SOLAR POWERED BLDC MOTOR DRIVE FOR AGRICULTURAL APPLICATION

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Abstract: *This paper deals with the utilization of solar PV array to drive the Brushless DC motor for tiller machine application. Solar PV array maximum power extracted using DC-DC converter and maximum power point tracking algorithm. Simple perturb and observe method is employed to achieve the maximum efficiency of the solar PV array. The reason that Brushless dc motor has been chosen for the project is that these motors are cheaper and more robust than the more conventional DC motor. The tiller machine used for small land cultivation and compared to diesel tiller machine or tractor which are low maintenance, long life and more efficient. The renewable energy such that the solar power used to drive the BLDC motor. The simulation and hardware of solar fed BLDC motor has been carried out.*

Keywords: *Photovoltaic system, MPPT, BLDC motor and agricultural.*

1. Introduction

Agriculture is the backbone of Indian economy. India being developing country in farming and industries based on cultivation products has major importance in the state financial system. Majority of the Indian populace depends on cultivation and agro-based industries and businesses [1]. Agricultural machines designed every stage of the agricultural development. These machines have especially increased farm output and noticeably changed the way people are employed and make food worldwide [2]. A well known example of agricultural machinery is the tractor. These tractors were powered by diesel engines. It has lots of issues such that the requirement of fuel, environmental pollution, maintenance cost etc. The most of farmers have small lands [3]. The tractor should be costlier for farmer who having small lands. therefore, the soil tiller and weeder must become a helpful machine in the internal cleaning of crops which having small distance between them like groundnuts, sugarcane, soya bin crops, cultivation of paddy, in particular, and other crops in general for the smaller farmers. Its main objective is to reduce the manpower as in today's scenario labors are very rigid to find as well as it reduces the working time [4]. The solar power is main useful energy in renewable energy system. Compared other renewable energy such that wind, hydraulic which is more available and cost less energy. The diesel replaced by the solar power in tiller machine [5]. The maximum solar power tracked by using of MPPT technique. The solar power tiller machine is self- propelled.

It consists of rotary blades can be driven by BLDC motor [6] - [7]. These machines are also used for breaking or working the soil in gardens, lawns, etc [8]- [9].

2. Mathematical model for a PV array

The proposed model of solar powered BLDC motor is shown in Figure 1. The boost converter and inverter are used as a photo voltaic interface between photo voltaic module and the BLDC motor. The solar radiations are immersed on solar panel by this process the solar energy is converted into electrical energy. The solar energy step up by the boost converter then dc voltage converted into ac voltage. The ac voltage runs the BLDC motor. When the motor runs also the rotor runs and finally the work is done by rotor where there is turn machine we can turn it easily. It is essential factor of this machine. Each block has been explained here.

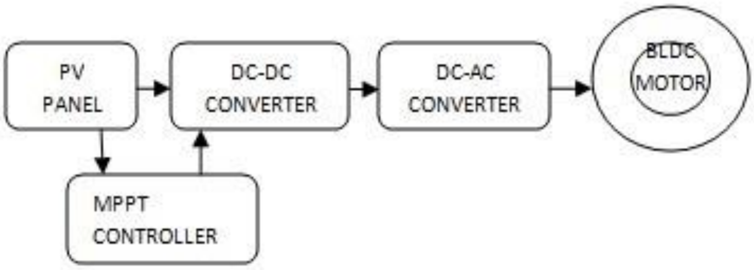

Fig. 1. Block diagram of solar powered BLDC motor

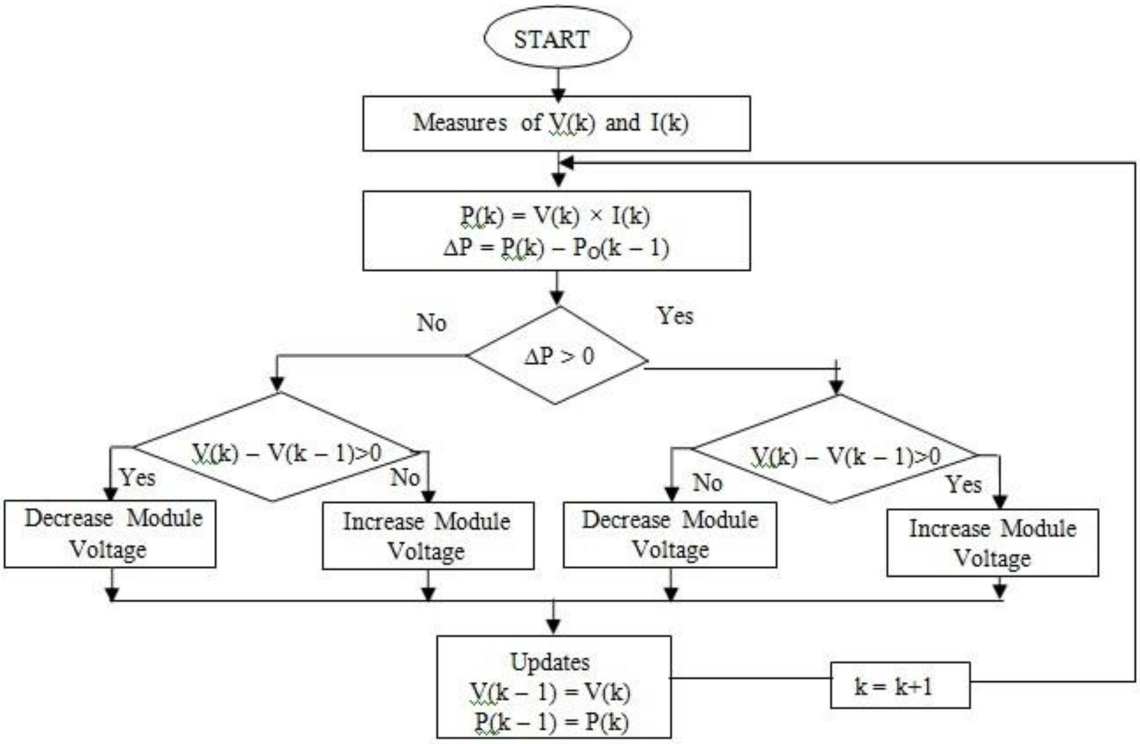

Fig. 2. Flowchart for P&O method

A. Photovoltaic panel:

The photovoltaic system is a system which is used converts the solar energy into electrical energy. It consists of number of solar modules and electrical connections. PV modules are prepared from semiconductor materials. When light energy hits the cell, electrons are taped loose from the material's atoms. Electrical conductors connected to the positive and negative sides of the material permit the electrons to be captured in the form of a DC power. The dc power used to drive the motor for tiller machine. The maximum power can be obtained by using of MPPT technique. The different types of MPPT algorithms are available. The perturb and observe method is also one of the method.

B. P&O (Perturb and Observe) MPPT Method

The P&O algorithms operate by periodically perturbing (i.e. incrementing or decrementing) the array terminal voltage or current and comparing the PV output power with that of the previous perturbation cycle. If the PV array operating voltage changes and power increases ($dP/dV > 0$), the control system moves the PV array operating point in that direction; otherwise the operating point is moved in the opposite direction. In the next perturbation cycle the algorithm continues in the same way.

A common problem in P&O algorithms is that the array terminal voltage is perturbed every MPPT cycle; therefore when the MPP is reached, the output power oscillates around the maximum, resulting in power loss in the PV system. Perturb & Observe (P&O) is the simplest method and is widely used. In this technique we generally use only one sensor, that is the voltage sensor, to sense the PV module voltage and hence the cost of implementation is less and hence easy to implement without any complexity.

In certain situations like changing atmospheric conditions and change in irradiance the maximum power point shifts from its normal operating point on the PV curve. In the next iteration it changes its direction and goes away from the maximum power point and results in multiple local maxima at the same point as shown in Fig.2 . So the maximum power point deviates from its original position.

Algorithm for Perturb and Observe Technique:

1. Read the value of current and voltage from the solar PV module.
2. Power is calculated from the measured voltage and current.
3. The value of voltage and power at k^{th} instant are stored.
4. Then next values at $(k+1)^{th}$ instant are measured again and power is calculated from the measured values.
5. The power and voltage at $(k+1)^{th}$ instant are subtracted with the values from k^{th} instant.
6. In the power voltage curve of the solar PV module, it is inferred that in the right-hand side curve where the voltage is almost constant and the slope of power voltage is negative (dP/dV<0) whereas in the left hand side, the slope is positive (dP/dV>0). Therefore, the right side of the curve is for the lower duty cycle (nearer to zero) whereas the left side curve is for the higher duty cycle (nearer to unity).

C. DC-DC Converter for Solar PV System

The DC-DC converter used to supply a regulated DC output with the given DC input. These are widely used as an interface between the photovoltaic panel and the load in photovoltaic generating systems. The load must be adjusted to match the current and voltage of the solar panel so as to deliver maximum power. DC/DC converters are described as power electronic switching circuits since they convert one form of voltage to other. These may be applicable for conversion of different voltage levels.

Generally three basic types of converters are accountable as per their use. They either step up by boosting voltage at output known as Boost converter or by stepping down by reducing voltage known as Buck converters. There is another class of converters used for both stepping up or down the voltage output described as Buck-Boost converters. Buck- Boost converters reverse polarity of output voltage, as such they are sometimes known as inverters.

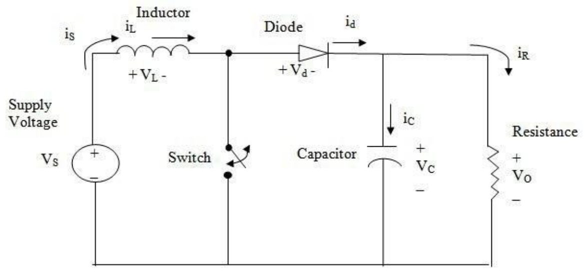

Fig. 3. Circuit diagram of boost converter

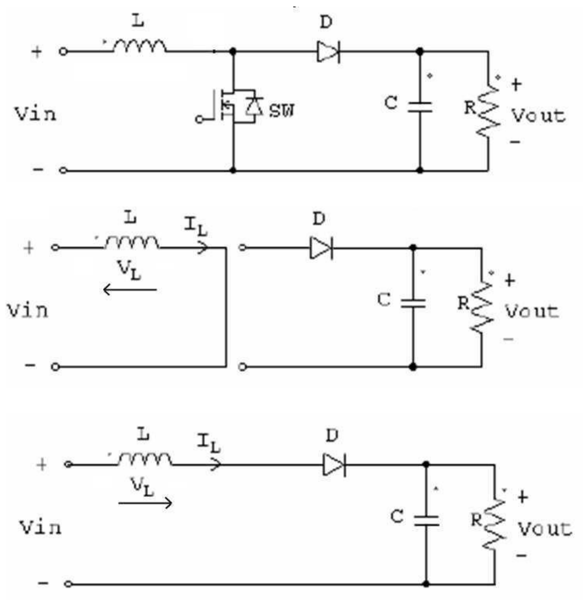

Fig. 4. Modes of operation boost converter

D. Boost Converter and its Mode of Operation

A simple boost converter consists of an inductor, a switch, a diode, and a capacitor. Fig.3 represents the circuit diagram of DC-DC boost converter and Figure 4 show the mode of operation of boost converter.

Boost converter circuit operation can be divided into two phases. Phase 1 begins when the switch SW is turned on at t = T_{on} . The input current which rises flows through inductor L and switch SW. During this mode, energy is stored in the inductor.

Phase 2 begins when the switch is turned off at t = T_{off}. The energy stored in the inductor causes its voltage to swap polarity and maintain current flow in the circuit, which is now directed through inductor L, diode D, capacitor C, load R, and the supply of V_{in}.

The inductor current falls until the switch is turned on again in the next cycle. The reversing of the inductor voltage polarity in phase 2 allows the V_{out} to be greater than V_{in}.

$$V_{out} = \frac{V_{in}}{1-D} \quad (1)$$

Where, V_{in} , V_{out} are the input and output voltage of the converter respectively and D is the duty cycle of the control switch. In an ideal circuit, the output power of the converter is equal to input power which yields.

3. Simulation Result and Discussion

Figure 5 presents the simulation of solar module used as a power generation with its MPPT for drive the BLDC motor. Here the proposed system simulated using PSIM software and the results were presented. The closed loop DC-DC boost converter is used in boost mode to maintain constant voltage within the specific range of load. The calculation of inductor and capacitor of the boost converter has done using equations. Further, the generated power from PV (P_{max} in simulation) is compared with actual power. The MPPT algorithm generated the reference voltage and with the actual voltage. This voltage is compared with actual PV voltage generated by the module. PI controller is fine tune with specific limits and the gate pulse generated which is shown in Figure 6.

The Boost converter step up the PV panel voltage 20-24v into 45-48v as per the duty ratio. The boost converter output voltage fed to the inverter circuit. The inverter circuit used to drive the BLDC motor. The VSI switches controlled by the feedback signal through the hall sensor. The speed of the motor controlled by this way. Figure 7 shows the gating pulse for Boost converter. Figure 8 shows the voltage and current waveform of BLDC motor.

The output waveform voltage and current waveform of inverter shown in fig.8the BLDC motor operated in 48 v. The Boost converter parameters are L=470 µH, Ci n =1000 µF, Cout =780 µF.The torque and speed waveform BLDC motor shown in Figure 9.

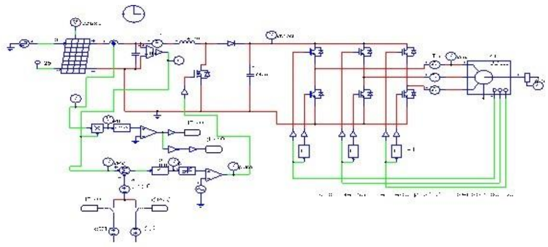

Fig. 5. Simulation circuit for solar powered BLDC motor

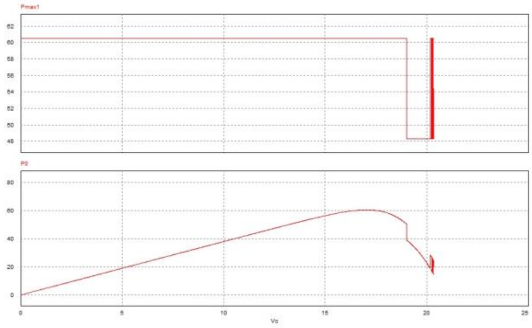

Fig. 6. Output Power of PV panel

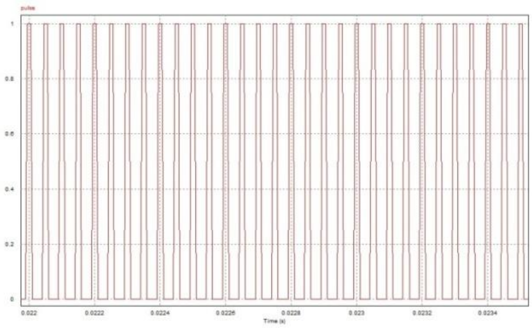

Fig. 7. Gate pulse for Boost converter

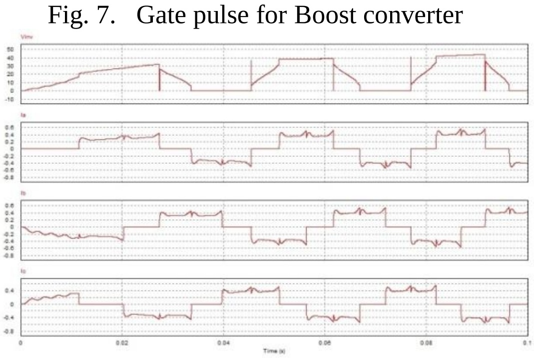

Fig. 8. Output voltage and current waveform of VSI

Fig. 9. Torque and speed response of the Brushless DC motor

4. Experimental Setup and Results

The experimental results of Inverter Fed BLDC motor. The experimental model of hardware has been designed and tested in laboratory and the observations were recorded. The MOSFET gate pulses are generated using Arduino Mega. Digital storage oscilloscope has been used to measure and display the output voltages and gate pulses of the MOSFET switches.

Fig. 10. Experimental setup of solar powered Brushless DC motor

The Figure 10 shows the experimental hardware of inverter fed BLDC motor. The hardware has driver Circuit, Arduino for PWM generation, BLDC Motor, Power Circuit. The waveforms of hardware gate pulse, output voltage are represented below Figure 11. The waveforms are measured using a Digital Storage Oscilloscope. The output voltage of inverter displayed using Digital Storage Oscilloscope which is shown in Figure 12.

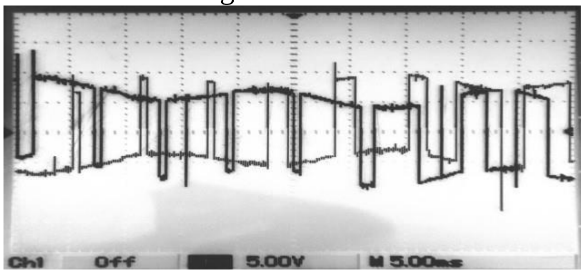

Fig. 11. Gate pulse output for inverter

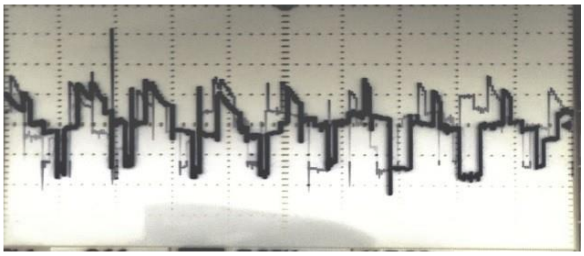

Fig. 12. Output voltage of inverter

5. Conclusion

In this work, simulation of solar power fed dc-dc converter with BLDC motor based MPPT algorithm has been carried out successfully using PSIM software. Today in the world fuel prices rises day by and the pollution may also. To control this pollution and to save the petroleum product and bio product hardware of this project is design and developed. This can be implemented in the solar Powered Tiller Machine. This system requires heavy initial investment but it gives the energy output for lifetime with low maintenance etc.

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