International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 1 Issue 3, December 2020

Grid Interfaced Solar PV Based Water Pumping Using BLDCM with Fuzzy Logic Controller

Pawan Adlak[1], Prof. M.S. Das[2] and Prof. Vasant Acharya[3]
Research Scholar, Department of Electrical and Electronics TIT BHOPAL(MP)[1]
Assistant Professor Department of Electrical and Electronics TIT BHOPAL(MP)[2]
Assistant Professor Department of Electrical and Electronics TIT BHOPAL(MP)[3]

Abstract: *In this paper a grid interface PVA source is used for running a BLDC motor water pumping system. The PVA is connected to booster converter for constant voltage generation during solar irradiation change. The booster converter is controlled using MPPT controller incremental conductance method. The grid controller is updated with fuzzy logic controller for better DC voltage settling time. The reaction time and power output of the grid are compared with these two control techniques. The graphs of voltages and powers of PVA and grid are generated with respect to time using MATLAB Simulink environment. The MATLAB/Simulink based simulations and the performance analysis are carried out to demonstrate the applicability of the system.*

Keywords: *Solar photovoltaic; Brushless DC motor; Unidirectional power flow control; PFC boost converter; Power quality conventional, Incremental MPPT PI controller, Fuzzy logic Controller*.

1. Introduction

As the demand for energy grows, the need for energy-saving measures has increased dramatically. Brushless DC (BLDC) engines play an important role, in being the energy-efficient vehicle, in this practice [1]. Compared to the most widely used imported solar water pump for photovoltaic (PV), BLDC motors have high power, high efficiency, high torque / inertia ratio and high power. Apart from this, unlike the import vehicle, the BLDC vehicle speed is not limited by the frequency of power. This leads to reduced size and increased engine power [3]. Among the most promising and highly significant renewable energy sources, the development of solar PV technology is reaching its full potential [4]. In the end saving energy, this technology plays a very important role. Therefore, solar PV-fed BLDC motor drive actually emerges as a suitable combination of source and drive application such as water pump While there is an innumerable motivating factor, natural aerospace, is a major problem with PV generation technology. This reduction in results results in unreliable water pumping with a PV-based pump system. During bad weather, water absorption is severely disrupted. In addition, the system is not operational as the pump can be fully utilized. In addition, the lack of sunlight (at night) leads to the shutdown of the entire water pump system. To overcome these errors, an external power-saving backup battery is provided in the PV-BLDC automotive pump system.

However, battery storage shortens service life, and increases installation costs and storage requirements [8]. To address this problem with battery technology, another solution is reported in [9-11] where the utility grid is used as a backup source for PV-powered water pumps.

Brushless dc (BLDC) motors are selected as small horse control motors for their efficiency, quiet operation, compact form, reliability and low adjustment. However, the problems encountered in these flexible speed motors over the decades have continued technological advances in electric semiconductors, microprocessors, speed driver control schemes and the production of permanent electric vehicles combined to enable a reliable, cost-effective solution for applications. adjustable speed. Home appliances are expected to be one of the fastest growing end product market of electric motorists for the next five years [4]. Large appliances include laundry air conditioners, refrigerators, washing machines, refrigerators, etc. Household appliances traditionally rely on older electrical equipment such as single-phase AC input,

International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 1 Issue 3, December 2020

including phase separation, capacitor-start, capacitor-run types, and universal vehicle. These standard motors are driven at a constant speed directly from high AC power without much efficiency. Consumers now want lower power costs, better performance, reduced acoustic sound, and ease of use. Those traditional technologies cannot provide solutions.

2. Proposed Methodology

2.1 1Structure Grid Interfaced Solar PV with BLDC motor Drive

The proposed grid scheme embedded PV-fed brushless DC driven by a water pump system is shown in Fig.2.1. The same PV members, powerful enough to move the water pump fully under normal weather conditions, feed the BLDC car with boost converter and VSI. The DC-DC and VSI amplifier converter respectively performs the MPPT for PV array and electrical equipment exchange. Three Hall Effect sensors are used to produce transition signals. A BLDC vehicle with an average speed of 6000 rpm at 410 V (DC), is used to move the water pump. Provides support for a single-phase grid, with a bridge fixer and a PFC reinforcement converter, on a standard VSI DC bus. The power transfer is controlled by the operation of the PFC converter using the inactive power flow control. The advanced controller enables the transfer of power from the power grid to the DC bus if the power generated by the PV is insufficient to meet the demand for power otherwise there is no transferable power from the system.

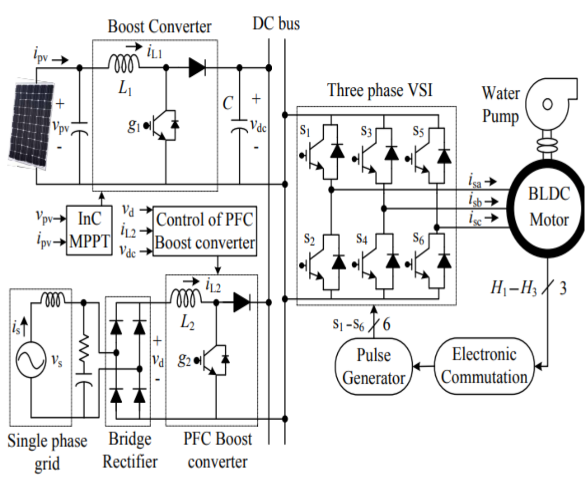

Fig. No.1 Proposed grid interfaced PV fed brushless DC motor

2.2 Principle operation of Brushless DC (BLDC) Motor

The brushless the dc motor is defined as a permanent synchronization machine with a rotor position response. Brush-free motors are usually controlled using a three-phase semiconductor bridge bridge. The motor needs a rotor position sensor to start and provide the proper flow sequence to turn on the electrical devices on the inverter bridge. Depending on the condition of the rotor, electrical devices are rotated continuously at 60 degrees. Instead of changing the power of weapons using brushes, the electronic flexibility used for this reason is an electronic vehicle. This removes the problems associated with the brush and the property arrangement, for example, explosion and wear and tear brush layout, thus, making the BLDC more difficult compared to a dc motor.

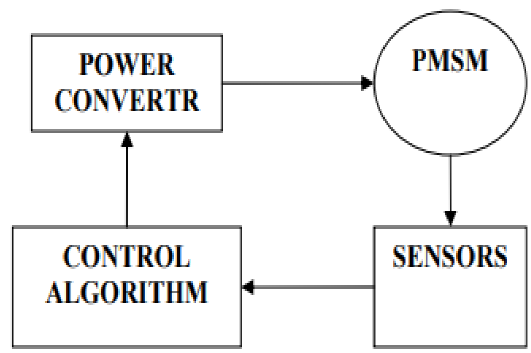

Fig.2 Basic block diagram of BLDC motor

The basic block diagram brushless dc motor as shown Fig.2.2 The brush less dc motor consist of four major power conversion components, permanent magnet-synchronous sensor (PMSM) sensors, and control algorithm. Power converter converts energy from source to PMSM which in turn converts energy into electrical energy. One of the most important features of the dc motor brush are the rotor position sensors, based on the rotor position and the command signals which can be torque command, voltage command, speed command and so on control algorithms that determine the gate signal on each semiconductor in the power converter electricity. The structure of the control algorithms determines the type of brush under the dc motor where there are two main categories of power derived from the driving source and equipment based on the current source. Both the source of electrical energy and the current source derived from the source used by a permanent magnetic synchronization machine with sinusoidal or non-sinusoidal fracture forms.

A machine with a sinusoidal back emf (Figure 3) can be controlled to obtain almost constant torque. However, a machine that provides a non-sinusoidal back emf (Figure 4) reduces inverter sizes and reduces the loss of the same power level.

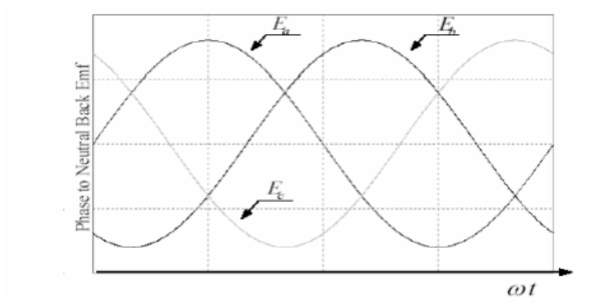

Fig.3 Sinusoidal phase back emf of BLDC motor

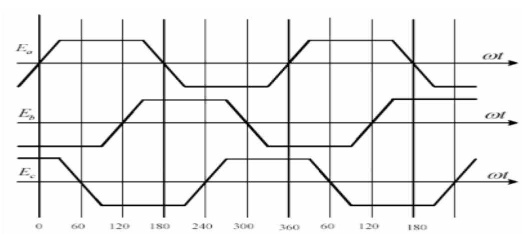

Fig.4 Trapezoidal back emf of three phase BLDC motor

BLDC drives operation with inverter Basically it is an electronic motor and requires a three-phase inverter in the front end as shown in Fig. 2,4 In self-control mode the inverter acts like an electronic commutator that receives the switching logical pulse from the absolute position sensors. The drive is also known as an electronic commutated motor. Basically, the inverter can operate in the following two modes. 1. 2π/3 angle switch-on mode 2. Voltage and current control PWM mode.

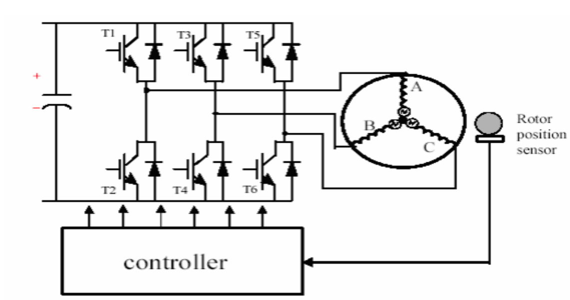

Fig.5 Brushless dc motor drive system

2.3 Rotor position sensors

Hall Effect sensors provide the portion of information need to synchronize the motor excitation with rotor position in order to produce constant torque. It detects the change in magnetic field. The rotor magnets are used as triggers the hall sensors. A signal conditioning circuit integrated with hall switch provides a TTL-compatible pulse with sharp edges. Three hall sensors are placed 120 degree apart are mounted on the stator frame. The hall sensors digital signals are used to sense the rotor position.

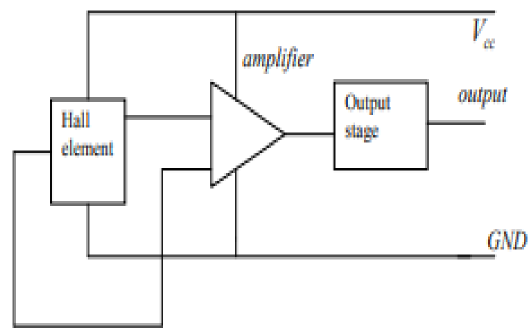

Fig.6 Hall position sensors

2.4 Fuzzy logic controller

The weak sensitivity control system has two input errors and an error change, the error is detected by comparing the input signal of the reference with the outgoing signal. This error was detected in relation to a period called the error change and this by the inclusion of two input sensor inputs. The intelligible mind control consists of three elements of fuzzification, the inference mechanism and the DE fuzzification. Similarly, an uninformed controller is supplied with the output of a vehicle or machine after the operation of the system. An incomprehensible mind control is shown in figs.

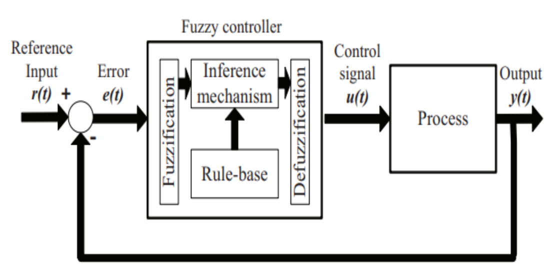

Fig.7 Scheme of a fuzzy logic controller

International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 1 Issue 3, December 2020

2.5 Advantages of Fuzzy Control

The advantages of fuzzy control over the adaptive control can be summed as follows:
a.It relates output to input, without much understanding all the variables, permitting the design of system to be more accurate and stable than the conventional control system.
b. The linguistic, not numerical; variables make the process similar to that of human thinking process.
The fuzzy controller uses two input membership variables; error E and change in error dE. The fuzzy function has only one output. The function considered is 'Mamdani' function with seven membership functions in each variable.

3. 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 two stage stages

A. Grid interfaced PV-INC MPPT system with BLDC Motor Drive Using PI logic controller

B. Grid interfaced PV- INC MPPT system with BLDC Motor Drive Using fuzzy logic controller

A. Grid interfaced PV-INC MPPT system with BLDC Motor Drive Using PI logic controller is shown in fig. no. 2.1 which is consist of Boost converter, Solar PV array, Incremental Conductance MPPT Hall Effect Sensor and PI controller.

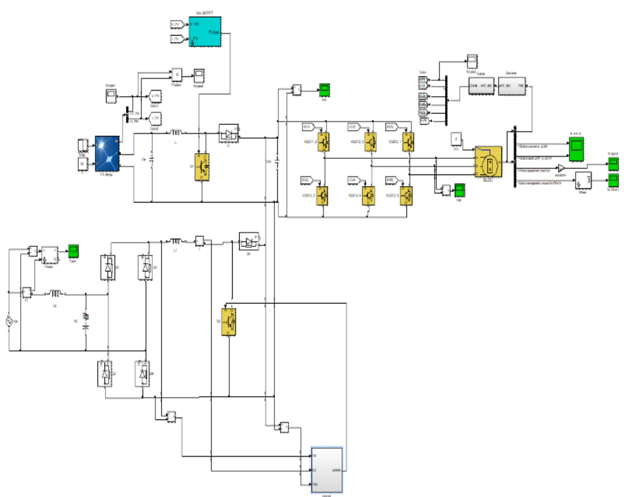

Fig.8 Grid interfaced PV- INC MPPT system with BLDC Motor Drive using PI controller

In the above scheme (shown in fig. 2.1) the proposed system, the utility grid is connected to the diode bridge converter for AC to DC and the DC variable voltage is stabilized using a booster converter. The feedback loop controller is connected to control the grid booster converter for use. DC power is stored at 500V even during solar radiation, which is maintained by an MPPT controller and a feedback loop control grid for use.
The Boost converter effect is shown in Fig. 9.

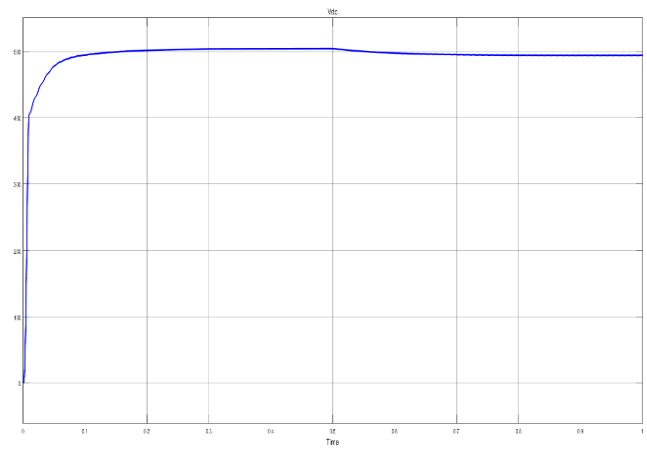

Fig. 9 DC Voltage at PCC

B. Grid interfaced PV-INC MPPT system with BLDC Motor Drive Using Fuzzy logic controller is shown in fig. no.9 which is consist of Boost converter, Solar PV array, Incremental Conductance MPPT Hall Effect Sensor and Fuzzy logic controller.

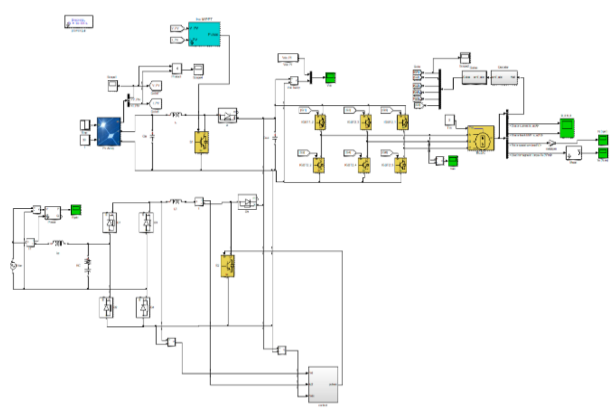

Fig. 10 Grid interfaced PV- INC MPPT system with BLDC Motor Drive using fuzzy logic controller

Increase in power of grid from 0W to 400W during drop in solar irradiation. From 0 to 0.6sec is the transient time for the system to settle which is neglected as we consider only steady state period.

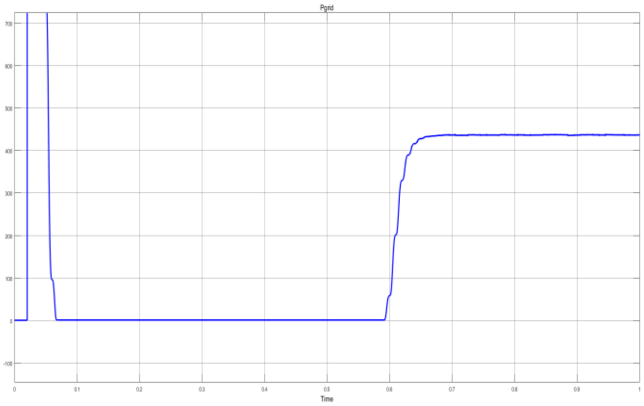

Fig.: 11 Grid power injected

3.1Speed Characteristic of BLDC Motor

The speed of BLDC motor is maintained at 6000 rpm

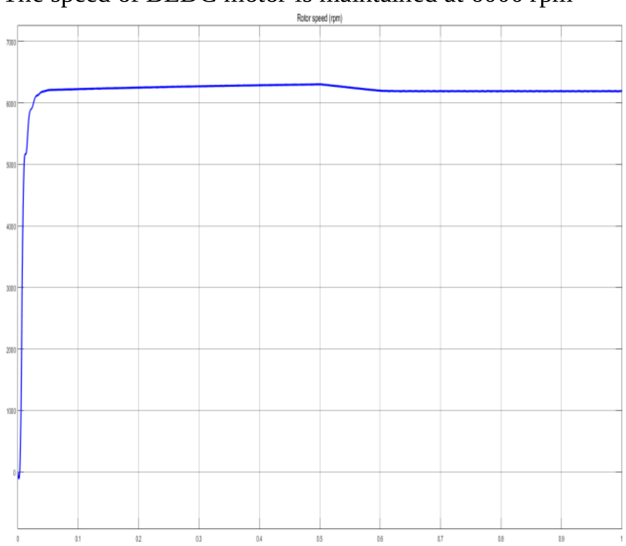

Fig.12 Speed of the BLDC motor

3.2 DC voltage comparison at PCC with PI and fuzzy logic controller

The grid controller is updated with fuzzy logic controller for better DC voltage settling time.

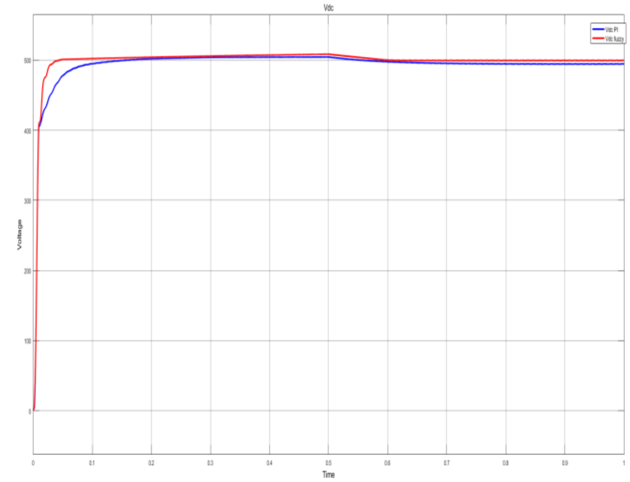

Fig. 13 DC voltage comparison at PCC with PI and fuzzy logic controller

4. Conclusion

A single-phase grid interfaced solar PV-water pumping system with a brushless DC motor drive has been proposed and demonstrated through its performance evaluation using MATLAB/Simulink platform. The utility grid support as a power backup has been provided at the common DC bus. A unidirectional power flow control has been developed and realized with a PFC boost converter in order to enable a power transfer conditionally. 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 DC voltage at PCC is settled faster with fuzzy logic controller and generated near to reference value. The power sharing graphs with respect time is shown in the report. Thus, the proposed topology has emerged as a reliable and efficient water pumping system.

References

[1] T. Mahtani, S. Morimoto, K. Yamamoto, Y. Isomura and A. Watanabe, “Comparing Brushless DC Motors: A Method of Suppressing the Shaft Voltage Even in a Grounded Motor Frame,” IEEE Ind. Appl. Mag., vol. 21, no. 6, pp. 29-35, Nov.-Dec. 2015.

[2] P. K. Singh, B. Singh and V. Bist, “Brushless DC motor drive with power factor regulation using Landsman converter,” IET Power Electron., vol. 9, no. 5, pp. 900-910, Apr. 2016.

[3] C. L. Xia, Permanent Magnet Brushless DC Motor Drives and Controls. Beijing, China: Wiley, 2012.
[4] M. Malinowski, A. Millcreek, R. Kot, Z. Goryca and J. T. Shuster, “Optimized Energy-Conversion Systems for Small Wind Turbines: Renewable energy sources in modern distributed power generation systems,” IEEE Power Electron. Mag., vol. 2, no. 3, pp. 16-30, Sept. 2015.
[5] Rajan Kumar and Bhim Singh, “BLDC motor driven water pump fed by solar photovoltaic array using boost converter,” Annu. IEEE India Conf. (INDICON), New Delhi, 2015.
[6] R. Kumar and B. Singh, “BLDC Motor Driven Solar PV Array Fed Water Pumping System Employing Zeta Converter,” IEEE Trans. Ind. Appl., vol. 52, no. 3, pp. 2315-2322, May-June 2016.
[7] Rajan Kumar and Bhim Singh, “Solar PV-Battery Based Hybrid Water Pumping System Using BLDC Motor Drive,” Accepted for publication, IEEE First Int. Conf. Power Electron., Intell. Control Energy Syst. (ICPEICES), 2016.
[8] A. Boussaibo, M. Kamta, J. Kayem, D. Toader, S. Haragus and A. Maghet, “Characterization of photovoltaic pumping system model without battery storage by MATLAB/Simulink,” 9th Int. Symp. Advanced Topics Electr. Eng. (ATEE), Bucharest, 2015, pp. 774-780.
[9] Huang, “Photovoltaic Water Pumping and Residual Electricity Grid-Connected System,” Chinese Patent CN 204131142 U, Jan. 28, 2015.
[10] Wang Xing, “High-Efficiency Photovoltaic Pump System,” Chinese Patent CN 203884338 U, Octo. 22, 2014.
[11] Chen steel, Ai Fang, Sun Weilong, Guo Jing and Zhao Xiong, “Photovoltaic Agricultural Power Generating Unit,” Chinese Patent CN 203859717 U, Octo. 1, 2014.
[12] M. Pahlevaninezhad, P. Das, G. Moschopoulos and P. Jain, “Sensorless control of a boost PFC AC/DC converter with a very fast transient response,” Twenty-Eighth Annu. IEEE Appl. Power Electron. Conf. Expo. (APEC), Long Beach, CA, USA, 2013, pp. 356-360.
[13] M. A. Elgendy, D. J. Atkinson and B. Zahawi, “Experimental investigation of the incremental conductance maximum power point tracking algorithm at high perturbation rates,” IET Renew. Power Gener., vol. 10, no. 2, pp. 133-139, Feb. 2016.
[14] D. C. Huynh and M. W. Dunnigan, “Development and Comparison of an Improved Incremental Conductance Algorithm for Tracking the MPP of a Solar PV Panel,” IEEE Trans. Sustain. Energy.