BLDC Motor Drive with PV Connected Employing P&O MPPT Controller

Niraj Kumar Pandey[1] and Varsha Mehar[2]
[1&2] Electrical Engineering Department, RKDF University, Bhopal, India
[1]pandeyneerajkumar151@gmail.com , [2]varshamehar86@gmail.com

* Corresponding Author: Niraj Kumar Pandey

Abstract: *As the load of a photovoltaic system with a Maximum Power Point Tracking (MPPT) controller, brushless DC motor drive is used in this paper. This MPPT controller uses a perturbation and observation (P&O)-based technique. It is successfully induced to use a brushless DC motor that couples a motor controller with a proportional integral (PI) speed control loop. The dynamic model and simulation of the system are built using MATLAB/Simulink. The MPPT controller is utilised by the solar photovoltaic system, and it uses the output signal to regulate the DC-DC boost converters in order to implement MPPT. This suggested MPPT controller increases power on average and quickly achieves MPPT and current management of the BLDC motor drive.*

Keywords: *MPPT; PV System; MPPT Controller; P&O.*

I. Introduction

Sunlight is converted into power via a photovoltaic system. The photovoltaic cell is the main component of a solar system. Panels or modules are created by grouping cells. In order to create huge solar arrays, panels are grouped. A solar panel (with many cells connected in series and/or parallel) or a collection of panels are typically referred to as an array. Any photovoltaic device made up of a number of basic cells is referred to as an array from here on [1 -4]. Solar irradiation level, temperature, and load current all affect the output voltage, current, and power of a PV array. As a result, the effects of these three factors must be taken into account when designing PV arrays in order to ensure that any variations in temperature and solar irradiation levels do not negatively impact the PV array's output to the load or utility, which may be a stand-alone electrical type load or the utility grid of a power company. Solar energy provides a lot of benefits, including being abundant, readily available, and emitting little carbon dioxide [5–8].

A maximum power point tracking (MPPT) controller is used to implement the connection between the motor load and the PV module in order to operate the PV system at its maximum output power at any temperature and solar radiation level. In theory, this regulates a PV panel's output voltage automatically so that it can run constantly at its maximum power points regardless of load variation, solar radiation, and temperature changes [9-11]. This essay's goal is to examine how Perturbation and Observation are carried out and how effective they are (P&O). By analysing actual values of PV voltage and current, P&O can continuously monitor the Maximum Power Point (MPP), regardless of the weather, the kind of PV panel, or even the age of the panel. On-line MPPTs are often used for larger PV arrays because they are more expensive to construct due to the circuitry needed [12-15].

II. PV Modeling

Multiple solar cells connected in parallel and series make up a PV array. While the current in the array is increased by a parallel connection rather than a series connection, the voltage of the module is increased by a parallel connection. An inverted diode coupled in parallel to a current source can typically be used to imitate a solar cell. Figure 1 is a single diode representation of a photovoltaic cell, each with its own series and parallel resistance [16].

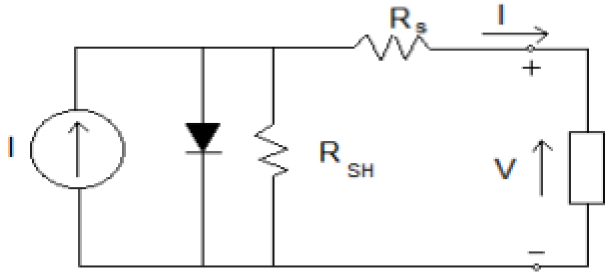

Figure 1 Single diode model of a PV cell

Series resistance is due to hindrance in the path of flow of electrons from n to p junction and parallel resistance is due to the leakage current. In this model we consider a current source (I) along with a diode and series resistance (Rs). The shunt resistance (Rsh) in parallel is very high, has a negligible effect and can be neglected [3]. The output current from the photovoltaic array is

$I=I_{sc} - I_d$…………………… (1)

Id= Io (eqVd/kT - 1) ……..... (2)

where Io is the reverse saturation current of the diode, q is the electron charge, Vd is the voltage across the diode, k is Boltzmann constant (1.38 * 10-19 J/K) and T is the junction temperature in Kelvin (K)

I = Isc – Io (eqVd/kT - 1) ……(3)

Using suitable approximations,

I = Isc – Io (eq((V+IRs)/nkT) - 1)…..(4)

where, I is the photovoltaic cell current, V is the PV cell voltage, T is the temperature (in Kelvin) and n is the diode ideality factor . Figure 2 I-V characteristics of a solar panel.

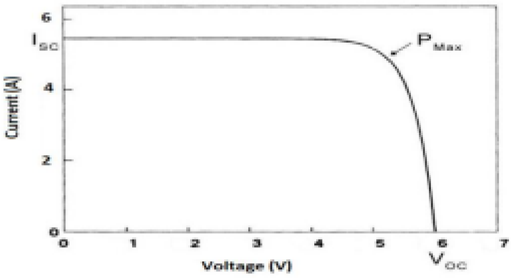

Figure 2 I-V characteristics of a solar panel

When the voltage and the current characteristics are multiplied we get the P-V characteristics as shown in Figure 3. The point indicated as MPP is the point at which the panel power output is maximum.

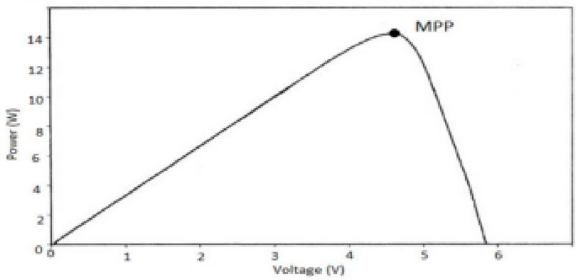

Figure 3 P-V characteristics curve of photovoltaic cell

III. INCREMENTAL CONDUCTANCE

The incremental conductance approach is based on the observation that the slope of the PV module's power versus voltage (current) curve is zero at the MPP, positive (negative) on its left, and negative (positive) on its right. It is possible to calculate the change in the MPP voltage by comparing the increase in power to the increase in voltage (current) between two successive samples. Figure 3.3 displays a diagram of the algorithm.

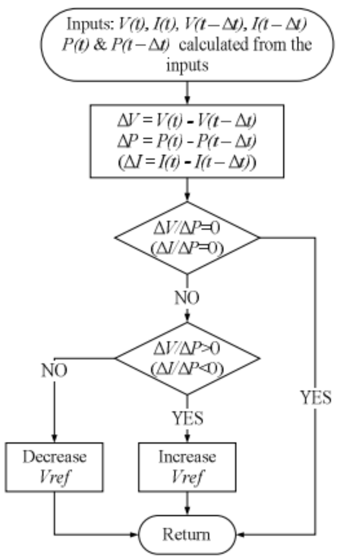

Figure 3.3 - Incremental Conductance algorithm

IV. Proposed Methodlogy

The suggested design of a PV-fed, brushless DC motor-driven water pumping system that interfaces with the grid is seen in Fig. 4.1. A BLDC motor is fed by a PV array via a boost converter and a VSI, which is equipped with enough power to drive the water pump at full capacity under the usual climatic circumstances. The MPPT of a solar panel array and an electronic motor commutation are carried out by the DC-DC boost converter and the VSI, respectively. For the purpose of producing the commutation signals, three Hall Effect sensors are employed. For powering the water pump, a BLDC motor with a rated speed of 6000 rpm at 410 V (DC) is employed. A bridge rectifier and a PFC boost converter are used at the common DC bus of VSI to offer support for a single phase utility grid. A unidirectional power flow control is used to operate the PFC converter and regulate the power transfer. The designed control allows for a power transfer from the utility grid to the DC bus if the PV-generated power is inadequate to satisfy the demand; otherwise, no power is transferred from the utility.

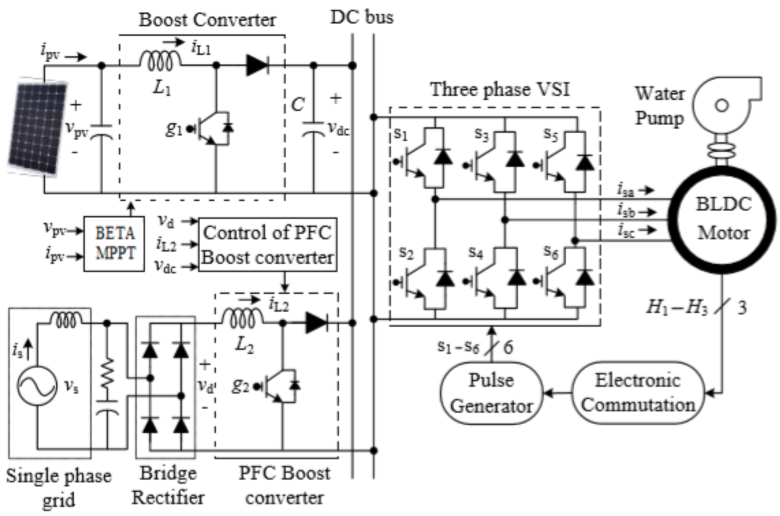

Fig. No.4.1 Proposed grid interfaced PV fed brushless DC motor

V. Brushless DC Motor

A permanent magnet stimulated synchronous motor is fed with a variable frequency inverter under the direction of a shaft position sensor in brushless dc motor drives, or BLDC motor drives. There doesn't seem to be any commercial simulation software available for designing controllers for these BLDC motor drivers. For their typical low cost fractional/integral kW application areas, such as NC machine tools and robot drives, the high software development costs incurred are not justified. This is true even if it could imply the possibility of demagnetizing the rotor magnets during commissioning or tuning stages. Nevertheless, for complex and specialised applications, recursive prototyping of the motor and inverter may be necessary, leading to a high drive system development cost. Improved magnet materials with high (B.H) products also aid in expanding the market for BLDC motors to tens of kW application areas where commissioning mistakes are unaffordably expensive. Therefore, modelling is crucial and might result in financial savings. A brushless dc motor is a dc motor that has been flipped inside out such that the armature is on the stator and the field is located on the rotor. The brushless dc motor is really an ac permanent magnet motor with torque-current characteristics that resemble those of a brushless dc motor. Electronic commutation is utilised to commutate the armature current as opposed to brushes. A BLDC motor is more durable than a dc motor as a result of this since it removes the issues with the brush and commutator arrangement, such as sparking and commutator-brush wear out. Because the armature is attached to the stator, it is simple to transmit heat away from the windings, and if necessary, it is much simpler to install a cooling system for the armature windings than it would be for a dc motor.

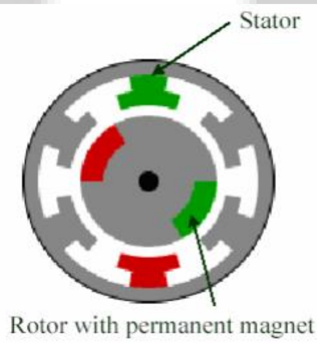

Fig 4.2 Cross-section view of a brushless dc motor

VI. Conclusion

The MPPT algorithms that can locate the true MPP were examined in this work. P&O is chosen for its simplicity and efficacy. The PV system was modelled in a more straightforward manner. The P&O approach is the one that is most frequently employed in commercial MPPT systems since it is simple, precise, and simple to operate. The amount of the perturbation affects the precision and tracking time.

The development of the interface with the BLDC motor was the primary focus of the effort. The goal was to create a model that would be straightforward, precise, flexible, and quick to run. Additionally, the motor's settling time is shortened. As a result of using genuine BLDC motor characteristics and confirming that the model behaved as expected, it is thought that the objectives have been met.

The interaction with the BLDC motor was the primary focus of the effort. The goal was to create a model that would be straightforward, precise, flexible, and quick to run. Additionally, the motor's settling time is shortened by 0.225 seconds. The characteristics of an actual BLDC motor were employed, hence it is thought that the objectives were achieved.

References

[1] Vertgewall, C.M.; Trageser, M.; Kurth, M.; Ulbig, A. Modeling Probabilistic Driving and Charging Profiles of Commercial Electric Vehicles. Electr. Power Syst. Res. **2022**, 212, 108538.

[2] Sheela, A.; Logeswaran, T.; Revathi, S.; Rajalakshmi, K. Distributed MPPT Configuration for Improving Solar Energy Production. In Proceedings of the 2022 3rd International Conference for Emerging Technology (INCET), Belgaum, India, 27–29 May 2022; pp. 1–5.

[3] Kee, S.H.; Chiongson, J.B.V.; Saludes, J.P.; Vigneswari, S.; Ramakrishna, S.; Bhubalan, K. Bioconversion of agro-industry sourced biowaste into biomaterials via microbial factories–A viable domain of circular economy. Environ. Pollut. **2021**, 271, 116311.

[4] Sethi, V.; Sun, X.; Nalianda, D.; Rolt, A.; Holborn, P.; Wijesinghe, C.; Xisto, C.; Jonsson, I.; Gronstedt, T.; Ingram, J.; et al. Enabling Cryogenic Hydrogen-Based CO_2-Free Air Transport: Meeting the demands of zero carbon aviation. IEEE Electrif. Mag. **2022**, 10, 69–81.

[5] Hridaya A; Gupta C, AN OPTIMIZATION TECHNIQUE USED FOR ANALYSIS OF A HYBRID SYSTEM ECONOMICS, Int. J. Curr. Trends Eng. Technol. 1, 136 (2015).

[6] Gupta C. and Aharwal V. K., Optimizing the Performance of Triple Input DC-DC Converter in an Integrated System, J. Integr. Sci. Technol. 10, 215 (2022).

[7] Hridaya A. and Gupta C., Hybrid Optimization Technique Used for Economic Operation of Microgrid System, Academia.Edu 5, 5 (2015).

[8] Khan S, Gupta C. An optimization techniques used for economic load dispatch. Int J Adv Technol Eng Res (IJATER). 2014;4(4).

[9] Wu, R.; Hao, J.; Zheng, S.; Sun, Q.; Wang, T.; Zhang, D.; Zhang, H.; Wang, Y.; Zhou, X. N dopants triggered new active sites and fast charge transfer in MoS_2 nanosheets for full Response-Recovery NO_2 detection at room temperature. Appl. Surf. Sci. **2021**, 571, 151162.

[10] Li, Y.; Han,W.; Shao,W.; Zhao, D. Virtual sensing for dynamic industrial process based on localized linear dynamical system models with time-delay optimization. ISA Trans. 2022, in press.

[11] Kim, M.-H.; Lee, S.-H.; Kim, S.; Park, B.-G. A Fast Weight Transfer Method for Real-Time Online Learning in RRAM-Based Neuromorphic System. IEEE Access **2022**, 10, 37030–37038.

[12] Zhang,W.; Xu, J.; Yu, T.X. Dynamic behaviors of bio-inspired structures: Design, mechanisms, and models. Eng. Struct. **2022**, 265, 114490.
Sustainability **2022**, 14, 14120 27 of 27

[13] Padmanaban, S.; Priyadarshi, N.; Bhaskar, M.S.; Holm-Nielsen, J.B.; Ramachandaramurthy, V.K.; Hossain, E. A Hybrid ANFISABC Based MPPT Controller for PV SystemWith Anti-Islanding Grid Protection: Experimental Realization. IEEE Access **2019**, 7, 103377–103389.

[14] Lei, D.; Cui, Z.; Li, M. A dynamical artificial bee colony for vehicle routing problem with drones. Eng. Appl. Artif. Intell. **2021**, 107, 104510.

[15] Rajeshkanna, G.; Sasiraja, R.M.;Winston, D.P. Design and development of Truncated Angle Variant (TAV) controller for multisource-fed BLDC motor drive. Electr. Eng. **2020**, 102, 1931–1946.

[16] Himabindu, N.; Hampannavar, S.; Deepa, B.; Swapna, M. Analysis of microgrid integrated Photovoltaic (PV) Powered Electric Vehicle Charging Stations (EVCS) under different solar irradiation conditions in India: A way towards sustainable development and growth. Energy Rep. **2021**, 7, 8534–8547.