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BLDC Motor Driven by Solar Power Using CUK Convert for Water Pump

K.Gomathi *,.Dr.A.Venkatesh[*1], Dr.J.Chandramohan[*2], R.Babyshalini[*3]

**PG Student, Gnanamani College of Technology,NH-7, A.K.Samuthiram,Pachal-PO, Namakkal-637 018.Tamilnadu, India.*

*[*1] Assistant Professor,Gnanamani College of Technology, NH-7, A.K.Samuthiram,Pachal-PO, Namakkal-637 018.*
Tamilnadu, India,

*[*2] Associate Professor, Gnanamani College of Technology, NH-7, A.K.Samuthiram,Pachal-PO, Namakkal-637 018.*
Tamilnadu, India.

*[*3] Assistant Professor, Gnanamani College of Technology, NH-7, A.K.Samuthiram,Pachal-PO, Namakkal-637 018.*
Tamilnadu, India,

Abstract— *A solar photovoltaic (SPV) powered brushless DC (BLDC) motor drive for water pumping is presented in this study. The current sensors of BLDC motor and the voltage sensor at the DC bus of voltage-source inverter (VSI) are eliminated completely. Instead, the speed is controlled by adjusting the DC bus voltage of VSI. The fundamental frequency switching pulses are generated to operate the VSI in order to minimise the switching losses and to enhance the efficiency of proposed system. A DC–DC Cuk converter is utilised to operate the SPV array at its maximum power. The starting current of BLDC motor is bounded by an optimal initialisation and selection of the control parameters, perturbation size and frequency while tracking the peak power of SPV array. The performance of proposed BLDC motor drive is thoroughly evaluated and its potential is demonstrated under realistic operating conditions. The simulated results and an experimental validation along with a comprehensive comparison with the existing techniques demonstrate prominence of the proposed drive for SPV-based water pumping.*

Index Terms—*Harmonic Reduction (HR), Varying Load (VL), Transient Response (TR),Adaptive Control (AC), Predictive Control (PC), Fuzzy Logic Control (FLC).*

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I. INTRODUCTION

However, the sensing of motor phase currents and DC bus voltage, and operation of the VSI in PWM mode are still required. In addition, the ZSI is unable to provide a soft starting to the BLDC motor without current control, which calls for the motor currents sensing. In order to resolve the aforementioned shortcomings, a cost-effective,simple and efficient photovoltaic (PV)-BLDC motor pumping system is proposed in this work as shown in Fig. 1. No phase currents or DC bus voltage sensors are used. The speed control is accomplished through a variable DC bus voltage. The VSI is operated through the fundamental frequency pulses which leads to a reduced switching losses. Such systems with a few DC–DC converter topologies for MPPT are reported in [1, 2].

Fig. 1 presents a schematic diagram of the conventional BLDC motor drive for SPV-water pumping [6–10]. The maximum power point tracking (MPPT) [9] is performed by a DC– DC converter [13]. Two phase currents and a DC bus voltage are required to be sensed for motor control.

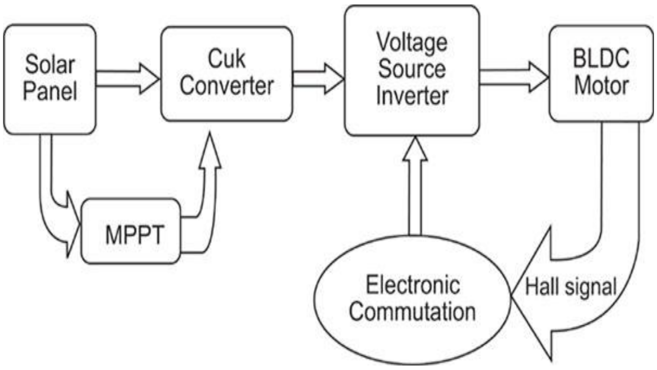

Fig. 1 Schematic diagram of conventional water pumping system

II. Proposed system

The schematic diagram of proposed topology is presented in Fig. 2.A Cuk converter is placed between the PV array and the VSI. The BLDC motor–pump is fed by a VSI. The three inbuilt Hall sensors are used to generate the gating signals for VSI by means of an electronic commutation. The electronic commutation refers to commutating the currents flowing through windings of BLDC motor in a predefined sequence using a decoder such that a symmetrical direct current is drawn from the DC bus of VSI for 120° and placed in phase with back electro-motive force (EMF).Additionally, the Cuk converter is operated for controlling the SPV array through an incremental conductance (INC) MPPT technique. It coerces the PV array to be operated at maximum power point (MPP) by steadily updating the duty ratio.

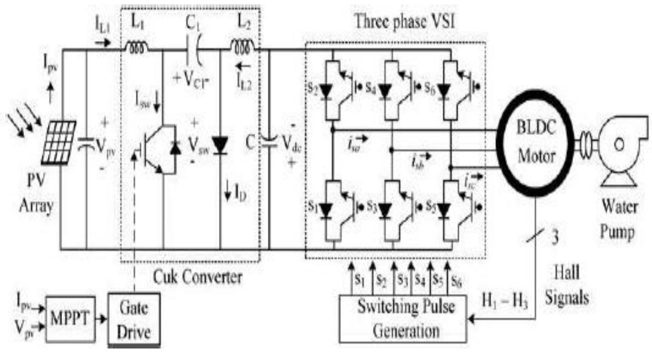

Fig. 2 Schematic diagram of proposed water pumping system

a. Control approach

The control of proposed system is classified into two major parts:control of SPV array operating point through an MPPT technique,and BLDC motor electronic commutation. These control methodologies are discussed as follows.

An appropriate design and specifications of BLDC motor–pump, SPV array and Cuk converter play a significant role in the desired operation of a water pump. A six-pole BLDC motor with 3000 rpm and 5.8 kW is selected. The PV array, Cuk converter and water pump are selected such that functioning of the system is not interrupted under any disturbance in the atmospheric conditions.

b. Brushless DC Motor (BLDC)

For the water pumping we use BLDC Motor. The various advantages of BLDC motors are lightweight, simple construction, less maintenance due to absence of brushes, less noisy than the brushed DC motor with the same output. The rotor of the motor is a permanent magnet and the stator is made by coil arrangement. The BLDC motor is operated by attraction and repulsion between stator and rotor. We use a star connected BLDC motor where the neutral point is not connected.

- High efficiency and reliability
- Lighter in weight
- The dynamic response is less
- speed range is high
- Life is long etc.

c. Design of Water Pump

A water pump is coupled to the shaft of the BLDC motor. In this we use a submersible pump which is submerged in the oil. Due to being submerged in oil the pump prevents the cavitation and it is the advantage of this pump using. Also, it is better than the jet pumps. Pumps consist of stages. Each stage lifts the water of about 5mtr. Use 12 stages pumps. 12 x 5 mtr = 60mtr Water is lifted by 60mtr height.

Table -3: Specification of Pump

HP	1HP
Efficiency	69%
Output Power	750 W

III. Simulation Results

SIMULATION

3.1 Ideal Performance

The ideal performance of the PV array is as shown in Fig -3. The performance shows the PV voltage (Vpv) in volts, PV current (Ipv) in Amp and Power (Ppv) in Watt.

3.2 Dynamic performance

Depending upon the atmospheric condition the voltage (Vpv), Current (Ipv) and Power (Ppv) is varied. Under variable atmospheric condition the result is also variable as shown in Fig -3.

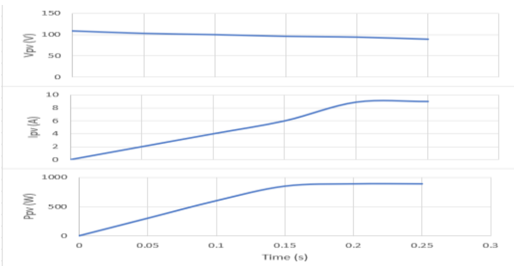

Fig -4 shows the PV array results under variable atmosphere condition. By changing the output PV voltage, the speed, voltage and current of the BLDC motor is also changed which is shown in Fig -5.

Table -4 shows the result of the parameter of PV array and BLDC motor.

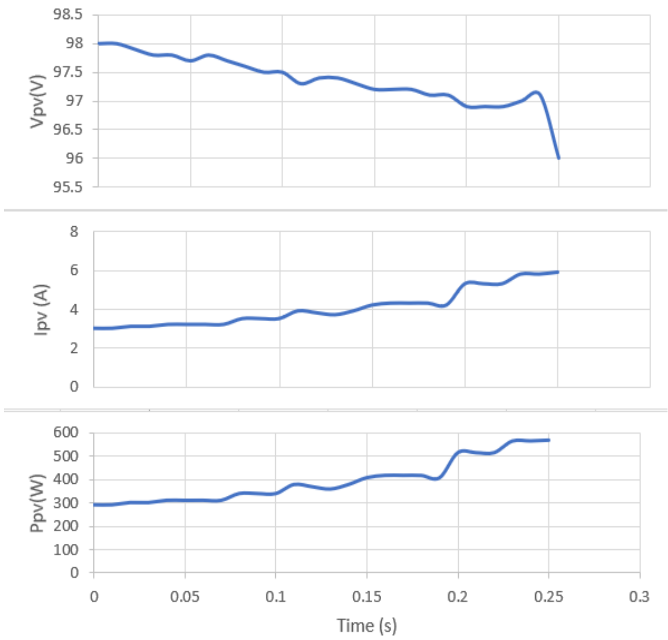

Fig -4: Dynamic performance of PV Array

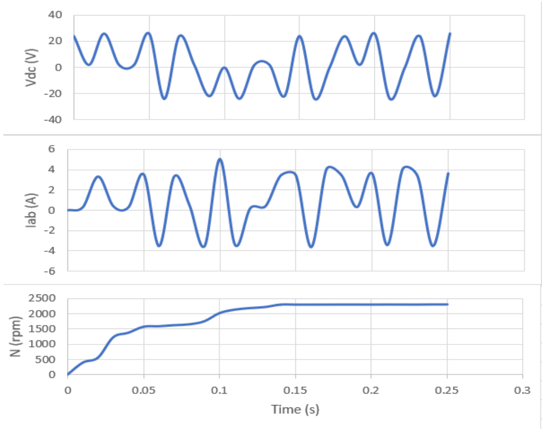

Fig -5: Dynamic Performance of BLDC Motor

IV. Response of Results

Fig -6 shows the response of PV array at steady state condition. It shows the DC voltage of PV array in volt versus Time in Second. The voltage is maintained in the range of 96V-98V. Fig - 7 shows the response of BLDC motor Voltage versus Time in second at steady state condition. Fig -8 and Fig -9 shows the photocopy of response of PV array and BLDC motor under the variable atmospheric condition.

Fig -6: Response of PV Array at steady state condition

Fig -7: Response of BLDC Motor at steady state condition

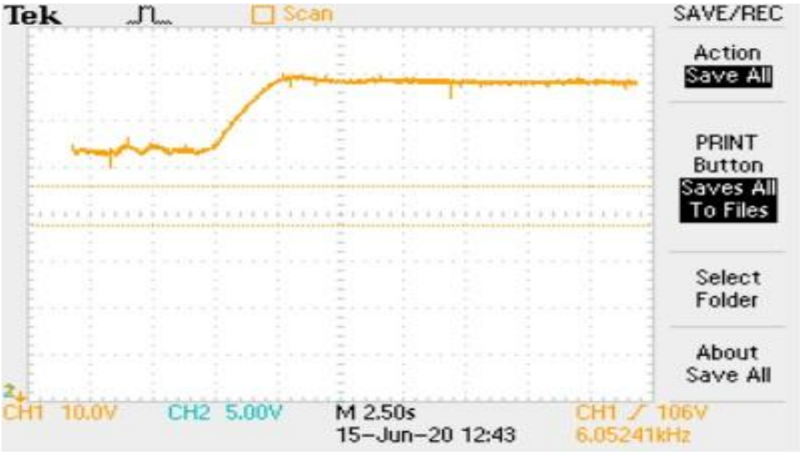

Fig -8: Response of PV Array at variable atmosphericcondition

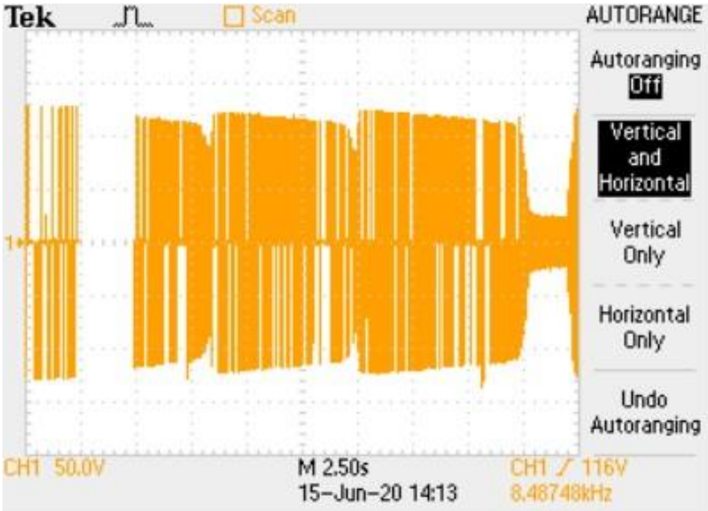

Fig -9: Response of BLDC Motor at variable atmosphericCondition

V. CONCLUSION

By using a DC link the DC-DC Conversion is removed so that the system is simple, less cost and compact. The efficiency of about 60-70% is achieved by using BLDC Motor. By using solar panels, we can reduce the pollution, and maintenance cost is very less or almost no maintenance. Due to use of the BLDC motor we can achieve maximum efficiency because there is no use of brushes and commutation. No additional control is required for the speed control.In the villages or where electricity is not possible to transfer or it is not economical if transfer then there is more scope.

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