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RESEARCH ARTICLE

A Solar-Powered Water Pumping System using a Cuk Converter-Based Brush Less Direct Current Motor

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ABSTRACT

The Paper proposes the best and Efficient Methodology for Photo Voltaic (PV) water pumping system using the maximum power point tracking technique. To reference optimal power, the optimum is suspended. This technique was created to ensure that the buck–boost converter's chopping ratio is ideal. The suggested MPPT technique is utilised to improve the efficiency of a solar water pumping system.An adaptive controller based on Fuzzy logic controller is utilised to optimise the duty ratio for PV maximum power at each irradiation level.The Cuk converter controls the DC connection voltage between the PV and the VSI. The Continuous Conduction Mode is used to manage the DC bus voltage in the Cuk converter, which helps to reduce DC-DC converter losses.The Brush Less DC motor's speed is controlled by a voltage source inverter with Pulse Width Modulation control. The Hall Effect sensor is used to generate the PWM pulse. The Brush Less Direct Current motor's Pulse Width Modulation switching will reduces switching losses while enhancing efficiency. MATLAB Software is used to simulate the whole system.

Keywords: Cuk Converter, MPPT, solar power, Brush less DC motor.

INTRODUCTION

Solar-powered water pumps are becoming increasingly popular in rural places where electricity transmission is either unfeasible or uneconomical. Solar energy is also non-polluting, abundant in nature, and costless. As a result, solar power can be used to replace the majority of traditional energy sources. For water pumping systems, solar-powered AC and DC machines are proposed [1-6].AC motors have a complicated control system and have a lower efficiency at low speeds. Brushes and commutation issues necessitate routine maintenance on the DC motor. A study proposes PMBLDC for water pumping systems using multiple MPPT algorithms.[5].The PMSM has also been proposed for a water pumping system. The SRM [7], which has a quick response, strong torque, and a wide operating range, has also been mentioned. However, because of their high efficiency, minimal maintenance, and wide range of speed control, BLDC motors are widely popular and recommended for driving applications [8, 9]. They are used in various residential applications [10], hybrid automobiles [11], robotics [12], and other areas because of these advantages. Brushes and a commutator segment are not present in a BLDC motor. As a result, the brushes' wear and tear properties, as well as the problem of sparking, must be addressed. However, this paper has substantial switching losses and low efficiency. The SEPIC converter-based PFC is presented as well as the circuit's substantial switching losses. When compared to FCM Segmentation- Boosting, FCM Segmentation, the Fuzzy Bee Segmentation Bagging method is used to improve accuracy. In order to track the maximum power, fuzzy logic control with MPPT is used, which employs linguistic variables to alter the inverter's firing angle. In the early stages of lung cancer, a neural network is used to diagnose tumours and develop novel therapeutic strategies.

To compensate for difficulties including power factor, current imbalance, and current harmonics, a four-leg inverter has been developed, as well as to inject energy generated by renewable energy sources. Sustainable energy power sources at the same time a few of ZETA, SEPIC, CUK, and buck-boost papers proposed. The goal of the converter was to reduce switching. Despite the fact that there were losses, the overall cost of the system climbed, as did the cost of the system as a whole implemented the continuous conduction mode (CCM) and discontinuous conduction mode of operation. The current multiplier is employed in continuous in this paper. In this application, the conduction mode (CCM) and voltage follower are used.

PROPOSED CIRCUIT

Figure 1 shows a solar-powered Cuk converter for water pumping systems based on a three-phase voltage source inverter (VSI) supplied BLDC motor (1). To alleviate voltage and current strains on its switching devices, the Cuk converter is designed to run in continuous conduction mode (CCM). In the Cuk and voltage source inverter, the MOSFET (IRFP840) is used as a switch (VSI).The CCM also realised that the DC-DC conversion is unaffected by the load. The discontinuous conduction mode (DCM) increases switching losses and creates electromagnetic interference noise. As a result, by using the CCM mode, these flaws are eliminated. PWM pulses are generated using a Hall Effect sensor positioned on the shaft and adjusted to the BLDC motor's rotor position.

METHODOLOGY AND OPERATION OF PROPOSED METHOD

Fuzzy logic Maximum Power Point Tracking is utilised in this circuit to get the most power from the solar panel, while PWM control is used to regulate the voltage source inverter, which regulates the speed of the BLDC motor that pumps the water.

Maximum Power Point Tracking for Solar Power Systems

Solar energy is inherently intermittent. To get the most electricity out of a solar panel, various strategies are used.In this paper, a fuzzy logic controller is used to extract the greatest amount of power from the solar panel seen in Figure 1. The MPPT controller uses this information to track the maximum power generated by changing sun intensities.

Cuk Converter CCM Operation

1) In this Cuk converter, the input inductor (Li) saves energy when the switch (Sw) is closed, and the intermittent capacitor stores energy when the switch (Sw) is open. The energy is discharged through Cd and stored in the output inductor (Lo).
2) When the switch (Sw) is open, the input inductor (Li) discharges its energy through C1. The energy held in the output inductor (Lo) is discharged to Cd in the meantime.
As a result, substantial values for the input inductor (Li), output inductor (Lo), and intermittent capacitor (C1) ensure that some energy is always available for continued operation throughout switching periods.

Switching Sequence of VSI

The VSI switching pulses are generated by a Hall Effect sensor. The rotor position is used to generate a signal by the Hall Effect sensor, which is positioned on the shaft. With the help of an encoder, pulses are generated. It's the procedure for making something. By transforming three hall signals into six switching pulses (s1-s6),It's worth noting that only two switches are required. Inverter with a voltage source that operates in a 120-degree mode. As a result, Overall efficiency is improved when switching losses are decreased.

SIMULATION RESULTS

A water pumping system using a solar-fed Cuk converter-based BLDC motor simulation circuit. Fuzzy logic MPPT is utilised in this circuit to get the most power out of the solar panel. Solar energy is delivered into the Cuk converter, which then feeds the output to a 3-Φ voltage source inverter. The MOSFETs are employed by VSI to regulate the BLDC motor as a switch. A Hall Effect sensor is added and fed into the comparator to sense the speed of the BLDC motor. To control the BLDC motor's speed, PWM pulses are created and fed to VSI.

CONCLUSION

The performance of a solar-powered water pumping system with a Cuk converter-based BLDC motor has been simulated in a MATLAB/ Simulink environment. By using a Cuk converter, switching losses are decreased. In addition, the VSI decreased by operating in the 120-degree conduction mode, switching losses are reduced. Hall signals effectively regulate the speed of the BLDC motor. By doing so, the cost of the circuits is effectively decreased when using the other form of regulating sensors. The total efficiency has increased.

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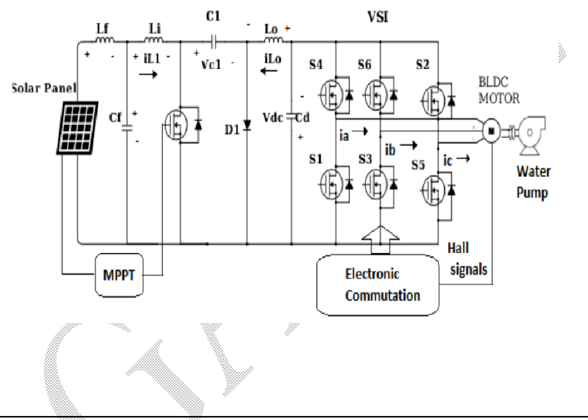

Fig.1: Solar-fed Brush Less DC motor with Cukconverter suggested circuit diagram for water pumping system

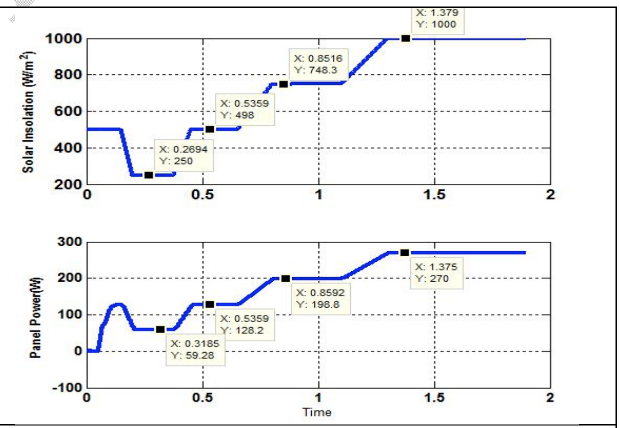

Fig.2: MPPT regulation of solar energy extraction and insolation

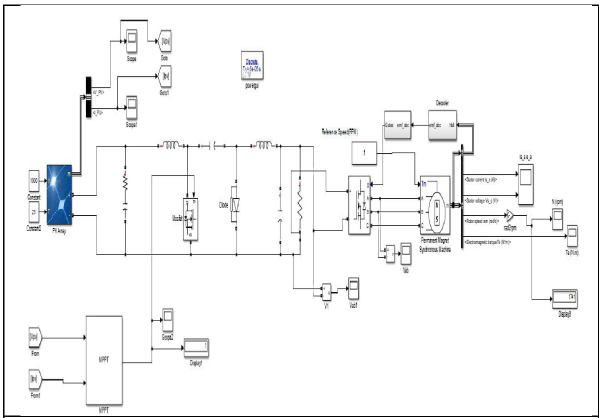

Fig.3: simulation circuit of Solar-powered Brush Less DC motor driving system

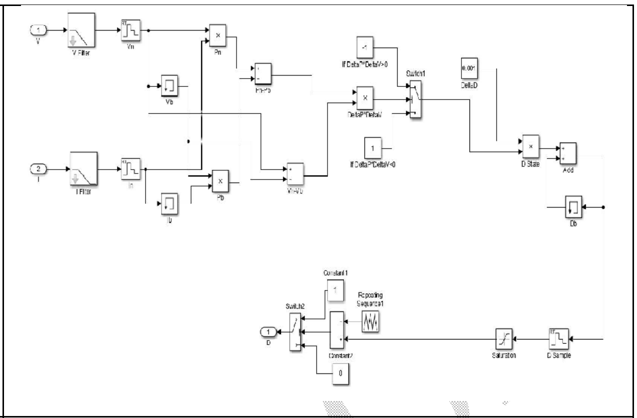

Fig.4: MPPT Model

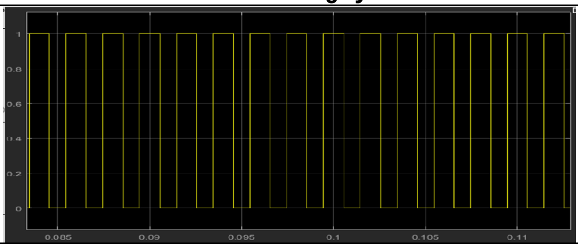

Fig.5.1: MPPT Voltage

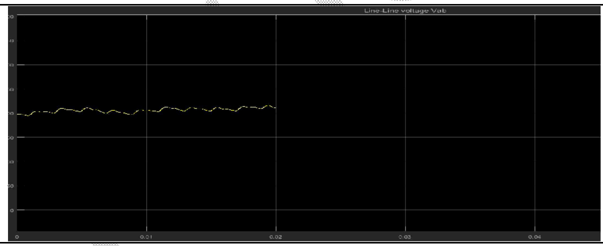

Fig.5.2: Converter output Voltage

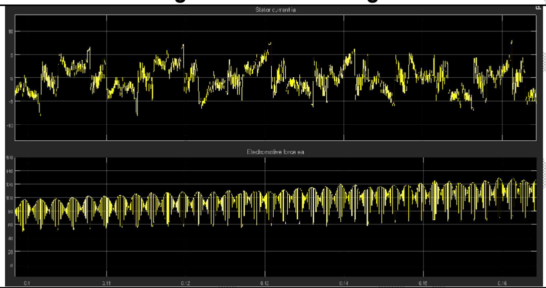

Fig.5.3: Stator Current and Voltage

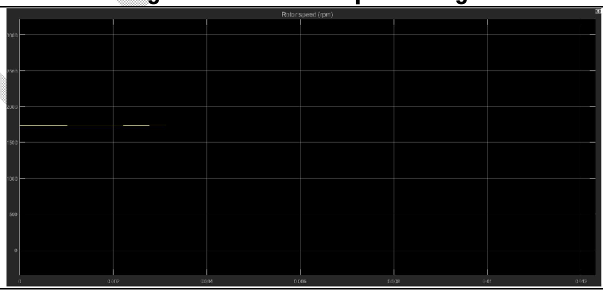

Fig.5.4: Rotor Speed

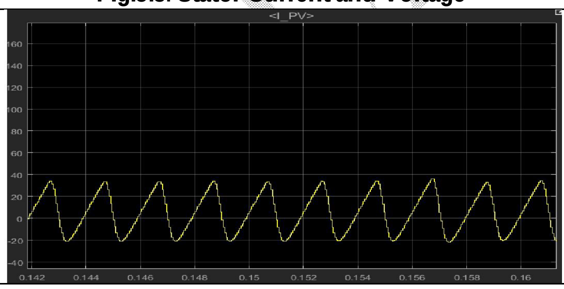

Fig.5.5: Solar output Voltage

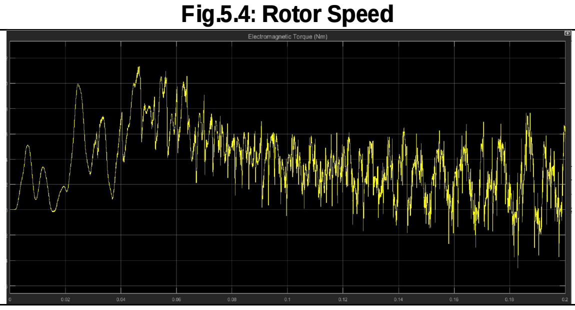

Fig.5.6: Electromagnetic Torque