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# Bi-Directional Power Flow Water Pumping Using UVT Generation Technique

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**Abstract:** By considering the limitation of the conventional energy resources, renewable energy plays a dominant role today. An innovator water pumping system is proposed to ensure the bi-directional power flow either from a single-phase ac supply or from a Photo Voltaic system to feed a three phase BLDC motor. One of the biggest benefits of this project is the continued water availability. A Brushless Dc Motor (BLDC) drive without phase current sensors are used here. The system utilises a Voltage Source Inverter (VSI) which can draw power either from a solar energy or sinlge phase ac supply to drives BLDC motor drive. A single-phase Voltage Source Converter (VSC) with Unit Vector Template generation (UVT) technique makes the system Bi-directional. To reduce the switching loss VSI is operated at the fundamental frequency. Maximum power can be achieved by PV panel with the help of MPPT. The above system is corroborate in different platform. Here it is completed with MATLAB/Simulink.

**Keywords:** PV Panel, DC-DC Boost converter, BLDC motor drives, VSI, UVT generation technique.

## I. INTRODUCTION

Providing a clean environmentally safe water for livestock in sufficient quantities continues to be a major concern. There are several technology alternatives for supplying power or lift to groundwater systems including wind turbines, wind mills, generators, solar arrays and hand powered pump. The main driving factor for selecting the appropriate technology are regional feasibility, water demand system efficiencies, and initial and long term costs. Other factors often include the need for power and water reserves in the form of batteries and storage tanks. Solar powered system are often considered for use in developing countries instead of other forms of alternative energy because they are durable and exhibit long term economic benefit. A solar powered water pumping system designed for remote area are operated to determine the performance and reliability of the system and component. Solar water pumping system operated on direct current. The output of the solar power system varies throughout the day and with changes in weather condition. Photovoltaic module the source for solar pumping, having no moving parts, require no maintenance lasts for decades. A properly designed water pumping system is efficient, simple and reliable. Sustainability concerns resulting from the consumption of natural resources, global warming, climate change and increasing worldwide energy use have brought renewable energy sources to forefront.

A grid interactive permanent magnet synchronous motor driven solar water pumping system deals with an effective power transfer scheme between the solar photovoltaic array and single phase grid, feeding a field oriented control permanent magnet synchronous motor drive applied to water pumping system[1]. In order to mitigate this, a grid integrated water pumping system is implemented. The grid integration enables the consumer an uninterrupted operation of water pump irrespective of solar insolation level. More over the PV power can be fed to utility grid when water pumping is not required. To make it possible one voltage source converter and voltage source inverter connected to a common DC link, are used for utility grid and PMSM control, respectively. Under the worst case irradiance level BLDC solar water pumping system operates with the operable limits and delivers the required water. Researches have been concentrated the study on electric motor drives to improves the performance and efficiency of water pumping systems run by PV with cost benefit. A permanent magnet BLDC motor is a high efficient, high power density , no maintenance, long service life, low electromagnetic interference issues and small size motor [2]. This is why we are chosen BLDC motor instead of an AC induction motor. From this it has been determined that BLDC motor reduces the cost and size of PV panel this will improve the performance and lead to less maintenance operation [3].

If introduce a standalone water pumping system, the BLDC motor only depends on the solar PV array. Standalone solar system has a major drawback such that it doesn't meet the required energy demand all the time, which is depend on the climatic condition. In case of bad climatic condition water pumping may interrupted and hence the pump is not operated at its full capacity. Inaccessibility of sunlight or may be at night leads to decrease the solar energy this may leads to shut down the overall system. This may be overcome by using a bi-directional power flow or may use the energy storage system. Few attempts on the basis of energy storage system or batteries done in [4]- [5]. But the main problem due to energy storage by batteries increase the overall cost and maintenance also reduces the service life [6]-[7]. The above-mentioned problems of energy storage system have leads to think about alternative solution which may be the best in all aspects. The main aim to generate an uninterrupted water pumping with its full capacity which will not depend on the operating condition whether the pump is working under day or night.

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Solar powered sensor less BLDC motor driven water pump deals with a position sensor less brushless DC motor driven solar photovoltaic fed water pump. A technique based on the back emf zero crossing is introduced for the operation of the BLDC motor. Here in a DC-DC conversion stage a Z source inverter is used [8]. However phase current sensors and DC link voltage are necessary for the operation. A high switching frequency voltage source inverter is used here. ZSI is not suited to give a soft start to the motor without sensing the current. Here the MPPT can be done by any other DC-DC converter. By comparing grid interactive system it can meet its energy demand.

In grid interactive water pumping system for bi-directional power flow a new method is introduced. The ordinary methods like PI control is not suited for bi-directional power flow hence a new method is Unit Vector Template generation technique is chosen due to its simplicity and ability to serve the objective, is used to doing the bi-directional power flow.

The maximum power point tracking can be done by CVT generation technique using a DC-DC boost converter. VSI when operated in PWM technique mode makes the starting of BLDC motor by controlling the magnitude of stator current. However the motor is started then VSI is working at fundamental frequency to reduce the switching loss and improve the converter efficiency. No phase current sensors is used for BLDC motor which increased the cost benefit. The main parts of these works are

1. The BLDC motor driven water pump is connected to utility grid for continued water availability.
2. UVT Generation technique controls the flow of power in either direction.
3. If there is no need of water supply power is transferred to the utility grid.
4. The proposed system is designed such that it delivers water in case of grid failure.
5. Three phase VSI is switched at fundamental frequency which reduces the switching losses.

## II. CONFIGURATION OF PROPOSED SYTEM

Proposed system configuration is shown the figure 1. In this a BLDC motor treat as a water pump. BLDC motor is powered by a PV array through boost converter and VSI. Maximum power point tracking is done by DC-DC (boost converter) converter. Here CVT generation technique is used.

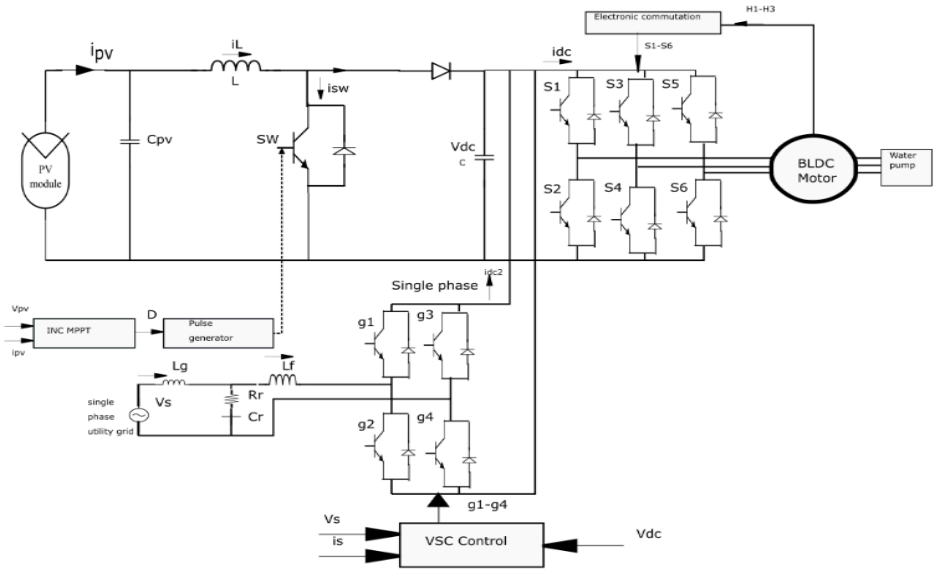


Fig. 1. Schematic of Proposed system

*a) Speed control of the BLDC motor*

The above system eliminates the phase current sensors. It is designed to operate the BLDC motor pump at its rated speed without considering the climatic condition. By controlling the DC bus voltage bidirectional power flow can be also controlled so the operating speed. Speed control enables the full amount of power required to pump the water with full capacity.

*b) Bi-directional power flow control*

Power flow on either direction can be done by bi-directional power flow control based UVT generation technique is shown in figure 2. This is the simplest way to make it easy to put into practice. It is important to note that complexities of mathematics are not used in this method. Single phase Locked Loop (PLL) combines the utility grid voltage and current. It generates a sinusoidal unit vector of supply voltage, sinθ at fundamental frequency. The amplitude of fundamental component of supply current, Isp is extracted by regulating the DC bus voltage, Vdc. A PI controller is used as a voltage regulator. Vdc is sensed and passed through a first order low pass filter to suppress the ripple contents. The filtered Vdc is then compared with a set value Vdc*. A fundamental component

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of supply current, is* is extracted by multiplying Isp and sin. The sensed supply current, is is compared with is* and error is processed through a current controller to generate the gating pulses for VSC.

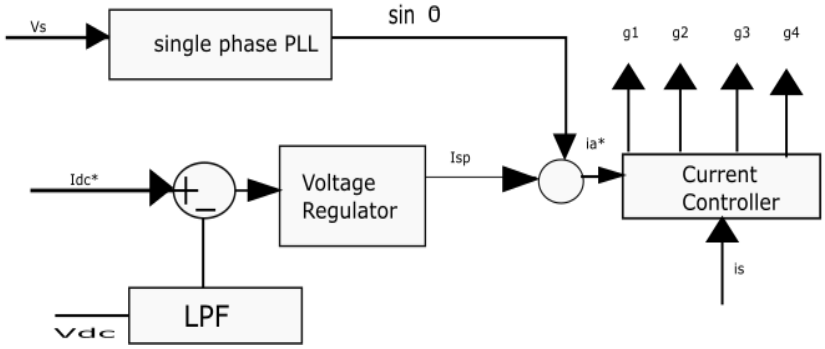


Fig. 2. UVT based power control of VSC

The positive Isp is generate when the required power drawn from the utility grid and the current drawn from the utility is in-phase current. A negative Isp is generate when the PV array powering the BLDC Motor drives. Hence these currents is an out-of-phase supply current. Direction of the power flow can be controlled by controlling the current through the system.

## III. SIMULATION RESULTS AND VALIDATION

Do the analysis of the designed system in MATLAB/Simulink under different condition. A 4 pole 746-watt motor pump is powered by a PV array of watt. A 1 phase utility grid of 230-volt 50 Hz is designed and simulated. Sometimes the water pump is operated alone with PV array or sometimes with the grid or with both, these all factors are considering in the simulation.

Table 1: Simulated parameters

| Performance Parameters | Specification |
|---|---|
| Input voltage | 300V |
| Inductor ( L1) | 25µH |
| Inductor (L2) | 12.7µH |
| Capacitor (C1) | 20µF |

Simulation for the designed system had been done under some operating conditions such as 1000W/m² Irradiance and constant temperature of 25ºC. Switching frequency of 10000Hz.

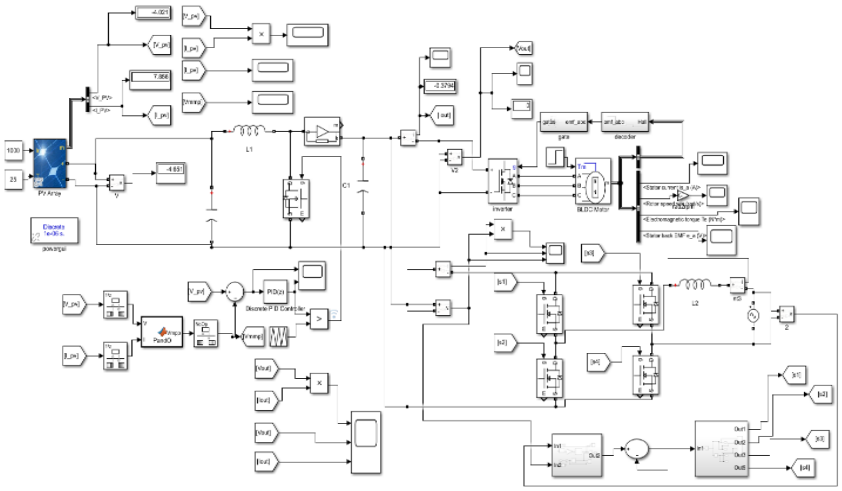

Fig. 3. Grid interactive solar PV based water pumping using BLDC motor drives

The figure 3 shows the simulation diagram of the entire topology. Here boost converter with PV panel, single phase Utility grid and BLDC motor are connected together. Here 1000 Watt boost is connected directly to the inverter which is connected to the BLDC motor. Single phase utility grid is connected to the DC link capacitor which is connected in between the boost converter and inverter.

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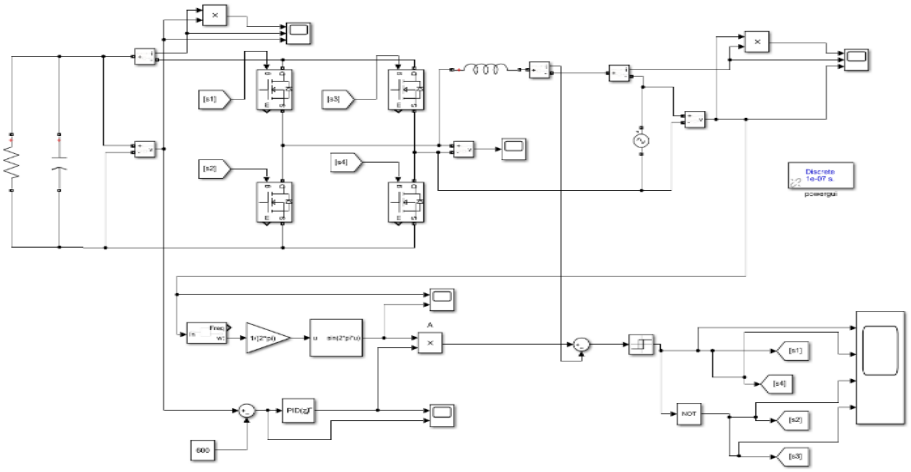

Fig. 4. Cross section of the grid side

Image indicates the grid's cross section. Both the grid and subsystem 1 & 2 in the third image can be accurately understood from the image above. In addition, it is possible to determine the direction in which the power is flowing and the power the motor is running. That is whether motor uses solar energy or grid side energy.

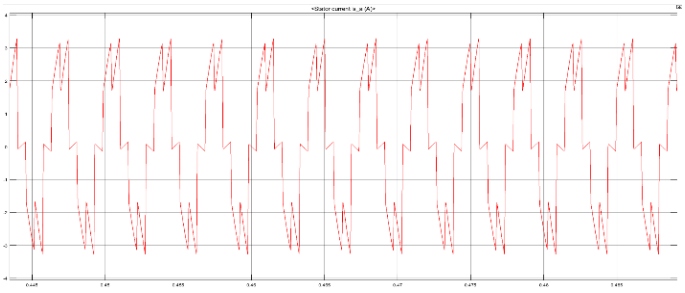

Fig. 5. Stator current of BLDC Motor

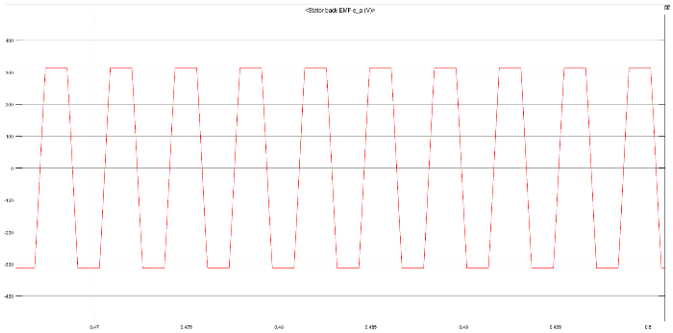

Fig. 6. Stator back emf of BLDC Motor

The two figures above show the stator current and back emf of BLDC Motor.

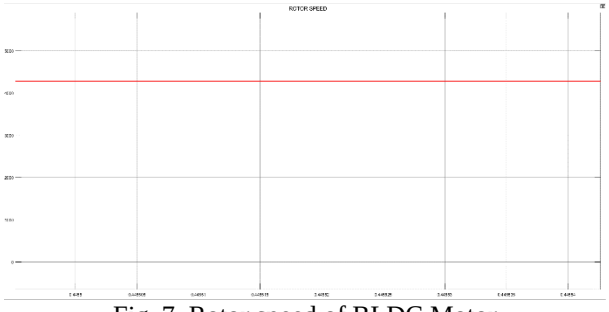

Fig. 7. Rotor speed of BLDC Motor

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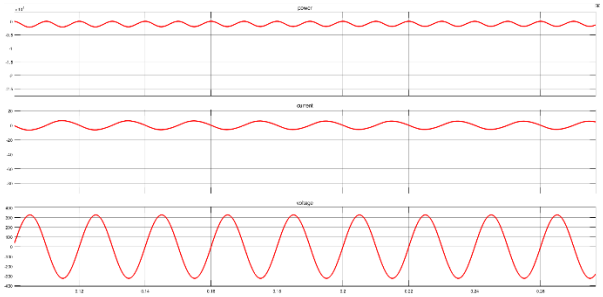

Fig. 7. Utility grid side power, current and voltage

As you can see from the image above, you can see the power flow. That is, the motor is working with which power. To be clear, the Current, the voltage regulator emits is positive, then the motor is powering from grid side as we mentioned above.

## IV. CONCLUSION

Grid interactive photo voltaic based water pumping system is simulated. Introduced a new method for Bi-directional power flow through PV array and utility grid from the conventional method. Unit vector template generation technique is a remarkable idea through-out the project. Bidirectional power flow control ensures the water pumping with full or maximum capacity. Control of the VSC helps to maximum usage of the resources. Without any current sensing element BLDC motor drives can achieve required speed. Because of the VSI has operated under fundamental frequency hence which improve the efficiency of the system and reduce the switching loss. The designed water pumping system is a reliable, efficient and good in all aspects as compared with any other existing system.

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