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Fuzzy Logic Controller Based Batteryless Autonomous Photovotaic Water Pumping System in Rural Areas

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Abstract

The main objective of this paper is to propose a new converter for photo voltaic water pumping system without the aid of any chemical storage. In this autonomous photovoltaic system an array of PV panels are connected to the proposed DC-DC converter then to voltage source inverter which drives the induction motor for pumping the water for irrigation proposes. The proposed DC-DC converter is a Two Inductor Boost Converter which is used for high power conversion.In addition, inorder to improve overall performance of the system fuzzy logic control for maximum power point tracking (MPPT). The proposed system is modeled and simulated using MATLAB/SIMULINK environment and simulation results are presented.

Keyword- Two Inductor Boost Converter(TIBC), Maximum Power Point Tracking (MPPT), Fuzzy Logic Control (FLC).

Introduction

According to geological survey, over 700 million people in various countries suffer from water scarcity. The main reason of this issue is that unavailability of electric power to pump water to rural areas. The feasible solutionto overcome this problem is to utilize solar energy.A solar-powered pump is a pump running on electricity generated by photovoltaic (PV) panels from collected sunlight [7].In classical topologies dc motors are used[10]. But the main problem of dc motor is maintenance

and cost.Therefore ac machines are preferred, especially induction machines. The main advantage of induction motor is greater robustness, high efficiency, low maintenance, low cost and availability in local markets [3].The proposed method is based on, to drive induction motor without the use of any intermediate storage system.The energy produced by the PV panel fed to motor with two power stages. First one is a DC/DC Two Inductor Boost Converter(TIBC) and second stage is a three phase voltage source inverter.In classical battery operated water pumping system[4], the main problem is the life span of battery.In classical system they use different types of DC-DC converter. They all have problem that it carries large current ripples and low voltage conversion. So in this proposed system, TIBC is adopted for low current ripples and high voltage conversion.In order to improve overall performance of the system, fuzzy logic control(FLC) is used for maximum power point tracking (MPPT).

Existing Converters

Based on the applications, different types of dc-dc converters are employed. Most of the classifications are primarily based on the power conversion factor. Power conversion factor varies depending upon the inner circuit parameters. In general they are classified into two categories; isolated converters and non-isolated converters. Isolated converters are normally used for high power conversion applications and non-isolated converters are used for low power conversion applications.

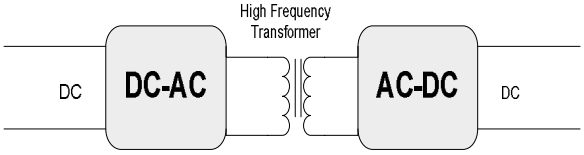

Figure 1: Isolated Converters

The Basic dc-dc converters such as buck and boost converters are coming under non isolated converters. The main drawback of non-isolated dc-dc converters is low input –output conversion. For solarpanel, as large voltage conversions are required, isolated converters as shown in fig.1 are preferred. Galvanic isolation is required for isolated converters.

Proposed Photovoltaic System

The proposed system is based on battery less solar powered induction motor based water pumping system in rural areas with MPPT using FLC. To ensure high efficiency, FLC is includedin TIBC as shown in fig. 2. It is followed by the three phase voltage source inverter and finally fed to a three phase induction motor for driving the water pump. In briefly proposed system is used to running induction motor directly from PV panel without the aid of chemical storage elements.

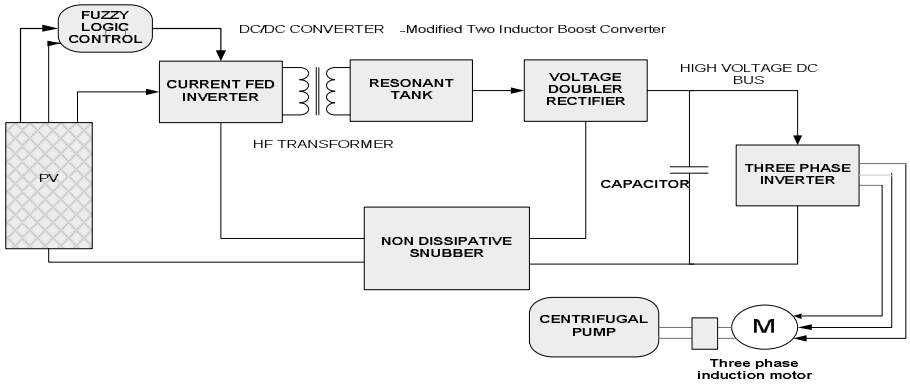

Figure 2: Proposed Block Diagram

Two inductor boost converters are the converters used for high power conversion. They are coming under isolated converters. The structure of DC-DC converter consists of two stage power conversion. First one is DC to AC then AC to DC. They provide separate galvanic isolation for more power transfer. Mainly it consists of two units. First unit is for high frequency switching inverter it is called as current fed inverter and second unit consist of High Frequency Transformer which primarily used for galvanic separation. In classical papers isolated voltage-fed converters are normally used to ensure high input current ripple, which forces the converter to have large input filter capacitors. Furthermore, the inherent step-down characteristic of the voltage-fed converters, yields voltage fed converters are not the best choice for this application [5].

When compared to the voltage-fed topologies, current-fed converters have some advantages [8], [9]. Inductor at the input so the system can be sized to have input current ripple as low as needed, thus eliminating the need of the input capacitor at the panel voltage. The only drawback of current fed converters have problems with high voltage spikes created due to the leakage inductance of the transformers, and high voltage stress on the rectifying diodes . One of the solutions to overcome the above drawback is the use of resonant topologies like Zero Current Switching (ZCS) and Zero Voltage Switching (ZVS) [2], [11].Non Dissipative Snubbers are used for the protection from high voltage and current spikes they are also used for providing easy path for energy transfer from input to output side. A voltage doubler is an electronic circuit which charges capacitors from the input voltage and switches these charges in such a way that, exactly twice the voltage is produced at the output as at its input.

MPPT Tracking using FLC

A new fuzzy-logic controller (FLC) for maximum power point tracking of photovoltaic (PV) systems is proposed. The new controller improves the hill-climbing search method and their limitations [1], [6]. The PV array power and current characteristics are highly nonlinear and are affected by the irradiance and temperature variation. In this method the input of the FLC are change in power ΔP and change in current ΔI there by controlling the duty cycle ΔD of the current fed inverter of the

TIBC. The inputs has four linguistic variables each positive big (PB), positive small (PS), negative big (NB), and negative small (NS). Therefore, the fuzzy rules requires 16 fuzzy control rule as shown in Table 1

Table 1: Fuzzy Control Rule

S.N	P	LOGICS	I	D
1	PB	AND	PB	PB
2	PB	AND	PS	PB
3	PB	AND	NB	NB
4	PB	AND	NS	NB
5	PS	AND	PB	PS
6	PS	AND	PS	PS
7	PS	AND	NB	NS
8	PS	AND	NS	NS
9	NB	AND	PB	NB
10	NB	AND	PS	NB
11	NB	AND	NB	PB
12	NB	AND	NS	PB
13	NS	AND	PB	NS
14	NS	AND	PS	NS
15	NS	AND	PS	NS
16	NS	AND	NS	PS

Simulation of Proposed System

The simulation of proposed system was shown in fig 3.It consists of solar panel, DC-DC converters, inverters and motor.It will be clear that the solar panel is fed to the TIBC, then fed the three phase voltage source inverter and finally fed to the motor. The proposed system was simulated using MATLAB software. In solar panel, in order to getthe required output voltage, number of cells and number of modules are multiplied. For example, to get 24V DC output voltage, 40cells of0.6V each are connected together . High voltage DC output voltage is obtained from the TIBC. After that this highvoltage DC is inverted for that purpose three phase voltage source inverter is required. For inverter sinusoidal pulse width modulation (SPWM) technique was adopted. Finally the output of three phase voltage source inverter as shown in fig 4 is fed to induction motor. The motor is coupled to centrifugal pump to achieve water pumping for irrigation purposes. The speed of the motor as shown in fig 5.

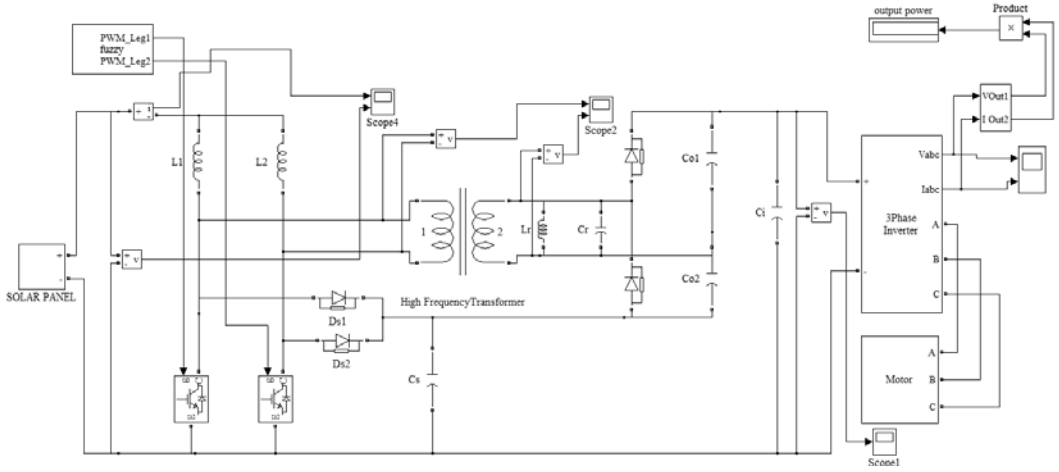

Figure 3: Simulation of Proposed System

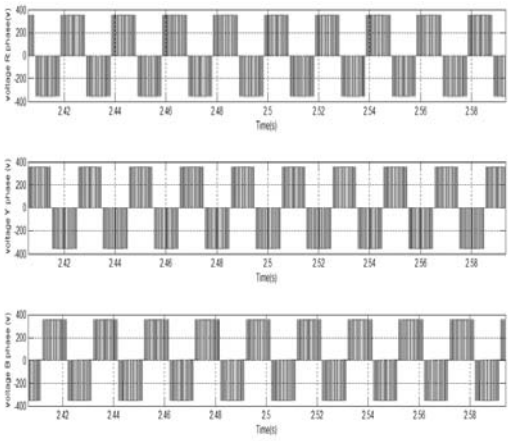

Figure 4: Output of VSI

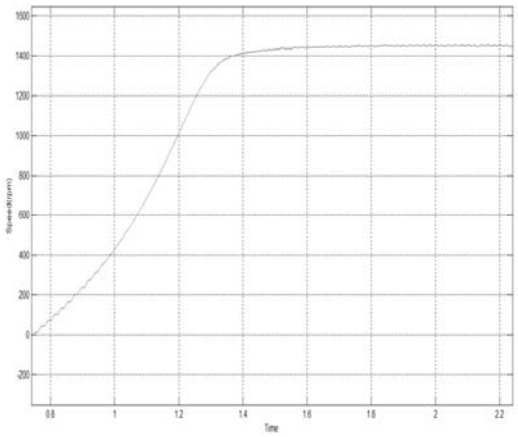

Figure 5: Speed of Motor

Fuzzy logic controller will improve the output power when compared to the conventional controller. Thus autonomous photovoltaic water pumping system is more efficient when using fuzzy based control system. From the comparisons of the system with fuzzy controller and without controller it is clear that with fuzzy controller the overall system efficiency and the output voltage of DC bus are improved.

CONCLUSION

In this paper, a new converter is proposed and designed for photovoltaic water pumping system without the use of battery storage system. The proposed system was based on Two Inductor Boost Converter for direct driving of induction motor from PV panel.In order to improve the overall performance of the system, a fuzzy logic controller is used for maximum power point tracking which controls the duty cycle of the current fed inverter in TIBC.The proposed system is modeled and simulated using MATLAB/SIMULINK .This system willalso be useful in rural electrification and smart grid synchronization.

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