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Positive Luo Converter Fed BLDC Motor Driven DPPO Control MPPT for Solar PV Array based Application

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Abstract - *This paper is about an efficient brushless dc (BLDC) motor drive for solar photovoltaic (SPV) Array based application. A positive luo converter is utilized to extract the maximum available power from the SPV array and the LUO converter is designed to operate on Discontinuous Conduction Mode DCM for Improve the PF. The LUO converter feeding the 3-phase supply to the BLDC motor via VSI circuit. Low frequency signals used for trigger the switches. Single sensor used for monitor the speed of the BLDC motor. A Direct Power Perturb & Observe (DPPO) algorithm is proposed to control the maximum power point tracking (MPPT) for a photovoltaic (PV) system. The proposed control algorithm eliminates phase current sensors and adapts a fundamental frequency switching of the voltage source inverter (VSI), thus avoiding the power losses due to high frequency switching. No additional control or circuitry is used for speed control of the BLDC motor. The speed control can be achieved through a VSI. An appropriate control of positive luo converter through a Direct power perturb and observe (DPPO) is proposed to control the maximum power point tracking (MPPT) for a photovoltaic (PV) system offers soft starting of the BLDC motor. The proposed system is designed and modelled such that the performance is not affected under dynamic conditions. The suitability of proposed system at practical operating conditions is demonstrated through simulation results using MATLAB/Simulink followed by an experimental validation.*

Key Words: Brushless dc (BLDC), Solar photovoltaic (SPV), A fuzzy logic control (FLC), Maximum Power Point Tracking (MPPT), Voltage Source Inverter (VSI).

INTRODUCTION

The drastic reduction in the cost of power electronic devices and annihilation of fossil fuels in near future invite to use the solar photovoltaic (SPV) generated electrical energy for various applications as far as possible [4]. The application of the SPV array-generated electricity, is receiving wide attention nowadays for household and industrial use. Researches are carried out in this area, combining various dc–dc converters and motor drives. The luo converter in association with a permanent-magnet brushless dc (BLDC) motor is now used in such kind of system. However, the positive luo converter has been used in some other SPV-based applications. The merits of both BLDC motor and positive luo converter can contribute to develop an SPV array-fed load possessing a potential of operating satisfactorily under drastic changing atmospheric conditions. The BLDC motor has high reliability, high efficiency, high torque/inertia ratio, improved cooling, low radio frequency interference, and noise and requires practically no maintenance. On the other hand, the modified positive output Luo converter is a type of a high-gain DC-DC converter. It is derived from the positive output Luo converter. This topology uses combination of inductors and capacitors to lift the input voltage to a higher value of the output voltage. The voltage gain of the converter in a re-lift configuration is two times of that provided by a boost converter while using a single switch. A direct power perturb and observe method maximum power point tracking (DPPO-MPPT) algorithm is used to operate the positive luo

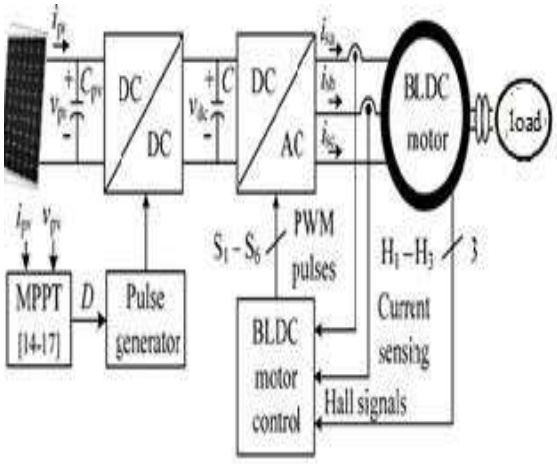

Fig -1: Conventional SPV-fed BLDC motor-driven load

converter such that SPV array always operates at its MPP[5]. The existing literature exploring SPV array-based BLDC motor-driven load is based on a configuration shown in Fig.

1. A dc–dc converter is used for MPPT of an SPV array as usual. Two phase currents are sensed along with Hall signals feedback for control of BLDC motor, resulting in an increased cost. The additional control scheme causes increased cost and complexity, which is required to control the speed of BLDC motor. Moreover, usually a voltage-source inverter (VSI) is operated with high-frequency PWM pulses, resulting in an increased switching loss and hence the reduced efficiency.

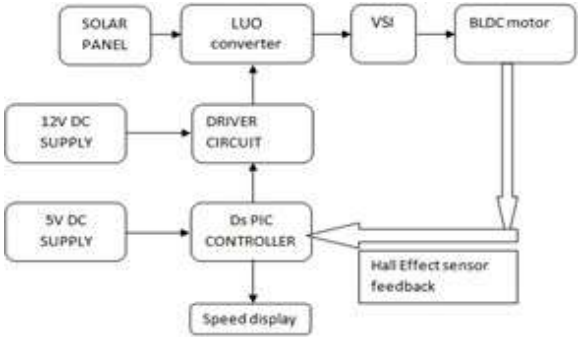

Fig -2: Proposed SPV-Positive Luo Converter-Fed BLDC Motor Drive Load

Although a Z-source inverter (ZSI) replaces dc–dc converter in other schematic of Fig. 1 remains unchanged, promising high efficiency and low cost. Contrary to it, ZSI also necessitates phase current and dc link voltage sensing resulting in the complex control and increased cost. To overcome these problems and drawbacks, a simple, cost effective, and efficient load based on SPV array-fed BLDC motor is proposed, by modifying the existing topology (Fig. 1) as shown in Fig.

2. A positive luo converter is utilized to extract the maximum power available from an SPV array, soft starting, and speed control of BLDC motor coupled to a load. Due to a single switch, this converter has very good efficiency and offers boundless region for MPPT. This converter is operated in continuous conduction mode (CCM) resulting in a reduced stress on its power devices and components. Furthermore, the switching loss of VSI is reduced by adopting fundamental frequency switching resulting in an additional power saving and hence an enhanced efficiency. The phase currents as well as the dc link voltage sensors are completely eliminated, offering simple and economical system without scarifying its performance. The speed of BLDC motor is controlled, without any additional control, through a variable dc link voltage of VSI. Moreover, a soft starting of BLDC motor is achieved by proper initialization of MPPT algorithm of SPV array. These features offer an increased simplicity of proposed system. The advantages and desirable features of both positive luo converter and BLDC motor drive contribute to develop a simple, efficient, cost-effective, and reliable fan based on solar PV energy. Simulation results using MATLAB/Simulink and experimental performances are examined to demonstrate the starting, dynamics, and steady-state behaviour of proposed load subjected to practical operating conditions. The SPV array and BLDC motor are designed such that proposed system always exhibits good performance regardless of solar irradiance level.

1. CONFIGURATION OF PROPOSED SYSTEM

The structure of proposed SPV array-fed BLDC motor driven load employing a luo converter is shown in Fig. 2. The proposed system consists of (left to right) an SPV array, a luo converter, a VSI, a BLDC motor, and a load. The BLDC motor has an inbuilt encoder. The pulse generator is used to operate the luo converter. A step-by- step operation of proposed system is elaborated in Section III in detail.

2. OPERATION OF PROPOSED SYSTEM

The SPV array generates the electrical power demanded by the load. This electrical power is fed to the load via a positive luo converter and a VSI. The SPV array appears as a power source for the positive luo converter as shown in Fig. 2. Ideally, the same amount of power is transferred at the output of positive luo converter which appears as an input source for the VSI. In practice, due to the various losses associated with a dc– dc converter, slightly less amount of power is transferred to feed the VSI. The pulse generator Generates, through DP POMPPT algorithm, switching pulses for insulated gate bipolar transistor (IGBT) switch of the luo converter.

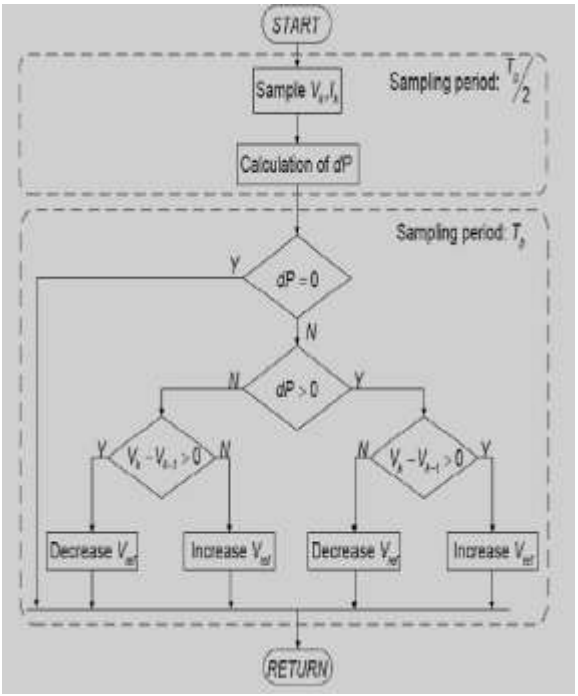

Fig -3: Flow chart of DPPO Algorithm

The DPPO-MPPT algorithm uses voltage and current as feedback from SPV array and generates an optimum value of duty cycle and it is compared with a high- frequency carrier wave to generate actual switching pulse. In this way, the maximum power extraction and hence the efficiency optimization of the SPV array is accomplished. The VSI, converting dc output from a positive luo converter into ac,

feeds the BLDC motor to drive a load coupled to its shaft. The VSI is operated in fundamental frequency switching through an electronic commutation of BLDC motor assisted by its built-in encoder. The high frequency switching losses are thereby eliminated, contributing in an increased efficiency of proposed load.

3. DESIGN OF PROPOSED SYSTEM

3.1 Design of SPV Array

As per above discussion, the practical converters area associated with various power losses [8]. In addition, the performance of BLDC motor-pump is influenced by associated mechanical and electrical losses. To compensate these losses, the size of SPV array is selected with slightly more peak power capacity to ensure the satisfactory operation regarding of power loss.

3.2 MPPT using DPPO Method

P&O method tracked wrong direction in rapid changing of irradiation level since dp P&O method is used to overcomes that drawback [8]. If the changes in intensity of irradiation cause bigger change of power than one caused to increment in voltage, the MPPT can get confused, as it will intercept the change in the power as an effect of its own action. DP P&O method is changed from P&O method by adding additional measurement of power in middle of the MPPT sampling without any perturbation. Flow chart of DPPO is shown below.

3.3 Design of positive LUO converter

LUO converter designed to operate on DCM for Improve the PF[10]. The LUO converter feeding the 3-phase supply to the BLDC motor via VSI circuit. Low frequency signals used for trigger the switches. Single sensor used for monitor the speed of the BLDC motor. LUO converter gives better output voltage gain than zeta converter and low ripple in output voltage. We have change the control technique informs of DPPO algorithm, helps the system stability and speed response and find exact error value.

3.4 .Electronic Commutation of BLDC Motor

The BLDC motor is controlled using a VSI operated through an electronic commutation of BLDC motor[8]. An electronic commutation of BLDC motor stands for commutating the currents flowing through its windings in a predefined sequence using a decoder logic. It symmetrically places the dc input current at the Centre of each phase voltage for 120◦. Six switching pulses are generated as per the various possible combinations of three Hall-effect signals. These three Hall-effect signals are produced by an inbuilt encoder according to the rotor position. A particular combination of Hall-effect signals is produced for each specific range of rotor position at an interval of 60◦. The generation of six switching states with the estimation of rotor. It is perceptible that only two switches conduct at a time, resulting in 120◦ conduction mode of operation of VSI and hence the reduced conduction losses. Besides this, the electronic commutation provides fundamental frequency switching of the VSI hence, losses associated with high-frequency PWM switching are eliminated.

4. SIMULATED PERFORMANCE

The simulation model of proposed positive luo converter fed BLDC motor driven DPPO control MPPT for solar PV array based application is developed in MATLAB/Simulink software.

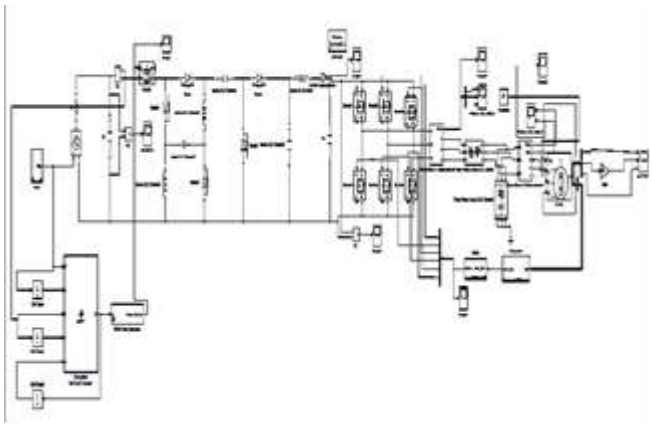

Fig -4: Simulation diagram

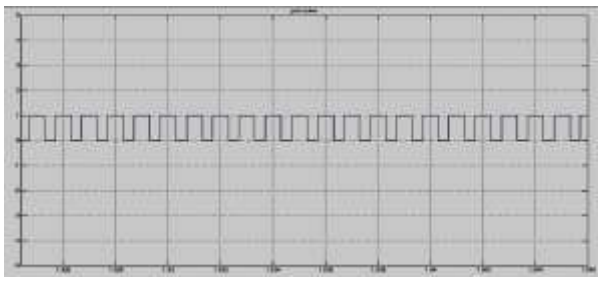

Fig -5: Gate pulse

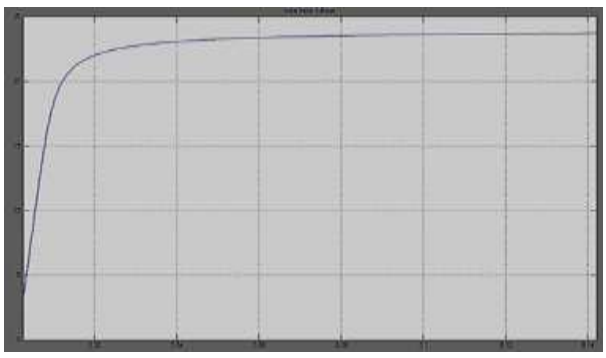

Fig -6: Solar input voltage

This system is simulated with accounting the output across the devices and the performance of BLDC motor. The simulated diagram shown in the Fig.4 and corresponding waveforms are also given in Fig. 5 to 8

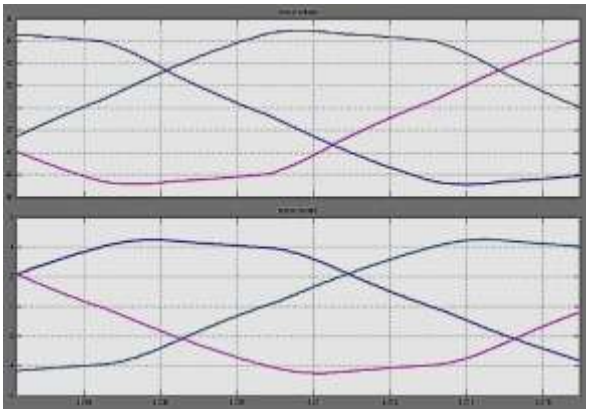

Fig -7: Output of LUO converter

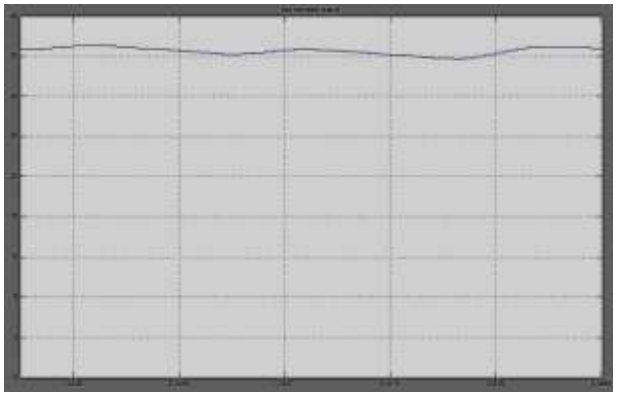

Fig -8: Inverter output voltage and current

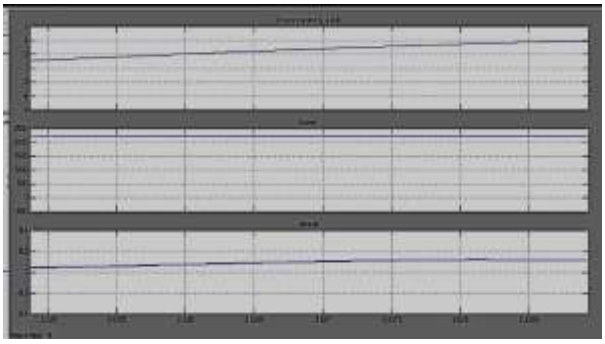

Fig -9: Stator current speed & torque of BLDC motor

5. CONCLUSIONS

The SPV array-positive luo converter-fed BLDC motor driven load has been proposed and its suitability has been demonstrated through simulated results and experimental validation. The proposed system has been designed and modelled appropriately to accomplish the desired objectives and validated to examine various performances under starting, dynamic, and steady-state conditions. The simulation result shows the combination of luo converter and BLDC motor for SPV array-based load. The system under study has shown various desired functions such as maximum power extraction of the SPV array, soft starting of BLDC motor, fundamental frequency switching of VSI resulting in reduction of losses and the use of sensors and controllers thus resulting in the reduced cost and complexity. The proposed system has operated successfully even under minimum solar irradiance.

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