Advanced MPPT Control System for Solar Connected Grid for Brushless Motor Drive

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Abstract — *In this paper, a brushless DC (BLDC) motor-powered water pumping system fed by solar photovoltaics (PV) is proposed. By employing a power grid as an external power backup, a promising instance of a water pumping disruption caused by the intermittent production of PV power is handled. In the event that the PV array is unable to supply the necessary power demand, the grid is utilised; otherwise, the PV array is preferred. Through the use of a power factor corrected (PFC) boost converter, a unidirectional power flow control for the same is created and implemented. The suggested system and control allow a customer to get a complete volume of water supply day and night, regardless of the weather. Thus, in addition to improving the pumping system's durability, the greatest possible use of motor pumps is made feasible. The created control complies with the needed power quality criteria at the utility grid. To show how the system may be used, performance analysis and simulations based on MATLAB/Simulink are conducted.*

Keywords — *Solar photovoltaic; Brushless DC motor; Unidirectional power flow control; PFC boost converter; Power quality conventional Beta MPPT Technique; Incremental MPPT* .

I. Introduction

The necessity for energy-saving solutions has been growing quickly as the energy demand rises. Being an energy-efficient motor, brushless DC (BLDC) motors are key players in this development [1]. The BLDC motors offer a high power density, high efficiency, high torque/inertia ratio, and a high power factor when compared to an induction motor, which is commonly used in solar photovoltaic (PV) based water pumping. In addition to this, a BLDC motor's speed is not constrained by power frequency as an induction motor is. The motor's size is thereby lowered, but its capacity is enhanced [2]. Solar PV technology development is at its mature stage, making it one of the most promising and major renewable energy sources [3] [4]. This technology is becoming more crucial in the effort to save energy. Therefore, for an application like water pumping, the solar PV supplied BLDC motor drive does definitely stand out as a worthwhile source and drive combination [1–3].

A battery store, however, shortens the service life and raises the expense of installation and maintenance [8]. An alternative approach that uses a utility grid as the backup supply in a PV-based induction motor-driven water pumping is published in [9-11] as a way to overcome this issue using battery technology.

Usually, the efficiency is not taken into consideration while operating these traditional motors at constant speed from main AC power. More convenience features, higher performance, lower acoustic noise, and lower energy costs are becoming priorities for consumers. The answers cannot be provided by such conventional technology.

II. PV Array System And Dc To Dc Converter

A. *Design Of Photo Voltaic Array*

For effective boundless power age PVA is connected to make control from sunshine essentially based gentle. since the heap solicitation is growing gradually the quality age furthermore ought to be expanded, anyway on account of the regular strategy for power age is causing an unnatural climate change, due to this the capability of the PVA should be raised through alongside silicon surface the board and in addition, use the MPPT procedures to follow most extreme serious quality in the midst of any light and cools. The blueprint of PVA is finished in MATLAB with Simulink.

$$V_c = \frac{AkT_c}{e} \; ln\,(\frac{I_{ph}+I_o-I_c}{I_o}) - R_s I_c \qquad (1)$$

Where, k = Boltzmann constant (1.38 × 10-23 J/K).
I_c = cell output current, Amp.
I_{ph} = photocurrent
I_o = reverse saturation current of diode 18601207777
R_s= series resistance of cell
T_c= reference cell operating temperature
V_c= cell voltage, V.

B. *Perturb and Observe Method*

Solar PV systems use a variety of MPPT techniques. Make a scene and watch Hill-climbing is another name for the P&O algorithm, however depending on how it is used, both terms relate to the same method. As a result of the power converter's duty cycle and the DC connection between the PV array and the power converter's operational voltage being perturbed, hill climbing occurs [12]. Both titles apply to the same process in the case of hill-climbing, which involves changing the voltage of the DC connection connecting the PV array and the power converter while also changing the duty cycle of the power converter [13]. The sign of the previous perturbation and the sign of the previous power increment are employed in this approach to determine what the following perturbation should be. As shown in Figure 1, increasing the voltage on the left of the MPP increases the power, whereas decreasing the voltage on the right increases the power.

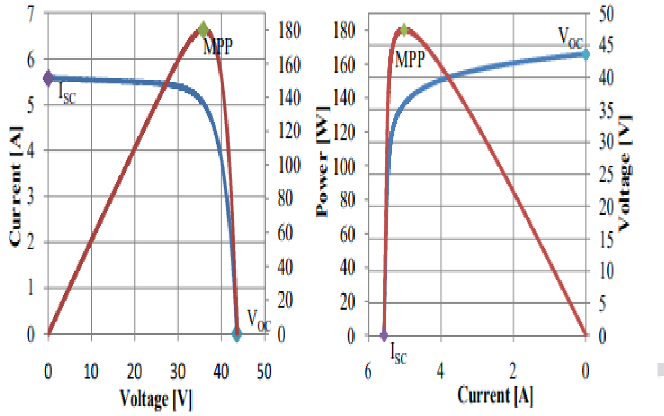

Fig. 1- PV panel characteristic curves.

The next perturbation should be in the opposite direction if there is a fall in power, and it should continue in the same direction if there is an increase in power. The algorithm is applied based on these information [8]. Repeating the procedure until the MPP is attained. Following that, the operational point rotates around the MPP. As was already mentioned, this issue also arises with the In Cond technique. Figure 2 displays the algorithm's layout.

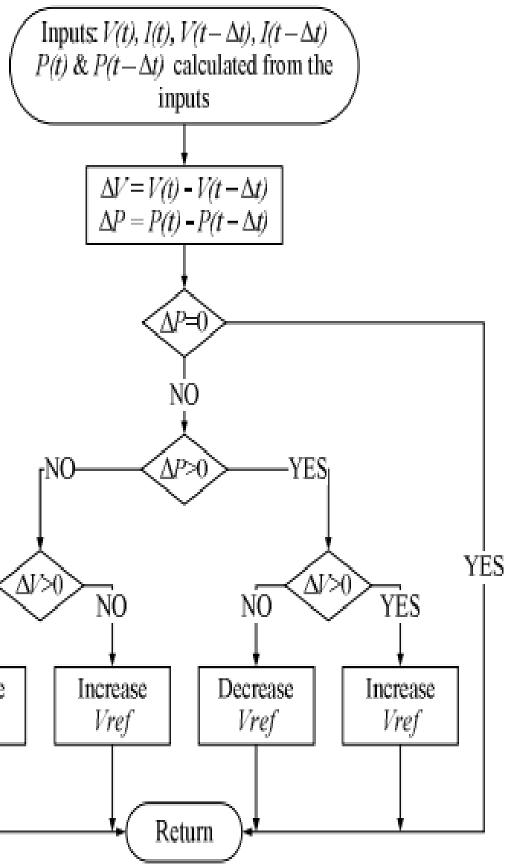

Fig. 2 - The flowchart of the P&O Algorithm.

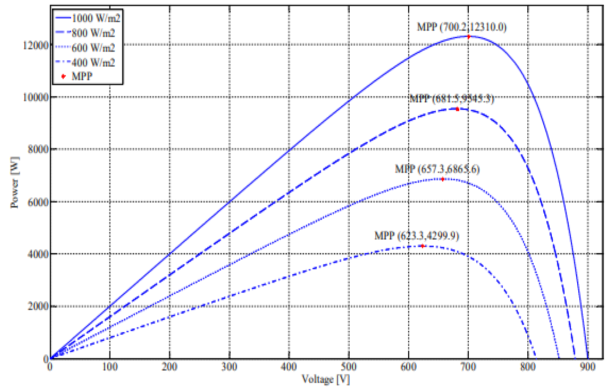

Fig. 3 P-V curve depending on the irradiation.

III. PRINCIPLE OPERATION OF BRUSHLESS DC (BLDC) MOTOR

A permanent synchronous machine with rotor position feedback is what is known as a brushless dc motor. In most cases, a three phase power semiconductor bridge is used to operate brushless motors. For beginning and supplying the correct commutation sequence to switch on the power devices in the inverter bridge, the motor needs a rotor position sensor. The power devices are consecutively commutated every 60 degrees depending on the position of the rotor. It is an electronic motor since electronic commutation is utilised in place of brushes to commutate the armature current. This makes a BLDC motor more durable than a DC motor by eliminating the issues related to the brush and the commutator arrangement, such as sparking and brush wear-out.

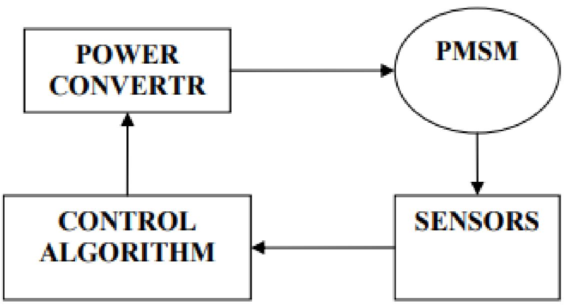

Fig. 4. Basic block diagram of BLDC motor

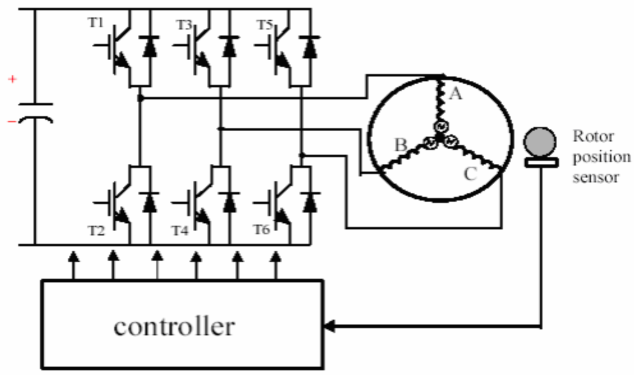

Fig. 5 Brushless dc motor drive system

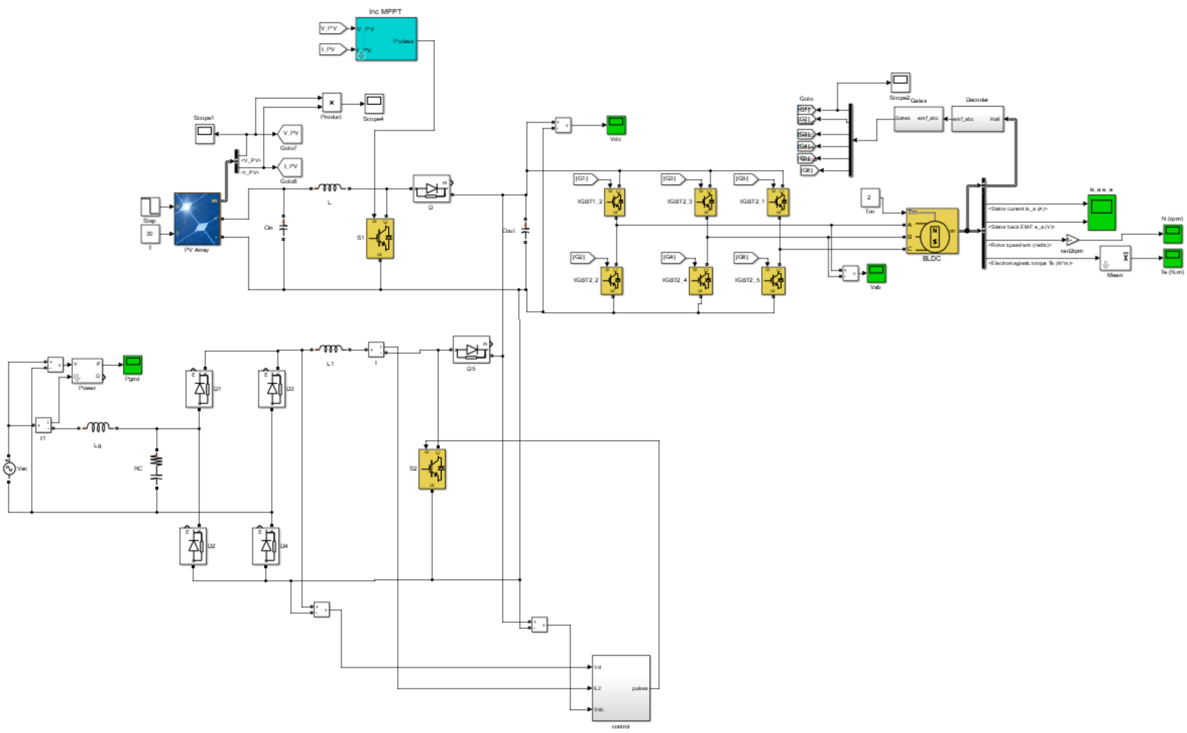

Fig. 6 Grid interfaced PV-INC MPPT system with BLDC Motor Drive

IV. Simulation Result And Discussion

The complete design related to the project is created in MATLAB & Simulation using Sim Power System Toolbox and thereby analysis the different MPPT Technique. This designing is conducted in stage as:- Grid interfaced PV-INC MPPT system with BLDC Motor Drive.

In the above proposed system figure 6, the utility grid is connected to a diode bridge rectifier for AC to DC conversion and the variable DC voltage is stabilized using booster converter. A feedback loop controller is connected to control the booster converter of the utility grid.

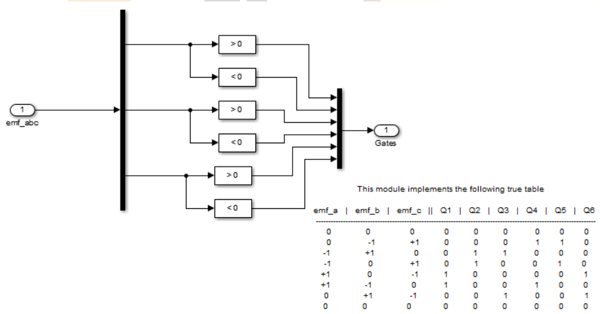

Fig. 7 Commutation signals for six switch VSC for BDLC motor drive

The above test system is run for 1sec with solar irradiation drop from 1000W/mt2 to 200W/mt2 at 0.5sec and powers of PVA and grid are recorded.

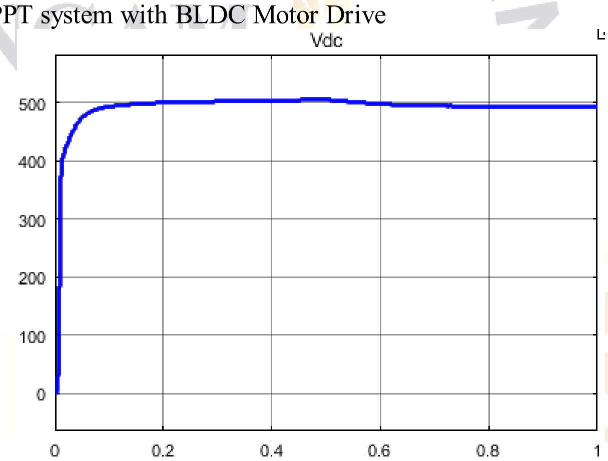

Fig. 8 DC voltage at PCC

The DC voltage is maintained at 500V even during drop in solar irradiation, which is maintained by the MPPT controller and the feedback loop controller of the utility grid.

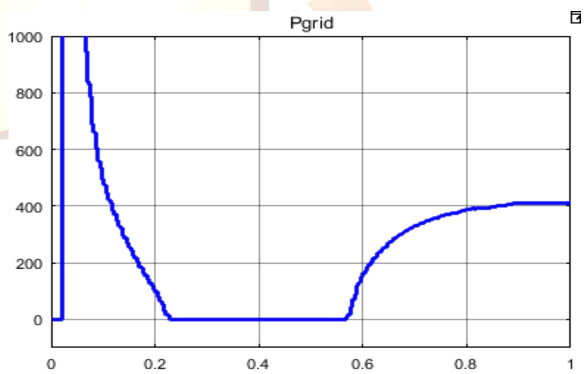

Fig. 9 Grid power injected

Increase in power of grid from 0W to 400W during drop in solar irradiation. From 0 to 0.2sec is the transient time for the system to settle which is neglected as we consider only steady state period.

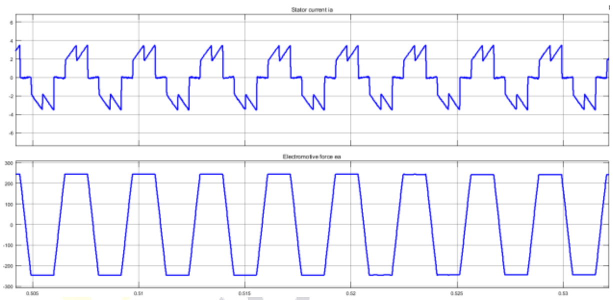

Fig. 10 Stator current and emf of A phase of BLDC motor

V. Conclusions

Through the performance assessment of its MATLAB/Simulink platform, a single phase grid interfaced solar PV-water pumping system with a brushless DC motor drive has been developed and proven. The common DC bus has been equipped with utility grid backup power. To enable a power transfer conditionally, a PFC boost converter and a unidirectional power flow control have been created and implemented. In the above graphs the power of the PVA is dropping from 1500W to 1100W when the irradiation is changed from 1000W/mt2 to 200W/mt2 and the remaining deficit power 400W is compensated by utility grid at 0.5sec. The BLDC motor is however running at the same speed even during solar irradiation change. The power output of the PVA is improved when the MPPT is updated with beta method as compared to conventional incremental conductance method. Thus, the proposed topology has emerged as a reliable and efficient water pumping system.

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