

POWER QUALITY IMPROVEMENT IN GRID INTEGRATED SOLAR WATER PUMPING SYSTEM USING PMSM DRIVES: REVIEW

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ABSTRACT

An independent, two-stage solar photovoltaic (PV) water pumping system is suggested in this research. This system makes use of a solar PV array, a boost dc-dc converter, the utility grid, a three-phase voltage source converter, a PMSM (Permanent Magnet Synchronous Motor), and a three-phase VSI (Voltage Source Inverter). The boost converter, which is used to transfer power from the PV array to the VSI, tracks the maximum power point (MPP) by altering the duty ratio using the INC (Incremental Conductance) approach. The goal of effective and efficient water pumping is accomplished in this manner. The suggested system is modelled in the MATLAB/Simulink environment, and its performance is simulated to examine how it responds to changes in solar illumination.

Keywords: PV array; Utility grid; Voltage Source Inverter; Voltage Source Converter; Permanent Magnet Synchronous Motor; Incremental Conductance.

1. INTRODUCTION

As energy demand continues to grow and traditional energy sources are depleted, renewable energy sources offer a promising alternative to bridge the rapidly expanding gap between supply and demand. Advances in semiconductor technology have continually improved PV array technology, increasing its efficiency and effectiveness. Among the various fields that utilize photovoltaic energy, water pumping for households and irrigation is likely to be one of the best and most economically viable uses of photovoltaic systems. . For the utilization of PV energy, he mainly uses two types of topologies. A traditional two-stage topology has a first stage that extracts maximum power and a second stage that maintains the DC-link voltage. However, a one-stage topology is more efficient as the first-stage DC/DC converter is completely eliminated and associated losses are reduced. Nevertheless, the two-stage topology allows better control of the intermediate circuit voltage even at low solar radiation. In addition, the presence of a DCDC converter reduces VSI as it only needs to keep current flowing to the load. Induction motors are primarily used to drive pumps and offer advantages such as low cost, robustness, ability to operate under adverse environmental conditions, easy availability and low maintenance. However, it cannot be used as a photovoltaic pump due to some limitations such as low efficiency, complicated control and overheating at low voltage. Extensive research in permanent magnet (PM) technology in recent decades has led to the development of PMs with significantly higher energy densities. This progress contributed to the development of permanent magnet brushless AC and DC motors. Permanent magnet AC motors are usually called PMSM (Permanent Magnet Synchronous Motor) and permanent magnet brushless DC motors are called BLDCM (Brushless DC Motor). It features high efficiency, large torque-to-weight ratio, long life, low noise, low torque ripple, high reliability and low maintenance, making it ideal for pumping photovoltaic arrays. A three-phase voltage source inverter (VSI), controlled using a high frequency PWM signal, is often used to power PMSMs.

2. LITERATURE REVIEW

M. A. Elgendy, B. Zahawi and D. J. Atkinson, The energy efficiency of commercial photovoltaic (PV) pump systems can be greatly improved by using a simple P&O (maximum power point tracking) algorithm. Two such P&O implementation techniques, reference voltage perturbation and direct duty cycle perturbation, are widely used in the literature, but no clear criteria are presented for the appropriate selection of method and algorithm parameters. This article presents a detailed theoretical and experimental comparison of two P&O implementation techniques based on system stability, performance characteristics, and energy utilization of a standalone PV pump system. The effects of algorithm parameters on system behavior are studied to identify various advantages and disadvantages of each technique for different weather conditions.

S. Jain, R. Karampuri and V. T. Somasekhar This article presents a single-stage solution for a photovoltaic (PV) pumping system using an open winding induction motor drive with dual inverter power supplies. 3-level dual inverters require lower PV bus voltages compared to their traditional 3-level counterparts. This avoids a large number of PV modules and reduces the voltage rating of the capacitors and semiconductor devices used in the system. This can contribute to further reductions in system costs.

A. Khiareddine, C. Ben Salah and M. F. Mimouni, In general, pumped storage is thought to be the most promising technology for increasing the penetration of renewable energy, especially in tiny autonomous systems. Combining the batter and pump is a practical and realistic way to attain great penetrations.

P. García, C. A. García, L. M. Fernández, F. Llorens and F. Jurado, This paper describes and evaluates an adaptive neuro-fuzzy inference system (ANFIS)-based energy management system (EMS) of a grid-connected hybrid system. It presents a wind turbine (WT) and photovoltaic (PV) solar panels as primary energy sources, and an energy storage system (ESS) based on hydrogen (fuel cell -FC-, hydrogen tank and electrolyzer) and battery.

I. Ducar and C. Marinescu, In this paper two operating modes available for permanent magnet synchronous machines (PMSM) are presented. This study aims to increase the efficiency of the motor-pump system. The PMSM is driven at variable speed and the inverter is controlled by space vector modulation theory.

A. B. C. S. B. Slama and A. Chrif, In this paper, we propose an efficient design along with modeling and simulation of a small scale water pumping system fed by a hybrid Photovoltaic-Fuel Cell (PV-FC) power system. An overview of the basic theory of such system along with their modeling and simulation package is presented. A switching Maximum Power Point Tracking (MPPT) control algorithm is applied to the proposed configuration.

R. Kumar and B. Singh, This paper proposes a solar photovoltaic (PV) fed water pumping system driven by a brushless DC (BLDC) motor. A promising case of interruption in the water pumping due to the intermittency of PV power generation is resolved by using a power grid as an external power backup. The power is drawn from the grid in case the PV array is unable to meet the required power demand, otherwise the PV array is preferably used. A unidirectional power flow control for the same is developed and realized through a power factor corrected (PFC) boost converter.

R. Kumar and B. Singh, A solar water pumping system employing a brushless DC motor drive is presented. The utility grid is utilised as a secondary power source. The total load demand is shared by photovoltaic array and the grid. This results in continuous water pumping. The amount of power shared by each source is controlled through a power factor corrected boost converter. The full utilisation of motor pump is achieved with increased reliability. The power quality is improved at the utility grid side. The simulation and hardware implementation are carried out to exhibit the performance of the system.

B. Singh and S. Murshid, This paper deals with an effective power transfer scheme between the solar photovoltaic (PV) array and single-phase grid, feeding a field-oriented-controlled (FOC) permanent-magnet synchronous motor (PMSM) drive applied to a water-pumping system (WPS). Owing to the intermittency associated with solar (PV) system, the requirement of constant water supply is not possible with the standalone system. In order to mitigate this, a grid-intergrated WPS is proposed here. The grid integration enables the consumer an uninterrupted operation of water pump irrespective of solar insolation level. Moreover, the PV power can be fed to the utility grid when water pumping is not required. To make it possible, one voltage-source converter (VSC) and one voltage-source inverter connected to a common dc link are used for utility grid and PMSM control, respectively. The unit vector template theory is utilized to generate switching pulses for VSC to control the bidirectional power flow between the solar PV system and utility grid through the common dc link.

E. Radziemska, and E.Klugmann This paper presents the experimental results and discusses the track of the maximum power point on the current-voltage curve of a PV module due to changes of the illumination level and temperature. A time decrease of the voltage and simultaneous temperature increase during the initial stage of irradiation has been observed. Some practical implementation aspects of a maximum power point tracking unit, which match the current and voltage characteristics of the load to the PV module's maximum power point automatically, are also discussed. A linear decrease of the maximum output power P_m with temperature increase has been observed and the temperature coefficient was derivate. Temperature coefficients for V_{oc} , I_{sc} , V_{mpp} , I_{mpp} , and $\eta(PV)$ have been determined for the photovoltaic module. Also the radiation rate coefficient at constant temperature has been calculated.

D. P. Hohm and M. E. Ropp, Maximum power point tracking (MPPT) is important in solar power systems because it reduces the solar array cost by decreasing the number of solar panels needed to obtain the desired output power. Several different MPPT methods have been proposed, but there has been no comprehensive experimental comparison between all the different algorithms and their overall maximum power point (MPP) tracking efficiencies under varying conditions (i.e. Illumination, temperature, and load). This paper such a comparison. Results are using a microprocessor controlled MPPT powered by a 250 W photovoltaic (PV) array and also a PV array simulator.

Chia-Hsi Chang, Yu-Hui Lin, The objective of this paper is to propose a simplified reactive power control (SRPC) strategy for single-phase grid-tied photovoltaic (PV) inverters. With the proposed SRPC strategy, a cost-effective microcontroller can be adopted to achieve an effectively reactive power control. Moreover, the current-mode

asynchronous sigma-delta modulation (CASDM) is adopted to enhance the current control's dynamic response and reduce both the current harmonic distortion and electromagnetic interference. In this paper, the operational principle of the proposed SRPC is introduced. Then, the small signal analysis for the PV inverter with the CASDM is presented. Finally, a 1-kVA single-phase PV inverter was built to verify the performance of the proposed control strategy.

3. PROPOSED SYSTEM

The system described in this study consists of a centrifugal pump, a three-phase VSI, a PMSM, a dc to dc boost converter, and a solar PV array. To get the most out of a solar PV array, an INC approach is used.

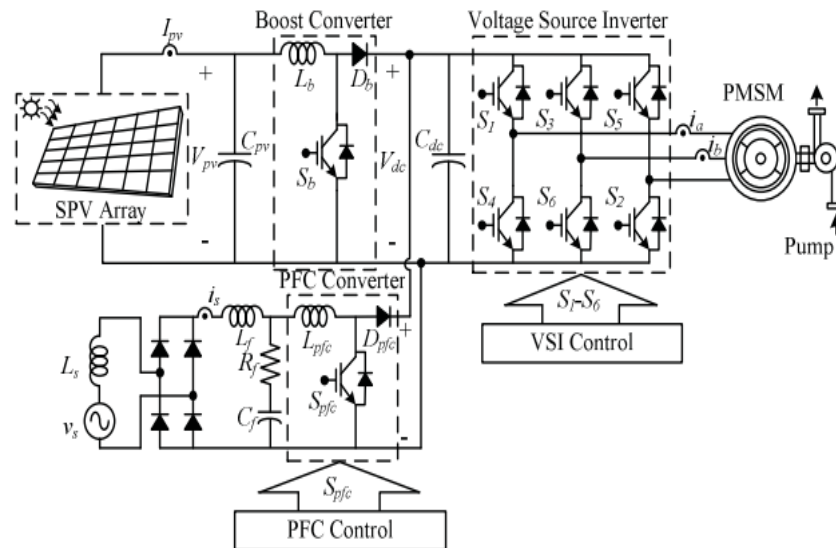


Fig. 1: Proposed System.

Solar cells are the basic building blocks of photovoltaic systems. PV cells are combined into photovoltaic modules. These modules have standard performance. Connecting these PV modules in series increases the voltage level, while connecting them in parallel increases the current level. The required power determines the number of photovoltaic modules. These modules are also arranged in series and parallel depending on the voltage and power requirements of the system. A. Photovoltaic System Design When designing a photovoltaic system, load power requirements are the most important aspect to consider. The nominal power of the photovoltaic device is chosen to be slightly higher compared to the load power. Real systems are never lossless, so this excess power offsets the losses in the converters used to process power in the intermediate stages, and the load is rated at normal insolation. B. Maximum Power Point Tracking (MPPT)

MPP tracking technology is mainly used to optimize the output power of photovoltaic systems. In this research, the INC method is adopted for MPP tracking, which enables highly accurate tracking even under conditions of rapidly changing solar radiation. The MPP tracking method adjusts the duty cycle of the DC/DC boost converter in small steps. Smaller increments ensure better MPP tracking. The drawbacks of perturbation and observation methods that track peak power under rapidly changing atmospheric conditions are overcome by the IC method. The IC detects when the MPPT reaches the MPP and stops disturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated from the relationship between D_i/D_v and $-i/v$. This relationship arises from the fact that dp/dv is negative if the MPPT is to the right of the MPP and positive if it is to the left of the MPPT. This algorithm has the advantage over P and O that he can determine when the MPPT reaches the MPPT where P and O oscillate around the MPP. Also, the increasing conductivity can track rapidly increasing and decreasing irradiation conditions with higher accuracy than P and O.

4. CONCLUSION

There have been several studies of a solar PV water pumping system driven by PMSM in the literature. A wide variety of insolation will be used to analyse the system's performance. It may be assumed that the suggested system with a fuzzy controller will be more stable if the PI controller is updated by a fuzzy logic controller. The WPS dependability has increased as a result of grid integration. No matter what the weather is like, the pump is always working at its maximum capacity. The solar PV array's maximum power has been efficiently harvested using the INC based MPPT algorithm. As a result, the suggested system provides a straightforward, trustworthy, affordable, effective, sturdy, and compact solution that is very practical for solar water pumping.

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