voltage is kept at a constant level. This regulation reduces motor losses due to the drop in motor currents at a higher voltage for the same power injection as a result of this regulation. Using an INC-based maximum power point tracking (MPPT) control method, the duty ratio can be controlled. Models and simulations of the proposed system's performance have been done in great detail. The speed sensor/encoder is no longer necessary with scalar control. Motor current sensors are also no longer required. An additional speed feed forward term in the control scheme enhances the dynamics even further. The pump's constant variation is not a problem for the proposed control method. BLDC motors, which are more efficient and quieter than DC motors, are used in our suggested system. Maximum PV generator power loss is well matched to the BLDC motor's load characteristics. Analyzed are the MATLAB/SIMULINK results for several DC-DC converter topologies.

Index terms- Photovoltaic cells (MPPT), water pumping (Scalar Control), and the introduction of BLDC motor drives

Introduction

Due to the rapid depletion of non-renewable resources in the modern period, renewable resources of energy are being supported by several governments to meet the increasing demand for electrical energy.

Engineers and scientists have been paying attention to escalating energy concerns throughout the world and environmental contamination for a few decades now. Rapid advancements in the ability to convert renewable energy sources into useable forms have occurred. The development of semiconductor technology and the emergence of quick switching power electronic devices have had a significant impact on energy conversion technologies. The use of renewable energy, which began with the conversion of energy from flowing water, has now spread to include the direct conversion of solar energy into electrical energy. Photovoltaic (PV) energy converters formerly had an efficiency of only 5% and were extremely expensive [1]. PV array efficiency has now reached 15-16 percent thanks to recent improvements in technology research and development. The prices have also been steadily decreasing. The absence of toxic pollutants, greenhouse gas emissions, fuel costs, maintenance costs, water use, and other drawbacks make PV energy conversion an attractive alternative to traditional electricity generation methods based on fossil fuels. There are, however, a number of issues that need to be solved, such as the technology's infancy, the high initial costs and the low efficiency.

It has emerged as an essential option for a wide range of applications [3]. Solar PV electricity is widely employed for water pumping in the irrigation industry[4-5]. The DC motor was first used for solar PV water pumping. DC motors have been replaced with induction motors due to their mechanical simplicity, durability and reliability as well as their reduced cost and improved efficiency. Vector control is utilised to feed an induction motor drive from a solar PV array [6]-[7]. Sun insolation and temperature are two important factors in solar photovoltaic (PV) power. PV modules have a single power peak as its defining attribute. The PV system relies heavily on the ability to extract the highest amount of power possible. The literature has therefore created and explained a variety of MPPT (Maximum Power Point tracking) systems. The speed, efficacy, and complexity [8] of these algorithms vary widely. To keep track of MPPT, we're using an incremental conductance (InC)-based approach. Some of the shortcomings of the perturb and observe algorithm (P&O) are addressed by this algorithm. The tracking time is improved and the energy output is boosted across a wide range of irradiation changes thanks to an algorithm. Compared to the P&O approach, which increases losses under slowly fluctuating air conditions by oscillating about MPP [9]-[10], this method has an advantage over For optimal efficiency and maximum MPPT, the majority of existing induction motor drives (IMDs) contain one DC-DC converter and a VSI (Voltage Source Inverter) [11]. Furthermore, VSI regulates the voltage on the DC link. Switching losses are exacerbated since the system requires seven power converter switches. The vector-controlled three-phase IMD feeds an additional DC-AC conversion with a VSI.

A single-stage regulated drive for water pumping is needed to reduce the number of switches and thus the number of losses. In a single-stage system, a VSI is responsible for maintaining the MPP and for controlling the DC link voltage as well. There is no way to accomplish the changeable DC link voltage discussed in [12] and [13]. In terms of response time and precision, vector control is superior to scalar control, as demonstrated in [14]-[16]. An AC motor can be made to act like a DC motor by applying feedback control in the vector control technique [16]. Controlling the active power at the right time. To put it another way, this is because the mechanical time constant of the motor pump system is significantly higher than that of the previously mentioned system. When solar insolation suddenly drops, the voltage of the PV array drops rapidly, and the flux level in the motor drops as well. For a motor to re-establish the flux, it must draw a higher current than that allowed by the PV array's short circuit current. A PV array's operational point in the I-V curve shifts to the current source region, characterised by low voltage and short circuit current. There is an unstable torque-speed relationship around the point where slip = 1 due to insufficient power. This is a dangerous situation for the health of the motor, and the control must be able to recognise this situation and restart the motor from a standstill state. As a result, the MPPT algorithm is responsible for taking care of such incidents, which would lower the pump's overall job. In [14], [15], a V/f (voltage/frequency) control technique is used to control the IMD-tied VSI. In [16]-[18], a DC-DC converter and VSI pumping system is employed for water pumping. The proposed method, on the other hand, is plagued by voltage instability in the DC link. Using the V/f method is straightforward, easy to implement, and cost effective. The SAZEPWM approach [19] calls for the employment of two inverters to power the centrifugal pump. V/f control, DTC (Direct Torque Control) and vector control approaches require additional current sensors for installation [20] that are difficult to implement. Just current, voltage and the DC bus voltage are measured in V/f control. To ensure that the IMD can extract the maximum power from the solar PV array at sustained torque for varying solar insolation levels, the suggested system alters the modulation frequency.

THE SYSTEM'S CONFIGURATION.

An SPV array-fed BLDC motor powered water pumping system employing a zeta converter has been proposed in Fig.2.1.

An SPV array, a zeta converter, a VSI, a BLDC motor, and a water pump are all part of the system under consideration. The encoder is incorporated within the BLDC motor. The zeta converter is controlled by the Fuzzy controller, which generates pulses. Power output and pulse duty cycle are detected via a fuzzy controller.

2.2 SYSTEM OPERATING CHARACTERISTICS

The motor-pump requires electrical power from the SPV array. Using a zeta converter and a VSI, this electrical power is transferred to the motor pump. Fig.2.2 shows the SPV array as a power supply for the zeta converter. The output of the zeta converter should provide the same amount of power to the VSI as the input source does. In actuality, a smaller amount of power is sent to the VSI because of the different losses involved with a dc–dc converter [23]. The zeta converter's insulated gate bipolar transistor (IGBT) switch is controlled by the pulse generator's INCMPPT algorithm. The INC-MPPT method calculates the optimal duty cycle based on inputs like as voltage and current from an SPV array. A high-frequency carrier wave is used to generate the actual switching pulses. As a result, the SPV array's efficiency is improved while also extracting the most power possible.

The BLDC motor drives a water pump attached to its shaft using dc output from a zeta converter and ac input from the VSI. With the help of an encoder incorporated into the BLDC motor, the VSI is driven in fundamental frequency switching mode by an electronic commutation. As a result, the proposed water pumping system has a higher efficiency because the high frequency switching losses have been avoided.

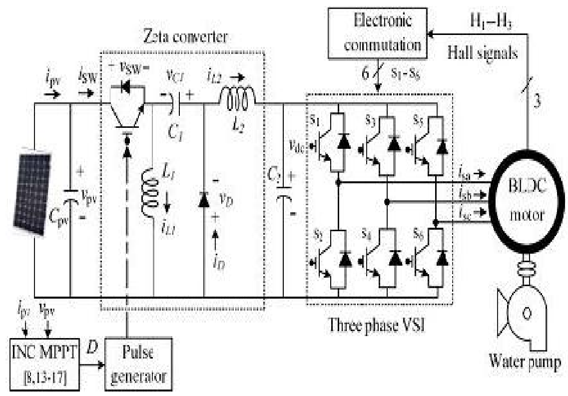

Fig.2.2 Conventional SPV-zeta converter-fed BLDC motor drive for water pump

3. RESULTS AND ANALYSIS

MATLAB/ Simulink is used to develop and design the PV array system equipped with the MPPT controller to drive a water pump.

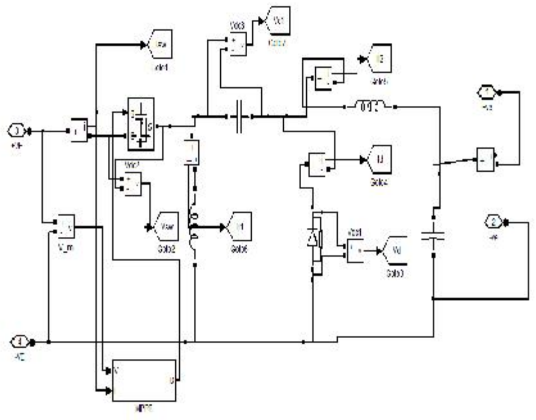

Fig 3.2 Sub system: Zeta converter

A zeta converter has been used in our simulation. It finds applications in various real life scenarios like charging of battery bank, running of dc motors, solar water pumping etc.

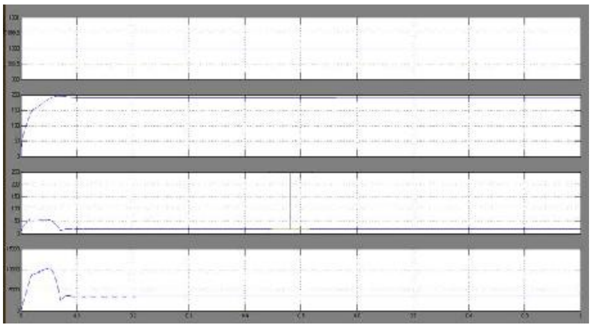

Fig 3.4 SPV array variables of dynamic performances of the proposed system.

CONCLUSION

After being proposed, its usefulness was demonstrated by simulations using PI Maximum power point tracking (MPPT) technique using a solar PV array supplied by a zeta converter. BLDC motor starting, dynamic, and steady-state performance have all been examined in the development of the proposed system, which has been built and modelled to meet the goals set forth. The combination of a zeta converter and a BLDC motor for SPV array-based water pumping was found to be effective based on the results of the performance evaluation. An array of desired functions, such as maximum power extraction from SPV arrays, smooth starting of BLDC motors with no additional control, and smooth motor-speed control with no further input control, have been demonstrated in the system under investigation. This has led to reduced costs and complexity. Even when the sun isn't shining, the planned system has been able to function.

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